MODULE 6

PAVEMENT CONDITION INDICES

6.1 Module Objectives

This module describes the historic development of pavement condition indices, the different types of indices, and their basic functions in a PMS. The module will also describe in detail how they may be developed and how they are computed. Several case studies are presented as examples of the use of different indices in a PMS.

Upon completion of this module, participants will be able to:

- Describe the different types of pavement condition indices
- Describe how condition indices are used in a PMS
- Describe how a condition index is developed
- Determine if an index is satisfying its intended purpose

6.2 Historical Development of Pavement Distress Indices

Pavement distress information is usually converted into a condition index. The condition index combines information from all of the distress types, severities, and quantities into a single number. This number can be used at the network level to define the condition state, to identify when treatments are needed, for ranking or prioritization, and as the number used to forecast pavement condition. The condition index may represent a single distress such as fatigue cracking or a combination of many pavement distresses which is then usually referred to as a composite index. Additional information has also been included in some indices such as traffic levels, highway class, etc. to produce priority ranking indices.

One of the earliest pavement condition indices was the Present Serviceability Rating (PSR) developed at the AASHO Road Test. The PSR was developed at the AASHO Road Test by having raters riding in an automobile assign a pavement condition value that indicated the level of service the pavement provided. Researchers wanted, however, to measure this index objectively. Therefore, a relationship was developed between the mean PSR assigned by the panel, and some objective measurements such as roughness, rutting and cracking *(1)*. The new index, which was based on the values of pavement smoothness, rutting cracking and patching was called the Present Serviceability Index (PSI). The resulting relationship for PSI for flexible pavements is shown in Equation 6.1.

Notice the difference between the PSI and the PSR. The “Index” is a statistical estimate of the panel’s mean “Rating”.

Equation 6.1 allowed the calculation of PSR directly from objective measurements. At the time it was a tremendous advancement for pavement management because it provided a network health index that could be calculated from objectively measured condition data. This was a breakthrough because panel ratings were expensive and unstable. Collecting RD, SV, C and P measurements was also expensive, but it was far more reliable.

Equation 6.1

$$PSI = 5.03 - \log(1 + SV) - 1.38(RD)^2 - 0.01(C + P)^{1/2}$$

Where

PSI = the present serviceability index which is a statistical estimate of the mean of the present serviceability ratings given by the panel,

SV = Slope variance over section from CHLOE profilometer (slope variance was an early roughness measurement)

RD = mean rut depth (in.),

C = cracking (ft / 1000 ft^2) (flexible),

P = patching (ft^2 / 1000 ft^2).

The Federal Highway Administration (FHWA) still requires states to submit PSR data for nationwide road health monitoring. The FHWA guidelines for collecting the PSR data are shown in Table 6.1.

PSR ranges from 0 to 5 based on a description of rideability, physical distress, and rehabilitation needs *(2).*

The AASHO Present Serviceability Rating or the Present Serviceability Index was adopted by many states as their pavement distress index in the development of their PMS. These are the most recognized indices that were specifically developed to reflect the special quality or service (ride) a pavement provides to the user (vehicle passenger).

In the late 1960's more unique indices were developed by several states as they developed their own pavement condition surveys *(3).* These indices were often developed through consensus when considering which distress to include and how they were to be computed.

The U.S. Army Corps of Engineers developed a very complete condition index for a pavement management system in 1976 *(4).* This included pavement condition survey procedures and a detailed method for calculating a Pavement Condition Index (PCI), which is still used today by many agencies. The computational procedures for this index will be shown later in this module *(4).*

As pavement management systems evolved to more complex systems, the form and utility of the indices used changed as well. Composite indices provide a fairly good indication of the general condition of the highway system. They indicate when action is needed but may not be discerning enough to help identify what treatment should be considered. Thus, they limit the ability of a PMS to efficiently and practically compute life-cycle cost analysis and perform network optimization. More distress specific indices are used to provide more information for the analysis requirements in the more

Table 6.1 FHWA guidelines for collecting PSR data

Verbal	Description	PSR
Very Good	Only new, superior (or nearly new) pavements are likely to be smooth enough and distress free (sufficiently free of cracks and patches) to qualify for this category. Most pavements constructed or resurfaced during the data year would normally be rated very good.	5.0 4.0
Good	Pavements in this category, although not quite as smooth as those described above, give a first class ride and exhibit few, if any, visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalding.	3.9 3.0
Fair	The riding qualities of pavements in this category are noticeably inferior to those of new pavements, and may be barely tolerable for high speed traffic. Surface defects of flexible pavements may include rutting, map cracking and extensive patching. Rigid pavements in this group may have a few joint failures, faulting and cracking, and some pumping.	2.9 2.0
Poor	Pavements in this category have deteriorated to such an extent that they affect the speed of free-flow traffic. Flexible pavement may have large potholes and deep cracks. Distress includes raveling, cracking, rutting, and occurs over 50 percent, or more, of the surface. Rigid pavement distress includes joint spalling, faulting, patching, cracking, scaling, and may include pumping and faulting.	1.9 1.0
Very Poor	Pavements in this category are in an extremely deteriorated condition. The facility is passable only at reduced speeds, and with considerable ride discomfort. Large potholes and deep cracks exist. Distress occurs over 75 percent or more of the surface.	0.9 0.0

sophisticated PMS. The distress specific indices used by different states usually consist of at least cracking, rutting and ride, but they may also consider the various cracking categories. More information on the development and computation of individual distress indices as well as composite indices will be discussed in a later section.

In addition, a brief summary of current practices in various states will be included.

6.3 Need for Pavement Condition Indices

Condition indices are used in most pavement management systems for the following four basic reasons *(5):*

- Trigger treatments
- Calculate life-cycle costs
- Evaluate the network condition
- Make use of the same relative scale between systems

TRIGGER TREATMENTS: During a PMS analysis, a list of maintenance and rehabilitation strategies is generated. In generating this list, it is important that only feasible treatments are considered; otherwise the list would be infinitely long. To make the list include only feasible treatments, the PMS needs to know when a treatment is feasible and when it is not.

The process used by most PMS can be described as a simple decision process, where decision trees or triggers are used. The major inputs to this process are the condition indices. For example, with a treatment such as a “thin overlay”, a condition index is needed to indicate when a road is in a condition that makes applying a ‘thin overlay’ feasible.

Feasibility can be examined from two perspectives: (1) operationally, and (2) economically. It is important not to confuse them. From an operational point of view, a thin (25 mm) overlay is sometimes impossible to actually place on the pavement. Consider a road with ruts, distortions, and severe roughness. If a PMS included a thin overlay treatment on the list of strategies for that pavement section it would lose credibility.

Therefore, from an operational perspective, the PMS needs condition indices to indicate when a road is outside the operationally feasible zone of receiving a particular treatment. Usually agencies begin their PMS by mimicking current practices, and thus this usually defines what is feasible from the operational point of view.

CALCULATE COSTS: Pavement condition indices are used to help calculate better cost estimates for the full range of pavement management strategies. This can assist in making better cost projections.

There are many ways condition indices can help calculate costs precisely. The cost of applying the same treatment changes with circumstance. For example, it costs more to fill cracks on a road with many cracks than on a road with few cracks. Or, it costs more to overlay a road with fatigue cracking than a road without fatigue cracking. Or, it costs more to fill potholes on a road with many potholes than on a road with few potholes. Then there is a leveling course for uneven surfaces, drainage repair for poor drains, base repairs for high deflections and so on.

Not only can condition indices signal the need for extra work, sometimes they can also be used to estimate quantities required for activities such as crack filling or patching.

Evaluate Network Health: A PMS is a tool an agency uses to get information to help make decisions. The individual condition indices used for calculations within a PMS are one-dimensional i.e. they only describe one measure of condition. An example is a ride index or a fatigue cracking index.

Composite indices have been developed by many agencies and are used to describe or account for many different measures of condition at once. Composite indices are often a combination of all of the distress data collected by an agency. They are often calculated from ride, cracking, and rutting and condition data at a minimum. The relative weighting of each distress within the composite index is often based on the collective opinion of those within the agency as to which are the most important pavement distresses.

Composite indices are used by most agencies to show the present condition (health) of the pavements in their highway system. The use of composite indices allows the comparison of roads that are experiencing distinctly different distresses but are all considered deficient. The composite index is also easier to explain at the non-technical level within and outside of an agency.

Comparing Roads with Different Distresses: The fourth reason why condition indices are needed is to compare one road directly to another that may have experienced different deterioration patterns. As long as different distress indices such as fatigue cracking, rutting, and ride are developed with different units but with the same relative scale, different roadways with different distresses may be compared to each other. In some cases, agencies have developed unitless scales to minimize the differences between indices.

With these unitless indices, a value of forty may represent a bad condition for one index, and also represents the same level of bad condition for another. In other words, forty is forty, no matter which measure of condition it stands for. This requires careful calibration between indices.

In *Ref. (6)*, the authors provided more specific benefits that can be derived from the use of pavement distress indices. They emphasize that:

§ Any pavement distress index allows better communication between the highway engineers of a state. For example, if the rating scale of the distress indices is 0 to 100 (100 = perfect pavement) and the threshold value is 60, then a value of a distress index of a pavement section of 45 has the same specific meaning to all engineers, regardless of the geographical location.

§ Pavement distress indices also permit highway organizations to establish a standard critical threshold level below which the pavement is considered unacceptable and in need of major maintenance or rehabilitation. This critical value may vary with the functional classification of the pavement (i.e., Interstate versus farm to market). For each distress index or for all indices, it is also possible to establish various threshold levels whereby one level will indicate the need for routine maintenance, another the need for minor repairs, and another to identify major rehabilitation needs.

§ Pavement distress indices also permit highway organizations to rank roads and highways for their maintenance / rehabilitation activities.

- Some distress indices such as PSI relate subjective ratings to objective distress measurements.

- Pavement distress indices collected over several years allow the SHA to determine the rate of deterioration of the different pavement sections of the network and permit engineers of an agency to modify or calibrate their performance prediction mode is based on this information.

- The distress indices allow the pavement designer to look back at the design method and analyze the effects of various design attributes on the pavement distress.

- If each distress index is calculated based on only one distress type (itemized distress indices), then it is possible to determine the relative amount of damage attributed by each distress mechanism. Hence, it is possible to conduct more detailed analyses of feasible rehabilitation alternatives.

- The distress indices allow highway engineers to assess the state of “health” of the pavement network and its rate of deterioration. This information along with the proper analysis of the cause of pavement distress, repair techniques and their associated costs are used to estimate the network’s needs.

In short, pavement distress indices form the numeric basis for quantifying pavement distress and may be used in many forms and processes within a pavement management system.

6.4 Development and Calculation of Pavement Distress Indices

As discussed in Module 5, it is common for agencies to describe pavement distress in terms of its severity and its extent. Severity indicates how bad the distress is. Extent indicates the quantity of distress. Extent can be estimated for an entire section length, estimated over a representative area (such as 100 m per km) or measured. Together, these two parameters can describe a great deal about a particular distress. In North America, this has become the standard manner to collect data for individual distresses.

Consider the example of a pavement distress matrix similar to the one shown in Table 6.2. The rows of the matrix divide the severity into three categories: low, medium and high. The columns represent five categories of extent. During a condition survey a rater describes the condition of the road by placing a check mark in one or more cells.

Table 6.2 **Example Matrix for Collection of Distress Extent and Severity**

	Extent				
Severity	None	1-10%	10-25%	25-50%	>50%
Low					
Medium			✔		
High					

Some survey procedures require the rater to put one check mark for each severity (i.e., one per row). Others simplify this by requiring the rater to only put one check mark in the cell representing the most predominant condition. Table 6.2 illustrates the case where the most predominant distress is recorded. In this example, the rater checked the cell for Medium Severity with an extent between 10 to 25%.

To transform this data into a meaningful condition index, deduct values are needed. Deduct values are points which are used to compute the index based on the severity and extent of the distress represented. The development and calibration of the proper deduct value is the most complicated and critical part in the development of a pavement condition index.

The concept of deduct values is described by its name. The index based is calculated by deducting a number of points from the index value of a pavement in perfect condition, depending on the severity and extent of the deficiency. The value deducted also depends on the condition of the pavement. The number of points deducted is called the deduct value. The very simple formula which uses a deduct value to compute a distress index is shown in the following equation.

Equation 6.2

$$PCI_i = PCI_{max} - \Sigma \text{ Deduct}$$

Where

PCI_i = individual condition index based on measured condition 1

PCI_{max} = value for perfect condition with no measured defects

Deduct = deduct value assigned to distress type, severity & extent

Obviously, using this equation implies that the condition index gets worse as the deduct value increases. Assume an agency uses an index with a scale from 0 (bad) to 100 (perfect = $D_{max,i}$). If the pavement was in perfect condition, the deduct value would be 0, resulting in an index value of 100. If the pavement was in terrible condition, the deduct value would be 100, resulting in an index value of 0.

The relative value of the pavement distress index which represents the condition of the pavement and the shape of the resulting pavement deterioration depends entirely upon the development of the deduct values. Two basic approaches are often used to develop deduct value:

- Expert opinion
- Engineering or mathematical

Both approaches have many variations.

The easiest way to allocate deduct values is to use expert opinion. Most agencies that have developed pavement condition indices begin with this process. To use this approach, agency experts meet to assign deduct values to each cell in a matrix similar to the one in Table 6.2. This approach, however, has provided for some awkward looking pavement trends, or in some cases has not produced any reasonable trends at all. If not approached properly, expert opinion can give erratic results at best or simply incorrect results at worst *(5,7)*.

To illustrate this process, consider the following example of historic deterioration trends for a typical road. In this example, Table 6.3 shows where a rater has placed his or her check mark during eight consecutive condition surveys. These eight surveys were conducted every two years, for a total of sixteen years. Together, then, the eight check marks indicate how the condition of the road changed during the sixteen years.

Table 6.3 Example of a typical failure trend for eight surveys over 16 years.

Severity	Extent				
	None	1-10%	10-25%	25-50%	>50%
Low	✔$_{2}$	✔$_{4}$	✔$_{6}$ ✔$_{8}$		
Medium			✔$_{10}$	✔$_{12}$✔$_{14}$	
High				✔$_{16}$	

This example provides an illustration of the historic condition trends for one arbitrarily selected road segment. The age of the road is indicated with a subscript on each check mark. Notice that the road had no distress when it was two years old. This check mark was from the first survey. The next survey at age four, resulted in a check mark in the 1-10% extent, low severity cell. In the eighth and final survey, when the road was sixteen years old, the check mark was placed in the 25 to 50% extent, high severity cell.

Double check marks in two of the cells do not imply that there was no change in pavement condition, but that change stayed within the limits of that cell. For example between the 12th and 14th years the distress may simply have progressed from 30% to 45%. The fact that the deduct values did not change is one of the primary problems in using a deficiency matrix or blocks of extent rather than measured values of extent. On the positive side, this approach is much simpler to survey and use and has been found accurate enough for network level PMS processes *(7)*.

In a sense, Table 6.3 shows the ‘failure mechanism’ of this road. By following the path the check marks took through the matrix, an agency can see how the condition in the field changed over time. The next step now is to see how the distress index for that road changed over time. To do this we need deduct values for each of the cells with check marks. Table 6.4 illustrates this concept. This type of matrix must be developed for each of the distress types included in the survey.

Table 6.4 Example deduct values assigned by expert opinion.

Severity	Extent				
	None	1-10%	10-25%	25-50%	>50 %
Low	0 $_{2}$	20 $_{4}$	30 $_{6,8}$	40	50
Medium	0	35	40 $_{10}$	60 $_{12,14}$	75
High	0	50	60	80 $_{16}$	100

The age is again used as a subscript to show the path the check marks took through this matrix. The subscripts on the deduct values help illustrate the road's failure mechanism. Another road may take an entirely different path through the matrix as it deteriorates over time. Failing to realize this leads to one of the biggest problems in assigning deduct values. If the deduct values are not smooth for each possible path, the performance curve for any road following that path will also not be smooth.

Plotting the condition index versus age for the example road gives the curve shown in Figure 6.1. The shape of this curve is totally dependent on the deduct values assigned in Table 6.3, and the path through the distress matrix. Any time one of the deduct values changes, a point on the curve will also move. That would change the shape of the curve. Two roads could take two entirely different paths through the matrix. This too would change the shape of the performance curve.

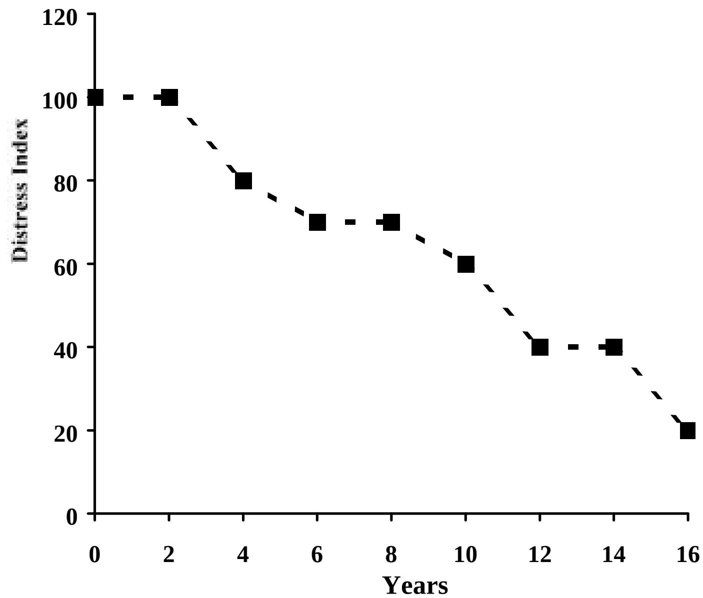
In order to develop smooth and continuous performance curves, it is important that deduct values be carefully assigned. The following discussion gives three examples of a more scientific approach developed to help automate the process. These approaches help express deducts as a function of extent and severity so it is easier to control the final shape of the performance curves.

One of the best introductions to developing individual condition indices is included in *Ref. (6).* The following section is paraphrased from this reference. The authors introduce three terms that are essential for developing individual condition indices:

Index Scale: The index scale is the scale used for the condition index. There are an infinite number of index scales to choose from. Some, such as the scale for the International Roughness Index (IRI), are open ended or 'unbounded', and can theoretically go to infinity. Others are bound by maximum and minimum values such as 0 (bad) to 100 (good), 0 (bad) to 5 (good), or 100 (bad) to 0 (good), to name a few.

The first step in developing individual indices will be to decide on a scale. A scale of 0 (bad) to 100 (good) is used as an example. Note that the minimum and maximum are only examples, and the fact that the scale decreases with decreasing condition is also only an example. This is not the only way of developing an index. In order to be able to compare one distress index with another, it is important that the same scale be used for each index.

Figure 6.2 Plot of example distress values versus age for deducts assigned by expert opinion.



Threshold Value: The threshold represents the value below which a pavement is considered to be in unacceptable condition based on whatever scale is being used. On a scale of 0 (bad) to 100 (good), a value of 60 is a reasonable example of a threshold value. This rating is based on the assumption that 40 deduct points were subtracted from the maximum rating of 100. One of the challenges involved in developing condition indices and assigning deduct points is ensuring that the index only falls below the threshold value when the road truly is in unacceptable condition, and not before. In many instances, threshold values are set consistently for each of the distress indices so that unacceptable conditions are reported consistently.

Engineering Criteria: These values relate the actual condition of the road to the threshold value. The engineering criteria are established setting the amount of distress for each severity level at which the road reaches an unacceptable condition.

For example, assume that three severity levels; low, medium and high, exist for a particular distress index. In this instance, three criteria would have to be defined. These three engineering criteria are established at the extent at which each of the three severities reaches the threshold value. In other words, the engineering criteria represent the values at which the threshold values would be reached if only that distress at that particular severity level were present. To illustrate how these values are used in this example, assume engineering criteria of 70% for low severity, 20% for medium severity, and 10% for high severity are used.

Ref. (5) provides examples of how the engineering criteria used. To demonstrate these examples, a sample graph of deduct values versus extent are shown in Figure 6.2. The three lines on this graph are determined by first calculating the deduct value of 40 from the threshold value of 60 (i.e. 100 – 60 = 40). Next, the threshold line is drawn horizontally at the deduct value of 40. The next step involves extending the engineering criteria from the axis up to this horizontal threshold line. Finally, a line joining each of the three intersecting points to the origin is drawn. These lines represents the deduct curve for the respective severity levels.

To use this graph, enter on the x-axis an extent, go up to the respective severity line, and then across to get the deduct value. Alternatively, the formula for each line can be derived so that the deduct value can be directly calculated. Since the slope of each curve equals the threshold deduct value (40) divided by the respective engineering criteria (70, 20, 10) as shown in the following equation:

Equation 6.3

$$DV_s = (D_{max} - TV_s)/Ec_s \times EXT_s$$

Where:

DV_s = current deduct value for severity *s*

D_{max} = maximum value on index scale

TV_s = threshold value for severity *s*

EC_s = engineering criterion for severity *s*

EXT_s = current extent for severity *s*

Table 6.5 shows a matrix of the deduct values that result from using Equation 6.3 for each severity level in the example. To obtain these deduct values, assume the extent for each severity is at the midpoint in the range. Using the midpoint, the deduct value can be determined for each severity level. For example, assume an extent of 5% was used for the 1-10% range, and 17.5%, 37.5% and 75% for the other three ranges, respectively.

The deduct values can then be determined from Figure 6.2 and the results entered into Table 6.5. Note that when the deduct value is determined to be greater than 100, a 'n/a' was placed in the cell. This was done to prevent a negative condition index value since deducts cannot be more than 100.

Figure 6.2 Deduct values for example using the straight line approach *(5,8)*

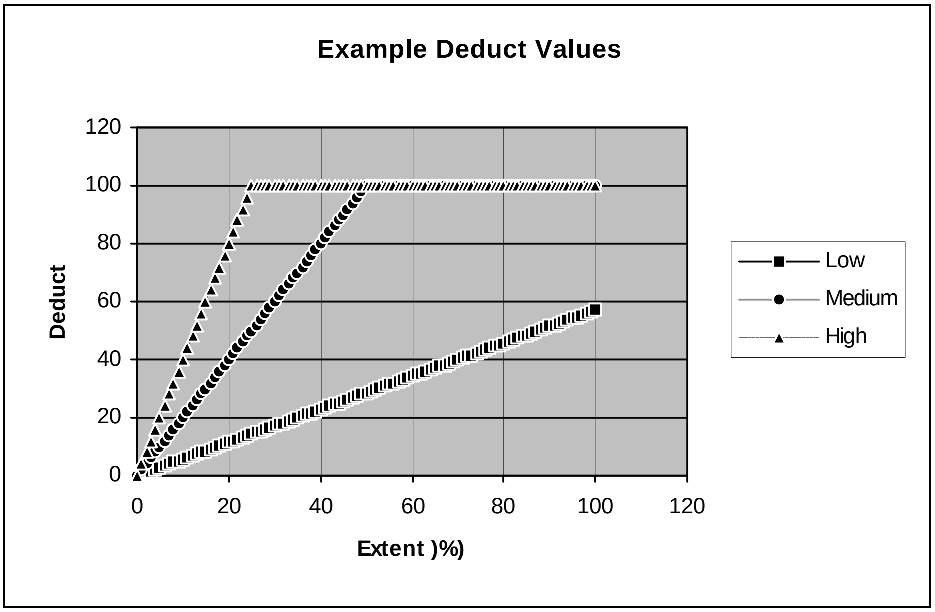
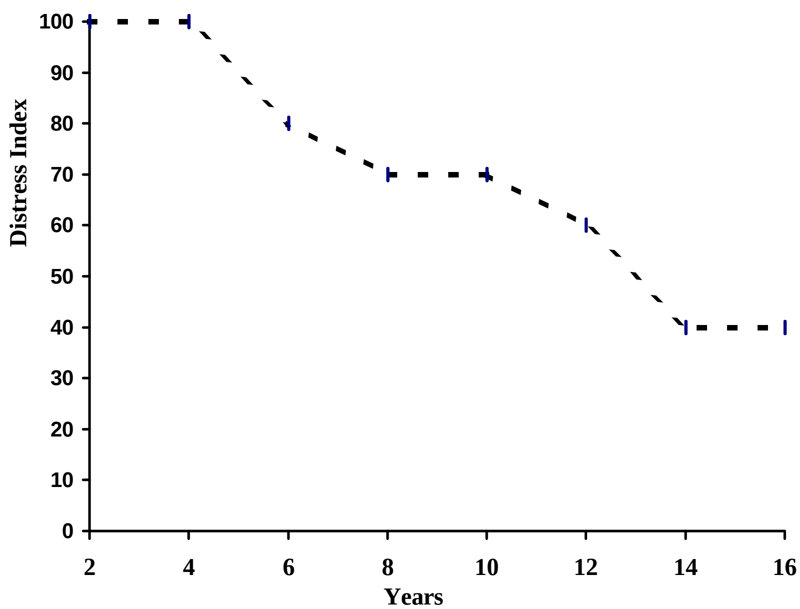


Table 6.5 Example deduct values assigned by the straight line approach *(5,8)*

	Extent				
Severity	None	1-10%	10-25%	25-50%	>50%
Low	0_{2}	3_{4}	10 $_{6,8}$	21	43
Medium	0	10	35 $_{10}$	75 $_{12,14}$	n/a
High	0	20	70	n/a $_{16}$	n/a

Recall the plot resulting from the deduct values assigned by the experts in Figure 6.1, and the upward trend between years 12-14. Figure 6.3 shows the performance curve that results from following the same path through the matrix using the new deduct values calculated in Table 6.5. This time there is an improvement between years 12 and 14.

Figure 6.3 Example distress values versus age for deducts assigned by the straight line method



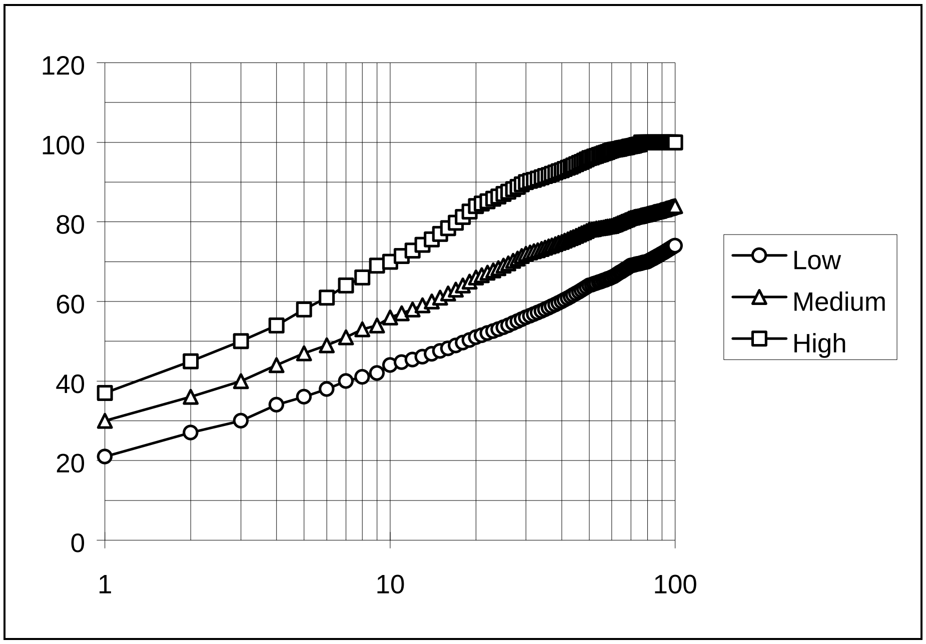
The issue that ultimately has to be addressed in developing the deduct values is the shape of the performance curves. In order to address this issue, an agency must be able to define the most likely path a typical road will take through the severity/extent matrix as the road deteriorates. In turn, this is also affected by the values chosen for the severity and extent.

ASTM Standard D5340 provides a set of deduct value versus extent curves based on work done by *Ref. (4).* These curves are different from those discussed earlier as a curved line on a semi-log graph was used as opposed to a straight line on a normal graph. Figure 6.4 illustrates the curves given for alligator (fatigue) cracking. The x-axis represents the density or extent, while the y-axis represents the deduct values.

Since this graph was taken directly from the reference, it is not expected to have the same threshold value of 60 as in the example above. If this index did have the same threshold value, then the engineering criteria would be 1.5% for high severity, 3% for medium severity and 8% for low severity. To confirm this, follow the line from the deduct value of 40 across the graph until it intersects each of the lines.

Conversely, if this index did have the same engineering criteria as our example (70, 20, 10), then the threshold value would be somewhere around 35 (with a deduct of 65). Once again, to confirm this follow the line from the deduct value of 65 across the graph until it intersects with the three lines.

Figure 6.4 Deduct values for fatigue cracking based on ASTM D5340 *(4,5)*



The resulting matrix of these deducts is shown in Table 6.6. Once again, the midpoint of the extent range was used to arrive at these values. Note that the subscripts indicate the age of the example road when the surveys were performed.

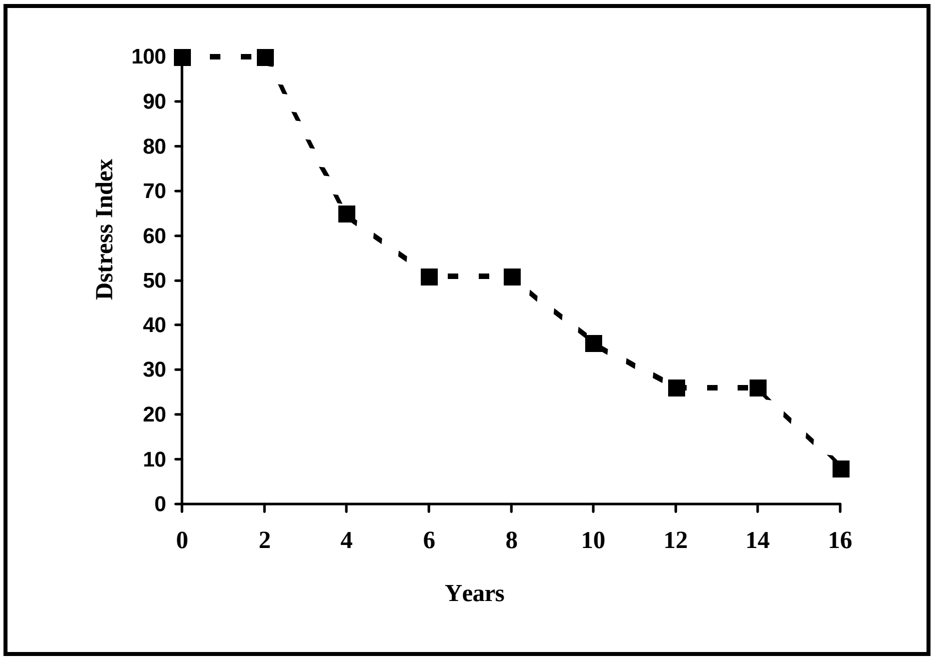
Table 6.6 Example deduct values assigned by a semi-log approach for fatigue cracking, from ASTM D5340 *(4,5)*

Severity	Extent				
	None	1-10%	10-25%	25-50%	>50%
Low	0_{2}	35_{4}	$49_{6,8}$	58	70
Medium	0	45	64_{10}	$74_{12,14}$	82
High	0	56	81	92_{16}	99

Notice the fairly large deducts for the first range (1-10%). This indicates that alligator or fatigue cracking has a large impact on deterioration at its early stages. This pattern affects the shape of the resulting deterioration curve. In this example, the deterioration curve for alligator cracking would reflect more of an S-shaped curve rather than the concave curves that may be more traditional.

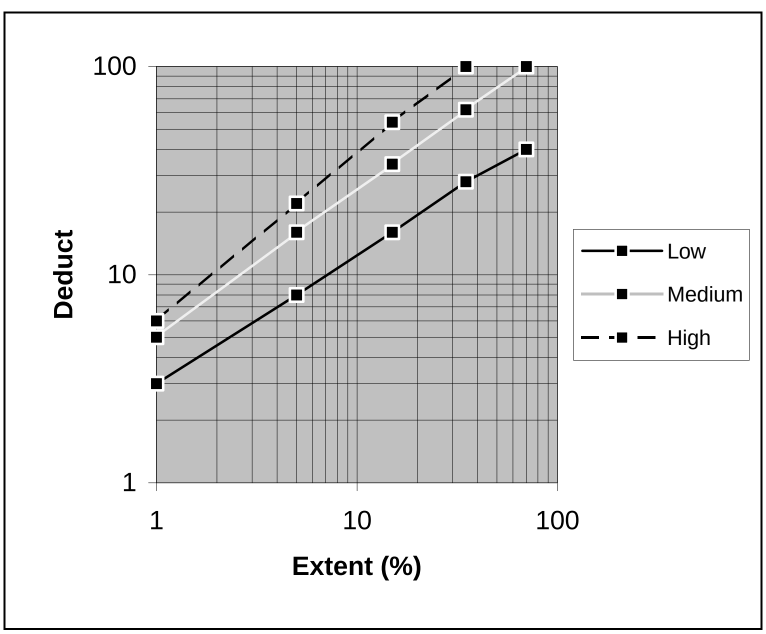
Figure 6.5 shows the performance curve which results from following the same path through the matrix using the new deduct values. This time there is an improvement between years 6 and 8. The important thing to notice regarding this curve is the fact that it is concave upwards. This happens because of the huge initial deduct values.

Figure 6.5 Example distress values versus age for deducts assigned by semi-log approach *(4,5)*



A variation of the straight line approach described in *Ref. (6)* was used in the development of pavement distress indices in South Dakota *(7)*. These curves were different from both previous examples because a straight line on a log-log graph was used. Figure 6.6 illustrates the curves developed for alligator (fatigue) cracking in South Dakota.

Figure 6.6 Deduct values for example using log-log approach.



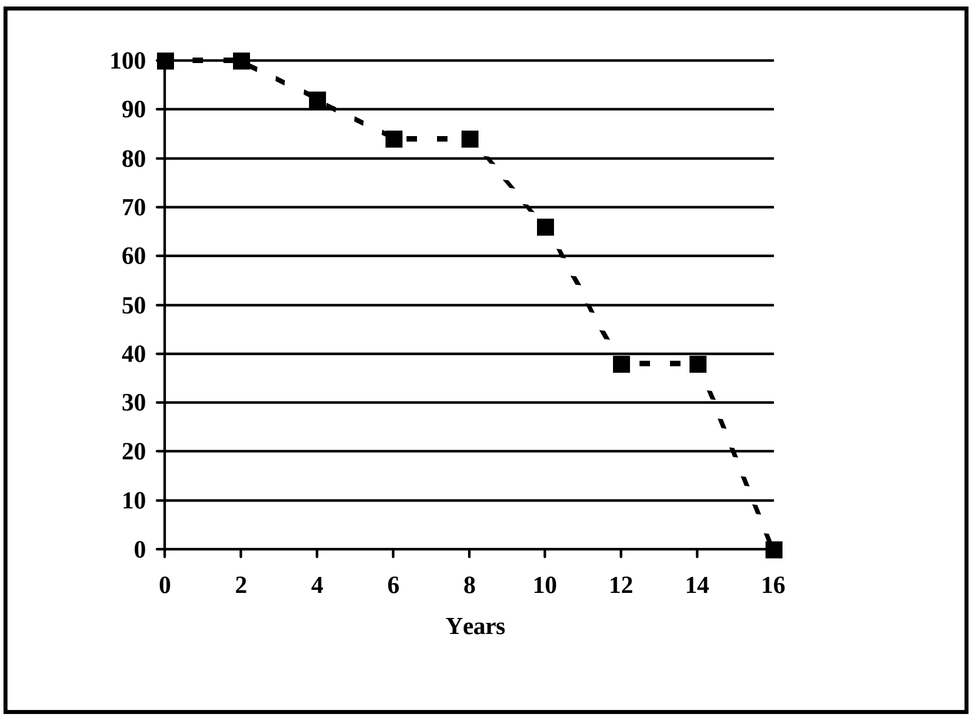
The resulting matrix of these deducts is shown in Table 6.7. Once again, the midpoint of the extent range was used to get these deduct values. As before, the subscripts indicate the age at which the surveys were performed. This time the deduct values did not take a huge jump in the initial extent category. This, as can be seen later, results in a concave downward slope.

Table 6.7 Example deduct values assigned by log-log approach

Severity	Extent				
	None	1-10%	10-25%	25-50%	>50%
Low	0_{2}	8_{4}	$16_{6,8}$	28	40
Medium	0	16	34_{10}	$62_{12,14}$	100
High	0	22	54	100_{16}	n/a

Figure 6.7 shows the performance curve which results from following the same path through the matrix using the new deduct values in Table 6.7. This time there is an improvement between years 12 and 14. The important thing to notice regarding this curve is the fact that it is concave downwards. This is the shape that is more traditional.

Figure 6.7 Example distress values versus age for deducts assigned by log-log approach.



Whatever method is chosen to assign deduct values for the individual condition indices is up to each agency. Each method has its strengths and weaknesses, and, each method can produce a different shape in the performance curve. After deciding on the threshold values and engineering criteria, an agency should then focus on:

- What is the most likely path through the matrix for that condition on a typical road?
- What should the shape of the performance curve be for that condition based on that path?

BASIC CRITERIA: As a final comment in developing condition indices, the following two very basic criteria should be considered *(8):*

The first and most critical criterion is that the deduct values should be scaled such that the resulting condition index threshold value (or action point) occurs at about the middle of the scale *(5)*. In the past, some have established the "should consider action" level at about 60 % of the scale and the "must consider action" level at 40% of the scale.

This concept is similar to the common Pavement Serviceability Index (PSI) developed by AASHO in the early 1960s following the AASHO Road Test. Recall that the PSI is a 0 to 5 scale where a value of 3 is usually considered the proper timing to take action on a high quality roadway, and a value of 2 is considered fairly poor condition for even a secondary road. The value of extent and severity corresponding to the threshold value is sometimes referred to as the engineering criteria *(5)*.

The second criterion is that the transition of the deduct values through the various levels of the distress matrix should produce a condition index that transitions as smoothly as possible with time. Pavement distress is usually observed in the field as a continuous process with time, as the distress progresses through the full range of severity and extent. The trends of the pavement condition index in the PMS should correspond to the trends observed in the specific pavement section represented by that index. Most deficiencies, once they become apparent, tend to increase in both severity and extent at an increasing rate with time. Thus the pavement condition index, which is the numeric representation of the pavement condition in the field, should have the same trends with time as the deficiency appears to have in the field.

In general, those pavements that deteriorate rapidly after the last treatment tend to have a fairly linear form i.e. the rate of change in pavement condition is about the same from one year to the next. Those pavements that last longer before some distress is observed tend to be more exponential in form.

Pavements that have lasted an unusually long time before distress occurs tend to deteriorate quite rapidly in the end; thus they appear to have a very sharp exponential trend. Though this second criterion is not absolutely required for a PMS to function, it is necessary for the PMS to have wide acceptance and is the best utilization of the tool in the decision making process.

6.5 Current Practices in Determining Pavement Condition

In 1994, a survey of all the states was performed to summarize the current practices used to determine the condition of pavements in North America *(9)*. Nearly all the respondents (50 states and 9 Canadian provinces) indicated that the agencies are performing data collection activities in one or more of the four main areas of pavement condition evaluation. These four areas were described in more detail in Module 6, but to briefly recapitulate, are:

- Distress
- Roughness
- Structural
- Friction

The methods and procedures used for the collection of roughness data and friction testing are the most standardized practices being followed. Both the use of the South Dakota type profiling device and reporting of roughness in terms of the IRI has increased sharply.

Many of the agencies evaluate structural capacity, but practices vary widely in programming, conducting, and reporting procedures. This information is used primarily for project-level design rather than at the network-level.

Nearly all the agencies perform friction or skid testing and ASTM methods are most commonly used. Only a few agencies perform friction testing on a continuous, annual, network-survey basis.

The widest variation of practices occurs in the collection and use of pavement distress information. Many of the agencies have recently updated their procedure manuals. Field survey procedures and distress definitions vary greatly. The methods and condition indices used allow little opportunity for exchange of performance data among agencies.

Approximately 80 percent of the agencies use a distress index, serviceability index/rating, or a priority rating as the output for the distress survey. There does not appear to be any evident trends in the way these indices have developed, although formulae are used more frequently than other methods. Over two-thirds of the agencies combine their distress index or ratings with other indices or ratings. The most often used additional index is roughness.

REFERENCES

1. Carey, W.N., Irick, P.E.; *The Present Serviceability Performance Concept*; Highway Research Board, Bulletin 250, National Research Council; Washington, DC; 1960.
2. Al-Omari, B., Darter, M.I.; *Relationships Between International Roughness Index and Present Serviceability Rating;* Transportation Research Record No. 1435 Pavement and Traffic Monitoring and Evaluation; National Academy Press; Washington; DC;. 1994.
3. LeClerc, R. V., Marshall, T. R. "Washington Pavement Rating System - Procedures and Application," presentation at the Western Summer Meeting of the Highway Research Board Sacramento, California, August 1970.
4. Shahin, M.Y., Darter, M.I., Kohn, S.D.; *Development of a Pavement Maintenance Management System, Vol I, II, V, Airfield Pavement Condition Rating*; US Air Force Civil Engineering Center; 1976.
5. Deighton, R., Sztraka, J., *Pavement Condition,* dTV Technical Guide (Volume 3), published by Deighton Associates Limited, 1995
6. Baladi, G. Y., Snyder, M. B., *Highway Pavements*, Student Workbook Publication No. FHWA HI-90-026 Federal Highway Administration, National Highway Institute Course No. 13114 September 1992
7. Jackson, N.C., Kay, R.K., Peters, A.J., "Predictive pavement Condition Program in the Washington State Pavement Management System", Proceeding Second North American Conference on Managing Pavements Toronto Ontario Canada, 1987
8. Jackson, N. C., Deighton, R., Huft, D. L., "Development of Pavement Performance Curves for Individual Distress Indices in South Dakota Based on Expert Opinion" Transportation Research Record No 1524, Transportation Research Board, Washington DC, 1996.
9. Gramling, W.L., "Current Practices in Determining Pavement Condition", NCHRP Synthesis 203, Transportation Research Board, 1994.

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