CHAPTER 3: PAVEMENT DISTRESSES

3.1 GENERAL

Various external signs or indicators make the deterioration of a pavement apparent, and often reveal the probable causes of the failure. This chapter provides a detailed discussion and description of the types of pavement distress and relates them to likely causal factors.

3.2 TYPES OF PAVEMENT DISTRESSES.

The discussions of problems related to pavement distress are generally based on whether the pavement has a rigid or flexible surface type. However, while different distresses possess their own particular characteristics, the various types generally fall into one of the following broad categories:

a. Cracking
b. Joint Seal Damage
c. Disintegration
d. Distortion
e. Loss of skid resistance

3.3 RIGID PAVEMENT DISTRESSES.

3.3.1 Cracking.

Cracks in rigid pavements often result from stresses caused by expansion and contraction or warping of the pavement. Overloading, loss of subgrade support and insufficient and/or improperly cut joints acting singly or in combination are also possible causes. Several different types of cracking can occur:

a) Longitudinal, Transverse, and Diagonal Cracks.

A combination of repeated loads and shrinkage stresses usually causes this type of distress. It is characterized by cracks that divide the slab into two or three pieces. These types of cracks can indicate poor construction techniques, underlying pavement layers that are structurally inadequate for the applied load, or pavement overloads.

b) Corner Breaks.

Load repetition, combined with loss of support and curling stresses, usually causes cracks at the slab corner. The lack of support may be caused by pumping or loss of load transfer at the joint. This type of break is characterized by a crack that intersects the joints at a distance less than or equal to one-half of the slab length on both sides, measured from the corner of the slab. A corner crack differs from a corner spall in that the crack extends vertically through the entire slab thickness; a corner spall intersects the joint at an angle.
c) Durability "D" Cracking.

"D" cracking usually appears as a pattern of cracks running in the vicinity of and parallel to a joint or linear crack. It is caused by the concrete's inability to withstand environmental factors because of variable expansive aggregates. This type of cracking may eventually lead to disintegration of the concrete within 1 to 2 feet (30 to 60 cm) of the joint or crack.

d) Shrinkage Cracking.

Shrinkage cracks are hairline cracks that are usually only a few feet long and do not extend across the entire slab. They are formed during the setting and curing of the concrete and usually do not extend through the depth of the slab. Typically, shrinkage cracks do not extend greater than 6.4 mm from the slab surface and may be primarily in the finished surface.

3.3.2 Joint Seal Damage.

Joint seal damage is any condition that enables soil or rocks to accumulate in the joints or that allows infiltration of water. Accumulation of materials prevents the slabs from expanding and may result in buckling, shattering, or spalling. Water infiltration through joint seal damage can cause pumping or deterioration of the sub-base. Typical types of joint seal damage include stripping of joint sealant, extrusion of joint sealant, hardening of the filler (oxidation), loss of bond to the slab edges, and absence of sealant in the joint. Joint seal damage is caused by improper joint width, use of the wrong type of sealant, incorrect application, and/or not properly cleaning the joint before sealing.

3.3.3 Disintegration.

Disintegration is the breaking up of a pavement into small, loose particles and includes the dislodging of aggregate particles. Improper curing and finishing of the concrete, unsuitable aggregates and improper mixing of the concrete can cause this distress. Disintegration falls into several categories:

a) Scaling, Map Cracking, and Crazing.

Scaling is the disintegration and loss of the wearing surface. A surface weakened by improper curing or finishing can lead to scaling. Map cracking or crazing refers to a network of shallow hairline cracks that extend only through the upper surface of the concrete. Crazing usually results from improper curing and/or finishing of the concrete and may lead to scaling of the surface. Alkali-Silica Reactivity (ASR) is another source of distress associated with map cracking. ASR is caused by an expansive reaction between aggregates containing silica and alkaline pore solutions of the cement paste.

b) Joint Spalling.
Joint spalling is the breakdown of the slab edges within 2 feet (60 cm) of the side of the joint. A joint spall usually does not extend vertically through the slab but intersects the joint at an angle. Joint spalling often results from excessive stresses at the joint or crack caused by infiltration of incompressible materials or weak concrete at the joint (caused by overworking) combined with traffic loads. Joint spalling also results when dowels, which can prevent slab movement, become misaligned either through improper placement or improper slippage preparation.

c) **Corner Spalling.**

Corner spalling is the raveling or breakdown of the slab within approximately 2 feet (60 cm) of the corner. It differs from a corner break in that the spall usually angles downward to intersect the joint, while a break extends vertically through the slab. The same mechanisms that cause joint spalling often cause corner spalling, but this type of distress may appear sooner because of increased exposure.

d) **Shattered Slab/Intersecting Cracks.**

A shattered slab is defined as a slab where intersecting cracks break up the slab into four or more pieces. This is primarily caused by overloading due to traffic and/or inadequate foundation support.

e) **Blowups.**

Blowups usually occur at a transverse crack or joint that is not wide enough to permit expansion of the concrete slabs. Insufficient width may result from infiltration of incompressible materials into the joint space or by gradual closure of the joint caused by expansion of the concrete due to ASR. When expansive pressure cannot be relieved, a localized upward movement of the slab edges (buckling) or shattering will occur in the vicinity of the joint. Blowups normally occur only in thin pavement sections, although blowups can also appear at drainage structures (manholes, inlets, etc.). The frequency and severity of blowups may increase with an asphalt overlay due to the additional heat absorbed by the dark asphalt surface. They generally occur during hot weather because of the additional thermal expansion of the concrete.

f) **Patching.**

A patch is defined as an area where the original pavement has been removed and replaced by a filler material. Patching is usually divided into two types:

i) **Small.** A small patch is defined as an area less than 0.5 m$^2$.

ii) **Large and Utility Cuts.** A large patch is defined as an area greater than 0.5 m$^2$. A utility cut is defined as a patch that has replaced the original pavement due to placement of underground utilities.

3.3.4 **Distortion.**

Distortion refers to a change in the pavement surface’s original position, and it results from foundation settlement, expansive soils or loss of fines through improperly designed sub-drains or drainage systems. Two types of distortion generally occur:
a) Pumping.

The deflection of the slab when loaded may cause pumping, which is characterized by the ejection of water and underlying material through the joints or cracks in a pavement. As the water is ejected, it carries particles of gravel, sand, clay, or silt with it, resulting in a progressive loss of pavement support that can lead to cracking. Evidence of pumping includes surface staining and base or sub-grade material on the pavement close to joints or cracks. Pumping near joints indicates poor joint-load transfer, a poor joint seal, and/or the presence of ground water.

b) Settlement or Faulting.

Settlement or faulting is a difference in elevation at a joint or crack caused by upheaval or non-uniform consolidation of the underlying pavement layer(s) material. This condition may result from loss of fines, loss of load transfer device (key, dowel, etc.), or swelling soils.

3.3.5 Loss of Skid Resistance.

Skid resistance refers to the ability of a pavement to provide a surface with the desired friction characteristics under all weather conditions. It is a function of the surface texture. Loss of skid resistance is caused by the wearing down of the textured surface through normal wear and tear or the buildup of contaminants.

3.3.6 Polished Aggregates.

Some aggregates become polished quickly under traffic. Naturally polished aggregates create skid hazards if used in the pavement without crushing. Crushing the naturally polished aggregates creates rough angular faces that provide good skid resistance.

3.3.7 Contaminants.

Rubber deposits building up over a period of time will reduce the surface friction characteristics of a pavement. Oil spills and other contaminants will also reduce the surface friction characteristics.

3.4 FLEXIBLE PAVEMENT DISTRESSES

3.4.1 Cracking.

Cracks in flexible pavements are caused by deflection of the surface over an unstable foundation, shrinkage of the surface, thermal expansion and contraction of the surface, poorly constructed lane joints, or reflection cracking. Five types of cracks commonly occur in these types of pavements:

a) Longitudinal and Transverse Cracks.

Longitudinal and transverse cracks often result from shrinkage or contraction of the HMA surface. Shrinkage of the surface material is caused by oxidation and age
hardening of the asphalt material. Contraction is caused by thermal fluctuations. Poorly constructed paving lane joints may accelerate the development of longitudinal joints cracks.

b) Block Cracking.

Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 1 by 1 foot (0.3m by 0.3m) to 10 by 10 feet (3m by 3m). Block cracking is caused mainly by contraction of the asphalt and cyclic daily temperature. It is not load associated. The occurrence of block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of pavement area, but sometimes will occur only in non-traffic areas. This type of distress differs from alligator cracking in that the alligator cracks form smaller, many-sided pieces with sharp angles. Also, unlike block cracks, alligator cracks are caused by repeated traffic loadings and are, therefore, located only in traffic areas (that is, wheel paths).

c) Reflection Cracking.

Vertical or horizontal movements in the pavement beneath an overlay cause this type of distress. These movements may be due to expansion and contraction caused by temperature and moisture changes or traffic loads. The cracks in HMA overlays reflect the crack pattern or joint pattern in the underlying pavement. They occur most frequently in HMA overlays on PCC pavements. However, they may also occur on overlays of HMA pavements wherever cracks or joints in the old pavement have not been properly repaired.

d) Alligator or Fatigue Cracking.

Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the HMA surface under repeated traffic loading. The cracking initiates at the bottom of the HMA surface (or stabilized base) where tensile stress and strain are highest under a wheel load. The cracks propagate to the surface initially as a series of parallel cracks. After repeated traffic loading or by excessive deflection of the HMA surface over a weakened or under-designed foundation, the cracks connect, forming many sided sharp angled pieces that develop a pattern resembling chicken wire or alligator skin. The pieces are less than 2 feet (0.6M) on the longest side.

e) Slippage Cracks.

Slippage cracks appear when braking or turning wheels cause the pavement surface to slide and deform. This usually occurs when there is a low-strength surface mix or poor bond between the surface and the next layer of the pavement structure. These cracks are crescent or half-moon-shaped with the two ends pointing away from the direction of traffic.

3.4.2 Disintegration.

Disintegration in a flexible pavement is caused by insufficient compaction of the surface, insufficient asphalt binder in the mix, loss of adhesion between the asphalt coating and aggregate particles, or severe overheating of the mix.
a) **Raveling and Weathering.**

The most common type of disintegration in HMA pavements is raveling/weathering. Raveling/weathering is the wearing away of the pavement surface caused by the dislodging of aggregate particles and the loss of asphalt binder. This distress may indicate that the asphalt binder has aged and hardened significantly. As the raveling/weathering continues, larger pieces are broken free, and the pavement takes on a rough and jagged appearance and can produce a significant source for Foreign Object Debris/Damage (FOD).

b) **Potholes.**

A pothole is defined as a disruption in the pavement surface where a potion of the pavement material has broken away, leaving a hole. Most potholes are caused by fatigue of the pavement surface. As fatigue cracks develop, they interlock forming alligator cracking. When the sections of cracked pavement are worked loose, they may eventually be picked out of the surface by continued wheel loads, thus forming a pothole.

c) **Asphalt Stripping.**

Asphalt stripping is caused by moisture infiltration into the HMA pavement structure leading to “stripping” of the bituminous binder from the aggregate particles. Asphalt stripping of HMA pavements may also be caused by cyclic water-vapor pressures within the mixture scrubbing the binder from the aggregates.

3.4.3 **Jet Blast Erosion.**

Jet blast erosion is defined as a darkened area of pavement surface where the bituminous binder has been burned or carbonized. Localized burned areas may vary in depth up to approximately 13 mm.

3.4.4 **Patching and Utility Cut Patch.**

A patch is defined as an area where the original pavement has been removed and replaced by a filler material. A patch is considered a defect in the pavement, regardless of how well it is performing. Deterioration of patch areas affects the riding quality and has FOD potential.

3.4.5 **Distortion.**

Distortion in HMA pavements is caused by foundation settlement, insufficient compaction of the pavement courses, lack of stability in the bituminous mix, poor bond between the surface and the underlying layer of the pavement structure, and swelling soils in the sub-grade. Four types of distortion commonly occur:

a) **Rutting.**
A rut is characterized by a surface depression in the wheel path. In many instances, ruts become noticeable only after a rainfall when the wheel paths fill with water. This type of distress is caused by a permanent deformation in any one of the pavement layers or sub-grade, resulting from the consolidation or displacement of the materials due to traffic loads.

b) Corrugation.

Corrugation results from a form of plastic surface movement typified by ripples across the surface. Corrugation can be caused by a lack of stability in the mix and a poor bond between material layers.

c) Shoving.

Shoving is the localized bulging of a pavement surface. It can be caused by lack of stability in the mix or lateral stresses produced by adjacent PCC pavement during expansion.

d) Depression.

Depressions are localized low areas of limited size. In many instances, light depressions become noticeable only after a rain, when ponding creates "birdbath" areas. Depressions may result from traffic heavier than that for which the pavement was designed, localized settlement of the underlying pavement layers, or poor construction methods.

e) Swelling.

An upward bulge in the pavement's surface characterizes swelling. It may occur sharply over a small area or as a longer gradual wave. Both types of swell may be accompanied by surface cracking. A swell is usually caused by excessive moisture variations in excessively expansive or weak soils.

3.4.6 Loss of Skid Resistance.

Factors that decrease the skid resistance of a pavement surface and can lead to hydroplaning include too much asphalt in the bituminous mix, too heavy a tack coat, poor aggregate subject to wear, and buildup of contaminants. In bituminous pavements, a loss of skid resistance may result from the following:

a) Polished Aggregate.

Aggregate polishing is caused by repeated traffic applications. Polished aggregate is present when the portion of aggregate extending above the asphalt is either very small, of poor quality, or there are no rough or angular particles to provide good skid resistance.
b) **Contaminants.**

Accumulation of rubber particles, oils, or other external materials on the pavement surface will reduce the skid resistance of a pavement. Buildup of rubber deposits in pavement grooves will reduce the effectiveness of the grooves and increase the likelihood of hydroplaning.

c) **Bleeding.**

Bleeding is characterized by a film of bituminous material on the pavement surface that resembles a shiny, glass-like, reflecting surface that usually becomes quite sticky. It is caused by excessive amounts of asphalt binder in the mix and/or low air-void content and occurs when asphalt binder fills the voids in the mix during hot weather and then expands out onto the surface of the pavement. Bleeding may also result when an excessive tack coat is applied prior to placement of the HMA surface. Since the bleeding process is not reversible during cold weather, asphalt binder will accumulate on the surface. Extensive bleeding may cause a severe reduction in skid resistance.

d) **Fuel/Oil Spillage.**

Continuous fuel/oil spillage on a HMA surface will soften the asphalt. Areas subject to only minor fuel/oil spillage will usually heal without repair, and only minor damage will result.

3.5 **DRAINAGE OF AERODROME PAVEMENTS**

3.5.1 A proper drainage system is essential to preventive maintenance. Probably no other factor plays such an important role in determining the ability of a pavement to withstand the effects of weather and traffic. The drainage system collects and removes surface water runoff, removes excess underground water, lowers the water table, and protects all slopes from erosion. An inadequate drainage system can cause saturation of the sub-grade and sub-base, damage to slopes by erosion, and loss of the load-bearing capacity of the paved surfaces. Whenever pavement failure occurs, the aerodrome should investigate the possibility of deficient drainage.

3.5.2 The damage mechanism of free water in the pavement system is related to the amount of free water in the boundaries between the structural layers of the pavement system. When water fills the voids and spaces at the boundaries between layers, heavy wheel loads applied to the surface of the pavement produce impacts on the water comparable to a water-hammer type of action. The resulting water pressure causes erosion of the pavement structure and ejection of the material out of the pavement.

3.5.3 There are two general classes of drainage systems: surface and subsurface. Classification depends on whether the water is on or below the surface of the ground at the point where it is first intercepted or collected for disposal. Where both types of drainage are required, it is generally good practice for each system to function independently.
a) **Surface Drainage**

Surface drainage controls, collects, and disposes of water from rainstorms that accumulate on the surface of the pavement and nearby ground. Surface drainage of pavements is achieved by constructing the pavement surface and adjacent ground in a way that allows for adequate runoff. The water may be collected at the edges of the paved surface in ditches, gutters, and catch basins. Surface water should not be allowed to enter a sub-drainage system as it often contains soil particles in suspension. As the water percolates through the granular material of the sub-drain, these particles cause it to silt up. Inevitably, some water will enter the pavement structure through cracks, open joints, and other surface openings, but this penetration may be kept to a minimum by proper surface maintenance procedures.

b) **Subsurface Drainage**

Subsurface drainage is provided for the pavement by a permeable layer of aggregate or permeable stabilized layers—such as cement-treated or asphalt-treated layers under the full width of the traveled way—with longitudinal pipes for collecting the water and outlet pipes for rapid removal of the water from the subsurface drainage system. Subsurface drains may also consist of perforated collection pipes or conduits in permeable sand or gravel trench encased in geo-textiles with outlet pipes. These systems remove excess water from pavement foundations to prevent weakening of the base and sub-grade and to reduce damage from movements. Subsurface drainage trenches placed at the pavement edge also prevent surface runoff moisture from entering the pavement structure from the pavement perimeter.