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Mechanistic-Empirical Structural Design of Standard Interlocking Concrete Pavements— Final Report, Including Design Catalog

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16. ABSTRACT This report presents the results of Phase I of a two-phase study to develop a new practice-ready design catalog for standard interlocking concrete pavements (ICP) based on a mechanistic-empirical (M-E) design approach. The new catalog is intended to replace the existing ASCE Standard 58-16 catalog, which was developed using the empirical AASHTO 1993 design method. Phase I objectives were to develop a framework for the M-E design process for ICP, assemble a database of appropriate values for critical design inputs, and develop an initial design catalog to be validated through accelerated pavement testing in Phase II. Field investigations were conducted on selected ICP sites representing a range of structures, ages, traffic volumes, and axle-load distributions. Deflection testing was conducted to backcalculate as-built stiffness and variability of different layers in ICPs. Performance modeling was conducted using <i>CalME</i>, the M-E design program developed and maintained by the University of California Pavement Research Center (UCPRC) for the California Department of Transportation (Caltrans). The results confirmed that rutting is the main structural failure mechanism for ICPs. <i>CalME</i> predictions were consistent with observed rutting performance for low-volume local streets but generally underpredicted performance for sites with higher traffic, such as the Port of Oakland. <i>CalME</i> was then used to develop a preliminary design catalog for ICP sections covering the full range of traffic and structures in the ASCE 58-16 empirical catalog. Worked examples were provided to illustrate catalog use and side-by-side comparisons with ASCE 58-16. Finally, the report outlines a plan for the next phase to address remaining critical questions and calibrate <i>CalME</i> models for ICP through accelerated pavement testing.		
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EXECUTIVE SUMMARY

This report presents the results and findings from Phase I of a two-phase study aimed at developing a new practice-ready design catalog for standard interlocking concrete pavements (ICPs) based on the mechanistic-empirical M-E design approach. The new catalog will replace the existing catalog in ASCE 58-16, which was developed using the empirical AASHTO 1993 design method. Compared to the empirical method, the M-E method can account for differences in pavement layer types and depths, as well as traffic volumes and loads, while directly predicting field performance rather than relying on indirect metrics such as serviceability. This enables structural optimization and cost savings by selecting the most suitable material options. Phase I objectives were to develop a framework for the M-E design process for ICP, assemble a database of appropriate values for critical design inputs, and develop an initial design catalog to be validated through accelerated pavement testing in Phase II.

The existing M-E design program, *CalME*, developed and maintained by the University of California Pavement Research Center (UCPRC) for the California Department of Transportation (Caltrans), was used in this study. Because *CalME* was originally designed for flexible pavements, which do not incorporate pavers and bedding sand, its models must be validated with field performance data from ICP. To validate the use of *CalME* for ICP field investigations, a series of ICP sections was examined. Field investigations were conducted on selected sites representing a range of structures, ages, traffic volumes, and axle-load distributions. Deflection testing was conducted to backcalculate as-built stiffness and variability of different layers in ICPs.

Results confirmed that rutting is the main structural failure mechanism for ICPs. *CalME* was then used to simulate the rutting performance of the field evaluation sites. It was found that *CalME* predictions are consistent with the observed rutting for local streets with low traffic volumes, but generally underpredict for sites with higher traffic, such as the Port of Oakland. *CalME* was then used to develop a preliminary design catalog for ICP sections covering the full range of traffic and structures in the empirical catalog of ASCE 58-16. **The new catalog is presented in Table B- 1 through Table B- 8 for various base types.**

Worked examples were included to illustrate how to use the catalog, and a comparison with ASCE 58-16 was presented and discussed. The new catalog was found to produce designs with slightly different aggregate base thicknesses, either thinner or thicker, depending on traffic and subgrade category, but with a significantly thinner subbase layer overall.

Finally, the report presents a list of remaining critical questions for the development of the new catalog. These questions can be addressed through accelerated pavement testing (APT). The ICP industry is encouraged to evaluate and prioritize these questions so that APT can be planned and carried out efficiently. Data collected from APT will then be used to calibrate the damage models required for the M-E design method, which in turn will support the development of the final version of the new catalog.

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1 BACKGROUND

1.1 Historical and Current Use of Segmented Pavements

Segmental pavements with tightly fitted paving units have a rich history (1). The origins of stone pavement blocks can be traced back to the Inca Empire in South America, as well as the Egyptians, who used such roads to transport materials for pyramid construction, and ancient Chinese roads. However, it was the Romans who greatly expanded the use of cobblestones for a durable road network with a sophisticated multilayer structure extending to 53,000 miles (about 85,300 km) of main roads (2). This length is comparable to today's United States interstate highway system, which spans approximately 46,876 miles (75,440 kilometers) (3).

Roman roads included stone aggregate at the base, followed by smaller rocks set with lime or lava dust, then a layer of sand or crushed stone, and finally, tightly packed stone slabs placed in a bed of sand. This technique ensured that the roads were resilient and long-lasting, as demonstrated by the existence of Roman road sections to this day (4). The significance of block pavements continued into the Middle Ages, with notable applications in England during the 1350s (5).

The modern version of segmental pavement with concrete units started in the Netherlands as a replacement for clay brick units in the late 1940s and early 1950s due to the shortage of clay masonry units for rebuilding structures after World War II. Paver production technology later spread to Germany and Western Europe (1). The transition from segmental paving systems to economical interlocking concrete pavement gained widespread acceptance in Western Europe and the United Kingdom for use on streets, ports, and airports in the late 20th century.

The modern production of concrete paver blocks in North America began in Canada in 1973. This innovation quickly spread to the United States, where paving stone manufacturing plants started to open across the country, moving from east to west. The first concrete pavers, known as Holland Stones, were shaped like bricks, measuring 100 by 200 mm (4 × 8 in.), and were recognized for their strength and economical production (6). Figure 1.1 (Top-left) shows a photograph of Elfreth's Alley in Philadelphia, PA, featuring preserved early American houses and a cobblestone street dating to early settlements in the 1770s. A noteworthy modern construction is the 1984 port project at the European Container Terminus in Rotterdam, The Netherlands, using 4 × 8 × 4¾ in. (100 × 200 × 120 mm) units across 9 million ft² (approximately 900,000 m²), later expanding to over 20 million ft² (approximately 2 million m²) (7).

Today, the versatility of concrete pavers is evident in their widespread use in various commercial, municipal, and industrial pavement applications. From sidewalks and driveways to low- and moderate-volume traffic streets and parking lots, pavers have proven their adaptability (Figure 1.1 shows a range of applications).

In addition to low-volume, trafficked roads, pavers have also been used on roads with higher-volume traffic, including those in port container terminals, airport aprons, taxiways, highway shoulders, and industrial yards (8). These applications demonstrate their potential in diverse applications.



Figure 1.1: Top-left: Elfreth's Alley, Philadelphia, PA. Other photos: Interlocking concrete pavement in city applications, Davis, CA.

According to David Smith, former Technical Director of the ICPI Foundation, other examples of ICP application are the 5 million ft² (approximately 500,000 m²) wharf and container-handling areas at the Port of Oakland, CA, which used 4 x 8 x 4 in. (100 x 200 x 100 mm) units placed in the early 2000s (9). The Seagirt Terminal at the Port of Baltimore, Maryland, used 4¾ in. (120 mm) thick rectangular paving units for an initial 230,000 ft² (approximately 23,000 m²) wharf area in 1988. (This area was removed in 2022-23 due to Seagirt Wharf expansion.) In the 1990s, the Maryland Port Authority used

dentated units of the same thickness at the Seagirt container storage backlots and along the Dundalk wharf, supporting bulk shipments and Ro-Ro (vehicle import) operations. In total, almost 2 million ft² (approximately 200,000 square meters) were installed at the Port of Baltimore (10).

Some general advantages of interlocking pavements over traditional asphalt concrete pavements for municipal roads have been reported to include easier access to utilities, significantly lower pavement damage from utility cuts, lack of aging from oxidation-related distress, higher reflectivity over asphalt with a darker surface, no temperature or loading rate sensitivity, and potentially less frequent maintenance requirements (11).

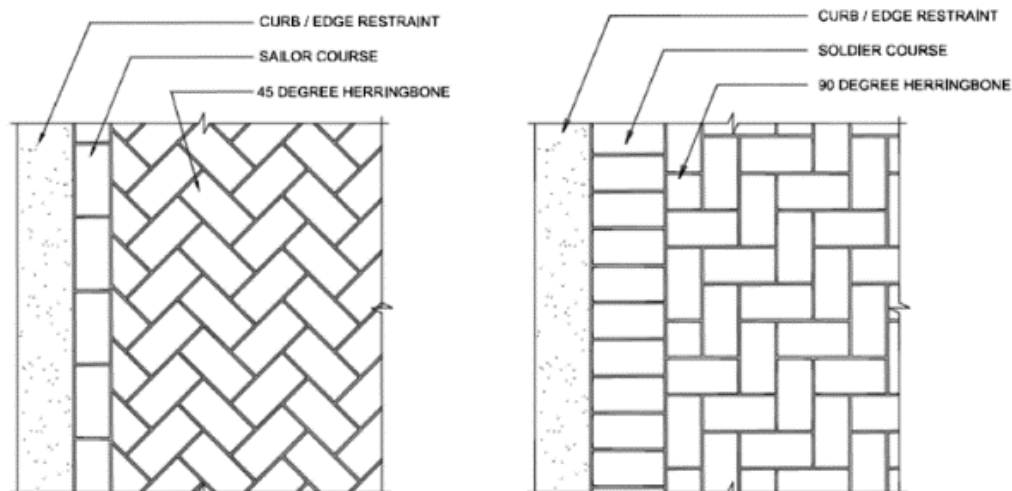
1.2 Primary Components of Interlocking Concrete Pavements

Interlocking concrete pavements (ICP), also referred to as segmental concrete pavements (SCP) or concrete block pavement (CBP) in the literature, consist of a surface layer of paver blocks. The paver blocks are laid in specific patterns, typically 45-degree or 90-degree herringbone patterns for streets, as shown in Figure 1.2. While many alternative patterns have been used, several studies have identified the herringbone patterns as structurally superior to stretcher bond patterns for trafficked applications (1,12).

A typical paver block thickness can vary from 2½ in. to 4¾ in. (60 mm to 120 mm). The two most common pavers used in structural applications have a typical thickness of 3½ in. (80 mm) or 4 in. (100 mm). The most used shape is rectangular at 4 in. by 8 in. (100 by 200 mm). Numerous products are available on the market in various shapes and colors. The concrete paver units must conform to the requirements of ASTM C936 in the United States and CSA A231.2 in Canada.

The paver blocks are placed manually or using machinery on a 1.0 in. to 1.2 in. (25 mm to 30 mm) thick bedding sand, conforming to the requirements of ASTM C33.

Restraints are provided along the edges to prevent lateral migration of paver units (1). The edge restraint is critical in maintaining the rotational and horizontal interlock, which resists forces from turning and braking tires and provides lateral resistance. Figure 1.2 shows ICP herringbone patterns with edge courses and a concrete curb edge restraint.



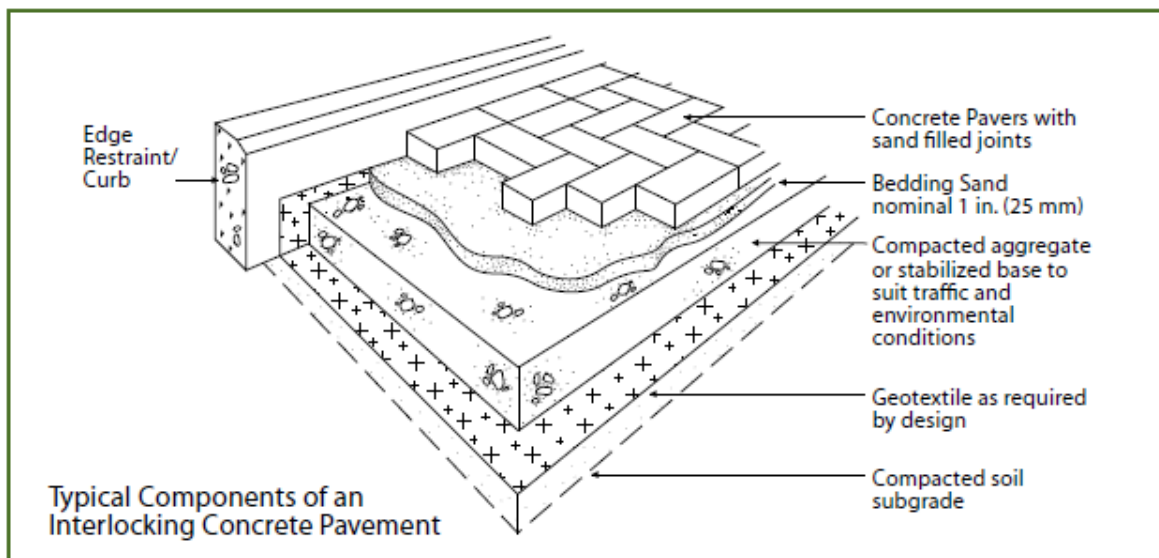
Source: Rada et al (1993) (1).

Figure 1.2: Left: 45-degree herringbone pattern and right: 90-degree herringbone pattern, and the demonstration of the edge restraint and the curb.

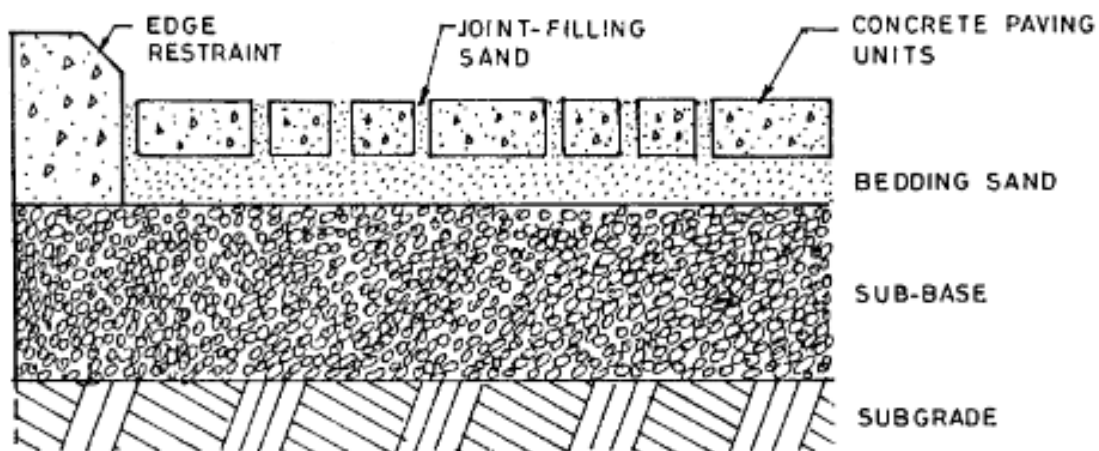
The base layer for ICP (the layer directly beneath the bedding sand) can be composed of unbound materials, such as dense-graded crushed stone, or bound materials, including asphalt-treated base (ATB) or cement-treated base (CTB) materials. A subbase layer may be used beneath the base layer, typically consisting of unbound aggregate. There is also interest in using cold-recycled pavement as the foundation for ICP, either recycled in place or with a mobile cold central recycling plant.

Finally, the subgrade layer consists of compacted native soil, and special treatment may be required for low-draining, frost-susceptible soils that are prone to swelling. While the previous assemblies described are designed as flexible pavements, concrete pavers and bedding sand on a concrete base are typically designed as rigid pavements (13).

Figure 1.3 summarizes the primary components of a typical ICP, including the three main layers in the pavement structure.



(a)



(b)

Source: (a): CMHA (2020) (14), (b): CMHA (2023) (13).

Figure 1.3: Schematic cross-sections of a typical ICP showing the primary components.

1.3 Functioning Mechanism

The paver unit layer undergoes an action referred to as lock-up or interlock with time under traffic loading (15). With the freedom provided by the sand joints, the blocks continuously wedge together (16). With continual early trafficking, the joint sand is compressed in the joints, resulting in progressive stiffening of the surface, a mechanism analogous to post-tensioning, according to Abate (11), except that the action is compression. This action distributes the load from one paver to the next, facilitated by the shear transfer from the joint sand. This interlocking action, referred to as progressive stiffening by Drenth (8), is the primary mechanism through which the paver block system distributes applied wheel loads as a unified layer rather than through individual blocks (15). This is the principal load-spreading mechanism by which ICP functions as a load-bearing surface. This interlock among the paver units forms a single, unified load-bearing layer, which enables the use of linear elastic theory in ICP system design. Shackel (12) estimated that about 10,000 wheel passes are required for the interlock to develop fully. This progressive behavior is crucial to how ICP performs, as permanent deformation or rutting can develop to the point where the interlock is complete (11).

1.4 Structural Design Methods for ICP

The current structural design procedure for ICP in North America is outlined in *Structural Design of Interlocking Concrete Pavement for Municipal Streets and Roadways*, Standard ASCE/T&DI/ICPI 58-16 (17). This is a purely empirical method based on the AASHTO 1993 flexible pavement design method (18). The key developments that supported this design procedure were two successive studies by Rada et al. in the early 1990s (1,19), which led to the adoption of a modified AASHTO 1993 flexible pavement design method for ICP systems. This design method was published as the American Society of Civil Engineers (ASCE)/T&D/ICPI 58-16 standard (17), initially released in 2010. This standard is used today for the design of ICP in North America.

Similar to the AASHTO 1993 flexible pavement design procedure, the ICP design procedure converts the mixed traffic loads over the design life into a composite 18 kip (80 kN) equivalent single-axle loads (ESALs) for use in the design equation. In the ASCE ICP procedure, 10 levels of ESALs are considered, ranging from 10,000 to 10,000,000 ESALs. The designer chooses an ESAL level based on a design life of 20 to 40 years, which is recommended for municipal pavements. The remaining parameters are defined as outlined in Table 1.1. A single-layer coefficient (a_1) of 0.44 is used to represent the paver block and the bedding sand as one composite layer at a starting ESAL of 10,000, at which point lock-up is expected to have fully developed, according to Shackel (20). Other studies reported full lock-up development at between 5,000 and 10,000 ESALs (1).

Table 1.1: List Of Design Parameters and Their Values Used in ASCE 58-16 ICP Design Procedure

Parameter	Values
Layer coefficients	$a_1 = 0.44$; $a_2 = 0.14$ for a dense-graded unbound base layer, 0.25 for ATB, 0.20 for CTB, and $a_3 = 0.09$ for unbound subbase layer
Subgrade resilient modulus (MR)	Varies depending on soil type, with eight categories (1-8) for drainage: good, fair, and poor.
Present and terminal serviceability	$P_0 = 4.2$; $P_t = 2.5$
Reliability and variability considerations	$R = 75\%$ resulting in $Z_R = -0.674$ with a standard deviation of $S_0 = 0.45$

Source: ASCE 58-16 catalog (2016) (17).

After the engineer determines the design life, subgrade category, drainage condition, and traffic, the design thicknesses can be found in a table from among three tables for the ESAL level and the desired base type. Based on the ASCE 58-16 design procedure, pavers with 3¼ in. (80 mm) depth and 1 in. (25 mm) bedding sand in a herringbone pattern placed on unbound aggregate base and subbase are sufficient for ESALs up to 10,000,000. To reduce the total thickness of the base or subbase, options are provided for including a stiffer base layer, typically an asphalt- or cement-stabilized layer (17).

As discussed comprehensively in the literature review report submitted in the previous phase of this project, researchers worldwide have applied M-E design procedures to ICP design. These procedures typically treat the paver blocks and the bedding sand as a single composite layer, placed on top of a base and then a subgrade layer. The use of multilayer linear elastic models to quantify the strains and deflection is common among the M-E procedures. Transfer functions, primarily to prevent rutting in the subgrade, have been employed in conjunction with Miner's Rule to prevent rutting of the ICP layer. This design procedure is analogous to that used for the M-E design of flexible pavements.

2 PROJECT OVERVIEW

2.1 Project Objectives

The Interlocking Concrete Pavement Institute Foundation for Education and Research requested that UCPRC develop an M-E design-based catalog for standard interlocking concrete pavements (ICP). The desired outcomes of the study are as follows:

1. Create a mechanistic model and web-based catalog tool for ICP using *CalME*.
2. Identify calibrated transfer functions that predict failure mechanisms of ICP.
3. Prepare deliverables that include an online design catalog of ICP pavement sections, written for municipal engineers and practitioners¹.

These outcomes will be achieved in two phases. In Phase I of the project, UCPRC's focus is on determining the outline of the M-E process for ICP and developing a database of appropriate values for critical design inputs: traffic and materials (based on field testing) for stress and strain calculations, identifying and using transfer functions for damage (and potentially distress) quantification. The specific tasks in Phase I include:

- Task 1.1: Literature review
- Task 1.2: Site surveys and field testing
- Task 1.3: M-E pavement design models and catalog
- Task 1.4: Plan for test track construction

In Phase II of the project, the M-E design process will be calibrated and validated using a Heavy Vehicle Simulator (HVS) that conducts accelerated pavement testing (APT) at UCPRC.

This final report fulfills the deliverables associated with Tasks 1.2, Task 1.3, and 1.4. A separate report, which focused on a literature review (Task 1.1), compiled relevant information in preparation for on-site testing and the M-E design of the ICP, was previously submitted to ICPI.

2.2 Report Structure

This report presents the site investigation results, including deflection testing of several ICP sections across California with various structures, traffic types, and traffic counts. The backcalculated layer moduli and measured rut depths were used to evaluate the application of the mechanistic-empirical M-E design tool *CalME* for ICP rutting prediction. *CalME* is a flexible pavement design tool developed and maintained by the UCPRC for the California Department of Transportation (Caltrans).

The validated *CalME* models were then employed to develop a full design catalog for ICP sections covering the complete range of traffic and the full combination of structures used in the empirical catalog of ASCE 58-16 (17). Worked examples were provided to illustrate how to use the catalog, and a comparison with ASCE 58-16 was also presented and discussed.

¹ Note that the catalog is provided as tables in this report. An online query tool based on these tables can be developed upon ICPI request at any time.

Finally, a plan is outlined for the next phase, which includes HVS testing to either develop a new rutting model or calibrate the existing one.

3 FIELD TESTING

3.1 Introduction

The goal of field testing was to understand how standard ICPs perform and confirm the layer moduli gathered identified in the Task 1.1 literature review. Each field visit began with a condition survey, followed by non-destructive deflection testing using a falling weight deflectometer (FWD) on a pre-selected ICP section. Information such as traffic, age, and structural cross-section was collected from the road agencies when available.

The condition survey revealed the primary distress mechanisms in these pavements, such as rutting and cracking, while deflection testing enabled the backcalculation of layer stiffnesses, providing crucial inputs for the mechanistic-empirical design methods used in this study.

The location and overview of the test sites are listed in Table 3.1 below. As shown in the table, these sites offer a diverse combination of ages, traffic volumes, and traffic types.

Table 3.1: Location and Overview of the Test Sites Evaluated in this Study

Site	Nearby Address	Construction Year	Neighborhood Characteristics	Layers Below Bedding Sand ^a	Date of Testing
Capay	24989 CA-16, Esparto, CA 95607	2007	Stamped and dyed (to look similar to ICP) asphalt shoulder of a state highway passing through a small town	Not applicable	7/17/2024
Colma	1500 Hillside Blvd, Colma, CA 94014	1997-1998	Residential street	100 to 150 mm aggregate base (AB)	2/5/2025
El Dorado Hills	Pequot and Ottawa St., El Dorado Hills, CA 95762	Around 2020	Gated residential neighborhood	200 mm of AB	4/14/2025
Rancho Cordova	11581 Tortuguero Wy, Rancho Cordova, CA 95742	Around 2023	Intersection in an area with some sections still under construction	50 mm asphalt concrete (AC) over 100 to 150 mm AB	4/14/2025
Westley	4437 Howard Rd, Westley, CA 95387	2014	Highway truck stop	350 mm of AB over biaxial grid	10/29/2024
Berths 30-32, Port of Oakland	1717 Middle Harbor Rd, Oakland, CA 94607	1993	Gantry tracks	225 mm of AC over engineered fill	9/19/2024
Berths 55-56, Port of Oakland	1717 Middle Harbor Rd, Oakland, CA 94607	2002	Gantry tracks	75 mm of AC over 450 to 500 mm of AB on engineered fill	9/19/2024

^aAll sites have 80 mm pavers and 25 mm of bedding sand, except Port of Oakland, where the pavers are 100 mm thick. The paver arrangement at all sites was a herringbone pattern.

The satellite views of different testing sites are shown in Figure 3.1 to Figure 3.6, with the tested streets or lanes indicated as well.

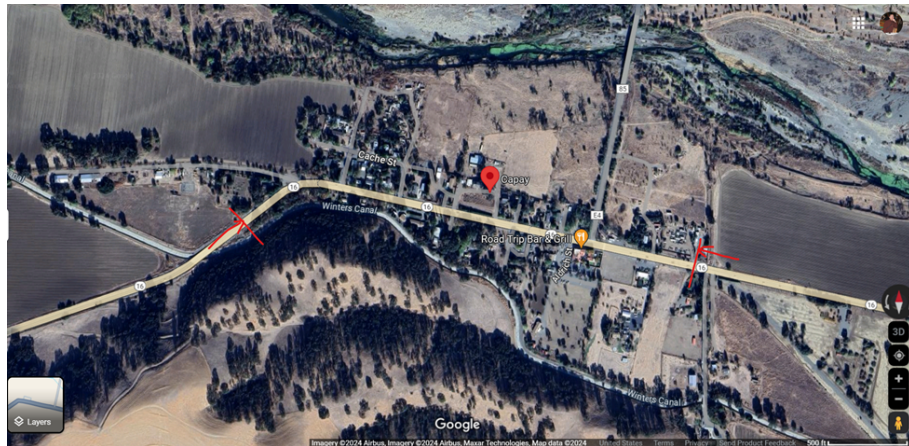


Figure 3.1: Satellite view of the Capay test site, with red arrows indicating ends of testing (map data from Google Maps, ©Google). This site was determined to be a stamped and dyed asphalt pavement made to look like an ICP.

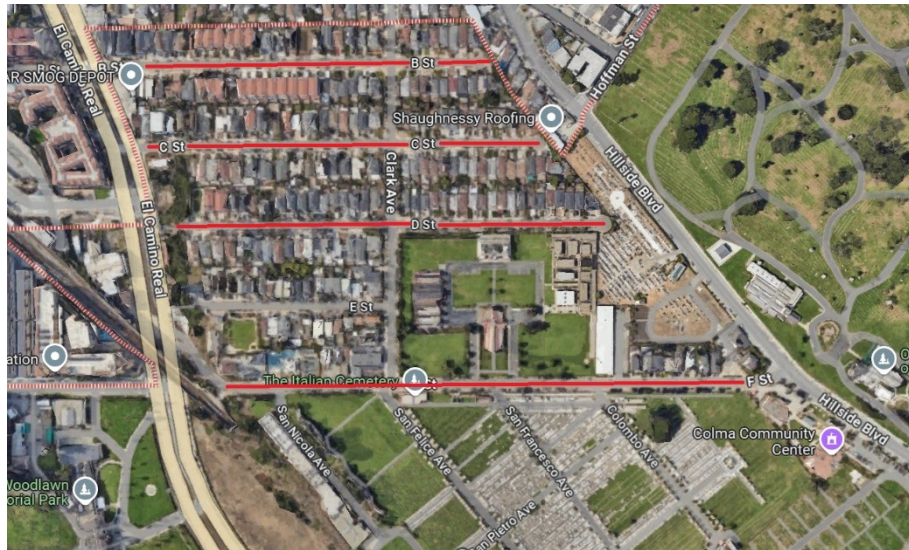


Figure 3.2: Satellite view of the Colma test site, with red lines indicating the tested streets (map data from Google Maps, ©Google)

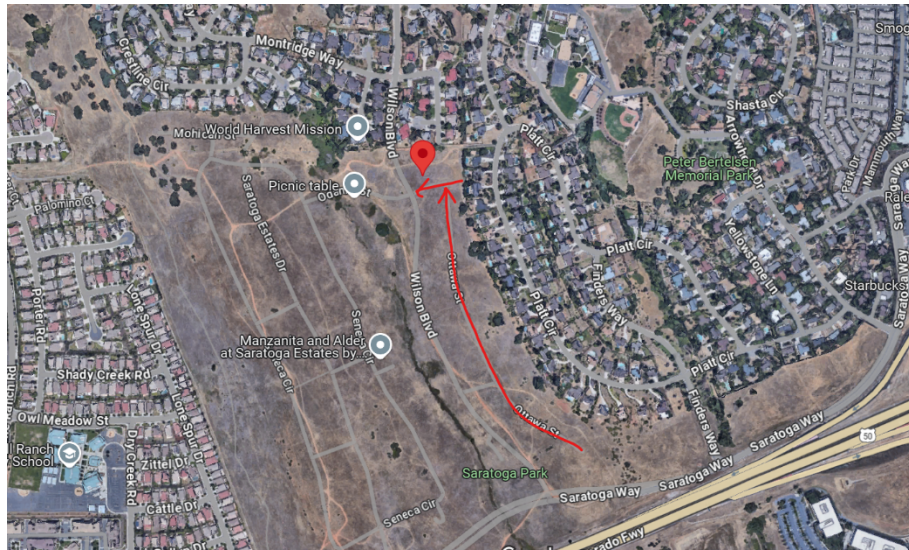


Figure 3.3: Satellite view of the El Dorado Hills test site, with red lines indicating the tested streets (map data from Google Maps, ©Google)

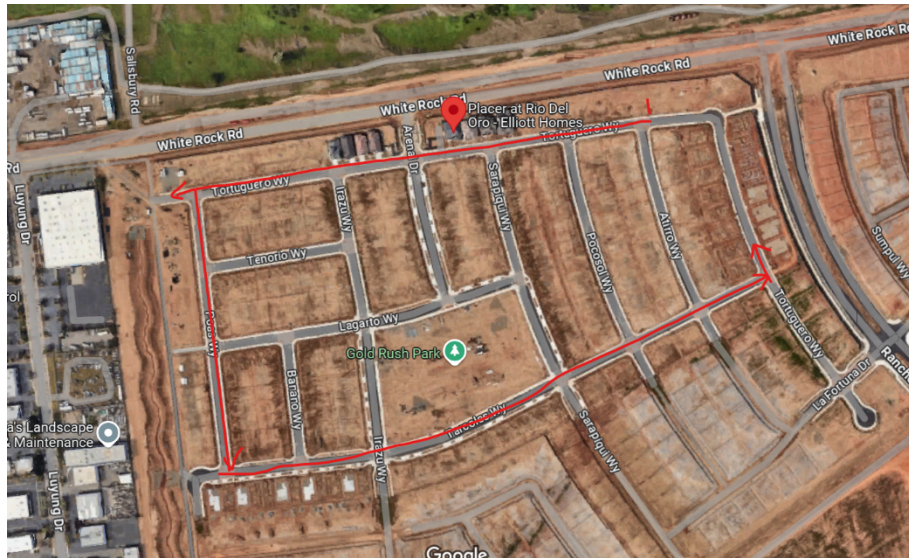


Figure 3.4: Satellite view of the Rancho Cordova test site, with red lines indicating the test locations (map data from Google Maps, ©Google)



Figure 3.5: Satellite view of the Westley test site, with red arrows indicating the ends of testing (map data from Google Maps, ©Google)



Figure 3.6: Satellite view of the Port of Oakland test site, with red lines indicating tested lanes (map data from Google Maps, ©Google)

3.2 Site Conditions

3.2.1 Capay Site

The Capay site is a small rural community located near a state highway. The tested apparent ICP was placed only on the shoulders of the state highway. The pavement surface, however, is not made of pavers but of asphalt pavement that has been stamped and dyed to resemble pavers (Figure 3.7). This explains the regular transverse cracks (e.g., Figure 3.8), which are characteristic of asphalt pavements, and occasional longitudinal cracks (e.g., Figure 3.9), which are also not a distress in ICP. Most of the transverse cracks run through the entire width of the pavement, including the mainline. No rutting was observed in the shoulder. This section was removed from further analysis and consideration in this study, as it is not an ICP.



Figure 3.7: Close-up picture of the shoulder showing stamped asphalt in the shape of pavers.

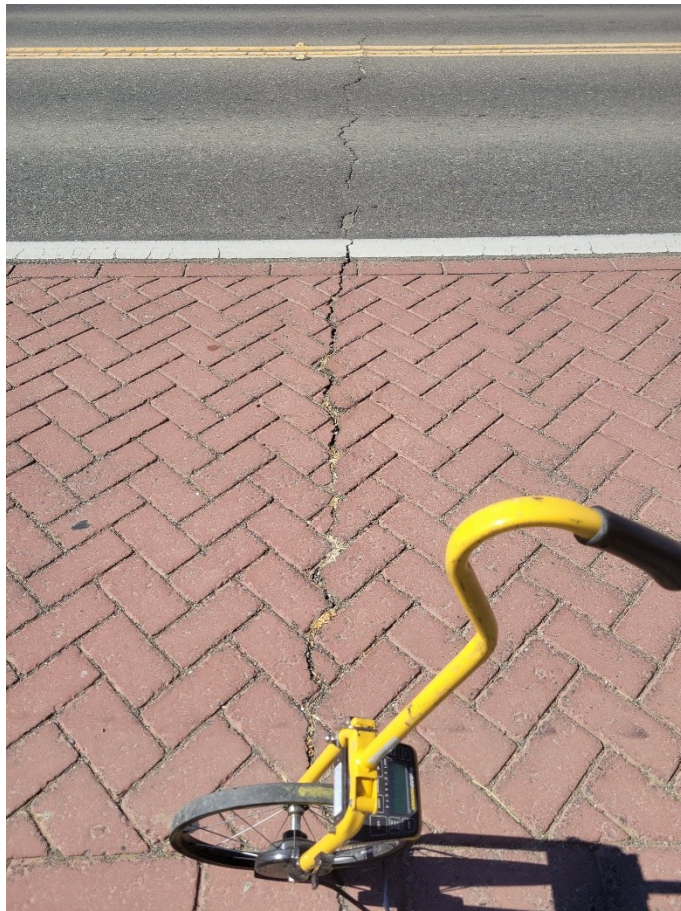


Figure 3.8: A transverse crack across both the hot mix asphalt (HMA) mainline and the ICP-looking shoulder at the Capay site. (The asphalt shoulder was stamped into paver shape.)



Figure 3.9: A longitudinal crack in the ICP-looking shoulder at the Capay site. (The asphalt shoulder was stamped into paver shape.)

3.2.2 Colma Site

The ICP pavements are overall in good condition at the Colma site, especially considering the age. There are a few areas with some rutting (see Figure 3.10). The cumulative distribution of measured rut at the Colma site is shown in Figure 3.11.

The figure shows cumulative probability plots of measured rutting (in millimeters) for five streets in Colma: B Street, C Street, D Street, F Street Eastbound, and F Street Westbound. The x-axis represents the rut depth, while the y-axis represents the percentage of observations at or below that rut depth.

F Street, both Eastbound and Westbound, exhibits the steepest curves, with most measurements below approximately 10 mm.

B Street also shows relatively low rut depths, with nearly all values below 15 mm.

C Street and D Street extend further along the x-axis, with rut depths exceeding 30–40 mm before reaching 100% probability, indicating more severe rutting compared to the other locations.



Figure 3.10: An area with some rut on the eastbound direction of the F Street at the Colma site.

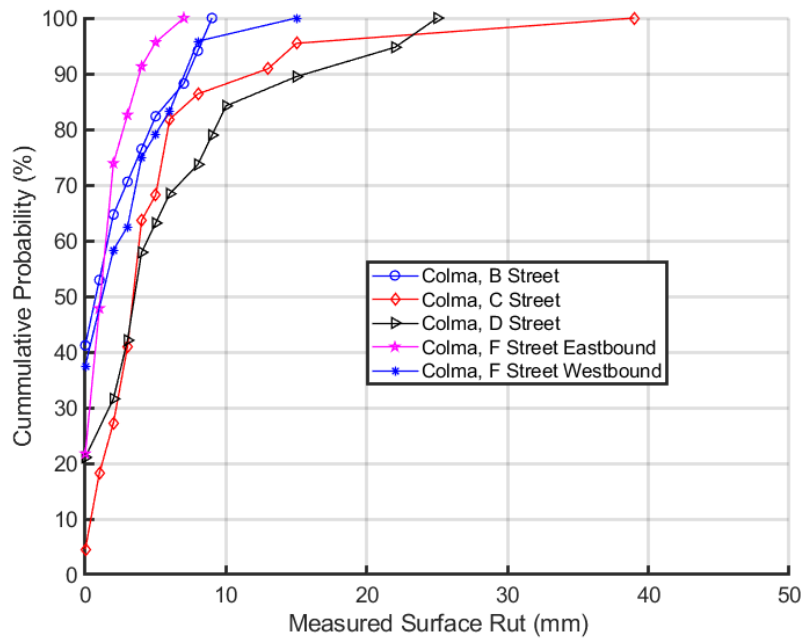


Figure 3.11: Cumulative distribution of measured rut at the Colma site.

F Street is a collector, while all other streets are residential with light traffic and a cul-de-sac at one or both ends. The higher traffic on F Street, however, did not result in more rutting than on the other streets.

The rutting performance of the streets can be divided into two groups: Streets B and F with less rut, and Streets C and D with more rut. The grouped cumulative distribution of rut at the Colma site is shown in Figure 3.12.

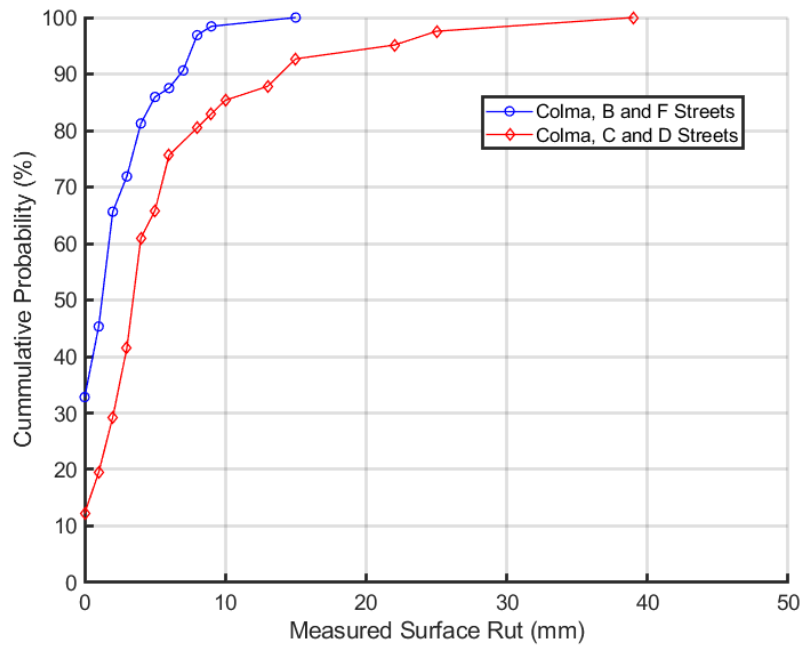


Figure 3.12: Grouped cumulative distribution of measured rut at the Colma site.

There was some paver replacement in D Street, which, according to the city staff, was due to utility damage and not from vehicular traffic loading. Localized large rut was also observed around manholes.

3.2.3 El Dorado Hills Site

The ICP is situated in a new gated community, with some houses still under construction. The pavements are generally in excellent condition (see Figure 3.13). There are some corner chips and a loss of jointing sand. No visible rut is observed. The cumulative distribution of measured rut at the El Dorado Hills site is shown in Figure 3.14.



Figure 3.13: ICP at the El Dorado Hills site.

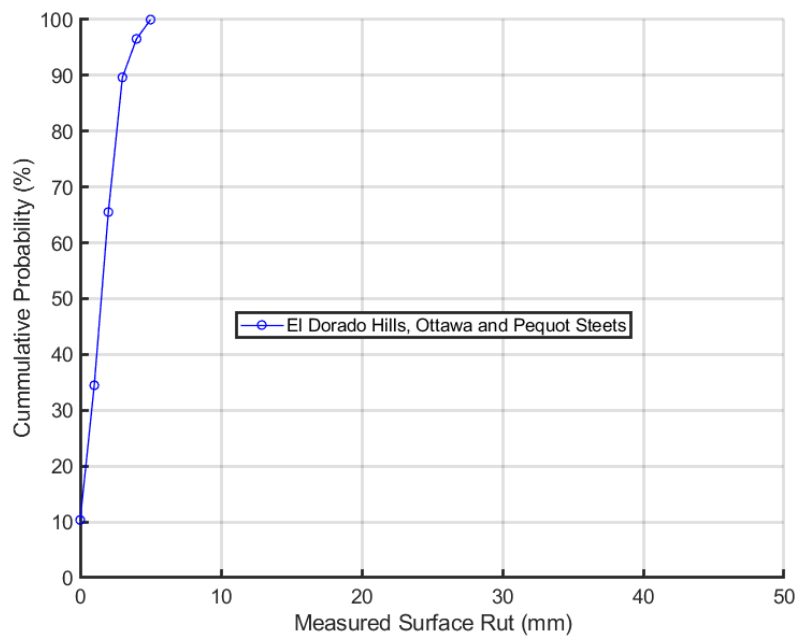


Figure 3.14: Cumulative distribution of measured rut at the El Dorado Hills site.

3.2.4 Rancho Cordova Site

The tested ICP section is located in the new housing project, which is currently under active construction. Only the intersections are placed with ICP (see Figure 3.15). There are limited areas with higher (up to 10 mm) ruts even though there should have been a limited amount of vehicular traffic on these pavements (see Figure 3.16). The cumulative distribution of measured rut at the Rancho Cordova test site is shown in Figure 3.17. These ruts may be related to the difficulty in achieving optimal construction due to the presence of multiple manholes at each intersection.



Figure 3.15: FWD testing on the ICP section at an intersection in Rancho Cordova.



Figure 3.16: A section with more than 10 mm (barely noticeable) rut at the Rancho Cordova site.

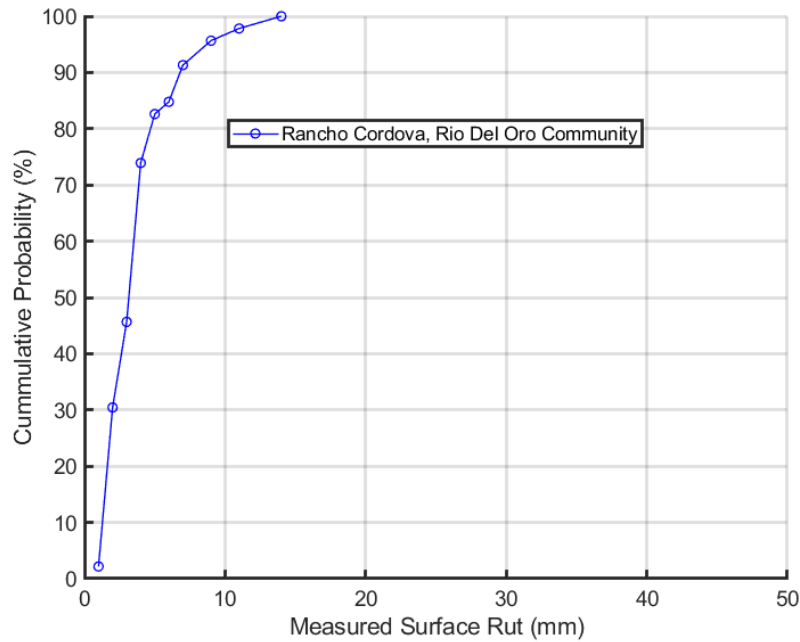


Figure 3.17: Cumulative distribution of measured rut at the Rancho Cordova site.

3.2.5 Westley Site

The pavements are overall in fair condition, with a few specific areas with significant material loss and missing pavers (see Figure 3.18). About 10% of the area has lost the top 10-15 mm (1/2 inch) of the paver. These areas are located at the north end of the entrance or exit to the gas station. The amount of rut is, in general, not severe, as shown in Figure 3.19. The figure also suggests that there is a much more notable rut in the northbound direction than in the southbound direction, likely due to differences in traffic in the two directions.



Figure 3.18: An area with extensive rutting and paver damage in the ICP at the Westley site.

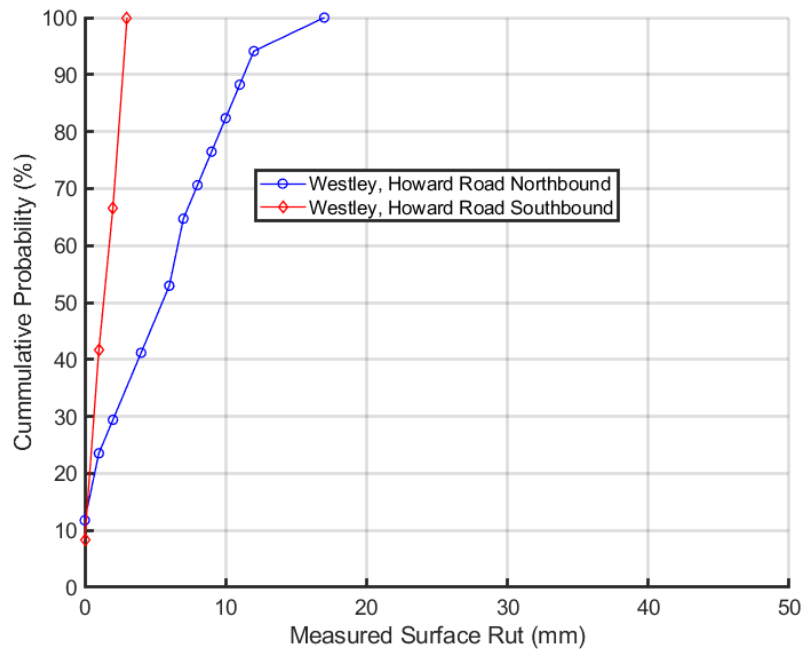


Figure 3.19: Cumulative distribution of measured rut at the Westley site.

3.2.6 Port of Oakland Site

Two different sections at Port of Oakland were tested (see Figure 3.6): Berth 55-56 and Berth 30-32. ICP covers the whole loading/unloading yards at these two sections. Both sections utilize rubber-tired gantries (RTG) to handle shipping containers. The deflection testing and condition survey were conducted along both the gantry lane and the truck lane (see Figure 3.20). The FWD testing was conducted along the wheelpaths.

The truck lanes are in good condition, with minimal rutting, while the gantry lanes have extensive areas with a significant amount of rutting. An example of a large rut is shown in Figure 3.21. The cumulative distribution of measured rut for different berths and lanes tested at the Port of Oakland is shown in Figure 3.22. As expected, the gantry lanes have more severe rut than the truck lanes.

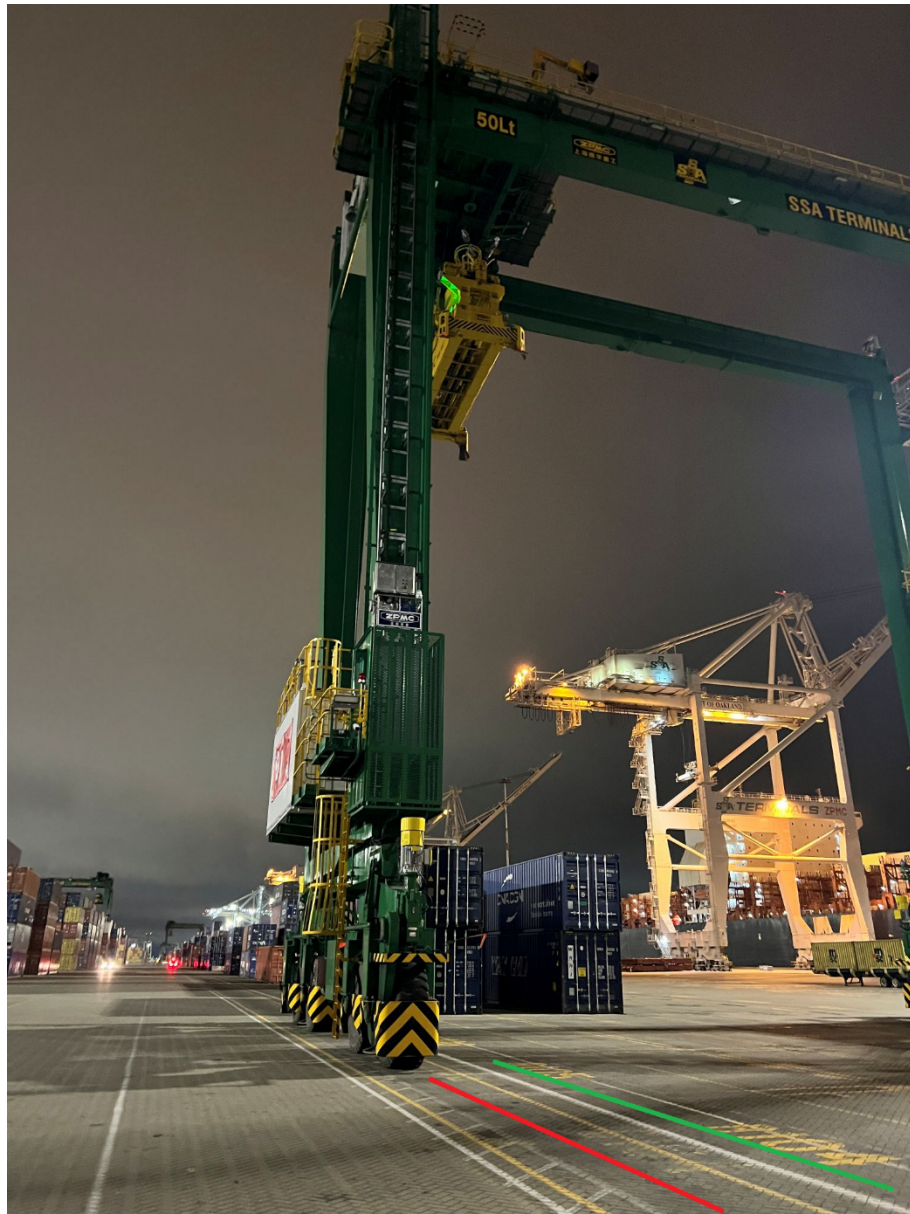


Figure 3.20: Port of Oakland near Berth 55 with wheelpath indicated (green for truck, red for gantry).



Figure 3.21: Example of a deep rut and damaged blocks in the gantry lane at the Port of Oakland near Berth 55.

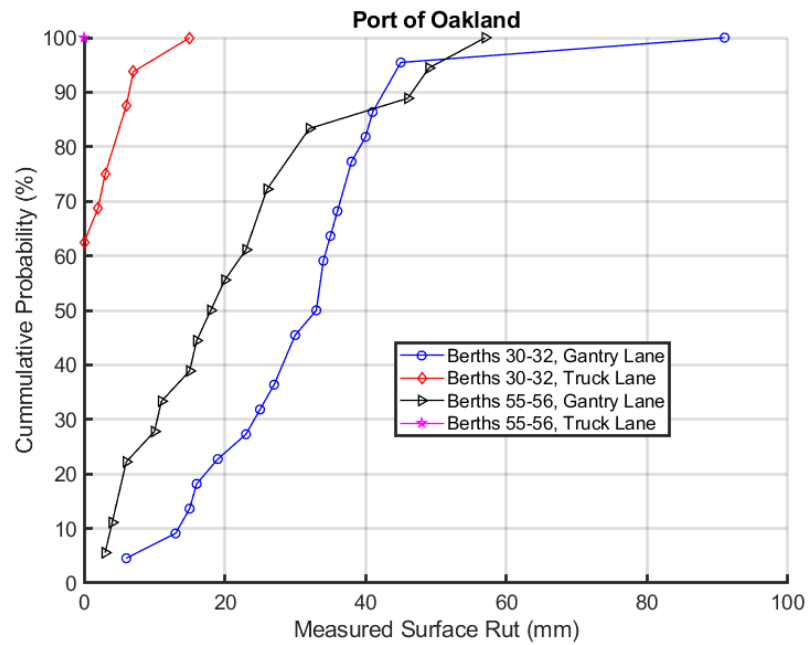


Figure 3.22: Cumulative distribution of measured rut at the Port of Oakland.

3.2.7 Summary of Site Conditions from Field Surveys

Some of the key observations related to measured rut for different testing sites and lines are shown in Table 3.2. The median ruts for all sites are less than 10 mm, except for the two gantry lanes in the Port of Oakland, indicating that, in general, all local streets tested are in good condition, while the Port of Oakland has severe ruts. The following are general trends observed:

- The streets tested have some failure with a 12.5 mm threshold, and almost no failure with a 25 mm threshold.
- The Port of Oakland has extensive failure along gantry lanes and no failure along truck lanes, regardless of the failure threshold.

Based on site observations, the failures at C and D Streets in Colma are likely caused by utility damage (which likely was not captured in the deflection testing), while failures at other sites are likely caused by vehicular traffic. The utility damage could occur both because of insufficient re-compaction during repair and intermittent increase in moisture content in the base and subgrade layer, both of which can lead to increased rutting.

Table 3.2: Statistics of Measured Rut at Different Sites and Lines

Site	Streets or Line	Median Rut, mm (inch)	Percent Length with Rut > 12.5 mm (1/2 inch) (%)	Percent Length with Rut > 25 mm (1 inch) (%)
Colma	B and F Streets	1.2 (0.047)	0.7	0
Colma	C and D Streets	3.4 (0.134)	13	2.4
El Dorado Hills	Ottawa and Pequot Steets	1.5 (0.059)	0	0
Rancho Cordova	Rio Del Oro Community	3.2 (0.126)	1.1	0
Westley	Howard Road Northbound	5.5 (0.217)	5.3	0
Westley	Howard Road Southbound	1.3 (0.051)	0	0
Berths 30-32, Port of Oakland	Truck Lane	0 (0.000)	0	0
Berths 30-32, Port of Oakland	Gantry Lane	33 (1.299)	91	68
Berths 55-56, Port of Oakland	Truck Lane	0 (0.000)	0	0
Berths 55-56, Port of Oakland	Gantry Lane	18 (0.709)	65	31

3.3 Deflection Testing Results and Analysis

The deflection testing was conducted using an FWD with three drop heights, targeting approximately 35, 45, and 55 kN (8, 10, and 12 kips) of load, respectively. Two drops were done at each drop height, resulting in a total of six drops at each testing point. The testing spacing was selected so that each testing session consisted of 20 to 25 points. The actual spacing used ranged between 20 m and 50 m.

3.3.1 List of Deflection Test Sites

A list of the deflection testing at different sites is shown in Table 3.3. Testing on local streets was conducted between wheelpaths rather than along the wheelpath, because the streets are narrow and the wheelpaths are not well defined.

Although deflection testing was also conducted at the Capay site, results were not included in this report because the section was actually a stamped asphalt pavement and not ICP.

Table 3.3: List of Deflection Testing Using FWD at Different Sites

Site	Streets and Line	Lateral Position	Testing Direction
Colma	B, C, D, F Streets	BWP	Eastbound on B and D Streets, westbound on C Street, and both directions on F Street
El Dorado Hills	Ottawa and Pequot Steets	BWP	Northbound on Ottawa Street and Westbound on Pequot Street
Rancho Cordova	Rio Del Oro Community	BWP	Westbound
Westley	Howard Road	RWP and BWP	Both directions
Berths 30-32, Port of Oakland	Gantry and truck lanes	RWP	Westbound
Berths 55-56, Port of Oakland	Gantry and truck lanes	RWP	Eastbound

Notes: BWP = between wheelpaths, RWP = right wheelpath

3.3.2 Measured Deflections and Observations

The boxplots for deflection normalized to 40 kN (9 kips) measured at the center of the loading plate (D1) and at 1.2 m (4.0 ft) away from the center of the loading plate (D7) are shown in Figure 3.23 and Figure 3.24, respectively. In general, D1 reflects the overall stiffness while D7 indicates subgrade stiffness. Note that lower deflections indicate stiffer structures. The normalization was performed by assuming that deflections are proportional to the applied load.

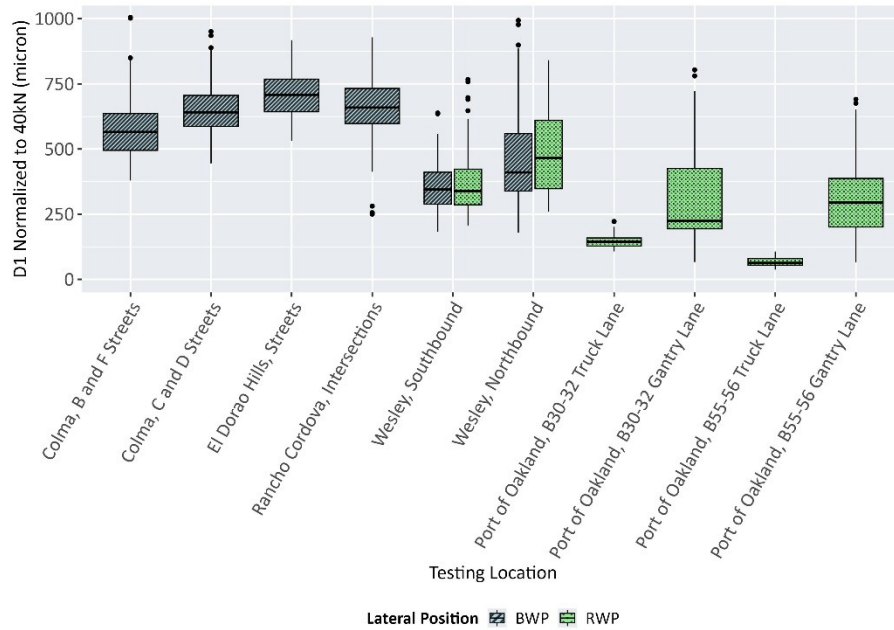


Figure 3.23: Normalized surface deflections measured at the center of the load.

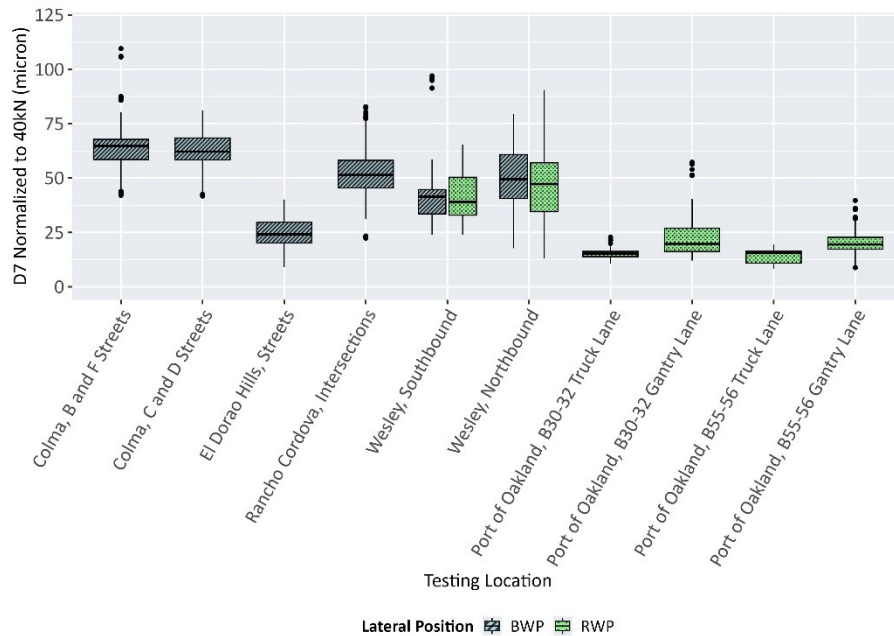


Figure 3.24: Normalized surface deflections measured at 1.2 m from the center of the load.

Figure 3.23 shows that the normalized surface deflections measured at the center of the load are highest for residential streets and lowest for the Port of Oakland. This indicates that overall stiffness of the ICPs is the lowest for residential streets and the highest for the Port of Oakland. This is consistent with the expected design traffic, as the Port of Oakland was designed to support much heavier and more frequent loads than residential streets.

Figure 3.24 show significant differences in normalized surface deflections measured at 1.2 m from the center of the load (i.e., D7). This suggests that there are significant differences in subgrade stiffness among the tested sites. The Port of Oakland has the stiffest subgrade due to the use of engineered fill. For other sites, the subgrade stiffness likely reflects the quality of the native soil. The use of geogrid at the Westley site does not seem to improve the subgrade stiffness.

The data measured at the Westley site indicate that the deflections are higher in the northbound direction than in the southbound direction, likely due to more severe damage in the northbound direction resulting from higher traffic volumes in that direction.

The effect of traffic damage can also be clearly seen in the deflection results for the Port of Oakland, which has significantly higher traffic in the gantry lanes compared to the truck lanes. Compared to the truck lanes, the corresponding gantry lanes have significantly higher D1 but only slightly higher D7. This suggests that the damage caused by traffic is not in the subgrade layer, which is expected.

The idea that traffic damage is limited to the layers above the subgrade is corroborated by the deflection data for the Westley site in the northbound direction. The D7 values for BWP in the northbound direction are comparable to those for RWP, but the D1 values for BWP are lower than those for RWP. This suggests the overall stiffness is higher along BWP than along RWP, while the subgrade stiffness is similar between the two lines.

3.3.3 Layer Stiffness Backcalculation and Results

A *MATLAB* script developed at the UCPRC was used to conduct layer stiffness backcalculation. Odemark's equivalent thickness method (21) was selected for estimating surface displacements. Data from all 8 sensors were used, with the outermost one placed 1.5 m (5 ft) away from the center of the loading plate. The structures were simplified into three layers: the combined paver and bedding sand layers, the combined layers between bedding sand and subgrade, and the subgrade.

The boxplots of backcalculated layer stiffnesses are shown in Figure 3.25 to Figure 3.27 for each of the three layers, respectively. The average and variability of backcalculated layer stiffnesses for different sites are listed in Table 3.4. Note that the variability, indicated by the standard deviation factor, was calculated after removing the outliers.

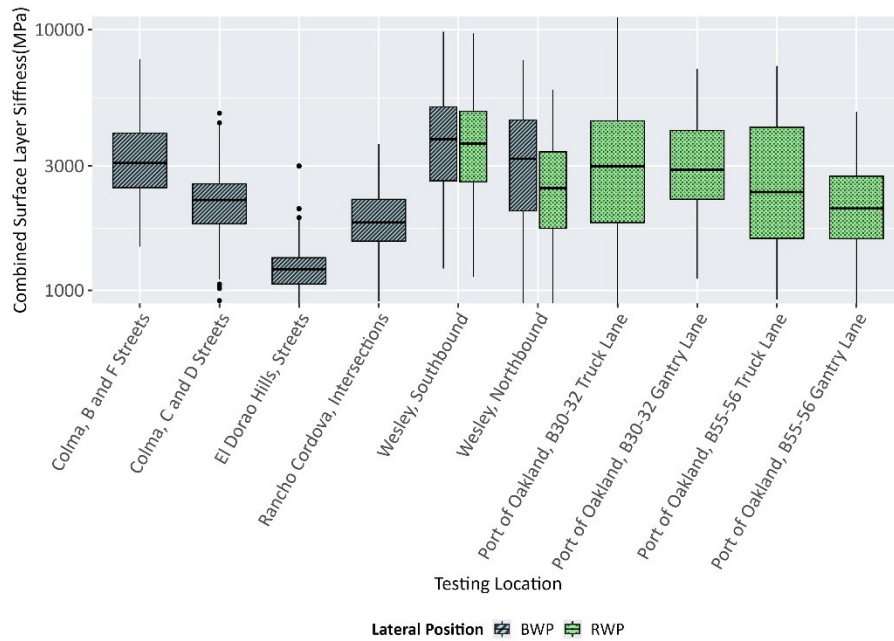


Figure 3.25: Backcalculated combined surface layer (paver and bedding sand) stiffness.

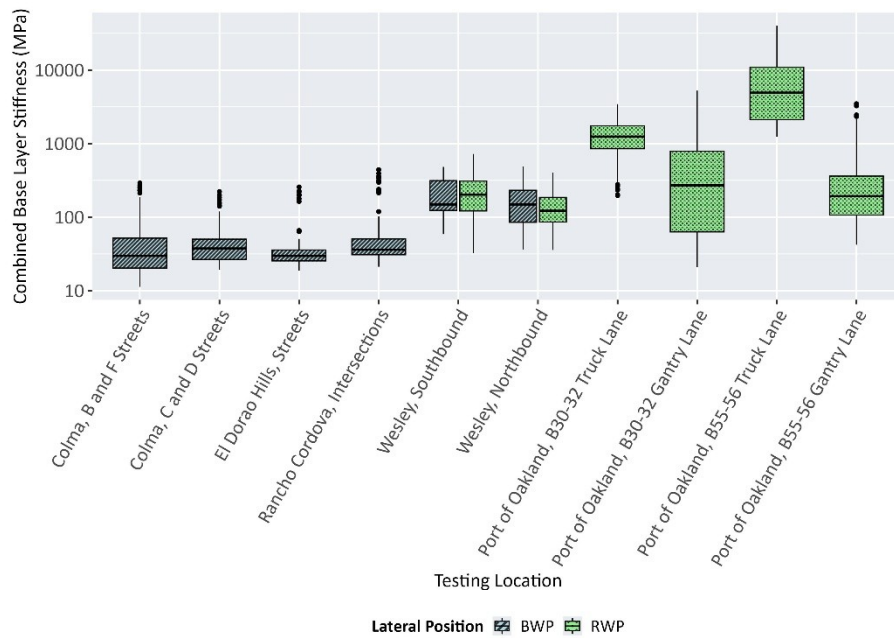


Figure 3.26: Backcalculated combined base layer stiffness.

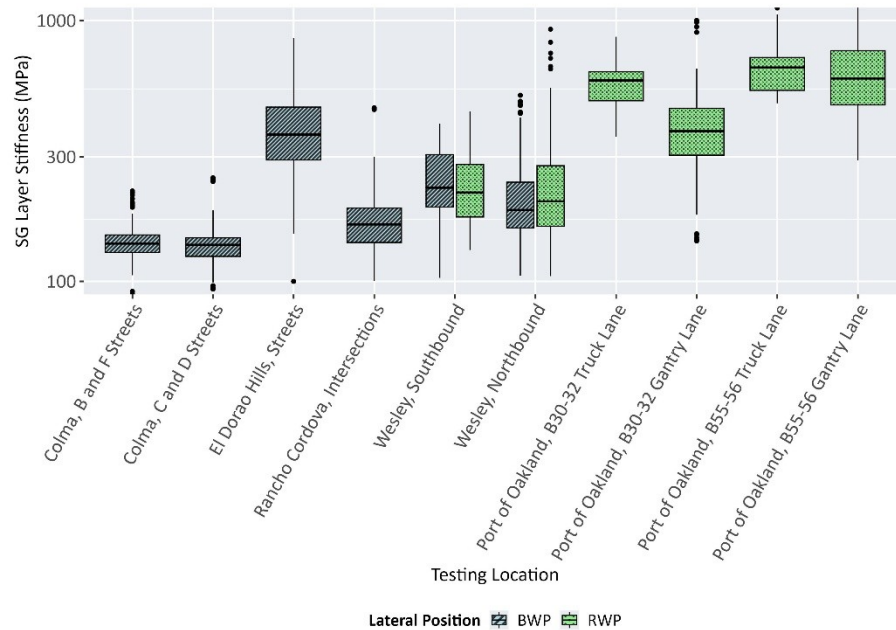


Figure 3.27: Backcalculated subgrade layer stiffness.

Table 3.4: Summary of Backcalculated Layer Stiffnesses and Their Variabilities

Site	Street and Lane	Lateral Position in the Lane	Combined Paver and Bedding Sand Layers*	Combined Base Layers*	SG Layer*
Colma	B and F Streets	BWP	3,387 (1.11)	40 (1.52)	140 (1.05)
Colma	C and D Streets	BWP	2,243 (1.08)	40 (1.28)	136 (1.06)
El Dorado Hills	Streets	BWP	1,216 (1.06)	31 (1.18)	391 (1.14)
Rancho Cordova	Intersections	BWP	1,954 (1.09)	41 (1.23)	170 (1.11)
Westley	Southbound	BWP	4,099 (1.14)	209 (1.28)	245 (1.14)
Westley	Southbound	RWP	3,788 (1.13)	237 (1.35)	235 (1.14)
Westley	Northbound	BWP	3,418 (1.16)	172 (1.40)	199 (1.15)
Westley	Northbound	RWP	2,660 (1.14)	142 (1.33)	222 (1.19)
Port of Oakland	B30-32 Truck Lane	RWP	3,620 (1.21)	1,397 (1.18)	574 (1.07)
Port of Oakland	B30-32 Gantry Lane	RWP	3,227 (1.13)	617 (1.91)	380 (1.13)
Port of Oakland	B55-56 Truck Lane	RWP	2,812 (1.18)	7,858 (1.29)	661 (1.07)
Port of Oakland	B55-56 Gantry Lane	RWP	2,282 (1.13)	320 (1.49)	598 (1.13)

*Numbers shown are average stiffness in MPa, followed by standard deviation factor, defined as $SDF(x) = 10^{c.o.v.(\log_{10}(x))}$, in parentheses.

The figures and table indicate that the stiffness for the combined paver and bedding sand layer ranges from 1,000 to 4,000 MPa (145 to 580 ksi). The stiffnesses for the base and subgrade layers, however, exhibit significant variations between different testing sites, reflecting the differences in base type and subgrade quality. The following are some other key observations regarding the backcalculated layer stiffnesses:

- The stiffness of the combined paver and bedding sand layer mostly falls between 1,000 MPa and 4,000 MPa (145 and 580 ksi). It is unclear why the stiffness reached as low as 1,200 MPa (174 ksi) at the El Dorado Hills test site. These values are consistent with values found in literature, for example, 500 to 7,000 MPa (72.5 to 1,015 ksi) from Shackel (20), 813 to 3,858 MPa (118 to 560 ksi) from Rada (1), and 410 to 4,330 MPa (59.4 to 628 ksi) from Abate (11).
- Regarding the base layer stiffness
 - The base layer stiffnesses are consistently between 30 and 40 MPa (4.4 to 5.8 ksi) for the residential test sites (Colma, El Dorado Hills, and Rancho Cordova), and around 140 to 240 MPa (20.3 to 34.8 ksi) for the industrial site at Westley. It is not clear whether this difference can be attributed to the thicker base at Westley (350 mm vs. 100 to 200 mm, 14 in. vs. 4 to 8 in.) or the use of geogrid at the Westley site.
 - The use of thick AC can significantly increase the intact base stiffness, reaching up to 7,800 MPa (1,131 ksi), as shown in the truck lane at Berth 55-56 of the Port of Oakland.
- Regarding the overall variability of backcalculated stiffness
 - The combined paver and bedding sand layer, as well as the subgrade layer, shows an SDF between 1.05 and 1.21, indicating consistency within each test site.
 - The base layer stiffness shows SDF mostly between 1.18 and 1.52, indicating larger but still reasonable variability.
 - The high SDF value of 1.91 for the base layer along the gantry lane at Berth 30-32 of Port of Oakland is likely due to nonuniform traffic-related damage in the layer
- Regarding the effects of traffic damage
 - At the Westley site, traffic-related damage can be identified by comparing the stiffness between results for BWP (not trafficked) and RWP (trafficked) in the northbound direction. The results suggest that traffic-related damage occurred both in the combined paver and bedding sand layer and the base layer.
 - At the Port of Oakland site, traffic-related damage can be identified by comparing the stiffness between results for the truck lane (not trafficked) and the gantry lane (trafficked). The results suggest that traffic-related damage primarily occurred in the combined paver and bedding sand layer, the base layer, and the subgrade layer. The damage in the subgrade layer is likely due to loss of cementation in the engineered fill.

3.4 Summary of Field Testing

The field condition survey and deflection testing were conducted on several ICP sections in residential, industrial, and port installations. The bases in these ICPs include aggregate base,

aggregate base with thin asphalt concrete on top, aggregate base with medium-thick asphalt concrete at the top, or thick asphalt concrete.

The condition survey confirmed that permanent deformation is the main failure mechanism for ICP.

The deflection testing and associated analysis provided typical values for the stiffness of different layers in ICPs. The analysis revealed that the combined stiffness of the paver and bedding sand layers is relatively consistent within each site but may differ significantly between different sites. Traffic-induced damage was the most severe in the base layer, but it also occurred in the combined paver and bedding sand layer. The engineered fill in the Port of Oakland also showed traffic-related damage.

4 CalME VALIDATION BASED ON THE TESTED SITES RESULTS

CalME, originally developed as design analysis tool for flexible pavements, was used in this project. It is a web application that analyzes pavement structural sections using a mechanistic-empirical (ME) methodology (22,23), and serves as the official structural analysis program used by the California Department of Transportation (Caltrans) for flexible pavements.

Before *CalME* could be used to develop a design catalog for ICP, the embedded models within had to be validated using data from the test sites. This validation was necessary to demonstrate that the models can provide reasonable predictions of rutting that are consistent with actual field observations. Only rutting was considered in this study, as it is the primary failure mechanism for ICP, based on the literature review and field evaluation in this project.

4.1 Model Inputs

Inputs to *CalME* include structure, layer moduli, traffic, and climate. These are all relevant to the model validation except climate. This is because the in-situ stiffness required for model validation was determined directly through backcalculation for each test site. Additionally, all materials are assumed to be linear elastic and not affected by pavement temperature.

4.1.1 Structure

Structure inputs for *CalME* include layer thickness, stiffness, and their variability. The thicknesses were derived from as-built information (Table 3.1). The stiffness and variability were derived from backcalculation results (Table 3.4).

For the Port of Oakland, the base layer includes an AC layer. The backcalculation results showed a significant loss of stiffness of the base layer for the gantry lane compared to the truck lane. The gantry lane also showed a significant rut, while the truck lane showed no observable rut. These observations suggest that the truck lane stiffnesses represent the initial condition, while the gantry lane stiffnesses represent the damaged stage caused by the port traffic.

4.1.2 Traffic Inputs

4.1.2.1 Local Streets

Traffic inputs for the M-E design include load spectrum and truck volume. However, no site-specific traffic data for the tested local streets or the port was available from the relevant agencies. As a result, traffic inputs were estimated based on street types and neighborhood characteristics, following the American Concrete Institute's (ACI) *Guide for Design of Jointed Concrete Pavements for Streets and Local Roads* (24). For the Port of Oakland, traffic input was estimated based on typical port operations and published throughput of the port.

A pavement structure is typically designed to last a specific number of years, referred to as its design life, e.g., 20 years. During this time, the pavement must withstand a predictable number of axle loads while remaining serviceable. Designers need to know the daily volume of various types of vehicles (light trucks, heavy trucks, service vehicles, buses, etc.) and their axle loads over the design life.

The concept of equivalent single-axle loads (ESALs) is used in the AASHTO 1993 pavement design procedure, which converts a mix of axle loads into one standard axle (an 80 kN or 18 kip single axle).

However, ESALs have several limitations and may not accurately quantify the damage caused by actual axle loads. In M-E design, an axle-load spectrum is commonly used with the number of axles over the anticipated pavement life.

ACI PRC-325.12-02: *Guide for Design of Jointed Concrete Pavements for Streets and Local Roads* (24) has recommendations for average daily traffic and typical axle loads for street applications. The suggested traffic volumes for various classes of streets and their maximum axle loads are shown in Table 4.1 (a) and (b), respectively.

ACI PRC-330-21: *Commercial Concrete Parking Lots and Site Paving Design and Construction* (25) has recommendations for traffic categories A through D for parking lot design. Categories B and C, developed by the Portland Cement Association, are composites of data averaged from several loadometer tables representing appropriate pavement facilities. Category A is the same as Category B, except that the heaviest axle loads have been eliminated. Category D consists only of tractor-semitrailer trucks with gross weights of 80 kips (360 kN). The suggested axle-load spectra for each category are shown in Table 4.2, with an assumed design life of 20 years and an overall reliability of 95%.

Table 4.1: (a) Street Classification and Traffic Volume, and (b) Maximum Axle-Load Levels for Various Classes According to ACI Committee 325.

(a)

Street Classification	VPD or AADT ¹ (two-way)	Heavy Commercial Vehicles (two-axle, six-tire, and heavier)	
		%	No. per day
Light residential	200	1 to 2	2 to 4
Residential	200 to 1,000	1 to 2	2 to 4
Collector	1,000 to 8,000	3 to 5	50 to 500
Minor arterial	4,000 to 15,000	10	300 to 600
Major arterial	4,000 to 30,000	15 to 20	700 to 1,500
Business	11,000 to 17,000	4 to 7	400 to 700
Industrial	2,000 to 4,000	15 to 20	300 to 800

¹VPD = vehicle per day, AADT = average annual daily traffic

(b)

Street Class	Axle Loads
Light residential	Trucks using these streets will generally have a maximum tandem-axle load of 150 kN (34 kips) and an 80 kN (18 kips) maximum single-axle load. Garbage trucks and buses most frequently constitute the overloads on these types of streets.
Residential	Maximum loads for these streets are 98 kN (22 kips) single axles and 150 kN (34 kips) tandem axles
Collector	A maximum single-axle load of 115 kN (26 kips) and a 200 kN (44 kips) maximum tandem-axle load
Arterial	Maximum loads for minor arterials are 115 kN (26 kips) single axles and 200 kN (44 kips) tandem axles. Major arterials have maximum loads of 130 kN (30 kips) single axles and 230 kN (52 kips) tandem axles
Business	Maximum loads are similar to collector streets.
Industrial	133 kN (30 kips) single axles and 230 kN (52 kips) tandem axles

Source: ACI Committee 325 (2002) (24).

Table 4.2: Axle-Load Spectra for Four Traffic Categories from ACI Committee 330

Axle Load in kN (Kips)	Axles per 1,000 Trucks*			
	Category A	Category B	Category C	Category D
Single Axles				
18 (4)	1693.31	1693.31	-	-
27 (6)	732.28	732.28	-	-
36 (8)	483.10	483.10	233.60	-
44 (10)	204.96	204.96	142.70	-
53 (12)	124.00	124.00	116.76	-
62 (14)	56.11	56.11	47.76	-
71 (16)	38.02	38.02	23.88	1000
80 (18)	-	15.81	16.61	-
89 (20)	-	4.23	6.63	-
98 (22)	-	0.96	2.60	-
107 (24)	-	-	1.60	-
116 (26)	-	-	0.07	-
125 (28)	-	-	-	-
133 (30)	-	-	-	-
142 (32)	-	-	-	-
151 (34)	-	-	-	-
Tandem Axles				
18 (4)	31.90	31.90	-	-
36 (8)	85.59	85.59	47.01	-
53 (12)	139.30	139.30	91.15	-
71 (16)	75.02	75.02	59.25	-
89 (20)	57.10	57.10	45.00	-
107 (24)	39.18	39.18	30.74	-
125 (28)	68.48	68.48	44.43	-
142 (32)	69.59	69.59	54.76	2000
160 (36)	-	4.19	38.79	-
178 (40)	-	-	7.76	-
196 (44)	-	-	1.16	-
214 (48)	-	-	-	-
231 (52)	-	-	-	-
249 (56)	-	-	-	-
267 (60)	-	-	-	-

*Excluding all two-axle, four-tire trucks.

Source: ACI Committee 330 (2012) (25).

4.1.2.2 Port of Oakland Traffic

The estimate of traffic load spectrum and volume for the Port of Oakland is based on publicly available information. For a typical RTG at the Port of Oakland:

- Load spectrum: The empty weight is 22.6 kN (5.1 kips) for 20-ft containers and 36.8 kN (8.3 kips) for 40-ft containers. The maximum gross weight is 235 kN (52.9 kips) for 20-ft containers and 299 kN (67.2 kips) for 40-ft containers². An RTG can lift either two 20-ft containers or one 40-ft container. Each lift can weigh between 22.6 kN (5.1 kips, one empty 20-ft container) and 471 kN (105.8 kips), the maximum weight of two 20-ft containers. Assume the lift weight at the port follows a normal distribution with an average lift weight of 196 kN (44.1 kips) and a standard deviation of 98 kN (22.0 kips).
- Volume: 154,000 20-ft. equivalent units (TEUs)/year per crane, based on the assumption that 2.0 million of the port's 2.3 million TEU³ throughput and 13 RTG cranes⁴.
- At the Port of Oakland, assuming 60–70% of containers are 40 ft (2 TEUs)⁵, and approximately 30–40% are 20 ft (1 TEU), based on typical U.S. port patterns. This means that each lift includes approximately 1.6 TEUs ($2.0 \times 60\% + 1.0 \times 40\%$).

The RTG used at Berth 55 has eight tires in single configurations with four on each side. The four tires on each side are grouped into two tandem axles.

A simple load spectrum for the RTG was developed by assuming a normal distribution for lift load with a mean of 20 tons and a standard deviation of 10 tons. The annual volume per RTG crane is estimated to be $154,000/1.6 = 96,250$ lifts, which is 264 lifts per day when spread equally over every day of the year. The lifts were also assumed to be evenly spread over each hour of the two shifts of operations, i.e., 7:00 AM to 16:30 PM and 8:00 PM to 2:00 AM.

A simple load spectrum for the trucks was developed by spreading the RTG throughput across the trucks. Typically, the RTG places the lifted container(s) onto a skeleton chassis similar to the one shown in Figure 4.1. This configuration has two dual tandem axles rather than two single tandem axles. The use of dual wheels helps spread the load and reduces damage to the ICP.

² <https://www.freightos.com/freight-resources/20ft-40ft-container/>

³ <https://www.oaklandseaport.com/business/facts-figures>

⁴ <https://www.hellenicshippingnews.com/ssa-marine-brings-in-the-west-coasts-largest-cranes-to-its-oict-terminal-in-the-port-of-oakland/>

⁵ <https://porteconomicsmanagement.org/pemp/contents/part1/maritime-shipping-and-international-trade/value-containerized-trade/>



Source: STU Supply Chain website:
<https://stusupplychain.com/container-chassis-in-logistics.html>

Figure 4.1: A truck with skeleton chassis receiving two 20 ft. containers at a port.

4.1.2.3 Summary of Traffic Inputs

The estimated traffic load spectrum and volume for different test sites are listed in Table 4.3. For streets (i.e., all test sites except the Port of Oakland), the load spectrum refers to the category defined in the *Guide for Design of Jointed Concrete Pavements for Streets and Local Roads* (24), and the average annual daily truck traffic (AADTT) ranges are based on the same source. For the Port of Oakland, the spectra were developed as explained in Section 4.1.2.2.

Table 4.3: Estimated Axle-Load Spectrum and Traffic Volume for Different Test Sites

Site	Streets or Line	Neighborhood Characteristics	Load Spectrum	Construction Year	AADTT
Colma	D Street	Cul-de-Sac	Light residential	1997-1998	2 to 4 ^c
Colma	B and C Streets	Residential	Residential	1997-1998	2 to 4 ^c
Colma	F Street	Residential	Collector	1997-1998	50 to 500 ^c
El Dorado Hills	Ottawa and Pequot Steets	Almost completed gated community	Light residential ^a	Around 2020	2 to 4 ^c
Rancho Cordova	Rio Del Oro Community	Still under construction	Light residential ^a	Around 2023	2 to 4 ^c
Westley	Howard Road	Highway truck stop	Collector	2014	50 to 500 ^c
Berths 30-32, Port of Oakland	Truck Lane	Truck loading and unloading	Port Truck	1993	264 lifts
Berths 30-32, Port of Oakland	Gantry Lane	Gantry loading and unloading	Port RTG ^b	1993	264 lifts
Berths 55-56, Port of Oakland	Truck Lane	Truck loading and unloading	Port Truck	2002	264 lifts
Berths 55-56, Port of Oakland	Gantry Lane	Gantry loading and unloading	Port RTG ^b	2002	264 lifts

^aInitial construction traffic may be heavier than normal use

^bRTG = rubber-tired gantry

^cThe average annual daily truck traffic (AADTT) values are for both directions.

4.2 Other Assumptions

Given the uncertainties in the traffic estimate (see the AADTT ranges in Table 4.3), the goal is not to exactly match the predicted and observed rutting performance, but rather to verify whether the observed performance is feasible with the given structure and estimated traffic.

A new type of material was created in *CalME* to simulate the combined layer of paver and bedding sand. The combined layer was modeled as not susceptible to fatigue damage or permanent deformation, and its stiffness remains constant regardless of pavement temperature and loading rate.

Monte Carlo simulations were used in *CalME* to account for the variability in backcalculated stiffness. Since the backcalculated stiffnesses and variabilities specific to each test site were used, the between-project variabilities were not included.

4.3 Results

The *CalME* validation results are summarized in Table 4.4, which includes the traffic volume used and observed vs. predicted probability of failure, defined as 12.5 mm (0.5 inch) of rut. The traffic index (TI) shown in the table is used in California as an overall indicator of traffic volume. It is directly correlated with ESALs using Equation 1:

$$TI = 9 \times \left(\frac{ESALs}{10^6} \right)^{0.119} \text{ Eq. 1}$$

The probability of failure for the field sections was determined using the cumulative probability curves of rut shown in Section 1.1. Specifically, the failure probability is the cumulative probability corresponding to the given failure threshold, i.e., 12.5 mm (0.5 inch).

As shown in Table 4.4, the predicted rutting failure probabilities were consistent for local streets with low traffic volumes; however, they generally underpredicted the failure probabilities for sites with higher traffic volumes. For example, *CalME* predicted no rutting failure at the Port of Oakland, even under damaged conditions in the gantry lanes; however, significant rutting failures were observed after as many as 32 years of service. Note that the traffic used for the Port of Oakland was based purely on public data and may not be accurate.

Given these results, it is concluded that, although further calibration is still required, *CalME* can be used to develop a design catalog.

Table 4.4: Summary of CalME Validation Results for the Test Sites

Site	Street or Lane	Typical AADT	Observed Failure Probability (%)	Simulation Duration (years)	Predicted Failure Probability (%)	AADTT Used	Applied Traffic Index (TI)	Agreement with Field Rutting
Colma	B Street	2 to 4	0.7	26	0	4	4.9	Consistent
Colma	F Street	50 to 500	0.7	26	4.4	250	8.1	Consistent
El Dorado Hills	Ottawa and Pequot Steets	2 to 4	0	5	0	4	3.9	Consistent
El Dorado Hills	Ottawa and Pequot Steets	50 to 500 ^b	0	5	0	85 ^b	5.7 ^b	Consistent
Rancho Cordova	Rio Del Oro Community	2 to 4	1.1	3	0	4	3.9	Underpredict
Rancho Cordova	Rio Del Oro Community	50 to 500 ^b	1.1	3	0	500 ^b	6.8 ^b	Underpredict
Westley	Howard Road Northbound	50 to 500	5.3	10	0	500	8.5	Underpredict
Westley	Howard Road Southbound	50 to 500	0	10	0	500	8.5	Consistent
Berths 30-32, Port of Oakland	Truck lane	264 lifts	0	32	0	264 lifts	15.7	Consistent
Berths 30-32, Port of Oakland	Gantry lane	264 lifts	91	32	0	264 lifts	15.7	Underpredict
Berths 30-32, Port of Oakland	Gantry lane ^a	264 lifts	91	32	0	264 lifts	15.7	Underpredict
Berths 55-56, Port of Oakland	Truck lane	264 lifts	0	23	0	264 lifts	15.1	Consistent
Berths 55-56, Port of Oakland	Gantry lane	264 lifts	65	23	0	264 lifts	15.1	Underpredict
Berths 55-56, Port of Oakland	Gantry lane ^a	264 lifts	65	23	0	264 lifts	15.1	Underpredict

^b Based on the load spectrum and the minimal traffic volume for collector streets to account for the initial construction traffic.

^a These simulations use backcalculation results from the corresponding truck lane, assuming they are similar to the initial conditions.

5 DESIGN CATALOG DEVELOPMENT

5.1 General Approach

This chapter describes the process of developing a design catalog for ICP pavements using an M-E design method. A description of the resulting catalog is also included. The intent is to replace the design catalog published in the ASCE Standard 58-16 (hereafter referred to as the ASCE catalog).

The new catalog was developed using *CalME*. As shown in Chapter 4, *CalME* predictions were consistent with field observations for the tested sections with residential traffic; however, the rutting performance was underpredicted for sites with higher traffic volumes.

The between-project variabilities were excluded when running *CalME* in Chapter 4, but need to be included when developing design catalogs. Between-project variabilities are used in *CalME* to account for uncertainties before construction begins, such as those associated with material suppliers and contractors. The inclusion of between-project variabilities will increase the predicted failure probability and possibly overpredict failure for low-traffic ICP applications, becoming consistent with higher-traffic applications.

Similar to other M-E design methods, *CalME* requires structure, climate, and traffic inputs for predicting pavement performance. As *CalME* was not originally developed for ICP analyses, minor modifications were needed to support ICP design.

For each design, *CalME* was used to predict performance and verify whether the assumed structure is sufficient for the anticipated traffic loads during the design life. An automated trial-and-error process was employed to identify the most economical design that meets the design requirements.

5.1.1 ICP Structure

The same set of structures used in the ASCE catalog was used in the new catalog. These structures all feature a standard 80 mm paver as the surface layer, supported by 25 mm of bedding sand. The following are the different combinations of layers between bedding sand and subgrade:

- Structure A: Aggregate base (AB) over aggregate subbase (ASB) (i.e., AB/ASB)
- Structure B: Asphalt-treated base (ATB) over AB and ASB (i.e., ATB/AB/ASB)
- Structure C: Cement-treated base (CTB) over AB and ASB (i.e., CTB/AB/ASB)
- Structure D: Asphalt concrete (AC) base over AB (i.e., AC/AB)

These structures can be distinguished from each other using the first layer below the bedding sand, i.e., the first base.

To simulate these ICPs in *CalME*, the paver and bedding sand layers were combined into an equivalent homogeneous layer. The combined paver and bedding layers were assumed to be made of a linear elastic material that is not subject to fatigue damage and permanent deformation.

CalME has a built-in library that includes typical materials used in flexible pavements. This library includes AB, ASB, ATB, CTB, and AC. However, no existing surface material matches the behavior of the combined paver and bedding layers, so a new surface material was added to *CalME* for these layers.

The layer stiffnesses and variabilities for different materials are listed in Table 5.1. Although included in the table, the structural coefficients provided in the ASCE catalog are not directly used by *CalME*. Instead, they are needed to estimate layer stiffness through correlations outlined in the *AASHTO Guide for Design of Pavement Structures* (1993) (18), which relate stiffness values to structural coefficients. Since there is no correlation between the paver and bedding sand combined layers, their stiffness was assumed to be similar to the AC stiffness, as they share the same structural coefficient. The same assumption was used in the ASCE catalog, which employs an a_1 of 0.44, the highest a_1 value used for the AC layer. The backcalculation result for the Westley site was chosen because it is closest in value to the AC layer stiffness.

The default standard deviation factors (SDF) values from *CalME* were used, which are close to the backcalculation results listed in Table 3.4. The SDF, defined as $10^{c.o.v.[\log_{10}(x)]}$ for variable x , is also listed in Table 5.1 for different materials. These are required by *CalME* to run Monte Carlo simulations to account for construction variability. These values are the default values for the given material type in the *CalME* library.

Table 5.1: List of Layer Stiffnesses and Variabilities for Materials Used in ICP Design Catalog

Material	Structural Coefficient	Stiffness (MPa/ksi)	Standard Deviation Factor
ICP and bedding sand combined layers	0.44	3,418/496	1.20
Aggregate base (AB)	0.14	207/30	1.20
Asphalt-treated base (ATB)	0.28	2,137/310 ¹	1.20
Cement-treated base (CTB)	0.20	5,033/730	1.20
Asphalt concrete (AC)	0.44	3,103/450 ¹	1.20
Aggregate subbase (ASB)	0.09	90/12.4	1.20
Subgrade (SG)	Not applicable	90/13 to 15/2.2 (depending on soil category and drainage) ²	1.20

¹ These stiffnesses are for 20°C.

² Source: Table 4-2 in the ASCE 58-16 catalog (17).

The thicknesses of various layers in ICP follow patterns similar to those used for the ASCE catalog, but with some minor adjustments. Specifically, the following are the rules for searching for viable designs:

- AB thickness: must be between 100 mm (4 in.) and 300 mm (12 in.) at an increment of 25 mm (1 in.)
- ASB thickness: must be either 0 (i.e., not used) or between 150 mm (6 in.) and 1,200 mm (48 in.) at an increment of 50 mm (2 in.)
- ATB and CTB thicknesses are fixed at 100 mm (4 in.) if used
- AC thickness: must be between 50 mm (2 in.) and 200 mm (8 in.) at an increment of 10 mm (0.4 in.)

The design variables for Structures A, B, and C include the thickness of AB and ASB. For Structure D, these include AC and AB thickness. The optimal designs are found by searching through different combinations of their thicknesses in steps, which are listed in Table 5.2.

Table 5.2: Thickness Combinations Used in Different Search Steps

Search Step	Structure A, B, and C	Structure D
1	100, 125, 150 mm AB with no ASB	50 mm of AC with 100 to 300 mm of AB at 25 mm increment
2	AB fixed at 150 mm but ASB can be 150, 200, 250, or 300 mm	60 to 200 mm of AC at 10 mm increment with AB fixed at 300 mm
3	(AB, ASB) thickness: (175, 350), (200, 400), (225, 450), (250, 500), (275, 550), or (300, 600)	Not applicable
4	AB fixed at 300 mm but ASB varies from 650 to 1,200 mm at 50 mm increment	Not applicable

5.1.2 Climate

Temperature has minimal impact on ICP performance because the asphalt-bound materials (ATB and AC) are only used as a base. The California Inland Valley climate zone was used in *CalME* as a conservative alternative because it is the hottest zone in California. Higher pavement temperatures cause asphalt-bound materials to be softer and more susceptible to rutting.

5.1.3 Traffic

Two types of traffic were considered: residential and industrial. These are street classifications defined in the ACI guidelines (24). The residential traffic is linked to Category 1 axle-load distribution, while industrial traffic is linked to Category 3 (24). These axle-load spectra were added to *CalME*'s built-in traffic database.

The traffic volume ranged from 10,000 to 10,000,000 ESALs (traffic index [TI] from 5.2 to 11.8), matching the levels used in the ASCE catalog.

Other parameters, such as design life, were defined as shown in Table 5.3. These assumptions were made in consultation with ICPI to match standard practice.

Table 5.3: Key Characteristics and Example AADTT Calculations for the Axle-Load Distributions Used

Axle-Load Distribution	Industrial	Residential
Axles per Truck	0.89	3.92
ESAL per Axle	0.76	0.078
Example Design ESAL	1,000,000	1,000,000
Example Design Traffic Index (TI)	9.0	9.0
Example Design Axle Count	1.13 million	12.8 million
Example Design Life (years)	20	20
Example Traffic Growth Rate (%)	0	0
Example AADTT	405	896

5.1.4 Other Analysis Parameters

To match the 75% reliability level used for developing the ASCE catalog, a 25% failure rate in Monte Carlo simulations was used as the criterion for satisfactory design in *CalME*. In other words, a design is considered sufficient only if fewer than 25% of the cases fail before the end of the design life.

CalME by default accounts for two surface distresses: cracking and rutting. For ICPs, cracking failure was disabled, and only rutting was considered. Three levels of failure threshold were used: 12.5 mm (1/2 in.), 19 mm (3/4 in.), and 25 mm (1.0 in.). Each failure threshold has its own design catalogs.

5.2 Results and Recommendations

The design catalogs are provided in [Appendix B](#). As expected, the lower the rutting failure threshold, the thicker the designs. Also, as expected, the designs for Structure A (i.e., no bound base) are thicker than those for the other structures. In addition, the following observations can be made regarding the new catalogs:

- The designs for Structure B (i.e., with ATB) are thicker than the corresponding designs for Structure C (i.e., with CTB). This differs from the ASCE catalog and requires further validation.
- With 100 mm (4.0 in.) of ATB or CTB, and up to 150 mm (6.0 in.) of AB, there is barely any need for ASB in the new catalog.
- There are no viable designs in the new M-E catalog for the 12.5 mm (0.5 in.) threshold: design scenarios of Structure A (i.e., no bound base) when the design ESAL is greater than 5.0 million (TI is higher than 10.9).

Given the need to have viable designs for design-ESALs of up to 10 million (TI = 11.8), it is recommended to use the 19 mm (0.75 in.) threshold designs for the new M-E catalog.

The difference in design thickness between the new M-E catalog for 19 mm (3/4 in.) designs in residential neighborhoods and the ASCE catalog is shown in Figure 5.1, averaged across all subgrade categories, and in Figure 5.2, averaged across all traffic volumes. The difference is calculated as the new M-E design thickness minus the ASCE 58-16 design thickness. In other words, a positive difference indicates a thicker design for the new catalog.

Figure 5.1 shows the difference in design thickness between the new catalog and the ASCE 58-16 catalog (new-ASCE). It is the same at the lowest TI, requires more AB and less subbase at the highest TI, but otherwise requires slightly less AB and significantly less subbase. The difference in AB thickness is no more than 50 mm (2.0 in.), while the difference in subbase thickness can be as much as 450 mm (18.0 in.) at higher TIs.

Figure 5.2 shows that the new catalog requires less AB when the subgrade is strong and requires more AB when the subgrade is soft. The new catalog typically requires less subbase, but the difference increases as the subgrade's stiffness decreases.

Compared to the ASCE catalog, the new catalog generally requires about the same thickness for AB but significantly lower thickness for the subbase. The reduction in subbase thickness can be partly attributed to the increase in maximum AB thickness from 150 mm (6.0 in.) to 300 mm (12 in.).

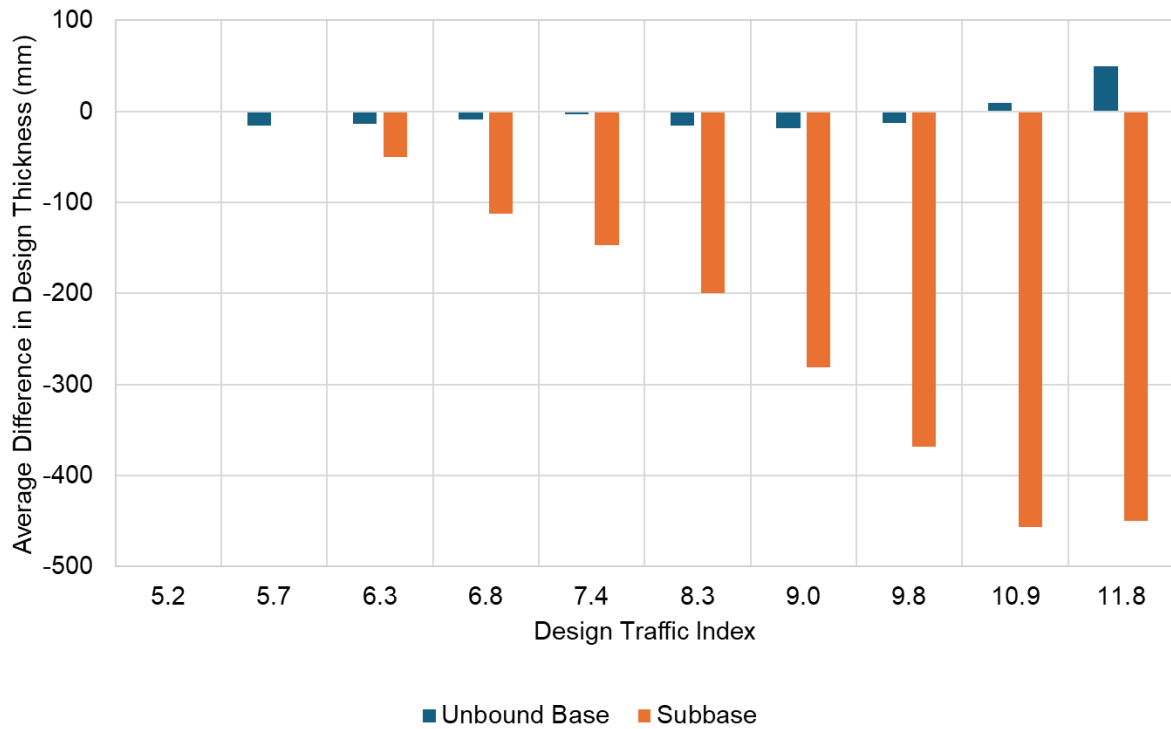


Figure 5.1: Difference in design thickness: New catalog design - ASCE 58-16 design averaged across all subgrade categories for all design TI levels.

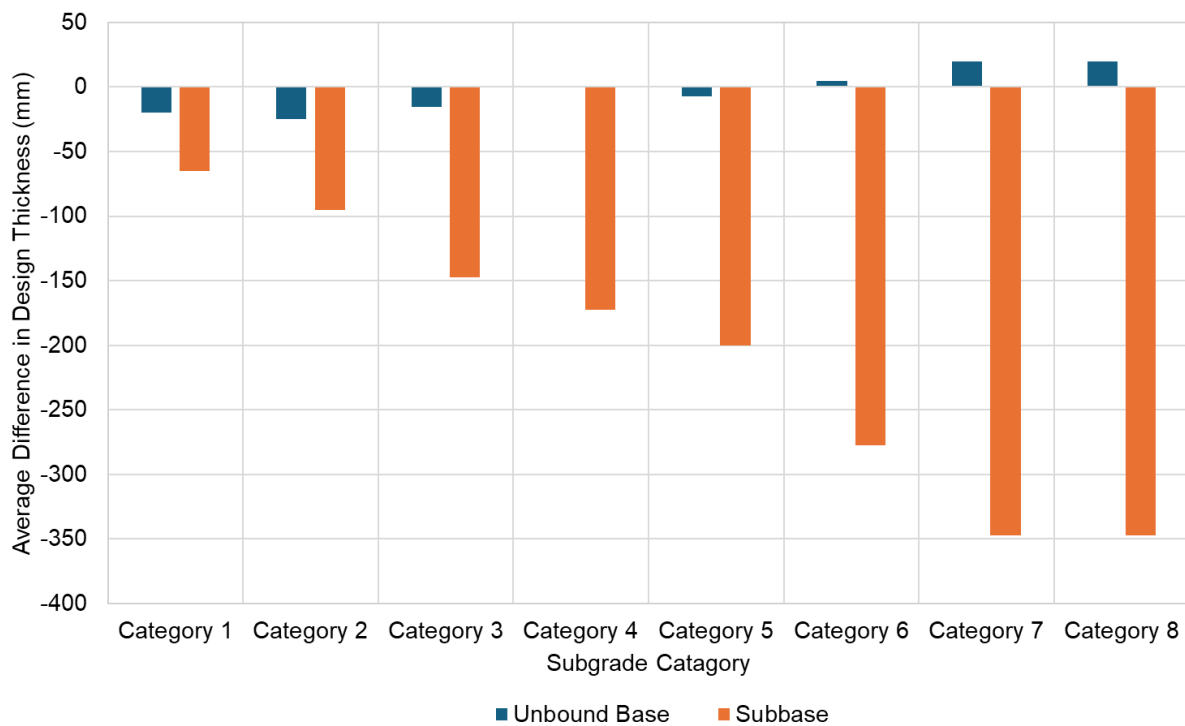


Figure 5.2: Difference in design thickness: New catalog design - ASCE 58-16 design averaged across all traffic volumes.

5.3 Worked Examples

The following examples are identical to those presented in Section 4.2 of the ASCE 58-16 catalog (17), except that the new catalog requires the addition of input regarding neighborhood characteristics. All designs were done using Table B- 1 through Table B- 8 for the recommended 19 mm (3/4 in.) threshold for rutting failure.

5.3.1 Case Study 1

Given: ESALs 2 million (TI 9.8), subgrade Category 3 (GP, SP) with good drainage, in a residential area.

Required: Interlocking concrete pavement structure.

Analysis: using Table B- 1 through Table B- 8 in [Appendix B](#), the following designs pass the criteria as shown in Table 5.4 and Figure 5.3:

Table 5.4: Possible Structural Designs for Case Study 1

Layer	Layer Thickness (mm)			
	Design 1	Design 2	Design 3	Design 4
Pavers	80	80	80	80
Bedding sand	25	25	25	25
ATB	0	100	0	0
CTB	0	0	100	0
AC	0	0	0	50
Unbound base	100	100	100	100
Subbase	0	0	0	0

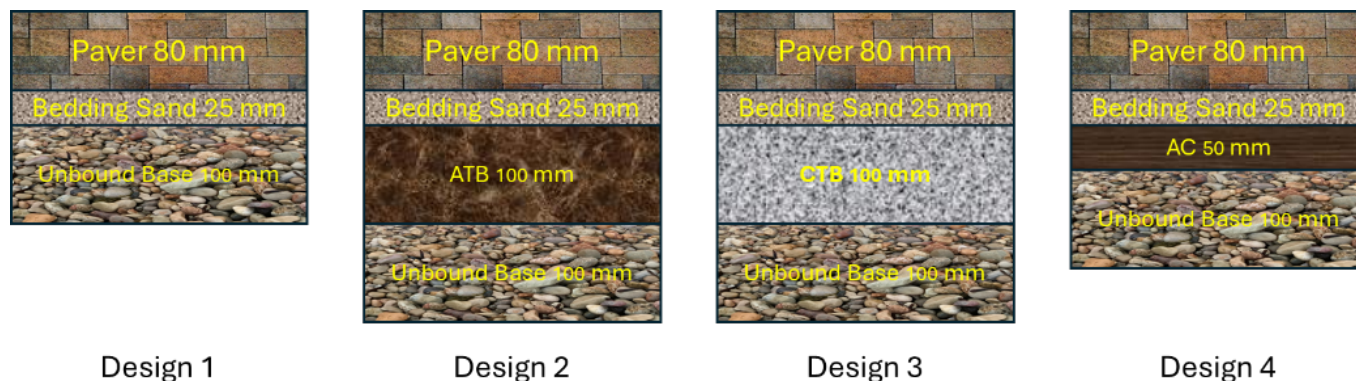


Figure 5.3. Schematic of designs for Case Study 1.

5.3.2 Case Study 2

Given: ESALs 500,000 (TI 8.3), subgrade Category 7 (CL, MH) with poor drainage, in a residential neighborhood.

Required: Interlocking concrete pavement structure.

Analysis: Using Table B- 1 through Table B- 8 in [Appendix B](#), the following designs were developed:

Table 5.5: Possible Structural Designs for Case Study 2

Layer	Layer Thickness (mm)			
	Design 1	Design 2	Design 3	Design 4
Pavers	80	80	80	80
Bedding sand	25	25	25	25
ATB	0	100	0	0
CTB	0	0	100	0
AC	0	0	0	50
Unbound base	150	100	100	125
Subbase	150	0	0	0



Design 1



Design 2



Design 3



Design 4

Figure 5.4. Schematic of designs for Case Study 2 based on the developed M-E catalog.

5.3.3 Case Study 3

Given: ESALs 10 million (TI 11.8), subgrade Category 8 (CI, CH) with poor drainage, in an industrial neighborhood.

Required: Interlocking concrete pavement structure.

Analysis: Using Table B- 1 through Table B- 8 in [Appendix B](#), the following designs were developed:

Table 5.6: Possible Structural Designs for Case Study 3

Layer	Layer Thickness (mm)			
	Design 1	Design 2	Design 3	Design 4
Pavers	80	80	80	80
Bedding sand	25	25	25	25
ATB	0	100	0	0
CTB	0	0	100	0
AC	0	0	0	70
Unbound base	250	150	125	300
Subbase	500	150	0	0



Design 1



Design 2



Design 3



Design 4

Figure 5.5. Schematic of designs for Case Study 3.

6 PLAN FOR TEST TRACK CONSTRUCTION AND ACCELERATED LOAD TESTING

Building on the findings from field testing, model validation, and preliminary catalog development, a targeted accelerated pavement testing (APT) program is essential to address key uncertainties that remain in the M-E design of ICP. The program should focus on the following critical issues:

A. Rate and time of stiffening of the combined paver and bedding sand layer with traffic:

- a. Quantify how repeated traffic loads alter the stiffness of the surface layers over time and how these changes affect long-term performance.
- b. This can be achieved through periodic deflection testing of the pavement during APT and measuring rut accumulation in each layer at the same time.

B. Effect of aggregate base (AB) thickness on effective stiffness in ICP:

- a. Determine how varying AB thickness influences the structural stiffness and load distribution, thereby refining design thickness recommendations.
- b. Based on the backcalculation results, two AB thicknesses should be used in building the test track: 150 mm (6 in.) and 300 mm (12 in.), one as the control, the other as the treatment.

C. Effect of traffic on the base layer stiffness in ICP:

- a. Evaluate how traffic-induced densification or degradation affects the mechanical properties of the base layer, which can be achieved by periodic deflection testing during APT.

D. Effect of traffic volume and load level on rut accumulation in the base and subgrade:

- a. Assess how different traffic volumes and axle loads contribute to rutting in the lower pavement layers, improving rutting prediction models. This can be achieved by periodically measuring rut accumulation in each individual layer during the APT.
- b. This needs to be evaluated in structures designed for both low and high traffic volume so that the model developed can be used for the full range of design traffic.

E. Relative performance of cement-treated base (CTB) versus asphalt-treated base (ATB):

- a. Compare CTB and ATB under controlled conditions to determine whether CTB truly provides superior structural benefits for ICP.
- b. This requires two test sections, one with CTB and the other with ATB.

F. Effect of drainage conditions on aggregate base, aggregate subbase, and subgrade stiffness

- a. The ASCE design catalog accounted for drainage conditions by reducing subgrade stiffness and R-value when drainage conditions change from good to poor. The amount of reduction may or may not be realistic. It is also possible that poor drainage can reduce the stiffness of both aggregate base and subbase.

- b. This can be studied after all APT is completed on the test track by discharging water into the ICP and soaking the unbound layers, followed by deflection testing on the surface using a falling weight deflectometer (FWD) to collect necessary data for layer stiffness backcalculation. The deflection testing may be conducted in multiple rounds after the water discharging is stopped to capture the effect of moisture content on backcalculated stiffness.

G. Effect of drainage conditions on ICP performance

- a. To fully account for drainage conditions in ICP design, one should compare two identical structures, one tested with good drainage conditions and the other with poor drainage conditions.
- b. This can be achieved by testing the same structure with or without discharging water into the pavement, simulating poor and good drainage conditions, respectively.
- c. This required two test sections. The one with good drainage can be used to study other issues.

The study of issues A, C, and F can be combined with other testing and does not require a separate test section. The study of issue D requires an ICP with low-designed traffic and an ICP with high design traffic, but it can be combined with other testing. A staged loading sequence should be used to evaluate the effects of load level for each of these issues.

The analyses above suggest a minimum of three sections:

- Two test sections (Section 1 and 2) to verify the effect of aggregate base thickness (Issue B)
- One additional test section (Section 3) with high design traffic to study Issue D.

If funding permits, the following additional test sections should be considered:

- Two sections to compare the structures with aggregate base to those with a cement-treated base (Section 4) and an asphalt-treated base (Section 5) or reclaimed asphalt pavement (RAP) base (in-place or cold central plant recycled) for Issue E. If Section 4 or Section 5 is designed to sustain high design traffic (10.0 million ESALs), then Section 3 becomes optional.
- One additional section (Section 6) for studying the effect of drainage conditions on ICP performance (Issue G).

It is likely that not all of these issues will be studied through APT. The most cost-effective approach would be to prioritize these issues and use the limited funding to address the most critical ones.

Data generated through this carefully prioritized APT program will be used to:

1. Calibrate and refine damage and rutting models within the *CalME* platform for ICP-specific conditions.
2. Update and finalize the design catalog, ensuring that recommended layer thicknesses and materials are supported by mechanistic evidence.

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APPENDIX A CORRELATIONS FOR LAYER STIFFNESS FOR DESIGN CATALOG

The contents of this appendix show how the stiffness of each layer was determined for developing the new design catalog using figures and tables from the 1993 AASHTO guidelines (18).

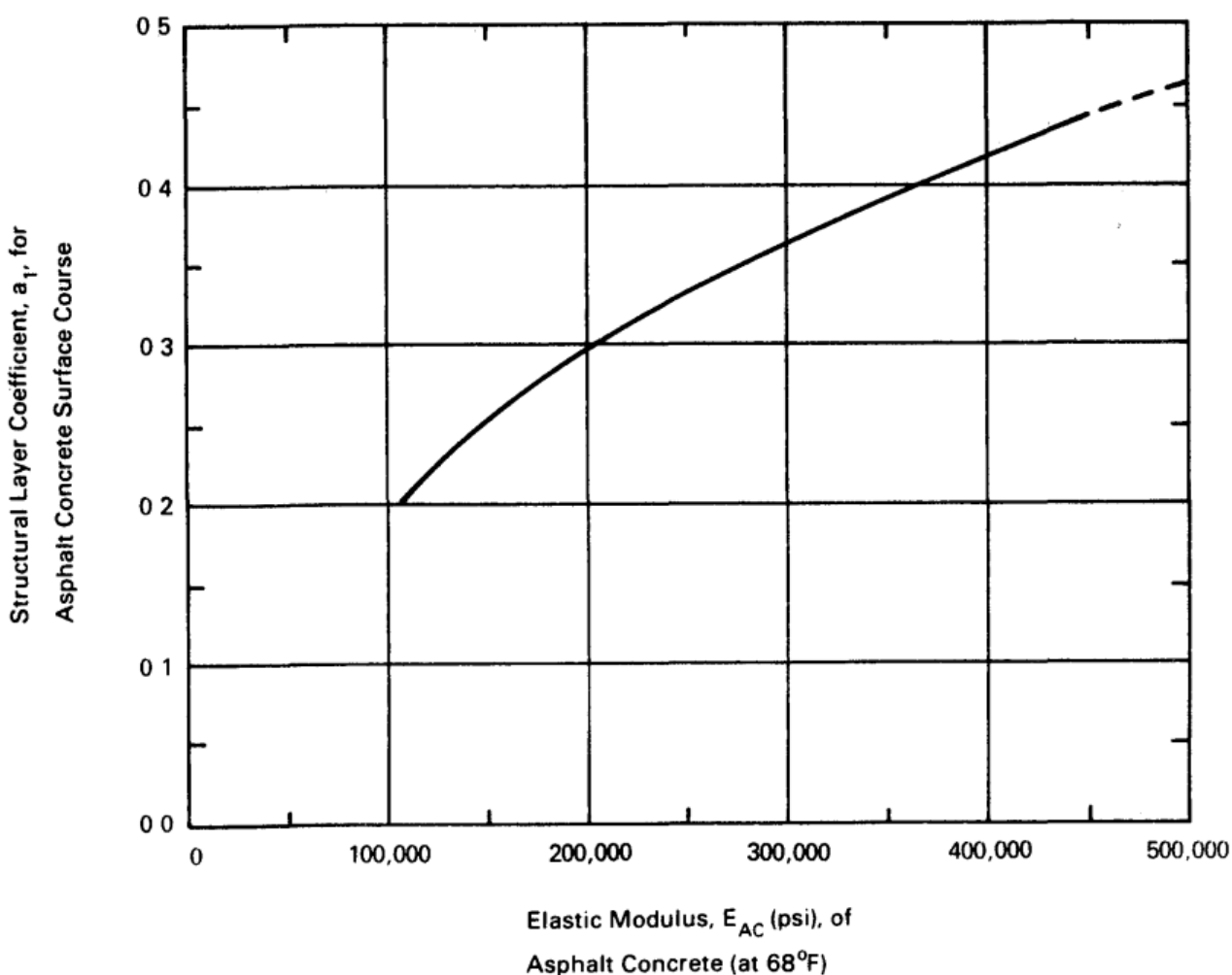
AB stiffness: use 0.14 for structural coefficient $a_2 = 0.249 \log_{10} E_{AB,psi} - 0.977$, $0.14 \Rightarrow E=30,000$ psi

ASB: use 0.09 for structural coefficient, $a_3 = 0.227 \log_{10} E_{ASB,psi} - 0.839$, $0.09 \Rightarrow E=12,374$ psi

AC: use 0.44 for the structural coefficient, which, according to Figure 2.5 from the 1993 AASHTO guidelines, is equal to 450 ksi in stiffness

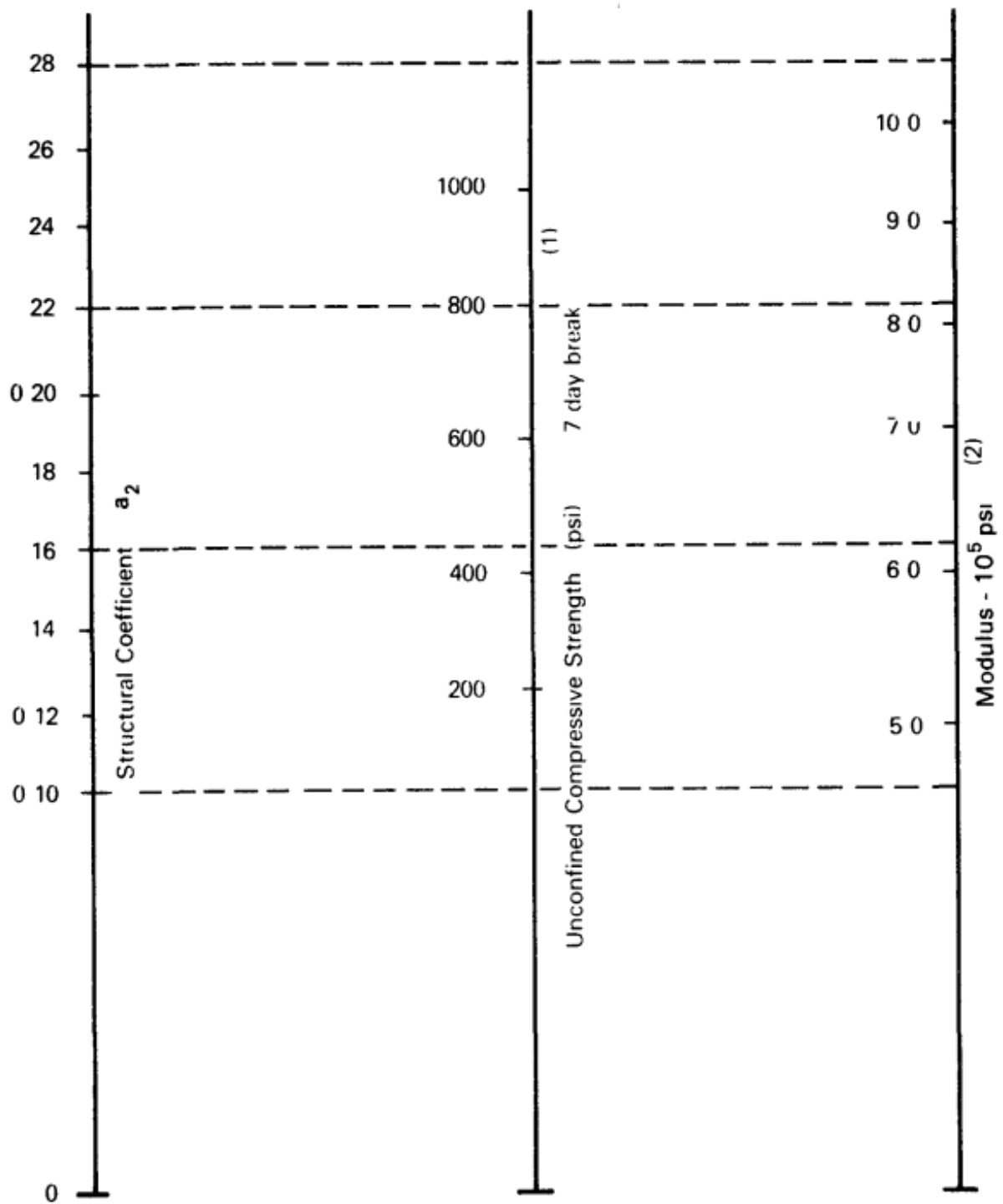
CTB: use 0.20 for the structural coefficient, which, according to Figure 2.8 from the 1993 AASHTO guidelines, is equal to 730 ksi in stiffness

ATB: use 0.28 for the structural coefficient, which, according to Figure 2.9 from the 1993 AASHTO guidelines, is equal to 310 ksi



Source: Figure 2.5 from *AASHTO Guide for Design of Pavement Structures*, 1993, American Association of State Highway and Transportation Officials. Used with permission. (18)

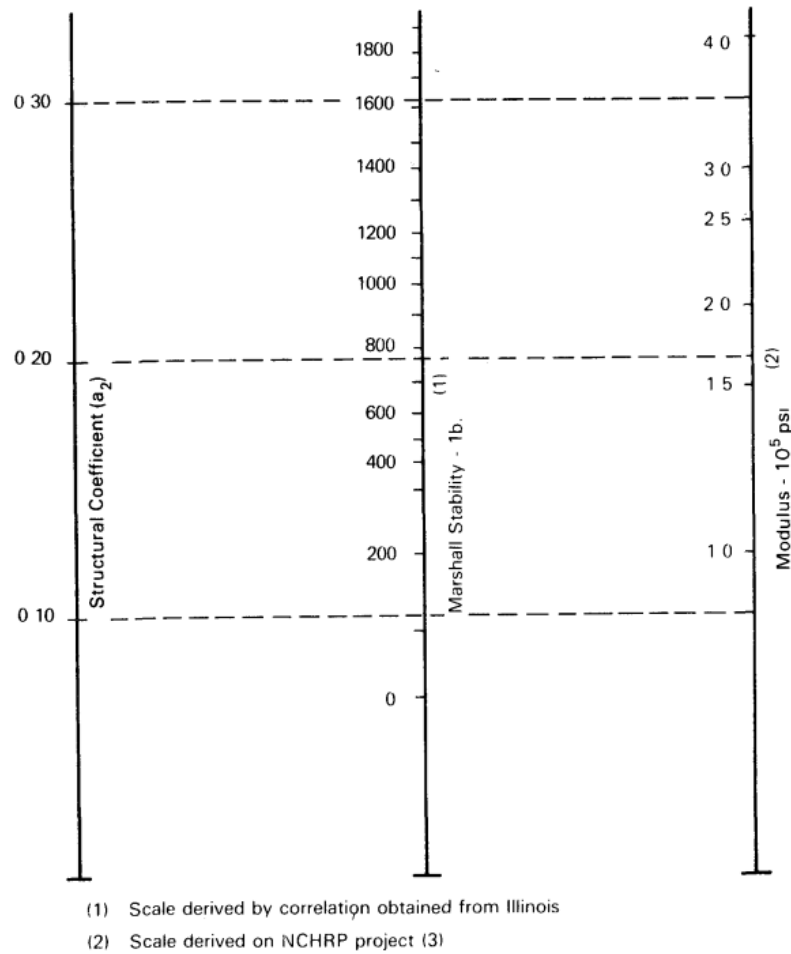
Figure A- 1. Correlation between structural layer coefficient and elastic modulus for asphalt concrete.



- (1) Scale derived by averaging correlations from Illinois, Louisiana, and Texas
 (2) Scale derived on NCHRP project (3)

Source: Figure 2.8 from *AASHTO Guide for Design of Pavement Structures*, 1993, American Association of State Highway and Transportation Officials. Used with permission. (18)

Figure A- 2. Correlation between structural layer coefficient and elastic modulus for cement-treated base.



Source: Figure 2.9 from *AASHTO Guide for Design of Pavement Structures*, 1993, American Association of State Highway and Transportation Officials. Used with permission. (18)

Figure A- 3. Correlation between structural layer coefficient and elastic modulus for asphalt-treated base.

The following table (Table 4-2 from the ASCE 58-16 catalog) was used to determine stiffness of subgrade for different categories and drainage conditions (17).

Resilient modulus for typical subgrade drainage conditions									
Category	Good			Fair			Poor		
	MPa	R ^a	CBR ^b	MPa	R ^a	CBR ^b	MPa	R ^a	CBR ^b
1	90	21	13	80	19	11	70	16	9
2	80	19	11	70	16	9	50	11	5
3	70	16	9	50	11	5	35	7	3
4	50	11	5	35	7	3	30	6	2
5	40	8	4	30	6	2	25	4	2
6	30	6	2	25	4	2	18	3	1
7	27	5	2	20	3	1	15	2	1
8	25	4	2	20	3	1	15	2	1

^aR-value, determined by California Test 301.

^bCalifornia Bearing Ratio, from ASTM D1883 (ASTM 2007).

APPENDIX B NEW M-E DESIGN CATALOG

Table B- 1: Design Table for Granular Base (thickness in mm) in Industrial Neighborhood with ¾ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	200
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	250
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	200
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	250
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	350
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	350
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	250	400
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	350
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	250	400
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	300	400
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	350
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	300	400
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	350	450
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	300	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	350	450
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	150	200	250
		Unbound dense-graded subbase	0	0	0	150	150	150	200	250	400	500
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	150	150	150	150	150	225
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	300	450
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	150	150	200	250	350	450
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	125	150	150	150	150	150	150	200	250
		Unbound dense-graded subbase	0	0	0	150	150	200	250	300	400	500
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	350	450
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	150	150	200	250	350	450
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded base	100	125	150	150	150	150	150	150	200	250
		Unbound dense-graded subbase	0	0	0	150	150	200	250	300	400	500

Table B- 2: Design Table for Asphalt-Treated Base (thickness in mm) in Industrial Neighborhood with ¾ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-	0	0	0	0	0	0	0	0	0	0

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		graded subbase										
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	125	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	150
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	125	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	150

Table B- 3: Design Table for Cement-Treated Base (thickness in mm) in Industrial Neighborhood with ¾ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0

Table B- 4: Design Table for Asphalt Concrete Base (thickness in mm) in Industrial Neighborhood with $\frac{3}{4}$ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	175
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	175
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded base	100	100	100	100	100	100	100	100	175	225
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	175
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	175	225
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200	250
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	225
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200	250
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	125	150	225	300
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	125	150	225	300
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	60
		Unbound dense-graded base	100	100	100	100	100	125	150	200	275	300

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	150	225	275
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	60
		Unbound dense-graded base	100	100	100	100	100	100	150	200	250	300
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	70
		Unbound dense-graded base	100	100	100	100	100	150	175	225	300	300
	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	125	150	225	300
Category 8	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	60
		Unbound dense-graded base	100	100	100	100	100	100	150	200	250	300
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	70
		Unbound dense-graded base	100	100	100	100	100	150	175	225	300	300

Table B- 5: Design Table for Granular Base (thickness in mm) in Residential Neighborhood with ¾ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	200
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	200
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	125	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	300
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	200
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	125	150	150

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	300
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	350
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	125	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	300
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	350
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	250	400
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	350
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	250	400
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	300	400
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	200

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	250	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	300	400
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	150	150	150	250	350	450
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	300	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	350	450
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	150	175	250
		Unbound dense-graded subbase	0	0	0	0	150	150	200	250	350	500
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	200
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	300	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	175	225
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	350	450
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	150	175	250

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	150	150	200	250	350	500

Table B- 6: Design Table for Asphalt-Treated Base (thickness in mm) in Residential Neighborhood with $\frac{3}{4}$ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Asphalt-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150

Table B- 7: Design Table for Cement-Treated Base (thickness in mm) in Residential Neighborhood with $\frac{3}{4}$ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Cement-treated base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0

Table B- 8: Design Table for Asphalt Concrete Base (thickness in mm) in Residential Neighborhood with ¾ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	200

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	150
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	200
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	175	225
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	125	175
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	175	225
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200	250
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	100	175	225
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200	250
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	125	175	250	300
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	175	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	125	150	225	275
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	60
		Unbound dense-graded base	100	100	100	100	100	125	150	200	275	300
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	50
		Unbound dense-graded base	100	100	100	100	100	100	125	150	225	275
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		AC	50	50	50	50	50	50	50	50	50	60
		Unbound dense-graded base	100	100	100	100	100	125	150	200	275	300

Table B- 9: Design Table for Granular Base (thickness in mm) in Residential Neighborhood with ½ Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9
Subgrade	Drainage	Layer type									
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	125	200
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	400
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	400
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	400
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	225
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	450
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	200
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	400
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	225

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9
Subgrade	Drainage	Layer type									
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	450
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	250
		Unbound dense-graded subbase	0	0	0	0	0	150	150	250	500
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	225
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	450
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	250
		Unbound dense-graded subbase	0	0	0	0	0	150	150	250	500
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	275
		Unbound dense-graded subbase	0	0	0	0	0	150	200	300	550
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	250
		Unbound dense-graded subbase	0	0	0	0	0	0	150	200	500
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	275
		Unbound dense-graded subbase	0	0	0	0	0	150	200	300	550
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	175	275
		Unbound dense-graded subbase	0	0	0	0	150	150	200	350	550
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	275

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9
Subgrade	Drainage	Layer type									
		Unbound dense-graded subbase	0	0	0	0	0	150	200	300	550
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	175	275
		Unbound dense-graded subbase	0	0	0	0	150	150	200	350	550
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	125	150	150	150	150	150	175	300
		Unbound dense-graded subbase	0	0	0	150	150	200	300	350	600
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	275
		Unbound dense-graded subbase	0	0	0	0	150	150	200	300	550
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	150	150	150	150	150	175	275
		Unbound dense-graded subbase	0	0	0	150	150	200	250	350	550
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	125	150	150	150	150	150	150	200	300
		Unbound dense-graded subbase	0	0	150	150	150	250	300	400	600
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	125	150	150	150	150	175	275
		Unbound dense-graded subbase	0	0	0	0	150	150	200	350	550
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	150	150	150	150	150	175	275
		Unbound dense-graded subbase	0	0	0	150	150	200	250	350	550
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	125	150	150	150	150	150	150	200	300

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9
Subgrade	Drainage	Layer type									
		Unbound dense-graded subbase	0	0	150	150	150	250	300	400	600

Table B- 10: Design Table for Granular Base (thickness in mm) in Residential Neighborhood with 1.0 Inch as Threshold for Rut

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
Category 1	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
Category 2	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	100
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
Category 3	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	100	125
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	0
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	200
Category 4	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	100	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	0	150
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	200
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	250
Category 5	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	100	125	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	0	150	150
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	250
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	250
Category 6	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	125	150	150	150

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	250
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	125	150	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	150	150	150	250	350
Category 7	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	100	150	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	150	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	200	350
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	300	350
Category 8	Good	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	125	150	150	150	150
		Unbound dense-graded subbase	0	0	0	0	0	0	0	150	200	250
	Fair	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	100	100	150	150	150	150	175
		Unbound dense-graded subbase	0	0	0	0	0	0	150	150	200	350
	Poor	Pavers and bedding	105	105	105	105	105	105	105	105	105	105
		Unbound dense-graded base	100	100	100	125	150	150	150	150	150	175

		ESALs	10,000	20,000	50,000	100,000	200,000	500,000	1,000,000	2,000,000	5,000,000	10,000,000
		TI	5.2	5.7	6.3	6.8	7.4	8.3	9.0	9.8	10.9	11.8
Subgrade	Drainage	Layer type										
		Unbound dense-graded subbase	0	0	0	0	0	150	150	200	300	350

