

PAVEMENT CONDITION ASSESSMENT

3.1 GENERAL

In this chapter, pavement condition Rating (PCR) is introduced as an indicator that rates the surface condition of the pavement. Different types of distress and severity are illustrated in this chapter, the method used for calculating PCR value is presented. Finally, the PCR Scale and the descriptive condition of a pavement associated with the various ranges of the PCR values are outlined.

3.2 PAVEMENT CONDITION RATING

One of the key components of an effective pavement management system is an accurate assessment of the condition of the existing pavement network. This assessment has historically been accomplished by an annual visual pavement condition survey. The surface cracking of a pavement is represented by a Surface Rating and Dominant Distress for each segment of the pavement network (ASTM, 2007).

However, the complete condition and performance of a pavement is broader than just an assessment of the surface distress. Other factors, such as ride quality, structural capacity and friction are also important components. Ride quality has emerged at the national level as a primary element of pavement performance and customer satisfaction. New technologies are now available to measure other important pavement distresses at the network level. Given these advancements, it is essential for the effective management of the pavement network to develop a more comprehensive metric of pavement condition, particularly a measure that provides the ability to include ride quality in condition assessment and decision making.

Pavement condition Rating (PCR) is an indicator that rates the surface condition of the pavement (FHWA, 1998). It is built based on visual inspection of road section. PCR is used to quantify the road condition. The inspection period for road might vary from segment to another depending on the type of road (i.e., main or branch. etc.) and the volume of traffic represented by Average Annual Daily Traffic (AADT). PCR provides a method for regular rating of road deterioration. PCR is used in Egypt to assess the road condition.
3.3 INSPECTION PROCEDURES

The key component to a quality PMS is quality data collection during the pavement evaluation process. It is important that the data collected during each inspection can be compared with previous pavement inspections. Several methods for data collection are available. The methods selected should reflect the capabilities and goals of the pavement management system. All pavement management systems should include a visual inspection of some type. A properly executed visual evaluation is one of the most reliable and efficient forms of pavement evaluation available. It is simple, inexpensive, and provides a great deal of valuable information about pavement condition. Visual inspection techniques range from informal drive-over’s to formal methods such as the PCR or Long Term Pavement Performance methods. Larger transportation networks, like Metro's, tend to use the more formal systems. These systems, particularly PCR, provide a comprehensive record of pavement distresses at the time of the evaluation and are highly repeatable. Larger systems also tend to use image-based survey methods, which use a vehicle to collect film, video, or digital images of the pavement system. These images are then analyzed for the required distress data. An image-based assessment has the advantages in safety and speed of a drive-over survey without sacrificing the quality of a walking survey. The survey vehicles may also be used to collect additional data, such as roughness or right-of-way images, concurrently with the images ASTM Standard D6433-99 (ASTM, 2007).

A visual inspection of the pavement surface can provide valuable information. Visual inspection data can be used to evaluate current pavement condition, predict future pavement performance, determine and prioritize pavement maintenance and rehabilitation needs, estimate repair quantities, and evaluate the performance of different maintenance and rehabilitation techniques and materials. Most roads rely on a visual inspection as the network level condition assessment used within their Pavement Management System (Broten et al. 2001).

Pavement inspection is conducted on inspection units. An inspection unit is a small segment of a pavement section or management unit selected of convenient size which is then inspected in details. The distress found in the inspection unit is used to calculate the PCR for
the inspection unit inspected. The PCR of the inspected inspection units in the section are then used to represent the condition of the entire section.

An inspection unit can vary from 15 to 60 m long by one to four lanes wide. Generally, inspection unit should have a relatively uniform size within a uniform section. For instance, if a two lane road 7.8 m wide is being inspected, the inspection units could be approximately 30 m long. For a four lane road 15.6 m wide, the inspection units can be 30 m long by 7.8 m wide and only go to the centerline. The units selected for inspection can be alternated between lanes (ASTM, 2007).

When a small area of pavement is found to be much worse than the majority of the pavement, it can be inspected and identified as a "special" inspection unit. This is used to identify areas of localized deterioration such as an area damaged by utility cuts, crossing of construction traffic, or other localized problems. A weighted average is used to calculate the PCR when special inspection units are inspected.

The inspector checks the sample unit and recording the type, severity and amount must correspond to those defined in this Distress Identification Manual. The quantities and severities should normally be estimated using measuring techniques as accurate as possible (ASTM, 2007).

3.4 DISTRESS TYPES AND SEVERITY

Alligator Cracking (Fatigue): Alligator or fatigue cracking is a series of interconnecting cracks caused by fatigue failure of the asphalt concrete surface under repeated traffic loading. Cracking begins at the bottom of the asphalt 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 longitudinal cracks. After repeated traffic loading, the cracks connect, forming many sided, sharp-angled pieces that develop a pattern resembling chicken wire or the skin of an alligator. The pieces are generally less than 0.5 m on the longest side. Alligator cracking occurs only in areas subjected to repeated traffic loading, such as wheel paths (FHWA, 1998).
Severity Levels:

**L**—Fine, longitudinal hairline cracks running parallel to each other with no, or only a few interconnecting cracks. The cracks are not spalled (Figure 3.1).

**M**—Further development of light alligator cracks into a pattern or network of cracks that may be lightly spalled (Figure 3.2).

**H**—Network or pattern cracking has progressed so that the pieces are well defined and spalled at the edges. Some of the pieces may rock under traffic (Figure 3.3).
Figure 3-3: High-Severity Alligator Cracking

How to Measure: Alligator cracking is measured in square meter of surface area. The major difficulty in measuring this type of distress is that two or three levels of severity often exist within one distressed area. If these portions can be easily distinguished from each other, they should be measured and recorded separately. However, if the different levels of severity cannot be divided easily, the entire area should be rated at the highest severity level present.

Block Cracking: Block cracks are interconnected cracks that divide the pavement into approximately rectangular pieces. The blocks may range in size from approximately 0.3 by 0.3 m to 3 by 3 m. Block cracking is caused mainly by shrinkage of the asphalt concrete and daily temperature cycling, which results in daily stress/strain cycling. It is not load-associated. Block cracking usually indicates that the asphalt has hardened significantly. Block cracking normally occurs over a large portion of the pavement area, but sometimes will occur only in non traffic areas. This type of distress differs from alligator cracking in that alligator cracks form smaller, many-sided pieces with sharp angles. Also, unlike block, alligator cracks are caused by repeated traffic loadings, and therefore, are found only in traffic areas, that is, wheel paths (FHWA, 1998).

Severity Levels:  

L—Blocks are defined by low-severity cracks (Figure 3.4).

M—Blocks are defined by medium-severity cracks (Figure 3.5).

H—Blocks are defined by high-severity cracks (Figure 3.6).
Figure 3-4: Low-Severity Block Cracking

Figure 3-5: Medium-Severity Block Cracking
Figure 3-6: High-Severity Block Cracking

How to Measure: Block cracking is measured in square meters of surface area. It usually occurs at one severity level in a given pavement section. However, if areas of different severity levels can be distinguished easily from one another, they should be measured and recorded separately.

Bleeding: Bleeding is a film of bituminous material on the pavement surface that creates a shiny, glasslike, reflecting surface that usually becomes quite sticky. Bleeding is caused by excessive amounts of asphaltic cement or tars in the mix, excess application of a bituminous sealant, or low air void content, or a combination thereof. It occurs when asphalt fills the voids of the mix during hot weather and then expands onto the pavement surface. Since the bleeding process is not reversible during cold weather, asphalt or tar will accumulate on the surface (FHWA, 1998).

Severity Levels:

L—Bleeding only has occurred to a very slight degree and is noticeable only during a few days of the year. Asphalt does not stick to shoes or vehicles (Figure 3.7).

M—Bleeding has occurred to the extent that asphalt sticks to shoes and vehicles during only a few weeks of the year (Figure 3.8).

H—Bleeding has occurred extensively and considerable asphalt sticks to shoes and vehicles during at least several weeks of the year (Figure 3.9).
Figure 3-7: Low-Severity Bleeding

Figure 3-8: Medium-Severity Bleeding

Figure 3-9: High-Severity Bleeding
How to Measure: Bleeding is measured in square meters of surface area. If bleeding is counted, polished aggregate should not be counted.

Depression: Depressions are localized pavement surface areas with elevations slightly lower than those of the surrounding pavement. In many instances, light depressions are not noticeable until after a rain, when bonding water creates a “birdbath” area; on dry pavement, depressions can be spotted by looking for stains caused by bonding water. Depressions are created by settlement of the foundation soil or are a result of improper construction. Depressions cause some roughness, and when deep enough or filled with water, can cause hydroplaning (FHWA, 1998).

Severity Levels (Maximum Depth of Depression):

\[ L \rightarrow \text{13 to 25 mm (Figure 3.10).} \]

\[ M \rightarrow \text{25 to 50 mm (Figure 3.11).} \]

\[ H \rightarrow \text{More than 50 mm (Figure 3.12).} \]
How to Measure: Depressions are measured in square meters of surface area.

Edge Cracking: Edge cracks are parallel to and usually within 0.3 to 0.5 m of the outer edge of the pavement. This distress is accelerated by traffic loading and can be caused by frost-weakened base or subgrade near the edge of the pavement. The area between the crack and pavement edge is classified as raveled if it is broken up (sometimes to the extent that pieces are removed), (FHWA, 1998).

Severity Levels:  
L—Low or medium cracking with no breakup or raveling (Figure 3.13).

M—Medium cracks with some breakup and raveling (Figure 3.14).

H—Considerable breakup or raveling along the edge (Figure 3.15).
Figure 3-13: Low-Severlty Edge Cracking

Figure 3-14: Medium-Severlty Edge Cracking

Figure 3-15: High-Severlty Edge Cracking
How to Measure: Edge cracking is measure in linear meters.

Longitudinal and Transverse Cracking: Longitudinal cracks are parallel to the pavement’s centerline or lay down direction (FHWA, 1998). They may be caused by:

1- A poorly constructed paving lane joint.
2- Shrinkage of the asphalt cement (AC) surface due to low temperatures or hardening of the asphalt, or daily temperature cycling, or both.
3- A reflective crack caused by cracking beneath the surface course.
4- Transverse cracks extend across the pavement at approximately right angles to the pavement centerline or direction of laydown. These types of cracks are not usually load-associated.

Severity Levels: L—One of the following conditions exists (Figure 3.16): nonfilled crack width is less than 10 mm, or filled crack of any width (filler in satisfactory condition).

M—One of the following conditions exists (Figure 3.17): nonfilled crack width is greater than or equal to 10 mm and less than 75 mm; nonfilled crack is less than or equal to 75 mm surrounded by light and random cracking; or, filled crack is of any width surrounded by light random cracking.

H—One of the following conditions exists (Figure 3.18): any crack filled or nonfilled surrounded by medium- or high-severity random cracking; nonfilled crack greater than 75 m or a crack of any width where approximately 100 mm of pavement around the crack is severely broken.
Figure 3-16: Low-Severity Longitudinal and Transverse Cracking

Figure 3-17: Medium-Severity Longitudinal and Transverse Cracking
Figure 3-18: High-Severity Longitudinal and Transverse Cracking

How to Measure: Longitudinal and transverse cracks are measured in linear meters. The length and severity of each crack should be recorded. If the crack does not have the same severity level along its entire length, each portion of the crack having a different severity level should be recorded separately.

Patching and Utility Cut Patching: A patch is an area of pavement that has been replaced with new material to repair the existing pavement. A patch is considered a defect no matter how well it is performing (a patched area or adjacent area usually does not perform as well as an original pavement section). Generally, some roughness is associated with this distress (FHWA, 1998).

Severity Levels:  

**L**—Patch is in good condition and satisfactory. Ride quality is rated as low severity or better (Figure 3.19).

**M**—Patch is moderately deteriorated, or ride quality is rated as medium severity, or both (Figure 3.20).

**H**—Patch is badly deteriorated, or ride quality is rated as high severity, or both; needs replacement soon (Figure 3.21).
Figure 3-19: Low-Severity Patching and Utility Cut Patching

Figure 3-20: Medium-Severity Patching and Utility Cut Patching

Figure 3-21: High-Severity Patching and Utility Cut Patching
How to Measure: Patching is rated in square meters of surface area; however, if a single patch has areas of differing severity, these areas should be measured and recorded separately.

Rutting: A rut is a surface depression in the wheel paths. Pavement uplift may occur along the sides of the rut, but, in many instances, ruts are noticeable only after a rainfall when the paths are filled with water. Rutting stems from a permanent deformation in any of the pavement layers or subgrades, usually caused by consolidated or lateral movement of the materials due to traffic load (FHWA, 1998).

Severity Levels: (Mean Rut Depth)

L—6 to 13 mm (Figure 3.22).

M—13 to 25 mm (Figure 3.23).

H—25 mm (Figure 3.24).

Figure 3.22: Low-Severity Rutting
How to Measure: Rutting is measured in square meters of surface area, and its severity is determined by the mean depth of the rut. The mean rut depth is calculated by laying a straight edge across the rut, measuring its depth, then using measurements taken along the length of the rut to compute its mean depth in millimeters.

Shoving: Shoving is a permanent, longitudinal displacement of a localized area of the pavement surface caused by traffic loading. When traffic pushes against the pavement, it
produces a short, abrupt wave in the pavement surface. This distress normally occurs only in unstable liquid asphalt mix (cutback or emulsion) pavements (FHWA, 1998).

Severity Levels:

L- Shove causes low-severity ride quality (Figure 3.25).

M- Shove causes medium-severity ride quality (Figure 3.26).

H- Shove causes high-severity ride quality (Figure 3.27).
3.5 PAVEMENT CONDITION RATING CALCULATION

The rating method is based upon visual inspection of pavement distress. Although the relationship between pavement distress and performance is not well defined, there is general agreement that the ability of a pavement to sustain traffic loads in a safe and smooth manner is adversely affected by the occurrence of observable distress. The rating method provides a procedure for uniformly identifying and describing, in terms of severity and extent, pavement distress. The mathematical expression for pavement condition rating (PCR) provides an index reflecting the composite effects of varying distress types, severity, and extent upon the overall condition of the pavement. The model for computing PCR is based upon the summation of deducts points for each type of observable distress. Deduct values are a function of distress type, severity, and extent. Deduction for each distress type is calculated by multiplying distress weight times the weights for severity and extent of the distress. Distress weight is the maximum number of deductible points for each different distress type. The mathematical expression for PCR is as follows as shown in Equation (3.1), (FHWA, 1998).

\[
\text{PCR} = 100 - \sum_{i=1}^{n} \text{Deduct} \tag{3.1}
\]

Where:

- \( n \) = number of observable distresses, and
- \( \text{Deduct} = (\text{Weight for distress}) \times (\text{Weight for severity}) \times (\text{Weight for Extent}) \)

The values shown in Table 3-1 present the various distresses for flexible pavement and current guidelines for establishing their severity and extent. Three levels of severity (Low, Medium and High) and three levels of extent (Occasional, Frequent, and Extensive) are defined. The definition for distress type, severity, and extent must be followed closely and be clearly understood by field personnel if the rating method is to provide meaningful data. To illustrate the method for calculating PCR, consider the distress “Longitudinal Joint Cracking”. If the severity of this distress in the pavement is “Medium” and extent is “Frequent”, then, the deduct points for “Longitudinal Joint Cracking” in the pavement would be equal to \([(5) (0.7) (0.7)]\) or 2.45. If an extensive amount of medium severity “Rutting” is
also observed the deduct points for this distress would be equal to [(10) (0.7) (1)] or 7.0. The PCR for the pavement based upon these 2 distresses would equal to:

\[
\text{PCR} = 100 - (2.45 + 7.0) = 90.55
\]

Table 3-1: Flexible Pavement Condition Rating Form (FHWA, 1998)

<table>
<thead>
<tr>
<th>Section:</th>
<th>Data:</th>
</tr>
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<tbody>
<tr>
<td>Log mile:</td>
<td>Rated by:</td>
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<td>Sta:</td>
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**FLEXIBLE**

<table>
<thead>
<tr>
<th>PAVEMENT CONDITION RATING FORM</th>
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<tbody>
<tr>
<td>DISTRESS</td>
</tr>
<tr>
<td>----------</td>
</tr>
<tr>
<td>RALEVEL</td>
</tr>
<tr>
<td>BLEEDING</td>
</tr>
<tr>
<td>PATCHING</td>
</tr>
<tr>
<td>POTHOLES/DEBONDING</td>
</tr>
<tr>
<td>CRACK SEALING DEFICIENCY</td>
</tr>
<tr>
<td>RUTTING</td>
</tr>
<tr>
<td>SETTLEMENT</td>
</tr>
<tr>
<td>CORRUGATIONS</td>
</tr>
<tr>
<td>WHEEL TRACK CRACKING</td>
</tr>
<tr>
<td>BLOCK AND TRANSVERSE CRACKING</td>
</tr>
<tr>
<td>LONGITUDINAL JOINT CRACKING</td>
</tr>
<tr>
<td>EDGE CRACKING</td>
</tr>
<tr>
<td>RANDOM CRACKING</td>
</tr>
</tbody>
</table>

* L = LOW | **O = OCCASIONAL | TOTAL DEDUCT =
| M = MEDIUM | F = FREQUENT | SUM OF STRUCTURAL DEDUCT (✓) =
| H = HIGH | E = EXTENSIVE | 100 - TOTAL DEDUCT = PCR =

*** DEDUCT POINTS = DISTRESS WEIGHT X SEVERITY WT. X EXTENT WT.

A Pavement Condition Rating (PCR) Scale was developed to describe the pavement condition using the PCR numbers calculated from previous Equation. This scale has a range from 0 to 100; a PCR of 100 represents a perfect pavement with no observable distress and a PCR of 0 represents a pavement with all distress present at their “High” levels of severity and “Extensive” levels of extent. Figure 3.28 illustrates the PCR Scale and the descriptive
condition of a pavement associated with the various ranges of the PCR values (FHWA, 1998).

![Pavement Condition Rating Scale](image)

**Figure 3-28: Pavement Condition Rating Scale**

In order to facilitate determining of Pavement Condition Rating (PCR) for road sections a simple program is coded and implemented using Visual Basic with simple and friendly user interface as shown in Figure 3.29. During this interface the user can choose distress type, severity weight categories (low or medium or high) and extent weight categories (occasional
or frequent or extent) then, deduct points will be calculated, Pavement Condition Rating (PCR) value and Pavement Condition Grade (PCG).

Figure 3-29 Pavement Condition Rating Interface
REFERENCES

