Present Serviceability Rating Computation from Reported Distresses

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Research, Development, and Technology
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FOREWORD

This report provides an approach for estimating present serviceability rating (PSR) from measured surface distress data to report overall pavement condition, where permitted, to support implementation of the National Performance Management Measures. *The National Performance Management Measures; Assessing Pavement Condition for the National Highway Performance Program* provided in Subpart C of 23 CFR Part 490 permitted the use of PSR as an alternative method for reporting pavement conditions for Interstate and non-Interstate National Highway System locations where the speed limit is less than 40 mph.[(1)]

In 23 CFR 490.309(b)(1)(iv), the portion of the Interstate mainline highway pavements where PSR is allowable includes border crossings and toll plazas. Additionally, PSR is allowable on portions of non-Interstate mainline highways where the posted speed limit is less than 40 mph, as provided in 23 CFR 490.309(b)(2)(iii). However, many agencies do not collect PSR on their pavement segments; instead, they use Pavement Condition Index (PCI) or other indices computed from measured surface distresses in their pavement management systems. In light of this, section 490.309(b)(2)(iii) also allows State DOTs to convert other pavement-condition-assessment methods (e.g., the U.S. Army Corps of Engineers PCI) to PSR if the State establishes to FHWA's satisfaction that the conversion produces pavement-condition ratings equivalent to the PSR method. In support of this rule, FHWA developed this report and a companion Microsoft® Excel® workbook to assist with estimating PSR from measured surface distress data.[(2)] It also illustrates correlations between commonly used indices and the PSR, as described in the *Highway Performance Monitoring System Field Manual*.[(3)] This report also includes a guide for using the Excel workbook.

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16. Abstract
The *National Performance Management Measures; Assessing Pavement Condition for the National Highway Performance Program* provided in Subpart C of 23 CFR Part 490 includes an alternative method to report pavement conditions for Interstate and non-Interstate National Highway System locations where the speed limit is less than 40 mph.(1) This alternate method uses present serviceability ratings (PSR) to report pavement condition in lieu of using the International Roughness Index, measures of rutting and faulting, and percentage of cracking where the posted speed limit is less than 40 mph. Per 23 CFR 490.309(b)(1)(iv), the portion of the Interstate mainline highway pavements where PSR is allowable includes border crossings and toll plazas.(1)

To address stakeholder concerns about the appropriate application of PSR, the Federal Highway Administration (FHWA) developed resources to support agencies that prefer to use PSR as an alternate pavement-condition-rating system, where permitted. In addition, many agencies do not collect PSR on their pavement segments; instead, they use Pavement Condition Index (PCI) or other indices computed from measured surface distresses in their pavement management systems. In light of this, section 490.309(b)(2)(iii) also allows State DOTs to convert other pavement-condition-assessment methods (e.g., the U.S. Army Corps of Engineers PCI) to PSR if the State establishes to FHWA's satisfaction that the conversion produces pavement condition ratings equivalent to the PSR method. In support of this rule, FHWA has developed this report to provide an approach for estimating PSR from measured surface distress data. It also illustrates correlations between commonly used indices and the PSR, as described in the *Highway Performance Monitoring System Field Manual*.(3) The appendix includes a guide for using a Microsoft® Excel®–based PSR Computation Workbook that was developed to assists with estimating PSR from measured surface distresses.(2)

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SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.093	square meters	m^2
yd^2	square yard	0.836	square meters	m^2
ac	acres	0.405	hectares	ha
mi^2	square miles	2.59	square kilometers	km^2
		VOLUME		
fl oz	fluid ounces	29.57	milliliters	mL
gal	gallons	3.785	liters	L
ft^3	cubic feet	0.028	cubic meters	m^3
yd^3	cubic yards	0.765	cubic meters	m^3
	NOTE: volumes greater than 1,000 L shall be shown in m^3			
		MASS		
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2,000 lb)	0.907	megagrams (or "metric ton")	Mg (or "t")
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	5 (F-32)/9 or (F-32)/1.8	Celsius	°C
		ILLUMINATION		
fc	foot-candles	10.76	lux	lx
fl	foot-Lamberts	3.426	$candela/m^2$	cd/m^2
		FORCE and PRESSURE or STRESS		
lbf	poundforce	4.45	newtons	N
lbf/in^2	poundforce per square inch	6.89	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.039	inches	in
m	meters	3.28	feet	ft
m	meters	1.09	yards	yd
km	kilometers	0.621	miles	mi
		AREA		
mm^2	square millimeters	0.0016	square inches	in^2
m^2	square meters	10.764	square feet	ft^2
m^2	square meters	1.195	square yards	yd^2
ha	hectares	2.47	acres	ac
km^2	square kilometers	0.386	square miles	mi^2
		VOLUME		
mL	milliliters	0.034	fluid ounces	fl oz
L	liters	0.264	gallons	gal
m^3	cubic meters	35.314	cubic feet	ft^3
m^3	cubic meters	1.307	cubic yards	yd^3
		MASS		
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg (or "t")	megagrams (or "metric ton")	1.103	short tons (2,000 lb)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C+32	Fahrenheit	°F
		ILLUMINATION		
lx	lux	0.0929	foot-candles	fc
cd/m^2	candela/m2	0.2919	foot-Lamberts	fl
		FORCE and PRESSURE or STRESS		
N	newtons	2.225	poundforce	lbf
kPa	kilopascals	0.145	poundforce per square inch	lbf/in^2

*SI is the symbol for International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380. (Revised March 2003)

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LIST OF ABBREVIATIONS

AC	asphalt concrete
Caltrans	California Department of Transportation
CFR	Code of Federal Regulations
DOT	department of transportation
FHWA	Federal Highway Administration
HPMS	Highway Performance Monitoring System
IRI	International Roughness Index
MTC	Metropolitan Transportation Commission
NHS	National Highway System
PASER	Pavement Surface Evaluation and Rating
PCC	portland cement concrete
PCI	Pavement Condition Index
PCI2PSR	PCI-to-PSR
PM2	National Performance Management Measures to Assess Pavement Condition
PSR	present serviceability rating

CHAPTER 1. INTRODUCTION

Except for the statutes and regulations cited, the contents of this document do not have the force and effect of law and are not meant to bind States in any way. This document is intended only to provide clarity regarding existing requirements under the law or agency policies.

BACKGROUND

The Notice of Proposed Rulemaking for 23 Code of Federal Regulations (CFR) Part 490 Subparts C and D, *National Performance Management Measures; Assessing Pavement Condition for the National Highway Performance Program,* initially proposed that International Roughness Index (IRI) data be collected on all National Highway System (NHS) roadways.[4] Ultimately, the final rule established performance measures to assess Good and Poor pavement conditions on the Interstate System and non-Interstate NHS using four distress metrics: IRI, measures of both rutting and faulting, and percentage of cracking along with the associated inventory identification (i.e., the road ID at which these four metrics are measured).[1] However, for portions of the Interstate mainline (e.g., border crossings, toll plazas) and non-Interstate NHS locations where posted speed limits are less than 40 mph, a State department of transportation (DOT) may collect and report present serviceability ratings (PSRs) as an alternative to IRI, measures of rutting and faulting, and percentage of cracking.

To address stakeholder concerns, the Federal Highway Administration (FHWA) provides technical assistance for using the alternative PSR measures to report overall pavement condition for both Interstate and non-Interstate NHS sections where the posted speed limit is less than 40 mph, as permitted in 23 CFR 490.309(b)(1)(iv) and 23 CFR 490.309(b)(2)(iii).[1] The intent of the regulation is to allow continued use of a method that has been a part of the Highway Performance Monitoring System (HPMS) for many years and provides pavement-condition information for locations with a speed limit less than 40 mph where IRI data collection with a high-speed profiler is not practical. In addition, the legislation permitting the use of an alternative condition-assessment method provides that State DOTs may convert the other methods they choose to use, such as the U.S. Army Corps of Engineers Pavement Condition Index (PCI), to PSR, but FHWA must approve the method an agency uses to correlate the method with the PSR, as required in the *Highway Performance Monitoring System (HPMS) Field Manual*.[1,3]

Present Serviceability Rating

PSR is based on an observer's judgment as to the current ability of a pavement to serve the traffic it is meant to serve. Since it is based on the observer's interpretations of ride quality, it generally reflects road roughness because roughness largely determines ride quality. The subjective PSR scale ranges from 5 (excellent) to 0 (essentially impassable). Table 1 shows the PSR descriptions from the *HPMS Field Manual*.[3] Table 2 summarizes the PSR thresholds from 23 CFR 490.313(c)(4) for all pavements.[1]

Table 1. PSR description.[1,3]

PSR	Description
4.0–5.0	Only new (or nearly new) superior pavements are likely to be smooth and distress free enough (sufficiently free of cracks and patches) to qualify for this category. Most pavements constructed or resurfaced during the data year would normally be rated in this category.
3.0–4.0	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 spalling.
2.0–3.0	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/or cracking, and some pumping.
1.0–2.0	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, and rutting and occurs over 50 percent of the surface. Rigid pavement distress includes joint spalling, patching, cracking, and scaling and may include pumping and faulting.
0.1–1.0	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.

Note: This rating system is described in 23 CFR 490.309(b)(1)(iv)(A), 490.309(b)(2)(iii)(A) and presented in OMB (2016), "Chapter 4. Data Requirements and Specifications," table 4.4.

Table 2. Overall pavement-condition rating thresholds from 23 CFR 490.313(c)(4) using PSR metrics for all pavements.[1]

PSR	Rating
≥4.0	Good
>2.0 and <4.0	Fair
≤2.0	Poor

Table 3 summarizes the distress types defined in 23 CFR 490.313 and their thresholds broken out by pavement surface type, and table 4 summarizes rating criteria for Interstate and non-Interstate NHS pavements.

Table 3. 23 CFR 490 distresses and thresholds for different pavement surface types.[1]

Surface Type	IRI (Inch/Mile)	Rutting (Inches)	Cracking (Percent)	Faulting (Inches)	Rating
AC Pavement	<95	<0.2	<5	N/A	Good
	95–170	0.2–0.4	5–20		Fair
	>170	>0.4	>20		Poor
Jointed Concrete Pavement	<95	N/A	<5	0.1	Good
	95–170		5–15	0.1–0.15	Fair
	>170		>15	>0.15	Poor
CRCP	<95		<5	N/A	Good
	95–170		5–10		Fair
	>170		>10		Poor

AC = asphalt concrete; CRCP = continuously reinforced concrete pavement.
Note: This information is from 23 CFR 490.313(b)(1) through 23 CFR 490.313(b)(3).

Table 4. Rating criteria for pavement.

Rating	AC Pavement and JPCP	CRCP
Good	All three conditions (i.e., IRI, rutting (for AC) or faulting (for JPCP), and percentage cracking) should be Good	Both IRI and cracking should be Good
Poor	If two or more of the three conditions are exhibiting Poor ratings	Both conditions should have Poor ratings
Fair	Everything else	Everything else

AC = asphalt concrete; CRCP = continuously reinforced concrete pavement; JPCP = jointed plain concrete pavement.

METHODOLOGY

Currently, State and local highway agencies are using a wide variety of pavement-rating scales, including pavement-condition rating, PCI, ride-quality index, and others. Standardizing the reporting process using PSR involves developing and verifying conversions from the various indices. As a reference scale, this study considers the procedure used by the San Francisco Bay area's Metropolitan Transportation Commission (MTC) for computing PCI values from recorded pavement distresses and subsequently uses the California Department of Transportation (Caltrans)-recommended procedure to compute PSR from the MTC PCI.[1(5)] Based on the MTC procedure, a Microsoft® Excel® workbook was developed as a companion to this report to assist in computing PSR.[(2)] The PSR Computation Workbook is intended to help FHWA Division Office engineers assess the compatibility of a State's rating scale with the MTC's rating scale.[(2)] Note that a State agency's rating scale may use different distress definitions and thresholds than the MTC. The workbook is available to State highway agencies for computing PSR using the approach described in this report for comparing the result to the respective State rating scale.

[1]Smith, R. (2017). "Description of Condition Assessment used in Streetsaver® Pavement Management Program." (Unpublished internal document developed for the Metropolitan Transportation Commission, Oakland, CA).

CHAPTER 2. DISTRESS RATINGS

Pavement-distress ratings can be subjective or objective. As explained by Bektas, Smadi, and al-Zoubi, "a subjective rating system involves an individual panel [of inspectors] that drives over the pavement (normally at posted speed) and subjectively rates the pavement sections either using a numeric scale or categorical descriptions such as good, fair, poor, etc., based on observed distress types and ride quality."[6] Examples of these systems include the PSR and Pavement Surface Evaluation and Rating (PASER) methods.[7]

Correlating PSR with any subjective ratings can be straightforward provided there is clear understanding of the description of the individual rating system. Keeping in mind that the description of the same index may vary across agencies, care is needed when matching ratings with PSR. The PSR description shown in table 1 should be used to reconcile these differences. For example, comparing the PASER descriptions presented in table 5 with PSR descriptions, the correlation may be a simple ratio of 2, as shown in table 6. However, the PASER system provides ratings using natural numbers, while PSR presents ratings in positive real numbers.

Table 5. PASER system.[7]

Surface Rating	Visible Distress*	General Condition
10 (Excellent)	None.	New construction.
9 (Excellent)	None.	Recent overlay. Like new.
8 (Very Good)	No longitudinal cracks except reflection of paving joints. Occasional, widely spaced transverse cracks (40 ft or greater). All cracks sealed or tight (open less than ¼ inch).	Recent sealcoat or new cold mix.
7 (Good)	Very slight or no raveling, surface shows some traffic wear. Longitudinal cracks (open ¼ inch) due to reflection or paving joints. Transverse cracks (open ¼ inch) spaced 10 ft or more apart, little or slight crack raveling. No patching or very few patches in excellent condition.	First signs of aging.
6 (Good)	Slight raveling (loss of fines) and traffic wear. Longitudinal cracks (open ¼ to ½ inch), some spaced less than 10 ft. First sign of block cracking. Sight to moderate flushing or polishing. Occasional patching in good condition.	Shows signs of aging. Sound structural condition.
5 (Fair)	Moderate to severe raveling (loss of fine and coarse aggregate). Longitudinal and transverse cracks (open ½ inch) show first signs of slight raveling and secondary cracks. First signs of longitudinal cracks near pavement edge. Block cracking up to 50 percent of surface. Extensive to severe flushing or polishing. Some patching or edge wedging in good condition.	Surface aging. Sound structural condition.
4 (Fair)	Severe surface raveling. Multiple instances of longitudinal and transverse cracking with slight raveling. Longitudinal cracking in wheel path. Block cracking (over 50 percent of surface). Patching in fair condition. Slight rutting or distortions (½-inch deep or less).	Significant aging and first signs of need for strengthening.
3 (Poor)	Closely spaced longitudinal and transverse cracks often showing raveling and crack erosion. Severe block cracking. Some alligator cracking (less than 25 percent of surface). Patches in fair to poor condition. Moderate rutting or distortion (1- or 2-inches deep). Occasional potholes.	Needs patching and repair prior to major overlay.
2 (Very Poor)	Alligator cracking (over 25 percent of surface). Severe distortions (more than 2-inches deep) Extensive patching in poor condition. Potholes.	Severe deterioration. Needs reconstruction with extensive base repair.
1 (Failed)	Severe distress with extensive loss of surface integrity.	Failed. Needs total reconstruction.

*Individual pavements will not have all types of distresses listed for any particular rating. They may have only one or two types.
Note: This table is reprinted with permission from the Wisconsin Transportation Information Center.

Table 6. PASER and PSR correlation.[7]

PASER	PSR
9 and 10	4.5 and 5.0
7 and 8	3.5 and 4.0
5 and 6	2.5 and 3.0
3 and 4	1.5 and 2.0
1 and 2	0.5 and 1.0

By contrast, an objective rating system involves an index computed from measured or estimated distresses type, extent, and severity. One example is PCI.

PCI DEFINITION AND VARIATION

PCI, a widely used index derived from individual distress-deduct values, was developed in the late 1970s by the U.S. Army Corp of Engineers.[8] It provides a measure of the current condition of the pavement based on the distresses observed on the surface and is intended to be an indicator of a pavement's structural integrity and surface operational condition (i.e., localized roughness and safety). The type and severity of pavement distress is assessed by visually inspecting pavement sample units. The quantity of distress is measured as described in Shahin, Darter, and Kohn.[8] The distress data are used to calculate the PCI value for each sample unit.

The PCI scale ranges from 0 to 100, with 100 representing a perfect score (a pavement in excellent condition). The general expression for computing the PCI value is shown in equation 1.[8,9]

$$PCI = C - \sum_{i=1}^{p} \sum_{j=1}^{m_i} a(T_i, S_j, D_{ij}) F(t, q) \quad (1)$$

Where:

PCI = pavement condition index.
C = maximum value of the condition index (perfect score, usually 100).
a(*T, S, D*) = deduct-value function that varies with distress type (*T*), severity (*S*), and density (*D*).
F(*t,q*) = adjustment function that varies with total-deduct value (*t*) and number of deducts (*q*).
i and *j* = counters for distress types and severity levels, respectively.
p = total number of observed distress types.
m_i = number of severity levels for the *i*th distress type. (Typically, three levels of severity are used: low, medium, and high.)

ASTM D6433-16

The definition for and manner of computing the PCI value also vary across agencies. In 2000, ASTM International (formerly known as the American Society for Testing of Materials) adopted the PCI calculation method from the *PAVER™ Asphalt Distress Manual* and the *PAVER™ Concrete Distress Manual*,[10,11] which in turn used findings from Shahin, Darter, and Kohn[8,9] as a standard practice for pavement-condition surveys of roads and parking lots. With a recent update in 2016, ASTM specification D6433-16, which is not required under FHWA regulations, includes 20 distresses for pavements surfaced with asphalt concrete (AC) and 19 distresses for pavements surfaced with portland cement concrete (PCC), as summarized in table 7.[12] The PAVER software tool, which is designed to describe a pavement's condition and predict its maintenance and rehabilitation needs, incorporates the *PCI* computation procedure, and users can customize the PCI using selected distress types and severity levels.

Table 7. ASTM D6433 distresses.[12]

Distress ID	Pavement Surface	Distresses
1	AC	Alligator cracking
2	AC	Bleeding
3	AC	Block cracking
4	AC	Bumps and Sags
5	AC	Corrugation
6	AC	Depression
7	AC	Edge cracking
8	AC	Joint reflective cracking
9	AC	Lane/shoulder drop-off
10	AC	Longitudinal and transverse cracking
11	AC	Patching and utility cuts
12	AC	Polished aggregate
13	AC	Potholes
14	AC	Railroad crossing
15	AC	Rutting
16	AC	Shoving
17	AC	Slippage cracking
18	AC	Swell
19	AC	Weathering and raveling
20	AC	Weathering (surface wear), roads
21	PCC	Blow up/buckling
22	PCC	Corner break
23	PCC	Divided slab
24	PCC	Durability crack
25	PCC	Faulting
26	PCC	Joint seal
27	PCC	Lane/shoulder
28	PCC	Linear cracking
29	PCC	Patching (large)
30	PCC	Patching (small)
31	PCC	Polished aggregate
32	PCC	Popouts
33	PCC	Pumping
34	PCC	Punchout
35	PCC	Railroad crossing
36	PCC	Scaling
37	PCC	Shrinkage
38	PCC	Spalling corner
39	PCC	Spalling joint

MTC PAVEMENT CONDITION INDEX

MTC customized the *PCI* computation procedure for its local pavement management needs. The MTC guidelines use ASTM distress-deduct curves but reduce the number of distresses to eight and seven for pavements with AC and PCC surfaces, respectively, as shown in table 8 and table 9.[13,14] The tables also present the ASTM distresses that MTC guidelines combine to simplify the data-collection process. Table 10 summarizes the distresses not accounted for in the MTC guidelines.

Table 8. MTC AC distresses and equivalent ASTM distresses.[12,13]

MTC Distress	Equivalent ASTM	
	Distress ID	Distress
Alligator cracking	1 and 13	Alligator cracking and potholes are characterized as high-severity alligator cracking
Block cracking	3	Block cracking
Distortions	4, 5, 16, and 18	Bumps and sags, corrugation, shoving, and swell
Longitudinal and transverse cracking	7, 8, and 10	Edge cracking, longitudinal and transverse cracking, and joint-reflective cracking
Patching and utility cuts	11	Patching and utility cuts
Rutting and depressions	6 and 15	Rutting and depression
Raveling	19	Weathering and raveling
Weathering	20	Weathering (surface wear), roads

Table 9. MTC PCC distresses and equivalent ASTM distresses.[12,14]

Serial No.	MTC Distress	Equivalent ASTM	
		Distress ID	Distress
1	Corner breaks	22	Corner breaks
2	Divided slabs	23	Divided slabs
3	Faulting	25	Faulting
4	Linear cracking	28 and 37	Linear cracking, shrinkage
5	Patching and utility cuts	29 and 30	Small and large patching
6	Scaling and map cracking	36	Scaling and map cracking
7	Spalling	39 and 38	Corner and joint spalling

Table 10. Distresses not directly accounted for in MTC guidelines.

Distress ID	AC Distress
2	Bleeding
9	Lane/shoulder drop-off
12	Polished aggregate
14	Railroad crossing
17	Slippage cracking
21	Blow up or buckling
24	Durability crack
26	Joint seal
27	Lane/shoulder
31	Polished aggregate
32	Popouts
33	Pumping
34	Punchout
35	Railroad crossing

Like ASTM, MTC defines three severity levels for each distress type. The thresholds used by ASTM and MTC are summarized in table 11 and table 12 for AC and PCC pavements, respectively. A detailed description of the MTC distresses is provided in the references worksheet in the PSR Computation Workbook. In AC pavements, the distress thresholds are the same except for rutting, as shown in table 13. However, for PCC pavements, the distress thresholds are different for all distresses except for patching and scaling. Thresholds for PCC divided slabs are presented in table 14. Table 15 shows the ASTM and MTC categorical ratings based on PCI.[12,13]

Table 11. Three severity levels and their thresholds for each AC distress type in ASTM and MTC.[12,13]

Distress	Units	Low	Medium	High
Alligator cracking*	ft^2	Fine cracks with few interconnected, no spalling	Alligator pattern with light spalling	Well-defined pattern and spalled edges, potholes
Block cracking	ft^2	<⅜ inch	⅜ to 3 inches	>3 inches
Distortions	ft^2	Defined by ride quality		
Longitudinal and transverse cracking	Linear ft	<⅜ inch	⅜ to 3 inches	>3 inches
Patching and utility cuts	ft^2	Defined by ride quality		
Rutting and depressions	ft^2	See table 13		
Raveling	ft^2	N/A	>20 missing aggregate per m^2	Surface rough and pitted
Weathering	ft^2	Noticeable loss of fine aggregate	¼ of the width of coarse aggregate is exposed	>¼ of the width of coarse aggregate is exposed

*Potholes are included under the high-severity distress definition.
N/A = not applicable.

Table 12. Three severity levels and their thresholds for each PCC distress type in ASTM and MTC.[12,14]

Distress	ASTM			MTC		
	Low	Medium	High	Low	Medium	High
Corner breaks	<½ inch	>½ to <2 inches	>2 inches	<1 inch	>1 to <3 inch	>3 inches
Divided slabs	See table 14			See table 14		
Faulting	>⅛ and <⅜ inch	>⅜ and <¾ inch	>¾ inch	>⅜ and ≤½ inch	>½ and ≤1 inch	>1 inch
Linear cracking	≤½ inch and no faulting	>½ to ≤2 inches and faulting <⅜ inch	>2 inches and faulting >⅜ inch	<1 inch and no faulting	>1 to <3 inches and faulting <½ inch	>3 inches and faulting >½ inch
Patching and utility cuts	Based on condition of the patch			Based on condition of the patch		
Scaling and map cracking	Minor scaling	Scaling <15% slab	Scaling >15% slab	Minor scaling	Scaling <15% slab	Scaling >15% slab
Spalling	Spall pieces are still intact	Length >1½ ft and spall <1 inch	Length >1½ ft and spall >1 inch	Spall pieces are still intact	Length >2 ft and spall <1 inch	Length >2 ft and spall >1 inch

Table 13. AC rutting threshold at three different severity levels.[12,13]

Rutting Severity	ASTM	MTC
Low	¼ to ½ inch	½ to 1 inch
Medium	½ to 1 inch	1 to 2 inches
High	>1 inch	>2 inches

Table 14. PCC divided slab threshold at three different severity levels.[12,14]

Severity of Majority of Cracks	MTC Threshold for Number of Pieces in Cracked Slab			ASTM Threshold for Number of Pieces in Cracked Slab		
	4 to 5	6 to 8	More than 8	4 to 5	6 to 8	More than 8
Low (L)	L	L	M	L	L	M
Medium (M)	M	M	H	L	M	H
High (H)	M	H	H	M	H	H

Table 15. ASTM and MTC ratings based on computed *PCI* value.[12,13]

PCI Threshold	ASTM Rating	MTC Rating
100 to 85	Good	Excellent
85 to 70	Satisfactory	Very Good
70 to 55	Fair	Good
55 to 40	Poor	Fair
40 to 25	Very Poor	Poor
25 to 10	Serious	Very Poor
10 to 0	Failed	Failed

CHAPTER 3. *PCI* TO *PSR* EQUATIONS

Both 23 CFR 490.309(b)(1)(iv) and 23 CFR 490.309(b)(2)(iii) allow agencies to report overall pavement condition using PSRs for roadways with a posted speed limit less than 40 mph.[1] For those using the PCI rating scale, including many local agencies, the computed *PCI* should be converted to an equivalent *PSR*, as defined in table 1. Caltrans recommended using the PCI-to-PSR (PCI2PSR) relationship developed by Mok and Smith when reporting PSR for HPMS data submittal.[15,5] Mok and Smith gathered data for developing the relationship by having raters conduct a windshield survey to rate the PSR for the sampled pavements and compute the *PCI* using MTC guidelines. The calculation for the PCI2PSR relationship for AC pavement is shown in equation 2.

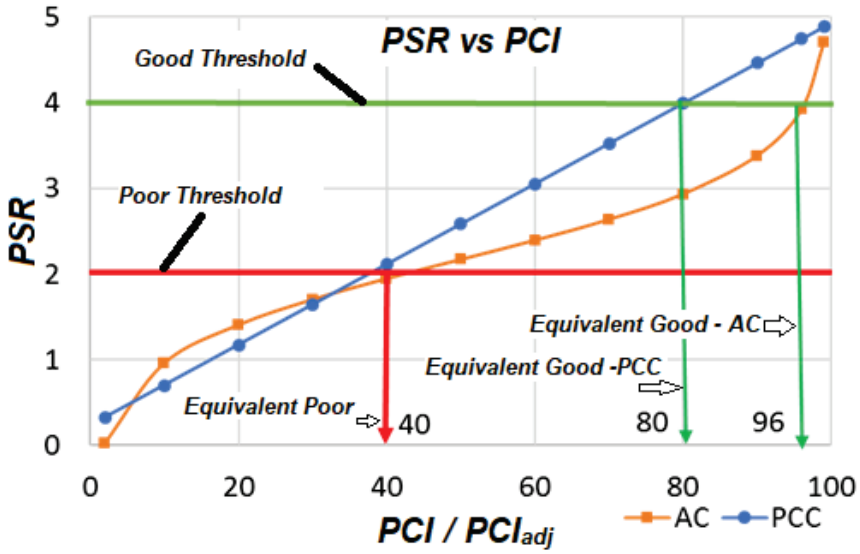
$$PSR = -0.55 * \ln\left[\left(100 * PCI_{adj}\right) - 1\right] + 2.17 \quad (2)$$

In equation 2, PCI_{adj} is *PCI* computed without low-severity cracking. For AC pavements, Mok and Smith found a better relationship between *PCI* and *PSR* when low-severity cracking was excluded from the *PCI* computation. They theorized that it was likely because the raters may not have been able to readily notice low-severity cracking while rating PSR through the windshield. Hence, they excluded low-severity cracking when computing *PCI* and defined it as PCI_{adj}.

The calculation for the PCI2PSR relationship for PCC pavement is shown in equation 3.

$$PSR = 0.047 * PCI + 0.231 \quad (3)$$

Figure 1 shows the graphical depiction of the PCI2PSR relationship presented in equation 2 and equation 3.



Source: FHWA.

Figure 1. Illustration. Caltrans PCI2PSR relationship for AC and PCC pavements.

OBSERVATIONS ON CALCULATING *PSR* FROM THE PCI2PSR RELATIONSHIP

The following observations should be considered when using the PCI2PSR relationship shown in equations 2 and equation 3 to compute *PSR*:

- **AC versus PCC pavements:** In the case of AC pavements, the *PCI* should be greater than 96 to be rated as Good, which corresponds to a *PSR* of 4 or better (figure 1). For PCC pavements, a *PCI* greater than 80 represents a rating of Good, or a *PSR* value of 4 or better. Thus, based on *PCI* values, PCC pavements have a higher probability of being rated as Good. In the case of a Poor rating, the *PSR* threshold of 2 ($PSR < 2$) corresponds to a *PCI* of 40 in both pavements (figure 1).

- **Threshold for a Good rating:** The *PSR* threshold for good pavements is set at 4.0 in 23 CFR 490.313(c)(4)(i) (see the PSR rating definitions in table 1). At the outset, this threshold may appear stricter compared with the definition of good pavements in 23 CFR 490.313(c)(1) (table 4) based on individually reported distresses (table 3). However, low-severity distress thresholds defined by MTC and ASTM (table 11 and table 12) are mostly higher than the distress thresholds for a Good rating defined in 23 CFR 490.313(b) (table 3). Thus, it is possible that a pavement section with high *PCI* (i.e., low-severity distresses as defined by MTC and ASTM thresholds) can still be rated Fair based on the individual distress thresholds established in 23 CFR 490.313(b).[(1)]

  Consequently, when the equations that define the PCI2PSR relationship are used, a *PCI* of 96 appears to be a reasonable threshold for a Good rating and is consistent with the National Performance Management Measures to Assess Pavement Condition (PM2) (23 CFR 490.307) based on individual distress thresholds.[(1)] In the case of PCC pavements, when equation 3 is used, a *PCI* of 80 or higher would be rated as Good but may not be fully consistent with PM2 rating based on individual distress thresholds.

- **Effect of PCI_{adj}:** In AC pavements, the relationship uses PCI_{adj} computed without low-severity cracking instead of *PCI*.

- **Variability in distress definition:** The equations that define the PCI2PSR relationship were developed based on MTC guidelines for distress definitions and thresholds. They should be employed with caution when being used with a *PCI* that is computed based on different guidelines. FHWA Division Offices evaluating alternate scales among the States should carefully consider these distress definitions and thresholds when assessing the appropriateness of the computed *PSR*.

WORKSHEET

As part of this project, the *PCI* computation procedure was programmed into an Excel-based PSR Computation Workbook.[(2)] The ASTM deduct curves, distresses, and severity levels are programmed for pavements with both AC and PCC surfaces. The workbook also computes *PSR* using the PCI2PSR relationship. The input includes the extent of distresses (if any) in each severity level.

CHAPTER 4. ALTERNATE PSR REPORTING SCENARIOS

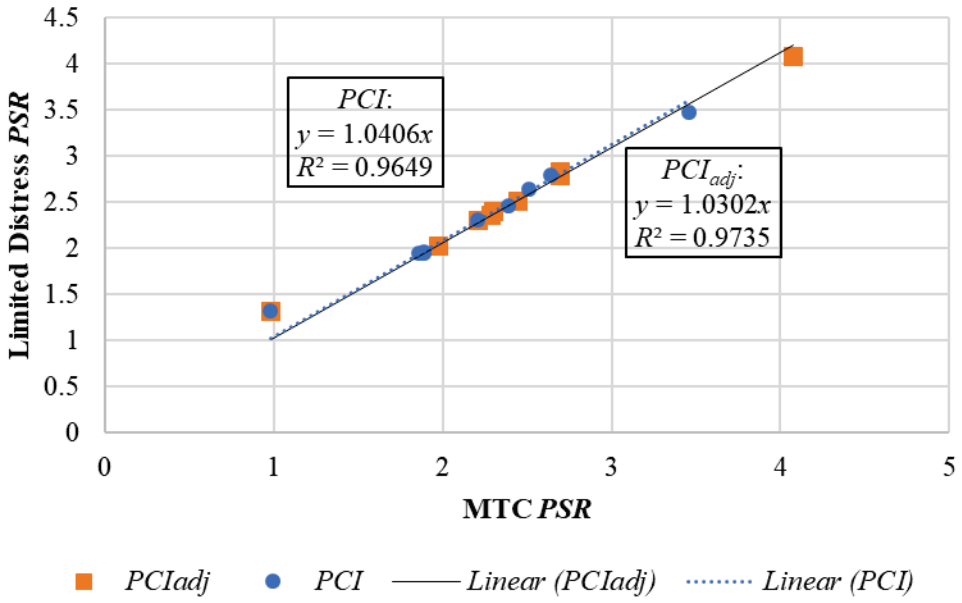
While the PCI2PSR relationship shown in equations 2 and 3 can be used to convert a *PCI* computed using MTC guidelines, agencies may have alternate scales to compute *PSR*. Thus, FHWA Division Offices should evaluate those scales to assess the reasonableness of the *PSR* computation. The Excel-based PSR Computation Workbook developed as a companion to this report can aid in the evaluation process.[(2)]

The following section examines PCI computation using MTC guidelines under several possible scenarios. The results are shown in terms of *PSR* computed using the PCI2PSR relationship.

LIMITED DISTRESS TYPES

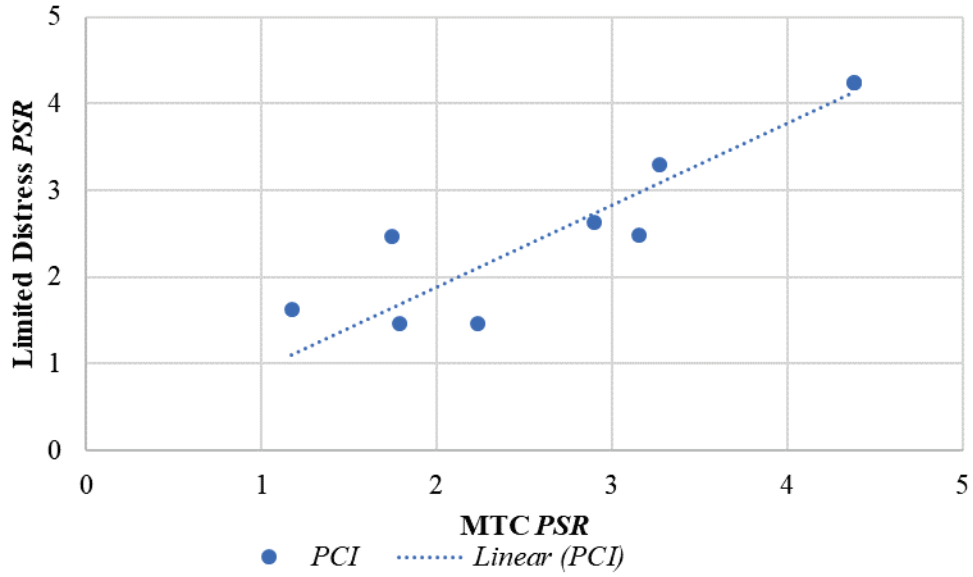
In addition to the StreetSaver® tool used by MTC, PAVER is also used by many local agencies.[(16)] PAVER can use all 20 of the distresses for AC or all 19 distresses for PCC in computing *PCI*. However, for this evaluation, it is suggested that only MTC distresses be considered, omitting the distresses listed in table 10.

PAVER or other tools can also be used with a more limited number of distress types than those defined in the MTC approach. For AC pavements, alligator cracking, rutting, and distortion are kept as minimum distresses to be reported. Figure 2 compares *PSR* computed by incorporating all reported MTC distresses (depending on pavement condition) and only the three minimum distresses. Figure 2 shows two correlations: one using PCI_{adj} (computed without low-severity cracking) and the second using *PCI* (computed with low-severity cracking). For PCC pavements, only divided slabs and faulting are kept as minimum distresses to be reported. However, it is assumed that agencies would combine linear cracking with a divided slab when they conduct the field measurements. Thus, for scenarios with linear cracking, this distress type was combined with divided slabs in the *PCI* calculation. Figure 3 compares PSR computed by incorporating all reported MTC distresses (depending on pavement condition) and only the two minimum distresses. Note that the distress extents are computed based on MTC guidelines in all cases. In both AC and PCC comparisons, distress extents are taken to consider pavements in different stages, as defined in table 4.



Source: FHWA.

Figure 2. Graph. *PSR* from MTC and limited distress types: AC pavements.



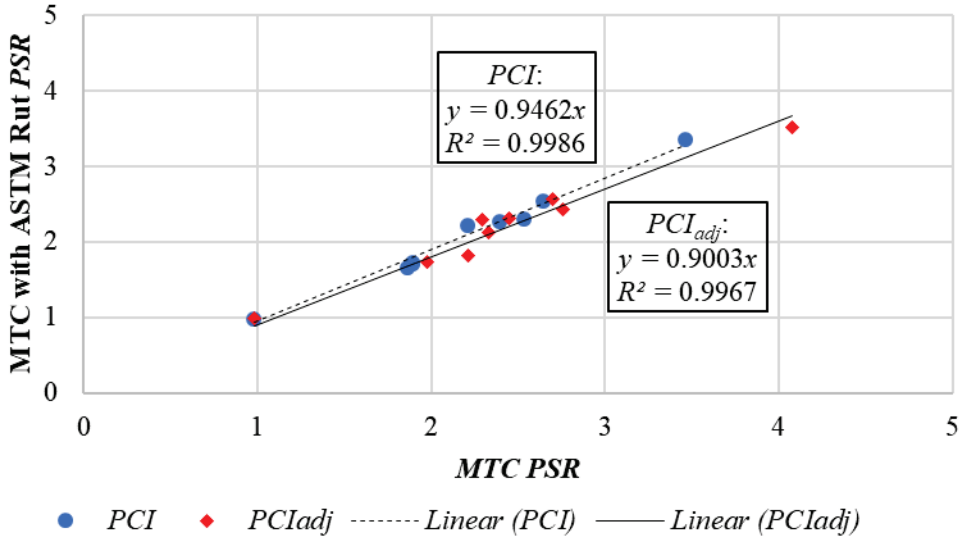
Source: FHWA.

Figure 3. Graph. *PSR* from MTC and limited distress types: PCC pavements.

VARIATION IN DISTRESS DEFINITION AND THRESHOLD

Another PSR reporting scenario includes distresses with different distress definitions and thresholds than those used in the MTC approach. For example, as in ASTM, PAVER uses rutting threshold (table 13), so a pavement section rated as having medium-severity rutting per ASTM would be rated as having low-severity rutting per MTC. Thus, the effect of different distress thresholds on computed *PSR* should be evaluated. Figure 4 compares *PSR* computed using MTC

guidelines but with MTC and ASTM rutting thresholds. The figure shows that, in AC pavements, using different distress (rutting) thresholds, such as those in PAVER, did not cause significant differences to the computed *PSR*. Thus, FHWA Division Office evaluation of States' alternate scales may not necessarily require adjusting the distress extent reported by the agency to match the MTC thresholds.



Source: FHWA.

Figure 4. Graph. *PSR* computed with different rutting definitions.

Similar comparisons for PCC pavements should use measured distress magnitudes. This is because the distress thresholds in MTC and ASTM overlap, and it is not possible to reclassify severity levels (e.g., from low to medium) as was done for AC pavements.

RUTTING MEASUREMENTS

In AC pavements, MTC guidelines require rutting to be reported in terms of the extent of the area of distress per severity level. However, it is a common practice to report average rut depth instead of area. For PSR comparison, it is acceptable to convert rut depth to rut area by assuming the rut width is equal to 2 ft per wheel path and using the severity levels defined in the MTC guidelines based on rut depth.

USING *PCI* INSTEAD OF PCI_{ADJ}

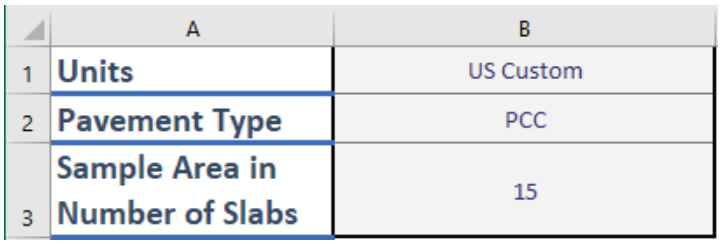
The PCI deduct value increases with the severity level of the distress type, with low-severity cracking expected to have minimal effect on computed *PCI* for AC pavements. Thus, when the pavement is close to Poor condition, which is critical in the evaluation of the scale, the difference between *PCI* and PCI_{adj} is reduced. This is demonstrated in figure 2, which includes *PSR* computed with (*PCI*) and without (PCI_{adj}) low-severity cracking incorporated into the PCI computation. Additionally, with improved accuracy through automated data collection, *PSR* can be expected to account for low-severity cracking. Thus, it may be reasonable to assume that the equations used to define the PCI2PSR relationship are still valid when both *PCI* and *PSR* include low-severity cracking.

APPENDIX. USER GUIDE FOR THE PSR COMPUTATION WORKBOOK TO COMPUTE *PSR* FROM REPORTED DISTRESSES

This appendix summarizes the general procedure for computing *PSR* from reported distresses using the Excel-based PSR Computation Workbook. The procedure includes illustrations that cover scenarios in which distress data could be collected using different guidelines.

To begin, using the dropdown menu options in each cell, select or enter the following information, as illustrated in figure 5:

1. Cell B1: Select either US Custom or SI Units.
2. Cell B2: Select either AC or PCC Pavement Type.
3. Cell B3: Enter Sample Area using either square units for asphalt (i.e., ft^2 or m^2 based on the units selected in step 1) or number of slabs for PCC pavements.

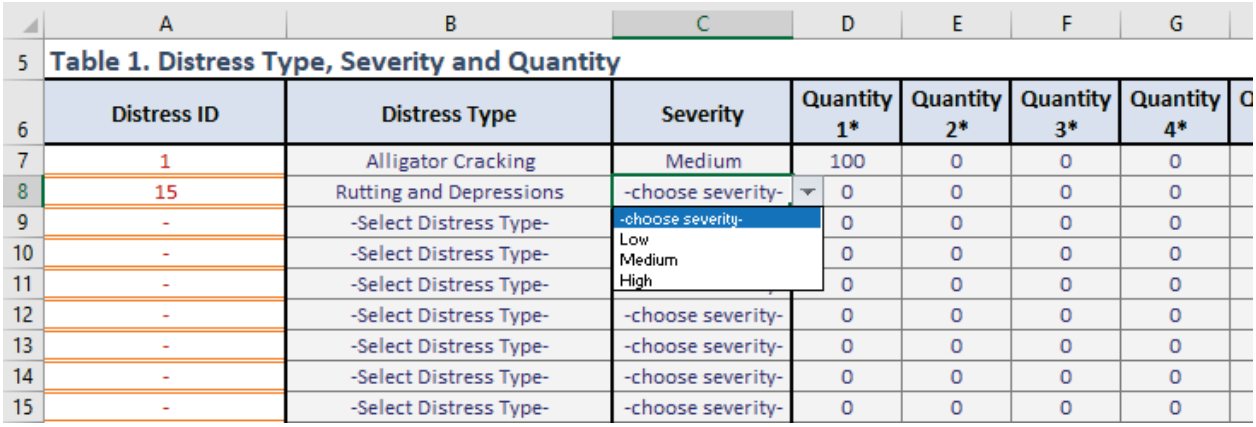


	A	B
1	Units	US Custom
2	Pavement Type	PCC
3	Sample Area in Number of Slabs	15

Source: FHWA.

Figure 5. Screenshot. Input location for units, pavement type, and sample area.

4. Columns B through L: For the selected pavement type, available distress types are automatically populated in the dropdown list in column B. When the distress type is selected, a corresponding ASTM distress ID is automatically populated in column A and a severity dropdown list appears in column C. Select the appropriate severity level from the dropdown list (figure 6). The spreadsheet shown in figure 7 presents MTC-defined distresses and the corresponding ASTM distress ID for AC and PCC pavements.



	A	B	C	D	E	F	G
5	Table 1. Distress Type, Severity and Quantity						
6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*
7	1	Alligator Cracking	Medium	100	0	0	0
8	15	Rutting and Depressions	-choose severity-	0	0	0	0
9	-	-Select Distress Type-	-choose severity-	0	0	0	0
10	-	-Select Distress Type-	Low	0	0	0	0
11	-	-Select Distress Type-	Medium	0	0	0	0
12	-	-Select Distress Type-	High	0	0	0	0
13	-	-Select Distress Type-	-choose severity-	0	0	0	0
14	-	-Select Distress Type-	-choose severity-	0	0	0	0
15	-	-Select Distress Type-	-choose severity-	0	0	0	0

Source: FHWA.

Figure 6. Screenshot. Input locations for distress type, severity, and extent.

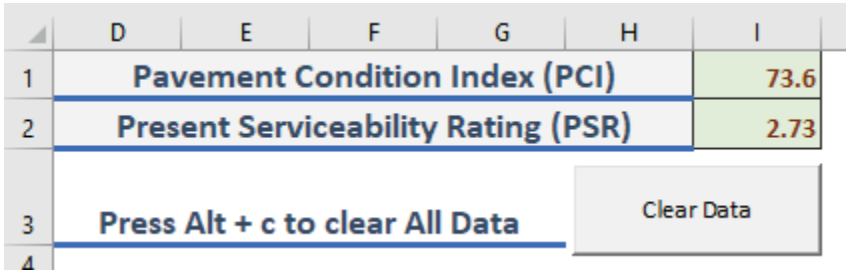
	N	O	P	Q
5	Table 2. Distress Type and Code for AC and PCC Surfaced Pavements			
6	AC Distress Code	AC Pavements Distress Type	PCC Distress Code	PCC Pavements Distress Type
7	1	Alligator Cracking	22	Corner Break
8	3	Block Cracking	23	Divided Slab
9	5	Distortions	25	Faulting
10	10	Longitudinal & Transverse Cracking	28	Linear Cracking
11	11	Patching & Utility Cut Patching	29	Patching and Utility Cuts
12	15	Rutting and Depressions	36	Scaling/Map Cracking/Crazing
13	19	Raveling	39	Spalling
14	20	Weathering	-	-

Source: FHWA.

Figure 7. Screenshot. Distress types and associated ID codes used in the workbook.

5. Column D: Enter the quantity representing the extent of the distress. If additional distress extents are reported, enter them in columns E to L for each unique combination of distress type and severity. Do not repeat same distress type and severity combination in another row as it would lead to erroneous *PSR* calculation.
6. Following steps 4 and 5, enter all other recorded distresses types and severities in subsequent rows without leaving any intermediate blank rows.

The *PCI* and *PSR* are automatically calculated as the distress data are entered (figure 8).



Source: FHWA.

Figure 8. Screenshot. Computed *PCI* and *PSR* values.

To clear the distress data from the form, either click the Clear Data button or use keyboard shortcut Alt-C.

ILLUSTRATIONS

The following sections provide illustrations for three possible scenarios that States might use for their distress data collection or recording and explain how the accompanying Excel workbook could be used to compute *PSR*. The scenarios are applicable to agencies that use the following:

1. PAVER guidelines.
2. MTC guidelines.
3. More limited distress types than those in the MTC guidelines.

PAVER Guidelines

As mentioned earlier in this report, PAVER and ASTM guidelines both use distress types as in table 7. Since the PCI2PSR relationship used in the workbook is based on the MTC guidelines, users are recommended to combine PAVER distresses to match MTC guidelines. Table 16 and table 17 summarize equivalent MTC distresses for each PAVER distress in AC and PCC pavements, respectively. Users are also advised to disregard those PAVER distresses that are not included in MTC guidelines (marked with an asterisk and shown in red in table 16 and table 17).[10,11]

Table 16. PAVER AC pavement distresses and its equivalent MTC distresses.

Distress ID	PAVER AC Distresses	Equivalent MTC Asphalt Distresses
1	Alligator cracking	Alligator cracking
2	Bleeding*	Not included
3	Block cracking	Block cracking
4	Bumps and sags	Distortions
5	Corrugation	Distortions
6	Depression	Rutting and depression
7	Edge cracking	Longitudinal and transverse cracking
8	Joint reflective cracking	Longitudinal and transverse cracking
9	Lane/shoulder drop-off*	Not included
10	Longitudinal and transverse cracking	Longitudinal and transverse cracking
11	Patching and utility cuts	Patching and utility cuts
12	Polished aggregate*	Not included
13	Potholes	High-severity alligator cracking
14	Railroad crossing*	Not included
15	Rutting	Rutting and depression
16	Shoving	Distortions
17	Slippage cracking*	Not included
18	Swell	Distortions
19	Raveling	Raveling
20	Weathering (surface wear), roads	Weathering

*Not included in MTC distress and thus not considered in calculating PSR.

Table 17. PAVER PCC pavement distresses and its equivalent MTC distresses.

Distress ID	PAVER PCC Distresses	Equivalent MTC PCC Distresses
21	Blow up/buckling*	Not included
22	Corner break	Corner break
23	Divided slab	Divided slab
24	Durability crack*	Not included
25	Faulting	Faulting
26	Joint seal*	Not included
27	Lane/shoulder*	Not included
28	Linear cracking	Linear cracking
29	Patching (large)	Patching and utility cuts
30	Patching (small)	Patching and utility cuts
31	Polished aggregate*	Not included
32	Popouts*	Not included
33	Pumping*	Not included
34	Punchout*	Not included
35	Railroad crossing*	Not included
36	Scaling and map cracking	Scaling and map cracking
37	Shrinkage	Linear cracking
38	Spalling corner	Spalling
39	Spalling joint	Spalling

*Not included in MTC distress and thus not considered in calculating PSR.

Illustration 1: Asphalt Pavement

A sample of distress types and extents measured in an AC pavement section using PAVER guidelines is summarized in table 18. The sample area is 2,500 ft^2. As required for the PSR computation, distress types and their extents as defined by the PAVER guidelines were regrouped to match MTC guidelines, as shown in table 19. The bleeding distress type reported in table 18 was excluded because it is not considered in the MTC guidelines.

In the MTC guidelines, potholes are classified as high-severity alligator cracking; however, PAVER includes both the number of potholes and their severity levels. If the area of the pothole is not provided directly by the agency, it can be computed using 0.5-, 1-, and 2-ft diameter potholes representing low, medium, and high severities, respectively, per ASTM D6433-16.[12] In this illustration, a medium-severity pothole would cover $\pi \times 1^2 \div 4$ multiplied by the number of potholes (1) or an area of 0.785 ft^2. When combining PAVER distress types with different severities, retain the severity rating of the corresponding MTC distress type (demonstrated in Illustration 2: PCC Pavement).

Table 18. Measured distress extent in asphalt pavements as defined by PAVER guidelines.

Distress ID	PAVER Distress	Severity	Area (ft^2)
1	Alligator cracking	Low	10
2	Bleeding*	Low	5
3	Block cracking	Low	5
4	Bumps and sags	High	5
5	Corrugation	High	5
6	Depression	Low	5
8	Joint reflective cracking	Low	5
10	Longitudinal and transverse cracking	Low	10
13	Potholes	Medium	1
15	Rutting	Low	40
16	Shoving	High	3
18	Swell	High	5
19	Raveling	Medium	5
20	Weathering (surface wear), roads	Low	5

*Not included in MTC distress and thus not considered in calculating PSR.

Table 19. Equivalent MTC asphalt pavement distress extent for illustration 1.

Distress ID	MTC Distress	Equivalent PAVER Distress ID	Severity	Area (ft^2)
1	Alligator cracking	1	Low	10
1	Alligator cracking	13	High	0.785
3	Block cracking	3	Low	5
5	Distortions	4, 5, 16 and 18	High	18
10	Longitudinal and transverse cracking	7, 8, and10	Low	15
11	Patching and utility cuts	11	Not reported	
15	Rutting and depressions	6 and 15	Low	45
19	Raveling	19	Medium	5
20	Weathering	20	Low	5

Following steps 1 through 6, the computed *PCI* and *PSR* were 59.7 and 2.38, respectively (figure 9). The computed *PCI* and *PSR* show that the pavement is in Fair condition.

	A	B	C	D	E	F	G	H	I
1	Units	US Custom		Pavement Condition Index (PCI)					59.7
2	Pavement Type	Asphalt		Present Serviceability Rating (PSR)					2.38
3	Sample Area in Sq.feet	2500		Press Alt + c to clear All Data				Clear Data	
4									
5	Table 1. Distress Type, Severity and Quantity								
6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*	Quantity 5*	Quantity 6*
7	1	Alligator Cracking	Low	10		0	0	0	0
8	1	Alligator Cracking	High	0.785	0	0	0	0	0
9	3	Block Cracking	Low	5	0	0	0	0	0
10	5	Distortions	High	18	0	0	0	0	0
11	10	Longitudinal & Transverse Cracking	Low	15	0	0	0	0	0
12	15	Rutting and Depressions	Low	45	0	0	0	0	0
13	19	Raveling	Medium	5	0	0	0	0	0
14	20	Weathering	Low	5	0	0	0	0	0

Source: FHWA.

Figure 9. Screenshot. Results from illustration 1 for asphalt pavements.

Illustration 2: PCC Pavement

Table 20 summarizes the distress types and their extents in a sample PCC pavement section as measured using PAVER guidelines. The sample consisted of 20 slabs. As suggested, distress types and their extents as defined by the PAVER guidelines were regrouped to match MTC guidelines, as shown in table 21. Blow ups or buckling, durability cracking, polished aggregate, pumping, punchouts, and railroad crossing distress types reported in table 20 were left out as they are not considered in MTC guidelines. When combining PAVER distress types with different severities, users should retain the severity level of the corresponding MTC distress type. In this example, PAVER spalling corner and spalling joint distress types were merged with MTC spalling. Since PAVER spalling corner is low severity and PAVER spalling joint is medium severity, MTC spalling has both low- and medium-severity levels, matching the distress extent of PAVER spalling corner and PAVER spalling joint, respectively. The same procedure should be followed for merging PAVER linear cracking and shrinkage. The PAVER shrinkage distress type does not have an associated severity level, but it can be considered equivalent to the MTC definition of low-severity linear cracking.

Table 20. Measured distress extent in PCC pavements as defined by PAVER guidelines.

Distress ID	PAVER Distress	Severity	Number of Slabs
21*	Blow up/buckling	Low	2
22	Corner break	Medium	1
23	Divided slab	Medium	2
24*	Durability crack	Low	2
25	Faulting	Low	2
28	Linear cracking	Medium	4
29	Patching (large)	Low	1
31*	Polished aggregate	—	1
33*	Pumping	—	1
34*	Punchout	Low	2
35*	Railroad crossing	Low	2
36	Scaling	Low	1
37	Shrinkage	—	2
38	Spalling corner	Low	1
39	Spalling joint	Medium	1

—Not applicable.
*Not included in MTC distress and thus not considered in calculating PSR.

Table 21. Equivalent MTC PCC pavement distress extent for illustration 2.

Distress ID	MTC Distress	Equivalent PAVER Distress ID	Severity	Area (ft^2)
22	Corner breaks	22	Medium	1
23	Divided slabs	23	Medium	2
25	Faulting	25	Low	2
28	Linear cracking	28	Medium	4
28	Linear cracking	37	Low	2
29	Patching and utility cuts	29 and 30	Low	1
36	Scaling and map cracking	36	Low	1
39	Spalling	38	Low	1
39	Spalling	39	Medium	1

Following steps 1 through 6, the computed *PCI* and *PSR* were 64.6 and 3.26, respectively (figure 10). The computed *PCI* and *PSR* show that the pavement is in Fair condition.

	A	B	C	D	E	F	G	H	I
1	Units	US Custom		Pavement Condition Index (PCI)					64.6
2	Pavement Type	PCC		Present Serviceability Rating (PSR)					3.26
3	Sample Area in Number of Slabs	20		Press Alt + c to clear All Data				Clear Data	
4									
5	Table 1. Distress Type, Severity and Quantity								

6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*	Quantity 5*	Quantity 6*
7	22	Corner Break	Medium	1	0	0	0	0	0
8	23	Divided Slab	Medium	2	0	0	0	0	0
9	25	Faulting	Low	2	0	0	0	0	0
10	28	Linear Cracking	Medium	4	0	0	0	0	0
11	28	Linear Cracking	Low	2	0	0	0	0	0
12	29	Patching and Utility Cuts	Low	1	0	0	0	0	0
13	36	Scaling/Map Cracking/Crazing	Low	1	0	0	0	0	0
14	39	Spalling	Low	1	0	0	0	0	0
15	39	Spalling	Medium	1	0	0	0	0	0

Source: FHWA.

Figure 10. Screenshot. Results from illustration 2 for PCC pavements.

MTC Guidelines

As mentioned previously in this report, MTC guidelines use only eight and seven distress types for AC and PCC pavements, respectively. The use of the Excel PSR Computation Workbook, which uses distresses measured based on MTC guidelines to compute PSR, is straightforward.

Illustration 3: Asphalt Pavement

Table 22 summarizes distress types and their extents in an asphalt pavement as measured using MTC's guidelines. The sample area is 2,500 ft^2.

Table 22. Measured distress extent in asphalt pavement.

Distress ID	Distress	Severity	Area (ft^2)
1	Alligator cracking	Low	500
1	Alligator cracking	High	1.57
3	Block cracking	Low	200
5	Distortions	Low	160
10	Longitudinal and transverse cracking	Low	55
11	Patching and utility cuts	Low	40
15	Rutting and depressions	Low	700
19	Raveling	Medium	50
20	Weathering	Low	50

Following steps 1 through 6, the computed *PCI* and *PSR* were 36.3 and 1.86, respectively (figure 11). The computed *PCI* and *PSR* show that the pavement is in Poor condition.

	A	B	C	D	E	F	G	H	I
1	Units	US Custom		Pavement Condition Index (PCI)					36.3
2	Pavement Type	Asphalt		Present Serviceability Rating (PSR)					1.86
3	Sample Area in Sq.feet	2500		Press Alt + c to clear All Data				Clear Data	
4									
5	Table 1. Distress Type, Severity and Quantity								
6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*	Quantity 5*	Quantity 6*
7	1	Alligator Cracking	Low	500	0	0	0	0	0
8	1	Alligator Cracking	High	1.57	0	0	0	0	0
9	3	Block Cracking	Low	200	0	0	0	0	0
10	5	Distortions	Low	160	0	0	0	0	0
11	10	Longitudinal & Transverse Cracking	Low	55	0	0	0	0	0
12	11	Patching & Utility Cut Patching	Low	40	0	0	0	0	0
13	15	Rutting and Depressions	Low	700	0	0	0	0	0
14	19	Raveling	Medium	50	0	0	0	0	0
15	20	Weathering	Low	50	0	0	0	0	0

Source: FHWA.

Figure 11. Screenshot. Results from illustration 3 for asphalt pavements.

Illustration 4: PCC Pavement

The table 23 summarizes distress types and their extents in a PCC pavement as measured using MTC's guidelines. The sample area includes 20 slabs.

Table 23. Measured distress extent in PCC pavement.

MTC	Distress	Severity	No. of Slabs
22	Corner breaks	Medium	2
23	Divided slabs	High	2
25	Faulting	High	4
28	Linear cracking	High	7
29	Patching and utility cuts	Medium	3
36	Scaling and map cracking	Low	1
39	Spalling	Medium	3

Following steps 1 through 6, the computed *PCI* and *PSR* were 33.1 and 1.79, respectively (figure 12). The computed *PCI* and *PSR* show that the pavement is in Poor condition.

	A	B	C	D	E	F	G	H	I
1	Units	US Custom		Pavement Condition Index (PCI)					33.1
2	Pavement Type	PCC		Present Serviceability Rating (PSR)					1.79
3	Sample Area in Number of Slabs	20		Press Alt + c to clear All Data				Clear Data	
4									
5	Table 1. Distress Type, Severity and Quantity								

6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*	Quantity 5*	Quantity 6*
7	22	Corner Break	Medium	2	0	0	0	0	0
8	23	Divided Slab	High	2	0	0	0	0	0
9	25	Faulting	High	4	0	0	0	0	0
10	28	Linear Cracking	High	7	0	0	0	0	0
11	29	Patching and Utility Cuts	Medium	3	0	0	0	0	0
12	36	Scaling/Map Cracking/Crazing	Low	1	0	0	0	0	0
13	39	Spalling	Medium	3	0	0	0	0	0

Source: FHWA.

Figure 12. Screenshot. Results from illustration 4 for PCC pavements.

Limited Distresses

As stated in the report, PAVER or other tools can be used with a more limited number of distress types than those defined in the MTC guidelines. In this scenario for asphalt pavements, alligator cracking, rutting, and distortion were kept as minimum distresses to be included. For PCC pavements, only divided slabs and faulting were kept as minimum distresses to be included. However, it is assumed that when fewer distress types are used, agencies would combine linear cracking with divided slabs when they conduct the field measurements. Thus, linear cracking, when it exists, was combined with divided slabs in the *PCI* calculation.

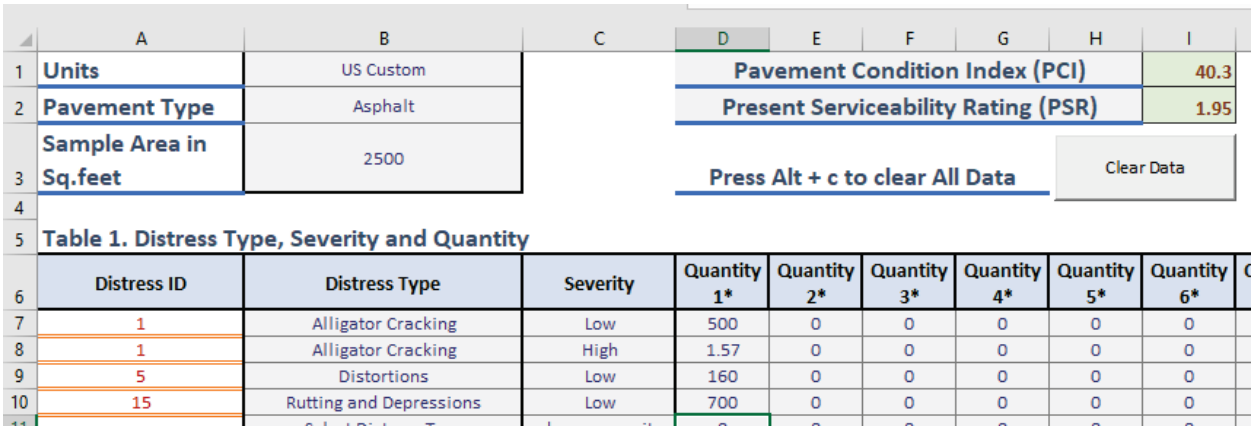
Illustration 5: Asphalt Pavement

The example shown in illustration 3 was reanalyzed here using only alligator cracking, rutting, and distortion distress types, as shown in table 24.

Table 24. Limited measured distress extent in asphalt pavement.

Distress ID	Distress	Severity	Area (ft^2)
1	Alligator cracking	Low	500
1	Alligator cracking	High	1.57
5	Distortions	Low	160
15	Rutting and depressions	Low	700

Following steps 1 through 6, the computed *PCI* and *PSR* were 40.3 and 1.95, respectively (figure 13). The computed *PCI* and *PSR* show that the pavement is in Poor condition; note that the *PSR* value is close to 2.0, which is the threshold between Fair and Poor conditions. With the full set of MTC distresses, the computed *PCI* and *PSR* were 36.3 and 1.86, respectively.



	A	B	C	D	E	F	G	H	I
1	Units	US Custom		Pavement Condition Index (PCI)					40.3
2	Pavement Type	Asphalt		Present Serviceability Rating (PSR)					1.95
3	Sample Area in Sq.feet	2500		Press Alt + c to clear All Data			Clear Data		
4									
5	Table 1. Distress Type, Severity and Quantity								
6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*	Quantity 5*	Quantity 6*
7	1	Alligator Cracking	Low	500	0	0	0	0	0
8	1	Alligator Cracking	High	1.57	0	0	0	0	0
9	5	Distortions	Low	160	0	0	0	0	0
10	15	Rutting and Depressions	Low	700	0	0	0	0	0

Source: FHWA.

Figure 13. Screenshot. Results from illustration 5 for asphalt pavements.

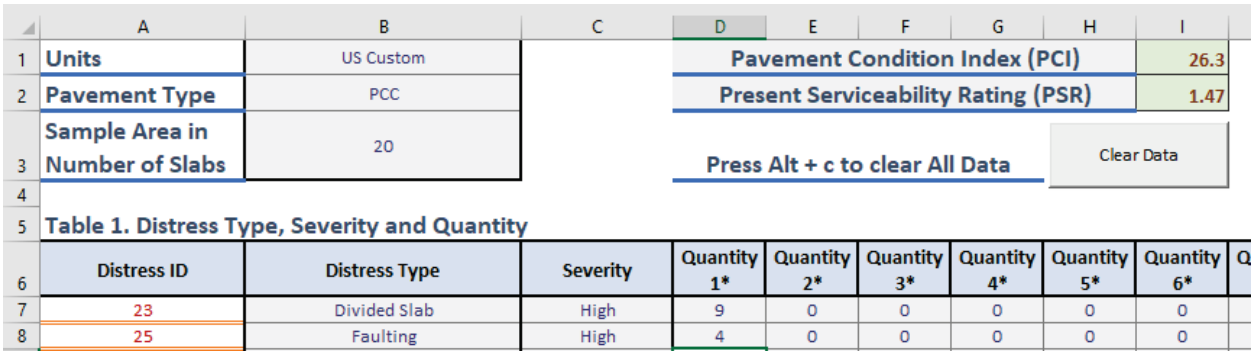
Illustration 6: PCC Pavement

The example shown in illustration 4 was reanalyzed here using only divided slabs and faulting. For this illustration, it was assumed that agencies would include linear cracking with divided slabs when they conduct field measurements. As a result, table 25 shows only these two distresses.

Table 25. Limited measured distress extent in PCC pavement.

MTC	Distress	Severity	No. of Slabs
23	Divided slabs (including linear cracking)	High	9
25	Faulting	High	4

Following steps 1 through 6, the computed *PCI* and *PSR* were 26.3 and 1.47, respectively (figure 14). The computed *PCI* and *PSR* show that the pavement is in Poor condition. With the full set of MTC distresses, the computed *PCI* and *PSR* were 33.1 and 1.79, respectively.



	A	B	C	D	E	F	G	H	I
1	Units	US Custom		Pavement Condition Index (PCI)					26.3
2	Pavement Type	PCC		Present Serviceability Rating (PSR)					1.47
3	Sample Area in Number of Slabs	20		Press Alt + c to clear All Data			Clear Data		
4									
5	Table 1. Distress Type, Severity and Quantity								
6	Distress ID	Distress Type	Severity	Quantity 1*	Quantity 2*	Quantity 3*	Quantity 4*	Quantity 5*	Quantity 6*
7	23	Divided Slab	High	9	0	0	0	0	0
8	25	Faulting	High	4	0	0	0	0	0

Source: FHWA.

Figure 14. Screenshot. Results from illustration 6 for PCC pavements.

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