Oregon Department of Transportation

ODOT PAVEMENT DESIGN GUIDE

Pavement Services Unit
January 2019

ODOT PAVEMENT DESIGN GUIDE
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OREGON DEPARTMENT OF TRANSPORTATION
PAVEMENT DESIGN GUIDE
January 2019

USER RESPONSIBILITY

The Oregon Department of Transportation (ODOT) Pavement Design Guide will be updated periodically to remain current with ODOT design, Specification, and construction policies. When necessary, the guide will also be updated to reflect changes or developments in industry practices, procedures and materials.

When updates are made, the date indicated on the cover sheet of the design guide will be changed. ODOT will not attempt to track the identity of all users of this guide, since the design guide can be downloaded at any time from the ODOT website.

Therefore it is the responsibility of the user to confirm that they are using the current version of the ODOT Pavement Design Guide.

CHAPTER 1: INTRODUCTION

The Oregon Department of Transportation (ODOT) Pavement Design Guide (PDG) provides design requirements for use by ODOT personnel and private consultants (Contractors) for preparing pavement designs for projects administered through ODOT.

Acronyms

- AASHTO: American Association of State Highway Transportation Officials
- ACP: Asphalt Concrete Pavement
- CRCP: Continuously Reinforced Concrete Pavement
- DCP: Dynamic Cone Penetrometer
- FWD: Falling Weight Deflectometer
- ESAL: Equivalent Single Axle Load
- FHWA: Federal Highway Administration
- JPCP: Jointed Plain Concrete Pavement
- JRCP: Jointed Reinforced Concrete Pavement
- LCCA: Life Cycle Cost Analysis
- MEPDG: Mechanistic Empirical Pavement Design Guidelines (AASHTOWare Pavement ME)
- ODOT: Oregon Department of Transportation
- PCC: Portland Concrete Cement
- PDG: Pavement Design Guide
- PG Binder: Performance Grade Binder

Definitions

1. *Designer:* Designer means the ODOT technical staff responsible for pavement designs for “in-house” projects completed by ODOT. For out-sourced projects, “Designer” means the professional consultant under contract to provide pavement design services for projects administered through ODOT.
2. *Design Life:* the period of time the pavement is engineered to perform before reaching its terminal serviceability or a condition that requires pavement rehabilitation, based on calculations.
3. *Service Life:* the period of time the pavement is expected to perform before reaching a condition that is not suitable to be open for the traveling public at posted speed , based on real world conditions (past performance, institutional knowledge, engineering judgment, etc.)
4. *Project Scope*: a description of the parameters of the project which can be found in the project prospectus.
5. *Project Charter:* a document which initiates the project, and to describe the key objectives and goals of the project, assumptions, constraints, risks, etc.
6. *V-files*: ODOT’s nomenclature for As-Constructed drawings.

7. *Field reconnaissance*: Field reconnaissance is a site visit for the purpose of determining the type and extent of field investigation work required on the project and any specific locations the Designer wants tested.
8. *New Work*: the construction of new pavement, including widening of existing facilities and new alignments.
9. *Pavement reconstruction (4R)*: refer to ODOT Highway Design Manual
10. *Pavement resurfacing, restoration, and rehabilitation (3R)*: refer to the ODOT Highway Design Manual
11. *Pavement resurfacing (1R)*: refer to the ODOT Highway Design Manual
12. *Pavement Design Memo:* This document provides the pavement section recommendations, pavement design notes, and a table of specifications required, as well as boiler plate special provisions required.
13. *Pavement Design Summary:* This document summarizes the pavement condition, construction history, summarizes all data analysis completed, design criteria – inputs (such as but not limited to traffic data, subgrade modulus, directional factors, design coefficient), and a narrative on the specific recommendations made in the pavement design memo, based on analysis done and design life calculated.

Intent of the PDG

This document provides general guidance and minimum acceptable standards for pavement design, analysis, and supporting documentation. The Designer should apply engineering judgment on a project basis, justify deviations from the Guide, and in some cases obtain prior approval from ODOT Pavement Services. The ODOT Pavement Design Engineer, or her or his designee, will review all pavement designs for structural adequacy and compliance with the guidelines set forth in this document.

This document will be updated periodically. We welcome any comments or suggestions you may have for improving this guide.

Specification references are based on the Oregon Standard Specifications for Construction, 2018, unless otherwise noted. The Standard Drawings and Standard Details are referenced based on the numbers at the time of guide publication.

Questions regarding any of the information presented in this guide may be directed to:

Pavement Services Unit 503-986-3000

Copies of the ODOT Pavement Design Guide can be obtained online.

What's New for 2019?

The 2019 Revision includes the following updates:

- Addition of several new definitions
- Updates for 2018 Construction Specifications, including use of 00740 Commercial Asphalt Concrete Pavement (CACP)
- Revised PG binder guidelines
- Corridor Planning guidelines
- Mechanistic-Empirical Design guidelines (AASHTOWare Pavement ME)
- Guidance for design of In-Place Cement Treated Base (iCTB), as well as guidance for use of other pavement recycling methods
- Guidance for treatments of open-graded shoulders during paving projects
- Guidance for assessing the suitability of a pavement for a chip seal treatment
- Updated methods of obtaining traffic data
- Updated design service life requirements for grade-constrained flexible pavements
- Reduced spacing of photographs during field investigation
- Guidance for design of temporary cross over sections
- Rumble strip guidance
- Guidance on the design of asphalt/PCC roadways ("black and white" sections)
- Guidance on precast concrete panel technology
- Expansion of Chapter 12 for clarification on Consultant contracts
- Several new hyperlinks to supporting documents or research
- Design information for roundabouts
- Revision/updating of all Appendices

CHAPTER 2: PAVEMENT DESIGN PROCEDURES

2.1 Acceptable Pavement Design Methods for ODOT Jurisdiction Highways

All pavement designs for State Highways must use the most cost-effective design that meets the objectives of the project and all applicable design standards. Develop all pavement designs for State Highways using a recognized design procedure. Examples of acceptable procedures include, but are not limited to:

- 1993 AASHTO Guide for Design of Pavement Structures and Supplements
- MEPDG/AASHTOWare Pavement ME (2015 Ed. plus any addendums)
- Mechanistic Design based on NCHRP
- The Asphalt Institute
- Portland Cement Association
- Asphalt Pavement Association of Oregon (APAO) (based on AASHTO)
- American Concrete Pavement Association

Appendix A contains contact information for these pavement design procedures. There is no universally accepted pavement design procedure. The use of procedures not listed above must be approved in advance and in writing (e-mail acceptable) by the ODOT Pavement Design Engineer. Whichever procedure is used, it is important that the pavement design meet the requirements outlined in the following chapters.

2.2 Local Agency Roadways – Federal Funding

ODOT has agreed to a Stewardship Plan for projects with funding from FHWA which includes various responsibilities and agreements as well as an oversight role for certain National Highway System (NHS) and non-NHS roads. According to the Plan:

> *"Stewardship, as used in this plan, is the process of providing oversight and accountability for all resources used in carrying out the Federal-aid Highway Program in the State of Oregon. It has three components:*
> *(1) ensuring compliance with laws, regulations, and other applicable requirements;*
> *(2) ensuring that the expenditure of resources results in high quality, cost effective products for the taxpayer; and*
> *(3) providing appropriate technical assistance to all involved personnel and agencies to assist the accomplishment of items (1) and (2)."*

ODOT Pavement Services interprets the stewardship plan thusly:

- If a Local Agency project involves work on a state highway, that work item is to meet ODOT standards and policy.
- If a Local Agency project involves work on a local jurisdiction roadway on the NHS, that work shall meet AASHTO standards.
- If a Local Agency project involves work on a local jurisdiction roadway not on the NHS, that work shall meet AASHTO standards, unless the jurisdiction selects a standard of their own choice, as according to ORS 368.036.

This information is summarized in Table 1.

Table 1: Local Agency Standards and Policy Requirements

Type of Local Agency Project	Standards Recommended	Pavement Design Recommended
Local Agency on State Highway Route	ODOT Standards and Policy	ODOT Pavement Design Guide
Local Agency on NHS Route	AASHTO Standards	ODOT Pavement Design Guide
Local Agency on non-NHS Route	AASHTO Standards or per ORS 368.036	Up to 1 million ESALs: APAO Design Guide or AASHTO Low Volume Guide
		Less than 50,000 ESALs: APAO Design Guide

Most of the methodology in the ODOT Pavement Design Guide (PDG) is based on the 1993 AASHTO Guide for Design of Pavement Structures (and Supplements). In most cases, ODOT-specific policy is clarified when it deviates from general AASHTO standards. Pavement materials recommendations made within the PDG are still relevant for Local Agency projects, including appropriate testing requirements, since ODOT Specifications are used for contracts.

The ODOT PDG is the basis for Local Agency pavement design. The Local Agency can request exception from non-policy ODOT standards for non-NHS local jurisdiction roadway work that requires compliance with AASHTO standards. The ODOT Pavement Design Engineer can approve the written exception request (email acceptable) through the ODOT Local Agency Liaison. Other exceptions to AASHTO or ODOT standards should follow the design exception process as outlined in the ODOT Highway Design Manual.

For non-state highway applications up to 1 million ESALs, use a procedure such as the one demonstrated in the APAO Asphalt Paving Design Guide or the AASHTO Low Volume procedure. The APAO Design Guide is preferred for applications where the anticipated ESAL level is 50,000 or less. **The** APAO Asphalt Paving Design Guide **is not acceptable for work on the state highway system**.

If the structural section design for a non-state highway is based on a local agency standard, check the standard using a nationally recognized pavement design procedure. This check is required to make sure the design standard is applicable to the present situation. If the local agency has a functional Pavement Management System and can provide performance data (for ODOT review) to justify the design, this may be accepted in place of using the design procedure verification.

2.3 Multi-Use Paths

Multi-use paths for bikes and pedestrians separated from the roadway do not require a formal pavement design. However, a design of roadway shoulders to a reduced thickness, such as for bike lanes, may require a pavement design report. Multi-use paths should be engineered and designed using guidance from the *Oregon Bicycle and Pedestrian Plan,* found at:

https://www.oregon.gov/odot/programs/pages/bikeped.aspx

Standard drawings for construction of new multi-use paths are available on RD 602. In addition, use best engineering practices including those documented in the APAO Asphalt Paving Design Guide.

CHAPTER 3: PROJECT SCOPE AND SCHEDULE

The project scope is typically developed 4 to 6 years in advance of construction. The scoped pavement solution is based on a pavement condition assessment and a brief review of the construction history at the time of project conception **and is preliminary**. The scope is meant as an estimate only, to be used for budgeting purposes, and should not be considered a final pavement design recommendation. The project scope can change during project development. The ODOT Designer should keep in contact with the Project Leader; or in the case of consultant Designers, the Consultant Project Manager (or Work Order Contract Manager). It is good protocol for the Designer to continuously monitor the business case and the Project Charter to make sure they match, and stay aware of any scope, schedule, or budget adjustments.

Pavement Services has set a guideline to produce a review draft or final pavement design by the Design Acceptance Phase (DAP) milestone.

The pavement design is a work product used by the Project Delivery Team (specifically, the roadway Designer) to complete the plans sheets and cost estimates. Therefore, the pavement Designer may work with the roadway Designer during DAP, but the review draft or final pavement design should be delivered to the project team no later than the DAP plans due date. Although delivering a final stamped pavement design by DAP is standard practice, some projects justify a review draft document by DAP to better facilitate coordination on certain design features. Be aware that some projects will have project-specific timelines.

Special Provision wording should be provided by the Advance plans due date.

3.1 Project Types

Project standards in regard to the types of paving improvements allowable by category (1R, 3R, etc.) are available in the most recent copy of the ODOT Highway Design Manual.

The types of project categories are defined in ODOT's Highway Design Manual (Chapter 1.3.2).

CHAPTER 4: DATA COLLECTION

This chapter provides information on how to obtain:

- construction history
- pavement condition
- traffic data
- minimum acceptable levels of field work required for pavement designs

4.1 Resource Information

4.1.1 Construction History

Pavement designs begin with researching construction history. Construction history:

- develops a field investigation strategy,
- determines the existing material types and depths, and
- evaluates the performance of existing materials.

ODOT maintains a record of As-Constructed drawings commonly referred to as “V-Files”. Use information from the cover sheet, details, typical pavement sections and summary. V-File information can be obtained from

http://highway.odot.state.or.us/cf/highwayreports/vfile_parms.cfm

The V-Files are valuable resources, but the information contained in the files is not always complete. Also, maintenance preservation work is usually not included in the V-Files.

4.1.2 Pavement Condition

The Pavement Management System (PMS) can provide construction history, condition trends, and pavement condition information. Obtain summary information for each section of highway in the Pavement Condition Report, available online at:

https://www.oregon.gov/ODOT/Construction/Pages/Pavement-Management-System.aspx

The report provides condition information on each section of highway and information on the rating procedures.

4.1.3 Traffic Data

Traffic data is a critical component of any pavement design analysis. Traffic data typically consists of average annual daily traffic (AADT), an annual growth rate or expansion factor, and a percentage of the AADT in each of the 13 federally designated vehicle classes (axle categories). A more detailed discussion of the traffic data analysis is found in Chapter 5.

Traffic information can be obtained from the ODOT Transportation Management System (OTMS) at 503-986-4251. **The growth rate and traffic data for ESAL calculations for ODOT projects must be obtained from ODOT for each specific project requiring a pavement design**.

For locations where the roadway use or configuration is not changing, and has not recently changed, use ODOT Transportation Management System (OTMS) data located at:

http://highway.odot.state.or.us/cf/highwayreports/traffic_parms.cfm

For all other situations, including areas where a OTMS truck or traffic volume count does not suitably capture a segment of road, request traffic data from the ODOT Region traffic engineer or the project-specific traffic engineer. Check traffic data, such as:

- Data trends (year to year)
- Check sudden growth increases in urban areas where truck count goes up, but there is no place for additional trucks to join traffic flow
- Check growth decreases (they are unusual)
- Check possible construction influences at time of count

4.2 Field Reconnaissance

The Designer should visit the site to determine the type and extent of field investigation needed for the project, specific testing locations, and possible traffic control requirements. If the Designer is unable to visit the site, the pavement section can be viewed on ODOT's Digital Video Log (internal link only):

http://rssa.odot.state.or.us/cf/dvl/index.cfm?&fuseaction=entry

4.3 Field Investigation

This section discusses the type and extent of field investigation required to develop a pavement design recommendation. This guidance should be considered as a starting point and represents the minimum required level of field investigation. Each project will be unique, so adjust the field investigation plan accordingly.

The following sub-sections outline the field investigation requirements for ODOT projects. Each sub-section discusses the requirements for a particular type of testing, such as deflections, cores, etc. Review the project scope and perform a field reconnaissance to develop the field investigation plan. The field reconnaissance provides the Designer an opportunity to plan investigative work and testing and sampling locations and frequencies. This work is compiled on a Field Work Request (FWR) which is sent to ODOT's Pavement Testing Crew, where they will perform the requested testing per their schedule and availability. Keep crew safety in mind when selecting test locations.

4.3.1 Traffic Control

Traffic control for field investigation and testing must be conducted in accordance with the latest version of "Oregon Temporary Traffic Control Handbook" published by the Oregon Department of Transportation. In the case of Contractor field investigations, traffic control must be conducted in accordance with the contract documents.

4.3.2 Falling Weight Deflectometer

For ODOT projects, deflections must be measured with a Falling Weight Deflectometer (FWD), in accordance with ASTM-D4694. The FWD applies loads to the pavement of approximately 6,000, 9,000, and 12,000 pounds and measures the deflections in at least 7 locations. Sensors must be located per AASHTO R32-09 Guidelines. Deviations from the above applied loads and sensor spacing must be approved in writing by the ODOT Pavement Design Engineer (email acceptable).

The FWD must be calibrated routinely per the manufacturer's recommendations. The FWD load cells and sensors must be calibrated at a Regional Calibration Center within a 12-month period preceding the date of testing on a project. More information on FWD calibration can be found at:
https://www.fhwa.dot.gov/publications/research/infrastructure/pavements/ltpp/07040/07040.pdf

Prior to beginning work on a project, and as needed or directed, calibrate the FWD's Distance Measurement Instrument to ensure proper distance measurement.

Deflection testing is not required for roadway construction on new alignments. However, deflection testing of adjacent roadways may provide data for the back-calculation of subgrade resilient modulus that may be appropriate for new work design. The Designer must consider the most cost-effective means of obtaining the subgrade resilient modulus (see Section 5.2).

Submit deflection data and analysis as well as FWD calibration information per Chapter 12 of this guide.

4.3.2.1 Deflections on Asphalt Concrete Pavement (ACP)

FWD deflection testing is ordered by the Designer (or, for Consultants, is usually provided by ODOT- see Chapter 12). The field work request (FWR) will detail to the field crew the locations and tests desired by the Designer. If there are deviations from the standard testing, they will be noted on the FWR. The FWR will also include maps. If specific testing locations are needed, the Designer can assist the field crew by going to the site and marking the desired locations. Keep in mind that utility locations must be identified prior to testing if they may be present.

If there are locations that are unsafe to collect (for example, every 250′ ends up with a test location in an intersection or on a bridge), the field crew should adjust and move the test location to as close to the desired location while remaining safe.

Table 2: Standard FWD testing for ACP roadways

Type of facility	Testing required
2-lane facility	Deflections every 250′, one direction, outer wheeltrack (OWT)
Multi-lane facility, Outside lane, truck lane, or B lane	Deflections every 250′, one or both directions (if construction history shows there is a significant difference, test both directions), outer wheeltrack (OWT) of most distressed lane
Multi-lane facility inside lane, passing lane, or A Lane	Deflections every 500′, both directions, inside wheeltrack (IWT) of most distressed lane
Interstate or divided highway	Deflections every 250′, both directions, outer wheeltrack (OWT) of most distressed lane
Widening shoulders, NON structural	Not required
Widening shoulders, structural	Deflections every 250′, in the widening direction, for the appropriate length
Bridge approaches	Perform deflection testing at 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, and 200 feet from each end of the structure
At-grade railroad crossings	Deflection testing at 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, and 200 feet from the stop bar

Deflections are typically measured in the outer wheelpath of the outside lane ("Truck" or "B lane" for multi lanes) for pavement rehabilitation projects. Where multilane facilities exist, the inside lane ("passing" or "A lane") is also tested in the inside wheeltrack (IWT).

If project research, analysis, or institutional knowledge indicates the potential for moisture-related damage, consider obtaining cores and/or deflection data in the inside wheelpath based on engineering judgement. Refer to Section 4.4 for a discussion of moisture sensitivity.

Multi-lane facilities:

Where there are more than 2 lanes in each direction on the same roadbed, the ability to test must be weighed on a case by case basis. These lanes pose both traffic staging and safety complications for the testing crew. The typical spacing for deflection testing is 250 feet. This spacing can be reduced in urban areas or areas of localized structural failure.

Only measure deflections in both travel directions if the construction history warrants it (if sections have differing pavement layers) in accordance with the above requirements for highway sections of multi-lanes in the same direction. Use professional judgment to consider additional testing in the same direction lanes of a multi-lane section if the pavement condition and/or construction history varies significantly.

If widening an existing asphalt concrete (AC) roadway, measure deflections on the shoulder at a maximum spacing of **250 feet** to help determine if the shoulders are structurally sufficient to carry travel lane traffic during construction after widening (Refer to Section 6.1.4 for construction joint location requirements).

Deflection testing is not required if the widening is only to increase shoulder width and the widened shoulder will not carry travel lane loads now or in the future. If the shoulder may become a lane in the future, deflections may be warranted.

4.3.2.2 Portland Cement Concrete Pavement (PCC)

The deflection testing requirements for Portland Cement Concrete (PCC) pavement are different than for asphalt concrete pavement and depend on the type of PCC pavement. Deflection measurements on PCC pavement can determine material properties, load transfer at the joints, and detect voids. Understand the limitations of FWD testing to evaluate subgrade modulus.

4.3.2.2.1 Continuously Reinforced Concrete Pavement (CRCP)

To determine CRCP material properties, conduct testing in the outside wheelpath or between the wheelpaths based on the requirements of the design procedure used. Consider split tensile testing of concrete cores to estimate existing flexural strength. Test often enough to provide a statistical representation of the material properties along the project. Use the AASHTO R32-09 Guidelines for sensor spacing (previously discussed).

Consider testing at transverse cracks that are spalling or faulted to determine load transfer and the presence of a void. Follow the procedure outlined in Section 4.3.2.2.2.

4.3.2.2.2 Jointed Plain and Jointed Reinforced Concrete Pavement (JPCP and JRCP)

Deflection measurements are required to estimate material properties, load transfer at the joints, and to detect voids for jointed plain concrete pavement (JPCP) and jointed reinforced concrete pavement (JRCP).

Conduct testing in the outside wheelpath or mid-slab to estimate material properties, based on the requirements of the design procedure used. Test often enough to provide a statistical representation of the material properties along the project. Use the normal AASHTO R32-09 Guidelines for sensor spacing unless otherwise approved by the Pavement Design Engineer (email acceptable).

The sensor spacing for load transfer and void detection testing is slightly different than the LTPP spacing. Place a sensor at a distance of 12 inches behind the load cell for JPCP and JRCP testing.

If the sensor located furthest from the load cell to the new location is moved, the resulting sensor spacing is inadequate for material property testing as described in the above paragraph. Instead, add an additional sensor at the required location.

The load cell is placed near the joint in the extreme corner of the slab so that the sensor located at 12 inches from the load cell is on the unloaded slab. Test both the approach and leave slabs at the three load levels discussed above. **All joint testing must be done when the PCC surface temperature is 50°-80°F due to the effects of temperature on the behavior of concrete slabs**. Test often enough to provide a representative sample of the load transfer on the section and the percentage of slabs with voids.

4.3.2.2.3 Composite Pavement

For composite pavements that are AC over PCC, follow the PCC guidelines in 4.3.2.2 based on the type of underlying PCC pavement. The guidance in this section assists in defining material properties. Consider using standard testing each preservation cycle to track potential degradation of the pavement.

4.3.2.2.4 Selecting PCC Test Locations

Consider the pavement condition when selecting test locations. Cracks in PCC pavements affect deflection results considerably. Make every effort to take mid-slab/wheelpath deflections at least 6 feet from a crack or transverse joint on both CRCP and jointed pavements.

CRCP

Transverse cracks naturally occur in CRCP pavements and may be spaced as close as 3 feet from each other and still be considered acceptable. Therefore, for CRCP pavements, testing at least 6 feet from a crack or transverse joint is applicable to transverse cracks that are spalled or faulted, longitudinal cracks and punchouts.

JPCP and JRCP

Test jointed pavements at least 6 feet from a crack or transverse cracks that are spalled or faulted, longitudinal cracks and punchouts. Do not test joints that are severely spalled, faulted or contain corner cracks or breaks and are going to be repaired.

Do not include joints which are tested and found to need repair in the load transfer and void analysis. The load transfer and void detection procedures were developed for intact slabs (NCHRP Project 1-21, 1985). Including test results for repaired slabs will affect the load transfer factor used in the AASHTO Design Procedure and affect the resulting overlay thickness. It will also artificially inflate the number of slabs that require undersealing.

Table 3: FWD testing for PCC roadways

Type of facility	Testing required
2-lane facility	Deflections often enough for statistical representation, both directions, outer wheelpath, mid-slab, at least 6′ away from crack
Multi-lane facility	Deflections often enough for statistical representation, both directions, outer wheelpath, mid-slab, at least 6′ away from crack
Widening shoulders, NON structural	Not required
Widening shoulders, structural	Deflections every 250′, both directions

Note: Designer to verify required load sensor spacing and temperature per 4.3.2.2.2.

4.3.3 Pavement Cores

Existing pavement depths are usually determined by cutting an asphalt concrete (AC) core. Cores must be of sufficient depth and circumference to determine the condition of the pavement layers and crack depths. Consider the requirements of any laboratory testing that may be conducted on cores. ODOT typically collects 4-inch diameter core samples. If pavement cracking is a concern, request that some of the cores to be cut through the cracks to evaluate the extent (depth), type, and severity of the cracking on the FWR for the project.

Take shoulder cores to determine the depth, type and condition of existing materials for the widening of existing facilities. Shoulder cores are required for minor shoulder widening and where the existing shoulder will be incorporated into a travel lane. Compare the core depths to the documented as-built depths and construction history and investigate any discrepancies.

Pavement depth measurements are required for all pavement rehabilitation projects. The maximum spacing for pavement depth measurements is one core every ½ mile for each travel lane or shoulder to be tested.

These core testing requirements are summarized in Table 4:

Table 4: Core Testing Requirements

Project Type	Core Testing Required
Pavement resurfacing (1R)	As recommended by the Designer
New alignment/new construction	None
Widening	On shoulders (for shoulder widening or for shoulders becoming travel lanes)
Pavement resurfacing, restoration, and rehabilitation (3R)	1 core every ½ mile for each travel lane or shoulder
Bridge deck with ACP overlay	1 core mid-span (do not core through the PCC)
Bridge approaches	2 cores on each bridge approach at about 10 feet and 50 feet from each end of the structure or impact panel
At-grade railroad crossings	2 cores on each approach at approximately 10 feet and 50 feet from the stop bar

Record each core on a core log sheet which includes the following information:

- Project name and highway number
- Location of the core, including the mile point, direction, lane, and wheelpath
- Date the core was sampled
- Core length
- Depth of individual pavement lifts
- Description of the material characteristics (see Appendix C)
- If drilled on a crack, the type and depth of crack (fatigue, transverse, etc.)
- A drawing showing the location of the core in relation to stripes and pavement edges

Include core logs and color photographs of each core in the design report as per Chapter 12. An example ODOT Pavement Design Core Log is provided in Appendix C.

4.3.4 Exploration Holes

Exploration holes gather information about underlying base materials and subgrade soils. There is no standard testing for exploration holes; they are determined on a case by case basis, and are requested on the Field Work Request form. Exploration holes supplement as-constructed drawings for base depth, type, and quality and to obtain material information to characterize their properties for use in the design procedure. Base, soil, and moisture samples can be obtained from exploration holes.

Consider exploration holes for:

- New alignments, including top soil stripping depth evaluation
- Widening
- Areas exhibiting base failure
- Reconstruction
- Areas where construction history and/or aggregate base thickness is unknown, but critical to the design

Under Oregon Law (OAR 952, Division 1), a utility locate must be obtained at every location where an exploration hole is to be taken. Utility locates can be scheduled by calling the Oregon Utility Notification Center at 1-800-332-2344. You will need to provide the location, including township, range, section and quarter section for each exploration hole.

For more information: www.callbeforeyoudig.org

Submit copies of exploration hole logs and test results with the pavement design report as per the requirements outlined in Chapter 12 of this guide. Exploration logs must include the following information:

1. Project name and highway number
2. Location of the hole, including the mile point, direction, lane, and wheelpath
3. Depth of material layers
4. Description of the material characteristics, plasticity, moisture, soil classification by the Unified Soil Classification System, consistency or density
5. A drawing showing the location of the hole in relation to stripes and pavement edges

A sample ODOT Pavement Design Exploration Log is provided in Appendix D.

4.3.5 Photographs of Roadway Condition

Photographs provide a visual record of conditions at the time of the field investigation. Photos are recommended for new work sections, but are required on all rehabilitation projects. Photographs must have:

1. A maximum spacing of ½ mile.
2. Photographs must be taken with a digital camera.
3. Photos must be taken looking in both directions at each location.
4. Copies of all photos must be submitted as per the guidelines provided in Chapter 12 of this guide.
5. Photos must be arranged by milepoint and labeled with the date, milepoint and direction of the photograph.
6. Submit digital photographs electronically.

4.3.6 Rut Depths

Measure the rut depths on all rehabilitation projects at a maximum of ¼ mile increments. Measure the ruts in all wheelpaths using a 5- or 6-foot straight edge and estimate measurements to the nearest ⅛ inch. Report the average rut depth and standard deviation for each wheeltrack. Provide a summary of the rut measurements in the design report as per Chapter 12.

Table 5: Rut testing and photograph requirements

Project Type	Rut Testing	Photographs
Pavement Preservation	As recommended by the Designer	As recommended by the Designer
New alignment	None	As recommended by the Designer
Widening	None	As recommended by the Designer
Pavement Rehabilitation	Maximum ¼ mile increments	Maximum ½ mile increments

4.3.7 Bridge Approaches

Structures can present grade control issues for paving projects. Typically, the profile grade at the bridge must be maintained or reduced. Reducing grade occurs when removing asphalt concrete from the bridge deck. When testing at or near a structure:

1. For structures with AC on the deck, obtain at least one core at approximately the mid-span (through the AC only, do not core through the concrete deck). Send core photo to Project Bridge Engineer
2. If an existing approach consists of AC pavement, obtain two cores on each bridge approach at approximately 10 feet and 50 feet from each end of the structure or impact panel
3. Perform deflection testing at 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, and 200 feet from each end of the structure
4. Do not core on a bare Portland Cement Concrete (PCC) deck
5. Do not core on an impact panel. If an impact panel is present, measure from the end of the panel for the above testing locations

A graphical representation of the above testing is provided in Appendix E. If the design plans to replace the bridge approaches, the above testing is not required. However, if they will be rehabilitated, the above testing is required. Refer to Chapter 8 for more information.

4.3.8 Bridge underpasses

Structures that cross over the highway also control proposed grade elevations. If the existing vertical clearance is substandard (check with the Roadway Designer, Project Team Leader, or Consultant Project Manager), complete additional testing of the pavement similar to that completed for bridge approaches. Refer to Sections 6.5.3 and 7.4 for more information.

4.3.9 At-Grade Railroad Crossings

Railroad crossings require the existing grade to be maintained. Testing in the area of railroad crossings has several additional requirements, primarily contacting the railroad company to coordinate any work within the area of the crossing.

Do not perform any testing on railroad right of way (the area between the crossing gates or stop bars when gates are not present) without prior arrangements with the railroad company. Contact ODOT Pavement Design for assistance in arranging field work testing at railroad crossings. The following minimum guidelines apply when testing at or near an at-grade railroad crossing:

- If existing approach consists of AC pavement, obtain two cores on each approach at approximately 10 feet and 50 feet from the stop bar
- Deflection testing at 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, and 200 feet from the stop bar
- Do not test between railroad gates or stop bars if gates are not present

A graphical representation of the above testing is provided in Appendix F.

4.3.10 Pavement Distress Surveys

Pavement distress surveys are an integral part of a successful pavement design. Pavement distresses are visible defects in the pavement surface such as ruts and cracks. Proper distress identification helps the Designer determine the likely cause of failure such as whether the distress is due to structural or environmental effects. The distress surveys also help the Designer:

- develop the field investigation plan
- determine if reflective cracking will be a factor in the rehabilitation performance
- locate areas that require localized repairs

ODOT has adopted pavement distress definitions for both network and project level pavement distress surveys based on the Strategic Highway Research Program Distress Identification Manual for the Long Term Pavement Performance Project, SHRP-P-338. However, ODOT has modified some of the definitions and measurement protocols to better suit Oregon conditions. The ODOT Pavement Management Group Distress Survey Manual is available at the following link:

https://www.oregon.gov/ODOT/Construction/Pages/Pavement-Management-System.aspx

There are no required methods or forms for conducting distress surveys. It is up to the Designer to develop a system that works best for the particular project.

The minimum information required in a distress survey includes:

1. Type of distress
2. Severity of distress
3. Extent of distress
4. Location of distress

For asphalt concrete and CRC pavements, use a simple form such as the one shown in Appendix H. For reinforced and plain concrete pavements with joints, ODOT recommends that the Designer review the 10th mile detailed distress data available in ODOT's Pavement Condition Data (available from the Pavement Services Unit). "Drive" the ODOT video log and examine the pavement. Cross reference the visual defects with the distress data to map out possible locations that will require Asphalt Concrete Pavement Repair (ACPR) or concrete repair. The Region's maintenance crews may also be a valuable resource for recurring issues that require repair in the field.

4.4 Laboratory Investigation

Use laboratory testing on a case-by-case basis to supplement the field investigation and to evaluate material samples collected in the field. Laboratory testing should not replace field investigation unless absolutely necessary.

Laboratory testing should be kept to a practical minimum to reduce project costs.

Soil sample naming convention for ODOT projects is typically done with the Unified Soil Classification System (USCS).

4.4.1 Laboratory Tests

Laboratory testing of materials may include (but are not limited to) the following:

- Existing ACP: Void content, bulk & theoretical maximum density (Rice), indirect tensile strength, susceptibility to stripping, binder extraction/grading.
- Existing aggregate base: Gradation, Atterberg Limits
- Existing subgrade: Classification, Atterberg Limits, moisture/density, resilient modulus, natural moisture content

The condition of asphalt core samples can be compared based on percent density. The asphalt lift(s) of interest can be tested for bulk specific gravity, and the maximum theoretical density can be obtained from construction records or by performing AASHTO T-209.

Compare the strength of asphalt core samples based on the as-received (unconditioned) indirect tensile strength value. The asphalt lift(s) of interest are placed in a 77 ± 1°F water bath for 2 hours ± 10 minutes, and then tested for indirect tensile strength according to AASHTO T-283.

MOISTURE RELATED TESTING

Consider and possibly investigate moisture-induced stripping. A significant number of highways have been improved since the 1970s- 1980s. The potential for moisture-related damage has increased as those pavements age, as evidenced by several recent ODOT rehabilitation investigations. ODOT sponsored a research project to examine and recommend procedures to reduce moisture-related damage and distress in asphalt pavements as a result of several rehabilitation failures. That research resulted in a publication which includes checklists for investigation, testing, and design of pavements that have potential for moisture-related damage. More information is available in the report *Investigating Premature Pavement Failure Due to Moisture*, FHWA-OR-RD-10-02, Scholz and Rajendran, ODOT/FHWA, July 2009. A copy can be obtained from the ODOT Research website.

Within the document is a link to the appendices, which contain the appropriate checklists.

The checklist for investigation and design should supplement the standard design methodology for asphalt pavements with greater than 10 million 20-year design ESALs and meeting the criteria for mandatory lime, or the lime/latex treatment requirements of Section 10.4.

ODOT Pavement Services has not found a strong correlation between subgrade CBR or R-value tests and Resilient Modulus. Therefore, CBR or R-value testing is not appropriate for use in ODOT designs without site-specific correlations approved by ODOT.

4.4.2 Testing Frequency

The specific needs of the project will dictate the frequency of laboratory testing of existing materials. Factors to consider may include (but are not limited to) the following:

- Low confidence level in field investigation test analyses as a result of unexplainable variability or deviation from normally accepted values
- Project locations that are not conducive to on-site field testing
- Verification of marginal or borderline field test results
- Analysis of material properties that are non-testable in the field

CHAPTER 5: DESIGN PROCEDURE INPUT PARAMETERS

The material presented in this chapter relates to the 1993 AASHTO Pavement Design Procedure. Other pavement design procedures may have additional design requirements not discussed in this chapter. The Designer is responsible for following the guidelines of the pavement design procedure that is selected.

ODOT has approved the use of the Pavement ME software provided by AASHTO as a pavement design method **for PCC pavements**. Each of these subsections will detail the parameters accepted by ODOT for Pavement ME as well as for the conventional method.

5.1 Traffic Analysis

Traffic analysis begins with the conversion of traffic into 18-kip Equivalent Single Axle Loads, or ESALs. This is true for both conventional methods and Pavement ME, which requires it for input for analysis.

In order to estimate design ESALs, the Designer must know:

- the average daily traffic (ADT)
- percent trucks (CAADT)
- vehicle class distribution
- an annual growth rate or expansion factor

ODOT uses conversion factors to convert daily truck counts into annual ESALs. The conversion factors were developed from the AASHO Road Test Equivalency Factor Equations (Volume 2, AASHTO Guide for Design of Pavement Structures, Appendix MM). ODOT Conversion Factors were first based on studies of average truck weights found on the Oregon State Highway System. Research on truck axle weights from weigh-in-motion (WIM) technology updated the previous ESAL conversion factors. Based on this research, and a study of national and adjacent state conversion factors, ODOT updated the matrix (Table 7) for selecting the appropriate conversion factor based on FHWA truck classification (Table 8) and pavement type (flexible (AC) or rigid (PCC)).

AASHTO 1993 Pavement Design uses a Lane Distribution Factor D_L. The lane distribution factor is expressed as a ratio, which accounts for distribution of traffic when two or more lanes are available in one direction. AASHTO 1993 Design of Pavement Structures suggests the following guidelines, which ODOT uses also:

Table 6: Lane Distribution Factors

Number of Lanes in Each Direction	Percent of 18-kip ESAL in Design Lane
1	100
2	80-100
3	60-80
4	50-75

One-way or two-way traffic conversion factors have been replaced with a "directional factor." The directional factor accounts for the adjustment to the ESAL calculation, which brings the traffic data in line with the methodology used in AASHTO's Pavement ME.

The ADT may be based on a one-way traffic count or a two-way traffic count depending on where the Designer obtains the traffic data. For one-way traffic, the directional factor will equal 100%. For two-way traffic, the typical directional factor will be from 50 to 60%, with ODOT adopting a 55% value as recommended by the AASHTO Mechanistic-Empirical Pavement Design Guide, Interim Edition: A Manual of Practice and subsequent addendums, (2015) (2015 MEPDG), unless otherwise documented. Roundabouts should use a directional factor of 75%.

Table 7: Directional Factors

Type of traffic	ODOT Directional Factor
One-way	100%
Two-way	55%
Roundabouts	75%*

*If there are project specific traffic counts that provide further detail, use that data instead.

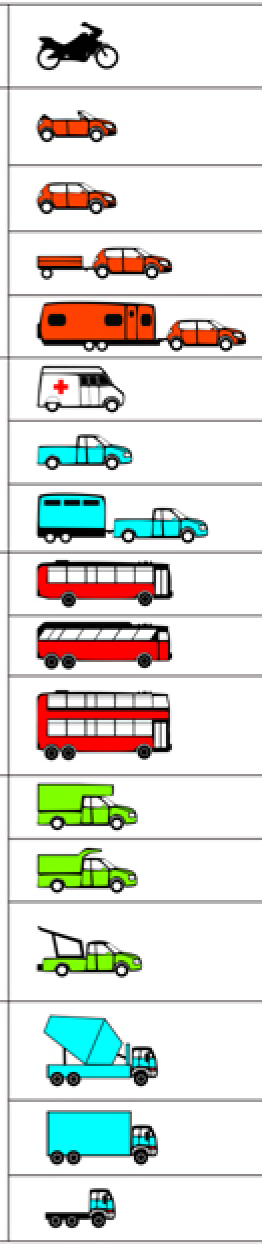
CAUTION: AASHTOWare Pavement ME currently uses average annual daily *truck* traffic (AADTT) as the traffic input rather than average annual daily traffic (AADT).

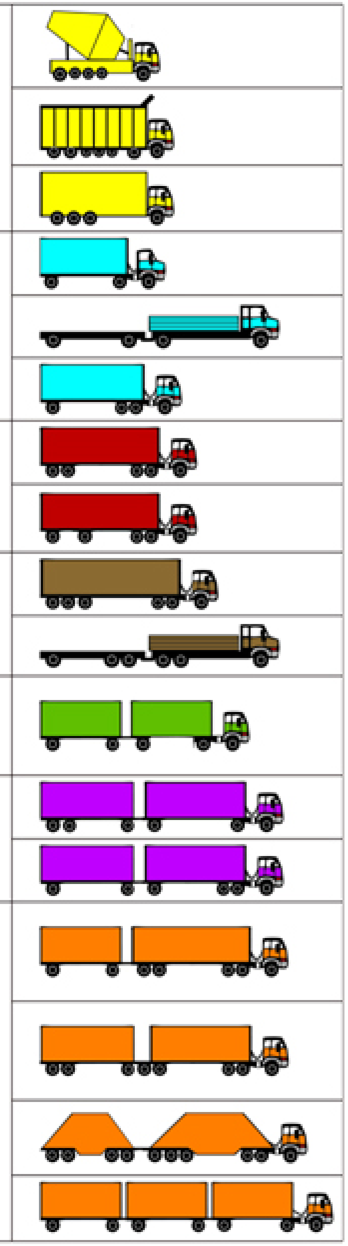
Table 8: ESAL Annual Conversion Factors

ESAL Conversion Factors		
FHWA Classification	**Flexible Pavement**	**Rigid Pavement**
4	246	269
5	104	99
6	284	417
7	757	1199
8	253	277
9	466	715
10	561	912
11	603	606
12	546	663
13	1037	1660

Table 9: FHWA Truck Classifications

Class	Description
Class 1	Motorcycles
Class 2	Passenger cars
Class 3	Four tire, single unit
Class 4	Buses
Class 5	Two axle, six tire, single unit
Class 6	Three axle, single unit
Class 7	Four or more axle, single unit
Class 8	Four or less axle, single trailer
Class 9	5-Axle tractor semitrailer
Class 10	Six or more axle, single trailer
Class 11	Five or less axle, multi trailer
Class 12	Six axle, multi-trailer
Class 13	Seven or more axle, multi-trailer





Source: Federal Highway Administration

CALCULATING DESIGN ESALs

The daily truck counts from each FHWA classification are multiplied by the conversion factor in Table 1 to arrive at an annual ESAL value. The annual ESALs from each class are summed to a total annual ESAL value. The ESALs must be expanded to the year of construction and then forecasted to the end of the design life using the annual growth rate. The design ESALs are the sum of the annual ESALs through the design life, starting with the year following construction. A spreadsheet can be developed to expedite calculations.

Part 2, Section 2.1.2 of the 1993 AASHTO Guide for Design of Pavement Structures provides guidance on the percentage of total ESALs to assign to the design lane on multi-lane highways.

A detailed discussion on ESAL calculations is provided in Appendix D of the 1993 AASHTO Guide for Design of Pavement Structures. Although Pavement ME does not use ESALs directly in the damage calculations, the traffic inputs are as defined in this section. The ODOT method of traffic conversion discussed above was developed specifically for Oregon truck traffic. An example ESAL calculation using the revised ODOT Conversion Factors is provided in Appendix I.

5.2 Subgrade Resilient Modulus (M_R)

The resilient modulus (M_R) of the subgrade soil is an important factor in pavement design methods. Selection of an M_R value for subgrade is a critical step in the 1993 AASHTO Pavement Design Procedure and is necessary for each material type in MEPDG analysis. A discussion on roadbed soil can be found in Part 1, Section 1.5 of the 1993 AASHTO Guide for Design of Pavement Structures.

The Designer must be familiar enough with the project roadway design to understand if the subgrade will be in "cut or fill" (native soil versus embankment – on-site or imported) and the types of soil material (granular or fine-grained).

Back-calculation from deflection data is the standard method to calculate the subgrade M_R for pavement rehabilitation projects. Back-calculation can also be used to determine an M_R for widening or minor realignment of highways. Back-calculation requires knowledge of the existing pavement structure and data collected from a Falling Weight Deflectometer (FWD). (Refer to Chapter 4: Data Collection for FWD testing requirements). Back-calculation methods include those defined in the AASHTO 1993 guide, and programs such as:

- *EverCalc* from the Washington DOT
- BAKFAA from the Federal Aviation Agency
- Backcalculator Tool (BcT) from Pavement ME
- MODULUS from TXDOT

Lab or field determined values of resilient modulus can be used for new work sections where back-calculated subgrade M_R values are not attainable. Another available method is to perform on-site Dynamic Cone Penetrometer (DCP) testing and apply an appropriate correlation. The correlation equation chosen for ODOT work is from TRB Paper No. 99-1007:

M_R (psi) $= C_f \times 49023 \times (DCP)^{-0.39}$ (Must be multiplied by correction factor if used as input into AASHTO 1993, see discussion in following paragraphs)

- DCP is mm/blow
- M_R is in psi
- C_f is defined below

Note that this equation, while used for both plastic and non-plastic soil types, is not suitable for high plasticity clays.

For the pavement design of minor roads off the State Highway System, soil classification (AASHTO or USCS) and experience/engineering judgment can be used as part of the basis for selecting a reasonable subgrade M_R value.

Most pavement design procedures are sensitive to subgrade modulus. Calculate or test the modulus with procedures that are consistent with the design procedure. Historical records, experience, and sound engineering judgment are valuable tools to assist in arriving at a final design M_R.

The Designer should be cautious of any M_R values found to be greater than 8,000 psi (55 MPa) for use in the 1993 AASHTO design procedure, as this value represents a strong subgrade, which is not commonly encountered in Oregon.

HISTORY OF AASHTO FLEXIBLE DESIGN EQUATION

The soil at the AASHO Road Test Site was A-6 silty clay with a M_R of 3,000 psi (20.7 MPa). The AASHTO flexible pavement design equation was developed using the M_R value from the AASHO Road Test Site. M_R values back-calculated from non-destructive testing data were three or more times the value determined from lab tests and therefore must be multiplied by an adjustment factor to make them consistent with saturated laboratory-tested samples used in the AASHTO design equation. This adjustment procedure is explained in detail in Part 3, Section 5.3.4 of the 1993 AASHTO Guide for Design of Pavement Structures.

CORRECTION FACTORS RECOMMENDED FOR ODOT PROJECTS

Since the 1993 AASHTO Guide was published, additional research has been conducted which further refines the correction factor (Cf) for both the DCP, FWD, and select other types of non-destructive testing.

In general, the research supports AASHTO's recommended correction factor of **0.33** for subgrade under AC pavement.

The coefficients listed in Table 8 should be used for most ODOT projects, based on AASHTO (1993), MEPDG (2015 plus addendums), FHWA-RD-97-076 (1997), FHWA-RD-97-083 (1997), Resilient Modulus Testing for Pavement Components - ASTM STP1437 (2003), and limited ODOT Pavement Services calibration. Note that site-specific conditions, especially the time of year the non-destructive testing is performed, may justify the use of alternate correction factors. Provide justification for using alternate correction factors in pavement design documentation.

Table 10: C_f for DCP and FWD to Convert M_R to an Equivalent Saturated Laboratory M_R

Layer Type and Location	C_f
Subgrade Below AC and Aggregate Base	**0.35**
Aggregate Base or Subbase Below AC	**0.62**
Subgrade Below PCC or CTB	**0.25 to 0.35***
Aggregate Base or Subbase Below PCC	**0.62****

** A higher coefficient may be appropriate for DCP values or areas where the subgrade has been deflected enough with a FWD to more closely represent a laboratory M_R test. Some studies have indicated that FWD testing on PCC or above CTB indicates inflated M_R values due to low subgrade strain and associated apparent low-strain stiffness. Use engineering judgment substantiated by field data and parametric comparison.*

***Use caution when back-calculating FWD dates for base or subbase modules below PCC due to commonly a thin base layer and low deflections. ODOT Pavement Services typically groups all layers below PCC as one layer during back-calculation.*

Provide documentation showing the procedure used to determine the design subgrade M_R. Include any lab test reports, FWD data, and any other relevant information, and a summary providing support for the subgrade M_R used in the pavement design. When a design subgrade M_R value of 8,000 psi or greater is used, specific site data is required. Specific site data shall be either laboratory M_R testing, back-calculated M_R from FWD data, or Dynamic Cone Penetrometer using ODOT correlation. Refer to Chapter 12 for specific requirements.

5.3 Typical AASHTO Design Inputs

The 1993 AASHTO Guide basic design equation for flexible pavements is widely used and has the following form:

$$\log_{10}(W_{18}) = Z_R \times S_o + 9.36 \times \log_{10}(SN+1) - 0.20 + \frac{\log_{10}\left(\frac{\Delta PSI}{4.2-1.5}\right)}{0.40 + \frac{1094}{(SN+1)^{5.19}}} + 2.32 \times \log_{10}(M_R) - 8.07$$

where: W_{18} = predicted number of 80 kN (18,000 lb.) ESALs

Z_R = standard normal deviate

S_o = combined standard error of the traffic prediction and performance prediction

SN = Structural Number (an index that is indicative of the total pavement thickness required)

= $a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \ldots a_i$ = i^{th} layer coefficient
D_i = i^{th} layer thickness (inches)
m_i = i^{th} layer drainage coefficient

ΔPSI = difference between the initial design serviceability index, p_o, and the design terminal serviceability index, p_t

M_R = subgrade resilient modulus (in psi)

5.3.1 Reliability

Reliability is "a means of incorporating some degree of certainty into the design process to ensure that the various design alternatives will last the analysis period. The reliability design factor accounts for change variations in both traffic prediction (w18) and the performance prediction (W18), and therefore provides a predetermined level of assurance (R) that pavement sections will survived the period for which they were designed." (AASHTO Guide for Design of Pavement Structures, 1993).

Select a level of reliability for the pavement design in accordance with the pavement design procedure chosen. Table 9 shows the reliability levels for use in pavement designs for ODOT projects using the 1993 AASHTO Guide. Table 10 shows the reliability levels for designs using MEPDG. Deviations from either table must be approved in writing by the ODOT Pavement Design Engineer (email acceptable).

Table 11: Reliability Levels for 1993 AASHTO Guide Designs by Functional Class

Functional Class	Reliability Levels	
	Urban	**Rural**
Interstate	90	90
Principal Arterial	90	85
Minor Arterial/ Major Collector	85	85
Minor Collector	85	80
Local	75	75
Interstate Detour (<1 year)	75	70
Interstate Detour (>1 year)	75	75
Other detour (<1 year)	60	60
Other detour (>1 year)	65	65

Table 12: Reliability Levels for MEPDG Designs by Functional Class

Functional Class	Reliability Levels	
	Urban	**Rural**
Interstate/Freeway or Expressway	95	95
Principal Arterial	90	85
Minor Arterial/ Major Collector	85	80
Minor Collector	80	75
Local	75	70
Interstate Detour (<1 year)	75	70
Interstate Detour (>1 year)	75	75
Other detour (<1 year)	60	60
Other detour (>1 year)	65	65

5.3.2 Initial and Terminal Serviceability

The difference in present serviceability index (PSI) between construction and end-of-life is the serviceability life. AASHTO 1993 Guide for Design of Pavement Structures has the range of PSI as “0 (impossible road) to 5 (perfect road).”

AASHTO 1993 Guide recommends a post-construction PSI of 4.0 – 5.0 depending upon construction quality, smoothness, etc.

The Guide recommends an end-of-life PSI (called “terminal serviceability”) of: 2.0 – 3.0 depending upon road use (e.g., interstate highway, urban arterial, residential).

Typical ODOT values for initial serviceability are 4.5 for rigid pavement and 4.2 for flexible pavement. For terminal serviceability, AASHTO recommends 2.0 – 2.5 for low volume roads (<3,000 ADT), 2.5 – 3.0 for medium volumes (3,000 – 10,000 ADT) and 3.0 – 3.5 for high volumes (>10,000 ADT). Part 2, Section 2.2.1 of the 1993 AASHTO Guide for Design of Pavement Structures discusses serviceability.

Table 13: Initial Serviceability Values

	Flexible Pavement	Rigid Pavement
Initial Serviceability	4.2	4.5
AASHTO	4.0- 5.0	4.0- 5.0

Table 14: Terminal Serviceability Values

	Low Volume Roads (<3,000 ADT)	Medium Volume Roads (3,000- 10,000 ADT)	High Volume Roads (>10,000 ADT)
AASHTO	2.0- 2.5	2.5- 3.0	3.0- 3.5
ODOT Pavement Design	2.5	2.5	2.5
ODOT Detours	2.0	2.0	2.0

ODOT pavement designs usually use a terminal serviceability value of 2.5; detour or diversion pavement designs for non-interstate roads can be designed to a value of 2.0. Different values from those shown for ODOT can be used if the Designer provides adequate justification.

5.3.3 Overall Standard Deviation

Overall standard deviation is a design input for the AASHTO procedure for uncertainty in traffic estimation and varying construction materials and conditions. AASHTO recommended values are included in Part 1, Section 4.3 of the 1993 AASHTO Guide for Design of Pavement Structures.

Use an overall standard deviation value for ODOT pavement designs of 0.49 for flexible pavements and 0.39 for rigid pavements.

Table 15: Overall Standard Deviation Values

	Flexible Pavement	Rigid Pavement
ODOT Overall Standard Deviation	0.49	0.39

5.4 Layer Coefficients for AASHTO Design Procedure

Table 3 summarizes layer coefficients for use in the AASHTO Design Procedure which Designers should use for analyzing and/or designing **new** pavement structures. Other layer coefficients for new material may be used at the Designer's discretion if they are justified with an engineering assessment of the material.

For existing materials, use coefficients obtained from material testing performed in the field or laboratory (such as back-calculated values from FWD testing.)
A discussion on AASHTO layer coefficients can be found in the 1993 AASHTO Guide for Design of Pavement Structures, Part 2, Section 2.3.5. Generalized values that correlate pavement condition or soil type to modulus values should be used only when pavement testing values are not available, and should be well justified and documented in the report. These values are only an option for small projects and require the Pavement Design Engineer's approval (email acceptable).

Table 16: Layer Coefficient by Material Type

Material	Layer Coefficient (per 1 inch of thickness)
New Asphalt Concrete	**0.42**
New Aggregate Base	**0.10**
New Asphalt Treated Permeable Base (ATPB)	**0.24**
New Aggregate Subbase	**0.08**

If the pavement investigation reveals stripping (usually found by examining cores), provide calculations for a minimum depth of PCC or AC over the stripping to ensure structural capacity (or show how the stripped material will be removed in the design).

5.5 Drainage Coefficient

Adequate drainage is essential for any pavement to succeed long-term. Drainage issues can impact both the subgrade and aggregate base materials. The AASHTO pavement design method allows the Designer to modify the aggregate base or subbase layers based on drainage characteristics. The drainage coefficient (m_i) varies based on the quality of drainage (Excellent to Poor) and the percent of time the structure is exposed to moisture levels approaching saturation.

AASHTO 1993 Guide has a chart of guidance for drainage coefficients, with "excellent drainage" having water removed within 2 hours and "very poor" being water that will not drain. Quick draining layers would have a higher coefficient while poor draining soils would be below 1.0. Since ODOT takes care to ensure that poorly draining bases and subbases are supplemented with subgrade stabilization, a value of 1.0 is used for pavement design calculations.

For ODOT pavement designs, assume that the layer coefficients for new aggregate base or subbase produced under ODOT specifications already include modification for field performance due to moisture conditions. **A drainage coefficient of 1.0 will normally be used for design purposes**. The use of any other drainage coefficient will require written approval (e-mail acceptable) by the ODOT Pavement Design Engineer.

CHAPTER 6: NEW WORK AND RECONSTRUCTION DESIGN

New work is defined as the construction of new pavement. New work includes widening of existing roads and construction of new alignments. The reconstruction of roadways on existing alignments is considered *pavement rehabilitation*. Although they have different definitions, the design and analysis for new work and reconstruction are the same and are outlined in the following section.

6.1 Asphalt Concrete Pavement Design Requirements

6.1.1 Minimum Design Life

Design Life is defined the period of time the pavement is engineered to perform before reaching its terminal serviceability or a condition that requires pavement rehabilitation, based on calculations.

The minimum structural design life for new AC pavements is 20 years. Minimum structural design life criteria for new work designs in urban or curbed corridors or at ODOT bridge approaches, grade-constrained underpasses, and railroad crossings is 30 years, and is further discussed in Chapter 8.

Table 17: Minimum Pavement Design Life: AASHTO 1993 Method

Pavement project type	Minimum design life (years)
Rehabilitated AC Pavements	15
New AC Pavements, rural and not grade constrained	20
New AC pavements at bridge approaches	30
New AC pavements in urban or curbed corridors	30
New AC pavements at grade-constrained underpasses	30
New AC for roundabouts, urban and/or grade constrained	30
New AC pavements at railroad crossings	30

All MEPDG (Pavement-ME) designs require a 50-year design life.

6.1.2 Minimum AC Thickness

6.1.2.1 Structural Requirements

Base the design AC thickness on a layered analysis approach, which determines the minimum thickness of AC required above the base layer for the design ESALs. This analysis determines the minimum thickness of AC required to resist structural deterioration (fatigue cracking) of the asphalt layer. This procedure is explained in Part II, Section 3.1.5 of the 1993 AASHTO Guide for Design of Pavement Structures.

The thickness of the AC layers should be rounded up to the nearest ½ inch.

MINIMUM AC CALCULATION EXAMPLE

ODOT uses an aggregate base modulus of 20,000 psi. Using the base modulus as the input for subgrade M_R (all other AASHTO design inputs remaining the same), what is the minimum ACP thickness required?

From the AASHTO 1993 pavement design equation and the discussion on Layered Analysis in the AASHTO 1993 book, Section II, 3.1.5:

$SN= a_1D_1+ a_2D_2m_2+ a_3D_3m_3$

Where:
a= layer coefficient representative of surface, base, and subbase
D= thickness (in inches) of the surface, base, and subbase courses, respectively
m= drainage coefficient (typically 1.0 for ODOT designs)

To calculate the SN required for minimum AC, calculate the SN from the AASHTO 1993 pavement design equation using the M_R of 20,000 (the value for the aggregate base.) Then solve for the thickness of the AC layer.

If the required SN is 2.5 for the aggregate base,

$SN= a_1D_1$
$SN_{\text{agg base}} = a_{AC}D_{AC}$
$2.1= (0.42)(D_{AC})$
$D_1= 5.0$ inches

A minimum AC thickness of 5.0 inches is required above the base layer (2.1/0.42).

If a design procedure other than AASHTO is used, the minimum AC thickness must be determined in accordance with the design procedure.

For high volume applications (>30 million ESALs), ODOT research and experience indicates that a practical maximum thickness of quality new ACP (4 to 7% in-place air voids) is 10-13 inches based on fatigue resistance at the base of the AC layers.

ACP thickness greater than 12 inches should be checked for fatigue resistance based on limiting strain criteria at the bottom of the ACP. A mechanistic pavement design may be required to check the limiting strain and determine a cost-effective pavement design. Contact ODOT Pavement Services for additional information.

For projects with greater than 60 million design-lane ESALs or 30 inches total AC and aggregate base depth (excluding subgrade stabilization), contact the ODOT Pavement Design Engineer for appropriate design procedures.

Table 18: Practical AC Thickness for High Volume Applications

ESAL Volume	Practical Maximum Thickness (inches)
> 30 million	10- 13
> 60 million	Contact Pavement Design Engineer

6.1.2.2 Shoulders

For new work or reconstruction where shoulders are built at the same time as travel lanes, design the shoulders to the same asphalt thickness and materials as the travel lane. Where shoulders are reconstructed separate from the travel lane, refer to the following section *Roadway Widening*.

In rare instances, a design life of 2-years for shoulder design is acceptable with Pavement Design Engineer approval and proven adequate drainage. The rationale for a 2-year design life is that this period corresponds to a typical maximum detour duration. Examples include widening in a very rural area with low AADT/ESALs for a bicycle facility.

Consider risks such as:

- Future realignment that may want to include this section
- Future widening that may want to include this section
- Drainage issues caused by a thin shoulder

OPEN GRADED SHOULDERS (F-MIX)

The following are recommendations regarding projects where open graded mix is present on the roadway.

CRCP sections: For sections with 2″ of ACP over existing CRCP, moisture damage to the underlying ACP is not a concern. Consider the following recommendations:

- Leave the open graded shoulders on the uphill side
- Mitigate drainage issues caused by longitudinal gradients
- Consider fog sealing the shoulders

For sections with 4″ of ACP or more over existing CRCP, or for ACP sections, consider the following recommendations:

- Slurry seal the shoulders (unless the shoulders are narrow enough to simply pave, typically 2′-4′ wide)
- Inlay the shoulders with dense mix in critical areas, such as longitudinal gradients
- Make sure rumble strips are located in the dense mix

- If the project raises grade, overlay downslope open-graded mix on shoulders. Allow upslope open graded mix to be buried on shoulders only on a case by case basis, with the Pavement Design Engineer's approval (email acceptable)

6.1.2.3 Temporary Construction Crossovers

Some projects require a temporary construction crossover in order to mitigate traffic needs during construction. At the time of the publication of this Guide, temporary crossovers are being constructed as if they will remain in place and be used again in the future.

The design process for a temporary crossover is to treat it as if it were the required section for a 24-month detour unless longer staging needs are required for the project.

Additionally, the temporary crossover should be fogsealed after the construction is finished, to help protect it against environmental decay (oxidization and hardening).

6.1.2.4 Rumble Strips

Rumble strips are an important road safety feature. However, there are some existing pavement types that do not accept the milling action well, and can crumble or become damaged from their installation. Chip seals over rumble strips are an effective way to prevent deterioration or moisture damage.

Rumble strips should not be installed on existing EAC or existing oil mat pavement, either in the shoulder or centerline.

See Section 7.7.5 for additional guidance.

6.1.3 Roadway Widening

Use the existing shoulder for widening travel lanes if the Designer's calculations show that the shoulder section has the structural capacity to carry the expected traffic loads (Refer to Chapter 4: Data Collection for testing requirements). The structural capacity should at least match the existing travel lanes or newly widened section (whichever is greater). Check whether the existing AC thickness is sufficient to resist fatigue cracking (described in Section 6.1.2). If the shoulder is structurally inadequate, it must be reconstructed or rehabilitated sufficiently to carry the anticipated design traffic.

When widening a roadway, provide continuity with the adjacent pavement section. Examples to **avoid** are:

- Asphalt to concrete transitions (particularly in wheelpaths)
- Pavement sawcutting in the wheelpath
- Using a stiff base next to a flexible base (avoid if possible)

At a minimum, the design must use materials of comparable structure and provide adequate drainage from underneath the existing pavement. This may require constructing the top of subgrade for the widening at the same elevation as the existing subgrade, or providing an underdrain at the edge of the existing pavement which outlets beyond the new pavement structure.

Interstate highway shoulders present a unique design situation. Shoulder widening may be required to provide a paved surface to meet updated safety standards. Many sections of interstate highway shoulders were originally designed to a minimum depth of 4 inches, and now need to be reconstructed to meet staging needs for travel lane repairs or bridge replacements. Consider the staging needs of current or upcoming projects.

As a practical minimum, interstate shoulders should have at least 6 inches ACP and 12 inches aggregate base, placed according to specifications 00745 and 00641 respectively.

CORRIDOR PLANNING

A planned and scoped project may call for shoulder widening, or the addition of a lane, without considering the existing pavement structure and whether or not it also needs improving. It is essential that the Designer also analyze the condition of the existing lanes and shoulder, and make recommendations to the Project Team as early as possible in the design if the existing lanes need improvement.

It is important to attempt to match the design life of the new pavement to the existing pavement. If, for example, a new lane is added to an interstate (widening), and the existing interstate lanes are at the end of their design life, it does not make financial or engineering sense to add a new lane with a 30-year design life knowing that the existing lanes need improvement immediately. It is costly to cause construction in the same corridor two or more times in a short period of time, and cost beneficial to combine construction efforts when mobilized.

If the design adds a new full-width travel, turn, or auxiliary lane for more than 1000 feet, then the pavement service life of the existing adjacent lanes must match the required service life of the new lane (unless a Life Cycle Cost Analysis shows that this does not have enough cost benefit).

For downtown or urban corridors, a project with ADA improvements, bike/pedestrian improvements, or other non-paving improvements may be programmed on a corridor that has poor pavement. Every effort should be made to include needed paving activities in the project at the same time, so the traveling public only endures construction once, and we can realize the financial benefits of performing several construction activities at the same time.

6.1.4 Joint Location

Construction joints in a pavement-wearing surface must not be placed in a wheelpath. In addition, for widening projects, the saw-cut edge of the existing pavement should be at a stripe or mid-lane (between the wheelpaths).

Construction joints in wheelpaths have a harmful effect on long-term pavement performance. Joints in the wheelpath contribute to differential movement across the joint, material segregation and compaction problems under traffic loading. In urban areas where the wearing surface must be tapered to maintain curb exposure, the construction joint is sometimes forced into, or near, the wheelpath. This is considered acceptable when geometric constraints control.

For pavement preservation treatments only, follow the additional guidelines below to accommodate for bicycle traffic:

BICYCLE TRAFFIC ACCOMMODATIONS (PAVEMENT PRESERVATION ONLY)

Overlays

- Overlays, including thin lift overlays, should extend across the entire shoulder.

Inlays

- If shoulder is in poor condition, inlay the shoulder. Use the ODOT condition rating system.
- If the shoulder is 2 feet wide or less, inlay the shoulder. Consider inlaying the entire shoulder from a cost, convenience of construction, and travel lane smoothness perspective if the shoulder is on the order of 2 to 4 feet wide.
- If the shoulder is in fair or better condition and wider than the 2 to 4 feet mentioned in the previous bullet – Follow the following guidance:
    - If there is a significant potential for truck traffic on the shoulder, extend the inlay joint beyond the fog line, typically 2 feet. Otherwise, place the inlay joint on the fog stripe.
    - Paving smoothness (for automobile travel lane) may be specified in accordance with current guidance without any additional regard for inlay joint smoothness, since standard specification section 00745.60(e) addresses quality of joint and provides for a smooth joint. However, consider if a smooth travel lane can be constructed if the shoulder, or a portion of it, is left in place.
    - Do not place a longitudinal construction joint within a designated standard width bicycle lane.

Chip Seals and Microsurfacing

- Extend these treatments to either the fog line or one foot beyond the fog line to protect the edge of the treatment from plow damage. Extend the treatment to the edge of pavement if the shoulder needs to be treated based on pavement condition or age.

Published Cycling Routes

- Refer to Appendix P for a map of published Oregon cycling routes.
- The ODOT Bicycle and Pedestrian Program prefers the inlay joint position out of the probable bicycle wheel path. Refer to the guidance below from the ODOT Bicycle and Pedestrian Program for the location of the probable bicycle wheel path. If the inlay joint needs to be further into the shoulder, specifically and only for the purpose of accommodating the probable bicycle wheel path, inform the ODOT project leader or project manager. Pavement preservation funds are intended to preserve the pavement from further deterioration, but not for recreational improvements.

Probable Bicycle Wheel Path:

“Per Oregon law, bicyclists ride “as far right as practicable.” But what does this mean? On roadways with shoulders, it is dependent on the width of the shoulder. On shoulders 4 feet or wider, bicyclists will generally ride about 2 feet off of the fog line. This area of pavement is ‘swept’ by passing motor vehicle traffic and is normally free of debris. Even on wide shoulders 6 feet or greater, most bicyclists will ride within the swept area. If rumble strips are present bicyclists are forced further right – often into debris strewn pavement. Some will chose to ride between the fog line and rumble strip to avoid debris. On narrower shoulders – under 4 feet, bicyclists will ride 1 foot to 18 inches off the edge of pavement. As the shoulder narrows they move into the travel lane.”

Other Considerations

- Do not make a bicycle consideration where bicycles are currently prohibited or on roads where a separate bike path runs along the roadway.
- On roads with less than 2500 ADT, bicyclists typically ride in the automobile travel lane and these roadways typically do not have shoulders. There is no requirement to consider bicycles in the design unless local knowledge of bicycle usage or engineering judgment suggests otherwise.
- If the Designer believes that the extra width of a treatment, required based on this guidance, does not actually improve bicyclist travel on a particular project, consult with the project lead or project manager for an exception to this guidance.

6.1.5 Aggregate Base Design

Aggregate base is a cost-effective material that provides a durable foundation for both protection of the subgrade and a foundation for asphalt concrete. Aggregate base thickness is often calculated after solving for the remaining structural capacity needed after a given thickness of asphalt concrete is specified. However, the Mechanistic-Empirical design method (MEPDG) does not use the concept of Structural Number like the AASHTO 1993 method.

Section 11.1.6 of the 2015 MEPDG, Second Edition, provides an excellent discussion on the concept of moduli ratio as a method of determining minimum aggregate base and subbase depths. Full-strength modulus of an aggregate material may not be obtained using a thinner aggregate base section on soft underlying materials. Also, use of a subbase material may be desirable for economic and other reasons.

ODOT experience has shown that poorly drained pavement sections are more susceptible to asphalt stripping. Therefore, when designing an aggregate base course, consider factors such as thickness of aggregate base, drainage to a ditch, or drainage to a subdrain.

6.2 Portland Cement Concrete (PCC) Pavement Design Requirements

This section covers information related to the construction of new PCC pavements and the widening of existing PCC pavements. For a description of the PCC pavement types typically used in Oregon, refer to Chapter 10. Existing concrete pavement rehabilitation is discussed in Chapter 7. Use the latest version of AASHTOWare Pavement ME program along with the MEPDG 2015 guidance (and addendums) for concrete pavement design.

For projects less than 1 lane mile, AASHTO Guide 1993, with the *Supplement to the AASHTO Guide for Design of Pavement Structures, Part II, Rigid Pavement Design & Rigid Pavement Joint Design*, 1998 may be used. The use of new (jointed or continuously reinforced) concrete pavement for these short projects must be justified by an LCCA.

Continuously reinforced concrete pavement (CRCP) is the standard for concrete pavement on highways with more than 10 million 20-year ESALs, unless the highways are urban streets. If they are urban streets, a jointed PCC should be considered since it better accommodates utilities and intersection needs.

6.2.1 Minimum Design Life

The minimum design life for Portland Cement Concrete Pavement on ODOT highways is 50 years in Pavement ME Analysis.

This minimum life is for all types of PCC – jointed and continuously reinforced pavements. If AASHTO 1993 with the 1998 supplement is used for design of short segments with low traffic, the design life may be reduced to 30 years with approval by the PDE (email acceptable).

6.2.2 Minimum and Maximum PCC Thickness

The minimum recommended thickness for PCC on state highways is 8 inches.

If PCC is used for bus stop pads, roundabouts, roundabout entrances/exits, or other heavy truck stop and start areas, a thicker panel may be needed, due in part to sustained loading. Pavement ME software can accommodate slower traffic and how that affects loading; a separate analysis with slower speeds can be run to calculate the proper thickness for a heavy loaded section. For 1993 AASHTO design method, consult with the PDE. Reference DET-1610, bus pad.

Typically, the thickness for PCC is rounded to the nearest inch, but consider rounding to the nearest ½ inch if the project is large enough to use controlled grade slip form pavers.

If the Designer's calculations recommend a PCC section thicker than 13″, consult with the Pavement Design Engineer.

Ensure that the PCC is designed with enough thickness between the traffic surface and the rebar so that the surface can be diamond ground for maintenance at least twice. The typical depth is 4″ to top of rebar.

6.2.3 Roadway widening

When widening next to existing PCC pavement, consider PCC for the new pavement. Match the existing PCC in thickness and contraction joint location (if jointed). Tie the new PCC to the existing PCC.

6.2.4 Joint Location and Spacing

When constructing a new section of PCC, place the joints per the standard specifications and standard drawings. When widening an existing PCC pavement, place the longitudinal joints at an edge line (skip stripe, fog stripe, etc.) or mid-travel lane. This may require cutting the existing PCC to get the correct placement. Match the new transverse contraction/expansion joints with the existing joints. Do not place joints in wheel tracks. Consider joint location and spacing carefully for roundabouts.

Proper joint design is a key factor in the performance of jointed plain concrete pavement (JPCP).

- Dowelled JPCP is the ODOT standard for jointed concrete pavement.
- Do not use undowelled JPCP in travel lanes unless approved by the PDE.
- Jointed Reinforced Concrete Pavement (JRCP) is only allowed for localized slabs and should not be used on mainline paving. Do not exceed 30′ spacing.

ODOT standard contraction joint spacing is 15 feet for JPCP. Refer to standard details on DET 1600 and DET 1602.

Joint spacing that is too far apart will result in intermediate transverse cracks in the slab. These intermediate cracks can cause pumping, faulting and additional cracking that eventually lead to costly repair.

Give special consideration to non-standard situations. These situations may include:

- intersections
- taper sections
- bus stops
- urban areas with obstacles such as manholes, inlets, etc.
- roundabouts

These special areas require a joint layout detail in the plans and may require additional drawings and modifications to the specifications. The American Concrete Pavement Association (ACPA) provides various documents with guidance for specialized slab details.

There is no design standard for regularly spaced transverse contraction joints for in continuously reinforced concrete pavement (CRCP). However, the Designer does need to design for the transverse crack spacing that naturally occurs. Design transverse cracks for a spacing of 2.5 to 6 feet. The crack spacing and width are controlled by the percentage of longitudinal reinforcing steel in the pavement.

Controlling terminal expansion should allow for expansion and contraction to occur and minimize damage to the pavement. Historically, ODOT used two basic types of terminal expansion joints in CRCP:

1. The lug system. The lug system was used to restrain free end movement.
2. The wide flange beam system. The wide flange beam system was designed to accommodate the free end movement and minimize damage. Several issues had

arisen concerning the long-term performance of the wide flange beam in Oregon, including snow plow damage, fracture and displacement of the top flange, and difficulties in maintenance and repair.

Currently, ODOT uses a terminal system consisting of sleeper slabs supporting the end of the CRCP (constructed without lugs or a beam) and supporting expansion slabs. Design the number of expansion slabs and the space between based on the anticipated thermal movement of the CRCP.

The current ODOT standard is to use a 2-inch wide joint east of Troutdale on I-84, east of the Cascades, or on the Siskiyou Pass. The remainder of the state uses a 1-1/2-inch wide joint.

A terminal end joint system is required in CRCP at all bridge approaches and at the ends of the CRC pavement. Refer to standard details DET 1603 and DET 1604. Contact ODOT Pavement Services with questions.

Where there are longitudinal joints between PCC and ACP pavements on the skip stripe ("black and white" sections), the joint should be sawed and sealed.

6.2.5 Design Details

This section covers specific design related details. Chapter 11 of this guide discusses the specifications and Standard Drawings/Details required for new PCC pavements.

6.2.5.1 Load Transfer

Load transfer refers to the ability of a concrete pavement to transfer or distribute a load across discontinuities such as joints or cracks. This is typically accomplished through aggregate interlock, dowel bars, or steel reinforcement. PCC pavements will exhibit distresses such as faulting, pumping, and corner breaks without adequate load transfer.

Dowel bars are required for jointed concrete pavement on state highways. The dowel bar diameter should be equal to 1-1/4 inches or the slab thickness (inch) multiplied by ⅛, whichever is greater. The dowel bar length shall be a minimum of 18 inches or 2 times the slab thickness (American Concrete Pavement Association (ACPA) Concrete Pavement for Trucking Facilities).

Dowel bars are only used with CRCP in the expansion joints at bridges. There are no contraction joints in CRCP that require dowel bars as in JPCP or JRCP. However it is important to maintain load transfer at construction joints and transverse cracks. This is accomplished with the longitudinal reinforcing steel.

6.2.5.2 Base/Subbase Materials

Although the rigid nature of PCC allows it to bridge minor imperfections in the underlying material, good uniform support is essential. The base layer may:

- Assist in controlling shrinking and swelling of soils
- Aid in controlling frost heave

- Help prevent pumping of fine grained soils
- Act as a working platform for pavement construction

ODOT prefers to use at least 1 lift of dense graded ACP beneath PCC pavement. Open graded ACP may only be used under PCC pavement on a case by case basis for localized design challenges.

A discussion of the types of base and subbase materials used for PCC pavements can be found in the following documents, among others:

- Construction and Rehabilitation of Concrete Pavements, A Training Manual, FHWA, Contract No. DTFH-61-81-C-00051, pg VI-20
- Subgrades and Subbases for Concrete Pavements, Engineering Bulletin EB204P, 2007, ACPA
- Base and Subbases for Concrete Pavements, FHWA HIF-16-005, August 2017
- Continuously Reinforced Concrete Pavement Manual- Guidelines for Design, FHWA-HIF-16-026, August 2016.

Base materials may take several forms including:

- granular materials
- asphalt or cement treated materials
- lean concrete base

ODOT has used all of these types of base materials under PCC pavements. Based on guidance from the ACPA and ODOT experience, stabilized bases provide better performance than un-treated base materials. Stabilized bases provide better uniform support and are less susceptible to pumping and erosion beneath the PCC pavement. The type of base to be used depends on the project.

Small projects replacing or widening existing PCC pavement should consider matching existing base types. Large projects should use a stabilized base, although unbound granular base on projects with less than about 5 million ESALs during the service life and well drained subgrade may be considered. PDE approval is required for use of unstabilized base.

Design recommendations from the ACPA (EB204P and TS204.10P) discourage permeable subbases directly under PCC based on field experiences and a national performance evaluation study. ODOT currently specifies either ½″ dense or ¾″ dense ACP for asphalt stabilized bases.

6.2.5.3 Subdrainage

Water infiltration from the surface or the subgrade can cause joint faulting and pumping of the subgrade fines. As this process progresses, support can be lost, which leads to more serious distresses such as faulting, corner cracks/breaks, and punchouts. Subdrainage, in conjunction with other design features, can be used to help prevent the problems noted above.

Subdrainage is good practice and should be considered for all PCC pavement designs. Subdrainage could include the use of adjacent ditches, longitudinal edge drains, or in special cases an open graded ACP base course with drains.

Prior to designing open graded ACP under PCC pavement, obtain approval of the ODOT Pavement Design Engineer. Standard Drawing RD312 is used for both the longitudinal edge drains and the open graded ACP base course drains. However, the drawing is general and should be supplemented with a project specific detail for use with either of the subdrainage methods mentioned above.

It is the Designer's responsibility to provide an appropriate detail for the subdrainage in the project plans. For more information related to subdrainage drawings and details, please contact the ODOT Pavement Services Unit.

6.2.5.4 Shoulder Design

1993 AASHTO DESIGN METHOD

In the 1998 *Supplement to the AASHTO Guide*, an edge support adjustment factor is used to account for the reduction in slab stress assumed to result from the use of either a concrete shoulder or widened slab (AASHTO 1998a). The edge support adjustment factor E enters into the equation for total slab stress due to load and curling. The AASHTO design method considers the lane edge support condition as a design element. An edge support adjustment factor is as follows:

E = edge support adjustment factor (1.00 for original AASHO Road Test)
= 1.00 for conventional 12-ft wide traffic lane
= 0.94 for conventional 12-ft wide traffic lane plus tied concrete shoulder
= 0.92 for 2-ft widened slab with conventional 12-ft wide striped lane

The three-dimensional finite element analyses by which the edge support adjustment factors were determined are described by Kuo (1994) and Darter et al. (1995). The reduction in stress with a widened slab or a tied concrete shoulder is estimated to correspond to about a 40 to 45 percent increase in the allowable load applications for a given slab thickness, or conversely a reduction of about 13 mm (0.5 inch) or more in required slab thickness for a given traffic level.

MEPDG DESIGN METHOD

The MEPDG design method allows for designation of a tied or untied shoulder. For widened shoulders, increase the slab with jointed concrete pavement.

For CRCP with widened shoulders, change the tire offset from the edge of pavement if paving multiple lanes. If paving only a single lane of CRCP, do not account for the widened shoulder, since trucks may tend to drive near the opposite edge of pavement.

ODOT has adopted the use of a 14-foot wide slab adjacent to the shoulder, striped as a 12-foot lane. For JPCP, the adjacent shoulder may be JPCP or ACP. For CRCP, the adjacent shoulder should be ACP, designed according to Section 6.1, unless justified as PCC. In areas where future widening is a strong possibility (the full width shoulder could become a lane), strongly consider the use of the travel lane section as the shoulder section. Variance from the 14-foot width will require written approval (e-mail acceptable) from the ODOT Pavement Design Engineer.

6.2.5.5 PCC Preservation Techniques

ODOT diamond grinds concrete pavement to remove studded tire wear ruts at least one time prior to overlaying with ACP, when the structural section of the concrete pavement allows for reduction in thickness. The cost of a ½″ diamond grind and a 2-inch ACP overlay are similar, whereas the concrete surface wears more slowly than ACP. The 50-year service life requirement takes into consideration the possibility of a future diamond grinding. However, in areas of high studded tire wear, consider adding up to an inch additional concrete structure to facilitate multiple future diamond grinding.

Since nearly all concrete pavements will ultimately need an overlay, confirm with the project design team that an additional 4 inches of clearance is provided above the pavement for future overlays, where feasible.

6.3 Subgrade Improvement

Subgrade soil can be improved in excavation areas to increase the workability and structural value of weak native materials. Subgrade can be improved by:

- replacing the soil with a more desirable material (subgrade stabilization),
- by treating the soil with an admixture such as lime or cement
- by using one or more layers of geogrids or strong geosynthetic fabrics

The ODOT Qualified Product List (QPL) maintains a list of approved subgrade reinforcement geogrids, including strong geosynthetic fabrics. When subgrade is constructed with embankment material, ensure adequate subgrade conditions when designing embankment materials (usually a geotechnical responsibility).

Improve the subgrade when the site has soft or unstable soils, saturated soils, or the construction time-line does not allow for drying a wet subgrade. If an admixture is proposed for the subgrade improvement, perform lab tests to determine the proper amount of admixture to achieve the desired soil properties. The ODOT Pavement Design Engineer must approve in writing (e-mail acceptable) alternative methods (not listed above) of subgrade improvement prior to final design recommendation. There are separate specifications (Refer to Chapter 11: Specifications) for each of the subgrade improvement methods described above.

For most projects that require subgrade stabilization, 18″ is a typical depth that can be field adjusted. Consider 24″ or more for poor soils. Check with the ODOT Region for local soil information.

A discussion of Subgrade improvement is available in the ODOT Geotechnical Design Manual. Additionally, the specification for this activity is discussed in Chapter 11.

6.4 Design Alternatives

Consider several design alternates for new construction. Alternates may include, but are not limited to:

- variations in AC/aggregate base thickness
- full depth AC
- PCC over base (unstabilized or stabilized)

Cement Treated Base (CTB) is currently **not** an acceptable structural component for AC pavements on State Highways in Oregon. If there is a compelling reason to use CTB, confer with the Pavement Design Engineer. Cement stabilization for subgrade improvement or for preparing a construction platform (cement modified soil) is acceptable.

For reconstruction of asphalt pavements, consider using In-Place Cement Treated Base (iCTB), which is a form of Full Depth Reclamation (FDR). The pavement engineer is responsible for determining the suitability of iCTB for the project as well as performing laboratory testing for the iCTB mix design. Although ODOT does not have a formal procedure for iCTB mix design, the engineer should measure the strength of the designed mixture for the range of material that could reasonably be encountered. The compressive strength of iCTB should typically be limited to 500 psi.

Other design section alternatives (not discussed in this guide) must be approved in writing (e-mail acceptable) by the ODOT Pavement Design Engineer prior to submission of the design. A discussion of each alternate considered and a Life Cycle Cost Analysis (LCCA) must be included in the design report (if applicable). For more information on LCCA, refer to Chapter 9: Life Cycle Cost Analysis.

The Designer does not need to develop design alternatives for minor widening of existing roads.

6.5 Asphalt/PCC Design Requirements ("Black and White" pavement)

Oregon has some interstates where the pavement has been constructed in both asphalt and concrete (typically, the truck lane, or B lane, is concrete while the A lane, or passing lane, is asphalt.)

When considering this as an option for your design, there are several factors to be considered, and the Designer should contact the Pavement Design Engineer for permission to proceed.

- Existing condition of lanes: usually this becomes a viable option when the left lane is in good or good/fair condition, and the existing pavement is asphalt in both lanes. The existing, poor ACP in the truck/B lane can be inlaid with PCC (typically CRCP), and the existing good/fair ACP in the passing/A lane can be overlaid with new ACP.
- Check the traffic loading. The weaving from lane to lane will stress the longitudinal joint between the two pavement types, so areas where passing traffic is infrequent (rural areas) are preferred. Using a black/white section in an urban or high traffic area, such as I-5, is not recommended.

- Consider construction. Are both materials readily available? The concrete will likely have to be paved first Consider maintenance and future preservation treatments. The joint may need maintenance, as well as the ACP. Chip seals, microsurfacing, and mill/inlay are options for the ACP pavement.

6.6 Precast PCC Panels

Precast PCC panels are a relatively recent technology that allows rapid placement of fully cured panels on a roadway surface, greatly improving the speed at which a road can be opened to traffic. Several DOTs are using this technology to reconstruct roads using only nightly closures.

At the time of this Guide's publication, ODOT has not used this technology on a large scale paving project. However, the following guidelines are known to the technology and are shared here for reference.

6.6.1 Precast Panel Sizing

Precast PCC panels can be formed in almost any required shape and thickness; however, there are limitations to the lengths and widths due to dowel bar placement and trucking constraints. In general:

- A single lane width panel should not exceed a length of 16 feet
- A 2-lane wide panel should not exceed a length of 12 feet

Keep in mind the construction area needed to perform the panel placement; the highway may have the width to accommodate a 2-lane panel, but not the vertical clearance necessary for the cranes or the width necessary for the trucks to get to the construction site.

Precast panels can be formed with superelevations, profiles and curves as necessary for the design. The base of the panel remains a constant elevation and the panels are trapezoidal to fit the desired curve. **Correct survey data is paramount to proper design; a high concentration of survey points is recommended.**

6.6.2 Base Preparation for Precast Panels

Precast panels can be placed with a modified base (such as cement treated) or with an unmodified base (such as aggregate). Typically, the panels are placed in layers thusly:

PCC Panel
½″ – 1″ bedding (with grout mixture)
Approx. 4″ recompacted/reconditioned base (if base is existing)
New base or existing base

6.6.3 Construction

The construction of precast panels is typically:

1. Remove existing pavement

2. Condition the base
3. Lay the panels
4. Grout the panels (the following night)
5. Diamond grind (near completion of project)

Typical construction times for panel placement have several variables, but in general, with 1 crew in 1 lane, approximately 8-10 panels per hour can be laid, with an experienced contractor in typical conditions. That is approximately 600′ in length of one lane in about 6-7 hours.

Each panel (assumed 1-lane width) weighs approximately 20,000 pounds.

Keep in mind that in order to reach optimal panel placing speed, the contractor needs to have a ready supply or backlog of precast panels on site or near the site. The placement can only be as rapid as the panels are available.

Additional information about precast panels can be found in this FHWA report.

6.7 Special Considerations

6.7.1 Bridge Approaches

Bridge approaches require special consideration for new work pavement designs. Refer to Chapter 8 for a discussion and design guidelines for bridge approaches.

Note that the Pavement Services unit is not responsible for the design of any pavement **on the actual bridge decks** (including ACP overlays). That is designed by the Bridge Unit. Pavement Services staff is available as a resource.

6.7.2 Frost Design

Consider frost heave and thaw weakening for projects where the following three elements exist:

- frost susceptible soil,
- freezing temperatures/high freezing index
- water

If any one of the three elements is not present, then frost heave and thaw weakening will not exist. In Oregon, frost heave and thaw weakening are primarily concerns east of the Cascade Mountain Range.

The design must eliminate at least one of the three elements where frost problems could occur. Typically, the Designer can eliminate the issue by making the total depth of the pavement structure greater than the frost depth.

Also consider a positive drainage that eliminates the water in the soil. Positive drainage design may be too expensive compared to removing one of the other two elements.

The design can propose to remove or treat the frost susceptible soil to below the depth of frost penetration to change its frost-susceptible properties. Treatment can include mixing cement or lime at low percentages. Calculate the freezing index for the area (see the Army Corps of Engineer's CRREL procedure) to estimate frost depth.

More information on frost design is available from Cold Regions Research and Engineering Laboratory (CRREL), and the 1993 AASHTO Guide for Design of Pavement Structures, Part 1, Section 1.7.

6.7.3 Vertical Clearance At Bridge Underpasses

The **minimum vertical clearance** standard under bridges on the interstate is currently **17′-6″** for new work areas (includes 0′-6″ for future AC overlays). For new construction, confirm that the Roadway Engineer is allowing for future overlays in the design. Reference Highway Directive TRA07-15d.

A standard may apply on other highways depending on local trucking requirements. Lowering the roadway or replacing the bridge are also alternatives to improve vertical clearance.

The pavement design life shall be 30 years when rebuilding a pavement under any structure to gain minimum vertical clearance requirements and there is insufficient clearance for future overlays.

The design life applies regardless of the type of project (preservation, modernization, bridge). Structures with vertical clearance issues are to be identified by the Project Team.

CHAPTER 7: REHABILITATION OF EXISTING PAVEMENT STRUCTURES

Pavement rehabilitation restores or extends the pavement serviceability for a given design life. Rehabilitation can include structural improvements to provide necessary structural capacity for anticipated traffic loading. It may also include non-structural improvements in situations where additional structural capacity is not required.

Typically, structural improvements can be achieved in two ways:

- Additional depth of materials, which increase the structural capacity of the section, or
- replacement of deficient existing materials with new materials.

The rehabilitation of deficient existing materials may require complete reconstruction of the roadway under specific circumstances.

Mitigate existing pavement deficiencies that could impact pavement rehabilitation longevity for the required design life. These deficiencies include, but are not limited to, cracking, raveling, stripping, flushing, shoving, or potholes.

Adequately design for frost heave and thaw weakening. For more on this, reference Section 6.5.2, Frost Design.

Establish the most effective form of rehabilitation while attempting to minimize project costs, in coordination with the design team.

7.1 Design Life

The minimum structural pavement design life required by ODOT is **15** years for the preservation of an existing pavement structure (this is the basis for ODOT's present preservation strategy). A reconstruction or new pavement has a design life of 20 or 30 years for AC and 50 years for PCC. However, under specific circumstances, the Designer can justify a reduced design life for preservation. The design must meet certain requirements for a reduced design life.

Table 19: Design Life Requirements

Type of Pavement Project	Design Life Required (years)
Preventative Maintenance	Not applicable
Preserving existing structure	15
New ACP	20-30 (see 6.1.1)
New PCC	50

Consider a reduced design life for rehabilitation only if a Life Cycle Cost Analysis (LCCA) indicates significant cost savings by doing so. An example is an urban section where a relatively thick overlay is required to restore structural capacity. Complete reconstruction is often the most viable full design life alternative if grade constraints such as curb exposure, right of way, or cross slope inhibit a thick overlay. However, repeated thin surface treatments such as a thin inlay at shorter time intervals may be more cost effective than the complete reconstruction of the pavement.

Consider a reduced design life if there is a State Transportation Improvement Plan (STIP) project for future rehabilitation, reconstruction, or replacement of the pavement section. An example is a section of highway that was scheduled for replacement under a future project, but needs some form of immediate rehabilitation to mitigate significant safety concerns for the motoring public.

DESIGN LIFE EXCEPTIONS

Pavement designs for ODOT highways with a design life of less than eight years require a design life exception. In these instances, provide a written description of and justification for the exception in the deliverables (see Chapter 12). The primary form of justification shall be a life cycle cost analysis (LCCA) which clearly demonstrates the cost effectiveness of the exception. The ODOT Pavement Design Engineer must review all requests for pavement design lives of less than the minimum 15 years. The appropriate roles must approve the design life exception in writing for design lives less than 8 years (refer to Table 14-2 in the Highway Design Manual, Design Exception Request Form). The design exception process is discussed in more detail in Chapter 14 of the ODOT Highway Design Manual. The Highway Design Manual also provides the design exception request form.

Local agency roads receiving direct federal funds follow a similar process for design life less than 8 years, seeking approval as described in the ODOT Local Agency Guidelines Manual.

For additional information on the development of Life Cycle Cost Analyses, refer to Chapter 9 of this guide.

1R PROJECTS

ODOT has a 1R program for streamlined project delivery and construction of preservation projects. The 1R designation is for single lift paving, inlay or overlay, with some allowance for leveling. The1R designation is part of an overall program including a separate funding source to address substandard safety features on a priority basis. 1R program guidance is found in the ODOT Highway Design Manual, Section 1.3.2.5 and Section 5.4.2.1. For 1R projects under the program, contact ODOT Pavement Services for design life and design alternative considerations. At this time, ODOT does not have a recognized 1R program for local agency projects.

Since 1R projects are mostly performed on structurally sound pavements, a design pavement service life of less than 8 years is an unlikely outcome of a pavement design. However, in some special circumstances, it may be the least-cost method of preserving the pavement on a life cycle basis. Consult with the ODOT 1R policy and the PDE for how to proceed in this scenario.

PREVENTATIVE MAINTENANCE PROJECTS

Similar to the 1R program, the Designer may be asked to provide a design for a preventative maintenance pavement treatment. The primary purpose of the design is to confirm that the pavement is a suitable candidate for a preventative maintenance treatment and to select the treatment. Chip seals are the primary preventative maintenance treatment used by ODOT, although microsurfacing is used occasionally.

There is no pavement design service life requirement for preventative maintenance and a structural evaluation is not required. The design process should align with FHWA's definition of preventative maintenance: "a planned strategy of cost-effective treatments to an existing roadway system and its appurtenances that preserves the system, retards future deterioration, and maintains or improves the functional condition of the system (without significantly increasing the structural capacity)."

Some of the considerations for a preventative maintenance project are listed below:

- If cracking has started to occur, will a preventative maintenance treatment seal those cracks?
- Has maintenance crack sealed the year prior to the chip seal? Note that, in general, cracks should be sealed prior to chip sealing.
- Has oxidation of the ACP surface progressed too far or is the wearing course to stiff to begin with? If so, sealing the surface will likely not prevent future cracking or other deterioration.
- Will a treatment tend to seal in trapped moisture within a high void ACP mix, thus causing stripping?
- Is the wearing course delaminated? If so, the wearing course may continue to crack and pothole regardless of the treatment.
- Is the intent of the project to fix rutting?

7.2 Field Work

Follow the requirements in Chapter 4 of this guide for field work on preventative maintenance projects.

7.3 Bridge Approaches

Pavement designs for rehabilitation at bridge approaches require special considerations. Please refer to Chapter 8 for a discussion on bridge approaches.

7.4 Vertical Clearance at Bridge Underpasses

The vertical clearance under structures requires special treatment on both the interstate and state highways. Depending on the existing vertical clearance, an overlay may not be acceptable if it causes a decrease in vertical clearance. If the existing clearance will be maintained or increased, consider additional fieldwork to determine if an inlay is acceptable. If the existing vertical clearance is below Freight Mobility standards, consider rebuilding the roadway or raising the structure. Reconstruction of a pavement under a bridge is discussed in Section 6.5.3. Actual bridge clearance requirements should be determined through the Project Team. Reference Highway Directive TRA07-15d.

7.5 Evaluation of Functional and Structural Pavement Conditions

Structural pavement condition refers to the load (traffic) carrying capacity; *functional pavement condition* refers to the ride character or quality of the roadway surface.

Pavement distress impacting one or both of these functions may need an inlay and/or overlay repair.

7.5.1 Evaluation of Functional Condition

To determine the functional condition of a pavement, evaluate the available data, as demonstrated in the AASHTO Guide (1993), Section III, subsection 2.3.2. Visually observe the pavement surface for conditions such as cracking, roughness, potential skid resistance issues, and rutting severity. If the visual survey is unclear, search for or obtain test data indicators such as IRI, friction, and laser-measured rut depth. ODOT Pavement Management collects some functional condition data to produce various condition reports. Data such as IRI, rut depth measurements, and skid test values may exist from previous pavement condition assessments. Contact ODOT Pavement Services staff for assistance in obtaining available functional condition data.

7.5.2 Evaluation of Structural Condition

7.5.2.1 Non-Destructive Testing

ODOT uses non-destructive testing to quantify existing pavement structural capacity. The primary method is FWD testing (see Chapter 4). The deflection data provides analysis results depending on pavement type, as shown in Table 18.

Deflection data can quantify pavement condition variability through the project limits, such as changes in subgrade M_R and average deflection value. This data allows the Designer to calculate various uniform sections for analysis. Use deflection analysis to back-calculate the individual layer moduli for use in mechanistic-empirical design methods.

Table 20: Deflection Data Analysis Results by Pavement Type

PCC (rigid)	**AC (flexible)**
• Examine load transfer efficiency at joints and cracks • Estimate the effective modulus of subgrade reaction (effective k-value) • Estimate the modulus of elasticity for the concrete (strength)	• Estimate subgrade soil resilient modulus • Provide a direct estimate of the effective Structural Number (SN) for the pavement • Back-calculate modulus values for asphalt and aggregate layers

7.5.2.2 PCC Joint Load Transfer

Joint load transfer is the efficiency of the slabs to dampen the deflections due to wheel loads across the joint by transferring the load. Successful load transfer can result from:

- aggregate interlock
- foundation support
- dowel bar shear transfer

- a combination of mechanisms (NCHRP Project 1-21, 1985).

Load transfer is calculated as:

$$LT\% = \left[\left(\frac{du}{dl}\right) \times 100 \right] \times B$$

du = deflection of unloaded slab
dl = deflection of loaded slab
B = Slab bending correction factor, where

$$B = \frac{d0}{d12}$$

d0 = deflection under load cell
d12 = deflection at 12 in (300 mm) from load cell

For further information on load transfer, refer to Part III, Section 5.6.5 of the 1993 AASHTO Guide for Design of Pavement Structures. Use the results of the load transfer calculations to determine the average load transfer for the section tested.

7.5.2.3 Remaining Life Calculation

No single, specific method exists for evaluating structural capacity. AASHTO 1993 method outlines four possible methods to determine the declining structural capacity of an existing pavement:

- Structural capacity based on visual survey and materials testing
- Structural capacity based on nondestructive deflection testing (NDT)
- Structural capacity based on fatigue damage from traffic
- Structural capacity based on remaining life

The remaining life evaluation method relies on a fatigue damage concept that repeated loads gradually damage the pavement and reduce the number of additional loads the pavement can carry to failure. This is calculated by determining traffic loading from the past and anticipated into the future. A known issue with Remaining Life calculation is the definition of the terminal end of a pavement; at which point is the pavement considered to be terminal, and have no more design life? AASHTO recommends a PSI value of 1.5 and a reliability of 50 percent.

The remaining life approach is further discussed in AASHTO Guide (1993) Section III, subsection 5.3.3- “Structural Evaluation of Existing Pavement.”

7.6 Applying Multiple Rehabilitation Design Alternatives

Rehabilitation alternatives may include differing material types or differing depths of the materials involved. An alternative may be based on a functional condition issue such as deep rutting or severe roughness.

Eliminate alternatives based on issues such as:

- cost
- ease of construction
- risk of premature failure
- staging and traffic
- right of way
- construction safety
- etc.

Other design alternatives may require detailed study and life cycle cost analyses to determine the preferred alternative. The preferred alternative is the one that meets the desired pavement survivability and design life at both the lowest cost and least impact to the traveling public.

7.7 AC Pavement Rehabilitation

7.7.1 Structural Requirements for AC Overlay

There are two structural requirements which a pavement section must meet or exceed in order to qualify for an overlay as a treatment:

- total structural capacity, and
- fatigue life of the pavement components themselves.

All components of the design section (including the underlying native subgrade) must provide a combined structural capacity capable of supporting the anticipated traffic loading in accordance with an acceptable design procedure (see Chapter 2 of this guide).

In addition, each pavement layer must have a total depth sufficient to support the anticipated traffic loading without suffering premature fatigue failure. Determine the minimum asphalt concrete pavement depth required over the underlying layer(s). The Designer can determine the Structural Number (SN) required for the asphalt concrete based on the anticipated resilient modulus of the structural layer immediately beneath the asphalt concrete (Refer to Section 6.1.2). The process is outlined in the 1993 AASHTO Guide for Design of Pavement Structures under Part II, Section 3.1.5.

The primary method for determining the thickness of AC overlays is by the AASHTO Guide (1993).

The Designer should use field data to backcalculate a structural value if field data is available. Refer to Section 5.2.

7.7.2 Pre-Overlay Repairs

Perform a visual survey prior to the placement of an overlay or inlay, which includes the type, quantity, and severity of pavement distress that is present. Inventory where pre-overlay pavement repairs are necessary. The pre-overlay repairs may include (but are not limited to):

- Localized areas of thin grind and inlay to repair non-structural conditions such as surface cracking, delamination, shoving, etc.
- Localized areas of structural failure that require surfacing stabilization
- Leveling with ACP of wheeltrack ruts with depths greater than ½ inch
- ACP leveling to restore correct cross section or profile
- Removal of existing open graded wearing course (see Section 10.1.1)

Consider using the data to calculate more than one type of repair by isolating areas with more fatigue that do not represent the entire section.

7.7.2.1 Reflective Crack Control

The Designer must evaluate the type of cracking that is present as well as the extent and the severity of the cracks. Field explorations should focus on whether or not the cracks are moving (working cracks). Some techniques to mitigate reflective cracking are listed in the subsections below. When evaluating alternatives, consider the items below:

- Cost to the project
- Type and severity of cracking
- Impact on staging and/or right of way
- Reliability of the technique
- Grade constraints
- If future reflective cracking will reduce the functional service life

COLD PLANING (CPPR)/MILLING

A common technique to control reflective cracking is milling all or part of the cracked surface prior to placement of an inlay or overlay. Cold plane pavement removal (CPPR) is effective if:

- the cracking is top-down
- does not extend deep into existing pavement
- the design does not require a thick increase in total structure

INCREASE OVERLAY DEPTH

Another approach to controlling reflective cracking is to increase the depth of the ACP overlay. Thicker pavement prevents reflective cracking longer. This approach is effective if the design requires a substantial increase in structural capacity; otherwise weigh the potential additional cost against the risk of using a thinner treatment. Also stay aware of vertical clearance issues with adding pavement thickness.

USING EMULSIFIED ASPHALT CONCRETE (EAC)

The flexible binders found in Emulsified Asphalt Concrete (EAC) allow a greater degree of flexure than ACP, thereby retarding reflective cracking. Use EAC in Eastern Oregon where climatic conditions allow for proper curing. Do not use this technique in Western Oregon where temperature and humidity impede proper curing of EAC. For more information on mix type selection please reference Chapter 10 of this guide.

GEOSYNTHETIC LAYERS

Various geosynthetic materials are available to retard reflective cracking. ODOT has seen a benefit from these materials on high volume roads, although the materials did not provide enough benefit to justify the cost. Low volume roads may experience a greater benefit from geosynthetic materials. However, consider future rehabilitation in the design, since most of these materials cannot be recycled as part of Recycled Asphalt Pavement (RAP).

STRESS ABSORBING INTERLAYERS

Chip seals and other asphaltic materials with increased levels of binder have been shown to retard reflective cracking.

A rehabilitation strategy which provides for long term reflective crack mitigation may not be economically feasible to implement. Cracking such as full depth thermal cracks, shrinkage cracks in underlying cement treated base, and joint cracks in underlying jointed concrete pavement can be difficult to mitigate on a long-term basis. The Designer should not attempt crack mitigation for the full design life of the new pavement if these types of cracking exist. In such a case, the Designer must provide adequate explanation in the deliverables (Chapter 12) as to why such a decision was made.

7.7.2.2 Cold Planing (CPRR) Guidelines

The designer can cold plane (CPPR) full width or to a selected width beyond the existing fog stripe.

Typically, full width cold planing is used in situations such as:

- An existing open graded wearing course where the cross section slopes toward the travel lane
- Narrow shoulders
- Traffic control
- Potential grade constraints

Cold plane pavement removal 2 feet outside the existing fog stripe (or beyond rumble strips) may be used for:

- High truck traffic combined with wide shoulders
- Winding roads with the likelihood of vehicles straying outside the fog stripe
- Wide shoulders, where vehicles are more likely to “hug” the fogline
- Joint performance or location
- Overlay of the inlay is less than 4 inches and one of the other conditions apply
- Substandard (<12 ft) travel lane width causing vehicles to shy away from the centerline
- On the interstate (where rumble strips are used, then 3-4 feet beyond fog stripe)
- As deemed necessary on a project by project basis

When shoulders are also bike lanes, consider the impacts of placing a joint within the bike lane. This decision should include discussion from within the Project Team.

It is the Designer's responsibility to determine if traffic can be allowed on the cold planed surface prior to placing an inlay or overlay.

Consider the following:

- thickness of existing pavement after the section has been cold planed;
- depth of existing delamination or stripped pavement;
- depth to existing cement treated base (CTB), if present;
- traffic volumes.

This list is not all inclusive. Allowing traffic on a milled surface must be specifically addressed in the Pavement Design Report. If specific material or surface texture risks are present, and there is a significant staging benefit by allowing traffic on the cold planed surface, the Designer should consult Region management.

Fine milling (5/16-inch tooth spacing on the milling drum) should be used in the following scenarios:

- If traffic is allowed on the cold planed surface on interstates or similar facilities.
- If the thickness of ACP being placed above the cold planed surface is 1 inch or less.
- If the material near the cold planed surface is particularly sensitive to disturbance, micro-cracking, or other deterioration during milling. Fine milling tears and impacts the pavement less, and is thus gentler.

Note that fine milling can significantly slow down the milling process if more than 3 inches depth are milled in one pass.

7.7.2.3 Asphalt Concrete Pavement Repair (ACPR)

When visual survey or testing identifies localized areas of apparent structural failure, design for their repair using Asphalt Concrete Pavement Repair (ACPR). ACPR repairs severely deteriorated pavement by removing and replacing the existing pavement, the underlying base material, and soft or unstable subgrade located beneath the base. ACPR applies to existing flexible pavements only (AC over aggregate base or CTB). The ACPR ACP Detail should not include any overlay lifts in the pavement design for the section; the design shall match existing grade. Rigid pavements (jointed or continuous PCC) require special considerations and specifications, as discussed in Section 7.8.

DETERMINING LOCATIONS FOR ACPR

The Designer determines the locations of ACPR, identifying them by length, width, milepoint or station, and the lane in which they occur. Try to locate ACPR sites prior to (but as close as possible to) Advance Plans preparation. If possible, prior to construction, mark the desired ACPR locations along the shoulder with white paint (or other semi-permanent marker such as a tack and/or lath). Typically, ACPR repair requires a width of no less than 6 feet (1.8 m). 6 feet is half the width of a typical travel lane and is generally considered a practical minimum for constructability reasons. An estimated quantity should be provided in the Pavement Design Report for estimation purposes.

Provide an estimated depth for the subbase or stone embankment material that will be used to replace soft or unstable subgrade. Since the depths of soft or unstable subgrade in each location are not always known, the specification covering ACPR allows for the depth of the subbase/stone embankment to vary once the pavement and base have been removed and the subgrade evaluated.

In some instances, subgrade may not need to be removed. The pavement design can clarify that if upon exposure, the existing subgrade is found to be stable, the subbase portion of the ACPR may be omitted. (Note: It is ODOT standard specifications guidance to not include 00331 Subgrade Stabilization at the same locations as Asphalt Concrete Pavement Repair. See Section 11.4.1 for additional discussion on specification 00331.)

Provide a specific structural section for use in areas requiring ACPR. Refer to Chapter 11 of this guide for information related to the application of this specification. The design life for ACPR is usually 20 years; however, the Designer may use a design life of 15 years with adequate justification and written approval (e-mail acceptable) by the ODOT Pavement Design Engineer.

7.7.2.4 Open Graded Friction Course Removal ("F-mix")

In the 2000's, ODOT placed several hundred miles of open graded friction course ("F-mix") on the state highway system. While the F-mix performed well in early years, it became apparent over time that the open graded mix was problematic and should be removed. F-mix can trap water, and overlays of dense mix placed over F-mix proved to cause stripping. F-mix left as the wearing course soon became noisy and began to ravel and pothole, especially after extreme winters. While ODOT had well-performing F-mix pavement, they resulted in higher maintenance and rehabilitation costs. At the time of this Guide's publication, ODOT is removing F-mix as a wearing course and is no longer using it as a recommended mix.

When the Designer encounters a project that requires F-mix removal, the following items should be considered in the design:

- Depth of milling. Write the specifications and the design to clarify that all of the F-mix must be removed, even if the F-mix found in the field does not exactly match the depth in the construction history or the cores. For example, the as-built plans may show 2″ of F-mix was placed, but the cores show an average of 2.5″. Call out a minimum milling depth of 2.5″ and specify that all must be removed. F-mix skiff left behind has proven to cause issues in the newly overlaid dense AC.
- "Buried" F-mix: if the project has F-mix underneath a dense layer of AC, examine the cores carefully. F-mix under only a few inches of dense may have water trapped and may be stripped, or prone to stripping. Remove the F-mix or bury it under enough new ACP to mitigate the consequences of the F-mix stripping in the future.

7.7.3 AC Pavement over Cement Treated Base

In years past, ODOT used Cement Treated Base (CTB) fairly extensively around the state. Many of these locations now require rehabilitation. When evaluating an existing pavement section with underlying CTB, the Designer should evaluate the integrity and condition of the CTB visually by examining the overlying pavement and cores taken through the pavement and CTB.

As freshly placed CTB cures, it will naturally develop shrinkage cracks. With time and exposure to heavy traffic loads, stress will cause the CTB to continue cracking into smaller pieces. If this process is not mitigated by reducing the stress, the CTB will eventually deteriorate to the point where it functions more as an aggregate base than as a bonded base layer.

REHABILITATING ACP OVER CTB

ODOT's most common method for rehabilitating a pavement with underlying CTB is to place additional new pavement over the CTB. This is a viable option if the underlying CTB is not severely distressed or broken, and vertical clearance allows. In many cases, this involves placing additional AC (even though deflection testing may indicate that little or no additional AC depth is required for structural improvement). A grind and inlay prior to the overlay is also an option.

The rehabilitation needs of the AC layer can be analyzed by calculating the traffic as **rigid** ESALS, as discussed in AASHTO Part I, Section 1.4.1.

Typically, ODOT considers 6.0-inch of asphalt concrete to be the target minimum depth over any CTB. Reconstruction may be the only viable option in an urban location, or other setting where the option of increasing grade through an overlay is limited, or the CTB is severely distressed or broken.

An evaluation of an existing pavement and underlying CTB (such as back-calculation of layer moduli) may determine that a severely deteriorated CTB is no longer stabilized, or that the pavement is unbonded between the AC and CTB. The pavement Designer may consider the CTB to be an unbonded layer, or non-stabilized with a layer coefficient closer to that of an aggregate base than that of a cement-treated base, then develop the overlay design accordingly (and can consider using flexible ESALs conversion factors).

ODOT rarely constructs new CTB. Where it is used, it is usually limited to areas where new construction is placed adjacent to an existing section which has AC over an underlying CTB. However, this may not be cost effective in a small quantity, since CTB could be very expensive to produce and place.

Instead of constructing new CTB, ODOT Designers will often use an AC over aggregate base section that minimizes the aggregate base depth (no less than 6.0 inches). This usually results in a depth of AC that is greater than the minimum required to resist fatigue. This can reduce flexure in the new section which minimizes the difference in flexure between the two pavement sections.

7.7.4 ASPHALT RECYCLING

Hot In-Place Recycling (HIR) or Cold In-Place Recycling (CIR) may be an appropriate design choice for unusual circumstances. This guide does not discuss the selection criteria, as ODOT does not employ these technologies for standard pavement design. The Asphalt Recycling and Reclaiming Association (ARRA) website provides introductory references on both technologies.

When designing HIR or CIR, remember that ACP typically uses 20 to 30 percent RAP. Consider how the availability of RAP may impact the cost of ACP, both from the project under design as well as from nearby stockpiles. For example, recycling the upper 2 inches of existing ACP, and overlaying it with ACP not containing recycled asphalt, may not realize cost savings from recycling technology.

PDE approval is required for use of HIR or CIR.

7.7.5 Rumble Strips

Centerline rumble strips (CLRS) have proven to be an effective safety measure in reducing lane departure crashes, and have performed well on dense-graded pavement that was not significantly cracked or deteriorated. The level of risk for pavement deterioration or failure due to CLRS installation is typically associated with the type of pavement, its age, whether or not it has been sealed (typically chip sealed), and its existing condition rating. Pavement ratings are available on the Oregon State Highway System Pavement Condition maps.

The following guidance should be used:

Dense-Graded Pavements

- CLRS installed in a dense-graded pavement which is rated in good to very good condition (76 out of 100, or better) has a low risk of expected failures.
- Dense-graded pavements in fair or lower condition (0 to 75 out of 100) have a higher risk of failure, and the ODOT Pavement Services Unit should be contacted early in the design phase to evaluate the potential impacts to these pavements. Note that fair pavements may have a deteriorated longitudinal joint, which could require some additional work.
- At elevations above 2500′ in the Cascade Mountains, CLRS should only be placed in dense pavement which is 5 years old or less and in good or better (76 – 100) condition. If CLRS is installed in pavement that does not meet these criterion, then a chip seal should be applied over the rumble strips for a minimum width of 2′.
- If CLRS are placed in a dense pavement that has been chip sealed, then a chip seal should be applied over the rumble strips for a minimum width of 2′.
- If CLRS are being installed over a deteriorated longitudinal joint, it is recommended to fog seal the CLRS and the joint.
- CLRS are not recommended in thin lifts of dense-graded pavement (less than or equal to 1.5″ thick).
- All dense-graded pavements older than 2 years should be fog sealed.
- It should be noted that there is an issue with pavement marking materials adhering to fog seals. Paint has to be applied multiple times, and it typically takes 2 years before urethane will adhere.

Open-Graded Pavements

- There is a moderate risk when installing CLRS in an unsealed open-graded pavement. The CLRS may not last due to raveling.
- CLRS should not be installed on sealed open-graded pavements. There is a high risk for pavement deterioration and failure.

Emulsified Asphalt Concrete (EAC) Pavements

- Regardless of condition, it is **not recommended** to install CLRS in an EAC pavement due to a high risk of early failure. The cost and safety impacts of pavement failure likely outweigh the safety benefit gained on these typically low volume highways.

Portland Cement Concrete (PCC)

- CLRS can be installed into good or better PCC pavements provided that the centerline joint is cleaned and resealed, and only if the CLRS are intended to be permanent.

It is not recommended to partially inlay the existing longitudinal joint (strip paving) prior to the installation of CLRS. This effectively creates a permeable area in the pavement and may potentially lead to pavement deterioration, failures, or increased maintenance activities.

7.8 PCC Rehabilitation

Structural and surface deficiencies in existing PCC pavement must be corrected as described below:

PCC OVERLAID WITH ACP

If existing PCC has been overlaid with ACP, it may not be possible to identify broken PCC pavement in need of repair. If a visual evaluation suggests that the underlying PCC is cracked or broken, use professional engineering judgment to determine which areas warrant repairs and which do not. If the PCC joints are identifiable, then perform deflection testing across the joints to determine voids and load transfer. Often, older PCC pavements were constructed to lesser widths than modern pavement sections. This can result in a longitudinal joint between the old PCC and more recent widening within or near a wheel track. When the underlying PCC width causes such a joint, the design must address the pavement immediately on either side of the longitudinal joint as this pavement is subjected to edge loading.

EXPOSED PCC THAT WILL NOT BE OVERLAID WITH AC

If the PCC pavement surface will remain exposed, (no AC overlay will be applied), all structural deficiencies in the existing PCC will require repair.

EXPOSED PCC THAT WILL HAVE AN AC OVERLAY

If placing an AC overlay over the PCC, then only repair those distresses in the PCC that will affect the structural performance of the new AC surface. However, consider future rehabilitation of distresses left unrepaired prior to an overlay. Further deterioration of low severity cracks and breaks may be masked by the overlay and go unnoticed until a major structural problem develops. An overlay can also make future repairs more difficult in terms of traffic staging and construction because the ACP must be removed prior to making the repairs. The Designer may need to mark repair areas in the field or provide specific locations via a map or project stationing.

Deflection testing across the joints to evaluate voids and load transfer is required. For more information on load transfer and void detection testing refer to the subsections of 7.8.

SAWCUTTING FOR REPAIRS

If a repair of PCC requires sawcutting of a small portion of roadway (for example, a utility repair or a structural repair), the sawcut width shall be either 6′ (half a lane) or the full lane width.

7.8.1 Structural Requirements for PCC Pavement

To determine the structural requirements for PCC pavement, establish the structural adequacy of the pavement and compare that adequacy to future anticipated traffic loadings over the rehabilitation design life. An overlay is not required if the pavement rehabilitation design life for functional and structural needs can be met with just pavement repairs. If the pavement repairs cannot provide the required design life, or are not cost-effective in restoring function, then an ACP overlay, or possibly reconstruction, is required. Design methods for PCC overlays exist, but are not well correlated to performance at the time of this manual. Use engineering judgement and institutional performance history to when designing an overlay of PCC pavement.

A minimal depth PCC overlay with small panels ("whitetopping") is currently not considered an appropriate design for ODOT highways.

7.8.2 PCC Pavement Repairs

ODOT employs partial depth or full depth patching to repair existing concrete. Where concrete pavement repairs are necessary, consult the ODOT Pavement Design Unit (503-986-3000) for assistance in determining appropriate repair techniques, details, and special provisions.

7.8.2.1 Partial Depth PCC Repairs

Partial depth PCC patching repairs spalls at joints, voids, or imperfections in a concrete surface. Partial depth patching is not intended to repair structural deficiencies in PCC pavements. This work consists of a partial depth saw cut around the perimeter of the affected area, removing the existing concrete, and placing an approved low slump PC patch material selected from the Qualified Products List (QPL). The Designer shall provide an appropriate detail for partial depth repairs in the contract plans.

Partial depth repairs should be limited in depth to the top third of the slab and should not come in contact with dowel bars or reinforcing steel. If dowel bars or reinforcing steel are encountered, a full depth repair is required.

7.8.2.2 Full Depth PCC Repairs

Full depth patching of PCC pavements repairs structural deficiencies such as corner cracks or breaks, longitudinal cracks, and punchouts. The type of full depth patching varies depending on the type of PCC pavement to be repaired.

JOINTED CONCRETE PAVEMENTS

For jointed concrete pavements, full depth patching involves sawcutting and removing the existing distressed concrete. Tie the patch area to the existing PCC with tie bars, as appropriate. If the patch edge is 3 feet or less from a transverse joint, extend the patch to the existing transverse joint. Refer to standard detail DET 1601.

CONTINUOUSLY REINFORCED PAVEMENTS

For full depth repair areas in CRCP, the repair shall be a minimum of 3 feet beyond the end of a longitudinal crack extending from a broken area. When repair areas have been shorter than this, the risk of failure has been shown to be high in Oregon and in other states. Transverse edges of the repair areas shall be a minimum of 18 inches from a tight transverse crack. This avoids patch edge failure (punchouts).

In addition to the full depth saw cut around the distressed area, remove an additional area on each end of the patch to splice the longitudinal steel reinforcement. This area is commonly referred to as the "bar lap area". Refer to standard details DET 1605 and 1606.

When making CRCP full depth repairs, take care to avoid damaging the existing PCC that will remain in place. If the remaining concrete is spalled or damaged, extend the patch area to include the damaged area. Damage to the existing pavement surrounding the patch will lead to patch failure.

Take care during construction to avoid damaging the existing base materials. Provide for replacement of base materials that are damaged, deteriorated, or in poor condition. If the existing base requires removal, replace it with plain concrete conforming to the applicable parts of 00758 and to the depth shown. Place a 6 mil polyethylene bond breaker between the new plain concrete base and the new reinforced concrete pavement.

The minimum patch length (including distance from a transverse joint) in PCC pavements is 6 feet. The minimum repair width is full-lane for jointed plain concrete pavement, and 6 feet for reinforced pavements.

Reference the appropriate details in the contract plans and provide information to fill in the tables on the standard details.

7.8.2.3 Other Repair or Maintenance Activities

Other rehabilitation work may include items such as:

- joint sealing
- undersealing
- diamond grinding
- dowel bar retrofits

Joint sealing seals the joints to prevent water from entering into the base materials and to keep incompressibles out of the joints.

Undersealing fills voids or stabilizes the support underneath an existing pavement subject to excessive movement. Undersealing is usually performed on concrete pavements at joints or working cracks. Undersealing consists of drilling holes in the existing pavement and pumping grout underneath. If too much grout is used, the pavement can be lifted which creates voids under other portions of the slab and leads to additional distress. The Designer shall provide a detail showing the number and spacing of the holes and estimated grout quantities. The method for determining the existence of a void and grout quantities is provided in this chapter.

Diamond grinding removes shallow ruts and improves the ride quality of the PCC pavement. Ride quality can be improved in JPCP and JRCP where minor faulting is a problem. Diamond grinding is also done in conjunction with other techniques such as patching and dowel bar retrofits.

Dowel bar retrofit restores, or provides better load transfer across transverse joints or cracks by using dowel bars. Dowel bar retrofit is needed when there is evidence of excessive faulting (loss of load transfer) in an otherwise structurally sound pavement. To date, Oregon has not conducted any dowel bar retrofit projects. However, it has been used successfully in many other states, including in the Pacific Northwest.

7.8.2.4 PCC Slab Void Detection

Part 3, Section 3.5.5 of the 1993 AASHTO Guide for Design of Pavement Structures presents three methods for detecting voids under PCC pavements. The three methods are:

1. Corner Deflection Profile method –based on exceeding a predefined maximum 9,000 lb deflection under the load cell to determine the existence of a void.

2. Variable Load Corner Deflection –based on using three load levels to determine the existence of a void. This procedure was developed under NCHRP Project 1-21, 1985.

3. Void Size Estimation –identifies the existence of a void and the approximate area. The procedure was developed under NCHRP Project 1-21, 1985.

The AASHTO Guide (1993) and NCHRP report referenced above state that a void exists if the zero load deflection is greater than or equal to 0.002 inches. However, based on experiences in Oregon and Washington, when undersealing slabs that meet the AASHTO criteria for repair (a 0.002 to 0.006 inch (0.05 – 0.15 mm) zero load deflection), additional problems can be created which off-set the undersealing benefits. Since these voids tend to be relatively small, there is a tendency to raise the slab, creating a larger void elsewhere under the pavement. Thus, ODOT has designed an internal method for void detection.

ODOT METHOD FOR VOID DETECTION

The ODOT method, as described below, detects voids by a maximum deflection and the variable load procedure. Specific information related to the testing involved can be found in Chapter 4 of this guide, the above referenced section of the AASHTO Guide, or the NCHRP Report noted above.

The steps involved in the ODOT void detection process are:

1. Plot load versus deflection.
2. Plot a best-fit line through the data and determine where the line crosses the deflection axis.

3. Normalize deflection to a 9,000 pound load.

A void exists if either of the following criterion is met:

A zero load deflection of greater than 0.008 inches

or

The normalized 9,000 pound deflection is greater than 0.024 inches.

This procedure is intended only to identify the existence of voids. Do not use it to estimate the area of the void. Analyze both the approach and leave sides of all joints tested. Use the results of the analysis to estimate the percentage of joints that require undersealing.

Use the ODOT criteria for all ODOT projects. Deviations from the above criteria must be approved in writing from the ODOT Pavement Design Engineer (email acceptable).

7.8.2.5 Estimating Grout Quantities

The Designer must estimate the quantity of grout required for bidding purposes. NCHRP Project 1-21, 1985 provides guidance for estimating quantities. For the projects evaluated, the authors state that slabs having no voids took an average of 1.8 ft^3 of grout per joint. In addition they found that joints with voids ranging from 4 to 36 ft^2 took an average of 2 to 3 ft^3 of grout per joint. Although the report speculates that much of the grout is going somewhere besides the void cavity, they recommend using 2 to 3 ft^3 of grout per joint for estimating purposes.

7.8.3 ACP Overlays on PCC

ACP overlays are suitable for PCC pavements that have minor structural deficiencies or where rutting is the primary distress and vertical clearance is not prohibitive. Structural distresses in the PCC must be repaired prior to placing the ACP overlay. Those distresses include, but are not limited to, moderate to high severity corner cracks, punchouts and corner breaks. This option may not be cost effective if the extent of repairs exceeds 20 to 30% of the surface area. More extensive rehabilitation such as rubblization or complete reconstruction may be more cost effective. Complete a life cycle cost analysis to determine the most cost effective strategy (refer to Chapter 9 of this Guide).

Reflective cracks originating in the underlying PCC are a critical design concern. For jointed pavements, contraction joints will reflect through the new ACP overlay in time. Options to prevent reflective cracking include placing a thicker ACP overlay, placing geotextiles, or sawing and sealing the joints in the PCC before the overlay. However, sawing and sealing the joints or the use of geotextiles may be cost prohibitive. Typical overlay depths on jointed concrete pavements are 4 to 6 inches.

CRC pavements do not have joints to reflect through the overlay; however reflective cracking is a concern for working transverse cracks and punchouts. For CRC pavement where rutting is the primary distress, a leveling course and a 2 inch ACP overlay is typically an acceptable solution. When distresses of a more structural nature exist, such as longitudinal cracks or punchouts, core and deflect the CRCP and use an approved design procedure to determine the appropriate overlay thickness. Based on ODOT experience, structural overlays of CRC pavements are typically in the 4-inch to 6-inch range.

The primary method for determining the thickness of AC overlays is by Pavement-ME, although the AASHTO Guide (1993) may be used for substantiation.

7.8.4 Rubblization

Rubblization is the process of breaking an existing PCC pavement into small pieces ranging in size up to 18 inches. Rubblization is a remedy for all types of PCC pavement in poor to very poor condition. The process breaks up the concrete into pieces small enough that it is no longer acting as a concrete slab, but more like a very high quality aggregate base material. The process should also de-bond any reinforcing steel. Typical modulus values for rubblized PCC vary from 50,000 to 1 million psi, depending on the efficiency of the breaking process. Due to this variation, the procedure for designing an AC overlay over rubblized PCC is more complex than designing a normal overlay. Literature on the subject is available from several sources. For projects where rubblization is being considered, contact the ODOT Pavement Services Unit for more information. There are research reports available about rubblization on the ODOT Research website.

7.9 Reconstruction

When complete reconstruction is the best alternative, perform a Life Cycle Cost Analysis to determine if the new pavement should be ACP or PCC. Refer to Chapter 9 for more information on LCCA. If AC pavement is chosen and the adjacent section is CRCP, design to construct a terminal end joint system at the joint between the existing CRC and the new AC pavement. The Designer is responsible for providing an appropriate detail for the construction of the terminal end joint system. Contact the ODOT Pavement Services Unit for assistance in developing the detail.

7.10 Life Cycle Cost Analysis

On many projects, repairs and overlay, rubblization, and reconstruction are all viable options. In this situation a life cycle cost analysis (LCCA) is required to determine which of the alternatives is most cost effective. For more information regarding LCCA refer to Chapter 9 of this guide.

CHAPTER 8: BRIDGE APPROACH ANALYSIS AND DESIGN

Sections of pavement located immediately off the ends of the bridge or viaduct are areas of specific interest in pavement rehabilitation, new construction, or bridge replacement/rehabilitation. These areas are typically referred to as *bridge approaches*, regardless of whether they are located on the approach side or leave side of a structure. Load restrictions and grade constraints on bridge structures require special consideration.

Any time a bridge structure is replaced on a State Highway, the pavement bridge approaches must be analyzed for a distance of 200 feet from the ends of the bridge (or bridge end panels).

The Designer must analyze the existing pavement for a pavement rehabilitation and proposed roadway/bridge profile using a structural design life of **30 years**. Rehabilitation options may include:

- raising the grade of the new bridge structure to allow for ACP overlay
- deep inlay or inlay/overlay of the existing pavement

If profile grade constraints, poor pavement condition, staging issues or other limitations are not cost effective, reconstruction of the approaches is required. Reconstruction ensures quality placement of paving materials and a pavement that is structurally sufficient to meet the demands of current and future traffic. Also, coordinating bridge approach reconstruction with bridge reconstruction maximizes the use of the traffic staging and reduces future impacts to traffic.

The pavement designer should work closely with the bridge engineer to ensure the pavement design is constructible with the bridge deck and end panel treatments, and other bridge design elements. **Note that the Pavement Design is not responsible for the design of the pavement on the bridge deck itself.** That is the responsibility of the Bridge Engineering Unit, although Pavement Services is a resource.

8.1 Preservation of AC Pavement Bridge Approaches

Bridge approaches can suffer accelerated levels of deterioration for a variety of reasons. Consequently, evaluate the pavement on all bridge approaches carefully. If necessary, develop a separate rehabilitation strategy for the bridge approaches, either for each individual bridge or for all bridges collectively. It is common practice to test bridge approaches in just one direction, and then assume that the approaches in the other direction are the same. If visual observation suggests that the approaches in one direction are in substantially worse condition, test that side.

In some cases, the ODOT Bridge Engineering Unit requires some or all of the ACP to be removed from structures to reduce the dead load on the bridge. Removing AC from the bridge deck also requires AC to be removed from the bridge approaches. Depending on the AC reduction, there may not be sufficient structural capacity left to support traffic loads on the bridge approaches. In these cases, consider rehabilitating the bridge approach with a deep ACP inlay (1- lift) that meets a 15-year design life. A deep inlay is favored by construction crews because it is faster than reconstructing the approach. If a deep inlay is the recommended solution, the Designer must provide justification for each individual bridge approach. If a deep inlay (1- lift) cannot meet a minimum 15-year design life (or the design life agreed upon for the project), then reconstruction to a 30-year new work design life is required.

For information on bridge approach field testing, please see Section 4.3.7 of this guide.

8.2 New Work Design of AC Pavement Bridge Approaches

New work may be required for bridge approaches due to:

- a significant grade reduction across an existing structure
- the inability to overlay the approaches due to grade constraints
- or new bridge construction or reconstruction

Due to weight constraints on bridge structures, ODOT discourages AC overlays across the structure and adjacent approaches. Therefore, bridge approaches need to last longer than typical AC pavements.

The minimum design life for new or reconstructed bridge approach pavement (200 feet off each end) is 30 years.

All bridge approach pavement designs will meet the requirements and documentation under Chapter 6.

8.3 Bridge Approaches adjoining PCC Pavement

Design considerations for bridge approaches adjoining PCC include, but are not limited to:

- the type of PCC pavement
- condition of the existing pavement
- elevation of the new structure in relation to the existing elevation
- whether the existing pavement has previously been or is to be overlaid with asphalt concrete under this contract or in the near future.

ODOT typically replaces PCC pavement in kind (including thickness) or equivalent when reconstructing a bridge approach. For more information on the types of PCC pavement refer to Chapter 10 of this guide.

JOINTED PCC PROJECTS

For bridge replacement projects on jointed plain concrete pavement, use ODOT Standard Detail 1601 for constructing the new concrete pavement. Adjust the standard taper length of 1 inch:100 feet such that only whole panels are replaced. In some situations the required PCC panels can be removed and replaced with an asphalt concrete section meeting the requirements presented earlier in this chapter. Examples include, but are not limited to:

- the existing PCC is in poor condition
- the existing PCC is to be overlaid
- the existing PCC is to be rubblized and overlaid

Bridge approaches cannot be reconstructed with ACP if the existing approaches are PCC and the adjacent PCC pavement will remain exposed.

CRCP PROJECTS

Two issues are of critical importance for CRCP: maintaining steel integrity and controlling terminal expansion.

CRCP STEEL INTEGRITY

If steel integrity is not maintained, the pavement can show signs of structural failure quickly and may require costly repairs. Maintain steel integrity by assuring the steel is properly tied or spliced in the appropriate locations. Contact the ODOT Pavement Services Unit for more information on the requirements regarding maintaining steel integrity. For information regarding terminal joint systems in CRCP, refer to Chapter 10 and Standard Detail 1604.

TERMINAL EXPANSION

Prior to 2010, ODOT has used the following two terminal joint systems: terminal anchors (lugs) or (wide flange beam) expansion joints. Make sure to research which system was used in the original construction. This information can be obtained from ODOT as-constructed drawings and should be field verified.

Since 2010, ODOT has primarily used a wide joint filled with a two-part highly elastic/compressible sealant. For projects where the grade of the new structure is virtually unchanged, consider reconstructing only the reinforced concrete transition panel without disturbing the adjacent CRCP and terminal joint system. However, if a change in grade requires reconstruction beyond the terminal joint, construct a new terminal joint. The specific type of terminal joint will depend on the required reconstruction length and the existing terminal joint system. If the existing system is adversely disturbed, it may require reconstruction.

Contact ODOT Pavement Services Unit for assistance in developing the appropriate strategy and the necessary drawings and details required for construction.

CHAPTER 9: LIFE CYCLE COST ANALYSIS

This chapter provides information on Life Cycle Cost Analysis (LCCA) for pavement design alternatives and alternative selection. Deterministic and probabilistic life cycle cost analysis is discussed as well as typical analysis procedures, inputs, and evaluation of alternatives.

Life cycle cost analysis techniques assist with pavement type selection and appropriate pavement design or pavement rehabilitation choices. The pavement design alternative with the lowest life cycle cost will typically be the preferred alternative. However, when alternatives have comparable life cycle costs, other factors need to be considered. A resource to aid in the pavement type selection and life cycle cost analysis is an NCHRP Report 703 entitled "Guide for Pavement Type Selection."

According to the September 1998 FHWA Interim Technical Bulletin entitled "Life Cycle Cost Analysis in Pavement Design - In Search of Better Investment Decisions", the FHWA position on LCCA is that it is a decision support tool, and the results of LCCA are not decisions in and of themselves. The FHWA encourages the use of LCCA when analyzing all major investment decisions where LCCA can increase the efficiency and effectiveness of investment decisions.

9.1 Projects Requiring LCCA

9.1.1 New Pavement Construction

Perform an LCCA on new pavement construction projects where more than one mile of new roadbed will be constructed.

Use the results of the LCCA to aid in pavement type selection and to select an appropriate pavement design. Projects not requiring an LCCA under this section still require a cost analysis to compare the construction costs for each alternative. The pavement design memo/summary should include a discussion of the cost analysis and justification for the chosen alternative.

9.1.2 Pavement Rehabilitation or Reconstruction

Conduct an LCCA for major rehabilitation projects (such as total reconstruction, rubblization, etc.) or where there are options of different life expectancies. Also conduct a LCCA for pavement design strategies with structural life less than the minimum of 15 years. Note that a pavement design exception is also required for options with less than 8 years of structural pavement life. Projects not requiring a LCCA under this section require a cost analysis to compare the construction costs for each alternative. Include a discussion of the cost analysis and justification for the chosen alternative in the memo and summary.

9.2 LCCA Methods

There are two approaches to LCCA— deterministic and probabilistic.

9.2.1 DETERMINISTIC METHOD

Traditional LCCA uses deterministic analysis procedures. Input factors are expressed as single "fixed" values without regard to variability. The deterministic method is appropriate when the input factor variables (such as unit costs or timing of rehabilitation) are reasonably well known. To verify that the deterministic method is appropriate, check the sensitivity of the results to the input variables by adjusting the input variables to the high and low end of their expected values, i.e., *best-case* and *worst-case* scenarios. Recalculate the life cycle cost and reevaluate the results. Deterministic procedures are appropriate when one alternative appears to have a clear economic advantage over other alternatives under both best-case and worst-case scenarios. An example of this is when Alternative A has a lower life cycle cost than Alternative B even when the input variables are chosen to handicap Alternative A and favor Alternative B.

9.2.2 PROBABILISTIC METHOD

The concept of verifying the sensitivity of the results can be taken one step further by performing a probabilistic LCCA. Probabilistic LCCA is a method involving risk analysis and is considered good practice by FHWA. This process involves Monte Carlo simulation to incorporate variability of the LCCA inputs. Use this technique when there is uncertainty in the input variables or when the Designer desires a probability distribution of the results. This technique is also appropriate when the favored alternative in a deterministic analysis switches depending on the values used for the input variables. The probabilistic approach to LCCA is documented in a FHWA September 1998 Interim Technical Bulletin entitled "Life Cycle Cost Analysis in Pavement Design – In Search of Better Investment Decisions". This document will be referred to hereinafter as the "September 1998 FHWA Bulletin". Please refer to the September 1998 FHWA Bulletin for a detailed explanation of the procedure. In addition, the FHWA provides the program RealCost as a spreadsheet add-in, available for download on the FHWA website.

9.3 General Approach to LCCA

Conduct an LCCA as early in the project development cycle as possible. The level of detail should be consistent with the level of investment.

This is the general approach to a life cycle cost analysis for a project with a high level of investment:

- Develop the new work or pavement rehabilitation alternatives.
- Determine the length of the analysis period and the discount rate.
- Determine the performance period and rehabilitation sequence for each alternative over the duration of the analysis period.
- Determine the agency cost for each alternative and rehabilitation strategy.
- Determine the type of probability distribution and the statistical inputs necessary for the type of distribution.
- Enter the above information into the RealCost program and run the analysis. User costs for each strategy can be input by the Designer or calculated by the program (if appropriate).
- Compute the Net Present Value (NPV) for each alternative.

- Analyze the results.
- Adjust input variables and re-run the analysis to determine the sensitivity of the results to the input variables (best-case/worst-case scenarios).
- Use the data to select the appropriate alternative.

The September 1998 FHWA Bulletin discusses *constant* or *nominal* dollars to estimate future costs. The bulletin recommends that costs be estimated in constant dollars and discounted to the present using a real discount rate. This combination eliminates the need to estimate an inflation premium for both cost and discount rates.

According to the September 1998 FHWA Bulletin, Net Present Value (NPV) is the economic efficiency indicator of choice. The Equivalent Uniform Annual Cost (EUAC) indicator is also acceptable, but should be derived from the NPV. **Both indicators should be calculated for ODOT projects.** This will enable the decision-makers to compare the annual cost and see if maintenance costs could affect the results.

Evaluate agency costs and user costs separately. Do not add the results together at the end to provide one cost for a given alternative. For more detail, refer to the September 1998 FHWA Bulletin.

9.4 Analysis Period

According to the September 1998 FHWA Bulletin, the life cycle cost analysis period should be long enough to show the long-term cost differences associated with the design strategies. Generally, the analysis period should be longer than the pavement design period, except in the case of extremely long-lived pavements. As a rule of thumb, the analysis period shall be long enough to perform at least one rehabilitation for each alternative. The analysis period shall be the same for all alternatives.

A 40-year analysis period is appropriate for non-interstate new construction or projects with extensive pavement rehabilitation.

ODOT projects on the Interstate Highway system should use at least a 50-year analysis period.

A shorter analysis period is permissible if the intent of the design is to provide pavement life until total reconstruction is possible.

9.5 Discount Rates

Discount rates are used to convert future expenditures into today's dollars. *Real discount rates* reflect the true value of money with no inflation premium and should be used in conjunction with non-inflated cost estimates of future investments.

Higher discount rates typically favor lower initial costs and higher future costs. Lower discount rates do the opposite. White House OMB Circular A-94 Appendix C, "Discount Rates of Cost-Effectiveness, Lease Purchase, and Related Analyses" discusses the discount rate and provides a yearly update to the rate for federally funded projects. Use the most current discount rate available at the time the pavement design is completed.

9.6 Establishing Strategies, Performance Periods and Activity Timing

Establish feasible and reasonable strategies for initial construction and subsequent maintenance and rehabilitation. Develop these strategies using the pavement design guidelines described in other sections of this guide. Where applicable, consider designs that take future modernization into account. Unrealistic or inappropriate strategies to favor one particular alternative shall not be accepted.

ODOT's Pavement Management System (PMS) can provide data on performance strategy longevity. Search for existing performance models with similar life cycle strategies, and use that data as the basis for expected longevity. The Designer can also examine similar projects in the area to determine the expected life range for the analysis. If no other data is available, gather expert opinions and document the reasoning for the expected performance period for the rehabilitation type.

9.7 Agency Costs

The LCCA only needs to consider differential costs between alternatives, which are typically the costs for the pavement components. Costs common to all alternatives will cancel out. These common cost factors can be generally noted and excluded from LCCA calculations. Cost items that may vary between alternatives such as temporary pavement for staging, differing staging designs, and adjustment of structures, barriers, or guardrails, shall be evaluated for each alternative.

9.7.1 Initial and Rehabilitation Project Costs

Agency costs include all costs incurred directly by the agency over the life of the project. The largest cost is typically construction, but costs also include:

- initial preliminary engineering (PE)
- contract administration and supervision costs (CE)
- contingencies
- escalation
- bonus payments, etc.

Unit costs are typically determined by the ODOT Cost Estimating staff and from bid price data on projects with quantities of comparable scale and geographic location. This information can be found on the ODOT Cost Estimating Internet site:

https://www.oregon.gov/ODOT/Business/Pages/average_bid_item_prices.aspx

The Designer can also consult with Region construction offices for cost information. If considering products or techniques that have not been used previously in Oregon, gather data from other states.

9.7.2 Maintenance Costs

Routine, reactive maintenance costs may have only a marginal effect on NPV. These costs are difficult to estimate, and are generally small in comparison to initial and rehabilitation costs. Cost differences between maintenance strategies for two competing alternatives of the same pavement type are usually small, especially when discounted over the analysis period. **Maintenance cost analysis in the LCCA is not required unless area-specific data is available.**

9.7.3 Salvage Value

Salvage value is the value of an investment alternative at the end of the analysis period. It is used to account for differences in remaining pavement life between alternative pavement design strategies. It is based on the remaining life of the alternate as a prorated share of the last rehabilitation cost. The salvage value is a negative cost.

For example, if a 40-year analysis is conducted and a $100,000 rehabilitation strategy with a 10-year design life is applied in year 35, the salvage value at year 40 is calculated by multiplying the percent of design life remaining at the end of the analysis period (5 of 10 years or 50 percent) by the cost of the rehabilitation ($100,000 in this example).

GIVEN:
Length of analysis: 40 years
Cost of rehabilitation strategy: $100,000
Design life of rehabilitation strategy: 10 years
Year that the rehabilitation strategy is applied: Year 35

FIND: Salvage value in year 40

SOLUTION:
Years left of original rehabilitation strategy = 40- 35= 5 years
Design life remaining at end of analysis period = 10 – 5= 5 years
Percent of design life remaining at end of analysis period= (5/10) = 50%

Salvage Value Year 40: (50%) ($100,000) = $50,000

9.8 User Costs

User Costs are addressed in detail in the September 1998 FHWA Bulletin. *User costs* are the sum of the delay, vehicle operating, and crash costs incurred by users of the facility over the life of the analysis period.

According to the September 1998 FHWA Bulletin, vehicle delay and crash costs are unlikely to vary among alternative pavement designs between periods of construction or maintenance. Although vehicle-operating costs may vary between pavement design strategies, there is little research on quantifying such differences.

When the work zone capacity exceeds vehicle demand, differences in user costs are usually minimal and represent an inconvenience rather than a serious cost to the traveling public. This is the typical case for most ODOT projects. User costs only become significant when a large work zone queue occurs on one alternative but not the others.

If one of the alternatives will create a significant queue for an extended period of time during construction, calculate a user cost analysis in addition to an agency cost LCCA. A good example of this would be an alternative that requires a daytime lane closure of I-5 in Portland, which could create a large construction queue.

For ODOT projects, user cost analysis is treated separately from the agency cost analysis, and the two costs are **not** combined for a single LCCA value.

9.9 Probability Distributions

According to the September 1998 FHWA Bulletin, common probability distributions are the triangular, the normal, and the uniform distribution. Where possible, develop the normal distributions for performance periods and activity timing from pavement management system performance data.

When measured data is not available, use a triangular or uniform distribution to make a rough estimate of the distribution's shape. Use a triangular distribution when the data consists of a minimum, maximum, and most likely values. Use a uniform distribution when the data consists of minimum and maximum values, and all values have an equal likelihood of occurrence. The following distributions are shown in the September 1998 FHWA Bulletin:

Initial and Future Rehabilitation Costs	Normal Distribution
Pavement Service Life (Initial Construction)	Triangular
Pavement Service Life (Rehabilitation)	Triangular
Discount Rate	Triangular

One method to estimate the standard deviation of a normal distribution is: (Max-Min)/4.

The Designer should provide a justification for each probability distribution chosen, citing the FHWA reference.

9.10 Interpreting and Presenting Results

Once completed, perform a sensitivity analysis of the LCCA to identify best-case and worst-case scenarios. The *sensitivity analysis* helps the Designer analyze the impact of each input into the LCCA. Evaluate the LCCA for various discount rates. Unit cost or activity timing can also have an effect on the Net Present Value (NPV). Create summary tables or plots of NPV versus individual input variables to interpret results. Include this information in the pavement design memo/summary.

Where life cycle costs between alternatives are greater than 10%, the pavement design alternative with the lowest life cycle cost is typically preferred. However, in order to make decisions on probabilistic results, determine the level of risk the agency can tolerate. If a low level of risk is acceptable (90-95% probability), consider alternatives with a small spread in possible results. Where a higher level of risk is acceptable (75 to 90% probability), the less expensive alternative is likely the best choice, even though there is risk that it might actually cost more than the competing alternative.

For final selection of an alternative, when life cycle costs are within 10% (user costs not included), the Pavement Services Engineer, Pavement Design Engineer of Record, ODOT Pavement Design Engineer, Region Area Manager, and District Manager should reach and document a consensus decision. User costs, if evaluated, should be considered in the consensus decision.

In addition to LCCA, factor other issues into the selection of a given alternative, including but not limited to:

- Initial cost – availability of funds
- User costs
- Wearing surface factors – surface drainage, skid resistance, resistance to studded tires or chain wear, tire noise, etc.
- Availability of pavement materials
- Opportunity for recycling of pavement materials
- Constructability
- Availability of qualified contractors
- Mobility issues – Future grade limitations (vertical clearance), staging, etc.
- Future pavement maintenance needs
- Number and complexity of future rehabilitation
- Safety of public, contractor, and maintenance during construction and maintenance activities
- Public perception
- Overall risk
- Opportunity for evaluation of new technologies

CHAPTER 10: MATERIALS

10.1 Asphalt Concrete Mix Type and Size Selection

ACP is identified by the gradation type (open or dense), nominal maximum aggregate size, and level category based on traffic. PG graded asphalt binder is not included as part of the ACP name, but is included separately in the bid items. PG binder grade may also be shown on the plans for clarification. The ODOT Pavement Design Engineer must approve, in writing, deviations from the following guidelines (email acceptable). The ODOT Pavement Design Engineer also may direct a specific mix type based on past performance history for a specific project.

10.1.2 Asphalt Concrete Pavement (ACP)

ODOT permits three sizes of dense graded mix types in its ACP specifications:

- ¾-inch
- ½-inch
- ⅜-inch

Table 21: Mix Type and Application

Dense graded mix size	Typical application
¾-inch	Rarely used by ODOT because of reduced durability and construction segregation issues
½-inch	Default mix, may be placed in lifts from 2 to 3 inches thick
⅜-inch	Used for lift thicknesses less than 2 inches and leveling

ODOT typically uses a ½-inch dense mix. The current policy is to use ½-inch Dense ACP in the wearing course. The basis for this policy is problems with segregation during construction of ¾-inch dense ACP wearing courses, which can result in increased permeability and shorter pavement life. ¾″ mix can be used with the approval of the Pavement Quality and Materials Engineer.

Consider using the same mix in the base course as in the wearing course on projects with small quantities (2,500 tons or less of total ACP on the project). This reduces the number of aggregate stockpiles and typically allows for a single mix required on the project; thus increasing the quantity for the “lot”, which allows for better unit bid prices.

Table 22: Mix Type and Allowable Lift Thickness

Type of Mix	Minimum lift thickness	Maximum lift thickness
¾″ dense	3 inches	3 inches*
½″ dense	2 inches	3 inches*
⅜″ dense	1 inch (except when feathering or rut filling to 0″)	4 inches (for localized leveling)

* ODOT has recently had success with 4-inch lift paving that is confined at the edges of the panel. The Designer may request this thickness but it has to be approved in writing (email acceptable) by the Pavement Quality and Materials Engineer.

The first lift of ACP on aggregate base should be 3 inches thick unless precluded by other design elements.

The 3-inch lift provides more time for compaction than a 2-inch lift, thus giving the best opportunity to meet and exceed contract compaction requirements. Studies have shown that high compaction in this first lift (ideal in-place air voids of 4-6%) provides better fatigue resistance. The Designer must also consider the state of the underlying aggregate base and subgrade to determine if the minimum target compaction, typically 92%, can be achieved. Additional information and assistance is available from the ODOT Pavement Quality and Materials Engineer.

When a pavement structural evaluation results in a 3-inch overlay design, the Designer should typically use a 2-inch overlay and 1-inch (minimum) base course to avoid a 3-inch grade difference which is often a mobility problem due to the 3-inch lip at the edge of the mat. A ⅜-inch dense ACP must be used for the 1-inch ACP base course.

ODOT has found this layering improves the pavement smoothness and can alleviate bumps from cracks and irregularities in the pavement without significantly increasing paving cost. Also, by placing the 3 inches in this way, the traffic staging and construction is simplified by not having to pave the single 3-inch lift full width in one shift. Consider:

- whether the 1-inch base course lift can be paved according to specification (such as meeting minimum temperatures at night)
- the placement of an ACP lift less than 2 inches is by method specification rather than density testing
- if the 1-inch lift will occur within the critical 4-inch “rut depth” zone

The design should qualify for the pavement smoothness specification, and include the smoothness special provision in the contract. Require ODOT TM 301 “Establishing Roller Patterns for Thin Lifts of HMAC [ACP]” for the 1-inch lift. A 2.5″ overlay has similar issues with mobility as a 3″ lift. The Designer should compare cost and service life associated with 2″ or 3″ (1″ + 2″) overlay alternatives.

10.1.3 Emulsified Asphalt Concrete (EAC)

Emulsified Asphalt Concrete (EAC, a.k.a. “Cold Mix”) is a combination of graded aggregate and emulsified asphalt. EAC cures over time as the water (and/or other solvent) evaporates out of the mixture, leaving the asphalt behind to bind the aggregates.

There are benefits and drawbacks to using EAC. The Designer should be aware of the pros and cons when making the decision to use EAC.

Benefits of Emulsified Asphalt Concrete include the following:

- EAC may tolerate up to 25% more tensile strain than ACP. This property makes EAC an excellent choice for controlling reflective cracking.
- EAC seems to retain its flexibility, which may allow cracks to shrink in hot weather.

Drawbacks of Emulsified Asphalt Concrete include the following:

- EAC has a shorter construction season than ACP.
- EAC must cure for at least 72 hours between lifts. This might increase staging complexity and cost on multi-lift projects.
- Contractor is required to return to the site after two weeks to place fog coat and chip seal.
- EAC is not recommended for use in urban areas due to the chip seal requirements.
- Routine chip sealing is more critical for EAC pavements than for ACP counterparts.
- EAC can only be placed on low volume roadways (<2,500 ADT). This is due to the cure time of the EAC. High truck volume traffic within the first year after placing the EAC may rut the new wearing surface.
- EAC must be placed in a proper climate for curing. **EAC is not recommended for use in Western Oregon.**

Rural projects in Eastern and Central Oregon with low ADT, and a minimal amount of accesses, sharp curves, and low winter maintenance are good candidates for EAC.

ODOT has not developed a structural layer coefficient for EAC for use in the AASHTO Design Procedure. Typically, calculations are completed for ACP then converted to an EAC thickness.

Maintenance personnel are very familiar with their area and can provide insight on the appropriateness of EAC. Different maintenance districts also have specific chip seal methods that they prefer. The ODOT Pavement Design Engineer must approve the use of EAC before the design recommendation is finalized.

EAC should be placed in lifts of 2 inches or 2½ inches.

A fog coat and chip seal must be placed over the entire EAC surface the same year as it is constructed, as defined in the special provisions.

10.1.4 Chip Seals (Emulsified or Pre-Coated Aggregate [Hot] Asphalt Surface Treatments)

Chip seals are used as a finishing lift over EAC wearing courses and as a preventative maintenance treatment. **By definition and specification, a chip seal is not considered an EAC or wearing/base course.**

Historic data has shown chip seals last 5 – 10 years when placed in appropriate settings (rural projects in with low ADT, and a minimal amount of accesses, sharp curves, and winter maintenance). Chip seals are typically used on highways with 15,000 ADT or less (two-way).

Use hot chip seals for highways with greater than 10,000 ADT and emulsified chip seals for all others. Hot chips can be opened to full-speed traffic sooner than emulsified chip seals, but they are more sensitive to shot rates. The existing pavement must be in Fair to Good condition for a chip seal and photos and pavement management data must prove a chip seal is an appropriate remedy.

ODOT Pavement Services completed an LCCA showing that chip seals are a beneficial preventative maintenance technique that extends the life of a pavement. The FHWA has approved the use of chip seals as a preventative maintenance technique on pavements that are still structurally adequate and only showing minor or localized distress. If a chip seal is deemed appropriate, a design life exception is not required.

Chip seals do not enhance structural strength of a roadway, but do provide a new wearing surface, reduce the rate of pavement oxidation, improve friction, and protect against surface water infiltration. Place a chip seal when the pavement is still in good or fair condition, prior to significant oxidation or cracking of the surface.

Prior to placing a chip seal, repair localized and structural failures, seal cracks, and level rutting. For hot chip seals, crack seal the summer prior to chip seal placement to allow the sealant material time to harden and reduce the risk of melting and construction issues. Chip seals are not recommended for highways requiring a structural overlay.

Do not design chip seals for open graded wearing course pavements. It can cause trapping of moisture within the open graded layer, which tends to cause rapid stripping of the open graded mixture.

10.1.5 - Porous Asphalt Concrete (PAC)

PAC is intended to be used for drainage or storm water infiltration. **Do not design PAC for use in a travel lane.** When PAC is used, ensure the design team is aware that PAC has a relatively high future maintenance and rehabilitation cost.

10.1.6 - Slurry Seals and Microsurfacing

A *slurry seal* is a cold-mix pavement treatment that contains specially graded aggregate, asphalt emulsion, water, and other additives. A slurry seal typically has a cure time of 24 hours before traffic can be allowed on the pavement. Slurry seals are a preventative maintenance treatment option that replaces fines, fills minor cracks, and can improve friction. Slurry seals do not improve the structural strength of a pavement. It is typically not appropriate for roads in Fair condition or less, or for roads with cracks ¼″ or greater in width.

Microsurfacing is a cold-mix expansion of slurry sealing, with a higher polymer and asphalt residual content, better quality aggregate and faster-setting chemicals. A microsurface can have a curing time of only one hour before traffic is allowed on the pavement. Microsurfacing is a preventative maintenance treatment that typically has a higher skid resistance than slurry sealing and is able to be open to traffic at a much faster rate. It can also halt oxidation, address profile leveling, and fill ruts. It is typically not appropriate for roads in Fair condition or less, or for roads with cracks ¼″ or greater in width. Microsurfacing does not improve the structural strength of a pavement.

10.2 Mix Design Levels

To select the project mix type, select the correct mix design level category. The mix design level affects the mix design process and can affect the specified aggregate quality, the asphalt grade selected, and the minimum required compaction during placement. The mix design level is based on:

- the current and anticipated traffic volumes
- truck traffic volumes
- the Region of the project
- the classification of the roadway (rural or urban)
- the quantity of material needed
- other factors

Refer to Appendix J for mix design tables.

At the time of this report, the information in Appendix J was reviewed thoroughly to ensure that the recommendations were accurate for Oregon. The climate data for the LTTP database was recently improved which led to the need for a review. A map is also now included in the Appendix to clarify the regions where each recommended mix is valid.

Four levels of ACP are available for ODOT projects. The level designation does not imply a "quality rating." For example, given a truck traffic estimate of 3,000,000 ESALs, Level 4 is not "better" than Level 3. Level 3 is appropriate based on the anticipated truck traffic and Level 4 would be over-designed.

10.2.1 Level 1 ACP

Level 1 is not used on state highways and not recommended for most roads. Potential uses include residential driveways and cul-de-sacs, bike paths, hiking trails, and other recreational uses.

10.2.2 Level 2 ACP

Level 2 is used on low volume highways and roads, where the 20-year design lane ESALs are less than 1 million.

10.2.3 Level 3 ACP

Most state highways fall under the Level 3 category. Applications also include major arterials and heavy truck parking lots. Level 3 is used when the 20-year design lane ESALs range from 1 million to 10 million on rural highways, and 1 million to 3 million on urban highways.

10.2.4 Level 4 ACP

Level 4 100 gyration mix is for use in applications with very high traffic or heavy truck traffic where the 20-year design lane ESALs are greater than 10 million on rural highways, and greater than 3 million on urban highways. It is also used on all interstates.

Table 23: ACP Mix Levels and their Uses

Level of ACP Mix	20-year design ESALs
1	NA- not recommended for most roads
2	< 1 million
3	1 million – 10 million for RURAL 1 million – 3 million for URBAN
4	> 10 million RURAL > 3 million URBAN

Also refer to Appendix J for mix level use.

Secondary compaction typically only occurs in the top few inches of the pavement structure. Therefore, to provide a more durable pavement on projects that are placing more than 4 inches of new ACP pavement, **a level 4 mix is only required in the top 4 inches.** For lifts below the top 4 inches, a level 3 mix may be used. Weigh this option with the number of mixes required on the project, material quantities, and the staging needs of the project.

10.3 PG Asphalt Binder Grades

In the PG system, asphalt grades are defined by two numbers such as PG "64-22". The first number is the high temperature grade in °C. The high temperature grade signifies that the asphalt meets or exceeds the minimum specified physical properties up to that temperature. The second number is the low temperature grade in °C. The low temperature grade is the lowest temperature at which the asphalt must meet or exceed the minimum specified physical properties.

For example, PG 64-22 asphalt meets the minimum specified requirements in all temperatures from -22°C to 64°C (-7.6°F to 147.2°F). Per specification, the high and low temperature grades are in increments of 6 degrees Celsius. High temperature grades are 52, 58, 64, 70 and 76°C. Low temperature grades are -10, -16, -22, -28, -34 and in some areas -40°C. Appendix J details which PG binder grades have been deemed appropriate based on 20-year ESAL calculations.

Oregon added "PG xx-xx **ER**" designation. The ER, or "*elastic recovery*", provides for a modified binder, typically used in Level 4 applications. ER designation can provide additional rut resistance without excessively stiffening the binder. The benefit is rut resistance and a reduction in top-down cracking.

10.3.1 Asphalt Grade Selection

The asphalt grade selection depends on the calculated maximum and minimum pavement temperatures at the project location. FHWA provided software (LTTP InfoPave, or Long Term Pavement Performance program) has a database of weather station data from around the country including weather data from both NARR sources and MERRA sources. The software recommends a PG grade for a particular location based on historical temperature data and an algorithm that computes estimated maximum and minimum pavement temperature at that location.

If, for example, the estimated maximum pavement temperature at a certain location was 61 °C, the next highest PG grade, PG 64-##, would be selected. If the minimum was –19 °C, a PG ##–22 grade would be selected.

See Appendix J, Performance-Graded Asphalt Grades Recommendation, for ODOT's recommended asphalt grades for specific project locations. The use of other asphalt binder grades than specified in Appendix J requires written approval (e-mail acceptable) from the ODOT Pavement Quality and Materials Engineer.

10.3.2 Traffic Speed Adjustments

AASHTO recommends adjusting the asphalt grade when traffic speed is lower than 40 mph. For example, in urban areas with slower moving traffic, the asphalt grade may have to be increased from a PG 64-22 to a PG 70-22 to add additional rutting and shoving resistance. Various studies have shown that stiffer asphalts (higher high temperature grade) improve the rut resistance of the asphalt mixture. These adjustments are built in to the recommendations in Appendix J.

10.3.3 Traffic Volume Adjustments

AASHTO also recommends adjusting the asphalt grade when traffic volumes exceed certain levels. For example, in some locations if traffic volume exceeds 3 million 20-year design lane ESALs, the high temperature grade of the asphalt may be increased. Another step up in grade may be required if the traffic volume exceeds 10 million 20-year design lane ESALs. These adjustments are also built in to the recommendations for PG grade in Appendix J.

10.4 Treatments for Moisture Susceptibility

ODOT has developed a matrix for deciding when to require lime or latex polymers in ACP to help prevent stripping (Table 20). This decision matrix was developed in April 2000, with revisions in 2007 and 2010, and is intended to reduce the human exposure to lime for ACP projects by reducing the number of projects that require it. EAC currently does not require any lime treatment.

When lime treated and/or latex polymer treated aggregates are required per these guidelines, clearly indicate the requirement in the Materials and Specification section of the memo and summary. In addition, the specification writer shall include the appropriate portions from the boilerplate SP00745 in the project special provisions.

When an anti-stripping additive is mandatory, the typical sections in the plans must show "Lime Treated" when calling out the mix type. (When appropriate, the Latex Polymer Treated Aggregates is provided as an option by the special provisions.)

Table 24: Lime or Latex Treatment Requirements

Mandatory Lime Treated Aggregate	-Projects on US 97 from Madras to California -Projects on interstates east of Troutdale -Cascade Range mountain passes above 2,500 ft elevation with traffic levels above 3 million 20-year design lane ESALs
Mandatory Lime OR Latex Polymer Treated Aggregates	-Interstate 5 projects with substantial paving between MP 0 and MP 175 (NCL Cottage Grove) -US-101 projects in Coos and Curry Counties -Central and Eastern Oregon projects not covered in Part A with traffic levels above 1 million 20-year design lane ESALs
No aggregate treatment mandated	All projects not covered above. The ACP must meet the minimum specified Tensile Strength Ratio requirement during mix design development. Otherwise, the contractor shall improve stripping resistance.
Other	Other projects in areas where stripping has been a problem or in areas of severe climate, lime or latex polymers.

10.5 Aggregate Base

There are two types of aggregate base: open graded and dense graded. **ODOT uses dense graded aggregate base for pavement designs on most projects.** Open graded aggregate base is only recommended for areas where water is an issue (i.e., high water table or frost heave) and the pavement section needs to be drained. Using an open graded aggregate base requires a drainage plan. If not drained properly, an open graded aggregate base will perform worse than a dense graded aggregate base.

ODOT Designers usually recommend 1 in. – 0 or ¾ in. – 0 dense graded aggregate base for paving projects. The specifications offer larger sizes; however, at least the top 4 inches of aggregate base must be 1 in. – 0 or ¾ in. – 0 for grading and paving purposes.

10.6 Portland Cement Concrete

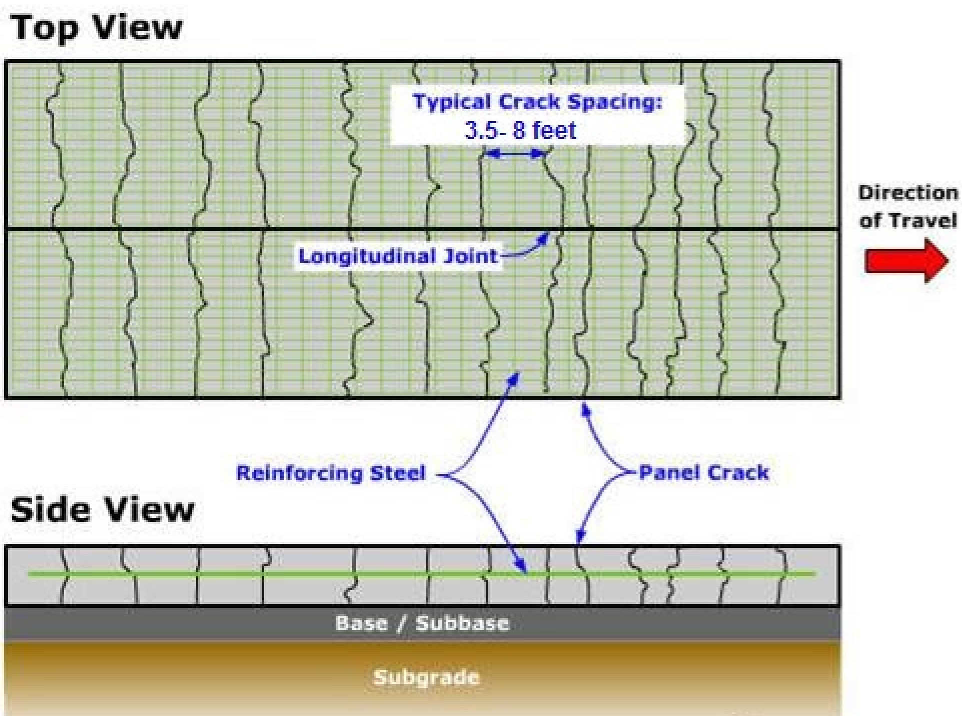
ODOT constructs two types of Portland Cement Concrete (PCC) Pavement: Jointed Plain Concrete Pavement (JPCP) and Continuously Reinforced Concrete Pavement (CRCP). Concrete pavements should be considered when a roadway is being rebuilt, or constructed on a new alignment. The new Portland Cement Concrete pavement should match the existing pavement in type and depth when widening an existing concrete pavement, unless traffic calculations prove that the current section is under-designed. Where widening next to an existing PCC pavement, tie the new pavement into the existing pavement.

The minimum thickness for PCC pavement on the state highway system is 8 inches. See standard details in the 1600 category for construction and steel placement.

It is the Designer's responsibility to verify that the steel design shown in the standard drawings is adequate for the type and thickness of PCC pavement being specified.

10.6.1 Continuously Reinforced Concrete Pavement (CRCP)

Continuously Reinforced Concrete Pavement consists of long stretches of PCC pavement that do not contain contraction joints. CRCP is constructed with longitudinal and transverse steel to control cracking and keep cracks tight. Terminal expansion joints, as discussed in Section 6.2.4, are required at the ends of CRCP and where CRCP meets bridges. CRCP is typically used on large projects with a high volume of heavy trucks.

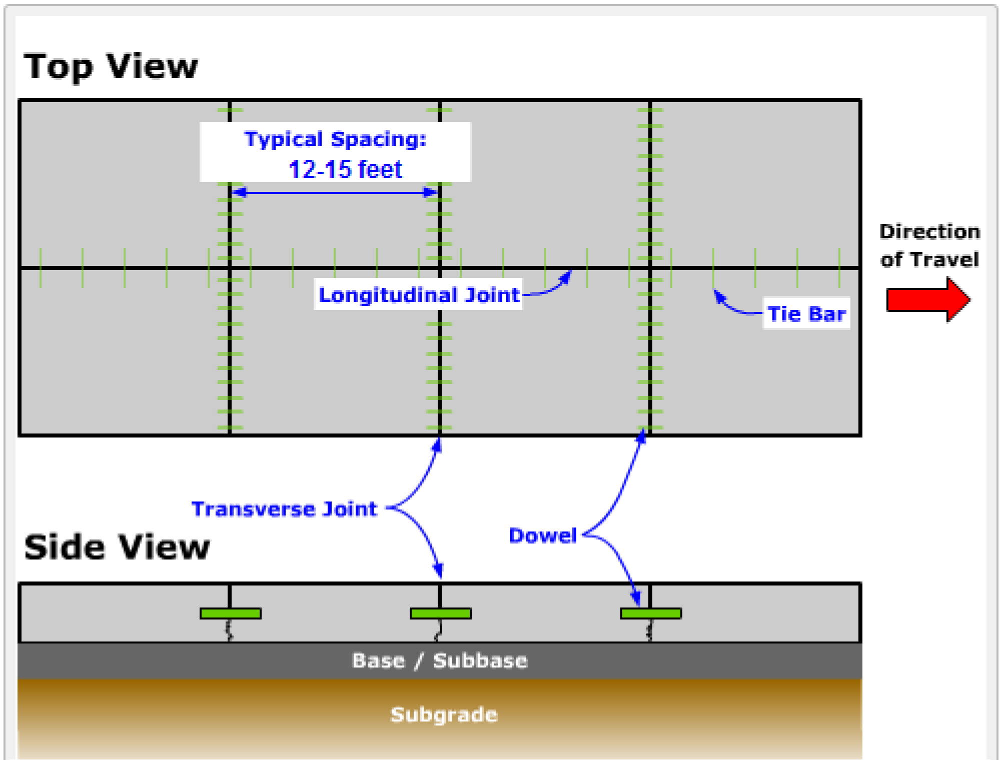


Continuously Reinforced Concrete Pavement (CRCP)

Photo credit Steve Muench

10.6.2 Jointed Plain Concrete Pavement (JPCP)

Jointed Plain Concrete Pavement is also commonly referred to as plain jointed concrete pavement. "Plain" refers to the lack of longitudinal and transverse reinforcing steel in the pavement. The contraction joints may be dowelled or undowelled. These pavements contain tie bars at longitudinal joints and must not contain dowel bars at the contraction joints in travel lanes. In addition to the thickness determination, specify joint spacing and joint location.



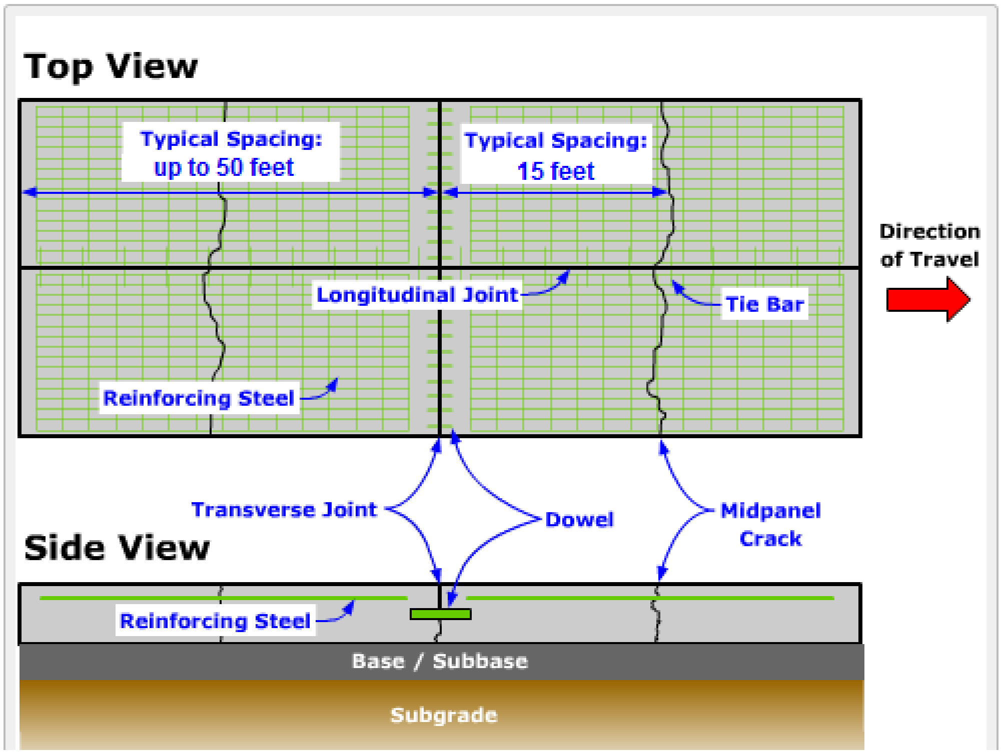
Jointed Plain Concrete Pavement (JPCP)

Photo credit Steve Muench

10.6.3 Jointed Reinforced Concrete Pavement (JRCP)

In contrast to Jointed Plain Concrete Pavement, JRCP uses both longitudinal and transverse reinforcing steel in the pavement section. The reinforcing steel is not intended to prevent cracks in the pavement, but to hold those cracks that do develop tightly together. Additionally, the contraction joint spacing in JRCP is considerably longer than those in JPCP. JRCP requires tie bars at construction and longitudinal joints as well as dowel bars at transverse contraction joints.

Jointed Reinforced Concrete Pavement was slowly phased out of Oregon and replaced with CRCP for most projects where steel reinforcement is required. JRCP may be appropriate in situations where joint spacing is greater than 15 ft (4.6 m) but CRCP is not applicable, such as approaches to weigh-in-motion scales. **Do not exceed a 30-foot joint spacing.**



Jointed Reinforced Concrete Pavement (JRCP)

Photo credit Steve Muench

10.6.4 PRECAST CONCRETE PAVEMENT SYSTEMS, PCPS

At the time of this publishing, ODOT has not performed a precast concrete panel project on a state highway. However, other nearby DOTs such as CALTrans are designing and constructing several dozen miles of precast panel roadways and the technology is becoming more mainstream. ODOT has placed several panels but has not completed a project only using PCPS.

Refer to Chapter 6.6 for more information on PCPS.

Research on PCPS can be found here:

http://onlinepubs.trb.org/onlinepubs/shrp2/SHRP2prepubR05.pdf

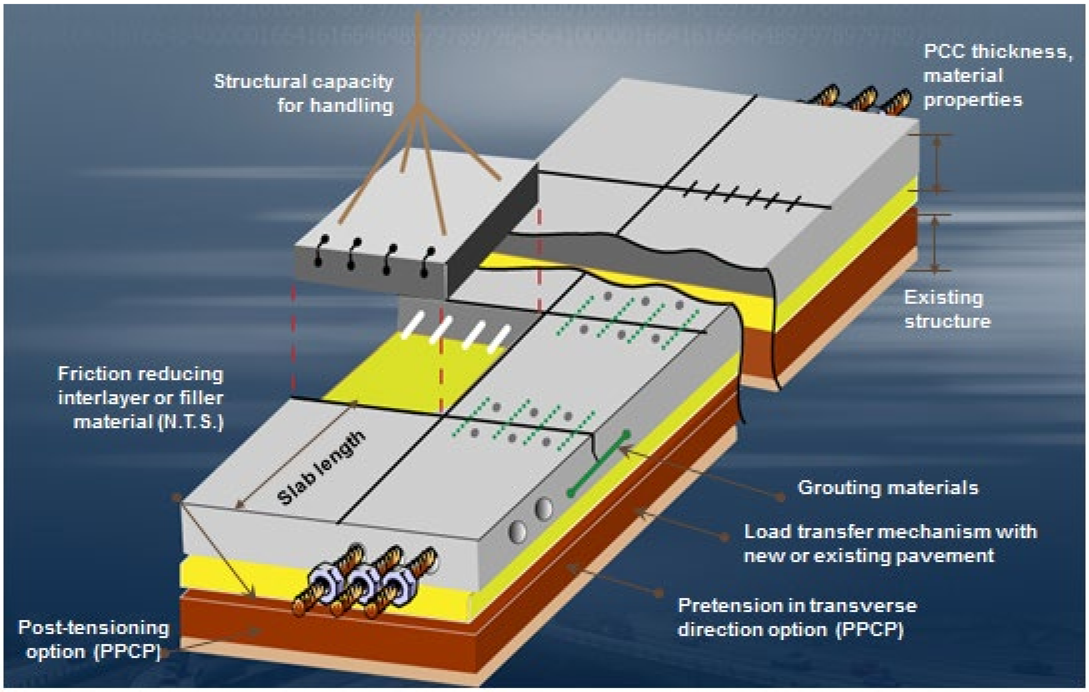


Photo credit FHWA

10.7 Geosynthetics

The standard geotextile material used in ODOT pavement is the subgrade separation geotextile. Geotextile separates the soil in the subgrade from the base or subbase materials. Geotextiles can also filter and drain wet subgrade soils which may "pump" due to high pore water pressures created by dynamic wheel loading.

Geogrid reinforcement has also been used for select projects (weak soils or shallow utilities), although there is no standard design method. Calculate the structural strength of the geogrid by performing independent testing. The use of geogrid as base course reinforcement must be approved in writing (e-mail acceptable) by the ODOT Pavement Design Engineer. Use of geogrids in subgrade stabilization is encouraged, if it is more cost effective than using additional aggregate material.

Subgrade geotextile application benefits are summarized by FHWA HI-95-038:

- Reducing the intensity of stress on the subgrade and preventing the base aggregate from penetrating into the subgrade
- Preventing subgrade fines from pumping or otherwise migrating up into the base
- Preventing contamination of the base materials which may allow more open-graded, free-draining aggregates to be considered in the design
- Reducing the depth of excavation required for the removal of unsuitable subgrade materials
- Reducing the thickness of aggregate required to stabilize the subgrade
- Reducing disturbance of the subgrade during construction
- Allowing an increase in subgrade strength over time
- Reducing the differential settlement of the roadway, which helps maintain pavement integrity and uniformity, geosynthetics will also aid in reducing

differential settlement in transition areas from cut to fill (Note: Total and consolidation settlements are not reduced by the use of geosynthetic reinforcement)
- Reducing maintenance and extending the life of the pavement

Subgrade geotextile is best suited for poor fine-grained soils (USCS: SC, CL, CH, ML, MH, OL, OH, PT, SM with fines greater than 30% and saturated fine sands SM and SC). Carefully consider the design of a subgrade geotextile on granular soil materials to determine if separation or filtration is actually needed. Use a non-woven geotextile fabric for subgrades near groundwater or saturated soils with greater than 30% fines.

If geotextile is approved for use in the design, ODOT has adopted the following design guidelines (FHWA HI-95-038):

- Design the pavement structure according to standard methods (AASHTO, using anticipated subgrade Resilient Modulus under design conditions)
- The geotextile is assumed to provide no structural support, so there is no reduction in the design aggregate thickness
- Aggregate material savings occurs as a result of the separation; thus no “waste” for material pushed into the subgrade during construction
- When subgrade geotextile is to be placed under Subgrade Stabilization (specification item 00331), the Designer must determine the appropriate depth of subgrade stabilization backfill material that will provide a construction platform upon which to build the pavement design structure

Additional information can be found in *Geosynthetic Design & Construction Guidelines*, FHWA HI-95-038, 1998.

Geosynthetics are used in Oregon to separate aggregate base from the subgrade layer. The exceptions to this are in the following cases:
- If the pavement is in the groundwater table, use a non-woven geotextile fabric
- If the pavement is on granular subgrade (where there is no risk of fines or sand migration)

CHAPTER 11: CONSTRUCTION AND SPECIFICATIONS

Construction documents consist of plans and specifications. These documents convey the design to the contractor who provides construction services. Pre-bid, the Designer ensures the pavement design is properly represented in the plans and specifications. The Designer should have a working knowledge of project-specific construction practices, types of restrictions placed on the contractor, cost-effective work practices, and application of specifications.

11.1 Construction Considerations

11.1.1 CONSTRUCTABILITY

Constructability refers to a review process that identifies potential issues:

- Can the design be built? Consider issues such as night work or traffic control restrictions, deep excavations adjacent to active traffic lanes, lane width restrictions, adequate drying time for wet soils, etc.
- Is the design buildable for the contractor?
- Is the design cost-effective? Consider issues such as material costs, specialized equipment, labor-intensive, 2″ overlay vs. 3″ overlay with traffic restrictions (specification 745.61(b)), etc.
- Is the design biddable? Is enough information provided to allow a contractor to estimate material and labor costs, and project risk? Do the bid items provide for potential variation in quantities?
- Is the design maintainable with existing maintenance equipment, budget and staff?

If the Designer cannot provide the answers, the Project Team should be asked. If the Project Team cannot adequately provide the answers, the Team may recommend an External Constructability Review. An external review invites contractors to participate in a meeting early in the design process to help address constructability issues. In most situations the Designer or the Project Team will answer constructability questions.

11.1.2 CONTRACT DOCUMENTS

11.1.2.1 Project Specific Information

Often for rehabilitation projects, a contractor requires no additional information than plans, specifications, and a site visit in order to provide a bid. On the other hand, new work or reconstruction projects often cannot be assessed with just a site visit. The contractor may seek additional information from agency reports, as-built drawings and subsurface investigations. The contractor is responsible for subsurface conditions that are considered "normal" for the type of site and work to be performed. According to specification 00140.40, Differing Site Conditions, a contractor can claim for *Unknown physical conditions of unusual nature that differ materially from those ordinarily encountered and generally recognized as inherent in the Work provided for in the Contract.* Therefore, to help avoid contract claims, if unusual conditions are encountered during the pavement design investigation, these conditions should be noted in the memo and summary or possibly in the contract plans.

The Designer can make available field testing results such as cores in order to assist the Contractor with bidding on a project. The project team commonly places this information in the electronic bidding documents as non-contractual information.

11.1.2.2 Contract Plans

Pavement design elements are provided in contract plans. The Designer shall review the plans and ensure that the pavement design has been incorporated into the plans and interpreted correctly. Elements are under one or more of the following items:

- Typical sections
- Project-specific details
- Standard drawings

Typical sections display pavement design elements. The typical section represents the final roadway cross section, and includes appropriate pavement elements such as:

- AC wearing and base course types and thicknesses
- binder grade(s)
- PCC type and thickness
- aggregate base course
- subgrade treatment (if appropriate)

The project limits for each typical section are identified by stationing. Typical sections are in the plans, typically in the front portion of the set.

Project-specific details provide further explanation of common design elements such as profile views of:

- pavement tapers
- subgrade or surfacing stabilization
- drainage
- reinforcement
- repairs

Standard Detail sheets provide project-specific information for standard design elements (such as rebar sizes for CRCP). Project details are in the plans after the typical sections.

Standard Drawings provide accepted design standards and elements that are similar from project to project. Note that these standards get revised, so check the ODOT Roadway website for the most recent version. The Standard Drawings used in a project are at the end of the contract plans.

11.1.2.3 Specifications

There are three types of specifications:

- Standard
- Supplemental
- Special Provisions

The *Standard Specifications* are the “base” specifications because both the Supplemental Specifications and the Special Provisions (SP) either append or revise the Standards. The Standard Specifications are divided into two Parts, and each Part is divided into Sections and Subsections. **Reference to a Section includes all applicable requirements of the Section.**

Supplemental Specifications append, revise or replace the Standard Specifications by adding to or modifying specifications in the Standard Specifications.

Special Provisions either append or revise a Standard or Supplemental Specification or add a specification that is not in either the Standard or Supplemental Specifications. They are used for project-specific construction requirements. “Standard” language special provisions are referred to as “boilerplate”, and are available from the ODOT Web Site. The Special Provisions are included with the Plans to create the bidding documents. Questions regarding specifications should be directed to:

Website: ODOT Specifications Unit
Email: mailto:ODOTSpecifications@odot.state.or.us

11.2 Asphalt Concrete Pavement Specifications

11.2.1 Section 00745 –Asphalt Concrete Pavement (ACP)

Specification 00745 is for projects with any quantity of Level 4 paving, and for projects with more than 2,500 tons of Level 2 or Level 3 dense graded ACP. The 00745 specification requires more extensive materials testing and quality control/quality assurance measures than specification 00744.

This specification may be used on projects with less than 2,500 tons of Level 2 and Level 3 paving if the specific use warrants the stricter specification. These situations could include:

- paving in an urban area with high traffic volume
- paving on a roadway with a high volume of heavy trucks
- paving in a location where lime treated aggregate is specified

The asphalt binder grades are separate bid items within the 00745 specification, and are measured and paid for separately. If they are not bid separately (such as with small quantities), then the grades of asphalt must be stated in the Special Provisions subsection 00745.11(a).

When specifying 00745, the following instructions must be included:

- Mix Design Level

- Nominal maximum aggregate size (i.e., ¾″, ½″, ⅜″)
- Dense or Open Graded ACP
- Whether or not lime and/or latex polymer treatment is required
- Whether or not the material transfer device is required
- Whether or not the pavement smoothness sections are required
- Asphalt Grade (PG ##-##)

11.2.1.1 Asphalt Cement Designation

For projects with multiple mix types and/or multiple asphalt cement grades, the typical sections or subsection 00745.11(a) should clarify which asphalt cement to use in the various mix types. The following language is recommended:

00745.11(a) Asphalt Cement – Delete the first sentence of this subsection. Add the following after the first paragraph.

Use PG XX – XX asphalt in Level _____________.

Example:
Use PG 70-22ER asphalt in Level 4, ½″ ACP Wearing Course
Use PG 64-22 asphalt in Level 3, ½″ ACP Base Course

11.2.1.2 Pavement Smoothness

The International Roughness Index (IRI) pavement smoothness incentive-disincentive subsections (00745.70, .72, .73, .75, .96) are part of the boilerplate unique specifications, and must be included for:

- Interstate projects over ½ mile long.
- Non-interstate new construction or reconstruction projects over ½ mile long and a posted speed limit of 45 mph or more.
- All other projects at least 1 mile long (continuous) and a posted speed limit of 45 mph or more.

For projects meeting these criteria, three separate payment schedules are used depending on how difficult the Designer anticipates it will be for the contractor to construct a smooth pavement. Schedule 1 is intended for pavements where constructing a smooth pavement is relatively easy, whereas Schedule 3 is intended for pavements where constructing a smooth pavement is relatively difficult. The guidance for schedule selection is below:

Schedule 1:
- <u>Use</u> for all multi-lift paving projects.
- <u>Use</u> for single-lift paving projects with IRI ≤ 90 inches/mile.
- <u>Do not use</u> for projects with signalized or stop sign controlled intersections or railroad crossings < 1/2-mile apart throughout project.

Schedule 2:
- <u>Use</u> for single-lift paving projects with 90 < IRI ≤ 105 inches/mile.

- Do not use for projects with signalized or stop sign controlled intersections or railroad crossings < 1/2-mile apart throughout project.

Schedule 3:
- Use for single-lift paving projects with IRI > 105 inches/mile.
- Use for all projects with signalized or stop sign controlled intersections or railroad crossings < 1/2-mile apart throughout project.

The Designer may choose to select a different schedule than indicated by the guidance, or remove the IRI smoothness specification, because of project-specific complexities. Any changes from the guidance must be approved by the Pavement Design Engineer. The primary considerations used in consider project-specific complexities are:
- Does a raveled or open graded existing wearing course give false high IRI readings based on the current observed, subjective ride quality?
- Does the profile, geometry, sunken grades, or landslide scarps cause smooth paving to be especially difficult?
- Are there factors related to special locations or special highway classifications, such as an access controlled expressway resembling an interstate, which would require a smoother pavement?

Unique Specification 00745.73(d-1) provides additional exclusion items from smoothness profile calculation, including bridges, ramps and auxiliary lanes. These items do not need to be considered during design since they are excluded from IRI testing requirements during construction.

11.2.1.3 Material Transfer Device

There are two basic types of transfer devices:
- a windrow pick-up machine which picks up the hot mix from a windrow and places it into the paver hopper
- an end-dump transfer machine which provides an additional material surge volume that allows for continuous paving and/or remix capability

Using a transfer device will increase the per-ton cost of ACP but can increase the mat quality. In addition to reducing segregation potential by remixing, smoother pavements are possible because the device allows for continuous delivery of hot mix to the paver which reduces stops and starts.

The material transfer device is part of the special provisions subsection 00745.48(b). A transfer device is needed when:

- Intent of the project is primarily paving
- Intended for dense graded wearing surfaces

A materials transfer device is not to be used on bridge replacement projects without significant travel lane paving, and is not to be used on urban projects

11.2.1.4 Latex Polymer Treatment Option

When latex polymers are included as an anti-stripping additive option (per Section 10.4), special provision subsection 00745.11(d) Option 1 needs to be included in the project special provisions.

11.2.2 Section 00744 – Minor Asphalt Concrete Pavement Quantities

Use Specification 00744 for projects with small ACP quantities (<2,500 tons) and reduced testing. 00744 may also be used for projects where there is minor paving for guardrail installation, barrier installation, or for installing new curbs and sidewalks, but no other paving will be completed on the project.

The boilerplate special provision includes some testing as directed by the engineer. This specification is meant for highway paving on small quantity projects requiring a Level 3 or lower mix design level. It is not appropriate on the interstate or other Level 4 high traffic applications. The contract project specifications should **not** include both specifications 00744 and 00745; if both types of paving are present, then 00745 should be specified.

For paving of sidewalks, planter strips, or other miscellaneous items, refer to Section 00749 – Miscellaneous Asphalt Concrete Structures.

11.2.3 Section 00735 – Emulsified Asphalt Concrete Pavement

Specification 00735 is for Emulsified Asphalt Concrete.

Projects using Specification 00735 must also include Specification 00730 (Asphalt Tack Coat) and Specification 00705 (Asphalt Prime Coat and Emulsified Asphalt Fog Coat). In addition, include one of the surface treatment (chip seal) specifications. Options are:

- Specification 00710 (Single Application Emulsified Asphalt Surface Treatment)
- Special Provision 00712 (Dry Key Emulsified Asphalt Surface Treatment)
- Specification 00715 (Multiple Application Emulsified Asphalt Surface Treatment)

The pavement design report must specify the aggregate gradation of the chip seal and whether or not the design requires polymer-modified emulsified asphalt. Note that Special Provision 00712 is not a standard specification; 00712 is a Unique Specification that is available from the specifications web site or by contacting the ODOT Pavement Services Unit. Historically, Unique 00712 was only used in District 14 (Southeast Oregon).

District maintenance personnel and/or the ODOT Pavement Services Unit should be contacted for assistance in selecting the appropriate chip seal specification to use.

11.3 Aggregate Base

11.3.1 Section 00641- Aggregate Subbase, Base, and Shoulders

Specification 00641 explains quality control/quality assurance. This specification is recommended for any base placed under a State Highway lane that will carry vehicle traffic. These lanes can include turn lanes, parking lanes, and shoulders if future widening is a strong possibility.

Also use 00641 if the aggregate quantity is moderate to large. Under 00641, the Designer may require the aggregate to be plant mixed. Specify if plant mixed only aggregates are desired, otherwise the specification allows for either road mixed or plant mixed aggregates. Plant mixed aggregates are recommended for projects where over-watering during road mixing may be an issue (i.e., tight schedules in urban areas) and for large quantities (20,000 tons or more). **Plant mix aggregates are required for projects in Regions 4 and 5**.

Subsections 00350.41(a-4) and 00641.42 of the Standard Specifications provide requirements for placing aggregate base on geotextile. The two main requirements are that the aggregate must be placed directly on the geotextile, without road mixing, and the minimum compacted thickness of the first lift directly on the geotextile is 6 inches. Six inches is also the maximum compacted thickness for aggregate bases allowed under subsection 00641.43 (a).

Do not place the aggregate base or shoulder material on top of newly constructed open graded ACP or EAC (subsection 00641.41(b)).

ODOT allows asphalt grindings in place of aggregate base or shoulder rock (when acceptable to ODOT Maintenance and Environmental Sections).

11.3.2 Section 00640 – Aggregate Base and Shoulders (Small Quantities)

Specification 00640 is for aggregate base and shoulders without quality control/quality assurance testing. The contract acceptance of the aggregate is visual by the Engineer (typically the Project Manager). This specification may be used for projects:

- where the only aggregate will be shoulder rock
- under guardrail flares
- maintenance pull outs
- mailbox turnouts
- sidewalks
- other non-travel lane applications

Consider this specification for travel lane use on small quantity projects on low volume highways. Use caution when using this specification for travel lanes, as future base failures are expensive to repair. This specification is not recommended when subbase material is specified (such as with 00331 or 00332) since subbase is only defined within 00641, and possible special provision revisions would not be included in the contract.

11.4 Subgrade Improvement

11.4.1 Section 00331 – Subgrade Stabilization

Specification 00331 is for subgrade stabilization work. This specification is for projects where the roadway is either being rebuilt, widened, or constructed on a new alignment.

Subgrade stabilization removes soft, poor soil to the specified depth shown in the plans and replaces it with a subgrade geotextile and subbase or stone embankment material. Subgrade stabilization only includes work below the top of subgrade and does not include placing the aggregate base and pavement.

Typically, ODOT recommends 18″ of subgrade stabilization for most projects that require it. For areas with poor soil, 24″ or more may be required. The Designer can contact the Construction PM office or the regional geotechnical engineer for more information on the soil types found at the project site.

Include a detail for subgrade stabilization in the plans and only show the work completed as part of this specification, including the placement of the subgrade geotextile or geogrid if specified. Estimate the percentage of subgrade surface area that requires subgrade stabilization. Consider subgrade stabilization for weak fine-grained soils (subgrade M_R of 4,000 psi and less) and soil materials subject to saturation if the construction schedule will include work during the "rainy season."

Determine if it is appropriate to allow deletion of this item during construction if conditions are firm and unyielding. Also consider subgrade stabilization for:

- Wet or marshy areas
- Geographic experience (check with PM office for past history)
- Reconstruction work within an existing roadbed (moisture trapped within roadbed prism)
- If construction schedule requires work in the wet season (typically September 30-June 15)

11.4.2 Section 00344 –Treated Subgrade

Specification 00344 applies where the subgrade is to be improved using lime, chloride or Portland cement. Laboratory testing must show that the chosen admixture is the appropriate treatment for the given soil. Approximately 1,000 square yards of treatment is needed to make treated subgrade economically desirable.

A reference for treated subgrade is available in the ODOT Geotechnical Design Manual.

More information Alaska DOT/FHWA Report FHWA-AK-RD-01-6B, *"Alaska Soil Stabilization Design Guide"*, (Hicks, R.G., 2002)

11.5 Milling/CPPR (Section 00620)

Specification 00620 is for cold plane pavement removal, commonly referred to as "milling". This specification removes existing AC. Specification 00620 applies only to asphalt concrete pavements. PCC Pavement repair has a separate specification.

11.5.1 Fine Milling (Forthcoming)

A forthcoming special provision under 00620 specifies the equipment necessary for a smoother finish and/or a shallower removal of ACP for the project. Specify the necessary tooth spacing (typically 5/16 of an inch) and the forward grinding speed (typically not faster than 60 feet per minute maximum and 30 feet per minute minimum.)

11.5.2 Secondary Removal Equipment (forthcoming)

This forthcoming special provision under 00620 discusses the equipment that should be used when the ACP has been milled off of existing PCC pavement and there are "skiffs" of ACP remaining that must be removed (typically, the remaining ACP is in localized areas such as superelevation transitions.) It also specifies the inspection process for the use of this special provision.

The special provision should include information about the inspection; specifically, that Agency Staff will inspect the primary CPPR surface after it is swept clean, to determine if Secondary CPPR is required. Agency staff will mark the locations and notify the contractor.

Secondary Removal Equipment: The contractor must provide secondary removal equipment that is capable of loosening the existing AC in the curved, non-uniform wheel path formed by ruts in the existing concrete. This specification provides method for the contractor to get paid for the additional removal of ACP that requires a separate milling operation. Additionally, in some instances, it provides a contractual tool for ODOT to ensure that all ACP is removed from a PCC pavement prior to application of a new surface.

Measurement and Payment: The quantities are measured on an area basis in place, under the bid item for CPPR. Payment is per square yard under the bid item for CPPR as its own pay item.

11.6 Asphalt Concrete Pavement Repair (ACPR) (Section 00748)

Specification 00748 is for localized areas needing partial or full depth repair in the existing pavement prior to the inlay and/or overlay. This specification removes the failed AC, base rock, subbase, and/or subgrade soil (as required); then places a subgrade geotextile, backfill (if needed), aggregate base, and asphalt concrete. Specification 00748 applies only to asphalt concrete pavements. PCC Pavement repair has a separate specification.

The bid item is "___-inch Asphalt Concrete Repair", and pays for all work except the asphalt concrete. The asphalt concrete quantity is paid as part of the 00735, 00744, or 00745 specification, and is measured separately. Include a detail in the plans for this work, and only show the replaced pavement depth up to the original existing grade. The overlay should not be shown as part of the detail. Detail either specific locations or estimate the percentage of the project area that may require ACPR.

Due to staging and curing issues associated with EAC, it is much less desirable for ACPR. If the project includes Emulsified Asphalt Concrete (EAC) paving, ACPR should be specified using ACP under section 00744 or 00745 of the specifications if available for the anticipated quantities.

11.7 Portland Cement Concrete Pavement (Sections 00755, 00754, 00756, 00758)

These sections refer to concrete pavements.

11.7.1 Section 00755 - Continuously Reinforced Concrete Pavement

Specification 00755 is used for CRCP. This specification is for **new construction** of reinforced concrete (use specification 00758 for repairs).

Measurement and payment for CRCP is in square yards. The terminal expansion joints are measured and paid for by the foot. For CRCP, use Standard Details from the DET1600 series. Fill out the table near the middle of the drawing with the appropriate concrete thickness, bar size, and spacing of the longitudinal steel.

11.7.2 Section 00754 – Plain Concrete Repairs

Specification 00754 is for plain concrete (JPCP) repairs. The pay item is the area of concrete repair in square yards. This pay item is for all work associated with completing the full depth repair.

Spall repairs are measured and paid for by the square yard. This may be included (when present) on CRCP, JRCP, or JPCP repair projects.

Modify the repair details (DET 1600 series) on a project to project basis since the repairs depend on the original construction standard drawing and current construction practices.

11.7.3 Section 00756 - Plain Concrete Pavement

Specification 00756 is used for new construction of (jointed) plain concrete pavement (JPCP). For concrete repairs of JPCP, refer to section 00754. The standard details for JPCP are In the DET1600 series. In addition to the standard details, work with the roadway designer to provide a project-specific detail showing the joint layout for areas that are not standard (i.e., intersections, taper sections).

For miscellaneous concrete paving, such as sidewalks, driveways, or traffic islands, use Specification 00759.

11.7.4 Section 00758 – Reinforced Concrete Repairs

Specification 00758 is for reinforced concrete repairs (in Oregon, typically CRCP). The pay items include square yard of repair area and extra for reinforced bar lap areas for CRCP. The square yard item includes the area of the full depth cut plus the area of the partial depth cut for the bar lap area. This bid item pays for the PCC material poured back and longitudinal steel, which is why the additional area of the bar lap is included.

The extra for the bar lap area includes the costs of chipping out the existing concrete and tying new reinforcing steel to the existing steel. The bar lap bid item is paid for by "each", where one bar lap area is equivalent to a single lane width (typically 12 feet wide) on one side of the repair. A repair one lane (12 feet) wide would have 2 bar lap areas (one for each side). Additional pay items for joint repairs are required for work at terminal expansion joints and expansion joints at bridge approaches.

Spall repairs are measured and paid for by the square yard.

Modify the details (DET 1600 series) on a project to project basis since the repairs depend on the original construction standard drawing and current construction practices.

11.8 Subgrade Geotextile

Specification 00350 is for all geosynthetics used in construction for ODOT projects. For pavement design, the primary geosynthetic is the subgrade geotextile as a part of new work sections, subgrade stabilization, or asphalt concrete repair (surfacing stabilization). The geotextile (woven or non-woven) and level of certification must be included in the pavement design recommendation. Typically, use non-woven subgrade geotextiles in areas with an increased potential for pumping fines, such as high groundwater at the subgrade surface.

The level of certification for subgrade geotextile is either "A" or "B". Level "A" is used for projects where a large quantity (>10,000 yd^2) of geotextile material is needed or where quality assurance of the material is critical. A minimum of 6 inches aggregate material is required over the geotextile per subsection 00350.41(a-4).

Unique spec language addresses the use of geogrids for either subgrade stabilization or base course reinforcement. Geogrid products for subgrade stabilization are listed on the QPL. Additional performance-based requirements for base course reinforcement are located in non-boilerplate language available from ODOT Pavement Services.

CHAPTER 12: DELIVERABLES

This chapter clarifies the minimum acceptable pavement design report content and supporting documentation for both ODOT and Consultant pavement designs.

The ODOT-internal Pavement Services QC Plan is attached as Appendix O. The procedures in the QC plan are used to review internal and external pavement designs. Calibration requirements for Falling Weight Deflectometer (FWD) equipment and required documentation are included in this section as well.

Where to Send Deliverables: Consultants should submit all pavement design related deliverables to ODOT Pavement Services.

Timeline: The deliverables required by this section must be submitted as indicated by the contract after the pavement design has been completed (and within agreed upon task due dates) to establish work activities and timelines of other project development tasks. Changes to the pavement design could delay the project schedule. Typically, an unstamped draft pavement design is submitted at least a month before the DAP package is developed, unless the contract specifies otherwise. Consultants shall follow all requirements in the contract.

12.1 FWD Calibration Requirements (for Consultant or ODOT)

Typically, on large pavement preservation projects, where the consultant is contracted directly to the Pavement Services Unit, field data will be collected by ODOT Pavement Services and provided to the Consultant to aid in the design. However, for some contracts, the Consultant may be asked to use their own testing equipment to perform the necessary pavement testing.

If that occurs, the Consultant shall submit written documentation from the calibration center to show that the calibration has been conducted successfully prior to the Consultant's FWD's use on a project. If the load cell has been replaced since the last calibration, the load cell and the equipment must be re-calibrated at the calibration center prior to use on a project. FWD equipment shall be calibrated annually. Copies of supporting documentation for routine calibrations of deflection sensors or distance measuring equipment shall be made available to the ODOT Pavement Design Engineer if requested.

12.2 General Expectations for Consultants

In the contract, the Consultant commits to oversee and direct the pavement design for the Project to obtain the best long-term value for the State of Oregon, which reflects prudent expenditure of public funds within the constraints of the Project, program, context and budget.

Additional information about the expectations of Consultants performing work for ODOT or ODOT Pavement Services will be provided in the project contract.

Below is an example of the items that should be included in every consultant contract:

EXHIBIT A – STATEMENT OF WORK AND DELIVERY SCHEDULE

A. PROJECT DESCRIPTION and OVERVIEW of SERVICES

OR-55: Point A to Point B, Hwy 55, MP 10.00 to 20.00 (Key 55555).

Scope:

Agency is contracting with Consultant for the following Project:

This project is to provide a cost effective means to restore the pavement condition. Other work will include median cable barrier work, guardrail updates, inlaid striping, recessed reflective pavement markings, rumble strips, and new signs as needed.

Site Map:
(Consultant shall include a visual map of the project showing the mileposting)

Consultant's final Pavement Design must include the following:

A Pavement Design Memo (executive summary):
This document provides the pavement section recommendations, pavement design notes, and a table of specifications required, as well as boiler plate special provisions required. See Appendix O for more detail.

A Pavement Design Summary (full report):
This document summarizes the pavement condition, construction history, summarizes all data analysis completed, design criteria – inputs (such as but not limited to traffic data, subgrade modulus, directional factors, design coefficient), and a narrative on the specific recommendations made in the pavement design memo, based on analysis done and design life calculated. See Appendix O for more detail.

Appendices:
The appendices and supporting documents for data collected, analysis done, or any information used to support the pavement specific recommendations belongs in the executive summary. Appendices will be organized according to subject matter. Traffic data, core logs, core photos, Falling Weight Deflectometer ("FWD") data, subgrade data and analysis, rut data, construction history, and condition data are examples of appendix topic headers. See Appendix O for more detail.

- Consultant may use pavement design procedures not specifically recommended in the current ODOT Pavement Design Guide only with prior written approval (email acceptable) by Agency's Pavement Design Engineer.
- A pavement design service life is necessary with each pavement section recommendation shown in the full report recommendation discussion.
- Pavement design recommendations must incorporate Agency standard or boilerplate construction and material specifications, unless otherwise approved in writing by Agency's Pavement Design Engineer (email acceptable). Consultant

shall ensure recommended material properties will follow Agency's materials use guidelines provided by Agency's Pavement Services Unit (for example, for 00745, the consultant will need to consider and specify binder type, binder level, smoothness, lime treatment, material transfer device, and time traffic is allowed on the top lift of the ACP base course).

The purpose of pavement design is to maximize the benefit of the funding spent on the project, both for the current and future projects.

GENERAL EXPECTATIONS

Consultant commits to oversee and direct the design for the Project to obtain the best long-term value for the State of Oregon, and which reflects the prudent expenditure of public funds within the constraints of the Project, program, context and budget. In pursuing this goal, Consultant commits to:

- Develop a design that is appropriate for the context of the Project and the nature of its function, both present and future;
- Develop a design that is *informed* in the strongest terms by scope and project budget set by scoping, but not *controlled* by scope and budget elements (i.e., when scoping expects and budgets for a 1R-type preservation remedy, the pavement solution should not be a complete reconstruction without very thorough justification). Any design recommendations or elements that require changes in scope and/or budget will be rigorously reviewed and must be supported in the pavement design summary based on least life cycle cost, sound analysis, and engineering judgement;
- Avoid expenditures for aesthetic effect which are disproportionate to the Project as a whole;
- Manage and facilitate all facets of the Project that are reasonably within Consultant's control to ensure the Project is completed on or ahead of time and within budget;
- Strive to reduce the construction cost of the Project while keeping life-cycle costs low;
- Use recycled/recyclable products to the maximum extent economically feasible in the performance of this Contract;
- Apprise ODOT throughout the Contract concerning the economic impact of all design decisions; and
- Embody sound and cost-effective sustainability principles in the Services performed under the Contract consistent with the provisions of the Oregon Sustainability Act (2001 HB 3948) that are included in ORS 184.421-.423.

PAVEMENT DESIGN DELIVERABLES

The contracted Services will be a phased development as follows:

1. Phase I – Analysis
2. Phase II – Design
    a. Draft Pavement design
    b. Draft Final Pavement Design
    c. Final Pavement Design
        i. Plan and spec review
        ii. PDT Meetings

3. Phase III - Construction

Following completion of a given phase, Agency may, at its discretion:

- Amend a Contract to add the next phase (or various elements), or
- Elect to complete subsequent phase tasks with in-house staff, or
- Assign subsequent phase tasks to another consulting firm.

Agency and Consultant shall negotiate the detailed tasks, deliverables, schedule and costs for each phase Agency elects to add. Each added phase will be authorized only by written Contract amendment with all required approvals and signatures.

AGENCY RESPONSIBILITIES

The Contract will clarify if the Agency will perform the minimum required pavement testing for the Project. Additional testing may be collected after review and analysis of minimum testing provided. Agency will make available to Consultant samples collected, logs created, and data collected by Agency.

For efficiency in many cases the Agency will have completed or have scheduled testing prior to assigning the Pavement Design to be done in house or outsourced. Therefore, the following outlines minimum testing that will be performed in order to develop a pavement design for a given project. Any given project may have variations of standards shown.

STANDARD MINIMUM AGENCY TESTING

<u>CORES:</u>

- Pavement Cores in the truck lane (B Lane) – Start and end of Project limits and every ½ mile over Project limits.
- Pavement Cores in the passing lane (A Lane) – Start and end of Project limits and every 1 mile over project limits.
- Pavement Cores at bridge approaches – Two approach cores at 50 feet and 10 feet, two leave cores at 10 feet and 50 feet, and one in the center of the structure (AC only) if deck has an AC overlay.

Truck lane (B lane) cores will be taken in the outside wheel track (“OWT”), passing lane (A lane) cores will collected in the inside wheel track (“IWT”).

<u>FWD:</u>

- Pavement Deflection in the truck lane (B Lane) – will be collected at the start and end of Project and at 250 foot intervals between these limits.
- Pavement Deflection in the Passing lane (A Lane) – will be collected at the start and end of Project and at 500 foot intervals between these limits.
- Pavement Deflections on bridge approaches – deflection tests at testing at 5, 10, 20, 30, 40, 50, 75, 100, 125, 150, and 200 feet.
- FWD data delivered in the following electronic formats (.ddx, .F20, .fwd, .mdb, .txt, and .xml files)

PHOTOS:

- Daytime testing – 6 photos will be taken at each core location. One of core ID, one in direction of travel, one opposite of travel, one of shoulder/drainage, one down core hole, and one of core.
- Night Testing – 3 photos will be taken; one of core ID plate, one down core hole, and one of core.

RUT MEASUREMENTS:

Rut depth must be measured and recorded at each core location. At a minimum this must include the IWT and OWT where core is being collected. Rut measurements collected may include adjacent lanes if collection of that data is safe for ODOT Pavement Services Field Crew.

Agency Pavement Testing Note 1:
Agency's Pavement testing results are based on the requirements in ODOT's Pavement Design Guide, current edition, Chapter 4.

Agency Pavement Testing Note 2:
It is possible that localized intermittent individual tests may be skipped by ODOT due to safety considerations. If determined that the information from a specific site is critical to design development, arrangements can be made for ODOT crew to test the location with additional traffic control to ensure safety, or Agency and Consultant may determine an alternative location for testing that is suitable to complete design.

Agency Pavement Testing Note 3:
Unique roadway geometries can affect standard spacing. Agency data provided in these locations may vary from standard spacing's indicated above. Agency will modify standard testing as needed and report the exact mile point of each test location. An example would be multiple structures within a single mile of highway. The opportunity to collect additional information is available under contingency items.

Acronyms and Definitions

Agency, ODOT – Oregon Dept. of Transportation	**NTP –** Notice to Proceed
APM – Agency's Project Manager	**ODOT –** Oregon Department of Transportation
BOC – Breakdown of Costs	**ORS –** Oregon Revised Statute
CPFF – Cost Plus Fixed Fee	**GPR** – Ground Penetrating Radar
DBE – Disadvantaged Business Enterprise	**PM – Consultant's** Project Manager
FP – Fixed Price	**SOW –** Statement of Work
MWESB – Minority, Women & Emerging Small Businesses	**T&M –** Time and Materials
NTE – Not to Exceed	**PPDC –** Pavement Project Delivery Coordinator
PDM– provides the pavement sections recommendations, pavement design notes, and a table of specifications required, as well as boiler plate special provisions required.	**PDS –** Pavement Design Summary is a detailed report that summarizes data analysis, calculations, and resulting conclusions that resulted in the pavement section recommendations in the pavement design memo.
PDMA# – Pavement Design Memo Addendum # - Pavement Design Addendums sequenced starting with 1….to #.	**PDMS# –** Pavement Design Summary Addendum # - Summary of work for the Pavement Design Addendums sequenced starting with 1….to #.
PD – Pavement Design (final deliverable): PDM, PDS, and appropriate associated pavement design appendices.	**AFW –** Agency Field Work. Pavement data collected to be given to consultant in order to complete pavement design.
PDT – Project Delivery Team	**PL –** Project Leader

12.3 Design Report and Supporting Documentation (for Consultant or ODOT)

The Designer shall compile and submit pavement design recommendations and all supporting documentation including design assumptions, background information, and field data, for review in a bound design report.

A Pavement Design is defined by the following 4 elements:

a. Draft Pavement Design – This will contain the 1st draft of the Pavement Design Memo (PDM), Pavement Design Summary (PDS), and supporting appendices. This document will only be reviewed by ODOT Pavement Services for outsourced projects or according to processes outlined under Appendix O for internally developed pavement designs. This draft document will be used as a tool for ODOT Pavement Services to provide comments on the pavement design package recommendations, specifications, special provisions, summary tables, analysis, calculations, or appendices.

b. Draft Final Pavement Design – After all comments have been addressed in the Draft Pavement Design, a draft Final Pavement Design will be provided to the Project Development Team (PDT). Each project will have a unique project schedule, but in general this Pavement Design package is provided a minimum of 1 month before DAP plan review. The pavement design work is informed by the scope provided and the data is used to complete the design work. Any changes or amendments to the draft Final Pavement Design would be to accommodate previously unidentified needs or Agency directed changes in scope.

c. Final Pavement Design – This is the final Pavement Design, sealed and stamped by a Professional Engineer licensed in the State of Oregon, which will be available to bidders when the project lets. Typically only the PDM is provided with other PS & E documents, but other elements will be made available on request. This product in general is best finalized after the PDT has had a chance to develop at least one set of plans (DAP minimum). In general, the stamped Final Pavement Design should be provided a minimum of 1 month prior to the development of the Advanced Plan package. This allows the PDT to communicate any minor pavement needs to the Pavement Designer. This will often be related to items such as turn outs, guard rail construction, or even loop replacement on a connection to the highway. Other common changes are changes to project specification such as including or removing Intelligent Compaction, which were not detailed in the original scope.

d. Addendums to Final Pavement Design – After the Pavement Design has been stamped by the Pavement Design Engineer of Record (EOR), changes in scope can occur. These changes range from updating specification and special provisions (minor) to changes in desired paving scope (major). These changes will be Agency directed and require the support of the Program Managers of the funds affected by the changes in scope. The PPDC will coordinate any communications necessary.

The design recommendations and supporting documentation shall be in English units as specified in the contract documents.

The bound design report must include an executive summary (See Appendix K for an example) and supporting documentation with contents as described in the following subsections.

12.3.1 Pavement Design Memo (PDM)

The goal of the PDM is provide a set of treatment sections that can be incorporated into a project plan set as well as the specifications and special provisions needed to construct the pavement recommendations therein. Pavement design notes in a PDM are project-specific notes that address unique issues related to pavement design implementation or constructability. At a minimum it should contain:

- A description of the project scope (typically derived from the Project Charter)
- The recommended pavement design(s) for all existing and new pavement features
- The materials recommended (reference applicable specification and bid item nomenclature for each recommendation)
- Any required modifications to special provisions or specifications
- The length of time the pavement design will be valid, typically through 2 construction seasons beyond the bid let date

An example Pavement Design Memo is included in Appendix K.

12.3.2 Pavement Design Summary (PDS)

The goal of a PDS is to provide the reader with details on how the Designer arrived at the recommended depths of treatment specified in the PDM. The documents provide the data, engineering inputs, calculations, rationales, and engineering assumptions required to arrive at the pavement treatment indicated in the PDM. At a minimum it should contain:

- A summary of historical “as-built” construction information (if available)
- A summary of the existing pavement structure based on a review of as-built construction history files provided
- A summary of the existing pavement condition based on the ODOT Pavement Management data provided and the Designer’s engineering judgement of current condition based on field observations
- A summary of the average, standard deviation, minimum and maximum deflections based on delineations made for the pavement treatments sections of the PDM.
- A summary of the average, standard deviation, minimum and maximum material depths found in the core samples based on delineations made for the pavement treatments sections of the PDM.
- A summary of the average, standard deviation, minimum and maximum rut information based on delineations made for the pavement treatments sections of the PDM.
- A summary of design traffic including truck spectra, current volume, projected 20 year volume, growth expansion factor, annual growth rate, distribution factor, directional factor, flexible or rigid factors used, and at a minimum the calculated 8, 15, 20, and 30 year projected ESALs.
- Design inputs based on ODOT Pavement Design Guidelines — initial and terminal serviceability, overall deviation, reliability, and structural coefficients that apply.
- Subgrade Resilient Modulus (M_r) – A summary of testing or calculations that lead to the design resilient modulus used for a given design recommendation section.
- The design procedure and design structural life for all new work and rehabilitation sections
- A summary of design calculations, including traffic, layer thickness, total structure, etc. Calculation worksheets and analysis tools attached as appendices shall be referenced (how did we arrive at the depth of treatment specified).
- A summary of any Life Cycle Cost Analysis (if required).
- For pavement design life exceptions, provide a description of, and justification for, the design exception (A Life Cycle Cost Analysis is required as part of the justification).
- Identify options considered and basis for the recommended design
- Provide any Life Cycle Cost Analysis calculation data in a separate appendix (when applicable). Reference the appropriate appendix as appropriate.

12.3.3 Pavement Design Appendices

For projects which involve pavement preservation, pavement rehabilitation, or construction of new pavement on portions of existing alignment, also include the following items:

a. Hard copy of deflection data - Deflections shall be shown for each sensor normalized to a 9,000 pound load
b. Plot of deflections by milepoint or station
c. Copies of all core logs (example see appendix C)
d. Copies of all Probe (soil) exploration logs (example see appendix D)
e. A summary of all test results conducted on material
f. Color copies or duplicates of all roadway photos — Photos must be arranged in milepoint order and labeled with the date, milepoint and direction of the picture
g. Color copies or duplicates of all core photos, properly labeled with Project Name, core number and against a scaled background with ½″ intervals (see section 4.3.3)
h. Summary of rut depth measurements. The average rut depth and standard deviation for each wheel track should also be indicated

12.3.4 Electronic Files

In addition to the above requirements, an electronic copy of all raw deflection data files for the project (if applicable) shall also be provided.

An electronic file copy of all digital photographs shall be provided.

A .pdf copy of the memo and summary shall also be provided electronically.

12.3.4 Deliverable Checklist

A checklist is provided in Appendix N to aid the Designer in providing all of the required documentation and deliverables.

12.4 ProjectWise (for Consultant or ODOT)

When required, the design report (memo, summary and appendices) shall be put in the appropriate ProjectWise folder (by key number, in the "Pavements" folder). As the draft pavement design develops, a draft version can be uploaded to the project folder for the project team to use in their design. Notify the project team of milestones (draft design, final design, and any addendums) as they occur.

Any additional information regarding the pavement design that can be of assistance to the project team (maps, core photos, pavement condition) should also be uploaded into ProjectWise.

For consultant projects, the consultant shall provide these items to the Pavement Services Unit per the contract.

APPENDICES

APPENDIX A

Pavement Design Procedure Contact Information

American Association of State Highway and Transportation Officials
(AASHTO): 202-624-5800
(https://www.transportation.org)

Asphalt Pavement Association of Oregon
(APAO): 503-363-3858
(http://www.apao.org)

American Concrete Pavement Association
(ACPA): 360-956-7080
(http://www.acpa.org)

The Asphalt Institute
(TAI): 859-288-4960
(http://www.asphaltinstitute.org)

Portland Cement Association
(PCA): 847-966-6200
(https://www.cement.org/pavements)

Mechanistic Design based on NCHRP:
(http://onlinepubs.trb.org/onlinepubs/archive/mepdg/home.htm)

International Slurry Surfacing Association
(ISSA):
(https://www.slurry.org/)

APPENDIX B

Project Charter Example

This appendix provides an example ODOT Project Charter. The example is provided to show what type of information can be found in this document.

SHOW KEY NUMBER AND PROJECT NAME FIELDS

Oregon Department of Transportation

ODOT PROJECT CHARTER
20162 OR99: Birch St to Coleman Creek Culvert (Phoenix)

☐ Draft ☒ Final

BUSINESS CASE INCLUDED? ☒ Yes ☐ No

PROJECT SPONSOR	PROJECT LEADER/LOCAL AREA LIAISON	DATE PREPARED
Mike Baker	Anna Henson	August 23, 2018

Project Description

At a high level, describe the work anticipated to be performed. This could include a brief summary of the end product such as: what will be built, services that will be provided, equipment that will be purchased, etc. Identify if the project can be completed in phases, and the end result of those phases.

Replace culvert at Coleman Creek, add and improve sidewalks to ADA compliance, add bike lanes and pedestrian crossings along OR99 from Birch St to Coleman Creek. Repave OR99 within project limits. Install Transit Signal Prioritization on OR99 Ashland to Central Point.

Additional Constraints

Describe any new or additional constraints/limiting factors that were not described in the business case.

Assumptions

Describe any current assumptions associated with this project. These assumptions will be validated by the project team in the early project development planning phase.

relocations of driveways along with nighttime road closures may be required

Risks

The team will register and investigate these risks during project development planning.

utility conflicts, relocations of driveways, relocation of historic sign

Proposed Milestones

Identify proposed dates for major milestones

MILESTONE	DATE
Initiation (kick-off)	08/09/2017
Project Management Plan Complete	
Design Acceptance Phase	3/21/2019
PS&E	8/31/2020
Obligation of funds for the Preliminary Engineering (PE) phase	Jul 28, 2017
Obligation of funds for the Right of Way phase	Mar 28, 2019
Obligation of funds for the Construction phase	Oct 30, 2020

Funding

AMOUNT	STIP CYCLE
$7,182,000	2018-2021

Funding Eligibility/Flexibility

1. Is the population in the project area	☐ < 5,000	☒ 5,000-200,000	☐ > 200,000
2. Is the project on the NHS?		☒ Yes	☐ No
3. Is the project eligible to use funding from the State Highway Fund (i.e., the gas tax)?*		☒ Eligible	☐ Not eligible
4. What Federal agency is this project eligible to be delivered through?	☒ FHWA	☐ FTA	☐ Both
5. Is the project making improvements to a rail crossing?		☐ Yes	☒ No
6. Is the project at a SPIS site?	☐ Top 5%	☐ Top 10%	☒ No

* Examples of non-eligible work are improvements outside the right of way or off-system.

Key Stakeholders

Who are the major stakeholders the project can affect and/or who can influence the project, as known to date?

STAKEHOLDER	HAS DECISION AUTHORITY	CAN INFLUENCE OUTCOME	WILL BE AFFECTED
City of Phoenix	☐	☒	☒
Adjacent residential and business property owners.	☐	☒	☒

Project Leader/Local Area Liaison Authority Level

Describe the project leader's authority to determine, manage and approve changes in the following areas:

Staffing decisions: Unit Managers shall be responsible for staffing decisions; PL will coordinate with Unit Managers on project team accountability concerns
Budget management and variances: Estimated amounts in excess of budget will be reported to Area Manager for approval or resolution.
Project Communication and/or Escalation Process: Key stakeholder, including adjacent property/business owners will be updated on the progress through various means such as press releases, direct contact, Moving Ahead with ODOT stories, project website, etc. Any decision escalation for significant change in scope, schedule or budget will be communicated to and approved by the Area Manager.
Change Management (determine when scope, budget and timeline changes are required and when a CMR is required): A project CMR shall be submitted when advancing or delaying a project PS&E date into a different federal fiscal year (FFY), advancing or delaying a phase (PE, R/W, CN) of a project into another FFY or adding Region 3 funds to a project, scope changes from the Final Business Case or subsequent approved CMRs, modifying the budget >$500,000 or 25% change whichever is less.

Resources

Identify the functional areas for the project team, including specialty groups, consultants, contractors, and other organizations or agencies that are involved in the development of the project.

Project team

Who should be included on the project team? Check all that apply:

☒ Bridge	☒ Community Affairs	☒ Construction	☒ Environmental	☒ Mobility/Freight
☒ Geo Technical	☒ District Maintenance	☒ Hydraulics	☒ Planning	☒ HazMat
☒ Utilities	☒ Right of Way	☒ Bike/Pedestrian	☒ Roadway	☒ Pavements
☒ Survey	☐ Rail	☒ Traffic	☒ Transit	☒ Geology
☐ City	☐ County	☐ Federal Highway Administration		

☐ Other (describe) ______

Comments

Signatures

Signatures indicate approval to move forward.

PROJECT LEADER/LOCAL AREA LIAISON NAME Anna Henson	PROJECT LEADER/LOCAL AREA LIAISON TITLE Region 3, Project Leader	PROJECT LEADER/LOCAL AREA LIAISON SIG. X Henson Anna Aug 23 2018 7:48 AM	DATE
AREA MANAGER PRINT NAME Art Anderson	AREA MANAGER TITLE Region 3 Area Manager	AREA MANAGER SIGNATURE X ANDERSON Arthur H Aug 23 2018 1:45 PM	DATE
PROJECT SPONSOR PRINT NAME Mike Baker	PROJECT SPONSOR TITLE Region 3 Planning Manager	PROJECT SPONSOR SIGNATURE X Mike Baker Digitally signed by Mike Baker Date: 2018.08.05 14:03:35 -07'00'	DATE
TECH CENTER MANAGER PRINT NAME Mark Thompson	TECH CENTER MANAGER TITLE Reg 3 Tech Center Manager	TECH CENTER MANAGER SIGNATURE X M. Thompson, PE Aug 28 2018 2:50 PM	DATE
DISTRICT MANAGER PRINT NAME Jerry Marmon	DISTRICT MANAGER TITLE District 8 Manager	DISTRICT MANAGER SIGNATURE X	DATE
LOCAL PARTNER PRINT NAME	LOCAL PARTNER TITLE	LOCAL PARTNER SIGNATURE X	DATE

734-2948A (5/15) 20162 OR99: Birch St to Coleman Creek Culvert (Phoenix) Page 2 of 2

APPENDIX C

Pavement Depth Core Log

These ODOT core logs are provided as an example only. This shows the type of information that should be included on the logs. Consultants may copy the ODOT logs or develop their own form.

Include:

- Lift line locations
- Delamination locations (breaks caused by coring operation should be noted)
- General crack locations
- Changes in core shape or areas of non-recovered material

The core condition should be visually rated by lifts:

- **Good** – Lift is recovered intact, tight vertical cracks may be present, no vertical or horizontal deformation

- **Fair** – Lift is recovered essentially intact, some single cracks may be present, small hairline cracks may be present, small void pockets may be visible, minor spots of AC stripping or PCC deterioration, some minor deformation but stable

- **Poor** – Lift is not recovered intact, lift has lost core shape, recovered material is loose (AC stripping or PCC deterioration)

CORE MP

PAVEMENTS CORE LOG

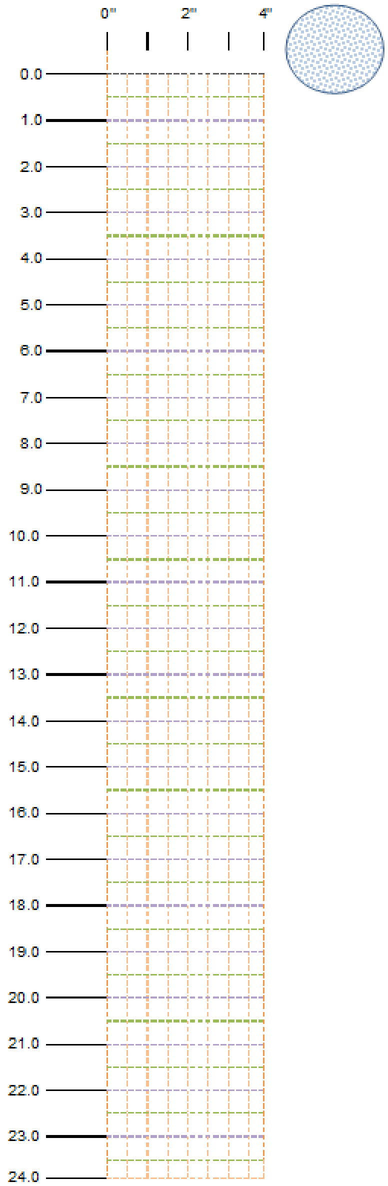
Logged by: RS ( ) TB ( ) BH ( ) SM ( ) Other ( )

Designer: BJS
EA: PE002926-000-J13
Project: OR99W: W. 3rd Ave - Enid Rd
Br#
BMP: 109.65
Highway: Pacific Highway West, 091
EMP: 116.74
County: Lane
Bridge: 50' A ( ) 10' A ( ) Ctr ( ) 10' L ( ) 50' L ( )
Key: K21235

Drilled On Crack	(No) (Yes)	Drilled On Patch	(No) (Yes)	DIR	(EB) (WB) (NB) (SB)	LANE	(A) (B) (Other) (C) (D)	LOC	IWT ( ) BWT ( ) OWT ( )	Date:

Depth:

Note:



Photos (a) (b) (c) (d) (e) (f) notes:

CORE 3 MP 7.80

PAVEMENTS CORE LOG

Logged by: RS ( ) TB ( ) BH ( ) RM (X) Other ( )

Designer: Karen Strauss
EA: C6035200-000-J71
BMP: 2.50
EMP: 10.30
Key: 19786

Project: I-205: Stafford Rd. to 99E
Highway: East Portland Freeway, Hwy 064
County: Clackamas
Br#
Bridge: 50' A ( ) 10' A ( ) Ctr ( ) 10' L ( ) 50' L ( )

Drilled On Crack	(No) (Yes) ☺ 😐 ☹	Drilled On Patch	(No) (Yes) ☺ 😐 ☹	DIR	(EB) (WB) (NB) (SB)	LANE	(A) (B) (Other) (C) (D)	LOC	IWT ( ) BWT ( ) OWT (X)	Date: 6-11-17

Depth: 7 1/4

Note:

0" 2" 4"

0.0 – 2.0	OPEN AC
2.0 – 4.5	DENSE AC
4.5 – 7.25	DENSE AC

0.0 1.0 2.0 3.0 4.0 5.0 6.0 7.0 8.0 9.0 10.0 11.0 12.0 13.0 14.0 15.0 16.0 17.0 18.0 19.0 20.0 21.0 22.0 23.0 24.0

EP EP

11⁴ 4⁰

tos ~~(a) (b) (c) (d)~~ (e) (f) notes:

APPENDIX D

Exploration Hole Log

These ODOT exploration logs are provided as an example only. This shows the type of information that should be included on the logs. Consultants may copy the ODOT logs or develop their own form.

Pavement Services Unit: Exploration Hole Log

Project Info			
Project	OR99W: W. 3rd Ave - Enid Rd	EA:	PE002926-000-J13
Highway	Pacific Highway West, 091	BMP	109.65
County	Lane	EMP	116.74
Designer	BJS	Key	K21235

Date:

Probe #	Probe MP	Core #	Core Depth	Total Depth	Measured Depth	Operator (Field)	Logged By (Lab)

Depth (in)	Graphic Depiction	**Material Description** **Soil Type:** Gravelly, Sandy, Silty, Clayey GRAVEL, SAND, SILT, CLAY w/some, trace (gravel, sand): w/some, trace (silt, clay) **Color:** Largest Rock; % Rock **Rock Texture:** Angular, Subangular, Rounded, Subrounded **Plasticity:** Non-, Low-, Medium-, or High Plastic **Moisture:** Dry, Damp, Moist, Wet **Consistency:** Very soft, Soft, Medium Stiff, Stiff, Hard, Very hard **Density:** Very Loose, Loose, Medium Dense, Dense, Very Dense	**Unit Description** Surfacing, Base, Subbase, or Subgrade	**Remarks**
4				
8				
12				
16				
20				
24				
28				
32				
36				
40				
44				
48				
52				
56				
60				

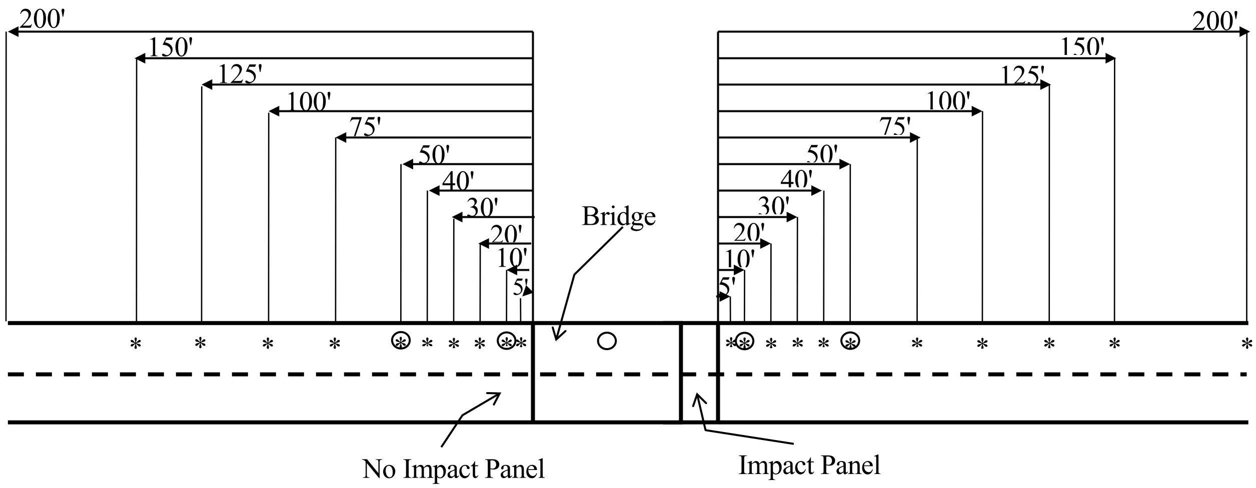
EP EP

Note distance from edge of Pavement, direction; and cut/fill lines.

APPENDIX E

Bridge Approach or Undercrossing Testing

Deflection Testing and Coring at Bridge Approaches



* = Deflection tests at the following intervals: 5′, 10′, 20′, 30′, 40′, 50′, 75′, 100′, 125′, 150′, 200′.

○ = Pavement Cores. Pavement Cores at the same locations as the 10′ and 50′ deflection tests.

Do not deflect or core on impact panels. For our testing purposes impact panels are considered part of the structure.

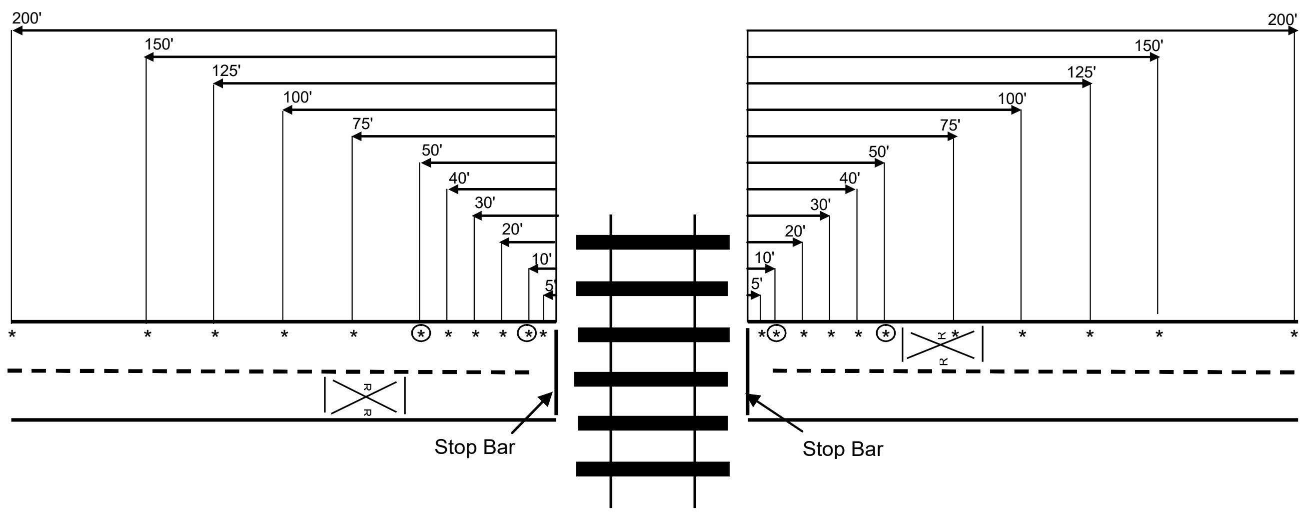
This testing is required at all bridge approaches. This testing should be considered at undercrossings where vertical clearance may be a design issue.

APPENDIX F

At-Grade Railroad Crossing Testing

Deflection Testing and Coring at Railroad Crossing Approaches

FIELD WORK @ RR CROSSINGS



(*) Deflection tests at the following intervals: 5', 10', 20', 30', 40', 50', 75', 100', 125', 150', 200'.

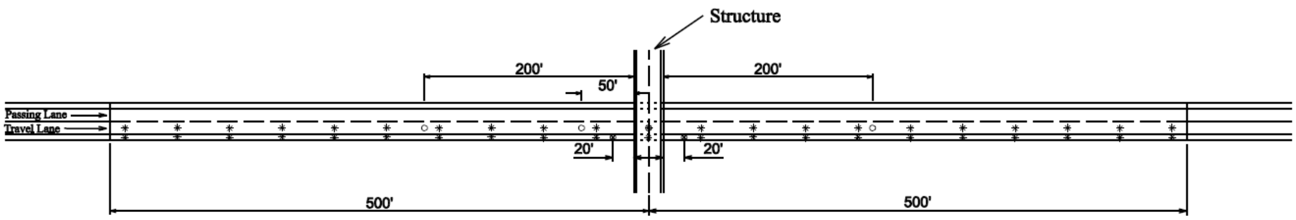
(○) Pavement cores.

Note: The specific quantities and locations of tests may vary from the drawing above based on specific site conditions.

APPENDIX G

Standard Testing for New Construction of Undercrossings

Minimum Deflection Testing, Coring, and Probes at Under Crossings.



See Next Page for Larger Scale Diagram of Testing Required Within 200′ of Structure

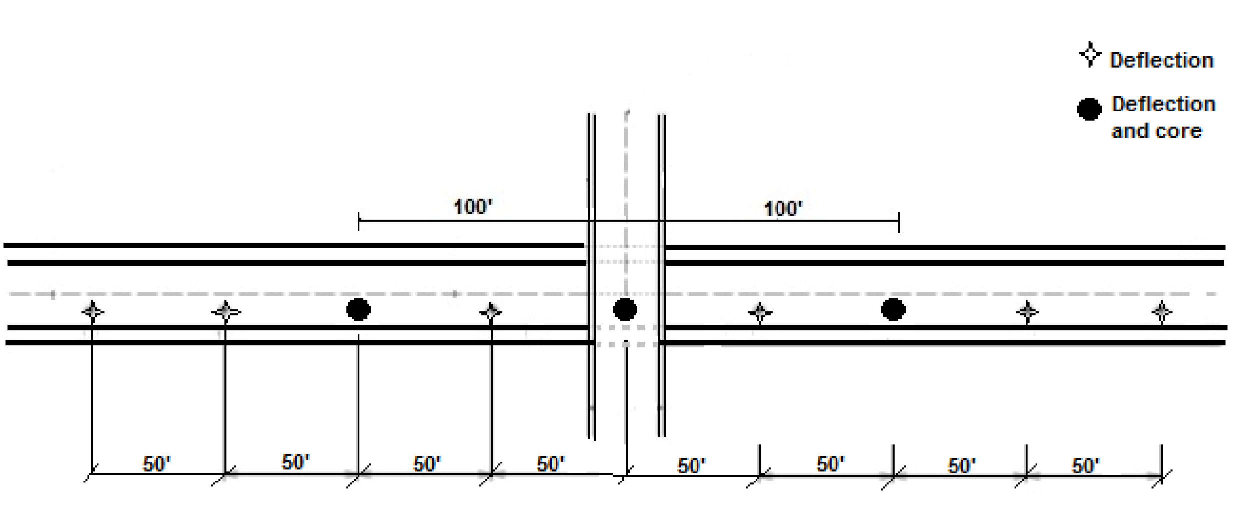
* = Deflection tests at 50′ intervals 500′ from each side of the center of the structure in the shoulder. Deflections in the travel lane should be considered on a project by project basis.

○ = Pavement Cores. If pavement removal is needed to lower grade at undercrossings, then cores will be required in the travel lane if the grade change will be less than 6″.

X = Probes at 20′ from each side of the structure in the shoulder, if the grade change will be over 6″. This is for traffic control reasons (vertical clearance posted is for travel lanes only.)

Note: When testing pavement at undercrossings, Freight Mobility must be contacted 30 days in advance if vertical clearance is less than 17′ 10″. Also Freight Mobility must be contacted if 22′ of horizontal clearance cannot be maintained while testing. Reference Highway Directive TRA07-15d.

Standard Testing for Undercrossings Detail



APPENDIX H

Sample Distress Rating Form

This ODOT Pavement Design distress rating form is provided as an example only. This shows show the type of information that should be included on the form. Consultants may copy the ODOT logs or develop their own form.

2018 GFP PAVEMENT CONDITION FORMS - CALIBRATION LOOP

ROUTE	DIR	HWY	RW	MT	OV	BEG MP	END MP	SECTION	LENGTH	AGE	PAVEMENT TYPE	BOUNDARY ADJUSTED
OR 22	E	030	1			11.70	15.34	DOLPH CORNER - RICKREALL INTCH	3.64	9	C-MIX DGAC INLY/OVLY A	

DISTRESS											
FATIGUE L M H	0	1	5	10	25	50	75	100	% length	16: 7%	
T-CRK L M H	____ # / 0.1 mi									16: 0	
PATCH L M H	0	1	5	10	25	50	75	100	% area	16: 0%	
RAVEL L M H S I E	BLEEDING >5% Y	POTHOLES S or D S I E									

RATING	10	12	14	16	2018
OVERALL					____
IRI	45	50	52	52	GD FR PR
RUT	0.1	0.1	0.2	0.2	____ in.

ROUTE	DIR	HWY	RW	MT	OV	BEG MP	END MP	SECTION	LENGTH	AGE	PAVEMENT TYPE	BOUNDARY ADJUSTED
OR 22	E	030	1			15.34	16.17	RICKREALL INTERCHANGE	0.83	12	C-MIX DGAC THK	

DISTRESS											
FATIGUE L M H	0	1	5	10	25	50	75	100	% length	16: 46%	
T-CRK L M H	____ # / 0.1 mi									16: 5	
PATCH L M H	0	1	5	10	25	50	75	100	% area	16: 0%	
RAVEL L M H S I E	BLEEDING >5% Y	POTHOLES S or D S I E									

RATING	10	12	14	16	2018
OVERALL					____
IRI	86	90	92	95	GD FR PR
RUT	0.1	0.1	0.2	0.2	____ in.

APPENDIX I

Example ESAL Calculation

Given: A 2-lane State Highway with Asphalt Concrete Pavement
Construction Year = 2012
20-year Structural Design Life

Traffic Data as provided by the Oregon Transportation Management System (OTMS) (contact phone number 503-986-4251):
2008 Two-way ADT = 13,400 2028 Two-way ADT = 19,300
20-year Expansion Factor = 1.44
Note – 20-year Expansion Factor = (2028 ADT)/(2008 ADT)

2008 Truck Count From ODOT OTMS, FHWA Truck Classes											
4	5	6	7	8	9	10	11	12	13	Total AADT	Trucks % ADT
5	350	200	4	80	140	55	5	5	20	864	6.4

Required: Determine 20-year Design ESALs for input into AASHTO Pavement Design Procedure.

Solution: 1) Determine Annual Growth Rate from the 20-year Expansion Factor:

$$R = \left[E^{\left(\frac{1}{n}\right)} - 1\right] * 100$$

Where: R = Annual Growth (%)
E = Expansion Factor
n = Number of Years

$$R = \left[1.44^{\left(\frac{1}{20}\right)} - 1\right] * 100 = 1.84$$

Annual Growth = 1.84%

2) Perform Initial ESAL Calculation for the year 2008 using ESAL conversion factors from Chapter 5, Table 1:

CLASS/ ITEM	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
(A) Count	5	350	200	4	80	140	55	5	5	20	864
(B) ESAL Factor	246	104	284	757	253	466	561	603	546	1037	-
(C) Direction Factor	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	0.55	-
Directional ESALs = A x B x C	**677**	**20,020**	**31,240**	**1,665**	**11,132**	**35,882**	**16,970**	**1,658**	**1,502**	**11,407**	**132,153**
% of	0.58	40.51	23.15	0.46	9.26	16.20	6.37	0.58	0.58	2.31	100

AADT											

3) Expand Initial ESAL Calculation to Year of Construction:
(2012 in this example)

Year 2008 ESALs = 132,153
Annual Growth Rate = 1.84%

$$E_n = \left[\left[1 + \left(\left(\frac{R}{100} \right) \right]^n \right) \right]$$

Where: R = Annual Growth (%)
E_n = Expansion Factor to year n
n = Number of Years

$$E_4 = \left[\left[1 + \left(\left(\frac{1.84}{100} \right) \right]^4 \right) = 1.075656 \right]$$

2012 ESALs = (2008 ESALs) * (4-year Expansion Factor)

<u>2012 ESALs = (132,153) * (1.075656) = 142,151</u>

4) Forecast ESALs to end of Design Life:

- (20 years in this example)
- Since no directional distribution was provided from traffic data, use 55% per PDG Section 5.1 discussion.
- For 2-lane highway, lane distribution factor = 1.0

Year	**ESAL's**	**Summation**
2012	142,151	142,151
2013	144,767	286,918
2014	147,430	434,348
2015	150,143	584,491
2016	152,906	737,396
2017	155,719	893,116
2018	158,584	1,051,700
2019	161,502	1,213,202
2020	164,474	1,377,676
2021	167,500	1,545,176
2022	170,582	1,715,759
2023	173,721	1,889,480
2024	176,917	2,066,397
2025	180,173	2,246,570
2026	183,488	2,430,058
2027	186,864	2,616,922
2028	190,302	2,807,224
2029	193,804	3,001,028
2030	197,370	3,198,398
2031	201,002	3,399,399
2032	204,700	3,604,099

Example Calculation

$$2013\text{ ESALs} = 2008\text{ ESAL's} \left[\left(1 + \left(\left(\frac{R}{100} \right) \right) \right] \right)$$

$$2013 ESALs = 142{,}151 \left[\left(1 + \left(\left(\frac{1.84}{100} \right) \right) \right] \right) = 144{,}767$$

20-year design ESALs are calculated by summing the annual ESALs as shown in the table to the left and subtracting the initial annual ESAL value (value for construction year).

(NOTE: numeric rounding can produce minor differences in the final value)

For this example the <u>20-year ESALs are 3,604,099 – 142,151 = **3,461,948**</u>

<u>Lane distribution factor = 1.0</u>
<u>DESIGN ESALs = 3,461,948</u>

APPENDIX J

Mix Type and PG Binder Recommendation

The following tables provide the recommended combinations of mix design level, type of mix (aggregate size designation), and performance graded (PG) binder selection.

In addition, information is provided for *consideration*. When considering the option(s) provided, the Designer should determine the most cost-effective selection considering such elements as:

- Quantities (tons) of resulting mixes
- Number of mix types (levels and aggregate sizes) for the project
- Types and quantities (tons) of PG binder for the project
- Availability of mix and constituents

The table provides for possible situations for *consideration* of PG 76-xx binder. Project experience with PG 76 grades in Oregon is limited. Contact the ODOT Pavement Quality and Materials Engineer before selecting a PG 76-xx grade.

EXAMPLE:
A project in the coastal area requires 2,000 tons of ACP dense graded mixture. The 20-year ESALs is 4 million. The location is designated as Urban. The design thickness is 8 inches.

- Option 1: Use full depth Level 3, ½″ dense, PG 70-22.
- Option 2: Use Level 3, ½″ dense, PG 70-22 for the top 4 inches, and Level 3, ½″ or ¾″ dense, PG 64-22 for the lower 4 inches.
- Recommendation: Option 1, since Option 2 will require two lots, and each lot will be only 1,000 tons. The effect of 2 small quantity lots would offset any cost savings from changing the aggregate size or reducing the binder grading based on factors such as: 2 mix designs, if using ¾″ dense then need a course size stockpile, QC testing would provide 1 test per lot rather than 2 tests for a single lot of Option 1, etc.

Definitions:

Urban Highway: A highway with slow moving traffic (less than 40 mph) or with multiple traffic lights or other stops.

Rural Highway: A highway outside of towns where traffic speeds normally exceed 40 mph and there are no traffic lights or other stops.

OREGON DEPARTMENT OF TRANSPORTATION

ASPHALT PERFORMANCE GRADE REGIONS

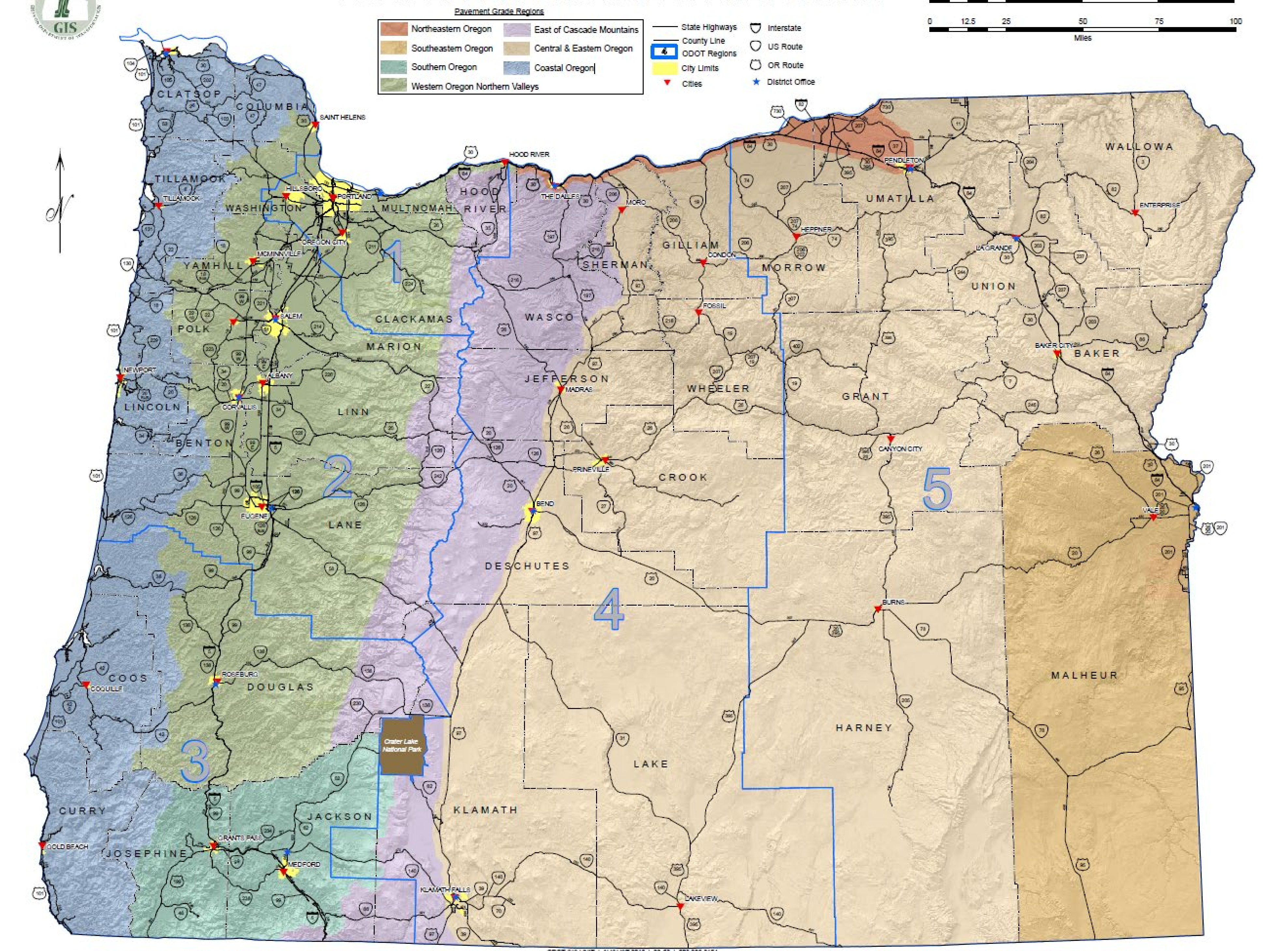


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Table J-1 — Coastal Oregon
(Coast Range to Ocean)

Traffic Designation	Dense Graded ACP 20-year ESALs			
	< 1 million	**1 – 3 million**	**>3-10 million**	**> 10 million**
Rural	Level 2, ½″ Dense PG 58-22	Level 3, ½″ Dense PG 58-22	Level 3, ½″ Dense PG 64-22	Level 4, ½″ Dense PG 70-22ER ***Consider:*** *Below 4" depth* Level 3 ½″ dense
Urban	Level 2, ½″ Dense PG 64-22	Level 3, ½″ Dense PG 64-22	Level 4, ½″ Dense PG 70-22ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-22ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*

Table J-2 – Western Oregon Northern Valleys below 2500 feet Elevation
(Portland Metro, Willamette Valley south including Douglas County & Columbia River Gorge to Hood River ECL)

Traffic	Dense graded ACP 20-year ESALs				
Designation	**< 1 Million**	**1 -3 Million**	**> 3 – 10 Million**	**> 10 – 30 Million**	**> 30 Million**
Rural	Level 2, ½″ Dense PG 64-22 ***Consider:*** PG 58-22	Level 3, ½″ Dense PG 64-22 ***Consider:*** PG 58-22	Level 3, ½″ Dense PG 64-22	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*
Urban	Level 2, ½″ Dense PG 64-22	Level 3, ½″ Dense PG 64-22	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ Dense PG 64-22 *(Preferred if cost-effective)*

Table J-3 — Southern Oregon below 2500 feet Elevation (Josephine & Jackson Counties between Coast Range and Cascades Foothills)				
Traffic Designation	**Dense Graded ACP 20-year ESALs**			
	< 1 million	**1 – 3 million**	**>3-10 million**	**> 10 million**
Rural	Level 2, ½″ Dense PG 64-22	Level 3, ½″ Dense PG 64-22	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ dense PG 64-22 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ dense PG 64-22 *(Preferred if cost-effective)*
Urban	Level 2, ½″ Dense PG 64-22	Level 3, ½″ Dense PG 64-22	Level 4, ½″ Dense PG 70-22 ER ***Consider:*** PG 76-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ dense PG 64-22 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 76-22 ER ***Consider****:* *below 4″ depth* Level 3 ½″ dense PG 64-22 *(Preferred if cost-effective)*
Urban (Critical)			**For Grants Pass/ Medford/Ashland:** Consult ODOT Pavement Quality and Materials Engineer	**For Grants Pass/ Medford/Ashland:** Consult ODOT Pavement Quality and Materials Engineer

Table J-4 —Cascade Mountains above 2500 feet Elevation and West of Crest of Cascades				
Traffic Designation	**Dense Graded ACP 20-year ESALs**			
	< 1 million	**1 – 3 million**	**>3-10 million**	**> 10 million**
Rural	Level 2, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28	Level 4, ½″ Dense PG 70-28ER
Urban	Level 2, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 4, ½″ Dense PG 70-28ER ***Consider****:* *below 4″ depth* Level 3 ½″ dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28ER ***Consider****:* *below 4″ depth* Level 3 ½″ dense PG 64-28 *(Preferred if cost-effective)*

Table J-5 — Northeastern Oregon
(I-84 along Columbia River Gorge from Hood River ECL to Pendleton ECL)

Traffic Designation	Dense Graded ACP 20-year ESALs			
	< 1 million	**1 – 3 million**	**>3-10 million**	**> 10 million**
Rural	Level 2, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4″ depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*
Urban	Level 2, ½″ Dense PG 64-28	Level 3, ½″ Dense PG 64-28	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4"depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4″ depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*

Table J-6 – Central & Eastern Oregon Mid-Elevation Desert/Plateau
(Except Cascades, Gorge, and Southeastern Oregon)

Traffic Designation	**< 1 Million**	**1 -3 Million**	**> 3 – 10 Million**	**> 10 – 30 Million**	**> 30 Million**
Rural	Level 2, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*
Urban	Level 2, ½″ Dense PG 64-28	Level 3, ½″ Dense PG 64-28	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*

Table J-7 — Southeastern Oregon – Malheur County and Snake River Vicinity
(Ontario, Vale, Nyssa, Hells Canyon)

Traffic Designation	Dense Graded ACP 20-year ESALs			
	< 1 million	**1 – 3 million**	**>3-10 million**	**> 10 million**
Rural	Level 2, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 3, ½″ Dense PG 64-28 ***Consider:*** PG 58-28	Level 4, ½″ Dense 70-28ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*
Urban	Level 2, ½″ Dense PG 64-28	Level 4, ½″ Dense PG 70-28ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense 70-28ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*	Level 4, ½″ Dense PG 70-28 ER ***Consider***: *below 4" depth* Level 3 ½″ Dense PG 64-28 *(Preferred if cost-effective)*
Urban (Critical)			**For Ontario/Vale/Nyssa:** Consult ODOT Pavement Quality and Materials Engineer	**For Ontario/Vale/Nyssa:** Consult ODOT Pavement Quality and Materials Engineer

APPENDIX K

Pavement Design Memo

This Pavement Design Memo is provided as an example only. The intent is to show the type of information and general format that should be included in the Memo.

Pavement Design Memo Example

Oregon Department of Transportation
Construction Section
Pavement Services Unit
800 Airport Rd, Salem, Oregon 97301-4798
Phone: (503) 986-3000, FAX: (503) 986-3096

DATE: December 12, 2017

TO: Brian Sheadel
Senior Roadway Designer
(541) 774-6385

FROM: T.H. Sophia Burkhart, E.I.T.
Pavement Specialist
(503) 986-3770

SUBJECT: Final Pavement Design Memo for:
I-5 Exit 33 Off Ramp Improvements
Northbound Off Ramp (Central Point Connection No. 1, 001BN), MP 32.47 – MP 32.70
E Pine Street (Central Point Connection No. 2, 001BO), MP 32.87 – MP 32.91
Jackson County
PE002761-000-J13
Key No. 19789

Problem:

The construction of a new Costco store on Table Rock Road will impact the traffic on the I-5 Exit 33 Northbound Off Ramp, by decreasing the v/c ratio below ODOT standards.

Solution:

The project will add another right turn lane on the I-5 Exit 33 Northbound Off Ramp (Central Point Connection No. 1, 001BN) to E Pine Street (Central Point Connection No. 2, 001BO) as a Modernization project. The additional lane will address safety concerns associated with queuing on the off ramp.

Scope:

A pavement design is needed for the new work associated with the new lane and resurfacing on the I-5 Exit 33 Northbound Off Ramp and E Pine Street.

New Work – New Right Turn Lane and Shoulder:

I-5 Exit 33 Northbound Off Ramp (Central Point Connection No. 1, 001BN) MP 32.47 – MP 32.70 and E Pine Street (Central Point Connection No. 2, 001BO) MP 32.87 – MP 32.91:

- 2.0" Level 4, ½" Lime or Latex Polymer Treated ACP Wearing Course (One Lift)
- 7.0" Level 4, ½" Lime or Latex Polymer Treated ACP Base Course
  (First Lift of 3.0", Second Lift of 2.0", and Third Lift of 2.0")
- 12.0" Dense-Graded Aggregate Base (1" – 0 or ¾" – 0)
- Subgrade Geotextile (Woven)

Resurfacing – Existing Roadway:

I-5 Exit 33 Northbound Off Ramp Terminal (Central Point Connection No. 1, 001BN) at the Intersection with E Pine Street (Central Point Connection No. 2, 001BO):

- 2.0" Level 4, ½" Lime or Latex Treated ACP Wearing Course
- 2.0" Cold Plane Pavement Removal

1

Subgrade Stabilization:

Pavement Services recommends 18.0" subgrade stabilization over 100% of the new roadway area for estimation purposes.

Specifications:

Pavement Services recommends verifying actual field conditions during construction, to determine the necessity of subgrade stabilization. If upon exposure the subgrade is dry and stable, Standard Specification 00331 – Subgrade Stabilization may be eliminated.

MATERIALS	2018 STANDARD SPECIFICATIONS
Specific Limitation	Special Provision **00180** • 00620.43. • 00745.51.
Subgrade Stabilization	Standard Specifications **00331**
Subgrade Geotextile – Woven	Special Provision **00350** • Level B Certification.
Cold Plane Pavement Removal	Special Provision **00620** • Traffic allowed up to 12 months after existing surface is removed.
Dense-Graded Base Aggregate	Special Provision **00641** • Base Aggregate shall be either 1" – 0 or ¾" – 0 size.
Level 4, ½" Lime or Latex Polymer Treated ACP	**PG 76-22ER** Asphalt Binder **00745.10(b)** Reclaimed Asphalt Pavement • No more than 15% RAP will be allowed in Level 4 wearing courses. **00745.10(c-4)** Recycled Asphalt Shingles • For Level 4 ACP mixtures: o No more than 3.0% RAS by total weight of aggregate is allowed. Restrict the maximum allowable percentage of asphalt binder replacement to 20.0 % for base courses and 10.0% for wearing courses in ACP containing only RAS. o When RAS is used in conjunction with RAP, restrict the maximum allowable percentage of binder replacement to 30.0% for base courses and 15.0% for wearing courses. Special Provisions **00745** • Lime or Latex Polymer Aggregate Treatment required. • Material Transfer Device required. • Paving through top Base Course required. Traffic will be allowed on the top Base Course up to 12 months.

If there are any questions regarding the content or application of this design, please contact Sophia Burkhart at (503) 986-3770.

APPENDIX L

Reserved

APPENDIX M

ODOT Mechanistic-Empirical Analysis Guidelines (MEPDG)

The current AASHTO publication of the *Mechanistic-Empirical Pavement Design Guide, A Manual of Practice*, is from July 2015 at the time of this Guide's publication. In addition there are several addendums available on the AASHTOWare Pavement-ME website once the user is logged in.

The manual and corresponding website provide basic guidance for installation of the MEPDG software and a brief introduction to the initial program user input screen.

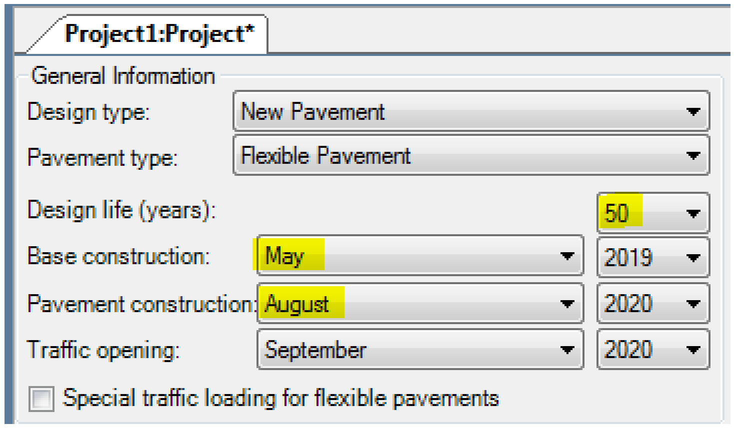
At the time of publication, the MEPDG software Pavement ME is available for download from the AASHTO Pavement ME website:

http://me-design.com/MEDesign/

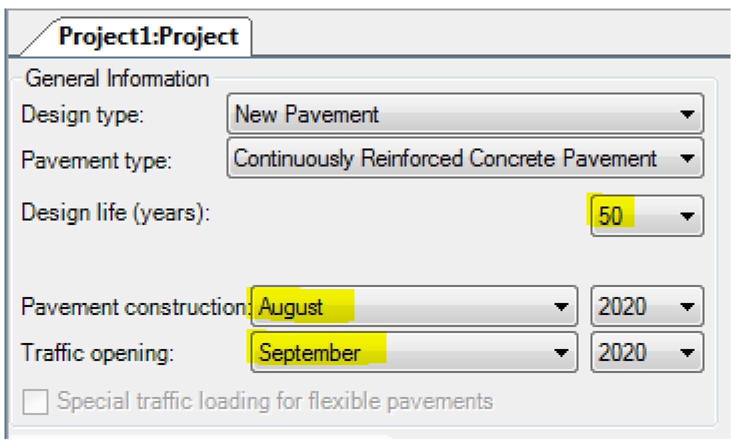
The following guidelines are provided for the use of Pavement ME software as a supplement to the AASHTO 1993 method, for new and rehabilitation designs of ODOT highway projects. These guidelines are provided as interim recommendations and are subject to revision.

Note that at the time of this publication (AASHTOWare v2.5), top-down is not precise enough for design.

Typical Initial MEPDG Input Screen – Flexible Pavement



Typical Initial MEPDG Input Screen – Rigid Pavement



The user should choose August or September as the month of Pavement Construction, because it will be the worst-case scenario (those are the wettest months in Oregon for construction, and the weather data from the Pavement-ME program will assign values accordingly.) All other dates can be taken from the project schedule.

Also, pavement designs run in Pavement-ME should be run for a minimum of 50 years.

Typical Analysis Parameters Screen – Flexible Pavement

Use the following Limit and Reliability Performance Criteria values for flexible pavement design analysis:

ODOT MEPDG Highway Parameters – Flexible Pavement (New and Overlay)

Performance Criteria	Maximum Value at End of Design Life		
	Interstate & Freeway/Expressway	Other Arterial & Major Collector	Minor Collector & Local
Initial IRI	60	60	60
Terminal IRI (smoothness) (in/mi)	160	180	180
AC top-down fatigue cracking (ft/mi)	1060	2000	2000
AC bottom-up fatigue cracking (% lane area)*	10	20	35
AC Thermal Cracking (ft/mi)	500	700	700
Permanent Deformation – Total Pavement (in)	0.9	1.0	1.0
Permanent Deformation – AC Only (in)	0.4	0.5	Speed ≥ 45 mph: 0.5 Speed < 45 mph: 0.65
* Pavement ME measures fatigue cracking as a percentage of the total lane area, not just the area of the wheeltracks			

Example input for flexible pavements:

Performance Criteria	Limit	Reliability	Report Visibility
Initial IRI (in/mile)	60		☑
Terminal IRI (in/mile)	160	95	☑
AC top-down fatigue cracking (ft/mile)	1060	95	☑
AC bottom-up fatigue cracking (% lane area)	10	95	☑
AC thermal cracking (ft/mile)	500	95	☑
Permanent deformation - total pavement (in)	0.9	95	☑
Permanent deformation - AC only (in)	0.4	95	☑

Typical Analysis Parameters Screen – Rigid Pavement

Use the following Limit and Reliability Performance Criteria values for rigid pavement design analysis:

ODOT MEPDG Highway Parameters – New Rigid Pavement (CRCP)

Performance Criteria	Maximum Value at End of Design Life		
	Interstate & Freeway/Expressway	Other Arterial & Major Collector	Minor Collector & Local
Initial IRI	60	60	60
Terminal IRI (smoothness) (in/mi)	160	180	180
CRCP [Existing] Punchouts (#/mi)	10	15	20

ODOT MEPDG Highway Parameters – New Rigid Pavement (JPCP)

Performance Criteria	Maximum Value at End of Design Life		
	Interstate & Freeway/Expressway	Other Arterial & Major Collector	Minor Collector & Local
Initial IRI	60	60	60
Terminal IRI (smoothness) (in/mi)	160	180	180
JPCP Transverse Cracking (% slabs cracked per mile)	10	15	20
Mean Joint Faulting (in)	0.15	0.20	0.25

Example input for rigid pavements:

CRCP:

Performance Criteria	Limit	Reliability	Report Visibility
Initial IRI (in/mile)	60		☑
Terminal IRI (in/mile)	160	95	☑
CRCP punchouts (1/mile)	10	95	☑

JPCP:

Performance Criteria	Limit	Reliability	Report Visibility
Initial IRI (in/mile)	60		☑
Terminal IRI (in/mile)	160	95	☑
JPCP transverse cracking (percent slabs)	10	95	☑
Mean joint faulting (in)	0.15	95	☑

Typical Analysis Parameters Screen – Traffic (Flexible or Rigid Design)

ODOT MEPDG Monthly Adjustment Factors – High Traffic West of Crest of Cascades

State Highways with > 10 million 20-year Design ESALs, I-5 and I-84
(Portland to Hood River)

Vehicle Class Distribution and Growth: Monthly Adjustment

Monthly Adjustment

Import Monthly Adjustmen

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.90	0.9	0.9
February	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9
March	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
April	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
May	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06	1.06
June	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
July	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
August	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
September	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
October	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
November	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02	1.02
December	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9	0.9

ODOT MEPDG Monthly Adjustment Factors – West of Crest of Cascades

State Highways with ≤ 10 million 20-year Design ESALs

Vehicle Class Distribution and Growth: Monthly Adjustment

Monthly Adjustment

Import Monthly Adjustmen

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
February	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62
March	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
April	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
May	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89	0.89
June	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
July	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
August	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28	1.28
September	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
October	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
November	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22	1.22
December	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62	0.62

ODOT MEPDG Monthly Adjustment Factors – High Traffic East of Crest of Cascades

State Hwy's with > 10 million 20-year Design ESALs and I-84 East of Hood River

Vehicle Class Distribution and Growth: Monthly Adjustment

Monthly Adjustment

Import Monthly Adjustmen

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
February	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76
March	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
April	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
May	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04	1.04
June	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
July	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
August	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19	1.19
September	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
October	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
November	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03	1.03
December	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76	0.76

ODOT MEPDG Monthly Adjustment Factors –East of Crest of Cascades

State Highways with ≤ 10 million 20-year Design ESALs

Vehicle Class Distribution and Growth: Monthly Adjustment

Monthly Adjustment

Import Monthly Adjustmen

Month	Class 4	Class 5	Class 6	Class 7	Class 8	Class 9	Class 10	Class 11	Class 12	Class 13
January	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
February	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69
March	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
April	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
May	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01	1.01
June	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
July	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
August	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23	1.23
September	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
October	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
November	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07	1.07
December	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69

Typical Analysis Parameters Screen – Traffic (Flexible or Rigid Design)

ODOT MEPDG Typical Vehicle Class Distribution

Choose "Compound" for the Growth Function.

- None: This option sets traffic volume to remain the same throughout the design life.
- Linear: This option allows traffic volume to increase by constant percentage of the base year traffic across each truck class growth to happen at the defined rate.
- Compound: This option allows traffic volume to increase by constant percentage of the preceding year traffic across each truck class.

The values for Vehicle Class Distribution and Growth can be obtained from the OTMS website (internal only) or ODOT's Traffic Data Unit.

Vehicle Class Distribution and Growth — Load Default Distribution

Vehicle Class	Distribution (%)	Growth Rate (%)	Growth Function
Class 4	3.3	1	Compound
Class 5	34	1	Compound
Class 6	11.7	1	Compound
Class 7	1.6	1	Compound
Class 8	9.9	1	Compound
Class 9	36.2	1	Compound
Class 10	1	1	Compound
Class 11	1.8	1	Compound
Class 12	0.2	1	Compound
Class 13	0.3	1	Compound
Total	100		

Use the following values for the Hourly Adjustment Traffic table.

ODOT MEPDG Hourly Truck Distribution

Hourly Adjustment

Time of Day	Percentage
12:00 am	2.2
1:00 am	1.9
2:00 am	1.8
3:00 am	1.8
4:00 am	2.5
5:00 am	3.1
6:00 am	3.7
7:00 am	4.4
8:00 am	5.0
9:00 am	5.8
10:00 am	6.4
11:00 am	6.6
12:00 pm	6.3
1:00 pm	6.3
2:00 pm	6.1
3:00 pm	5.9
4:00 pm	5.3
5:00 pm	5.0
6:00 pm	4.4
7:00 pm	3.9
8:00 pm	3.6
9:00 pm	3.1
10:00 pm	2.6
11:00 pm	2.3
Total	100.0

Typical Analysis Parameters Screen – Traffic (Flexible or Rigid Design)

Use the following values for the Axles per Truck table and the following axle configuration for all designs.

ODOT MEPDG Number of Truck Axles – Modified MEPDG Defaults for Quads

Axles Per Truck

Vehicle Class	Single	Tandem	Tridem	Quad
Class 4	1.62	0.39	0	0
Class 5	2	0	0	0
Class 6	1.02	0.99	0	0
Class 7	1	0.26	0.83	0.2
Class 8	2.38	0.67	0	0
Class 9	1.13	1.93	0	0
Class 10	1.19	1.09	0.89	0.2
Class 11	4.29	0.26	0.06	0
Class 12	3.52	1.14	0.06	0
Class 13	2.15	2.13	0.35	0.1

ODOT MEPDG Axle Configuration

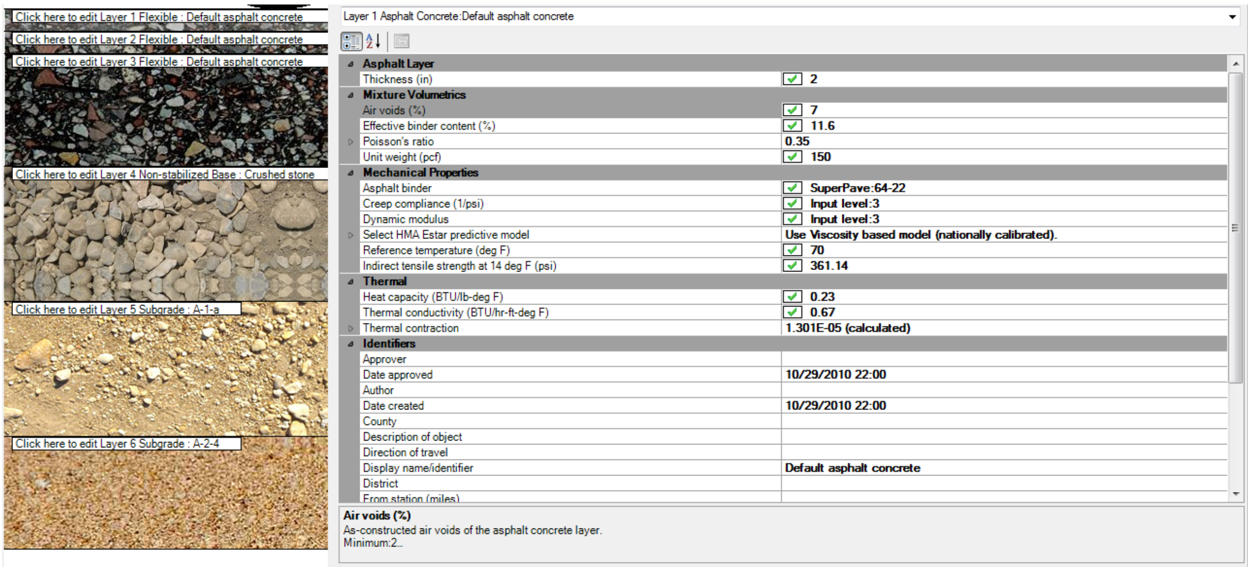
Axle Configuration	
Average axle width (ft)	8.5
Tandem axle spacing (in)	52.8
Dual tire spacing (in)	12
Quad axle spacing (in)	57.4
Tire pressure (psi)	120
Tridem axle spacing (in)	58.6
Lateral Wander	
Design lane width (ft)	12
Mean wheel location (in)	18
Traffic wander standard deviation (in)	10

Typical Analysis Parameters Screen – Flexible Rehabilitation

Below is a typical input screen for a flexible rehabilitation project- EXAMPLE ONLY

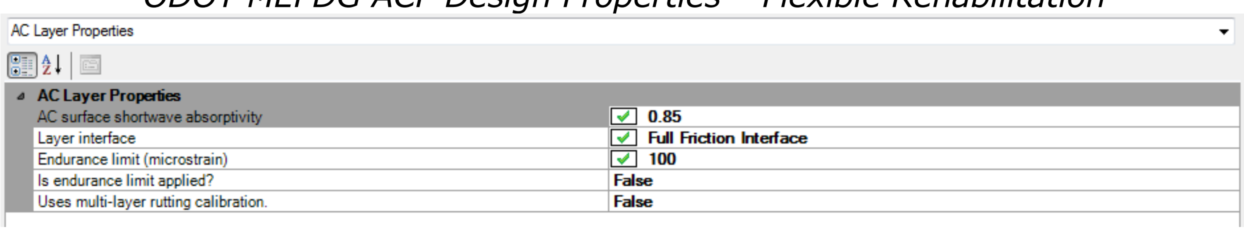
ODOT MEPDG Typical Structure Screen – Flexible Rehabilitation

Note that the right of the screen shows the details only for the top layer of 2″ ACP. The user can click on each layer on the left diagram to see the details of each layer.



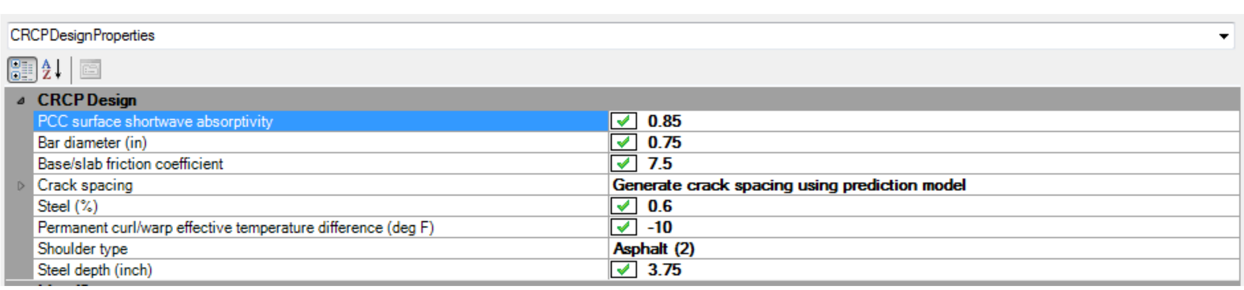
Asphalt Layer	
Thickness (in)	2
Mixture Volumetrics	
Air voids (%)	7
Effective binder content (%)	11.6
Poisson's ratio	0.35
Unit weight (pcf)	150
Mechanical Properties	
Asphalt binder	SuperPave:64-22
Creep compliance (1/psi)	Input level:3
Dynamic modulus	Input level:3
Select HMA Estar predictive model	Use Viscosity based model (nationally calibrated).
Reference temperature (deg F)	70
Indirect tensile strength at 14 deg F (psi)	361.14
Thermal	
Heat capacity (BTU/lb-deg F)	0.23
Thermal conductivity (BTU/hr-ft-deg F)	0.67
Thermal contraction	1.301E-05 (calculated)
Identifiers	
Approver	
Date approved	10/29/2010 22:00
Author	
Date created	10/29/2010 22:00
County	
Description of object	
Direction of travel	
Display name/identifier	Default asphalt concrete
District	
From station (miles)	

ODOT MEPDG ACP Design Properties – Flexible Rehabilitation



AC Layer Properties	
AC surface shortwave absorptivity	0.85
Layer interface	Full Friction Interface
Endurance limit (microstrain)	100
Is endurance limit applied?	False
Uses multi-layer rutting calibration.	False

ODOT MEPDG Typical CRCP Design Features



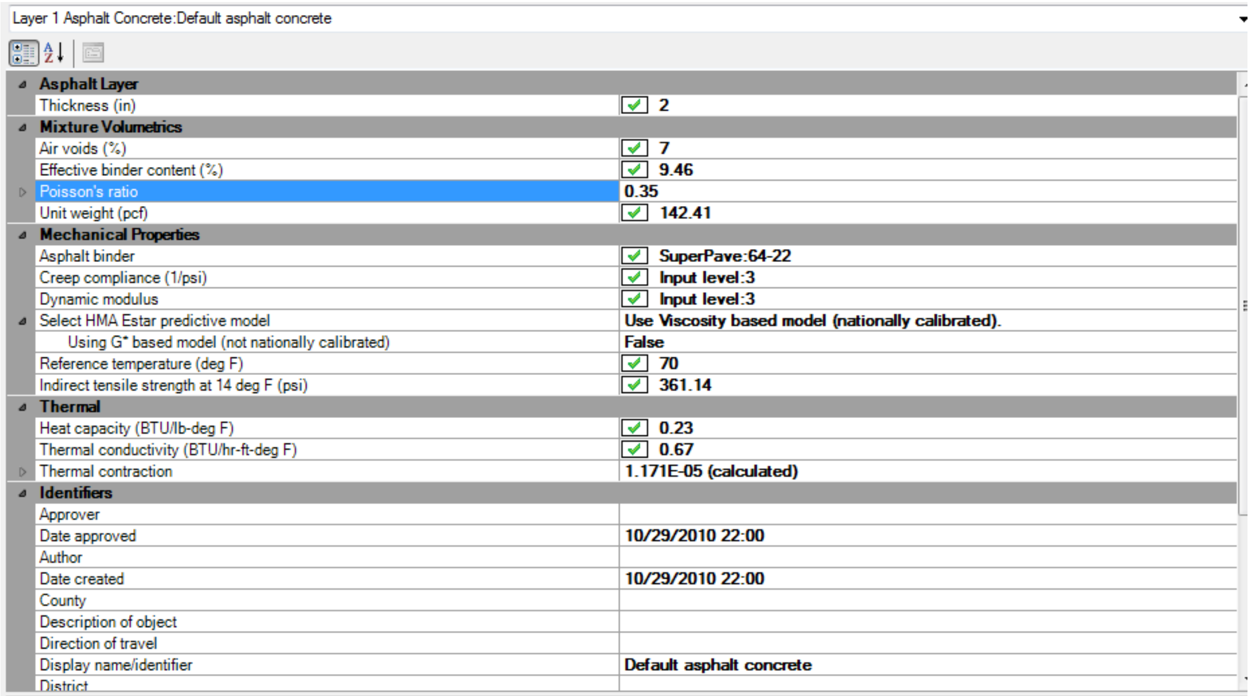
CRCP Design	
PCC surface shortwave absorptivity	0.85
Bar diameter (in)	0.75
Base/slab friction coefficient	7.5
Crack spacing	Generate crack spacing using prediction model
Steel (%)	0.6
Permanent curl/warp effective temperature difference (deg F)	-10
Shoulder type	Asphalt (2)
Steel depth (inch)	3.75

ODOT MEPDG Typical JPCP Design Features

JPCP Design Properties

JPCP Design	
PCC surface shortwave absorptivity	**0.85**
Doweled joints	**Spacing(12), Diameter(1.5)**
Dowel diameter (in)	**1.5**
Dowel spacing (in)	**12**
Is joint doweled ?	**True**
Erodibility index	**Erosion resistant (3)**
PCC-base contact friction	**Full friction with friction loss at (229) months**
PCC-Base full friction contact	**True**
Months until friction loss	**229**
UnbondedJPCP	**False**
PCC joint spacing (ft)	**15**
Is joint spacing random ?	**False**
Spacing of Joint 1	
Spacing of Joint 2	
Spacing of Joint 3	
Spacing of Joint 4	
Joint spacing (ft)	**15**
Permanent curl/warp effective temperature difference (deg F)	**-10**
Sealant type	**Other(Including No Sealant... Liquid... Silicone)**
Tied shoulders	**Not tied**
Tied shoulders	**False**
Load transfer efficiency (%)	
Widened slab	**Not widened**
Is slab widened ?	**False**
Slab width (ft)	

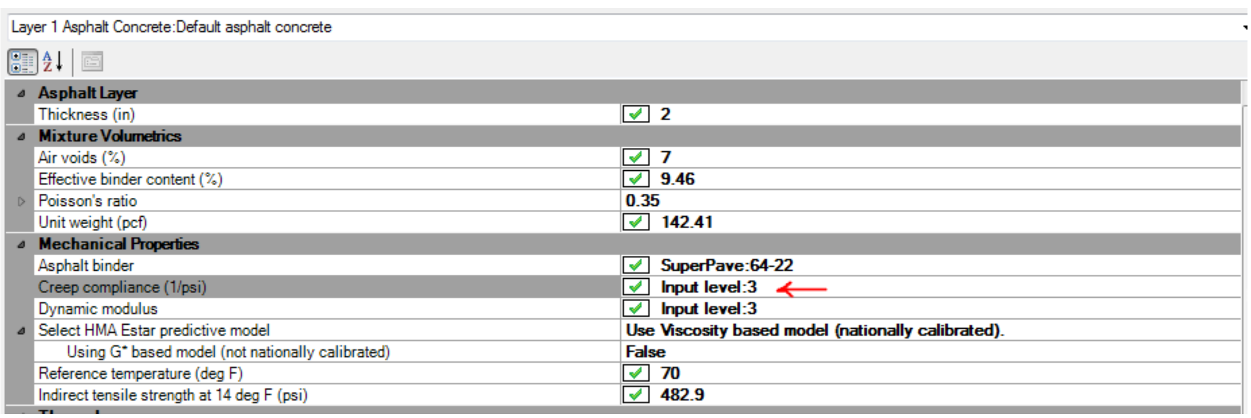
Typical Layers Input Screen – Asphalt General Tab



Layer 1 Asphalt Concrete:Default asphalt concrete

Asphalt Layer	
Thickness (in)	2
Mixture Volumetrics	
Air voids (%)	7
Effective binder content (%)	9.46
Poisson's ratio	0.35
Unit weight (pcf)	142.41
Mechanical Properties	
Asphalt binder	SuperPave:64-22
Creep compliance (1/psi)	Input level:3
Dynamic modulus	Input level:3
Select HMA Estar predictive model	Use Viscosity based model (nationally calibrated).
Using G* based model (not nationally calibrated)	False
Reference temperature (deg F)	70
Indirect tensile strength at 14 deg F (psi)	361.14
Thermal	
Heat capacity (BTU/lb-deg F)	0.23
Thermal conductivity (BTU/hr-ft-deg F)	0.67
Thermal contraction	1.171E-05 (calculated)
Identifiers	
Approver	
Date approved	10/29/2010 22:00
Author	
Date created	10/29/2010 22:00
County	
Description of object	
Direction of travel	
Display name/identifier	Default asphalt concrete
District	

ODOT Thermal Cracking – Use MEPDG Default, Level 3



Layer 1 Asphalt Concrete:Default asphalt concrete

Asphalt Layer	
Thickness (in)	2
Mixture Volumetrics	
Air voids (%)	7
Effective binder content (%)	9.46
Poisson's ratio	0.35
Unit weight (pcf)	142.41
Mechanical Properties	
Asphalt binder	SuperPave:64-22
Creep compliance (1/psi)	Input level:3
Dynamic modulus	Input level:3
Select HMA Estar predictive model	Use Viscosity based model (nationally calibrated).
Using G* based model (not nationally calibrated)	False
Reference temperature (deg F)	70
Indirect tensile strength at 14 deg F (psi)	482.9

APPENDIX N

Deliverables Checklist

Deliverables Checklist

Plan and Spec Review by Pavement Design Staff

	Date:
Project:	BMP:
Hwy:	EMP:
Designer:	Key No:

Plan Version: DAP: Prelim: Advance: Final: Other:

N/A	OK	Needs Attention	ID	PLAN SHEET REVIEW:
☐	☐	☐	1	Correct mix type and level. (00744 used? If so MHMAC)
☐	☐	☐	2	PG Binder type correct.
☐	☐	☐	3	Lime treatment required or not?
☐	☐	☐	4	Is CPPR/Grinding Concrete Pavement depth(s) correct?
☐	☐	☐	5	Is CCPR/Grinding Concrete Pavement width(s) correct?
☐	☐	☐	6	Pavement lift depths.
☐	☐	☐	7	Base material names and depths.
☐	☐	☐	8	Existing pavement width shown where widening.
☐	☐	☐	9	Does Alingnment reflect intent of pavement design?
☐	☐	☐	10	Vertical cuts in correct locations.
☐	☐	☐	11	Are neat lines required?
☐	☐	☐	12	Do typical sections adequately convey intent of pavement design.
☐	☐	☐	13	Do detailed sections adequately convey intent of pavement design?
☐	☐	☐	14	Appropriate detail drawings included?
☐	☐	☐	15	Do detail drawings match typicals?
☐	☐	☐	16	Bridge approaches drawn as designed.
☐	☐	☐	17	Geotextile included?
☐	☐	☐	18	Geogrid included?
☐	☐	☐	19	Are the AC/PCC repair locations noted & placed within plan set?
☐	☐	☐	20	Is the pavement repair typicals complete without incorporating final construction?
☐	☐	☐	21	Is staging plan compatible with pavement design?
☐	☐	☐	22	Ensure project stationing correlates with pavement design milepost limits?
☐	☐	☐	23	Review title sheet for correct milepost.
☐	☐	☐	24	Are the correct standard drawings included?
☐	☐	☐	25	Notes addressing PaVt design, are they referenced properly from sheet to sheet?

N/A	OK	Needs Attention	ID	SPECIFICATIONS REVIEW:	
☐	☐	☐	26		Is POR Sheet included?
☐	☐	☐	27	(180.40c)	Traffic allowed on CPPR? Proper time period?
☐	☐	☐	28	(180.40c)	Is traffic allowed on HMAC Base course?
☐	☐	☐	29	(180.50h)	Is construction completion compatible with Pave. Design?
☐	☐	☐	30	(195.10d)	Is tack & binder included in escalation?
☐	☐	☐	31	(331)	Subgrade stabilization included?
☐	☐	☐	32	(350)	Geotextile certification level (A or B)?
☐	☐	☐	33	(620)	Will the there be CPPR? Is 620 spec included?
☐	☐	☐	34	(620.42)	If this is included check with PL that it is not by error.
☐	☐	☐	35	(620.43)	No traffic on CPPR (Pave back same shift)?
☐	☐	☐	36	(622)	Does Grinding Concrete Pavement repair spec need to be included?
☐	☐	☐	37	(622.40)	Include if PCC repairs needed prior to PCC grinding?
☐	☐	☐	38	(622.41)	Is aggregate hardness selected
☐	☐	☐	39	(641)	SP00641 used?
☐	☐	☐	40	(641)	Correct aggregate sizes in 641 (3/4"-0" or 1"-0")?
☐	☐	☐	41	(645)	Is RAP allowed as aggregate base?
☐	☐	☐	42	(730)	Tack coat spec. included?
☐	☐	☐	43	(730.90)	Is there no separate payment for Tack?
☐	☐	☐	44	(744.11)	Correct grade of asphalt noted in 744.11?
☐	☐	☐	45	(745.00)	Is asphalt mix above 2500 tons?
☐	☐	☐	46	(745.00, 745.11d)	Lime treated?
☐	☐	☐	47	(745.00, 745.11d)	Is there latex treatment?
☐	☐	☐	48	(745.49(b-2-b), .80, .90)	Core correlations included for projects with >15,000 tons?
☐	☐	☐	49	(745.11a)	Is ER included?
☐	☐	☐	50	(745.48(b))	Material Transfer Device section included, if needed?
☐	☐	☐	51	(745.49(b-3)	Minimum 92% (or other) specified on all lifts?
☐	☐	☐	52	(745.51)	Is traffic allowed on HMAC Base course?
☐	☐	☐	53	(745.70, .72, .73, .96)	Smoothness spec. included?
☐	☐	☐	54	(745.80 & .90)	Asphalt measured and paid for separately in SP00745?
☐	☐	☐	55	(745.93)	Is there latex treatment?
☐	☐	☐	56	(748)	Are the asphalt concrete repairs included?
☐	☐	☐	57	(754)	Does JCP repair spec need to be included?
☐	☐	☐	58	(755)	Does CRCP spec need to be included?
☐	☐	☐	59	(756)	Does JCP spec need to be included?
☐	☐	☐	60	(758)	Does Reinforced Concrete repair spec need to be included?
☐	☐	☐	61	(XXX)	Are project specific spec modification included?

N/A	OK	Needs Attention	ID	BID ITEM REVIEW:
☐	☐	☐	62	All required bid items presented.
☐	☐	☐	63	Bid items named appropriately.
☐	☐	☐	64	Bid items match pavement design requirements.
☐	☐	☐	65	Correct units.
☐	☐	☐	66	Reasonable quantities for each bid item.
☐	☐	☐	67	Asphalt grade(s) correct?

APPENDIX O

ODOT Pavement Design Quality Control Plan

The ODOT Pavement Services Unit has had a technical review process in place for over twenty years. The current process is a two level review consisting of 1) checking for accuracy and errors by a peer review (review) and 2) a Deliverables Approval Review (DAR) conducted by the ODOT Pavement Design Engineer (PDE) or a designated Senior Engineer (SE), designated by the PDE. Since shifting project design responsibilities from a centralized function through Technical Services to the Regions and an increased use of consultant services, ODOT has developed a formalized Project Development QA/QC program. The program requires that each provider of design services develop a QC plan that includes appropriate QC checks and documents the process, including how comments have been addressed. For additional information on ODOT's QA/QC program for design services, please refer to the ODOT website for *Quality Assurance Program for Design*.

The individual design service providers have developed QC Plans to fit the organization of their respective Tech Center or discipline. These plans rely on the centralized functions, such as Pavement Design to develop their own QC Plan and certify that the specified product has been developed in accordance with that plan. This document provides a QC plan developed to meet the requirements of the ODOT Project Development Quality Program for ODOT Pavement Services requirements. Consultants should use their own ODOT-approved quality plan.

PAVEMENT DESIGN MEMO (PDM) AND PAVEMENT DESIGN SUMMARY (PDS)

All pavement designs will be developed using current office procedures and the latest version of the ODOT Pavement Design Guide (PDG). In addition to technical guidance, the PDG includes quality requirements for both ODOT and consultants, including:

- Requirements for policies, manuals, bulletins, and guidance documents,
- Data sources, and
- Approved design-related software.

Data used in Design

The Engineer of Record (EOR) is responsible for data integrity, regardless of whether the EOR is in the Designer (responsible for design tasks) or reviewer role. It is the responsibility of the EOR to understand which data sources have a quality plan in place for data processing; are simply raw, unprocessed data; and which need a data quality check as part of the review process. For example, pavement management data is used in design; and currently, a documented review process for that data is in place. However, older pavement management data is less reliable, both in terms of data collection and quality review. Common data sources and minimum data required for design are contained in the PDG.

Organization of Project files

To ensure consistency, the designer shall organize project files according to the following guidelines. These guidelines are intended to improve the organization of project folders by listing the most common elements of pavement design documentation and recommending the order in which they appear in the project folder. The elements involved and their order would of course be subject to change based on the needs of an individual project with these recommendations serving primarily as a guideline. The pavement design in a complete file contains three sections:

1. Pavement Design Memo - This document provides the pavement section recommendations, pavement design notes, and a table of specifications required, as well as boiler plate special provisions required.
2. Pavement Design Summary – A narrative of the data, rationale, design elements, and conclusions supporting the design recommendations in a report format.
3. Appendices – Includes all data, calculations, notes, etc. that support the design.

A list of elements and their order are shown below, with number 1 being the first item to be placed in the folder (therefore being on the bottom), number 2 being the second item, and so on.

PAVEMENT DESIGN MEMO

MAJOR SECTION	SUB-SECTION
Project Information	• To – Project Leader • From – Pavement Designer • Date, Project title, Highway, mile points, key number, county, and EA
Scope	• Scope statement based on signed project charter statement of scope (may be reduced or expanded as appropriate)
Recommendations	• Mainline preservation or rehabilitation recommendations. • New Construction • Ramps or connections • Minor misc. paving (shoulder widening for guardrail, turnouts, etc.) • Asphalt Concrete Repair • Pavement Design Notes (for example notes or instructions to improve constructability)
Specifications	• Specification / Special Provisions.
Signature Sheet	• Stamp by EOR and expiration date of design recommendations. This sheet shall include all appropriate project information

Pavement Design Summary and Summary Documentation

[NOTE: An effort is currently underway to match the report summary sections with the file sections to combine the tables above and below into one table.]

By introducing standardization in the design summary and in the documentation that accompanies a pavement design summary, design review by both the peer and the Engineer will be simplified. The summary will be organized with the various sections shown below, with number 1 being the first (top) item and so forth. The summary and supporting data will be 3-hole punched and placed in a binder at the time of review. The memo may be initially printed without binder holes to facilitate scanning after final signature, then hole punched according to final binder configuration.

MAJOR SECTION	SUB-SECTION
Background	• Title and project information. • Scope Statement (same as PDM) • Project Location (reference a vicinity map) • Construction History • Existing pavement condition
Field Work	• Summaries of field data - FWD data and analysis - Core data and analysis - DCP data and analysis - Probe (soil/exploration holes) data and analysis - Rut data and analysis - Other data and analysis
Input Information and Data Analysis	• Traffic summary of data and analysis • Design input summary • Serviceability • Reliability • Overall Deviation • Layer coefficients • Summary of Subgrade Resilient Modulus data, testing, and analysis
Recommendations and Justification (including costs and LCCA)	• A summary of pavement preservation or rehabilitation analysis. Reference appropriate supporting calculations sheets in appendices. New Work Analysis Reference appropriate supporting calculations sheets in appendices.

	• Bridge Approach Analysis Reference appropriate supporting calculations sheets in appendices. • Ramp preservation or rehab analysis. • Misc. minor pavement sections. • Asphalt Concrete Pavement Repair Reference appropriate supporting calculations sheets in appendices. •
Specifications and Construction	• Materials/Specifications Selection. List all specifications and related boiler plate special provisions required. Discuss here as appropriate justifications for any needs modifying standards with boiler plate special provisions. Discuss subgrade stabilization needs, applications, quantities, or restrictions. • Construction Issues – elaborate on any anticipated construction issues related to the pavement design.
Appendices	• Calculations • Cost Analysis (including LCCA) • (FWD) Deflection data and FWD based calculation sheets or forms. • Pavement Condition data • Traffic Data • Maps or Logs • Photos (project general, field, or conditions) • Rut data • Core Data, plots, logs, analysis, or spread sheets. • Soil – field data, probe logs, DCP data tables, lab results, or other. • Ground Penetrating Radar (GPR) data, tables, files, related files. • Copy of project Charter or Prospectus (source of paving scope). • Construction History Files • Other

The summary and organization of supporting data may be changed based on the specific needs of any one given project such as for a small project or consultant review project.

Pavement Design Review Process

For any pavement design review element, an EOR Log will be provided by the Designer along with the documents submitted for review. At the review and Product Approval Review stages, the Designer will provide a Pavement Design Peer Review Comment Form and Pavement Design Checklist along with the documents submitted for review.

Field Work Review

The completed field work request form and project file, including the project prospectus, schedule, construction history, vicinity map, etc., will be submitted to the PDE or designated SE for review prior to forwarding to the Pavement Design Field Crew.

The PDE or SE will document review on the EOR Log in the project file and return to the pavement Designer.

Pavement Design Review

Upon completion of the pavement design and all required documentation, the pavement Designer will forward the design file to a reviewer for a review of the design document as well as the entire design file. If the Designer elects to send a draft memo, the draft memo will be subject to the review requirements of a final stamped memo. (Note that sharing of preliminary design information is part of the multi-disciplinary iterative design process and does not require review, although the Designer may request a review.) After completing the review, the reviewer will return the file to the Designer with comments as appropriate for the level of review. Upon incorporating the responses to the review, the Designer will forward the design file to the PDE or SE for a product approval review. All pavement designs published by the ODOT Pavement Services Unit will be subject to one of the following reviews.

Class I Review

A Class I Technical Review will be required for projects with one or more of the following:

1. Structural improvements for roads with travel lane design traffic greater than or equal to 3 million 20-year ESALs
2. Interstate travel lanes
3. Interstate shoulders subject to traffic staging greater than 1 month
4. Interstate detour/diversions subject to traffic staging greater than 1 month
5. Modernization projects with complex design elements
6. Non-standard designs, such as new technology, use of MEPDG, etc.
7. Any project for which the PDE or SE requests a Class I review.

The Technical Reviewer will be designated by the PDE or SE, and the assignment will be based on subject matter experience and demonstration of technical analysis skills. The reviewer shall include the Pavement Design Checklist with the completed design. If requested by the PDE or SE, the Class I Technical Review Checklist will be used, and the elements requested by the PDE or SE shall be completed by the Designer, Reviewer, and

PDE or SE. based on pavement type. The Class 1 Technical Review Checklist is particularly useful for inexperienced designers or complex projects.

When an element is identified as “Need to Correct” by the reviewer, an attempt may be made between the reviewer and Designer to resolve the issue, or final resolution will be obtained at the Deliverables Approval Review stage.

New Designers will have a Class I review on all assigned projects through the trial service period or until they have demonstrated a working knowledge of pavement design principles and office procedures at the PDE’s discretion. Designs will be returned to the new Designer prior to final review.

<u>Class II Review</u>

Class II reviews will be required for projects not needing a Class I review.

Upon completion of the pavement design and all required documentation, the pavement Designer will forward the design file, including the Pavement Design Checklist, to another available pavement Designer for review. After completing the Class II review, the reviewer will return the design file to the Designer who will then submit to the PDE or SE for a Product Approval Review. <u>The PDE or SE may perform the Class II review in addition to the Product Approval Review.</u>

A Class II Review should include a conceptual/standards review. The intent is to check that the design:

- Is Complete and justified
- Contains no fatal flaws
- Identifies the alternatives considered

Class II Review comments should be documented on the Pavement Design Review Comment Form and included in the project file. If the Class II Review discloses any significant design issues that obviously require correction, route the design back to the Designer for correction prior to submittal to the PDE or SE.

<u>Deliverables Approval Review</u>

The Deliverables Approval Review (DAR) will be conducted by the PDE or SE on all pavement designs. The review will consist of a technical and conceptual review based on the appropriate documents and results of the calculations included within the file. Additionally, the PDE or SE will confirm that the appropriate level of review has been performed.

<u>Reconciliation</u>

Within Pavements Unit. – If designer and Deliverable Approval Reviewer cannot concur, then the PDE shall become the EOR and take responsibility as the designer as well, with the Pavement Services Engineer becoming the Deliverable Approval Reviewer.

Outside Pavements Unit with the design service provider. - Any issues that cannot be resolved at this level shall be brought to the attention of the PDE or Pavement Services Engineer.

<u>Pavement Design Review Documentation</u>

All review comments will be documented on the Pavement Design Peer Review or Technical Review Comment Form, and included in the project file. As an alternative to writing all comments in the review form, simple comments or edits can be made directly on the document, with the comment log referencing that comments exist on the reviewed documents. The original document shall be returned to the reviewer along with the edited document, electronically with tracked changes or with hard copies. Review and markups shall follow these protocols:

- Highlight all calculations and data evaluations once checked. If corrections are needed, do not highlight until corrections have been suitably completed.
- Make correction edits for direct inclusion with red ink (or with tracked changes, electronically).
- Make comments in blue ink (or with comment boxes, electronically).

The Designer shall be the sole generator of products. If, in a rare event, a portion of the design is accomplished by a reviewer, then the required reviews of that portion of the product must be accomplished by the reviews and roles above and agreed to by the designer.

Once all comments and issues raised during the review phase have been addressed, the Designer will stamp/sign the memo as appropriate and forward the design to the Reviewer and PDE or SE for signature. If the PDE or SE also provided the review, the title of "reviewer" will be added to the signature block.

A signature page will be included for all pavement design memos. Signature by the reviewer will signify that all comments have been appropriately addressed. If the project pavement Designer is not a registered P.E., then the PDE or SE will stamp the pavement design memo as the Engineer of Record; otherwise the PDE or SE will sign the memo and the Designer would stamp as the EOR. The stamp/signature of the PDE or SE shall signify approval of the final pavement design. The pavement design will be labeled with an appropriate validity date, typically dated to September 30 of 1 season beyond the anticipated construction season(s). The disclaimer will include a notation that if the design is to be used beyond that date, confirmation will be required by the ODOT Pavement Services Unit.

Pavement Design Revisions / Addendums

Revisions or addendums to the original pavement design are routinely required to provide additional designs not required at the time of publication, make revisions to materials or specifications, or revise the original design due to various reasons. Typically these do not require a peer or technical review unless the project pavement Designer would like to get additional input or the revision is of a significant nature. All revisions and addendums will be submitted to the PDE or SE for review and approval.

Plans and Specification Review

Plans and specifications are developed by the design service providers based on information provided in the Pavement Design Memo. The project pavement Designer will review each set of plans and specifications according to the current version of the ODOT Plan and Specification Checklist approved by the PDE, complete this checklist, and complete any additional individual requirements of each project. The pavement Designer will provide review comments in the format required by the design services provider. No other internal peer or product approval review is required for plan and specification reviews. The pavement Designer shall work with the appropriate provider resource to ensure all comments are addressed appropriately. Any issues that cannot be resolved at this level shall be brought to the attention of the PDE or Pavement Services Engineer. The pavement Designer shall provide the EOR with the completed ODOT Plan and Specification Checklist prior to requesting the EOR stamp the POR sheet for specifications.

CONSULTANT PAVEMENT DESIGNS

The Pavement Services Unit will administer and review, according to the Deliverables Checklist, all pavement designs conducted by consultants. Consultants are expected to perform their own internal technical review, and document the performance of such review. The Pavement Services Unit will confirm in writing to the Region contact that we have reviewed and accepted the design. The assigned pavement reviewer will also file consultant pavement designs according to the Filing System requirements below.

DATA INTEGRITY MANAGEMENT

The Designer shall keep raw field data in the design file with the FWD-generated file name as evidence. An electronic PDF copy is sufficient. The FWD raw output file generated in the field shall be kept in a central location for future statewide use in pavement management.

Any data restructuring or evaluation shall be checked and reviewed. Any application or spreadsheet developed in house for automated data processing needs to have a record of a quality check for the current version on file.

FILING SYSTEM

Guidance for filing is in three locations:

1. Above in Organization of Project Files
2. In the Document Filing portion of the Pavement Design Checklist
3. External Guidance
    1. Follow Projectwise filing guidance
    2. Follow Record Retention Schedule for ODOT Pavement Services

PAVEMENT DESIGN CHECKLIST

PROJECT NAME: ______________________________

Order	DESIGN DOCUMENTATION	NEEDED	NOT NEEDED	COMPLETED
1	**PROSPECTUS:**			
	PRELIMINARY WORK:			
2	*V-FILES:*			
	Research:			
	Summation:			
	TRAFFIC:			
	Request:			
	Analysis:			
	FIELD WORK REQUEST:			
	FIELDWORK;			
	Deflections:			
	Cores:			
	Probes:			
	DCPs:			
	Rut Measurements:			
	Photographs:			
	DESIGN WORK:			
3	*PHOTOGRAPHS:*			
	Mounted:			
4	*RUTS:*			
	Summary:			
	Graphical Plot:			
5	*TRAFFIC:*			
	Traffic Calculations:			
	Graphical Plot:			
6	*CORES:*			
	Summary:			
	Graphical Plot:			
7	*PROBES:*			
	Review:			
	Graphical Plot:			
8	*DCPS:*			
	Review:			
	Graphical Plot:			
9	*DEFLECTIONS:*			
	Hard Copy:			
	Analysis:			
	Graphical Plot:			
	Backup:			
10	*BRIDGE APPROACH ES*			
	Analysis:			
	OVERLAY DESIGN:			
11	ODOT:			
12	AASHTO:			
	NEW WORK DESIGN:			
13	AASHTO:			
	DESIGN SUMMARY:			
	DESIGN MEMO:			

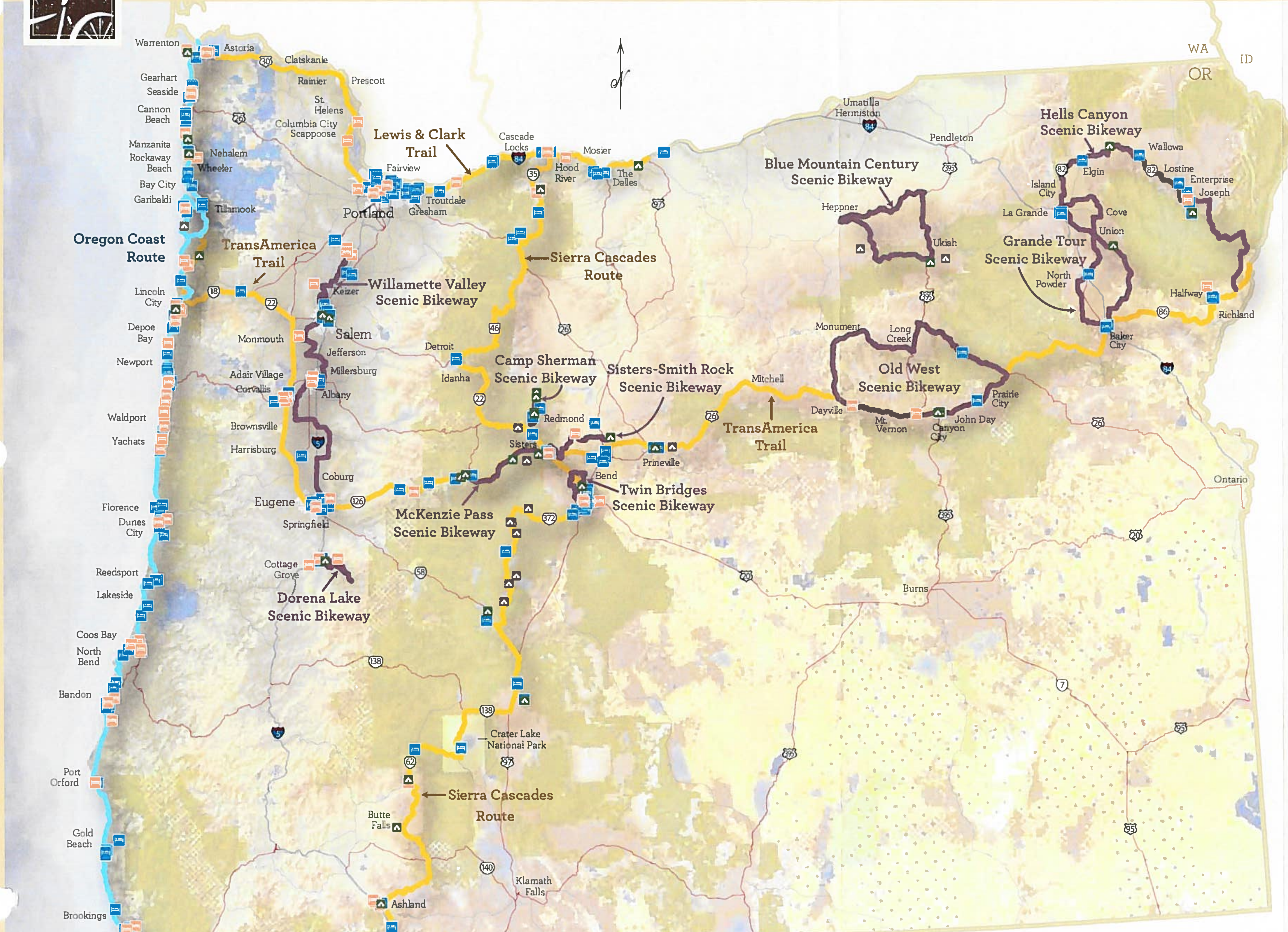
DESIGN COMPONENT	NEEDED	NOT NEEDED	COMPLETED
Subgrade Stabilization			
Asphalt Concrete Pavement Repair			
Cold Plane Pavement Removal (CPPR)			
Extra AC for CPPR damage			
Width of inlay on shoulders			
Asphalt grade			
Lime treatment			
Lime / Polymer treatment			
Smoothness spec			
Roadbed reconditioning			
Dense vs. Open Wearing Course			
Hot mix vs. Cold mix			
Subgrade Geotextile			
Core Correlations			

DOCUMENT FILING	NEEDED	NOT NEEDED	COMPLETED
Updated Core Logs Loaded to G:\CoreLogs Database			
Summary & Memo Uploaded to G:\Pavement Designs			
All Electronic Documents uploaded to G:\ProjectFiles			
Images and PDFs in G:\ProjectFiles have been compressed to reduce electronic file size			
All unused documents/spreadsheets have been deleted to reduce electronic file size			
Update Tracking Report			
Complete Date:			
Status:			
Design Comment:			

APPENDIX P

Oregon’s Growing Network of Scenic Cycling Routes

Oregon's Growing Network of Scenic Cycling Routes



Source: Map created for Travel Oregon by Ecotrust and In House Graphics. Data sets from Oregon Parks & Recreation Department, Adventure Cycling, Oregon Department of Transportation, Wildernet, and Travel Oregon. 2011

CYCLING TOURISM ON THE RISE

- Bicycle travel is becoming an increasingly visible part of the global adventure travel market, which generates $89 billion annually[1]
- Oregon has identified cycling tourism as a key economic development strategy
- In 2009, Oregon's outdoor recreation & entertainment market had $803 million in visitor spending[2]
- In 2009, 1.3 million tourists[3] bicycled while visiting Oregon[2]
- Those 1.3 million tourists spent $223 million primarily on lodging, meals, and retail[2]
- Overnight cycling visitors spent over eight times more than day travelers ($199 million vs. $24 million)[2]

1 Adventure Tourism Market Report by the Adventure Travel Trade Association, August 2010

2 Oregon 2009 Cyclist Visitor Analysis, Longwoods International, August 2010

3 A tourist is defined as someone traveling more than 50 miles from their residence or staying overnight. Tourists, in this case, are inclusive of in-state and out-of-state travelers.

Oregon Scenic Bikeways — Routes designated by Oregon Parks and Recreation Department

Adventure Cycling Routes — Routes promoted by Adventure Cycling Association

Oregon Coast Route — Route managed by the Oregon Department of Transportation

Bed & Breakfast

Hotel or Motel

Campsite

U.S. Forest Service

National Park or Wildlife Refuge

Bureau of Land Management

State Lands

Urban Areas

Interstate

Highway

Major Road

0 20 40 80 Miles

For comprehensive information on cycling tourism in Oregon, visit RideOregonRide.com.
For questions regarding the Oregon Bicycle Tourism Partnership, please contact Kristin@TravelOregon.com.