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Development of Caltrans Jointed Plain Concrete Pavement Design Catalog Tables Using Pavement ME

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Partnered Pavement Research Center (PPRC) Strategic Plan Element Number 3.53: Updated Caltrans Rigid Pavement Design Catalog Using Pavement ME (DRISI Task 3811)

PREPARED FOR:
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16. ABSTRACT

This report summarizes the work conducted to develop the jointed plain concrete pavement (JPCP) tables of the new Caltrans *Highway Design Manual (HDM) Rigid Pavement Design Catalog*. The tables consider the different pavement structures that are expected to perform properly on the Caltrans road network. The tables were developed using *Pavement ME* (version 2.5.5) with the nationally calibrated transverse cracking model. *Pavement ME* inputs were determined by considering the state's climate, traffic, materials, and construction practices. A design life of 40 years, 10% target transverse cracking, and 95% design reliability were chosen for development of the tables. Transverse joint faulting and the International Roughness Index (IRI) were also determined for the sections in the JPCP tables using *Pavement ME* (version 2.5.5) nationally calibrated models and compared to Caltrans faulting and IRI limits of 0.15 in. and 170 in./mi., respectively. The tables will be included in the printed version of the new *HDM Rigid Pavement Design Catalog*.

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7. PROPOSALS FOR IMPLEMENTATION

This report includes the proposed jointed plain concrete pavement design tables for the new HDM Rigid Pavement Catalog. The tables are directly implementable in the printed version of the new Catalog.

8. RELATED DOCUMENTS

Saboori, A., Harvey, J., Lea, J., Lea, J., Wu, R., and Mateos, A. 2021. *Pavement ME Sensitivity Analysis (Version 2.5.3)* (UCPRC-RR-2019-02). Davis and Berkeley, CA: University of California Pavement Research Center.

Saboori, A., Lea, J., Harvey, J., Lea, J., Mateos, A., and Wu, R. 2021. *Pavement ME JPCP Transverse Cracking Model Calibration and Design Catalog Framework (Version 2.5.5)* (UCPRC-RR-2020-02). Davis and Berkeley, CA: University of California Pavement Research Center.

9. LABORATORY ACCREDITATION

The UCPRC laboratory is accredited by AASHTO re:source for the tests listed in this report.

10. SIGNATURES

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PROJECT OBJECTIVES

The primary goal of Project 3.53 is to develop and implement a new *Caltrans Highway Design Manual (HDM) Rigid Pavement Design Catalog* using version 2.5.5 of *Pavement ME.* This catalog will consider climate, traffic, materials, design, and construction practices and standards applicable to the Caltrans road network. The new catalog will include jointed plain concrete pavements (JPCP), continuously reinforced concrete pavements (CRCP), and concrete overlay on asphalt (COA) pavements. The primary goal of Project 3.53 will be achieved by completing the following tasks:

- Task 1: Develop JPCP design catalog tables.
- Task 2: Develop COA design catalog tables.
- Task 3: Develop CRCP design catalog tables.
- Task 4: Implement design catalog tables in a web-based tool.

The goal of Task 1 is the development of the JPCP tables of the new *HDM Rigid Pavement Design Catalog*. This report summarizes the work conducted for Task 1.

LIST OF ABBREVIATIONS

AADTT	Average annual daily truck traffic
AASHTO	American Association of State Highway and Transportation Officials
ACI	American Concrete Institute
COA	Concrete overlay on asphalt
CRCP	Continuously reinforced concrete pavement
CTE	Coefficient of thermal expansion
HDM	Highway Design Manual
HMA	Hot mix asphalt
IRI	International Roughness Index
JPCP	Jointed plain concrete pavement
LCB	Lean concrete base
LTE	Load transfer efficiency
ME	Mechanistic-empirical
NCHRP	National Cooperative Highway Research Program
PG	Performance Grade
PPRC	Partnered Pavement Research Center
SE	Standard error
TI	Traffic Index
UCPRC	University of California Pavement Research Center
USCS	Unified Soil Classification System
WIM	Weigh in motion

SI* (MODERN METRIC) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
in.	inches	25.40	millimeters	mm
ft.	feet	0.3048	meters	m
yd.	yards	0.9144	meters	m
mi.	miles	1.609	kilometers	km
		AREA		
in^2	square inches	645.2	square millimeters	mm^2
ft^2	square feet	0.09290	square meters	m^2
yd^2	square yards	0.8361	square meters	m^2
ac.	acres	0.4047	hectares	ha
mi^2	square miles	2.590	square kilometers	km^2
		VOLUME		
fl. oz.	fluid ounces	29.57	milliliters	mL
gal.	gallons	3.785	liters	L
ft^3	cubic feet	0.02832	cubic meters	m^3
yd^3	cubic yards	0.7646	cubic meters	m^3
		MASS		
oz.	ounces	28.35	grams	g
lb.	pounds	0.4536	kilograms	kg
T	short tons (2000 pounds)	0.9072	metric tons	t
		TEMPERATURE (exact degrees)		
°F	Fahrenheit	(F-32)/1.8	Celsius	°C
		FORCE and PRESSURE or STRESS		
lbf	pound-force	4.448	newtons	N
lbf/in^2	pound-force per square inch	6.895	kilopascals	kPa

APPROXIMATE CONVERSIONS FROM SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
		LENGTH		
mm	millimeters	0.03937	inches	in.
m	meters	3.281	feet	ft.
m	meters	1.094	yards	yd.
km	kilometers	0.6214	miles	mi.
		AREA		
mm^2	square millimeters	0.001550	square inches	in^2
m^2	square meters	10.76	square feet	ft^2
m^2	square meters	1.196	square yards	yd^2
ha	hectares	2.471	acres	ac.
km^2	square kilometers	0.3861	square miles	mi^2
		VOLUME		
mL	milliliters	0.03381	fluid ounces	fl. oz.
L	liters	0.2642	gallons	gal.
m^3	cubic meters	35.31	cubic feet	ft^3
m^3	cubic meters	1.308	cubic yards	yd^3
		MASS		
g	grams	0.03527	ounces	oz.
kg	kilograms	2.205	pounds	lb.
t	metric tons	1.102	short tons (2000 pounds)	T
		TEMPERATURE (exact degrees)		
°C	Celsius	1.8C + 32	Fahrenheit	°F
		FORCE and PRESSURE or STRESS		
N	newtons	0.2248	pound-force	lbf
kPa	kilopascals	0.1450	pound-force per square inch	lbf/in^2

*SI is the abbreviation for the International System of Units. Appropriate rounding should be made to comply with Section 4 of ASTM E380.
(Revised April 2021)

1 INTRODUCTION

The University of California Pavement Research Center (UCPRC) evaluated the AASHTO *Mechanistic-Empirical Pavement Design Guide (MEPDG)* (version 0.8) in 2005 and 2006. This evaluation was based on the experimental data collected from 95 jointed plain concrete pavement (JPCP) sections on the Caltrans road network. The evaluation indicated that the *MEPDG* with nationally calibrated coefficients provided a reasonable prediction of JPCP performance in California. In 2007, the UCPRC developed a catalog of design tables using *MEPDG* (version 0.8). These tables were later adjusted based on a comparison with JPCP design catalogs from other states. The current version of the Caltrans *Highway Design Manual (HDM)*, Chapter 620, "Rigid Pavement," dated December 2020, includes the tables implemented in 2007.

The *MEPDG* software has evolved over the years to become the current *AASHTOware Pavement ME Design* software (version 2.6 was the latest version available in early 2021, when this report was written). This software is referred to as *Pavement ME* in this report. While some of the changes to the software included updates to the mechanistic models, these changes were not always well documented. In addition to differences in the mechanistic models, the empirical calibration coefficients differ between *Pavement ME* and *MEPDG* (version 0.8), which was used to develop the current *HDM Rigid Pavement Design Catalog*. *MEPDG* (version 0.8) was based on the original calibration conducted in NCHRP Project 1-37A in 2004. That calibration used data from the Long-Term Pavement Performance program sections from throughout the United States, including California. The models were updated and recalibrated in NCHRP Project 1-40D in 2006. Further adjustments were required to address the error in the measurement of the concrete coefficient of thermal expansion (CTE) introduced by the former AASHTO TP 60 test method. These adjustments were conducted in NCHRP Project 20-7 Task 288 in 2011 and Task 327 in 2014.

An evaluation of the capability of the latest version of *Pavement ME* to predict JPCP performance in California was recommended based on the differences between the latest version of *Pavement ME* and *MEPDG* (version 0.8) in terms of software, mechanistic models, and calibration coefficients. The availability of much better databases for mechanistic-empirical (ME) modeling compared to those available in 2005 made this evaluation possible. The evaluation was conducted as part of Partnered Pavement Research Center Project 3.49, “Implementation of Concrete *Pavement ME* Design Models” (2017–2020).

The *Pavement ME* evaluation conducted in Project 3.49 used network-level performance data with two orders of magnitude more observations and miles of pavement than are typically used in traditional *Pavement ME* calibrations. The Project 3.49 evaluation was possible because Caltrans and UCPRC have improved the data available for calibration of ME design models, including extensive performance data from automated pavement condition surveys, detailed as-built information, comprehensive traffic and weigh-in-motion (WIM) data, and databases of concrete materials properties (strength, density, and CTE) that can be used to estimate state median values for these material properties.

About 4,600 lane-miles of JPCP built on 446 lane replacement projects completed between 1947 and 2017 in California were used in the Project 3.49 *Pavement ME* evaluation. The evaluation used *Pavement ME* (version 2.5.5), which was the latest version when Project 3.49 was conducted. The framework that was followed in Project 3.49 does not require sampling of materials from specific sections. Instead, it uses the statewide median values from a representative sample of materials collected across the road network. Variability of performance and reliability of design (probability that the design will meet or exceed the design life) is accounted for through separate consideration of within-project and between-project variability. The evaluation indicated a bias of 13.3% and a standard error of 23.0% in *Pavement ME* transverse cracking model predictions for the Caltrans road network *(1)*. The model was then recalibrated to reduce both bias and error, which resulted in a new set of C4 and C5 coefficients for the transverse cracking transfer function (the empirical part of the ME model). This calibration removed the bias and reduced the standard error of the predictions to 5.7% *(1)*.

The differences in JPCP slab design thickness between nationally and locally calibrated *Pavement ME* models were small and very consistent over a range of different design conditions, including climate regions, base types, and annual average daily truck traffic. Overall, the locally calibrated *Pavement ME* models resulted in slabs 0.6 in. thinner than the nationally calibrated *Pavement ME* models. Both nationally and locally calibrated *Pavement ME* predictions resulted in thinner slabs compared to the current *HDM Rigid Pavement Design Catalog*, about 1 to 3 in. thinner depending mainly on the climate region.

Due to the small difference in the slab thickness using locally and nationally calibrated *Pavement ME* cracking models, Caltrans's decision was to move forward with the development of the JPCP tables of the new *HDM Rigid Pavement Design Catalog* by using the nationally calibrated *Pavement ME* cracking model. Subsequently, a number of meetings were held between the Caltrans Office of Concrete Pavements and UCPRC in order to define the JPCP tables factorial—the design variable levels, including slab thickness range, climatic regions, and base types—and the values for other relevant inputs to *Pavement ME*, such as concrete properties, reliability, and failure limit. The JPCP tables factorial and the values adopted for the different inputs to *Pavement ME* are presented and discussed in Chapter 2 of this report.

Once the JPCP tables factorial and *Pavement ME* inputs had been defined, the pool of *Pavement ME* runs was extracted from the database already created in Project 3.49. The outcome of these runs was used to generate the JPCP tables of the new *HDM Rigid Pavement Design Catalog*. The procedure that was followed to analyze the *Pavement ME* output in order to produce the JPCP design tables is presented in Chapter 3, and the tables are included in Chapter 4.

1.1 Project Objective

The primary goal of Project 3.53 is to develop and implement a new Caltrans *HDM Rigid Pavement Design Catalog* (also referred to as the *HDM Design Catalog*) using version 2.5.5 of *Pavement ME*. While Project 3.53 includes JPCP, continuously reinforced concrete pavement (CRCP), and concrete overlay on asphalt (COA), the work presented in this report focuses on JPCP. Specifically, the goal of the work presented in this report is to develop the JPCP tables of the new *HDM Design Catalog*.

1.2 Scope

The JPCP design tables presented in this report include the slab thickness required to meet 10% slab transverse cracking at the end of a 40-year design life at 95% reliability, including provision for grinding of 0.06 ft. (0.72 in.). The tables focus on JPCP with either 12 or 14 ft. wide slabs, 14 ft. transverse joint spacing, and doweled transverse joints. This configuration has shown optimum balance between performance and cost for JPCP on the Caltrans road network.

The JPCP design tables presented in this report are based on *Pavement ME* (version 2.5.5) calculations. This version was released in 2019, and it was the latest version available when the tables were generated. *Pavement ME* (version 2.6) was the latest one available in early 2021, when this report was written. The version discrepancy is not regarded a problem since the JPCP cracking, faulting, and longitudinal smoothness models and the calibration coefficients are the same for the two versions.

The JPCP design tables presented in this report were prepared by considering the transverse cracking failure since cracking is the critical distress mechanism of JPCP with doweled transverse joints. While *Pavement ME* can predict—in addition to transverse cracking—transverse joint faulting and the roughness of JPCP, based on the International Roughness Index (IRI), these two distresses were not considered in developing the tables for two main reasons. The first reason is that JPCP transverse joint faulting and the loss of longitudinal smoothness (an increase in roughness after construction) are not critical on the Caltrans road network that is paved with JPCP since Caltrans implemented the use of dowels in 1998. This outcome is due to the high load transfer efficiency (LTE) that the dowels provide to the transverse joints. The high LTE reduces faulting as well as roughness since roughness in JPCP is mainly driven by faulting. The second reason for not considering faulting and roughness in developing the JPCP design tables is that increasing the slab thickness is not the optimum approach to combat JPCP faulting and roughness. These two distresses can be better combated by using the appropriate doweling design (dowel diameter and spacing), providing the slabs with a non-erodible base material like hot mix asphalt or lean concrete, and achieving good initial longitudinal smoothness (low post-construction IRI).

While the JPCP design tables were prepared by considering only transverse cracking failure, the faulting and IRI calculations that are included in the design tables were determined using *Pavement ME* (version 2.5.5) nationally calibrated models for those designs. The faulting and IRI predicted at the end of 40-year design life at 95% reliability were compared to Caltrans faulting and IRI failure limits of 0.15 in. and 170 in./mi. respectively. This comparison is presented in Section 4.2.

The new *HDM Design Catalog* will be implemented with two different tools: a printed catalog and a web application. The printed version will resemble the current *HDM Design Catalog*. The JPCP design tables presented in Chapter 4 will be included in the printed version of the new catalog. The web version will include some features to aid the designer, including the automatic calculation of truck traffic based on project location.

2 PAVEMENT ME INPUTS FOR DEVELOPING THE DESIGN TABLES

2.1 Pavement ME Inputs

The inputs to the *Pavement ME* calculations are presented in Table 2.1 and Table 2.2. The former includes the variable options that the user of the new *HDM Design Catalog* (the designer) can choose from, shown in the column "variable levels." The combination of all options for the different variables in Table 2.1 constitutes the collection of cases that were run in *Pavement ME* for developing the JPCP design tables presented in Chapter 4. Table 2.2 includes the fixed variables, which are constants with predefined values that the designer cannot change. These variables had the same value in all *Pavement ME* runs. The rationale for the selection of the different variables values is presented in Section 2.2.

Table 2.1: User-Defined Variables

Variable	Pavement ME Cracking Sensitivity	Variable Levels	Pavement ME Inputs	Comments
Slab thickness	High	0.65 to 1.30 ft. (7.8 to 15.6 in.)	7 to 16 in., in 1 in. increments	Slab thickness is not a user-defined variable but the output of the design catalog
Initial AADTT	High	10 levels (*): 100, 200, 500, 1,000, 2,000, 4,000, 8,000, 12,000, 16,000, 20,000 per lane (*) Continuous variable in the web catalog	20,000	Concrete fatigue damage is linearly proportional to AADTT Truck traffic assumed to grow 3% annually, linear growth
Truck traffic characteristics	Low	3 levels: • WIM 1, WIM 2 • WIM 3 • WIM 4, WIM 5	3 levels: • WIM 2 • WIM 3 • WIM 4	WIM 4 is the spectra that produces the highest JPCP cracking
Base type	Medium	2 levels: • HMA • LCB	2 levels: • HMA, 0.25 ft. (3.0 in.) • LCB, 0.35 ft. (4.2 in.)	

Variable	Pavement ME Cracking Sensitivity	Variable Levels	Pavement ME Inputs	Comments
Shoulder type	Medium	3 levels: • Tied concrete • Untied concrete • Widened slab (+2 ft.)	3 levels: • Tied concrete (50% LTE) • Untied concrete (0% LTE) • Widened slab (14 ft.)	
Climate	Medium	3 levels[1]: • Group I: SC, NC • Group II: CC, LM, SM, HM, HD • Group III: IV, DE	3 levels[1]: • SC • SM • IV	

[1] Central Coast (CC), North Coast (NC), South Mountain (SM), Desert (DE), High Desert (HD), Inland Valley (IV), Low Mountain (LM), South Coast (SC), High Mountain (HM)

Table 2.2: Fixed Variables

Variable	Pavement ME Cracking Sensitivity	Pavement ME Inputs	Comments
Concrete 28-day flexural strength	Medium	637 psi	637 psi flexural strength corresponds to 4,500 psi compressive strength
Concrete CTE	High	4.8 με/°F	
Concrete thermal properties	High	• Albedo: 0.15 • Conductivity = 1.25 BTU/hr/ft/°F • Heat capacity: 0.28 BTU/lb/°F	*Pavement ME* defaults
Concrete composition and shrinkage	Medium	Type I cement, 600 lb/cy; 0.42 water to cement ratio; ultimate shrinkage internally calculated (646 με); 50% reversible shrinkage; time to develop 50% ultimate shrinkage is 35 days; curing method is curing compound	*Pavement ME* defaults
Transverse joint spacing	High	14 ft.	

Variable	Pavement ME Cracking Sensitivity	Pavement ME Inputs	Comments
Use of dowels	None	Doweled transverse joints. Dowel diameter (ϕ) is a function of slab thickness: • 0.65 ft. slab: ϕ = 1 in. • 0.70-0.85 ft. slab: ϕ = 1.25 in. • 0.90-1.30 ft. slab: ϕ = 1.5 in.	Use of dowels does not have any effect on *Pavement ME* predicted JPCP cracking Use of dowels does have a large impact on *Pavement ME* predicted faulting and longitudinal smoothness
Subgrade type	Low	A-3 soil (coarse grained)	
Subbase type	Low	No subbase	
Slab-base bonding	High	Debonded	
Permanent curl/warp	High	-10°F	
Calibration coefficients	High	• C4 = 0.52 • C5 = -2.17	National calibration
Design life	High	40 years	
Target cracking	High	10% transverse cracking	Cracking is the failure criterion that determines slab thickness
Target faulting	Not applicable	0.15 in.	
Target IRI	Not applicable	170 in./mi.	
Design reliability	High	95%	
Provision for grinding	Not applicable	0.06 ft. (0.72 in.)	Two blanket grinding operations

2.2 Justification of Pavement ME Inputs

2.2.1 User-Defined Variables

2.2.1.1 Slab Thickness

Variable levels: 0.65 to 1.30 ft. (7.8 to 15.6 in.)

Slab thickness is the output of the design catalog. Slab thickness values from 7 to 16 in., in 1 in. increments, were used for the *Pavement ME* calculations that were conducted in developing the JPCP tables of the new *HDM Design Catalog*.

The thickness range agrees with standard JPCP practices. The maximum thickness used for *Pavement ME* calculations, 1.30 ft. (15.6 in.), matches the maximum thickness in the current *HDM Design Catalog* while the minimum thickness used for *Pavement ME* calculations, 0.65 ft. (7.8 in.), is somewhat below the 0.70 ft. minimum recommended in the current *HDM Design Catalog*. Below a slab thickness of 0.65 ft., COA (either on existing or newly placed asphalt base) rather than JPCP may be considered.

2.2.1.2 Initial AADTT

Variable levels: 100, 200, 500, 1,000, 2,000, 4,000, 8,000, 12,000, 16,000, 20,000 per lane

The JPCP tables of the new *HDM Design Catalog* are based on average annual daily truck traffic (AADTT) rather than the Caltrans Traffic Index (TI). The initial AADTT in the JPCP design tables is truck traffic per lane, the value that results after applying directional and lane distribution factors to the two-way AADTT.

Truck traffic was assumed to grow linearly 3% per year.

The proposed AADTT range is equivalent, for 40 years design life, to 0.5 to 150 million equivalent 18-kip single-axle loads. This truck traffic corresponds to a TI range of 8.5 to 16.5 (see TI versus AADTT in Appendix A). The minimum AADTT, 100, corresponds to secondary roads with relatively low traffic. The maximum AADTT, 20,000, matches the highest truck traffic expected on the Caltrans road network, and it is compatible with a maximum slab thickness of 1.30 ft.

The adoption of AADTT levels is only applicable to the printed version of the new *HDM Design Catalog*. For the web version, the AADTT will be treated as a continuous variable, and the user will introduce the exact project location and lane number. Then the web tool will estimate the AADTT based on the Caltrans traffic database, first, and will determine the slab thickness for the estimated AADTT, second.

Only one AADTT level has been modeled in *Pavement ME*: 20,000 per lane. Because concrete fatigue damage (ω) is linearly proportional to AADTT, the fatigue damage for the different AADTT levels was determined by linear proportion (e.g., $\omega(2000) = \omega(20000) \times 2000/20000$). *Pavement ME* uses ω to determine the percentage of slabs with transverse cracking.

2.2.1.3 Truck Traffic Characteristics

Variable levels:

- WIM 1 and WIM 2
- WIM 3
- WIM 4 and WIM 5

Caltrans considers five different truck traffic groups for pavement design and management: WIM 1, WIM 2, WIM 3, WIM 4, and WIM 5. Each WIM is defined by the truck class, axle type, axle weight, and hourly traffic distributions *(2)*. The five WIMs represent truck traffic characteristics that exist on the Caltrans road network. Within *Pavement ME*, the WIMs can be regarded as the regional-level characterization of the truck traffic variables.

The frequency distribution of the *Single Equivalent* loading of the different WIMs is presented in Figure 2.1. The *Single Equivalent* loading frequency distribution is the result of splitting tandem axles into two and tridem axles into three (e.g., one tandem becomes two singles each with half the load), and it is a simple way to compare WIMs.

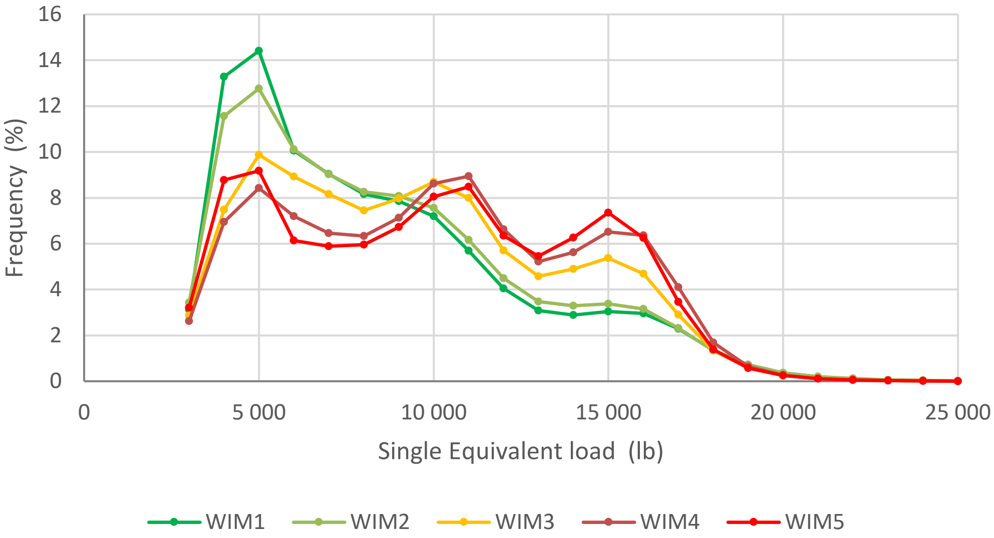

Figure 2.1: Distribution of *Single Equivalent* loading of the different WIM spectra.

The five WIMs were grouped into three groups for the JPCP design, based on similar *Pavement ME* cracking predictions. The first group includes WIM 1 and WIM 2, the second group includes WIM 3, and the third group includes WIM 4 and WIM 5. Each group was modeled in *Pavement ME* by adopting the WIM within the group that results in the highest concrete fatigue damage: WIM 2 for the first group, WIM 3 for the second group, and WIM 4 for the third group.

2.2.1.4 Base Type

Variable levels:

- HMA
- LCB

The JPCP tables of the new *HDM Design Catalog* consider two different base types: (1) hot mix asphalt (HMA) and (2) lean concrete base (LCB).

The default asphalt concrete was selected in *Pavement ME* for modeling the HMA alternative. This default material has 7% air voids, 11.6% effective binder content by volume, and a continuous and relatively dense gradation typical of standard HMA. The performance grade (PG) of the asphalt binder was set to PG 64-10 regardless of the climate zone.

The LCB was modeled in *Pavement ME* as a chemically stabilized material with a 2 million psi resilient modulus and default values for the rest of the material properties.

Thicknesses of 0.25 and 0.35 ft. (3.0 and 4.2 in.) were chosen for modeling HMA and LCB, respectively. These thickness values match those in the current *HDM Design Catalog*.

2.2.1.5 Shoulder Type

Variable levels:

- Untied concrete
- Tied concrete
- Widened slab (14 ft.)

The JPCP tables of the new *HDM Design Catalog* consider three different shoulder types: untied concrete, tied concrete, and widened slab. The untied and tied concrete shoulders were modeled by choosing *Pavement ME* default values for the slab-shoulder longitudinal joint LTE: 0% for untied concrete and 50% for tied concrete.

2.2.1.6 Climate

Variable levels:

- Group I: South Coast (SC), North Coast (NC)
- Group II: Central Coast (CC), Low Mountain (LM), South Mountain (SM), High Mountain (HM), High Desert (HD)
- Group III: Inland Valley (IV), Desert (DE)

Caltrans considers nine climate regions for pavement design and management *(3)*. The climate regions were grouped into three groups for development of the JPCP design tables. Group I includes SC and NC; Group II includes CC, LM, SM, HM, and HD; and Group III includes IV and DE. The Group I climate was modeled as SC (South Coast), and the Los Angeles 23174 climate station was specifically selected in *Pavement ME*. The Group II was modeled as SM (South Mountain), and the Palm Springs 3104d climate station was specifically selected. The Group III was modeled as IV (Inland Valley), and the Sacramento 23232 climate station was specifically selected.

Based on *Pavement ME* cracking predictions, the three climate regions were ranked on JPCP performance from best to worst. Group I (SC) had the best performance and Group III (IV) had the worst performance *(4)*.

The depth of the water table level was set to 10 ft., regardless of the climate region.

2.2.2 Fixed Variables

2.2.2.1 Concrete 28-Day Flexural Strength

Pavement ME input: 637 psi

The 637 psi flexural strength value corresponds to a compressive strength (f’c) of 4,500 psi, based on the American Concrete Institute (ACI) formula implemented in *Pavement ME* (*flexural strength* = 9.5 × *f’c*^0.5). The 4,500 psi value is the estimated statewide median compressive strength of the pavement concrete (the average is 4,540 psi). The estimation is based on the UCPRC database, which includes almost 100 projects. The compressive strength was measured on cores extracted from existing JPCP slabs and age-corrected by using the aging function in *Pavement ME*.

The selected flexural strength value does not represent rapid strength concrete. Based on the rapid strength concrete mixes tested at the UCPRC, the 28-day flexural strength reaches values from 600 to 1,000 psi. The design opening time of these mixes varied from 4 hours (4×4 mixes) to 24 hours. The large variations in opening time and 28-day flexural strength are due to the large variety of rapid strength mixes used in Caltrans concrete pavements, including cement contents up to 800 lb/cy; different cement types (Types I/II and III portland and calcium sulfoaluminate); and different admixtures.

2.2.2.2 Concrete CTE

Pavement ME input: 4.8 με/°F

The 4.8 με/°F value is the estimated statewide median CTE of the pavement concrete (the average is 4.9 με/°F). The estimation is based on the UCPRC database, which includes over 100 projects. A minor portion of the database records were affected by the former AASHTO TP 60 error in 304 stainless steel CTE. The affected records were corrected, so the 4.8 με/°F median is compatible with the current AASHTO standard (T 336) for measuring concrete CTE.

2.2.2.3 Concrete Thermal Properties

Pavement ME input:

- Albedo: 0.15 (0.85 PCC surface shortwave absorptivity)
- Conductivity = 1.25 BTU/hr/ft/°F
- Heat capacity: 0.28 BTU/lb/°F

Statewide information for pavement concrete thermal properties (albedo, conductivity, and heat capacity) is not available. Consequently, *Pavement ME* national defaults were used for these three variables: 0.15 albedo, 1.25 BTU/hr/ft/°F conductivity, and 0.28 BTU/lb/°F heat capacity.

2.2.2.4 Concrete Composition and Shrinkage

Pavement ME input:

- Cement type: Type I
- Cement content: 600 lb/cy
- Water to cement ratio: 0.42
- Ultimate shrinkage: Internally calculated, 646 με
- Reversible shrinkage: 50%
- Time to develop 50% ultimate shrinkage: 35 days
- Curing method: Curing compound

The *Pavement ME* default values were chosen for concrete composition and shrinkage-related inputs.

While Caltrans concrete paving mixes typically use Type II portland cement, Type I was chosen for *Pavement ME* calculations since most Type II cements used in Caltrans concrete paving fulfill the Type I specifications as well. According to the Rilem B3 model, implemented in *Pavement ME*, shrinkage of Type II cement is 15% less than shrinkage of Type I cement.

2.2.2.5 Transverse Joints Spacing

Pavement ME input: 14 ft.

The transverse joint spacing of 14 ft. is the value prescribed by current Caltrans specifications.

2.2.2.6 Use of Dowels

Pavement ME input:

- Doweled transverse joints. Dowel diameter (ϕ):
    - 0.65 ft. slab thickness: ϕ = 1 in.
    - 0.70 to 0.85 ft. slab thickness: ϕ = 1.25 in.
    - 0.90 to 1.30 ft. slab thickness: ϕ = 1.5 in.

All *Pavement ME* runs assumed that the transverse joints were provided with dowels, following current Caltrans specifications. Dowel spacing was set to 1 ft., and the dowel diameter was a function of slab thickness following current Caltrans specifications included in the standard Plan P10.

It should be mentioned that the use of dowels had no effect on *Pavement ME* cracking predictions. It did, however, have a large effect on faulting and IRI predictions.

2.2.2.7 Subgrade Type

Pavement ME input: A-3 soil

The type of subgrade soil had a minor effect on the *Pavement ME* predicted JPCP cracking. All *Pavement ME* calculations assumed A-3 coarse-grained soil, based on the AASHTO soil classification system implemented in *Pavement ME*. This soil type was selected because it generally produces the median performance for transverse cracking. *Pavement ME* predicts better performance for clay soils.

In the *Pavement ME* calculations, the subgrade soil stiffness changed depending on temperature and moisture. The change in stiffness was conducted automatically by the *Pavement ME* software.

2.2.2.8 Subbase Type

Pavement ME input: No subbase

The use of a granular (non-stabilized) subbase had a minor effect on the *Pavement ME* predicted JPCP cracking. All *Pavement ME* runs assumed that the pavement had no subbase.

2.2.2.9 Slab-Base Bonding

Pavement ME input: Debonded (parameter PCC-Base full friction contact = False)

All *Pavement ME* runs assumed that no bonding existed between the slab and the base, regardless of base material, following recommendations from the NCHRP Project 1-51 "A Model for Incorporating Slab/Underlying Layer Interaction into the MEPDG Concrete Pavement Analysis Procedures."

2.2.2.10 Permanent Curl/Warp

Pavement ME input: -10 °F

The -10°F value is the value assumed in the national calibration of the *Pavement ME* JPCP cracking model, and it is also the current *Pavement ME* default.

2.2.2.11 Calibration Coefficients

Pavement ME input:

- C4 = 0.52
- C5 = -2.17

C4 and C5 are the parameters of the empirical transfer function that relates the mechanistically determined concrete fatigue damage to cracking (transverse cracking), shown in equation (2.1). The chosen values are the outcome of the national calibration of the *Pavement ME* JPCP cracking model and current *Pavement ME* defaults.

$$Cr = \frac{100}{1 + \mathrm{C4}\,\omega^{\mathrm{C5}}} \qquad \textbf{(2.1)}$$

where Cr is the percentage of slabs with transverse cracking
ω is concrete fatigue damage

2.2.2.12 Design Life

Pavement ME input: 40 years

The 40-year period is the minimum design life that Caltrans considers for pavement new construction and reconstruction projects. It is the same design life assumed in the current *HDM Design Catalog*.

2.2.2.13 Target Cracking

Pavement ME input: 10% transverse cracking

The slab thickness in the JPCP design tables reflect JPCP sections that reach 10% transverse cracking, at 95% reliability, at the end of the 40-year design life. This value for transverse cracking, when translated to the corresponding expected level of the third-stage cracking level using models discussed by Saboori et al. (*1*), approximately corresponds to the 95% within-project reliability level used for asphalt surfaced pavement design in *CalME*.

2.2.2.14 Target Faulting

Pavement ME input: 0.15 in.

While the slab thickness in the JPCP design tables was determined based on transverse cracking, transverse joint faulting was predicted as well based on the *Pavement ME* nationally calibrated JPCP faulting model. The faulting predicted with 95% reliability at the end of the 40-year design life was compared, for each of the sections in the JPCP design tables, to the Caltrans faulting failure limit of 0.15 in.

2.2.2.15 Target IRI

Pavement ME input: 170 in./mi.

While the slab thickness in the JPCP design tables was determined based on transverse cracking, IRI was determined as well based on the *Pavement ME* nationally calibrated JPCP IRI model. The IRI predicted with 95% reliability at the end of the 40-year design life was compared, for each of the sections in the JPCP design tables, to the Caltrans IRI failure limit of 170 in./mi.

2.2.2.16 Design Reliability

Pavement ME input: 95%

Pavement ME design reliability is based on the standard error of the cracking prediction model. This standard error can be determined with equation (2.2), which is an output of the national calibration of the JPCP cracking model. The 95% reliability criterion is the same used in the development of the COA and CRCP tables of the new *HDM Design Catalog*, and it is also the between-project reliability used for asphalt pavement design with *CalME*.

$$SE\left(Cr\right)=3.5522\,Cr^{0.3415}+0.75 \tag{2.2}$$

where Cr is the percentage of slabs with transverse cracking

2.2.2.17 Provision for Grinding

Pavement ME input: 0.06 ft. (0.72 in.)

The 0.06 ft. (0.72 in.) provision accounts for two blanket grinding operations. The grinding operations may take place right after construction, with the goal of meeting Caltrans's strict smoothness specifications, or after years in service. The provision is introduced in the JPCP design tables by increasing the slab thickness that results from *Pavement ME* calculations by 0.72 in.

3 PROCEDURE FOR ANALYSIS OF PAVEMENT ME OUTPUT

The design tables presented in Chapter 4 were prepared by considering failure by transverse cracking since cracking is the critical distress mechanism of JPCP with doweled transverse joints. The methodology for developing the tables is presented in Section 3.1.

Faulting and loss of longitudinal smoothness are not expected to be considerable for the JPCP sections included in the design tables because of the use of dowels at the transverse joints. In any case, faulting and IRI at the end of the 40-year design life were also determined for the sections included in the JPCP design tables and compared to the failure limits that Caltrans considers for faulting, 0.15 in., and IRI, 170 in./mi. The methodology for determining the faulting and IRI, based on *Pavement ME*, is presented in Section 3.2.

3.1 Determination of Slab Thickness Based on Transverse Cracking

The user-defined variables allow the user of the new *HDM Design Catalog* to choose among different variable-specific options (Table 2.1). The user-defined variables are the following:

- Initial AADTT
- Truck traffic characteristics (WIM)
- Base type
- Shoulder type
- Climate

The goal of the *HDM Design Catalog* is to determine the slab thickness required for a given combination of user-defined variables. From a catalog operation perspective, the slab thickness is not a user-defined variable but the output of the design.

All combinations of user-defined variables and slab thickness values from 7 to 16 in. (*Pavement ME* does not consider the Caltrans design unit of feet), in 1 in. increments, were run in *Pavement ME*, with the only exception being the initial AADTT, for which a single value was considered (20,000 trucks/lane). A total of 540 combinations resulted, and each of them was run in *Pavement ME*. From a catalog development perspective, each of the 540 runs can be summarized as two individual values: the concrete fatigue damage at the top and at the bottom of the slab at the end of the 40-year design life. These values are referred to as *ωB20k* and *ωT20k* (the "B" and "T" refer to the slab bottom and top, respectively, while the "20k" refers to the 20,000 trucks/lane). *Pavement ME* uses the *ωB20k* and *ωT20k* values to determine the percentage of slab cracking at the end of the 40-year design life at a given reliability level by applying the empirical equations (2.1) and (2.2) presented in Chapter 2 and by assuming that bottom-up and top-down cracking are independent phenomena. Consequently, the set of 540 *ωB20k* and *ωT20k* pairs of values can be used to determine the slab thickness required for any combination of user-defined variables as explained in the following discussion.

For any combination of user-defined variables, the design slab thickness is the slab thickness value for which *Pavement ME* predicts 10% slabs with transverse cracking at the end of the 40-year design life with 95% reliability. The following is an example of a combination of user-defined variables:

- Initial AADTT: 8,000 trucks/lane
- Truck traffic characteristics: WIM 3
- Base type: HMA
- Shoulder type: Tied concrete
- Climate: Inland Valley (Group III climate)

For any given combination of user-defined variables, the required slab thickness is determined as follows:

1. Read the pair of fatigue damage values, *ωB20k* and *ωT20k*, for the different slab thickness values from the *Pavement ME* runs database. The slab thickness values are 7 to 16 in., in 1 in. increments.
2. Determine the pair of fatigue damage values (top and bottom of the slab) at the end of the 40-year design life for the user-defined AADTT for the different slab thickness values. The pair of fatigue damage values are referred to as *ωB* and *ωT*. They are linearly proportional to the initial AADTT:

$$\omega B = \omega B20k \times \text{AADTT}/20000$$

$$\omega T = \omega T20k \times \text{AADTT}/20000$$

3. Determine slab cracking (transverse cracking) at the end of the 40-year design life at 95% reliability, based on *ωB* and *ωT*, for the different slab thickness values, using equations (2.1) and (2.2).
4. Determine the slab thickness that corresponds to 10% slab cracking at the end of the 40-year design life by linear interpolation in the log-cracking versus slab thickness space.
5. Add the 0.06 ft. (0.72 in.) provision for grinding.

The slab thickness determination for the previous example (8,000 AADTT, WIM 3, HMA base, tied concrete shoulder, and Inland Valley climate) is illustrated in Figure 3.1, except for step 5 (provision for grinding).

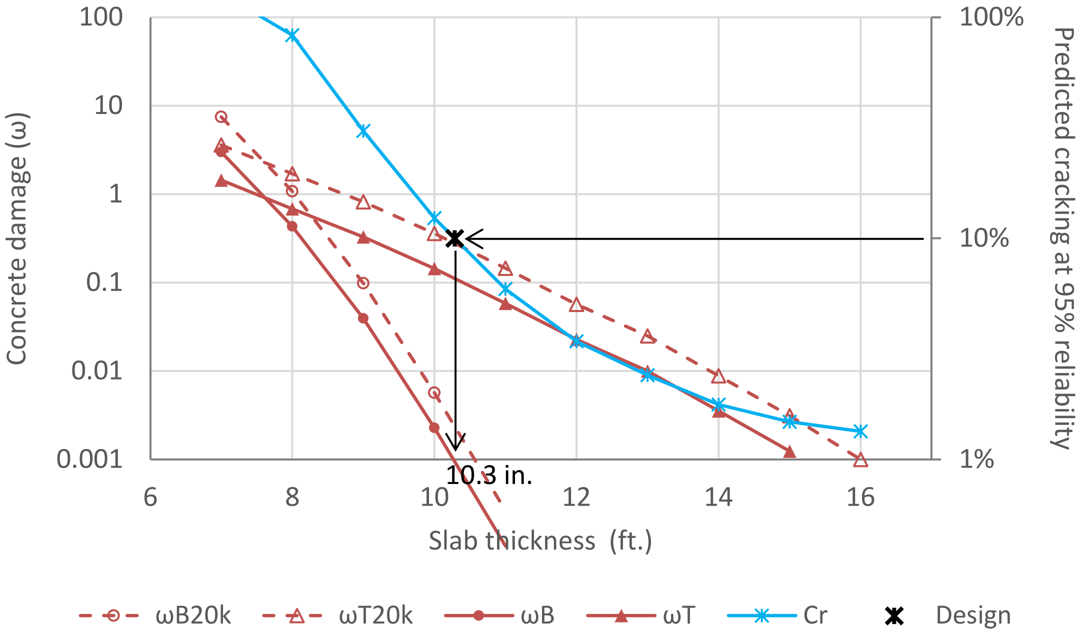

Figure 3.1: Illustration of approach for determining slab thickness.

3.2 Calculation of Faulting and IRI

The transverse joint faulting and the IRI at the end of the 40-year design life were determined for each of the sections in the JPCP design tables. The determination was based on the set of 540 *Pavement ME* runs used to develop the JPCP design tables. As discussed in Section 3.1, the 540 runs include all combinations of user-defined variables and slab thickness values from 7 to 16 in., in 1 in. increments, with the only exception being the initial AADTT, for which a single value was considered (20,000 trucks/lane).

The faulting calculation required the extrapolation of *Pavement ME* results (initial AADTT of 20,000 trucks/lane) to the actual initial AADTT of each section in the JPCP design tables. The procedure for this extrapolation, presented in Section 3.2.1, is based on the assumption that the monthly differential deflection energy (which *Pavement ME* uses to determine faulting) is linearly proportional to the AADTT. This is an accurate assumption for doweled pavements where the LTE remains relatively high throughout the design life regardless of truck traffic. Overall, the assumption may result in a slight overestimation of the 40-year predicted faulting, up to 0.002 in. This overestimation can be regarded as negligible.

Once the 40-year faulting was determined, the 40-year IRI was calculated with *Pavement ME*. The IRI model is explained in Section 3.2.2.

3.2.1 Calculation of Faulting

Pavement ME determines the faulting by applying equations (3.1) and (3.2). At the same time, the maximum faulting variable, *FM*—which plays a role in equation (3.2)—is determined in *Pavement ME* by applying equations (3.3) and (3.4). As shown in equation (3.2), the increase in faulting in a particular month ($\Delta Fault_i$) is linearly proportional to the differential deflection energy produced by the truck traffic in that particular month (DE_i). Once the history of the monthly differential deflection energy (DE_i for months i = 1, 2, 3, etc.) is known, the faulting can be easily determined.

$$Fault_m = \sum_{i=1}^{m} \Delta Fault_i \tag{3.1}$$

$$\Delta Fault_i = \mathrm{C34}\left(FM_{i-1} - Fault_{i-1}\right)^2 DE_i \tag{3.2}$$

where $\Delta Fault_i$ is the increase in faulting in month i, in in.

$FM_{i\text{-}1}$ is the maximum faulting (FM) in month i-1, in in.

$Fault_{i\text{-}1}$ is the faulting in month i-1, in in.

DE_i is the differential deflection energy in month i, in lb. × in.

C34 is C3 + C4 × $FR^{0.25}$, where C3 and C4 are calibration coefficients and FR is the base freezing index (percentage of time that the top of the base temperature is below freezing temperature)

$$FM_m = FM0 + \sum_{i=1}^{m} \Delta FM_i \quad \textbf{(3.3)}$$

$$\Delta FM_i = \mathrm{C7}\left(\log\left(1+\mathrm{C5}\times 5^{EROD}\right)\right)^{\mathrm{C6}} DE_i \quad \textbf{(3.4)}$$

where ΔFM_i is the increase in maximum faulting (FM) in month i, in in.

FM0 is function of the JPCP section properties, climate, and foundation (it does not depend on AADTT); its unit is in.

DE_i is the differential deflection energy in month i, in lb. × in.

C5-C7 are calibration coefficients

EROD is the erodibility index of the base (1 to 5)

As previously explained, the set of 540 *Pavement ME* runs assumed an initial AADTT of 20,000 trucks/lane. Because the monthly differential deflection energy can be assumed to be linearly proportional to the AADTT, the monthly differential deflection energy can be easily determined for any initial *AADTT*:

$$DE_i = DE20k_i \times \mathrm{AADTT}/20000$$

where $DE20k_i$ is the output of the *Pavement ME* calculation that assumed an initial AADTT of 20,000 trucks/lane. Once the history of differential deflection energy is known, the faulting can be easily calculated by applying equations (3.1) to (3.4). The *FM0* parameter, employed in equation (3.3) and determined by *Pavement ME*, can be used for any initial AADTT since this parameter does not depend on the truck traffic.

The following is a summary of the approach that was followed for faulting determination:

- Consider a specific cell of the JPCP design tables—for example, Group I climate, WIM 2 truck traffic, HMA base, untied shoulder, and initial AADTT of 2,000 trucks/lane (Table 4.2).
- Extract slab thickness (*PCCHTable*) from the corresponding JPCP design table (9.6 in. in this example).
- Determine slab thickness without provision for grinding: *PCCH* = *PCCHTable* – 0.72 in. (8.9 in this example).
- *PCCHUp* and *PCCHDown* are rounded-up and rounded-down slab thicknesses, respectively (8 and 9 in. in this example).
- For each of *PCCHUp* and *PCCHDown*, extract *FM0* and $DE20k_i$ from the *Pavement ME* runs database; *FM0* is a single value while $DE20k_i$ is a vector with 480 components (12 months × 40 years).
- For each of *PCCHUp* and *PCCHDown*, determine the differential deflection energy for the particular truck traffic of the JPCP design table cell (the initial AADTT is 2,000 in this example). The differential deflection energy is linearly proportional to initial AADTT:

$$DE_i = DE20k_i \times \text{AADTT}/20000$$

- For each of *PCCHUp* and *PCCHDown*, determine faulting by applying equations (3.1) to (3.4). An erodibility index of 1 was assumed, based on *Pavement ME* recommendation for HMA and LCB bases.
- Estimate faulting for *PCCH*, based on faulting for *PCCHUp* and *PCCHDown*, by using linear interpolation in the faulting versus slab thickness space. This faulting corresponds to 50% reliability.
- Determine faulting at 95% reliability by considering the standard error of the *Pavement ME* faulting prediction model: $0.07162 \times Fault^{0.368} + 0.00806$, where *Fault* is the faulting predicted at 50% reliability.

The faulting predicted at 95% reliability for each of the sections in the JPCP design tables is presented in Section 4.2 (Table 4.11 to Table 4.19).

3.2.2 Calculation of IRI

Pavement ME determines IRI by applying empirical equation (3.5), which considers initial IRI, cracking, spalling, faulting, and site conditions. Of these factors, the initial IRI and the faulting are the most relevant to IRI.

$$\mathrm{IRI} = IRI_I + \mathrm{C1}\,Cr + \mathrm{C2}\,Spall + \mathrm{C3}\,TFault + \mathrm{C4}\,SCF \qquad \textbf{(3.5)}$$

where IRI_I is initial (post-construction) IRI
Cr is percentage of slabs with transverse cracking
$Spall$ is percentage of transverse joints with medium and high-severity spalling
$TFault$ is cumulative faulting per mile (*Fault* × 5280/transverse joint spacing)
SCF is site condition factor, equal to $Age \times (1 + 0.5556 \times FI) \times (1 + P200) \times 10^{-6}$, where *Age* is age in years, *FI* is the freezing index (depending on the climate zone), and *P200* is percentage of subgrade soil passing through a #200 sieve
C1–C4 are calibration coefficients

The IRI calculations conducted for the JPCP design tables sections assumed the following parameters for the IRI equation:

- Age: 40 years
- Initial IRI: 63 in./mi.
- Cracking: 1.73%; this is the 50% reliability cracking that results in 10% cracking at 95% reliability
- Spalled transverse joints: 5%
- Faulting determined at 50% reliability, as explained in 3.2.1
- Freezing index is a function of the climate zone, as determined by *Pavement ME*: 0, 0.207, and 0.411 for Climate Groups I (SC), II (SM), and III (IV), respectively
- P200: 5.2% (A-3 soil)

The IRI value that results from equation (3.5) corresponds to 50% reliability. The 95% reliability prediction is conducted by considering the standard error of the *Pavement ME* IRI prediction model, shown in equation (3.6).

$$\mathrm{SE}\left(\mathrm{IRI}\right)=\left[\mathrm{SE}\left(IRI_I\right)^2+\mathrm{C1}^2\,\mathrm{SE}\left(Cr\right)^2+\mathrm{C2}^2\,\mathrm{SE}\left(Spall\right)^2+\mathrm{C3}^2\,\mathrm{SE}\left(TFault\right)^2+Se^2\right]^{1/2} \quad \textbf{(3.6)}$$

where	SE(IRI_I)	is 5.4^0.5
	SE(*Cr*)	is given by equation (2.2) applied to 1.73% cracking (it results in 5.03%)
	SE(*Spall*)	is 6.8%
	SE(*TFault*)	SE(*Faulting*) × 5280/14, with SE(*Faulting*) given by 0.07162 × $Fault^{0.368}$ + 0.00806
	Se	equals 29.03 × LN(IRI at 50% reliability) – 103.8
	C1–C3	are calibration coefficients

The IRI predicted at 95% reliability for each of the sections in the JPCP design tables is presented in Section 4.2 (Table 4.11 to Table 4.19).

4 JPCP DESIGN TABLES

4.1 JPCP Design Tables

The JPCP tables for the new *HDM Design Catalog* include the slab thickness required to meet 10% slab cracking at the end of 40-year design life at 95% reliability, including a provision for grinding of 0.06 ft. (0.72 in.). The following are the JPCP tables:

- Table 4.2: Group I climate and WIM 1 and WIM 2 truck traffic
- Table 4.3: Group I climate and WIM 3 truck traffic
- Table 4.4: Group I climate and WIM 4 and WIM 5 truck traffic
- Table 4.5: Group II climate and WIM 1 and WIM 2 truck traffic

Table 4.6: Group II climate and WIM 3 truck traffic

- Table 4.7: Group II climate and WIM 4 and WIM 5 truck traffic
- Table 4.8: Group III climate and WIM 1 and WIM 2 truck traffic
- Table 4.9: Group III climate and WIM 3 truck traffic
- Table 4.10: Group III climate and WIM 4 and WIM 5 truck traffic

The climate groups are defined as follows:

- Group I: SC and NC
- Group II: CC, LM, SM, HM, and HD
- Group III: IV and DE

Each JPCP design table contains the slab thickness for different combinations of base type and shoulder type.

- Base type:
    - HMA (hot mix asphalt), type A, 0.25 ft. (3 in.) thickness
    - LCB (lean concrete base), 0.35 ft. (4.2 in.) thickness
- Shoulder type:

  - Tied concrete
  - Untied concrete
  - Widened slab (14 ft.)

The HMA binder grade may be either PG 64-10 or PG 64-16, regardless of the climate zone. Different PG grades may be used, following chapter 632 of the Highway Design Manual, to prevent rutting associated to construction traffic, in case considerable construction traffic is expected.

The JPCP design tables consider any of the following subgrades:

- Type I: Coarse-grained soils SC, SP, SM, SW, GC, GP, GM, and GW (USCS)
- Type II: Fine-grained soils CL, MH, and ML (USCS)
- Type III: Fine-grained soil CH (USCS) stabilized with lime or cement

Type I includes subgrades made of coarse-grained soils that are primarily sand (S) and gravel (G), regardless of whether they are well or poorly graded (W, P) or have silt (M) or clay (C) in them (SC, SP, SM, SW, GC, GP, GM, and GW), based on the Unified Soil Classification System (USCS). Type II includes subgrades made of fine-grained soils with low (L) and high (H) plasticity (CL, MH, and ML). Finally, Type III includes subgrades made of fine-grained soil CH (clay with high plasticity).

Depending on the quality of the subgrade, a class 2 aggregate subbase should be provided for construction purposes, as specified in Table 4.1. Alternatively, the subgrade should be stabilized lime, cement, asphalt emulsion, or another stabilizer that is appropriate for the subgrade material.

Table 4.1: Minimum Subbase Thickness

Subgrade Soil (USCS)	Subgrade Type	Subbase Thickness
GW	Type I	Subbase not required
GP	Type I	Subbase not required
GM	Type I	Subbase not required
GC	Type I	0.35 ft. (4.2 in.)
SW	Type I	0.35 ft. (4.2 in.)
SP	Type I	0.35 ft. (4.2 in.)
SM	Type I	0.35 ft. (4.2 in.)
SC	Type I	0.35 ft. (4.2 in.)
ML	Type II	0.50 ft. (6.0 in.)
CL	Type II	0.50 ft. (6.0 in.)
MH	Type II	0.75 ft. (9.0 in.)
CH	Type III	Requires stabilization

JPCP is allowed with Type III subgrades (CH) stabilized with lime or cement. These subgrades can be considered as Type I with stabilization to determine the slab thickness.

The slab thickness in the tables is compatible with the following design features:

- Transverse joint spacing of 14 ft.
- Doweled transverse joints

The AADTT in the tables is the initial (year 1) average annual daily truck traffic per lane (the value that results after applying directional and lane distribution factors to the two-way AADTT).

The thickness in the tables is rounded to the nearest tenth of an inch and hundredth of a foot.

Table 4.2: JPCP Design Table for Group I Climate (SC, NC) and WIM 1 and WIM 2 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.66 ft. (7.9 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.70 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.72 ft. (8.6 in.)	0.67 ft. (8.0 in.)	0.65 ft. (7.8 in.)
500	0.74 ft. (8.8 in.)	0.69 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.76 ft. (9.2 in.)	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)
1,000	0.77 ft. (9.3 in.)	0.71 ft. (8.6 in.)	0.66 ft. (7.9 in.)	0.79 ft. (9.5 in.)	0.74 ft. (8.9 in.)	0.69 ft. (8.3 in.)
2,000	0.80 ft. (9.6 in.)	0.75 ft. (9.0 in.)	0.70 ft. (8.3 in.)	0.82 ft. (9.8 in.)	0.77 ft. (9.3 in.)	0.72 ft. (8.6 in.)
4,000	0.85 ft. (10.1 in.)	0.78 ft. (9.4 in.)	0.72 ft. (8.7 in.)	0.85 ft. (10.2 in.)	0.80 ft. (9.5 in.)	0.75 ft. (9.0 in.)
8,000	0.89 ft. (10.7 in.)	0.81 ft. (9.7 in.)	0.77 ft. (9.2 in.)	0.88 ft. (10.6 in.)	0.82 ft. (9.9 in.)	0.78 ft. (9.4 in.)
12,000	0.93 ft. (11.1 in.)	0.84 ft. (10.1 in.)	0.79 ft. (9.5 in.)	0.90 ft. (10.8 in.)	0.85 ft. (10.2 in.)	0.80 ft. (9.5 in.)
16,000	0.95 ft. (11.4 in.)	0.87 ft. (10.4 in.)	0.80 ft. (9.7 in.)	0.92 ft. (11.1 in.)	0.86 ft. (10.3 in.)	0.80 ft. (9.6 in.)
20,000	0.97 ft. (11.6 in.)	0.88 ft. (10.6 in.)	0.82 ft. (9.9 in.)	0.94 ft. (11.3 in.)	0.87 ft. (10.5 in.)	0.81 ft. (9.8 in.)

Table 4.3: JPCP Design Table for Group I Climate (SC, NC) and WIM 3 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.69 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.71 ft. (8.6 in.)	0.66 ft. (8.0 in.)	0.65 ft. (7.8 in.)
500	0.73 ft. (8.7 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.76 ft. (9.1 in.)	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)
1,000	0.77 ft. (9.3 in.)	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)	0.79 ft. (9.4 in.)	0.73 ft. (8.8 in.)	0.69 ft. (8.2 in.)
2,000	0.81 ft. (9.7 in.)	0.74 ft. (8.9 in.)	0.69 ft. (8.3 in.)	0.81 ft. (9.7 in.)	0.77 ft. (9.2 in.)	0.71 ft. (8.6 in.)
4,000	0.87 ft. (10.5 in.)	0.79 ft. (9.4 in.)	0.72 ft. (8.6 in.)	0.86 ft. (10.3 in.)	0.79 ft. (9.5 in.)	0.75 ft. (9.0 in.)
8,000	0.94 ft. (11.2 in.)	0.84 ft. (10.0 in.)	0.78 ft. (9.4 in.)	0.89 ft. (10.7 in.)	0.82 ft. (9.8 in.)	0.78 ft. (9.4 in.)
12,000	0.97 ft. (11.6 in.)	0.88 ft. (10.5 in.)	0.82 ft. (9.8 in.)	0.93 ft. (11.2 in.)	0.85 ft. (10.2 in.)	0.80 ft. (9.6 in.)
16,000	0.99 ft. (11.9 in.)	0.91 ft. (10.9 in.)	0.85 ft. (10.2 in.)	0.96 ft. (11.5 in.)	0.87 ft. (10.5 in.)	0.81 ft. (9.7 in.)
20,000	1.01 ft. (12.1 in.)	0.93 ft. (11.2 in.)	0.87 ft. (10.5 in.)	0.97 ft. (11.7 in.)	0.89 ft. (10.6 in.)	0.83 ft. (9.9 in.)

Table 4.4: JPCP Design Table for Group I Climate (SC, NC) and WIM 4 and WIM 5 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.69 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.71 ft. (8.6 in.)	0.67 ft. (8.0 in.)	0.65 ft. (7.8 in.)
500	0.73 ft. (8.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.76 ft. (9.1 in.)	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)
1,000	0.78 ft. (9.4 in.)	0.71 ft. (8.5 in.)	0.66 ft. (7.9 in.)	0.79 ft. (9.5 in.)	0.73 ft. (8.8 in.)	0.69 ft. (8.3 in.)
2,000	0.84 ft. (10.0 in.)	0.75 ft. (9.0 in.)	0.70 ft. (8.4 in.)	0.82 ft. (9.8 in.)	0.77 ft. (9.2 in.)	0.72 ft. (8.6 in.)
4,000	0.90 ft. (10.8 in.)	0.80 ft. (9.6 in.)	0.73 ft. (8.7 in.)	0.87 ft. (10.4 in.)	0.79 ft. (9.5 in.)	0.75 ft. (9.0 in.)
8,000	0.96 ft. (11.5 in.)	0.86 ft. (10.4 in.)	0.80 ft. (9.6 in.)	0.92 ft. (11.0 in.)	0.83 ft. (10.0 in.)	0.79 ft. (9.4 in.)
12,000	0.99 ft. (11.9 in.)	0.90 ft. (10.9 in.)	0.85 ft. (10.2 in.)	0.96 ft. (11.5 in.)	0.87 ft. (10.4 in.)	0.80 ft. (9.6 in.)
16,000	1.02 ft. (12.2 in.)	0.93 ft. (11.2 in.)	0.88 ft. (10.5 in.)	0.98 ft. (11.7 in.)	0.89 ft. (10.6 in.)	0.83 ft. (9.9 in.)
20,000	1.03 ft. (12.4 in.)	0.96 ft. (11.5 in.)	0.90 ft. (10.8 in.)	1.00 ft. (12.0 in.)	0.91 ft. (10.9 in.)	0.85 ft. (10.2 in.)

Table 4.5: JPCP Design Table for Group II Climate (CC, LM, SM, HM, HD) and WIM 1 and WIM 2 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.67 ft. (8.0 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.70 ft. (8.4 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.70 ft. (8.4 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.73 ft. (8.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)
500	0.75 ft. (9.0 in.)	0.70 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.78 ft. (9.3 in.)	0.72 ft. (8.7 in.)	0.67 ft. (8.0 in.)
1,000	0.79 ft. (9.4 in.)	0.72 ft. (8.7 in.)	0.67 ft. (8.1 in.)	0.80 ft. (9.6 in.)	0.76 ft. (9.1 in.)	0.70 ft. (8.4 in.)
2,000	0.82 ft. (9.9 in.)	0.76 ft. (9.1 in.)	0.71 ft. (8.5 in.)	0.84 ft. (10.1 in.)	0.79 ft. (9.4 in.)	0.73 ft. (8.8 in.)
4,000	0.88 ft. (10.5 in.)	0.80 ft. (9.6 in.)	0.74 ft. (8.9 in.)	0.87 ft. (10.5 in.)	0.81 ft. (9.7 in.)	0.77 ft. (9.2 in.)
8,000	0.94 ft. (11.2 in.)	0.85 ft. (10.2 in.)	0.79 ft. (9.5 in.)	0.90 ft. (10.8 in.)	0.85 ft. (10.2 in.)	0.80 ft. (9.5 in.)
12,000	0.97 ft. (11.6 in.)	0.88 ft. (10.6 in.)	0.82 ft. (9.9 in.)	0.94 ft. (11.2 in.)	0.87 ft. (10.4 in.)	0.81 ft. (9.7 in.)
16,000	1.00 ft. (11.9 in.)	0.91 ft. (11.0 in.)	0.86 ft. (10.3 in.)	0.96 ft. (11.5 in.)	0.88 ft. (10.6 in.)	0.83 ft. (10.0 in.)
20,000	1.02 ft. (12.2 in.)	0.94 ft. (11.2 in.)	0.88 ft. (10.6 in.)	0.97 ft. (11.7 in.)	0.89 ft. (10.7 in.)	0.85 ft. (10.2 in.)

Table 4.6: JPCP Design Table for Group II Climate (CC, LM, SM, HM, HD) and WIM 3 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.66 ft. (7.9 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.70 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.70 ft. (8.4 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.73 ft. (8.7 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)
500	0.75 ft. (9.0 in.)	0.69 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.77 ft. (9.3 in.)	0.72 ft. (8.6 in.)	0.67 ft. (8.0 in.)
1,000	0.80 ft. (9.6 in.)	0.72 ft. (8.6 in.)	0.67 ft. (8.0 in.)	0.80 ft. (9.6 in.)	0.75 ft. (9.0 in.)	0.70 ft. (8.4 in.)
2,000	0.86 ft. (10.3 in.)	0.77 ft. (9.2 in.)	0.71 ft. (8.5 in.)	0.84 ft. (10.1 in.)	0.78 ft. (9.4 in.)	0.73 ft. (8.7 in.)
4,000	0.92 ft. (11.0 in.)	0.82 ft. (9.8 in.)	0.76 ft. (9.1 in.)	0.88 ft. (10.6 in.)	0.81 ft. (9.7 in.)	0.77 ft. (9.2 in.)
8,000	0.97 ft. (11.7 in.)	0.89 ft. (10.7 in.)	0.83 ft. (10.0 in.)	0.94 ft. (11.2 in.)	0.86 ft. (10.3 in.)	0.80 ft. (9.6 in.)
12,000	1.01 ft. (12.1 in.)	0.93 ft. (11.2 in.)	0.88 ft. (10.5 in.)	0.97 ft. (11.6 in.)	0.88 ft. (10.6 in.)	0.82 ft. (9.9 in.)
16,000	1.04 ft. (12.4 in.)	0.96 ft. (11.5 in.)	0.91 ft. (10.9 in.)	1.00 ft. (11.9 in.)	0.91 ft. (10.9 in.)	0.85 ft. (10.3 in.)
20,000	1.05 ft. (12.6 in.)	0.98 ft. (11.7 in.)	0.93 ft. (11.2 in.)	1.02 ft. (12.2 in.)	0.93 ft. (11.2 in.)	0.88 ft. (10.5 in.)

Table 4.7: JPCP Design Table for Group II Climate (CC, LM, SM, HM, HD) and WIM 4 and WIM 5 Truck Traffic

AADTT (design lane)	HMA base Untied Sh.	HMA base Tied Sh.	HMA base Widened Sh.	LCB base Untied Sh.	LCB base Tied Sh.	LCB base Widened S.
100	0.67 ft. (8.0 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.70 ft. (8.4 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.70 ft. (8.5 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.73 ft. (8.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)
500	0.76 ft. (9.2 in.)	0.69 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.78 ft. (9.3 in.)	0.72 ft. (8.6 in.)	0.67 ft. (8.0 in.)
1,000	0.82 ft. (9.8 in.)	0.72 ft. (8.7 in.)	0.67 ft. (8.1 in.)	0.80 ft. (9.7 in.)	0.76 ft. (9.1 in.)	0.70 ft. (8.4 in.)
2,000	0.88 ft. (10.6 in.)	0.78 ft. (9.4 in.)	0.72 ft. (8.6 in.)	0.85 ft. (10.2 in.)	0.79 ft. (9.4 in.)	0.73 ft. (8.8 in.)
4,000	0.94 ft. (11.3 in.)	0.85 ft. (10.2 in.)	0.79 ft. (9.4 in.)	0.90 ft. (10.7 in.)	0.81 ft. (9.7 in.)	0.77 ft. (9.3 in.)
8,000	1.00 ft. (12.0 in.)	0.92 ft. (11.0 in.)	0.86 ft. (10.3 in.)	0.96 ft. (11.5 in.)	0.87 ft. (10.4 in.)	0.81 ft. (9.7 in.)
12,000	1.03 ft. (12.4 in.)	0.96 ft. (11.5 in.)	0.90 ft. (10.8 in.)	0.99 ft. (11.9 in.)	0.90 ft. (10.9 in.)	0.85 ft. (10.2 in.)
16,000	1.06 ft. (12.7 in.)	0.98 ft. (11.8 in.)	0.93 ft. (11.2 in.)	1.02 ft. (12.3 in.)	0.94 ft. (11.2 in.)	0.88 ft. (10.5 in.)
20,000	1.08 ft. (12.9 in.)	1.00 ft. (12.1 in.)	0.95 ft. (11.5 in.)	1.04 ft. (12.5 in.)	0.96 ft. (11.5 in.)	0.90 ft. (10.8 in.)

Table 4.8: JPCP Design Table for Group III Climate (IV, DE) and WIM 1 and WIM 2 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.69 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.72 ft. (8.6 in.)	0.66 ft. (8.0 in.)	0.65 ft. (7.8 in.)
500	0.74 ft. (8.9 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.76 ft. (9.2 in.)	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)
1,000	0.79 ft. (9.5 in.)	0.71 ft. (8.6 in.)	0.66 ft. (7.9 in.)	0.79 ft. (9.5 in.)	0.74 ft. (8.9 in.)	0.69 ft. (8.3 in.)
2,000	0.84 ft. (10.1 in.)	0.76 ft. (9.1 in.)	0.70 ft. (8.4 in.)	0.83 ft. (10.0 in.)	0.78 ft. (9.3 in.)	0.72 ft. (8.6 in.)
4,000	0.90 ft. (10.8 in.)	0.80 ft. (9.6 in.)	0.75 ft. (9.0 in.)	0.87 ft. (10.5 in.)	0.80 ft. (9.6 in.)	0.76 ft. (9.1 in.)
8,000	0.96 ft. (11.5 in.)	0.87 ft. (10.4 in.)	0.81 ft. (9.7 in.)	0.92 ft. (11.1 in.)	0.85 ft. (10.2 in.)	0.79 ft. (9.5 in.)
12,000	0.99 ft. (11.9 in.)	0.91 ft. (10.9 in.)	0.85 ft. (10.2 in.)	0.96 ft. (11.5 in.)	0.87 ft. (10.5 in.)	0.81 ft. (9.7 in.)
16,000	1.02 ft. (12.2 in.)	0.94 ft. (11.2 in.)	0.88 ft. (10.6 in.)	0.98 ft. (11.8 in.)	0.89 ft. (10.7 in.)	0.84 ft. (10.1 in.)
20,000	1.04 ft. (12.4 in.)	0.96 ft. (11.5 in.)	0.90 ft. (10.8 in.)	1.00 ft. (12.0 in.)	0.92 ft. (11.0 in.)	0.86 ft. (10.3 in.)

Table 4.9: JPCP Design Table for Group III Climate (IV, DE) and WIM 3 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.68 ft. (8.1 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.70 ft. (8.4 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.71 ft. (8.5 in.)	0.66 ft. (7.9 in.)	0.65 ft. (7.8 in.)
500	0.77 ft. (9.2 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.76 ft. (9.2 in.)	0.70 ft. (8.5 in.)	0.65 ft. (7.8 in.)
1,000	0.82 ft. (9.9 in.)	0.72 ft. (8.6 in.)	0.67 ft. (8.0 in.)	0.80 ft. (9.6 in.)	0.74 ft. (8.8 in.)	0.69 ft. (8.2 in.)
2,000	0.88 ft. (10.6 in.)	0.78 ft. (9.4 in.)	0.72 ft. (8.6 in.)	0.85 ft. (10.2 in.)	0.78 ft. (9.3 in.)	0.72 ft. (8.6 in.)
4,000	0.94 ft. (11.3 in.)	0.85 ft. (10.2 in.)	0.79 ft. (9.5 in.)	0.91 ft. (10.9 in.)	0.81 ft. (9.7 in.)	0.77 ft. (9.2 in.)
8,000	1.00 ft. (12.0 in.)	0.92 ft. (11.0 in.)	0.86 ft. (10.4 in.)	0.96 ft. (11.6 in.)	0.88 ft. (10.5 in.)	0.81 ft. (9.7 in.)
12,000	1.03 ft. (12.4 in.)	0.95 ft. (11.5 in.)	0.90 ft. (10.8 in.)	1.00 ft. (12.0 in.)	0.91 ft. (11.0 in.)	0.86 ft. (10.3 in.)
16,000	1.05 ft. (12.7 in.)	0.98 ft. (11.7 in.)	0.93 ft. (11.2 in.)	1.03 ft. (12.3 in.)	0.94 ft. (11.3 in.)	0.89 ft. (10.6 in.)
20,000	1.08 ft. (12.9 in.)	1.00 ft. (12.0 in.)	0.95 ft. (11.4 in.)	1.05 ft. (12.5 in.)	0.96 ft. (11.6 in.)	0.91 ft. (10.9 in.)

Table 4.10: JPCP Design Table for Group III Climate (IV, DE) and WIM 4 and WIM 5 Truck Traffic

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.66 ft. (7.9 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.68 ft. (8.2 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)
200	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)	0.65 ft. (7.8 in.)	0.72 ft. (8.6 in.)	0.66 ft. (7.9 in.)	0.65 ft. (7.8 in.)
500	0.79 ft. (9.5 in.)	0.69 ft. (8.3 in.)	0.65 ft. (7.8 in.)	0.77 ft. (9.3 in.)	0.71 ft. (8.5 in.)	0.65 ft. (7.8 in.)
1,000	0.85 ft. (10.2 in.)	0.74 ft. (8.8 in.)	0.68 ft. (8.2 in.)	0.81 ft. (9.7 in.)	0.74 ft. (8.9 in.)	0.69 ft. (8.3 in.)
2,000	0.91 ft. (10.9 in.)	0.81 ft. (9.7 in.)	0.75 ft. (9.0 in.)	0.87 ft. (10.5 in.)	0.79 ft. (9.4 in.)	0.72 ft. (8.7 in.)
4,000	0.97 ft. (11.6 in.)	0.88 ft. (10.5 in.)	0.82 ft. (9.9 in.)	0.94 ft. (11.2 in.)	0.84 ft. (10.0 in.)	0.78 ft. (9.4 in.)
8,000	1.03 ft. (12.3 in.)	0.95 ft. (11.4 in.)	0.89 ft. (10.7 in.)	0.99 ft. (11.9 in.)	0.90 ft. (10.9 in.)	0.85 ft. (10.2 in.)
12,000	1.06 ft. (12.7 in.)	0.98 ft. (11.8 in.)	0.93 ft. (11.2 in.)	1.03 ft. (12.4 in.)	0.95 ft. (11.3 in.)	0.89 ft. (10.7 in.)
16,000	1.08 ft. (13.0 in.)	1.01 ft. (12.1 in.)	0.96 ft. (11.5 in.)	1.05 ft. (12.6 in.)	0.97 ft. (11.6 in.)	0.92 ft. (11.0 in.)
20,000	1.11 ft. (13.3 in.)	1.03 ft. (12.3 in.)	0.98 ft. (11.7 in.)	1.07 ft. (12.9 in.)	0.99 ft. (11.9 in.)	0.94 ft. (11.3 in.)

4.2 Predicted Faulting and IRI

The 40-year faulting and IRI were predicted for each of the sections included in the JPCP design tables. The faulting and IRI predictions at 95% reliability are included in the following tables:

- Table 4.11: Group I climate and WIM 1 and WIM 2 truck traffic (design Table 4.2)
- Table 4.12: Group I climate and WIM 3 truck traffic (design Table 4.3)
- Table 4.13: Group I climate and WIM 4 and WIM 5 truck traffic (design Table 4.4)
- Table 4.14: Group II climate and WIM 1 and WIM 2 truck traffic (design Table 4.5)
- Table 4.15Group II climate and WIM 3 truck traffic (design Table 4.6)
- Table 4.16: Faulting and IRI Predicted (95% Reliability) for Design Table 4.7: Group II climate and WIM 4 and WIM 5 truck traffic (design Table 4.7)
- Table 4.17: Group III climate and WIM 1 and WIM 2 truck traffic (design Table 4.8)
- Table 4.18: Faulting and IRI Predicted (95% Reliability) for Design : Group III climate and WIM 3 truck traffic (design Table 4.9)
- Table 4.19: Group III climate and WIM 4 and WIM 5 truck traffic (design Table 4.10)

Caltrans failure limits for transverse joint faulting and IRI are 0.15 in. and 170 in./mi., respectively. When JPCP distresses exceed these limits, the Caltrans Pavement Management System decision tree requires a minor rehabilitation action with grinding (as soon as third-stage cracking remains below 10%). Depending on the amount of third-stage cracking, the grinding may be preceded by replacement of individual slabs. As shown in Table 4.11 to Table 4.19, the 40-year faulting and IRI predictions at 95% reliability are below the Caltrans failure limits for almost all sections included in the JPCP design tables. Nonetheless, there are some cases where these the limits are exceeded, and these cases are noted in the tables.

Almost all the cases noted in the tables (where Caltrans faulting and/or IRI limits are exceeded) correspond to JPCP with HMA base, either untied or tied shoulder, and a very high initial AADTT of 12,000 trucks/lane or higher. These scenarios may result, according to *Pavement ME*, in faulting above 0.15 in., IRI above 170 in./mi., or both, despite the doweled transverse joints. As shown in Table 4.11 to Table 4.19, the predicted faulting and IRI for the 40-year design life at 95% reliability may reach up 0.23 in. and 230 in./mi., respectively, in some scenarios. Increasing the slab thickness in these scenarios is not recommended since this approach would not considerably reduce the *Pavement ME* predicted faulting and IRI. While increasing the dowel diameter would be an efficient approach to reduce faulting and IRI, it is not recommended that Caltrans change current dowel diameter specifications, which were used for determining the faulting and IRI values presented in Table 4.11 to Table 4.19. In these scenarios, the JPCP may require grinding to correct faulting and/or IRI before the end of the 40-year JPCP design life.

Table 4.11: Faulting and IRI Predicted (95% Reliability) for Design Table 4.2 (Group I Climate and WIM 1 and WIM 2)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 104 in./mi.	0.03 in. 103 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 102 in./mi.	0.02 in. 99 in./mi.
200	0.02 in. 101 in./mi.	0.03 in. 106 in./mi.	0.02 in. 99 in./mi.	0.02 in. 101 in./mi.	0.03 in. 105 in./mi.	0.02 in. 99 in./mi.
500	0.03 in. 103 in./mi.	0.03 in. 102 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.02 in. 102 in./mi.	0.02 in. 100 in./mi.
1,000	0.04 in. 108 in./mi.	0.03 in. 105 in./mi.	0.02 in. 100 in./mi.	0.03 in. 106 in./mi.	0.03 in. 104 in./mi.	0.01 in. 99 in./mi.
2,000	0.05 in. 117 in./mi.	0.04 in. 111 in./mi.	0.01 in. 99 in./mi.	0.04 in. 112 in./mi.	0.04 in. 108 in./mi.	0.01 in. 99 in./mi.
4,000	0.09 in. 140 in./mi.	0.06 in. 124 in./mi.	0.01 in. 99 in./mi.	0.07 in. 128 in./mi.	0.05 in. 118 in./mi.	0.02 in. 99 in./mi.
8,000	0.06 in. 125 in./mi.	0.11 in. 156 in./mi.	0.02 in. 100 in./mi.	0.05 in. 117 in./mi.	0.09 in. 142 in./mi.	0.02 in. 100 in./mi.
12,000	0.08 in. 139 in./mi.	0.17 in. * 197 in./mi. *	0.02 in. 101 in./mi.	0.07 in. 126 in./mi.	0.13 in. 170 in./mi.	0.02 in. 100 in./mi.
16,000	0.11 in. 154 in./mi.	0.24 in. * 240 in./mi. *	0.03 in. 102 in./mi.	0.08 in. 135 in./mi.	0.17 in. * 198 in./mi. *	0.02 in. 101 in./mi.
20,000	0.13 in. 170 in./mi.	0.10 in. 149 in./mi.	0.03 in. 106 in./mi.	0.09 in. 145 in./mi.	0.22 in. * 227 in./mi. *	0.02 in. 102 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.12: Faulting and IRI Predicted (95% Reliability) for Design Table 4.3 (Group I Climate and WIM 3)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 106 in./mi.	0.03 in. 104 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.02 in. 99 in./mi.
200	0.02 in. 102 in./mi.	0.04 in. 108 in./mi.	0.02 in. 100 in./mi.	0.02 in. 101 in./mi.	0.04 in. 107 in./mi.	0.02 in. 99 in./mi.
500	0.03 in. 105 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.	0.03 in. 104 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.
1,000	0.04 in. 111 in./mi.	0.04 in. 107 in./mi.	0.02 in. 101 in./mi.	0.04 in. 109 in./mi.	0.03 in. 106 in./mi.	0.01 in. 99 in./mi.
2,000	0.07 in. 126 in./mi.	0.05 in. 115 in./mi.	0.01 in. 99 in./mi.	0.05 in. 119 in./mi.	0.04 in. 112 in./mi.	0.01 in. 99 in./mi.
4,000	0.12 in. 165 in./mi.	0.08 in. 136 in./mi.	0.01 in. 99 in./mi.	0.09 in. 143 in./mi.	0.07 in. 127 in./mi.	0.02 in. 99 in./mi.
8,000	0.08 in. 138 in./mi.	0.16 in. 190 in./mi.	0.02 in. 102 in./mi.	0.07 in. 127 in./mi.	0.12 in. 163 in./mi.	0.02 in. 100 in./mi.
12,000	0.12 in. 161 in./mi.	0.09 in. 142 in./mi.	0.03 in. 105 in./mi.	0.09 in. 141 in./mi.	0.18 in. * 204 in./mi. *	0.02 in. 101 in./mi.
16,000	0.15 in. 185 in./mi. *	0.11 in. 159 in./mi.	0.05 in. 117 in./mi.	0.11 in. 155 in./mi.	0.24 in. * 245 in./mi. *	0.03 in. 102 in./mi.
20,000	0.19 in. * 209 in./mi. *	0.14 in. 175 in./mi. *	0.07 in. 130 in./mi.	0.13 in. 170 in./mi.	0.11 in. 154 in./mi.	0.03 in. 106 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.13: Faulting and IRI Predicted (95% Reliability) for Design Table 4.4 (Group I Climate and WIM 4 and WIM 5)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 106 in./mi.	0.03 in. 105 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 104 in./mi.	0.02 in. 99 in./mi.
200	0.03 in. 102 in./mi.	0.04 in. 109 in./mi.	0.02 in. 100 in./mi.	0.02 in. 102 in./mi.	0.04 in. 107 in./mi.	0.02 in. 100 in./mi.
500	0.03 in. 106 in./mi.	0.03 in. 104 in./mi.	0.02 in. 100 in./mi.	0.03 in. 105 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.
1,000	0.05 in. 113 in./mi.	0.04 in. 108 in./mi.	0.02 in. 101 in./mi.	0.04 in. 110 in./mi.	0.03 in. 106 in./mi.	0.01 in. 99 in./mi.
2,000	0.07 in. 131 in./mi.	0.05 in. 117 in./mi.	0.01 in. 99 in./mi.	0.06 in. 122 in./mi.	0.05 in. 114 in./mi.	0.01 in. 99 in./mi.
4,000	0.06 in. 120 in./mi.	0.09 in. 142 in./mi.	0.01 in. 99 in./mi.	0.10 in. 150 in./mi.	0.07 in. 131 in./mi.	0.02 in. 99 in./mi.
8,000	0.09 in. 145 in./mi.	0.19 in. 209 in./mi.	0.03 in. 103 in./mi.	0.07 in. 130 in./mi.	0.14 in. 173 in./mi. *	0.02 in. 101 in./mi.
12,000	0.13 in. 171 in./mi. *	0.10 in. 148 in./mi.	0.05 in. 114 in./mi.	0.10 in. 146 in./mi.	0.20 in. * 220 in./mi. *	0.03 in. 102 in./mi.
16,000	0.17 in. * 199 in./mi. *	0.13 in. 167 in./mi.	0.02 in. 100 in./mi.	0.12 in. 163 in./mi.	0.10 in. 148 in./mi.	0.03 in. 105 in./mi.
20,000	0.21 in. * 226 in./mi. *	0.16 in. * 187 in./mi. *	0.02 in. 101 in./mi.	0.14 in. 179 in./mi. *	0.12 in. 160 in./mi.	0.04 in. 111 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.14: Faulting and IRI Predicted (95% Reliability) for Design Table 4.5 (Group II Climate and WIM 1 and WIM 2)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 103 in./mi.	0.03 in. 102 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 102 in./mi.	0.02 in. 99 in./mi.
200	0.02 in. 101 in./mi.	0.03 in. 105 in./mi.	0.02 in. 99 in./mi.	0.02 in. 101 in./mi.	0.02 in. 100 in./mi.	0.02 in. 99 in./mi.
500	0.03 in. 103 in./mi.	0.02 in. 102 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.02 in. 102 in./mi.	0.02 in. 100 in./mi.
1,000	0.04 in. 107 in./mi.	0.03 in. 104 in./mi.	0.02 in. 100 in./mi.	0.03 in. 106 in./mi.	0.03 in. 104 in./mi.	0.01 in. 99 in./mi.
2,000	0.05 in. 117 in./mi.	0.04 in. 110 in./mi.	0.01 in. 99 in./mi.	0.05 in. 114 in./mi.	0.04 in. 109 in./mi.	0.02 in. 99 in./mi.
4,000	0.04 in. 111 in./mi.	0.06 in. 124 in./mi.	0.02 in. 99 in./mi.	0.08 in. 134 in./mi.	0.06 in. 121 in./mi.	0.02 in. 100 in./mi.
8,000	0.06 in. 125 in./mi.	0.13 in. 166 in./mi.	0.02 in. 101 in./mi.	0.05 in. 119 in./mi.	0.11 in. 154 in./mi.	0.02 in. 100 in./mi.
12,000	0.09 in. 142 in./mi.	0.07 in. 127 in./mi.	0.03 in. 104 in./mi.	0.07 in. 130 in./mi.	0.16 in. * 191 in./mi. *	0.02 in. 101 in./mi.
16,000	0.12 in. 161 in./mi.	0.09 in. 140 in./mi.	0.05 in. 112 in./mi.	0.09 in. 143 in./mi.	0.07 in. 130 in./mi.	0.03 in. 105 in./mi.
20,000	0.15 in. 180 in./mi. *	0.11 in. 153 in./mi.	0.01 in. 99 in./mi.	0.11 in. 156 in./mi.	0.09 in. 140 in./mi.	0.04 in. 109 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.15: Faulting and IRI Predicted (95% Reliability) for Design Table 4.6 (Group II Climate and WIM 3)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 104 in./mi.	0.03 in. 103 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.02 in. 99 in./mi.
200	0.02 in. 101 in./mi.	0.04 in. 107 in./mi.	0.02 in. 99 in./mi.	0.02 in. 101 in./mi.	0.02 in. 101 in./mi.	0.02 in. 100 in./mi.
500	0.03 in. 105 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.	0.03 in. 104 in./mi.	0.03 in. 102 in./mi.	0.02 in. 100 in./mi.
1,000	0.04 in. 111 in./mi.	0.03 in. 106 in./mi.	0.02 in. 101 in./mi.	0.04 in. 109 in./mi.	0.03 in. 106 in./mi.	0.01 in. 99 in./mi.
2,000	0.07 in. 128 in./mi.	0.05 in. 115 in./mi.	0.01 in. 99 in./mi.	0.06 in. 122 in./mi.	0.05 in. 113 in./mi.	0.01 in. 99 in./mi.
4,000	0.05 in. 117 in./mi.	0.09 in. 139 in./mi.	0.02 in. 100 in./mi.	0.05 in. 113 in./mi.	0.07 in. 131 in./mi.	0.02 in. 100 in./mi.
8,000	0.09 in. 141 in./mi.	0.07 in. 126 in./mi.	0.03 in. 106 in./mi.	0.07 in. 130 in./mi.	0.15 in. 182 in./mi. *	0.02 in. 101 in./mi.
12,000	0.13 in. 169 in./mi.	0.09 in. 144 in./mi.	0.01 in. 99 in./mi.	0.10 in. 149 in./mi.	0.08 in. 134 in./mi.	0.03 in. 105 in./mi.
16,000	0.17 in. * 198 in./mi. *	0.12 in. 164 in./mi. *	0.02 in. 100 in./mi.	0.13 in. 169 in./mi.	0.10 in. 148 in./mi.	0.05 in. 113 in./mi.
20,000	0.22 in. * 228 in./mi. *	0.15 in. 184 in./mi. *	0.02 in. 101 in./mi.	0.16 in. * 190 in./mi. *	0.12 in. 162 in./mi.	0.02 in. 100 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.16: Faulting and IRI Predicted (95% Reliability) for Design Table 4.7 (Group II Climate and WIM 4 and WIM 5)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 105 in./mi.	0.03 in. 104 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.02 in. 99 in./mi.
200	0.02 in. 102 in./mi.	0.04 in. 107 in./mi.	0.02 in. 100 in./mi.	0.02 in. 101 in./mi.	0.02 in. 101 in./mi.	0.02 in. 100 in./mi.
500	0.03 in. 105 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.	0.03 in. 105 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.
1,000	0.05 in. 113 in./mi.	0.04 in. 107 in./mi.	0.02 in. 101 in./mi.	0.04 in. 110 in./mi.	0.03 in. 106 in./mi.	0.01 in. 99 in./mi.
2,000	0.04 in. 109 in./mi.	0.05 in. 118 in./mi.	0.01 in. 99 in./mi.	0.07 in. 126 in./mi.	0.05 in. 115 in./mi.	0.02 in. 99 in./mi.
4,000	0.06 in. 120 in./mi.	0.10 in. 150 in./mi.	0.02 in. 101 in./mi.	0.05 in. 116 in./mi.	0.08 in. 136 in./mi.	0.02 in. 100 in./mi.
8,000	0.10 in. 149 in./mi.	0.07 in. 131 in./mi.	0.04 in. 112 in./mi.	0.08 in. 135 in./mi.	0.17 in. * 197 in./mi. *	0.03 in. 102 in./mi.
12,000	0.15 in. 182 in./mi. *	0.10 in. 152 in./mi.	0.02 in. 100 in./mi.	0.11 in. 157 in./mi.	0.09 in. 139 in./mi.	0.04 in. 110 in./mi.
16,000	0.20 in. * 215 in./mi. *	0.14 in. 175 in./mi. *	0.02 in. 102 in./mi.	0.15 in. 180 in./mi. *	0.11 in. 155 in./mi.	0.02 in. 100 in./mi.
20,000	0.25 in. * 249 in./mi. *	0.17 in. * 199 in./mi. *	0.03 in. 104 in./mi.	0.18 in. * 204 in./mi. *	0.13 in. 172 in./mi. *	0.02 in. 101 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.17: Faulting and IRI Predicted (95% Reliability) for Design Table 4.8 (Group III Climate and WIM 1 and WIM 2)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.03 in. 106 in./mi.	0.03 in. 105 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.02 in. 99 in./mi.
200	0.02 in. 101 in./mi.	0.04 in. 109 in./mi.	0.02 in. 100 in./mi.	0.02 in. 101 in./mi.	0.03 in. 105 in./mi.	0.02 in. 99 in./mi.
500	0.03 in. 104 in./mi.	0.03 in. 102 in./mi.	0.02 in. 100 in./mi.	0.03 in. 103 in./mi.	0.03 in. 102 in./mi.	0.02 in. 100 in./mi.
1,000	0.04 in. 108 in./mi.	0.03 in. 105 in./mi.	0.02 in. 101 in./mi.	0.03 in. 106 in./mi.	0.03 in. 104 in./mi.	0.01 in. 99 in./mi.
2,000	0.06 in. 119 in./mi.	0.04 in. 111 in./mi.	0.01 in. 99 in./mi.	0.05 in. 114 in./mi.	0.04 in. 109 in./mi.	0.01 in. 99 in./mi.
4,000	0.04 in. 112 in./mi.	0.07 in. 127 in./mi.	0.02 in. 99 in./mi.	0.08 in. 133 in./mi.	0.06 in. 121 in./mi.	0.02 in. 99 in./mi.
8,000	0.07 in. 126 in./mi.	0.13 in. 171 in./mi. *	0.02 in. 101 in./mi.	0.05 in. 117 in./mi.	0.10 in. 151 in./mi.	0.02 in. 100 in./mi.
12,000	0.09 in. 142 in./mi.	0.07 in. 129 in./mi.	0.04 in. 109 in./mi.	0.07 in. 127 in./mi.	0.15 in. 186 in./mi. *	0.02 in. 101 in./mi.
16,000	0.12 in. 160 in./mi.	0.09 in. 141 in./mi.	0.01 in. 99 in./mi.	0.08 in. 137 in./mi.	0.07 in. 128 in./mi.	0.03 in. 105 in./mi.
20,000	0.14 in. 178 in./mi. *	0.11 in. 153 in./mi.	0.01 in. 99 in./mi.	0.10 in. 148 in./mi.	0.08 in. 136 in./mi.	0.04 in. 109 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.18: Faulting and IRI Predicted (95% Reliability) for Design Table 4.9 (Group III Climate and WIM 3)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.04 in. 108 in./mi.	0.03 in. 106 in./mi.	0.02 in. 99 in./mi.	0.02 in. 100 in./mi.	0.03 in. 104 in./mi.	0.02 in. 99 in./mi.
200	0.03 in. 102 in./mi.	0.04 in. 112 in./mi.	0.02 in. 100 in./mi.	0.02 in. 101 in./mi.	0.04 in. 107 in./mi.	0.02 in. 100 in./mi.
500	0.03 in. 106 in./mi.	0.03 in. 103 in./mi.	0.02 in. 101 in./mi.	0.03 in. 104 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.
1,000	0.05 in. 113 in./mi.	0.04 in. 107 in./mi.	0.03 in. 102 in./mi.	0.04 in. 110 in./mi.	0.03 in. 106 in./mi.	0.01 in. 99 in./mi.
2,000	0.04 in. 109 in./mi.	0.05 in. 117 in./mi.	0.01 in. 99 in./mi.	0.06 in. 122 in./mi.	0.05 in. 114 in./mi.	0.01 in. 99 in./mi.
4,000	0.05 in. 118 in./mi.	0.09 in. 145 in./mi.	0.02 in. 101 in./mi.	0.05 in. 113 in./mi.	0.07 in. 132 in./mi.	0.02 in. 100 in./mi.
8,000	0.09 in. 141 in./mi.	0.07 in. 127 in./mi.	0.04 in. 111 in./mi.	0.07 in. 127 in./mi.	0.06 in. 120 in./mi.	0.02 in. 102 in./mi.
12,000	0.13 in. 168 in./mi.	0.09 in. 145 in./mi.	0.02 in. 100 in./mi.	0.09 in. 142 in./mi.	0.07 in. 131 in./mi.	0.04 in. 109 in./mi.
16,000	0.17 in. * 195 in./mi. *	0.12 in. 163 in./mi.	0.02 in. 101 in./mi.	0.11 in. 159 in./mi.	0.09 in. 142 in./mi.	0.02 in. 100 in./mi.
20,000	0.21 in. * 222 in./mi. *	0.15 in. 183 in./mi. *	0.03 in. 103 in./mi.	0.14 in. 176 in./mi.	0.11 in. 155 in./mi.	0.02 in. 100 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

Table 4.19: Faulting and IRI Predicted (95% Reliability) for Design Table 4.10 (Group III Climate and WIM 4 and WIM 5)

AADTT (design lane)	HMA Base Untied Sh.	HMA Base Tied Sh.	HMA Base Widened Sh.	LCB Base Untied Sh.	LCB Base Tied Sh.	LCB Base Widened S.
100	0.04 in. 109 in./mi.	0.04 in. 107 in./mi.	0.02 in. 100 in./mi.	0.02 in. 101 in./mi.	0.03 in. 104 in./mi.	0.02 in. 99 in./mi.
200	0.03 in. 102 in./mi.	0.05 in. 113 in./mi.	0.02 in. 100 in./mi.	0.02 in. 102 in./mi.	0.04 in. 108 in./mi.	0.02 in. 100 in./mi.
500	0.04 in. 107 in./mi.	0.03 in. 104 in./mi.	0.02 in. 101 in./mi.	0.03 in. 105 in./mi.	0.03 in. 103 in./mi.	0.02 in. 100 in./mi.
1,000	0.05 in. 115 in./mi.	0.04 in. 109 in./mi.	0.01 in. 99 in./mi.	0.04 in. 111 in./mi.	0.04 in. 107 in./mi.	0.01 in. 99 in./mi.
2,000	0.04 in. 110 in./mi.	0.06 in. 121 in./mi.	0.02 in. 99 in./mi.	0.07 in. 126 in./mi.	0.05 in. 116 in./mi.	0.01 in. 99 in./mi.
4,000	0.06 in. 121 in./mi.	0.05 in. 114 in./mi.	0.03 in. 103 in./mi.	0.05 in. 114 in./mi.	0.08 in. 138 in./mi.	0.02 in. 100 in./mi.
8,000	0.10 in. 149 in./mi.	0.07 in. 132 in./mi.	0.02 in. 100 in./mi.	0.07 in. 130 in./mi.	0.06 in. 122 in./mi.	0.03 in. 106 in./mi.
12,000	0.14 in. 179 in./mi. *	0.10 in. 152 in./mi.	0.02 in. 101 in./mi.	0.10 in. 149 in./mi.	0.08 in. 135 in./mi.	0.02 in. 100 in./mi.
16,000	0.19 in. * 211 in./mi. *	0.14 in. 174 in./mi. *	0.03 in. 103 in./mi.	0.13 in. 168 in./mi.	0.10 in. 148 in./mi.	0.02 in. 101 in./mi.
20,000	0.24 in. * 242 in./mi. *	0.17 in. * 197 in./mi. *	0.03 in. 105 in./mi.	0.15 in. 186 in./mi. *	0.12 in. 162 in./mi.	0.02 in. 101 in./mi.

Note: The 40-year faulting and/or IRI predictions at 95% reliability exceed Caltrans failure limits.

5 SUMMARY AND RECOMMENDATIONS

5.1 Summary

This report summarizes the work conducted to develop the JPCP tables of the new *HDM Design Catalog*. The tables consider the different JPCP structures that are expected to perform properly on the Caltrans road network, including JPCP with either 12 or 14 ft. wide slabs, 14 ft. transverse joint spacing, and doweled transverse joints. The tables were develop using *Pavement ME* (version 2.5.5) with the nationally calibrated JPCP transverse cracking model. *Pavement ME* inputs were determined by considering the state's climate, traffic, materials, and construction practices.

The chosen values for design life (40 years) and design reliability (95%) are compatible with Caltrans pavement practices. The 95% reliability level is the same level used for developing the COA and CRCP tables of the new *HDM Design Catalog*, and it is also the reliability used for asphalt pavement design in *CalME*. The chosen transverse cracking failure limit is 10%, which also approximately corresponds to the fatigue cracking limit for asphalt pavement design in *CalME*.

The JPCP design tables, presented in Chapter 4, will be included in the printed version of the new *HDM Design Catalog*.

Overall, the JPCP tables of the new *HDM Design Catalog* result in thinner slabs compared to the current catalog, about 1 to 3 in. thinner depending mainly on the climate region.

While the JPCP design tables were prepared by considering the transverse cracking failure, the faulting and IRI were also determined, using *Pavement ME* (version 2.5.5) nationally calibrated models. For almost all sections, the faulting and IRI predicted at the end of 40-year design life at 95% reliability were below Caltrans's faulting and IRI failure limits of 0.15 in. and 170 in./mi., respectively. Nonetheless, these limits were exceeded in some scenarios with very high AADTT of 12,000 trucks/lane or higher. These specific scenarios may require grinding to correct faulting and/or IRI before the end of the 40-year JPCP design life.

5.2 Recommendations

While the JPCP design tables were developed by considering transverse cracking, the Caltrans Pavement Management System operates based on third-stage cracking, defined as a set of cracking—other than corner cracking—the divides the JPCP slab into three or more pieces. It is recommended that future versions of the Caltrans *HDM Design Catalog* JPCP tables be developed based on third-stage cracking rather than transverse cracking. It is also recommended that longitudinal cracking be considered in future catalogs, once research is completed that will provide a sufficiently accurate approach for calculating longitudinal cracking performance.

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APPENDIX A: TRAFFIC INDEX—AVERAGE ANNUAL DAILY TRUCK TRAFFIC TABLES

Table A.1: Average Annual Daily Truck Traffic Versus Traffic Index (40 years design life, 3% linear annual growth)

	Average Annual Daily Truck Traffic (AADTT) (per lane) (40 years design life, 3% linear annual growth)				
Traffic Index (TI)	**WIM1**	**WIM2**	**WIM3**	**WIM4**	**WIM5**
8.5	149	127	111	89	81
9.0	240	206	180	144	131
9.5	378	324	284	227	206
10.0	582	499	436	349	317
10.5	877	752	658	526	478
11.0	1,296	1,111	972	778	707
11.5	1,883	1,614	1,413	1,130	1,027
12.0	2,693	2,308	2,020	1,616	1,469
12.5	3,795	3,253	2,846	2,277	2,070
13.0	5,277	4,523	3,958	3,166	2,878
13.5	7,246	6,211	5,435	4,348	3,952
14.0	9,836	8,431	7,377	5,902	5,365
14.5	13,210	11,323	9,907	7,926	7,205
15.0	17,564	15,055	13,173	10,538	9,580
15.5	23,136	19,831	17,352	13,882	12,620
16.0	30,210	25,895	22,658	18,126	16,478
16.5	39,125	33,536	29,344	23,475	21,341

Table A.2: Traffic Index Versus Average Annual Daily Truck Traffic (40 years design life, 3% linear annual growth)

	Traffic Index (TI)				
Average Annual Daily Truck Traffic (AADTT) (per lane)	**WIM1**	**WIM2**	**WIM3**	**WIM4**	**WIM5**
100	8.5	8.5	8.5	9.0	9.0
200	9.0	9.0	9.5	9.5	9.5
500	10.0	10.5	10.5	10.5	11.0
1,000	11.0	11.0	11.5	11.5	11.5
2,000	12.0	12.0	12.0	12.5	12.5
4,000	13.0	13.0	13.5	13.5	14.0
8,000	14.0	14.0	14.5	15.0	15.0
12,000	14.5	15.0	15.0	15.5	15.5
16,000	15.0	15.5	15.5	16.0	16.0
20,000	15.5	16.0	16.0	16.5	16.5