Pavement Design Manual

Ohio™

Department of Transportation

Office of Pavement Engineering

Table of Contents

Simplified Pavement Designs for Short Projects   Appendix C

List of Figures

Preface

Name

The name of this manual is the Pavement Design Manual (PDM). It was previously known as the Pavement Design & Rehabilitation Manual. All references to the Pavement Design & Rehabilitation Manual shall be considered to reference the PDM.

Purpose

Many manuals, policies, guides, standards, etc., have been published regarding pavement design and rehabilitation. Many of these have been written using wide ranges of design recommendations (minimums and maximums) since the contents were intended to apply nationally. Furthermore, the Ohio Department of Transportation's pavement design and rehabilitation procedures have been scattered among many different publications, poorly documented or in some cases existed only in the minds of a select few engineers. The purpose of this manual is to bring all the information together in one document, reduce the selection of design variables to those most appropriate for the State of Ohio, to document Ohio's interpretation of various policies and to include design criteria which may be unique to Ohio.

Application

The pavement engineering concepts described herein are intended for use with all new or reconstruction projects, major and minor rehabilitation projects, and all surface treatment projects, which are under the jurisdiction of the Ohio Department of Transportation (ODOT). The information contained in this manual has been taken from and based on the results of the AASHO Road Test, the AASHTO Guide for Design of Pavement Structures, Federal Highway Administration (FHWA) guidelines and technical advisories, industry publications, various training course manuals, ODOT research reports, as well as from the experience of the authors. In addition, the application of other studies, experiences, and engineering judgments have been included to fit Ohio's conditions.

The pavement design procedures relate the performance of a pavement to its structural design and the loading applied to the pavement. Failure mechanisms derived from poor mix design, poor material quality, or poor construction practices are not addressed in this manual.

This manual is neither a textbook nor a substitute for engineering knowledge, experience or judgment. It is intended to provide uniform procedures for implementing design decisions, assure quality and continuity in design of pavements in Ohio, and assure compliance with Federal criteria. The recommendations given are intended to improve pavement performance.

Consideration must be given to design standards adopted by city, county, or other local governments when designing pavements under their jurisdiction.

Application on Design-Build Projects

For design-build type projects, anything in this manual said to be recommended or a best practice shall be a requirement. If the requirements of this manual are in conflict with specific, stated requirements in the design-build scope of services, the scope of services shall take precedence.

Distribution

The manual is distributed electronically through the publications gateway on the ODOT website at https://www.transportation.ohio.gov/working/publications. This manual is intended primarily for ODOT personnel who have received training from the Office of Pavement Engineering. It is made available to cities, counties, consultants, etc., to use at their own risk.

Preparation

The PDM has been developed by the Office of Pavement Engineering. Errors or omissions should be reported to the Ohio Department of Transportation, Office of Pavement Engineering, 1980 West Broad Street, Mail Stop 5200, Columbus, Ohio 43223.

Format and Revisions

The PDM is provided exclusively in electronic format through the publications gateway. The online pdf file is the official version of the manual. Other formats are provided for convenient viewing on mobile devices but are not considered official and are not guaranteed to match the official version. Users may print all or part of the manual but are responsible for keeping it up to date.

Revisions to the PDM are distributed through the publications gateway with notification through the e-mail subscription list. Revisions will be issued as necessary on the biannual release dates in January and July.

Although pages are individually numbered within each section, new pages may be added and identified with letter suffixes after the page number. Each page has the latest revision date shown in the lower left hand corner. Figures do not have page numbers but are numbered to coincide with the section number in the text. The revision date for figures is located in the upper right corner. Figures are located at the end of each section and, if printed, are best printed on colored paper for easy reference.

Ohio Department of Transportation
Districts

District 1
1885 N. McCullough St.
Lima, OH 45801-0040
419-222-9055
fax: 419-222-0438

District 2
317 East Poe Rd.
Bowling Green, OH 43402-1330
419-353-8131
fax: 419-353-1468

District 3
906 Clark Ave.
Ashland, OH 44805-1989
419-281-0513
fax: 419-281-0874

District 4
2088 S. Arlington Rd.
Akron, OH 44306
330-786-3100
fax: 330-786-2232

District 5
9600 Jacksontown Rd.
Jacksontown, OH 43030
740-323-4400
fax: 740-323-3715

District 6
400 East William St.
Delaware, OH 43015
800-372-7714 or 740-833-8000
fax: 740-833-8100

District 7
1001 St. Marys Ave.
Sidney, OH 45365-0969
888-200-9919 or 937-492-1141
fax: 937-497-9734

District 8
505 S. State Route 741
Lebanon, OH 45036-9518
800-831-2142 or 513-933-6568
fax: 513-932-7651

District 9
650 Eastern Ave. PO Box 467
Chillicothe, OH 45601
888-819-8501 or 740-773-2691
fax: 740-775-4889

District 10
338 Muskingum Dr. PO Box 658
Marietta, OH 45750
800-845-0226 or 740-568-3900
fax: 740-373-7317

District 11
2201 Reiser Ave.
New Philadelphia, OH 44663
330-339-6633
fax: 330-308-3942

District 12
5500 Transportation Blvd.
Garfield Heights, OH 44125-5396
216-581-2100
fax: 216-584-2274

Central Office
1980 W. Broad Street
Columbus, OH 43223
614-466-7170

ODOT Web Site:
www.transportation.ohio.gov

Ohio Counties

No.	County	Code	District
01	Adams	ADA	9
02	Allen	ALL	1
03	Ashland	ASD	3
04	Ashtabula	ATB	4
05	Athens	ATH	10
06	Auglaize	AUG	7
07	Belmont	BEL	11
08	Brown	BRO	9
09	Butler	BUT	8
10	Carroll	CAR	11
11	Champaign	CHP	7
12	Clark	CLA	7
13	Clermont	CLE	8
14	Clinton	CLI	8
15	Columbiana	COL	11
16	Coshocton	COS	5
17	Crawford	CRA	3
18	Cuyahoga	CUY	12
19	Darke	DAR	7
20	Defiance	DEF	1
21	Delaware	DEL	6
22	Erie	ERI	3
23	Fairfield	FAI	5
24	Fayette	FAY	6
25	Franklin	FRA	6
26	Fulton	FUL	2
27	Gallia	GAL	10
28	Geauga	GEA	12
29	Greene	GRE	8
30	Guernsey	GUE	5
31	Hamilton	HAM	8
32	Hancock	HAN	1
33	Hardin	HAR	1
34	Harrison	HAS	11
35	Henry	HEN	2
36	Highland	HIG	9
37	Hocking	HOC	10
38	Holmes	HOL	11
39	Huron	HUR	3
40	Jackson	JAC	9
41	Jefferson	JEF	11
42	Knox	KNO	5
43	Lake	LAK	12
44	Lawrence	LAW	9
45	Licking	LIC	5
46	Logan	LOG	7
47	Lorain	LOR	3
48	Lucas	LUC	2
49	Madison	MAD	6
50	Mahoning	MAH	4
51	Marion	MAR	6
52	Medina	MED	3
53	Meigs	MEG	10
54	Mercer	MER	7
55	Miami	MIA	7
56	Monroe	MOE	10
57	Montgomery	MOT	7
58	Morgan	MRG	10
59	Morrow	MRW	6
60	Muskingum	MUS	5
61	Noble	NOB	10
62	Ottawa	OTT	2
63	Paulding	PAU	1
64	Perry	PER	5
65	Pickaway	PIC	6
66	Pike	PIK	9
67	Portage	POR	4
68	Preble	PRE	8
69	Putnam	PUT	1
70	Richland	RIC	3
71	Ross	ROS	9
72	Sandusky	SAN	2
73	Scioto	SCI	9
74	Seneca	SEN	2
75	Shelby	SHE	7
76	Stark	STA	4
77	Summit	SUM	4
78	Trumbull	TRU	4
79	Tuscarawas	TUS	11
80	Union	UNI	6
81	Van Wert	VAN	1
82	Vinton	VIN	10
83	Warren	WAR	8
84	Washington	WAS	10
85	Wayne	WAY	3
86	Williams	WIL	2
87	Wood	WOO	2
88	Wyandot	WYA	1

Pavement Design Approval and Responsibility

All pavement design buildups pertaining to roadways designated as Interstates, US Routes, National Highway System (NHS) routes, State Routes, or otherwise under the jurisdiction of the Ohio Department of Transportation (ODOT) must be approved by ODOT prior to incorporation into a set of construction plans. Those Agencies, Municipalities, or Consultants seeking pavement design buildup or approval from ODOT should make the request through the appropriate ODOT District Office.

A formal request for pavement design buildup or approval should include the following:

- A schematic drawing of the project;
- Typical sections showing the existing pavement buildup and the lane and shoulder configurations and widths, if applicable;
- Proposed typical sections with no pavement buildup but showing the number and width of lanes and shoulders and all cross-slopes;
- Plan and profile sheets if changes are being made;
- Certified traffic data showing the current and design year ADT and the 24-hour truck percentage; and,
- All required soils information as determined by the Office of Geotechnical Engineering.

For projects which require Pavement Selection Committee approval (see Section 100), the above items, including the Subgrade Analysis Spreadsheet, must be submitted to the Office of Pavement Engineering.

Glossary of Terms

Analysis Period: The number of years included in a life-cycle cost analysis.

California Bearing Ratio (CBR): The quotient of a laboratory soil penetration test compared to a standard crushed rock penetration test. The test is performed on a saturated soil sample and is designed to represent the lowest bearing capacity of the soil.

Composite Modulus of Subgrade Reaction (K_c): A value used in rigid pavement design determined by dividing the load on a subgrade by the deflection, corrected for the effect of a base.

Composite Pavement: A pavement structure consisting of an asphalt concrete wearing surface on top of a hydraulic cement concrete slab.

Concrete Elastic Modulus (E_c): A measure of the rigidity of a pavement slab and its ability to distribute loads.

Concrete Pavement Restoration (CPR): Work performed on a concrete pavement consisting of any combination of diamond grinding, full or partial depth repair, dowel bar retrofit, etc., that preserves the concrete surface. A CPR project may be considered a surface treatment or minor rehabilitation.

Construction Joint: A transverse joint necessitated by an interruption in paving.

Contraction Joint: A joint at the end of a rigid pavement slab to control the location of transverse cracks.

Design Period: The number of years used in traffic loading predictions to design the new or rehabilitated pavement structure.

Design Serviceability Loss (ΔPSI): The change in the serviceability index of a pavement from the time it is constructed to the end of its design life.

Dielectric Constant: A measure of a substances ability to store electrical energy in an electric field.

Differential Costs: Costs that can be reasonably calculated, based on the information available at the time, that are different between the various alternatives in a life-cycle cost analysis.

Discount Rate: An economic factor to account for the effects of interest and inflation.

Drainage Coefficient: A factor used to modify structural layer coefficients in flexible pavements or stresses in rigid pavements as a function of how well the pavement structure can handle the effect of water infiltration.

Edge of Traveled Way: The intersection of the mainline pavement (driving lanes) with the shoulder (treated or turf) or the curb and gutter.

Effective Modulus of Subgrade Reaction (K): The composite modulus of subgrade reaction modified by loss of support.

Equivalent Single Axle Load (ESAL): Truck traffic loading expressed as the number of equivalent 18,000 lb (80 kN) single axle loads.

Expansion Joint: A transverse joint located to provide for the expansion of a rigid slab in the longitudinal direction without damage to itself or adjacent slabs. Generally placed near bridges or used to isolate mainline pavement from side road pavement at intersections.

Flexible Pavement: A pavement structure consisting of asphalt concrete, with or without an aggregate base, placed on a prepared subgrade.

Functional Characteristics: Those characteristics that affect the highway user but have little effect on the load carrying capacity of the pavement. Ride quality is the predominant functional characteristic. Others include skid resistance and surface oxidation.

Functional Classification: The grouping of highways by the character of service they provide.

Group Index: A number derived from the gradation, liquid limit and plasticity index of a soil.

Life-cycle cost analysis (LCCA): An economic analysis tool to quantify the differential costs of alternative pavement options by analyzing initial costs and discounted future costs over a defined period of time.

Liquid Limit: The water content, in percent, of a soil at the arbitrarily defined boundary between the semi-liquid and plastic states.

Load Transfer Coefficient (J): A factor used in rigid pavement design to account for the ability of a concrete pavement to distribute load across joints and cracks.

Longitudinal Joint: A pavement joint, in the direction of traffic flow, used to control longitudinal cracking on a rigid pavement or the joint formed between adjacent passes of a paver on a flexible pavement.

Loss of Support (LS): A factor included in the design of rigid pavement to account for the potential loss of support arising from base erosion and/or differential vertical soil movements.

Major Rehabilitation: Work performed on a pavement intended to restore structural and functional characteristics. Major rehabilitation includes such work as complete replacement, rubblizing with an asphalt overlay, cracking and seating with an asphalt overlay (non-reinforced concrete only), unbonded concrete overlay, whitetopping, and possibly others.

Mean Concrete Modulus of Rupture (S'_c): The flexural strength of concrete derived from a beam test with third point loading.

Minor Rehabilitation: Work performed on a pavement intended to restore functional characteristics and protect structural characteristics. Minor rehabilitation consists primarily of asphalt overlays of varying thickness or CPR.

Multi-Lane Pavements: Pavements with four or more lanes. Continuous two-way left turn lanes are considered lanes in this definition.

New Pavement: Pavement built on a new alignment where no pavement existed before, pavement replacing existing pavement that has been removed, and pavement built next to existing pavement to increase capacity (widening).

Overall Standard Deviation: A statistical measure to account for the error in the prediction of traffic and pavement performance.

Pavement Condition Rating (PCR): A numerical rating of pavement distresses on a 0 to 100 scale based on visual inspection. A PCR of 100 signifies a perfect pavement with no distress.

Plastic Limit: The water content, in percent, of a soil at the boundary between the plastic and semi-solid states.

Present Serviceability Index (PSI): A numerical index which correlates roughness measurements on a scale of 0 to 5. A PSI of 5 indicates an exceptionally smooth pavement.

Pressure Relief Joint: Similar to expansion joint but placed exclusively near bridges to prevent damage to the bridge from pavement expansion.

Reliability (R): A statistical measure of the probability that a section of pavement will meet or exceed the predicted performance.

Rigid Pavement: A pavement structure consisting of hydraulic cement concrete, with or without an aggregate base, placed on a prepared subgrade.

Salvage Value: The remaining value of an investment alternative at the end of the analysis period.

Serviceability: The ability of a pavement to serve traffic as measured by the present serviceability index.

Slab Length: The distance between adjacent transverse joints.

Structural Deduct: A part of the PCR indicating distresses that may be related to the structural characteristics of the pavement.

Structural Characteristics: Those characteristics related to the load-carrying capacity of the pavement.

Structural Coefficient (Layer Coefficient): A measure of the relative ability of a material to function as a structural component of a flexible pavement structure and used to convert a design structural number to actual thickness.

Structural Number (SN): A regression coefficient derived from an analysis of traffic, soil conditions, and environment which may be converted to thickness of flexible pavement layers using structural coefficients related to the type of material being used in each layer of the pavement structure.

Subbase Elastic Modulus: A measure of the ability of a subbase to carry a load.

Subgrade Resilient Modulus (M_r): A measurement of the stress dependency of a subgrade soil, determined by the LTPP P46 test procedure.

Surface Treatment: Work performed on a structurally sound pavement intended to preserve the pavement, retard future deterioration, and maintain or improve the functional characteristics without substantially increasing the structural capacity. Surface treatments include such things as chip seals, microsurfacing, thin overlays and diamond grinding.

Terminal Serviceability Index (P_t): The lowest present serviceability index used in the design equations; the point at which rehabilitation is anticipated.

Transverse Joint: A pavement joint perpendicular to the centerline alignment of the pavement, designed to control cracking, provide for load transfer, and allow for the contraction and expansion of the pavement. Transverse joints may be construction, contraction, or expansion joints.

User Costs: The increased cost incurred by the highway user, such as vehicle operating costs and value-of-time delay costs, due to construction activities during the analysis period.

Reference Documents

An Efficient and Accurate Genetic Algorithm for Backcalculation of Flexible Pavement Layer Moduli (ODOT - 2012)

Circular Number A-94 (Office of Management and Budget - 1992), Appendix C (OMB - Current Revision)

Construction Inspection Manual of Procedures (ODOT - Current Edition)

Construction and Material Specifications (ODOT - Current Edition)

Development of an Overlay Design Procedure for Composite Pavements (ODOT – 2017)

Effectiveness of Asphalt Penetrating Sealers in Extending New Asphalt Pavement Life (ODOT – 2017)

Effectiveness of Chip Sealing and Micro Surfacing on Pavement Serviceability and Life (ODOT – 2010)

Effectiveness of Crack Sealing on Pavement Serviceability and Life (ODOT – 2011)

Effectiveness of Thin Hot Mix Asphalt Overlay on Pavement Ride and Condition Performance (ODOT – 2008)

Engineering Characteristics of Ohio Soil Series, Principles of Engineering Soils Taxonomy, Vol. 1, Gene O. Johnson (1975)

Geotechnical Design Manual (ODOT - Current Revision)

Guide for Pavement Friction (NCHRP – 2009)

Guide for Design of Pavement Structures (AASHTO - 1993)

Highway Engineering Handbook (McGraw-Hill - 1996)

Improved Characterization of Truck Traffic Volumes and Axle Loads for Mechanistic Empirical Pavement Design (ODOT – 2012)

Incorporating Chemical Stabilization of the Subgrade in Pavement Design and Construction Practices (ODOT – 2014)

Location and Design Manual, Volume One - Roadway Design (ODOT - Current Revision)

Location and Design Manual, Volume Two - Drainage Design (ODOT - Current Revision)

Location and Design Manual, Volume Three - Highway Plans (ODOT - Current Revision)

Location and Design Manual, Volume Three - Highway Plans, Sample Plan Sheets (ODOT - Current Revisions)

Pavement Condition Rating System (ODOT - Current Revision)

Principles of Pavement Design (Wiley-Interscience - 1975)

Review of ODOT's Overlay Design Procedure (ODOT – 2008)

Specifications for Geotechnical Exploration (ODOT - Current Revision)

Standard Construction Drawings (ODOT - Current Revisions)

Effectiveness of Chip Sealing and Micro Surfacing on Pavement Serviceability and Life (ODOT – 2010)

Effectiveness of Crack Sealing on Pavement Serviceability and Life (ODOT – 2011)

Effectiveness of Thin Hot Mix Asphalt Overlay on Pavement Ride and Condition Performance (ODOT – 2008)

Review of ODOT's Overlay Design Procedure (ODOT – 2008)

An Efficient and Accurate Genetic Algorithm for Backcalculation of Flexible Pavement Layer Moduli (ODOT - 2012)

Improved Characterization of Truck Traffic Volumes and Axle Loads for Mechanistic Empirical Pavement Design (ODOT – 2012)

Structural Support of Lime or Cement Stabilized Subgrade Used with Flexible Pavements (ODOT – 2004)

100 Pavement Requirements

Table of Contents

100 Pavement Requirements

The requirements in this section replace ODOT policies 20-007(P) Pavement Design Policy and 22-009(P) Pavement Type Selection Policy, and standard procedure 520-001(SP) Pavement Type Selection Standard Procedure. Pavement designs for Interstate, US, and State routes, and other Federal-aid routes are to follow the requirements of this section and the procedures set forth in this Manual.

101 Design Responsibility

The districts are responsible for the pavement design for all priority system surface treatments, and general system minor rehabilitations and surface treatments. The districts or the local governing agency is responsible for pavement design for all urban system minor rehabilitations and surface treatments. The local governing agency is responsible for pavement design for Federal-aid routes off the state system. The Office of Pavement Engineering is responsible for the pavement design for all priority system minor rehabilitation.

Pavement design responsibility for all new pavements and major rehabilitations on the state system depends on the size of the project. The pavement design for projects in excess of four lane-miles of mainline driving lanes is the responsibility of the Office of Pavement Engineering. The pavement design for projects less than four lane-miles is the responsibility of the district or local governing agency.

102 Structural Design Period

Pavements must be structurally designed to accommodate the current and predicted traffic needs in a safe, durable, and cost effective manner. Pavement structural design is based on a projection of the anticipated traffic loading. The design period is the number of years in the traffic loading prediction. The design period for pavements is based in part on the geometric design period and the construction material quality specifications.

The design periods listed below are exact values, not maximums or minimums. A shorter design period would result in thin pavements more likely to fail prematurely. A longer design period would not be achievable without corresponding changes to the geometric standards, material quality specifications, and construction procedures.

Other roads not part of the priority, general, or urban systems should use the design period for the most similar roadway and rehabilitation type.

102.1 Priority System Design Period

New Pavement	20 years
Major Rehabilitation	20 years
Minor Rehabilitation	12 years
Surface Treatments	n/a

Surface treatments are applied to structurally sound pavements to correct or reduce deterioration of non-structural surface distresses. They are also used occasionally as short term, stopgap measures on structurally deficient pavements in advance of minor or major rehabilitation; this practice is discouraged however, as patching or spot paving may be more cost effective.

Sound engineering judgment should be used when determining where to apply surface treatments. Output from the pavement management system can assist in identifying appropriate locations and treatment types.

102.2 General System Design Period

New Pavement	20 years
Major Rehabilitation	20 years
Minor Rehabilitation	n/a
Surface Treatments	n/a

Because of the variability of the existing pavement buildup on general system routes, no structural design is required for minor rehabilitation and surface treatments. Output from the pavement management system should be used to assist in the timing and treatment for minor rehabilitation and surface treatments. A 12-year structural design may be used for minor rehabilitation where the existing pavement buildup is known and is relatively uniform.

102.3 Urban System Design Period

New Pavement	20 years
Major Rehabilitation	20 years
Minor Rehabilitation	n/a
Surface Treatments	n/a

Urban system minor rehabilitations and surface treatments are determined by or in conjunction with the local governing agency. The guidelines of the urban paving program apply (see the ODOT Program Resource Guide). Output from the pavement management system can assist in identifying appropriate treatments.

103 Subgrade Strength Parameters

The subgrade strength parameters for designing new pavement shall be determined in accordance with the Office of Geotechnical Engineering guidance.

104 Pavement Type Selection

Pavement type selection for new pavement and major rehabilitation projects on the state system in excess of four lane-miles of mainline driving lanes is subject to the requirements of this section.

Pavement type selection for all ramps is subject to the requirements of Section 104.7.

Pavement type selection for minor rehabilitation and surface treatment projects of any length, and new pavement and major rehabilitation projects less than four lane-miles is the responsibility of the district, the Office of Pavement Engineering, or the local governing agency as appropriate.

The requirements of this section do not apply to any roads off the state highway system.

104.1 Pavement Designs Considered

For pavements built along new alignments, both rigid and flexible pavement shall be considered. Composite pavement may be considered if there is a district or local preference to do so. Neither rigid nor flexible pavement shall be eliminated without justification in accordance with this section.

For projects on existing alignment, all major rehabilitation techniques shall be considered. Current major rehabilitation techniques include complete replacement with rigid, flexible, and possibly composite pavement; rubblizing with an asphalt overlay; unbonded concrete overlay; cracking and seating with an asphalt overlay (non-reinforced concrete only), and whitetopping. New or other techniques may be considered as well if applicable. Replacement is applicable to all existing pavement types. Rubblize, crack and seat, and unbonded concrete overlays are applicable to existing rigid or composite pavements. Whitetopping is applicable to existing flexible pavements. No major rehabilitation technique is to be eliminated without justification in accordance with this section.

Full depth reclamation (FDR) is a major rehabilitation technique for general system flexible pavements only. FDR is an alternative to extensive full depth repairs but is not feasible for all locations. Where feasible, FDR is preferred over extensive repair due to the uniformity of treating 100 percent of the pavement, and it is more cost effective and sustainable than removal and replacement. The selection of FDR is based on an engineering analysis of the existing pavement and base, the required overlay thickness, and the ability to detour traffic. No additional pavement type selection or life-cycle cost analysis is performed for FDR.

104.2 Principal Factors

After the potential pavement designs are identified, an engineering review and analysis of the principal selection factors shall be conducted. Application of the principal factors may eliminate some pavement designs from further consideration. If only one pavement design exists after the analysis of the principal factors, it is selected and no further analysis is required.

104.2.1 Research

The Department may wish to conduct research on a new or specific pavement type or treatment. If a project is identified for the research, the pavement type selection and design parameters will be based on the requirements of the research.

104.2.2 Adjacent Existing Sections

When systematically building or rehabilitating multiple pavement sections along a corridor, a single pavement type or treatment may be selected to provide continuity throughout the corridor. Also, short sections adjacent to or between pavements with the same surface type, may be selected to continue the same surface material for continuity. Short sections are generally considered to be less than three centerline miles.

104.2.3 Geotechnical Concerns

The subgrade conditions may eliminate the use of some pavement designs. For example, there is a minimum blow count requirement for rubblize and roll to be considered.

104.2.4 Geometrics

Correcting deficient geometrics and adapting to existing constraints (e.g. bridges) may require replacing much of the existing pavement. When the percentage of pavement requiring replacement becomes large, consideration will be given to eliminating the rehabilitation treatments and proceeding with complete replacement only. Adapting to the existing conditions may also require typical section configurations that do not conform to the design assumptions or could result in premature deterioration.

104.2.5 Amount of New Pavement

On projects with lane additions or other widening, the percentage of new pavement versus the percentage of salvaged pavement may become so large that it is preferable to replace the existing and have all new pavement. New, full depth pavement next to rehabilitated pavement may or may not perform the same and may want to be avoided in some cases.

When the existing pavement can be salvaged and performance differences are not a concern, the new pavement may be selected to match the existing pavement. It is standard practice to maintain one pavement surface type transversely across all adjacent driving lanes.

104.3 Life-Cycle Cost Analysis

A life-cycle costs analysis (LCCA) is prepared if more than one pavement design remains after the principal factors have been applied. The LCCA is prepared by the Office of Pavement Engineering with unit price estimates provided by the Office of Estimating. The analysis period for the LCCA is 35 years.

The future rehabilitation timing and treatments used in the LCCA shall be in accordance with Section 700.

A draft version of the completed LCCA is sent to the district and representatives of both paving industries for review. The purpose of the review is to identify any errors and provide comments when applicable. The Office of Pavement Engineering will submit the final LCCA and selection package along with any comments to the Pavement Selection Committee.

If there is no pavement design within 10% of the lowest cost design, the Pavement Selection Committee shall select the lowest cost design.

104.4 Secondary Factors

Secondary factors are evaluated by the Pavement Selection Committee when one or more pavement design is within 10 percent life-cycle cost of the lowest cost pavement design. The committee may use the secondary factors to pick a single pavement design, or they may select two or more designs for optional bidding. Alternate bidding may also be selected but optional bidding is preferred.[1]

104.4.1 Principal Factors

The committee may reconsider any of the principal factors as secondary factors.

104.4.2 Maintenance of Traffic

The Maintenance of Traffic Alternative Analysis (MOTAA) report details possible maintenance of traffic scenarios and the associated costs. This report should be available for the committee to evaluate as a secondary factor.

104.4.3 Smoothness

Smoothness is very important to the travelling public and to the Department. The Department collects ride quality data on a regular basis for new and existing pavements of all types. The initial and ongoing smoothness of a pavement yet to be constructed cannot be predicted but the collected data can indicate trends. The committee may consider expected smoothness as a secondary factor.

104.4.4 Initial Cost

There may be significant differences in the initial costs even when the total life-cycle costs are close. The committee may use differences in the initial costs to select one pavement design.

---

[1] Optional bidding requires a bidder to submit a bid for only one of two or more options. Alternate bidding requires a bidder to submit bids for all the alternatives.

104.5 Pavement Selection Committee

Pavement type selection for new pavement and major rehabilitation projects in excess of four lane-miles of mainline driving lanes is by the Pavement Selection Committee. The committee is comprised of the following individuals:

- Assistant Director of Transportation Policy
- Deputy Director of Engineering
- District Deputy Director (of the applicable district)

The committee may call on additional subject matter experts as needed such as for geotechnical or maintenance of traffic issues.

Once a selection is made, the Office of Pavement Engineering notifies the district and the Federal Highway Administration of the selected pavement design and buildup.

104.6 Reanalysis of Selections

Pavement selections are considered final and not required to be reanalyzed. Projects may be reanalyzed at any time, however. Likely reasons for reanalysis include delays in the project schedule, changes in the project scope, and changes in pavement market conditions.

104.7 Ramp Pavement Type

All new ramps and ramps replaced in their entirety shall follow the requirements of this section. When part of a ramp is being replaced, the requirements of this section should be considered when selecting pavement type. System and service interchanges are defined in the L&D Manual, Volume 1, Section 502 Interchange Design Considerations.

All service interchange ramps, from the crossroad to the nose of the physical gore area, are to be constructed using concrete pavement. Exceptions to this requirement may be granted upon request to the Office of Pavement Engineering. The longitudinal joints on concrete ramps are to be constructed in accordance with Standard Drawing BP-6.1 and should never be located in the wheelpaths.

For all system interchange ramps, districts may select the appropriate pavement type.

Pavement thickness design for all ramps is to be in accordance with the Pavement Design Manual. Acceleration and deceleration lanes shall match the pavement surface type of the adjoining mainline pavement.

105 Pavement Edge Treatments

The area beyond the edge of the paved surface must be treated to prevent drop-offs which can present a safety hazard. There are two methods for treating the pavement edge area, the safety edge treatment and the standard edge treatment.

105.1 Safety Edge Treatment

A safety edge is a wedge of pavement beyond the edge of the paved surface angled approximately 30 degrees from the surface to provide for the safe recovery of vehicles if the graded shoulder material has eroded, settled, rutted, etc., instead of a vertical dropoff. Details on safety edge construction are shown in BP-3.2 and BP-8.2.

A safety edge is required on all paving projects on state highways (Interstate, US, and State routes) including mainline highways, collector-distributor roads, and ramps meeting all the following criteria:

- Uncurbed sections only;
- Thickness of new material placed is greater than 1.5 inches (38 mm);
- Less than 4 foot (1.2 m) paved shoulder width on mainline or less than 3 feet (1 m) on ramps;
- At least 1500 feet (450 m) of continuous centerline paving, or less than 1500 feet (450 m) if the adjacent pavement on either end currently has a safety edge; and,
- Legal speed limit is greater than 35 mph.

Safety edge is not required on any service interchange ramp or anywhere behind the face of guardrail. It is prohibited for any pavement that abuts concrete barrier wall.

Safety edge requires approximately 10 inches (250 mm) of graded shoulder width (6:1 or flatter preferred) available beyond the edge of the paved surface. Plans must include a quantity of Item 209 Preparing Subgrade for Shoulder Paving for the locations where safety edge will be constructed. Include the asphalt needed to construct the safety edge with the surface course asphalt item. Do not include the additional width of safety edge in the square yard (square meter) calculation for concrete pavement.

If safety edge is used on part, but not all, of a project, the plans must indicate where it is or isn’t to be used.

Safety edge must be backed up with aggregate, embankment, topsoil, etc., flush with the pavement surface. Do not leave the safety edge exposed.

Safety edge may be used where it is not required. Follow the requirements of Section 105.2 for locations not using a safety edge.

105.2 Standard Edge Treatment

Uncurbed locations not meeting the requirements for safety edge (Section 105.1) must provide material to prevent a drop-off at the edge of the paved surface. On new alignments, this material may be aggregate, embankment, topsoil, or other suitable material as determined on a project basis. On overlays and rehabilitation projects, this material is most often Item 617 Reconditioning Shoulders. In residential or commercial areas topsoil and seeding may be necessary. The exact materials used and the locations are determined on a project basis.

100 Pavement Requirements

List of Figures

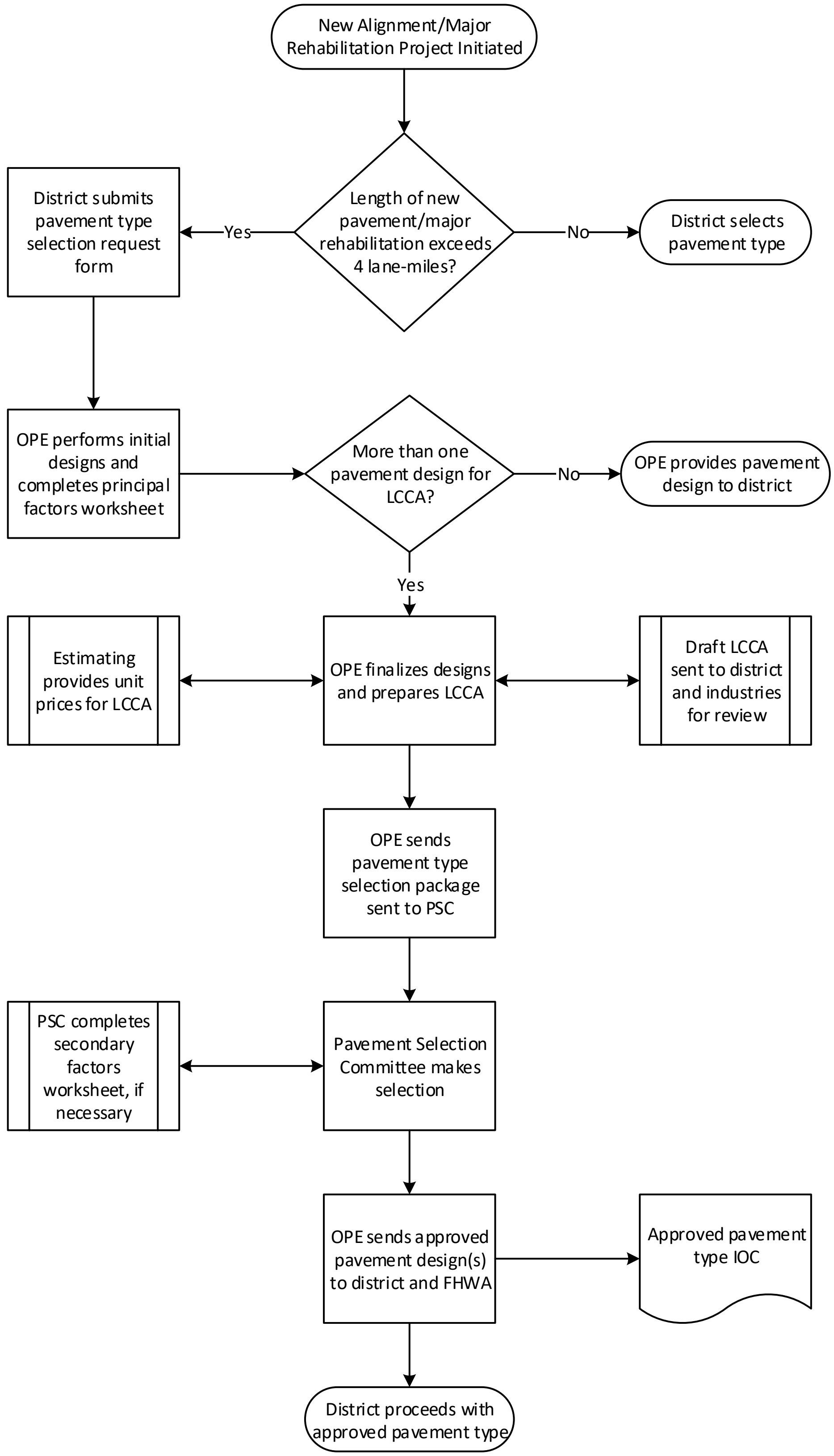
Pavement Type Selection Flowchart

104-1

January 2021

Reference Section

104



Sample Pavement Type Selection Request Form

104-2
July 2024
Reference Section
104

This form is available electronically on O:\Engineering\Pavement Engineering.

Pavement Type Selection Request Form

PID: _____________ Cou-Rt: ________________ Submitted by: ______________________________
Begin SLM: ____________ End SLM: ____________

Geotechnical Information:

GB1 Spreadsheet attached: ☐Yes ☐No Including sulfate testing: ☐Yes ☐No
Boring logs attached (only if they include pavement buildup information): ☐Yes ☐No
Pictures of pavement cores attached, if any: ☐Yes ☐No

Project Information:

Number of continuous through lanes current: ___________ Proposed: ___________
Width of shoulders: Inside* Outside*
Current: __________________
Proposed: __________________
*For undivided sections list one shoulder under Inside and the other under Outside

Does the project include curbs or curb and gutter: ☐Yes ☐No

For divided sections, proposed median type: ☐Grass ☐Concrete barrier ☐Concrete median
☐Other; Describe: ____

Any proposed vertical or horizontal alignment changes: ☐Yes ☐No

Describe: ____

Are there constraints other than bridges that impact raising or lowering the pavement surface elevation: ☐Yes ☐No

Describe: ____

What is the maximum acceptable change in pavement surface elevation?
Raise: _________inches Lower: _________inches

In the case of new alignment or complete replacement, will the project include global chemical stabilization**: ☐Yes ☐No
☐Undecided; Describe: ____

**Global chemical stabilization is 100% chemical stabilization without exception under the mainline lanes and shoulders.

Optional information to provide:

Generic typical section(s) showing widths, curbs, median, etc. (no pavement buildup)
Schematic drawing

Selection requested by date: ________________________

Selections typically take 6-8 weeks to finalize once all the required information is received depending on the office workload. Often the likely selection is known within 2-3 weeks but not official until finalized. OPE will strive to meet the requested date but cannot guarantee it.

Submit requests electronically to OPE: Craig Landefeld, Dave Miller, or Bill Feehan

Table of Contents

200 Pavement Design Concepts

200.1 Introduction

Perhaps the most widely used pavement design method in the United States and throughout the world is the American Association of State Highway and Transportation Officials (AASHTO) Guide for Design of Pavement Structures. A long history of pavement studies has led to the current edition. The ODOT method for the design of pavement structures is almost identical to the 1993 AASHTO method, but ODOT has simplified some parts of the AASHTO Guide since it needs to apply only to the conditions encountered in Ohio.

The AASHTO/ODOT pavement design equations have some variables common to both rigid and flexible pavement, including serviceability, traffic loading, reliability, overall standard deviation, and roadbed soil resilient modulus. These common variables are detailed in this section. The remaining variables needed for the design of a pavement structure are presented in the rigid and flexible pavement design sections, respectively.

201 Serviceability

The AASHTO pavement design method was developed around the concept of serviceability. Serviceability is defined as the ability of a pavement to serve traffic. The present serviceability rating (PSR) was developed to measure serviceability. PSR is a rating of pavement ride based on a scale of zero, for impassable, to 5, for perfect. For the development of the original AASHTO pavement design equation, individuals (the raters) would ride the pavements and assign a PSR value. To avoid riding and rating every pavement by all raters to determine serviceability, a relationship between PSR and measurable pavement attributes (roughness and distress) was developed. This relationship is defined as the present serviceability index (PSI).

201.1 Initial Serviceability

The initial serviceability for design is 4.2 for rigid pavements and 4.5 for flexible pavements. Figure 201-1 shows initial serviceability.

201.2 Terminal Serviceability

Terminal serviceability is the minimum level of serviceability the agency allows in design. Once built, pavements may or may not actually degrade to that level but the design terminal serviceability remains the same. ODOT pavements are designed for a minimum PSI (terminal serviceability) of 2.5. Figure 201-1 shows terminal serviceability.

201.3 Design Serviceability Loss

The design serviceability loss is the amount of serviceability the agency will tolerate losing before rehabilitation. The design serviceability loss is the difference between the terminal serviceability and the initial serviceability. Figure 201-1 shows design serviceability loss.

202 Traffic Considerations

Estimating the design traffic loading is a critical step in designing a pavement. Overestimation of the design traffic results in a thicker pavement than necessary with higher associated costs. Underestimation results in pavements thinner than needed and susceptible to premature failure resulting in increased maintenance and impact on the user.

202.1 Traffic Loading

For design purposes, truck traffic is converted to loading which is normalized by the concept of an equivalent 18,000 lb (80 kN) single axle load (ESAL). The conversion of traffic to the ESAL is accomplished with the use of axle load equivalency factors. Equivalency factors are a function of pavement type and thickness, among other factors. Equivalency factors are provided in the AASHTO Guide.

202.1.1 B:C Ratios

Truck counts can be broken down into two truck type categories. Multi-unit vehicles such as semi-tractor trailers are classified as B-type trucks. Single unit trucks and buses are classified as C-type trucks. The Office of Technical Services collects this data on a sampling basis and reports the data using statewide averages by functional classification. B:C Ratios are presented in Figure 202-1. These ratios should be used only where current project counts are not available. Actual B & C counts are always more accurate than the B:C ratio provided in Figure 202-1.

202.1.2 Conversion Factors

In order to simplify the process of converting each truck expected on the roadway to an ESAL, ODOT uses average ESAL conversion factors for B and C trucks. The Office of Technical Services monitors truck counts and axle weights. Conversion factors are calculated for both truck types for the different functional classifications monitored. The conversion factors printed in this Manual are ten-year averages to smooth out year-to-year fluctuations. Refer to Figure 202-1 for ODOT's most current ESAL conversion factors.

202.1.3 Traffic Data

Basic traffic data should be forecasted and certified by the Office of Statewide Planning and Research. This data must include the average daily traffic (ADT) for the current year as well as the design year and the 24-hour truck percentage. This data is typically found in the design designation for the project. It is important to ensure the truck percentage is a 24-hour percentage and not a peak-hour percentage. When only the peak-hour truck percentage is available, it should be multiplied by 1.6 to estimate the 24-hour percentage.

202.1.4 Design Lane Factors

There are two design lane factors. One is the directional distribution factor (D) and the other is the lane factor (LF). The ADT counts always include all lanes and both directions of travel. In order to design the required pavement thickness, the ADT needs to be adjusted to represent the loading on the design lane. This is done by applying the directional distribution, which defines the loading in each direction of travel, and the lane factor, which distributes the trucks into the different lanes in a given direction.

The directional distribution listed in the design designation is the peak-hour volume distribution and is for capacity analysis. For pavement structural design, a directional distribution of 50% should be used in all cases. If the designer has specific, credible information indicating unequal loading on the two directions, and this imbalance is expected to continue throughout the design life of the pavement, a directional distribution other than 50% may be used but caution is advised as this can have significant impact on the pavement thickness required. Figure 202-1 shows directional distribution.

Where there are multiple lanes in the same direction, not every truck travels in the same lane. To account for variability across multiple lanes, a lane factor is applied. Refer to Figure 202-1 for ODOT's most current lane factors.

202.2 Calculation of ESALs

The calculation of ESALs is very simple once all the data is available. The following equations are used. All percentages are to be expressed as a decimal.

B-ESALs = ADT * $\%T_{24}$ * %D * %LF * %B * CF
C-ESALs = ADT * $\%T_{24}$ * %D * %LF * %C * CF

B-ESALs + C-ESALs = Total Daily ESALs

Where:

ADT = Average Daily Traffic
$\%T_{24}$ = 24-hour truck percentage of ADT
%D = Directional Distribution (50%)
%LF = Lane Factor
%B, C = % B or C trucks of the total trucks
CF = Appropriate truck conversion factor

To calculate the design ESALs, the total daily ESALs are multiplied by 365.25 days per year and then by the number of years in the design period.

Examples of the calculation of design ESALs are provided in Figures 302-1 and 402-1.

202.2.1 Design Period

The design period is the number of years over which the pavement is expected to deteriorate from its initial condition to its terminal serviceability. It is the number of years for which the ESALs are predicted. The design period is established in Section 100 Pavement Requirements.

202.3 ESAL11

Another method for the calculation of ESALs is available for locations where historical traffic data is available. This method takes into account growth rates in numbers of trucks, changes in the conversion factors associated with the trucks, and changes in the B:C ratio. The method relies on the practice of forecasting the future based on trends of the past. However, trends of past traffic data may not be an accurate indication of future traffic projections.

The ESAL11 procedure calculates the daily ESALs for each year of truck count data entered. ESAL conversion factors corresponding to the year of the truck counts are used in the calculations instead of using ten-year averages. The daily ESALs are then used to calculate the cumulative ESALs from the first year of data to the most recent year of data. Finally, regression analysis is performed on the cumulative ESALs to develop equations used to predict the future ESALs.

The ESAL11 procedure is the preferred method for predicting ESAL loading. For more information regarding this method, contact the Office of Pavement Engineering.

203 Subgrade Soil Characterization

The subgrade is the foundation for all pavements. Trying to characterize the stiffness of this foundation for a particular pavement is a very difficult task because of the variability found in nature and during construction. The AASHTO pavement design equations used by ODOT characterize the subgrade stiffness using the roadbed soil resilient modulus. For pavement design, subgrade soil type is determined directly from soil tests made in conjunction with the soil profile or bridge foundation explorations. Information on subgrade explorations, soil classification, soil profiles, etc., can be found in the Specifications for Geotechnical Explorations published by the Office of Geotechnical Engineering. Additional information on soil boring analysis, stabilization and treatment methods, and design procedures, can be found in the Geotechnical Design Manual also published by the Office of Geotechnical Engineering.

General planning information about soil types and properties can be found in the Soil Survey books, which are published for every county in Ohio. Additional information on soils and proper construction practices can be found in the Construction Inspection Manual of Procedures published by the Office of Construction Administration. The ODOT soil classification method is presented in the Specifications for Geotechnical Exploration.

ODOT's pavement design procedure uses a statistical reliability factor (see Section 204) to account for variability in subgrade stiffness. Because of this, the average CBR is to be used for pavement design. Often designers want to use the lowest CBR value to add an additional safety factor but this results in unnecessarily thick, wasteful designs.

203.1 Subgrade Resilient Modulus

The subgrade resilient modulus is a measure of the ability of a soil to resist elastic deformation under repeated loading. Many soils are stress dependent. As the stress level increases, these soils will behave in a non-linear fashion. Fine-grained soils tend to be stress-softening, whereas granular soils tend to be stress-hardening. The laboratory resilient modulus test, AASHTO T 307 or NCHRP 1-28A, is designed to determine the strain due to a repeated load (deviator stress) which simulates the effect of loads passing over a section of pavement.

Based on limited research and several current publications, ODOT has adopted a standard relationship between modulus of resilience (M_r) and the California bearing ratio (CBR) shown below. The units for resilient modulus are pounds per square inch (psi).

$M_r = 1200 * CBR$

203.2 California Bearing Ratio

The California bearing ratio (CBR) is a value representing a soil's resistance to shearing under a standard load, compared to the resistance of crushed stone subjected to the same load. The CBR is obtained by performing a laboratory penetration test of a soaked sample of soil. The load required to produce a penetration at each 0.1 inch depth in the soaked sample is divided by a standard, which has been developed for crushed stone, then multiplied by 100.

203.3 Group Index

In order to reduce the amount of laboratory testing required to characterize the soil stiffness, ODOT developed a relationship between CBR and group index. This relationship was developed in the 1950's by testing hundreds of soil samples. Group Index is a function of a soil's Atterberg Limits and gradation. The equation for group index is given in Section 603 of the Specifications for Geotechnical Exploration published by the Office of Geotechnical Engineering. Figure 203-1 contains a nomograph that solves the group index equation. Group index is then correlated to CBR using the chart in Figure 203-2.

203.4 Subgrade Stabilization

Undercutting or chemical stabilization of the subgrade should be determined in accordance with the Subgrade Analysis. Questions regarding subgrade stabilization should be directed to the Office of Geotechnical Engineering.

203.4.1 Global Chemical Stabilization

When the entire subgrade is chemically stabilized without exception (global chemical stabilization), the subgrade resilient modulus of the native soil is increased. Research has shown that global chemical stabilization increases the stiffness of the subgrade and the effects are long lasting. The increased resilient modulus is calculated using the following formula:

$$M_{r\text{-}GCS} = 1.36 * M_r$$

Where:

$M_{r\text{-}GCS}$ = Improved subgrade resilient modulus due to global chemical stabilization (psi)
M_r = Subgrade resilient modulus of the native soil (psi)

Include sample plan note G123 Chemically Stabilized Subgrade in the plans when the pavement design is based on an increased resilient modulus due to chemical stabilization.

204 Reliability

AASHTO defines reliability as the probability that the load applications a pavement can withstand in reaching a specified minimum serviceability level is not exceeded by the number of load applications that are actually applied to the pavement. Reliability is a statistical tool used in pavement design that assumes a standard normal distribution exists for all pavement design parameters and allows the designer to account for deviation from the average equally for all parameters. Reliability can be thought of as a safety factor. Figure 201-1 lists the reliability factors to be used in pavement design for various classifications of highways.

204.1 Overall Standard Deviation

The overall standard deviation (variance) is a measure of the spread of the probability distribution for ESALs vs. Serviceability, considering all the parameters used to design a pavement. Figure 201-1 lists the overall standard deviation to be used in pavement design.

205 Subsurface Pavement Drainage

Subsurface pavement drainage is required on all projects greater than 0.5 miles (0.8 km) long that consist of constructing new pavement on subgrade or rubblizing the existing pavement. Subsurface drainage may be installed on any type of project and any length, if needed.

Lack of adequate pavement drainage is a primary cause of distress in many pavements. Excess moisture in the base and subgrade reduces the amount of stress the subgrade can tolerate without permanent strain. Strain in the subgrade transfers stress into the upper pavement layers resulting in deformation and ultimately distress. Trapped moisture in flexible pavement systems leads to stripping, raveling, debonding, and rutting. Excess moisture in rigid pavement systems leads to pumping, faulting, cracking, and joint failure.

205.1 Types of Drainage Systems

There are three means of draining the pavement subsurface - pipe underdrains, prefabricated edge underdrains, and aggregate drains. Pipe underdrains are the primary method to provide drainage and are generally used with paved shoulders and curbed sections. Occasionally, when an existing pavement is being overlaid, prefabricated edge underdrains are installed to provide drainage. Aggregate drains are generally used with aggregate shoulders, surface treated shoulders, and for spot improvements. In the past, another type of subsurface drainage, free draining base (FDB), was used but is no longer approved for use on ODOT projects and the specifications have been rescinded.

Figures 205-1 to 205-10 provide details on the placement of subsurface drainage systems. Additional examples are found in the Sample Plan Sheets.

205.1.1 Pipe Underdrains

Pipe underdrains are required when constructing new pavement on subgrade for all Interstates, freeways, expressways, and multi-lane divided facilities. Pipe underdrains are generally used with paved shoulders and curbed pavements.

Pipe underdrains generally follow the profile grade of the roadway as long as the pipe underdrain maintains a positive or zero slope. In the case of a zero slope, hydrostatic pressure is sufficient to ensure the proper drainage of the base and subgrade.

Underdrain depth is measured from the subgrade elevation to the bottom of the underdrain trench. Base pipe and shallow pipe underdrains are typically 4 or 6 inches (100 or 150 mm) in diameter. The 4 and 6 inch (100 and 150 mm) pipes are considered equivalent in hydraulic capacity for the base pipe and shallow pipe underdrains. Use a 6-inch (150 mm) pipe if the outlet interval is greater than 500 feet (150 m) or if the subgrade is saturated.

Underdrain systems are referred to as either dual underdrain systems or single underdrain systems. Dual underdrain systems have an underdrain at both the edge of travelled way and the edge of shoulder in a partial typical section as shown in the underdrain figures. Single underdrain systems have just one underdrain at either the edge of travelled way or edge of shoulder in a partial typical section as shown in the underdrain figures.

Shallow pipe underdrains have a depth greater than 18 inches (450 mm) with a maximum of 30 inches (760 mm) and are typically placed at the maximum depth. Shallow pipe underdrains are used at the edge of the travelled lane for both single and dual underdrain systems with rigid pavements where deep pipe underdrains are not otherwise required. For flexible pavements with a single underdrain system, the shallow pipe underdrain is placed at the edge of shoulder.

Base pipe underdrains have a constant depth of 18 inches (450 mm). There may be locations where base pipe underdrains are placed at less than 18 inches (450 mm) deep but this is rare. Where a dual underdrain system is provided (shoulder width greater than or equal to 8 feet (2.4 m)), the underdrain at the outside edge of shoulder is supplemental to the underdrain at the edge of the travelled lane and is typically a base pipe underdrain with a depth of 18 inches (450 mm). If dual underdrains are provided on a superelevated section, the underdrain at the edge of the travelled lane is not required on the high side.

When constructing new pavement with an 81-inch (2.05 m) single slope concrete barrier adjacent, always place a base pipe underdrain at the outside edge of the aggregate base under the barrier leveling pad, regardless of shoulder width. This underdrain replaces any required base pipe underdrain at the edge of shoulder.

Deep pipe underdrains have a constant depth greater than 30 inches (760 mm) with a maximum of 50 inches (1.3 m) and are typically placed at the maximum depth. Deep pipe underdrains are typically 6 inches (150 mm) in diameter and are used in cut sections or areas of high water table.

Unclassified pipe underdrains are those having a variable depth below the profile grade within a single continuous longitudinal run. Designers are not to use variable depth (unclassified) pipe underdrains where underdrains of constant depth can be provided.

Rock cut underdrains are used in cut sections where rock, shale, or coal subgrade exists. The depth of rock cut underdrains should be 6 inches (150 mm) below the cut surface of the rock (see Figure 205-9).

Where necessary, the depth of underdrains may vary slightly.

When a pipe underdrain spans the trench of a lower conduit (utility, storm sewer, culvert, etc.) and the vertical distance between the lower conduit and the underdrain is less than or equal to 12 inches (300 mm), use a Type F conduit to span the lower trench. Use a minimum of 10 feet (3 m) of the Type F conduit, centered over the lower trench.

Wrap the trench in geotextile fabric according to Item 605 when the surrounding soil consists of a sandy or sandy-silt composition.

205.1.2 Prefabricated Edge Underdrains

Prefabricated edge underdrains may be placed at the edge of existing concrete pavement on resurfacing projects where the existing pavement and asphalt shoulders are being retained and the existing drainage is inadequate. If existing asphalt shoulders are being replaced, use a 4 inch (100 mm) shallow pipe underdrain at the edge of the concrete, instead of the prefabricated edge underdrain. On resurfacing projects, where prefabricated edge underdrains already exist, existing outlets should be inspected and replaced where they no longer function. See SCD DM-1.2 for prefabricated edge underdrain details.

205.1.3 Underdrain Outlets

Underdrains that outlet to a slope should be provided with an outlet conforming to SCD DM-1.1. Additional details for underdrains and outlets are provided in SCD DM-1.2.

Underdrain outlets should be provided at a desirable interval of 500 feet (150 m) with a maximum interval of 1000 feet (300 m). It is desirable to outlet underdrains at least 12 inches (300 mm) above the flow line of a receiving ditch; and 12 inches (300 mm) above the flow line of a receiving catch basin, manhole, or pipe with 6 inches (150 mm) as a minimum. Underdrain outlets shall be type F conduit.

Underdrain outlet pipes flowing into a roadway ditch or fill slope should maintain a minimum slope of one percent.

Outlets should not be located at the top of high (over 20 feet [6 m]) 2:1 fill slopes. If this cannot be accomplished by adjusting the outlet spacing, special outlet treatments are required. Contact the Office of Hydraulic Engineering for special outlet treatments.

205.1.4 Aggregate Drains

Aggregate drains are used with surface treated shoulders, aggregate shoulders, and for spot improvements. Aggregate drains are primarily for lower volume roadways with an aggregate base or as a retrofit for any pavement system with an aggregate base that does not have pipe underdrains or prefabricated edge underdrains.

Aggregate drains should be located at 50-foot (15 m) intervals on each side of the pavement and staggered so each drain is 25 feet (7.5 m) longitudinally from the adjacent drain on the opposite side. If used on rigid pavements, the spacing should be adjusted to match up to the end of a transverse joint. For superelevated pavements, spacing should be at 25 feet (7.5 m) and drains should be located on the low side only. Place an aggregate drain on both sides of the low point of each sag vertical curve or the low side only in superelevated sections.

For short projects and spot locations such as bridge replacements or landslide corrections where the 50-foot (15 m) intervals may not apply, provide a list of the specific aggregate drain locations in the General Notes with length, station, and side.

Aggregate drains should be physically cut into the edge of the pavement-shoulder system, preferably the aggregate base. Refer to Figures 205-7 and 205-8; and Location & Design Manual, Volume 3 - Highway Plans, Sample Plan Sheets for details depicting aggregate drains with the various pavement-shoulder treatments.

205.1.5 Construction Underdrains

In fine-grained soils, excess water in the subgrade is the principal cause of unstable soil conditions during construction. Adequate subgrade drainage can be achieved by using temporary pipe underdrains. These underdrains are sacrificial in nature and are intended to perform throughout the construction process. Construction underdrains are usually placed along the centerline of the roadway. They may also be placed along the ditch line if water is coming into a cut section from a higher elevation.

The outlets for construction underdrains are the same pipe material and backfill as the construction underdrains (not Type F). The outlets should be discharged into a catch basin, manhole, pipe, or ditch. If discharging into a ditch, a precast concrete reinforced outlet is not required.

205.2 AASHTO Drainage Coefficient

The AASHTO pavement design equations attempt to consider the effects of drainage on pavement performance. The nomographs used in this Manual are reprinted from AASHTO and allow for the use of the drainage coefficient for rigid pavement design. The flexible design method in this Manual does not include the drainage factor. For ODOT pavement design the drainage coefficient shall always be 1.0 for design of both rigid and flexible pavements.

200 Pavement Design Concepts

List of Figures

Serviceability & Reliability

SERVICEABILITY FACTORS		
	Rigid	**Flexible**
Initial Serviceability	4.2	4.5
Terminal Serviceability	2.5	2.5
Design Serviceability Loss	**1.7**	**2.0**

RELIABILITY LEVELS (%)		
Functional Classification	**Urban***	**Rural***
Interstate and Freeway (01, 02)	95	90
Principle Arterial, Minor Arterial (03, 04)	90	85
Collectors (05, 06)	90	85
Local (07)	80	80

* The designer must determine if the location is urban or rural in character. The ODOT Highway Functional Classification System Concepts, Procedures and Instructions document available from the Office of Program Management should be used as a guide.

OVERALL STANDARD DEVIATION	
Flexible Pavement	0.49
Rigid Pavement	0.39

Traffic Factors

202-1
July 2016
Reference Section
202

RATIO OF B:C COMMERCIAL VEHICLES		
Functional Classification	**B:C Ratio**	
	Urban*	**Rural***
Interstate (01)	4:1	7:1
Other Freeway or Expressway (02)	3:1	
Principal Arterial (03)	2:1	5:1
All Other (04, 05, 06, 07)	1:1	2:1

ESAL CONVERSION FACTORS				
Functional Classification	**Rigid**		**Flexible**	
	B	**C**	**B**	**C**
Interstate (01), rural*	1.53	0.37	0.98	0.29
Principal Arterial (03), rural*	1.67	0.44	1.06	0.33
All Other (04, 05, 06, 07), rural*	1.26	0.76	0.79	0.48
Interstate (01), urban*	1.46	0.46	0.93	0.34
Expressway & Freeway (02), urban*	1.38	0.72	0.90	0.47
All Other (03, 04, 05, 06, 07), urban*	1.64	0.53	1.04	0.41

* The designer must determine if the location is urban or rural in character. The ODOT Highway Functional Classification System Concepts, Procedures and Instructions document available from the Office of Program Management should be used as a guide.

DESIGN LANE FACTORS		
Number of Lanes per Direction	**Lane Factor (LF) (%)**	**Directional Distribution (D) for two-way traffic (%)**
1 - Lane	100	50
2 - Lanes	95	50
3 - Lanes	80	50
4 (or more) - Lanes	70	50

Group Index Charts

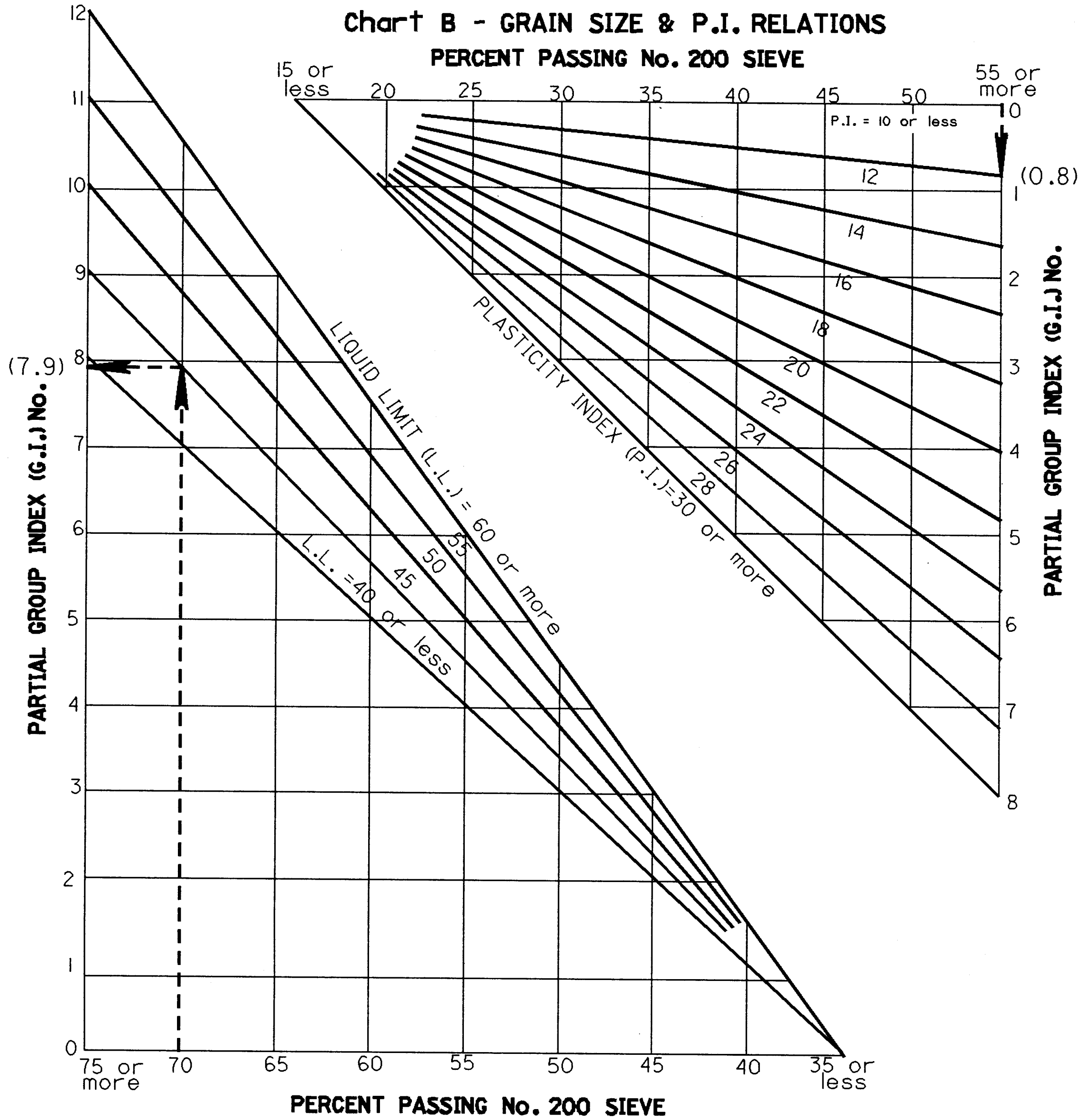
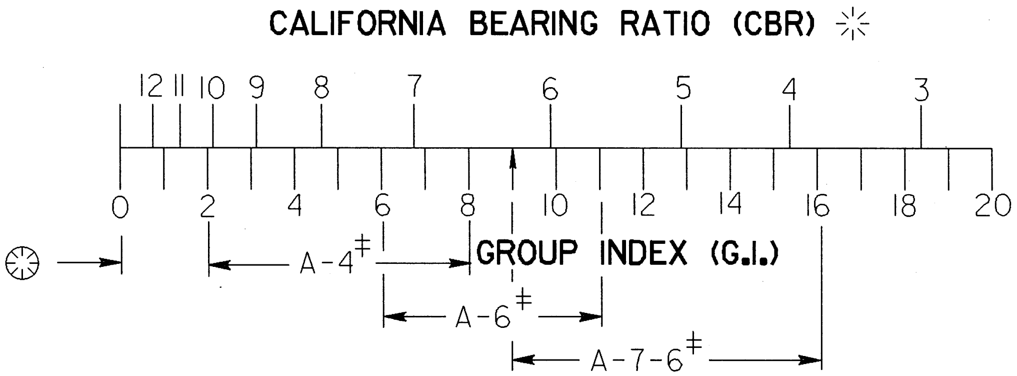


Chart A - GRAIN SIZE & L.L. RELATIONS

GROUP INDEX EQUALS SUM OF READINGS ON BOTH VERTICAL SCALES
Example: The G.I. of soil having 70% of its particles passing a No.200 sieve, with a L.L.=45 and a P.I.=12.
Chart A=7.9; Chart B=0.8
G.I. = 7.9+0.8 = 8.7 (rounded off to 9).

Subgrade Resilient Modulus

203-2
July 2015
Reference Section
203



⊛ AASHTO Classes A-1, A-2 & A-3. K=200+.

‡ Usual range of AASHTO Classes.

✳ 5-1/2 LB. hammer, 12" drop, 4 layers, 45 blows per layer, compacted at optimum moisture as determined by AASHTO T-99.

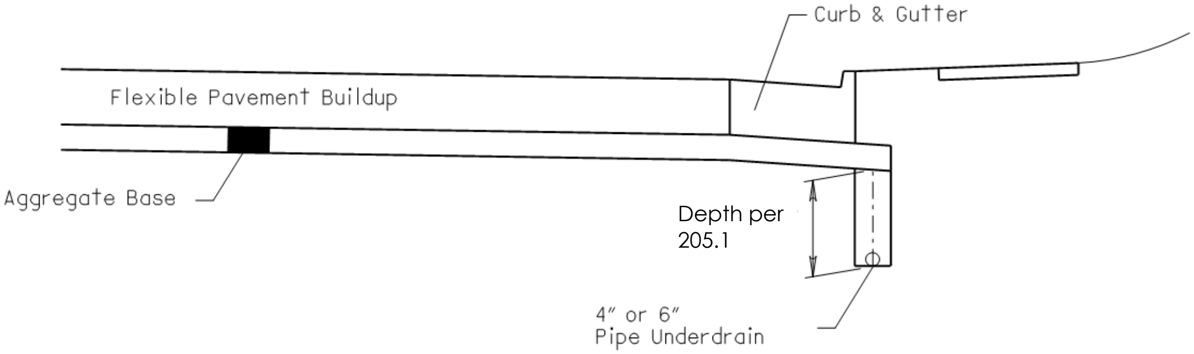
Example: G.I.=9 (Figure 203-2) CBR=6 (Rounded, from above)

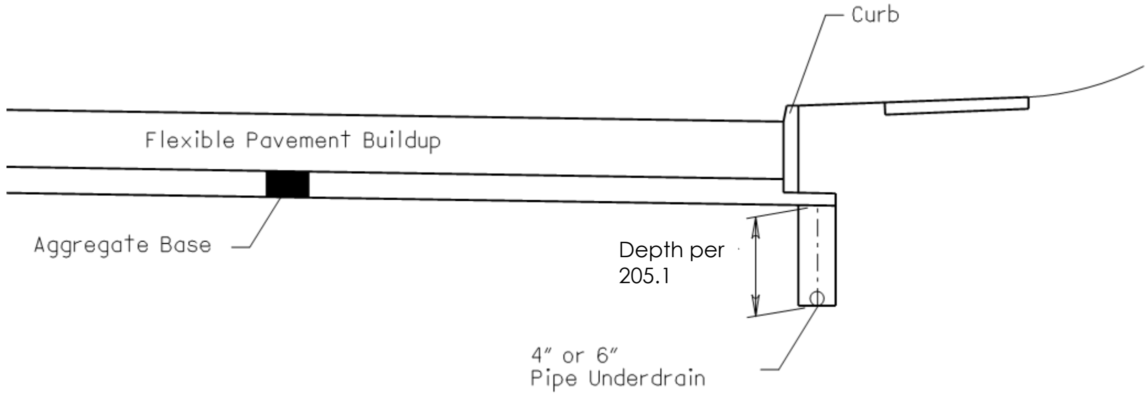
RESILIENT MODULUS (M_R) = 1200 × CBR

$M_R = 1200 \times 6 = 7200$ psi

# Typical Pipe Underdrain Locations	**205-1** July 2016
	Reference Section **205**

FLEXIBLE PAVEMENTS WITH CURB OR CURB AND GUTTER
SHOULDER WIDTH < 8 FEET (2.45 m)





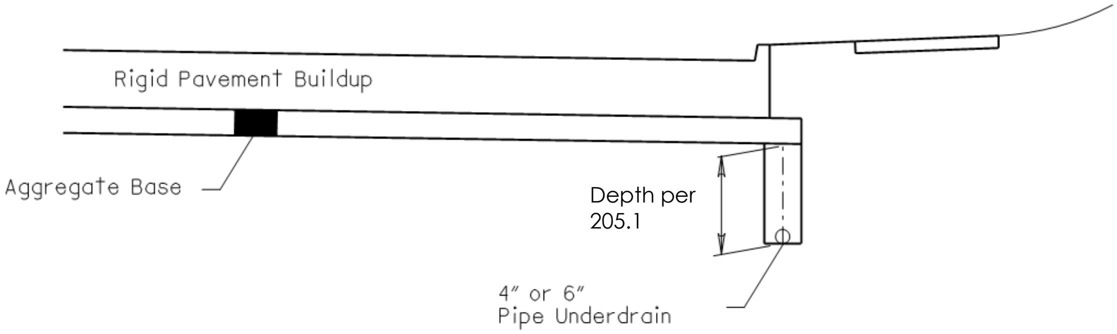
Notes:
Drawing is not to scale.

Drawing is not intended to depict allowable pavement buildups.

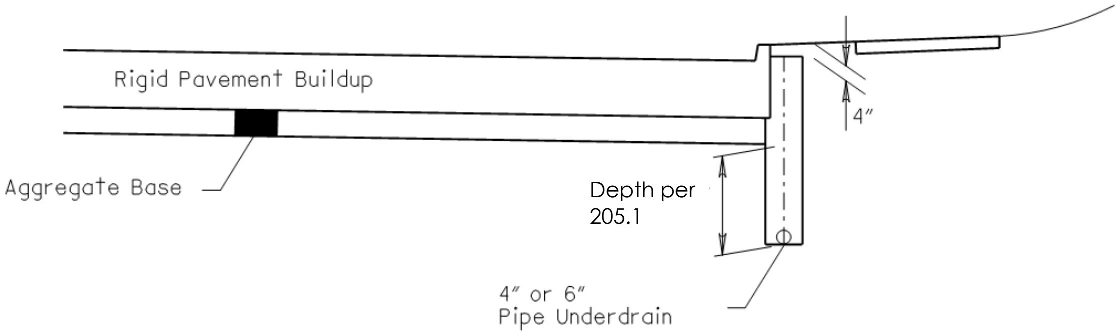
Typical Pipe Underdrain Locations

205-2
July 2016
Reference Section
205

RIGID PAVEMENTS WITH INTEGRAL CURB OR CURB AND GUTTER
SHOULDER WIDTH < 8 FEET (2.45 m)



PREFERRED UNDERDRAIN LOCATION



ACCEPTABLE UNDERDRAIN LOCATION

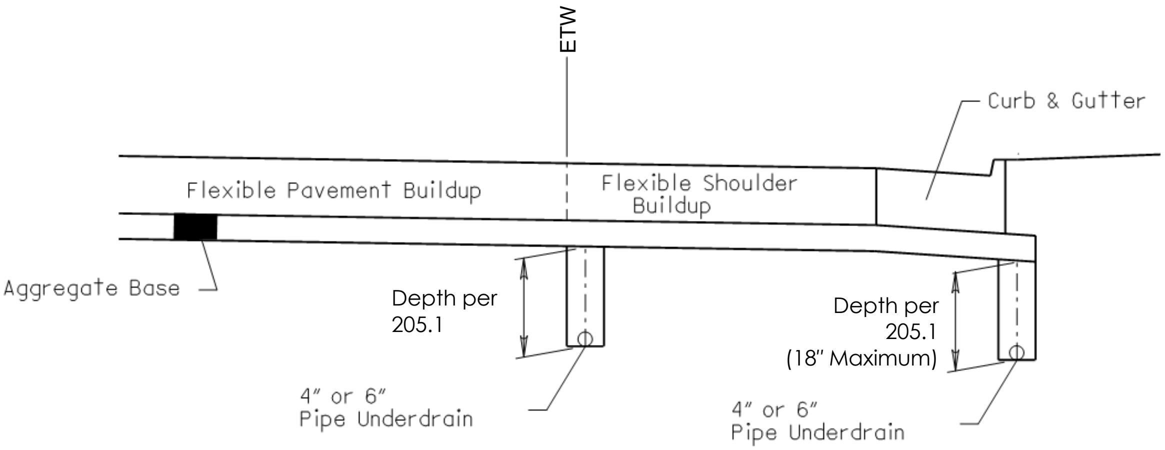
Notes:
Drawing is not to scale.

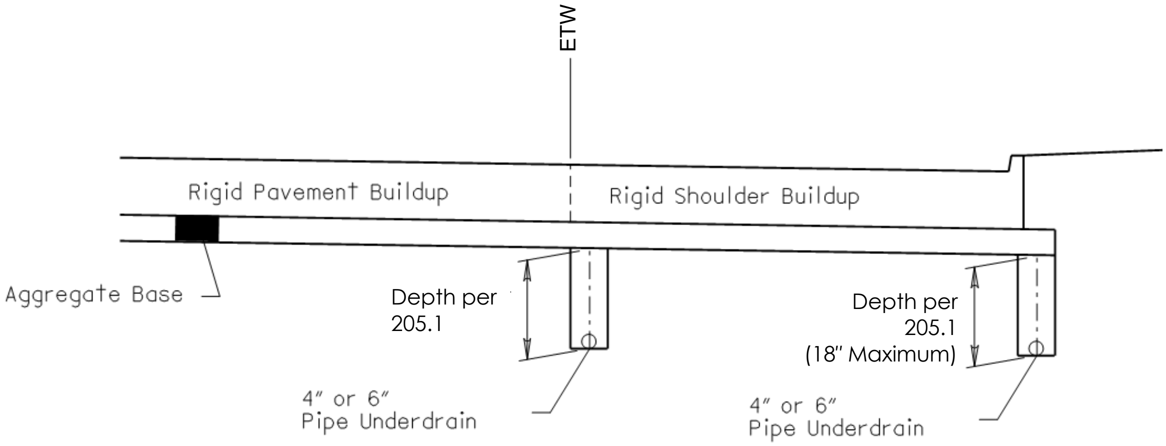
Drawing is not intended to depict allowable pavement buildups.

Typical Pipe Underdrain Locations

205-3
January 2022
Reference Section
205

PAVEMENTS WITH CURB OR CURB AND GUTTER
SHOULDER WIDTH ≥ 8 FEET (2.45 m)





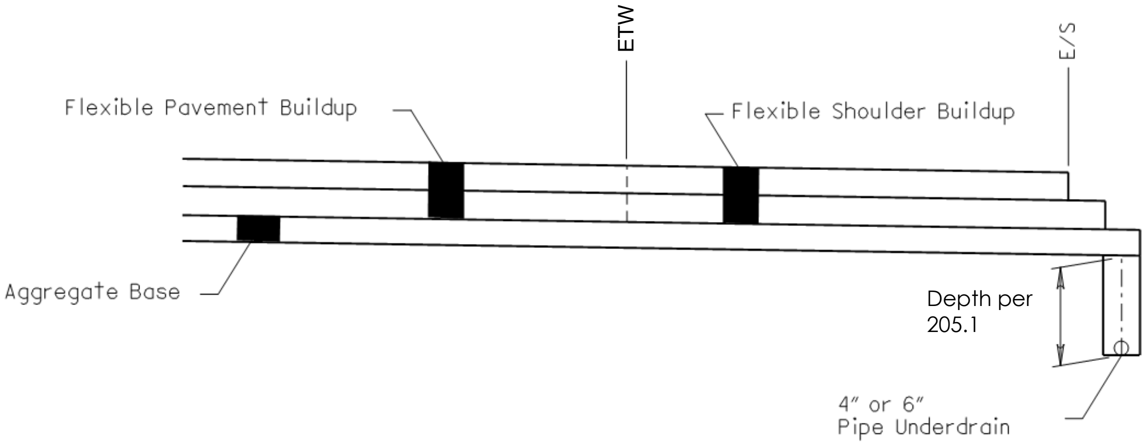
Notes:
Drawing is not to scale.

Drawing is not intended to depict allowable pavement buildups.

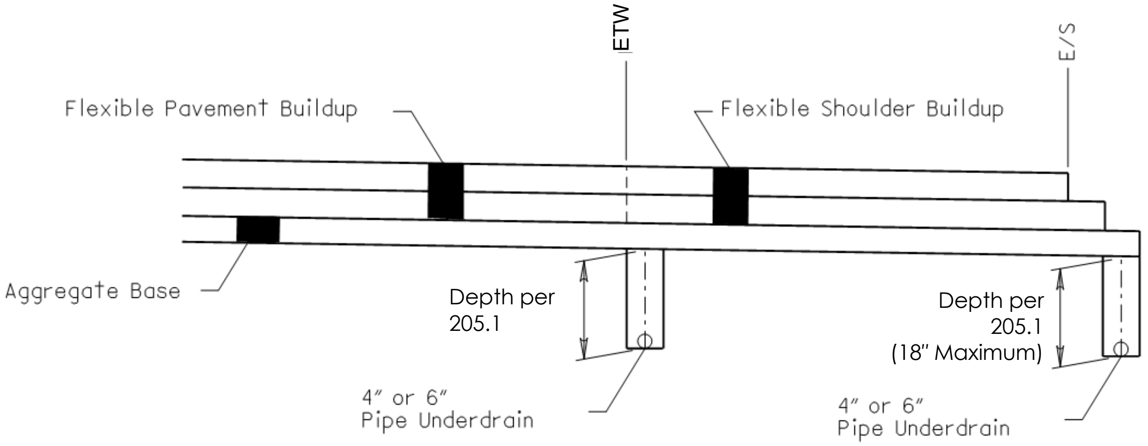
Typical Pipe Underdrain Locations

205-4
January 2022
Reference Section
205

FLEXIBLE PAVEMENTS WITH PAVED SHOULDER



Shoulder width < 8 feet (2.45 m)



Shoulder width ≥ 8 feet (2.45 m)

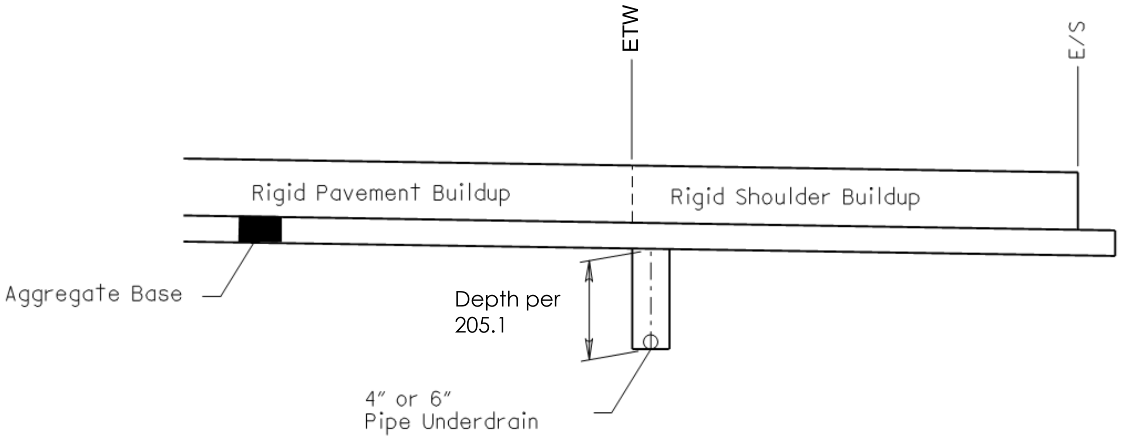
Notes:
Drawing is not to scale.

Drawing is not intended to depict allowable pavement buildups.

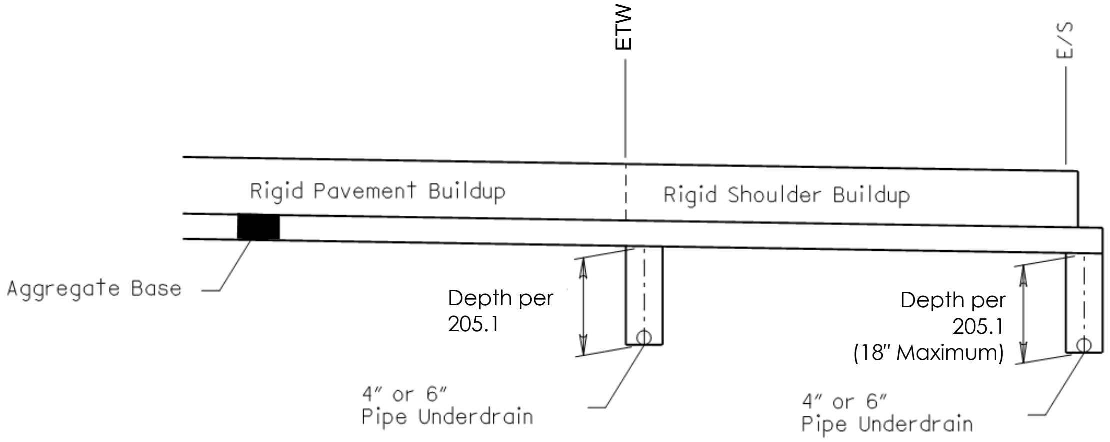
Typical Pipe Underdrain Locations

205-5
January 2022
Reference Section
205

RIGID PAVEMENTS WITH PAVED SHOULDER



Shoulder width < 8 feet (2.45 m)



Shoulder width ≥ 8 feet (2.45 m)

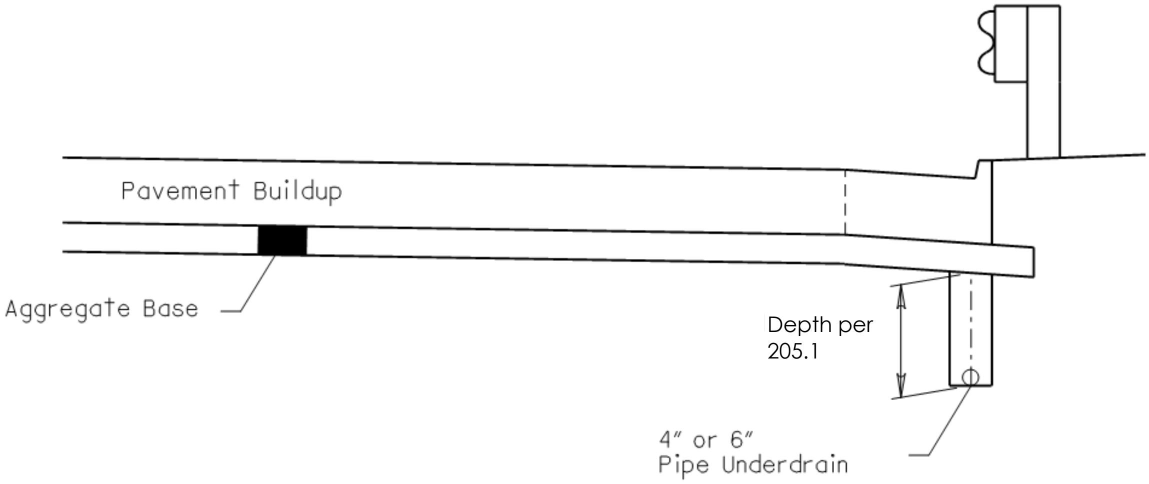
Notes:
Drawing is not to scale.

Drawing is not intended to depict allowable pavement buildups.

Typical Pipe Underdrain Locations

205-6
July 2016
Reference Section
205

MISCELLANEOUS LOCATION



Underdrain concurrent with guardrail

Notes:
Drawing is not to scale.

Drawing is not intended to depict allowable pavement buildups.

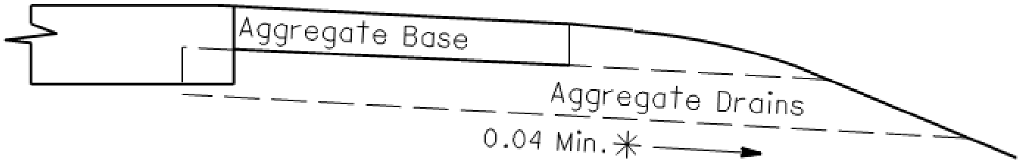
Typical Aggregate Drain Locations

205-7
January 2022
Reference Section
205

AGGREGATE SHOULDER

Less than 250 B & C Trucks in Design Year ADT

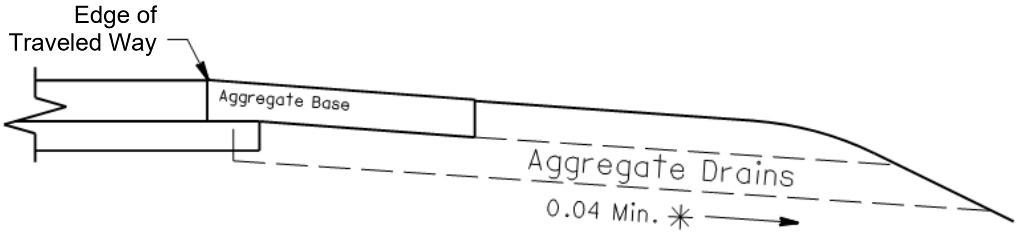
WITH FLEXIBLE OR RIGID PAVEMENT



BITUMINOUS SURFACE TREATED

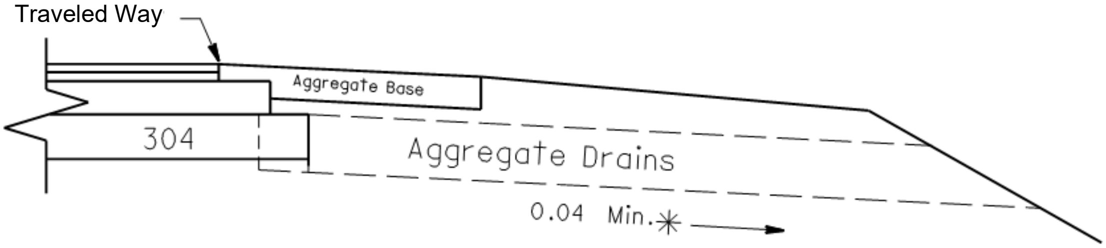
250 to 500 B & C Trucks in Design Year ADT

WITH RIGID PAVEMENT



WITH FLEXIBLE PAVEMENT

✳ 0.08 Desirable



Notes:
The bottom of the aggregate drains shall be at or below the bottom of the pavement's aggregate base at the point of contact.

The top of the aggregate drains shall be no higher than the bottom of the shoulder's aggregate base at the point of contact.

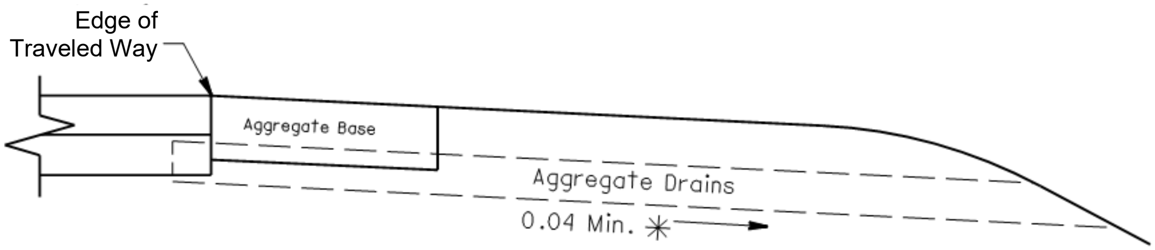
Typical Aggregate Drain Locations

205-8
January 2022
Reference Section
205

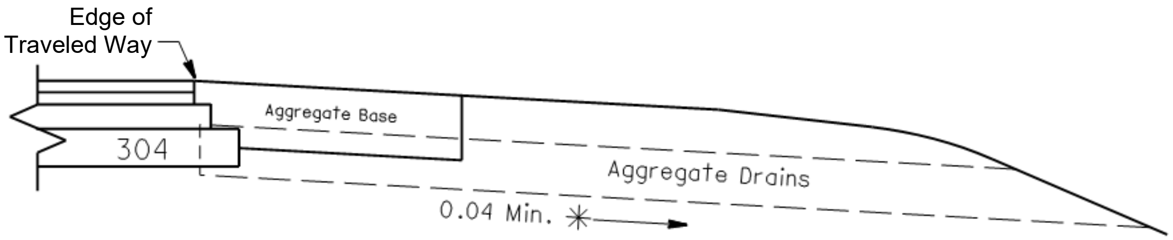
BITUMINOUS SURFACE TREATED

501 to 1000 B & C Trucks in Design Year ADT

WITH RIGID PAVEMENT



WITH FLEXIBLE PAVEMENT



* 0.08 Desirable

Notes:
The bottom of the aggregate drains shall be at or below the bottom of the pavement's aggregate base at the point of contact.

The top of the aggregate drains shall be no higher than the bottom of the shoulder's aggregate base at the point of contact.

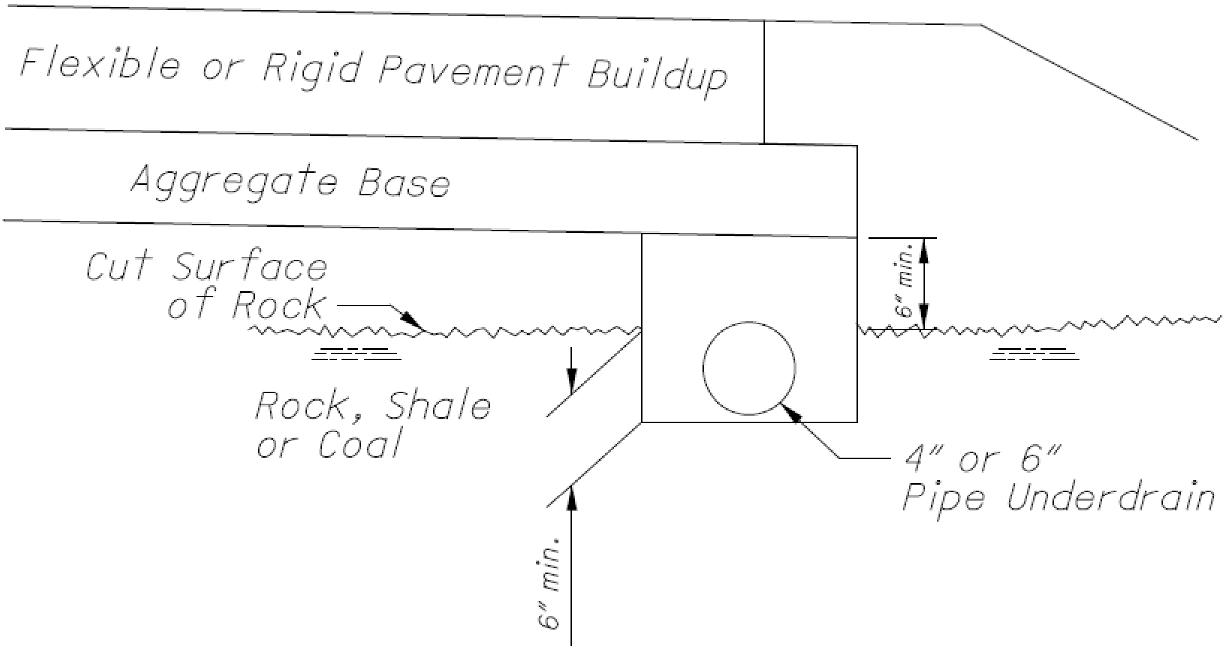
Typical Rock Cut Underdrain

205-9

January 2024

Reference Section

205



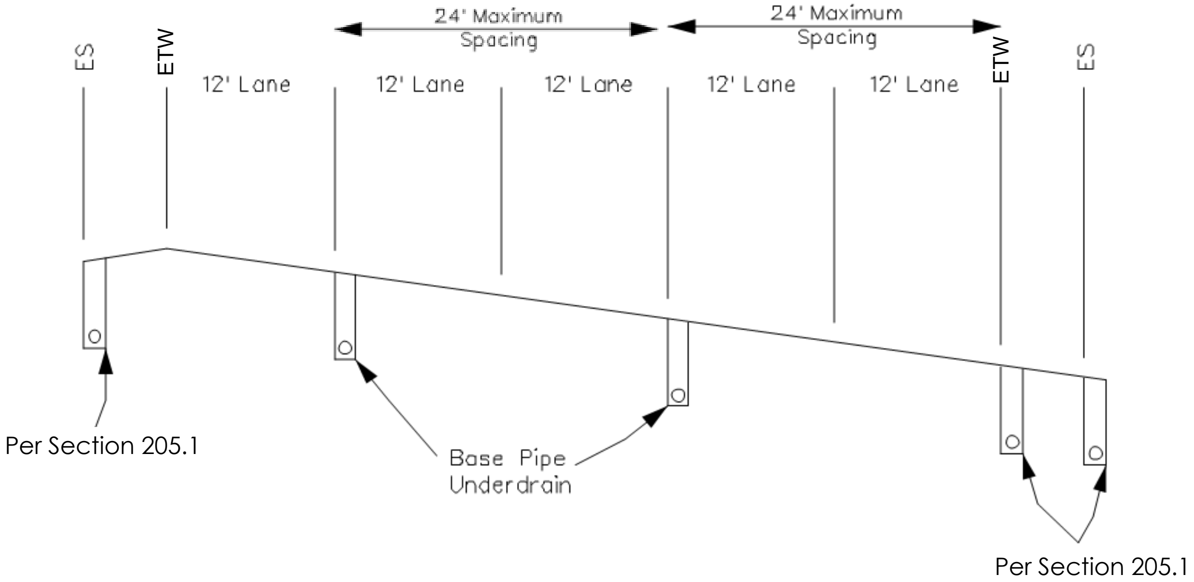
Notes:
Drawing is not to scale.

Drawing is not intended to depict allowable pavement buildups.

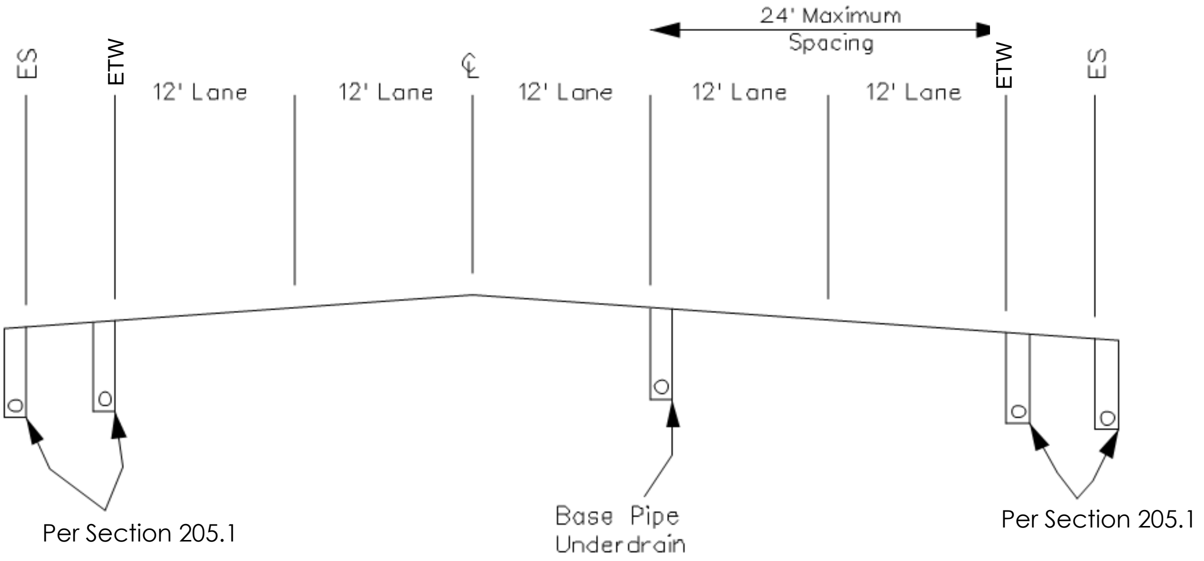
Typical Pipe Underdrain Locations

205-10
January 2022
Reference Section
205

SUPERELEVATED SECTIONS



NORMAL CROWNED SECTIONS



Notes:
Drawing is not to scale.

Drawing is not intended to depict required cross-slope or crown location.

300 Rigid Pavement Design

Table of Contents

300 Rigid Pavement Design

300.1 Introduction

Rigid pavements can be constructed with contraction joints or no joints, with dowels or without dowels, and with reinforcing steel or without steel. For jointed concrete pavements, regardless of whether reinforced or non-reinforced, the AASHTO/ODOT method of pavement design calculates the same required thickness. The required thickness is a function of loading, material properties including subgrade, and type of load transfer, if any. Alterations to rigid pavement material specifications, jointing considerations, and mesh provisions to something other than those provided in ODOT's Construction and Material Specifications (C&MS) or ODOT's Standard Construction Drawings may require adjustments to the procedures described herein.

The Construction Inspection Manual of Procedures published by the Office of Construction Administration contains additional information on rigid pavement and proper construction practices.

300.2 Types of Concrete Pavement

ODOT has two basic types of concrete pavement: reinforced and non-reinforced. There are currently three different specifications for concrete pavement and one for concrete base. All of the concrete specifications relate back to either reinforced or non-reinforced. The current specifications are: Item 451 Reinforced Concrete Pavement, Item 452 Non-Reinforced Concrete Pavement, Item 884 Portland Cement Concrete Pavement (7 Year Warranty), and Item 305 Concrete Base. All of the concrete pavements included in the C&MS and Supplemental Specifications are jointed. Continuously reinforced concrete pavement is no longer used and the specification item has been removed from the C&MS.

Item 451 Reinforced Concrete Pavement is the basic specification referred to by all other concrete pavement specifications. Reinforced concrete contains steel wire mesh intended to tightly hold together any cracks that occur. The steel mesh does not add any structural capacity and does not impact the thickness design. A reinforced pavement is the same thickness as a non-reinforced one. The reinforcing steel allows longer joint spacing with the expectation that mid-panel cracks will form but the steel will hold them tightly together and not allow further deterioration. Hairline cracks (less than approximately 1/8 inch (3 mm) wide) are common, even expected, in reinforced pavements and are little cause for concern. Wider cracks likely mean the steel has failed and the cracks are going to deteriorate and need repair. Throughout the 1950's, 60's, 70's, 80's, and early 90's ODOT built mainly reinforced pavements.

Item 452 Non-Reinforced Concrete Pavement is nearly identical to Item 451 but does not contain the steel reinforcing mesh. Non-reinforced pavements use shorter joint spacing in an attempt to eliminate mid-panel cracking. Any cracks in non-reinforced pavement, even hairline, are likely to deteriorate and require repair. In the late 1990's, ODOT began using more non-reinforced pavements. Currently, non-reinforced is the preferred concrete pavement type.

Item 884 Portland Cement Concrete Pavement (7 Year Warranty) requires the contractor to choose either 451 or 452 pavement and warrant it against specific distresses for seven years. As of publication, in most cases contractors have elected to use 452. The warranty requirements allow hairline cracks in 451 but not in 452.

Item 305 Concrete Base is non-reinforced concrete used when constructing a composite pavement. Because this item is intended to be overlayed with asphalt, the surface texture, curing, and smoothness requirements are less than for exposed concrete pavement surfaces. Item 305 is never to be used as a permanent pavement surface. Throughout this Manual, references to concrete or rigid pavement include item 305 unless stated otherwise.

301 Design Parameters

ODOT's method for the design of rigid pavement limits the designer to prescribed input parameters. The input values prescribed are based on Ohio materials and ODOT Specifications.

301.1 Modulus of Rupture

Modulus of rupture, as determined under a breaking load, measures the flexural strength or extreme fiber stress, of the concrete slab. There are many ways to determine the modulus of rupture and each way will give slightly different results, however, each method can be correlated to the measure defined for use in the AASHTO/ODOT method. The modulus of rupture used in ODOT's pavement design method is the 28-day, third-point loading test as defined by ASTM C 78. All rigid pavement designs should use a modulus of rupture of 700 psi, as shown in Figure 301-1. Average values obtained through beam breaks performed as part of C&MS requirements for opening to traffic should not be used directly for design purposes, as this test is defined by ASTM C 293 as center-point loading, and is generally done as early as 5 days.

301.2 Modulus of Elasticity

The modulus of elasticity of concrete is a function of the strength, age, aggregate properties, cement properties, and type and size of the specimen tested as well as the rate of loading during the test. Furthermore, there are various methods used to determine the modulus of elasticity. ODOT's method for rigid pavement thickness design is not highly sensitive to the value used for modulus of elasticity. Based on values obtained by ODOT research, a modulus of elasticity of 5,000,000 psi should be used for all rigid pavement designs. The modulus of elasticity is shown in Figure 301-1

301.3 Load Transfer Coefficient

The load transfer coefficient (J) is a factor used in rigid pavement design to account for the ability of a concrete pavement to distribute (transfer) load across discontinuities, such as longitudinal and transverse joints. Load transfer devices, aggregate interlock, widened lanes, and the presence of tied concrete shoulders all have an influence on this value. J factors are listed in Figure 301-1.

301.4 Composite Modulus of Subgrade Reaction

The composite modulus of subgrade reaction (k_c) represents the combined effect of the subgrade stiffness or subgrade modulus of resilience, as discussed in Section 203.1, and the stiffness, or elastic modulus, and thickness of the subbase material. The pavement design process requires the designer to choose the subbase prior to determination of the required slab thickness. The values for elastic modulus of the subbase for ODOT materials are listed in Figure 301-1. Figure 301-2 is a nomograph that determines the composite modulus of subgrade reaction.

A 6 inch (150 mm) granular base, item 304, is recommended as a subbase under all concrete pavements to prevent pumping. The granular base is required for concrete pavement built over a chemically stabilized subgrade. For very low traffic situations (less than 500,000 design ESALs) or on non-stabilized granular subgrades, consideration may be given to eliminating the granular base.

301.5 Loss of Support

Loss of support (LS) is included in the design of rigid pavements to account for the potential loss of support arising from subbase erosion or differential vertical soil movements. The potential of a material to pump is an indication support may be lost. Loss of support is treated in the design procedure by reducing the composite modulus of subgrade reaction. Figure 301-1 lists the LS factors to be used for ODOT materials.

301.6 Effective Modulus of Subgrade Reaction

The effective modulus of subgrade reaction (k) is the composite modulus of subgrade reaction as modified by the loss of support. Figure 301-3 is a nomograph that determines the effective modulus of subgrade reaction.

302 Thickness Determination

All of the design input information is required prior to determination of design thickness. Design thickness is determined using the nomographs found in Figures 302-2 and 302-3. An example rigid pavement design is provided in Figure 302-1. Concrete pavement thicknesses should be rounded to the nearest 0.5 inch (10 mm) increment.

Adequate concrete cover is needed to transfer stresses between the concrete and the dowel bars. Because of the required concrete cover, the minimum thickness of concrete pavement is 8 inches (200 mm). In special situations where the standard specifications are modified to eliminate the dowels, the minimum recommended thickness for concrete pavement is 6 inches (150 mm).

302.1 Ramps and Interchanges

If traffic and soils data is available, ramps, collector-distributor lanes, directional roadways, etc., may be designed individually. More common is to use the same thickness as the mainline or reduce the mainline thickness by 1-inch (25 mm).

303 Jointing and Shoulder Considerations

303.1 Transverse Joints

Transverse joints are provided to control cracking. The closer the joint spacing, the less likely a mid-panel crack will develop. Ohio uses 15-foot (4.6 m) joint spacing for non-reinforced concrete. For reinforced concrete, 60-foot (18.3 m) joint spacing was used before about 1967 when it was reduced to 40 feet (12.2 m), then in the early 1980's it was further reduced to 27 feet (8.2 m) for several more years and then to the current standard of 21 feet (6.5 m).

Load transfer is the critical element at joints. In undoweled pavements, load transfer is provided by aggregate interlock. Aggregate interlock is lost when slabs contract and the joints open up. Interlock is also slowly destroyed by the movement of the concrete as traffic passes over. Given the high temperature variations and heavy truck traffic in Ohio, aggregate interlock alone is not effective and faulting is the primary result. To provide load transfer at the joints, 18-inch (460 mm) long, smooth dowels are used which allow for expansion and contraction. ODOT specifications require dowels in all transverse joints in all mainline concrete pavements and bases. Transverse joint design and spacing requirements are shown in the Standard Construction Drawings.

303.2 Expansion and Pressure Relief Joints

As slabs contract due to seasonal temperature changes, joints and cracks open allowing incompressible materials into the pavement system. Subsequently, the pavement can grow in length and create pressure. Pressure can lead to spalling, blowups, or damage to bridge back-walls. Having a small amount of pressure in a pavement may be good since lack of pressure allows joints and cracks to open which reduces load transfer. Slight pressure buildup in rigid pavement seldom creates pavement distress. Nonetheless, when distresses are found, they tend to require some type of maintenance, and may require immediate care in the case of a blowup.

To control pressure buildup, expansion joints and pressure relief joints are used. The most common need for an expansion joint or a pressure relief joint is to protect bridge back-walls. For pressure relief at bridges, Standard Bridge Drawing AS-2-15 is preferred to prevent damage to the bridge. Where AS-2-15 is not used, the Standard Construction Drawings BP-series details four other types of pressure relief joints. Where bridges are less than 300 feet (90 m) apart, a full pressure relief joint is not required and the standard expansion joints as required by C&MS Item 451 and detailed in the Standard Construction Drawings are considered adequate. Use of pressure relief joints for pavements being rehabilitated is discussed in Section 500.

303.3 Longitudinal Joints

Longitudinal joints are required whenever the pavement width exceeds 16 feet (4.9 m) and are recommended whenever the width exceeds 15 feet (4.6 m). Joints in mainline pavement are to be located at the lane lines. Where project geometrics permit, 14-foot (4.3 m) wide slabs striped at 12 feet (3.7 m) are recommended to provide additional edge support for the outside, truck lane.

All lanes, shoulders, and ramps for traffic moving in the same direction should be tied together using a standard longitudinal joint as detailed in Standard Construction Drawing BP-2.1. Anytime traffic is expected to cross a longitudinal joint (between lanes, from lane to shoulder, etc.) the joint should be tied. Anytime traffic is not intended or expected to regularly cross a longitudinal joint (from shoulder to a barrier foundation, from shoulder to a paved gore area, anytime two shoulders meet, etc.) the joint should not be tied. Project specific details dictate exactly which joints need to be tied and which do not. The designer should consider the needs of traffic when deciding what type of joint to use. There is no strict limit on the maximum width that may be tied together. On undivided, bi-directional roadways, the centerline joint may or may not need to be tied depending on the project specifics.

On 16-foot (4.9 m) wide ramps, a tied longitudinal joint down the middle is required as shown in Standard Construction Drawing BP-6.1. This will guard against longitudinal cracking and may allow future repair work to be performed on half the ramp while traffic is maintained on the other half and shoulder.

At intersections, where two independent pavements meet, a longitudinal joint without tie bars is required to separate the two pavements and allow for independent movement.

303.4 Intersection Jointing Details

Intersections require careful consideration of the joint layout, and dowel and tie bar placement. In order to provide load transfer, control cracking, and prevent intersecting pavements from hindering the movement of one another, jointing diagrams should be provided as part of the plans. Joint diagrams should be designed with ease of construction in mind, as well as consideration of future rehabilitation and maintenance of traffic needs. The number of longitudinal joints should be kept to a minimum, and all slabs should be the same width, if possible. Examples of jointing diagrams are included in the Location & Design Plan Preparation Sample Plan Sheets-Volume Three. In addition, there are various publications provided by the American Concrete Pavement Association (ACPA) that provide guidance for intersection joint layout including roundabout intersections.

303.5 Shoulder Considerations

Shoulders are used to provide an area for accommodation of disabled vehicles, for lateral support of the base and surface courses, to improve the safety of a highway, and for maintenance of traffic operations during maintenance and rehabilitation work.

Shoulders for concrete pavements should be constructed of concrete with the same thickness as the driving lanes' pavement whenever a paved shoulder is required. Having the same thickness allows extensive use of the shoulder for maintenance of traffic with little, if any, risk of failure and reduces the complexity of construction. Tying concrete shoulders to the driving lanes provides lateral support and spreads the load over a greater area.

Concrete shoulders should use non-reinforced concrete even if the driving lanes are reinforced. The plans should include a note modifying the transverse joint spacing of the non-reinforced shoulders if tied to reinforced driving lanes. In all cases, the shoulder joints should match the spacing and alignment of the driving lanes to form one continuous joint across the pavement. Do not place any intermediate joints in the shoulder.

Transverse joints in shoulders are not dowelled except within 500 feet (150 m) of a pressure relief joint. Dowels may be added by plan note if the shoulders will be used to carry traffic during extended (9 months or more) maintenance of traffic operations. The amount of truck traffic using the shoulder should be evaluated prior to requiring dowels.

Using other types of shoulders, such as flexible, surface treated, stabilized aggregate, or turf shoulders should be in accordance with the Location & Design Manual, Volume One - Roadway Design. Regardless of the type of shoulder used, the base and subgrade should be designed to drain water away from the pavement, rather than towards it. Examples of typical sections depicting rigid pavement with different types of unpaved shoulders are shown in Figure 303-1.

303.6 Edge Course Design

The aggregate base for a rigid pavement should extend 18 inches (450 mm) beyond the edge of the travelled way, or to the outside edge of the porous backfill over the pipe underdrain, or to 6 inches (150 mm) beyond the outside edge of the paved shoulder, whichever is greater.

Where curb and gutter or integral curb is used, subbase should extend 12 inches (300 mm) beyond the back of the curb or to the outside edge of the porous backfill over the pipe underdrain, whichever is greater. Refer to Figure 205-2 and the Sample Plan Sheets.

304 Concrete Pavement Usage Guidelines

304.1 Item 451 Reinforced Concrete Pavement

The use of item 451 is seldom recommended. It is most commonly used when new concrete is being tied to reinforced concrete constructed by a previous project. It is also used in intersection work or near skewed bridges where long or odd shaped slabs may exist.

304.2 Item 452 Non-Reinforced Concrete Pavement

Item 452 is recommended for all large-scale concrete pavement projects. Item 452 is also recommended for small projects as long as the proper joint spacing can be achieved. Projects that have numerous irregular shaped slabs may be better suited to item 451.

304.3 Item 884 Warranty Concrete

The use of warranty concrete is allowed only with permission of the Division of Construction Management. Requests to use warranty concrete should be directed to the warranty coordinator.

304.4 Item 305 Concrete Base

Item 305 is used anytime a composite pavement is being constructed. The most common use of 305 is widening next to an existing composite pavement.

304.5 Class of Concrete

Class QC1P is recommended for all mainline, shoulder, and ramp concrete in excess of 250 feet (75 m) of continuous pavement.

Class QC MS may be used for smaller, repair-type areas. It is intended for joint and crack repairs or individual slab replacements. It is not intended for long stretches of continuous pavement and is not expected to perform well if used in such applications.

The QC/QA designation is to be added if any single concrete pavement pay item exceeds 10,000 square yards (8500 square meters). The QC/QA designation may be added to all concrete pavement items if any single item meets the threshold.

305 Warranty Concrete

The use of warranty concrete does not change the thickness design in any way. The same inputs are used and the same thickness is determined regardless of whether warranty concrete will be used or conventional Item 451 or 452 concrete. More information on concrete pavement warranties is available in the Warranty Application Guidelines in the Innovative Contracting Manual published by the Office of Construction Administration and in the Item 884 Portland Cement Concrete Pavement (7 Year Warranty) specification.

306 Smoothness Specifications

Incentive/disincentive for smoothness is specified using Proposal Note 420 Surface Smoothness Requirements for Pavements. PN 420 is recommended for all eligible projects. The Designer Note details the eligibility requirements. Smoothness incentives generally result in better attention to detail by the contractor and higher quality pavement overall. Smooth, high quality pavements are expected to perform better for a longer time, potentially resulting in cost savings to the Department.

The designer should ensure the contractor has a reasonable opportunity to achieve the incentive. Projects that may otherwise be eligible but have numerous manholes, drainage structures, business or residential driveways, etc., are usually not good candidates for smoothness incentive.

307 Composite Pavement

Composite pavement herein refers to a rigid base with an asphalt surface. Composite pavements are rarely designed and built on ODOT projects. When they are used it is often at the request of a local government agency. Where local preference is strong and there has been good performance, consideration may be given to the design and specification of a composite pavement.

307.1 Composite Pavement Design

Composite pavements are designed as rigid pavements. Once the required thickness is determined, the concrete thickness is reduced by one inch (25 mm) and replaced with 3 or 3.25 inches (75 mm or 83 mm) of asphalt. This ratio of 1 inch (25 mm) of concrete to 3 inches (75 mm) of asphalt holds true only for the first inch (25 mm) of concrete removed and is an approximation at best.

The minimum asphalt overlay thickness on a rigid pavement or base is 3 inches (76 mm). Lift thickness requirements for specific asphalt materials may require a 3.25 inch (83 mm) minimum overlay thickness. The minimum concrete thickness of 8 inches (200 mm) still applies.

307.2 Composite Pavement Typical Section Design

Composite pavement should be constructed using Item 305 Concrete Base. The width of the concrete base should be extended beyond the wearing surface by 3 inches (75 mm). Item 409 Sawing and Sealing Asphalt Concrete Pavement Joints is recommended for most newly constructed composite pavements.

307.3 Composite Pavement Warranty

There is not a seven year warranty specification for composite pavements. The only warranty that could be used on a composite pavement is a three year warranty, Supplement 1059, on the asphalt concrete surface course. The use of Supplement 1059 is allowed only with permission of the Division of Construction Management. Requests to use a warranty should be directed to the warranty coordinator.

307.4 Composite Pavement Smoothness Specifications

Proposal Note 420 Surface Smoothness Requirements for Pavements may be used with composite pavements for smoothness incentive/disincentive. The guidelines in Section 306 apply.

300 Rigid Pavement Design

List of Figures

Rigid Pavement Design Parameters

301-1

July 2016

Reference Section

301

MATERIAL PROPERTIES	
Modulus of Rupture (S'_c)	700 psi
Modulus of Elasticity (E_c)	5,000,000 psi
Load Transfer Coefficient (J) - Doweled, Edge Support*	2.7
Load Transfer Coefficient (J) - Doweled, No Edge Support*	3.2

* Edge support includes tied concrete shoulders, integral curb, widened lane, etc. Widened lane refers to concrete slabs built 14 feet (4.2 m) wide or wider, but striped for a standard 12-foot (3.6 m) lane, leaving 2 feet (0.6 m) outside the traveled lane to provide edge support.

SUBBASE FACTORS			
ODOT Specification	**Recommended Thickness (in.) (D_{SB})**	**Elastic Modulus (psi) (E_{SB})**	**Loss of Support (LS)**
Item 301, 302 Asphalt Concrete Base	4	300,000	0
Item 304 Aggregate Base**	6	30,000	1
Natural Subgrade***			2

** When the entire subgrade is chemically stabilized (global chemical stabilization), the elastic modulus of the Item 304 Aggregate Base is increased to 36,000 psi.

*** Not recommended for most applications. See Section 301.4

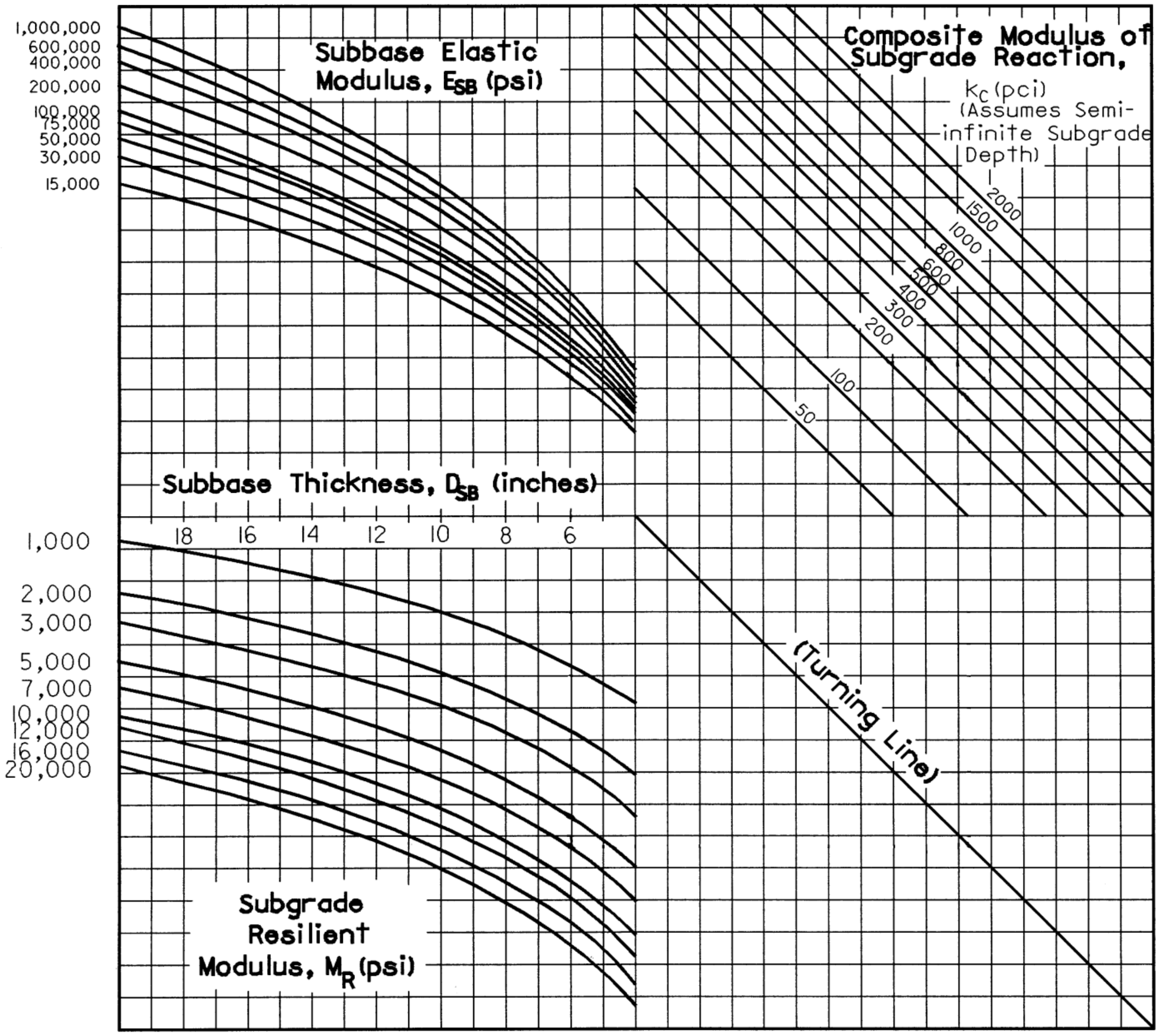
Composite Modulus of Subgrade Reaction (k_c)

301-2

July 2008

Reference Section & Figure

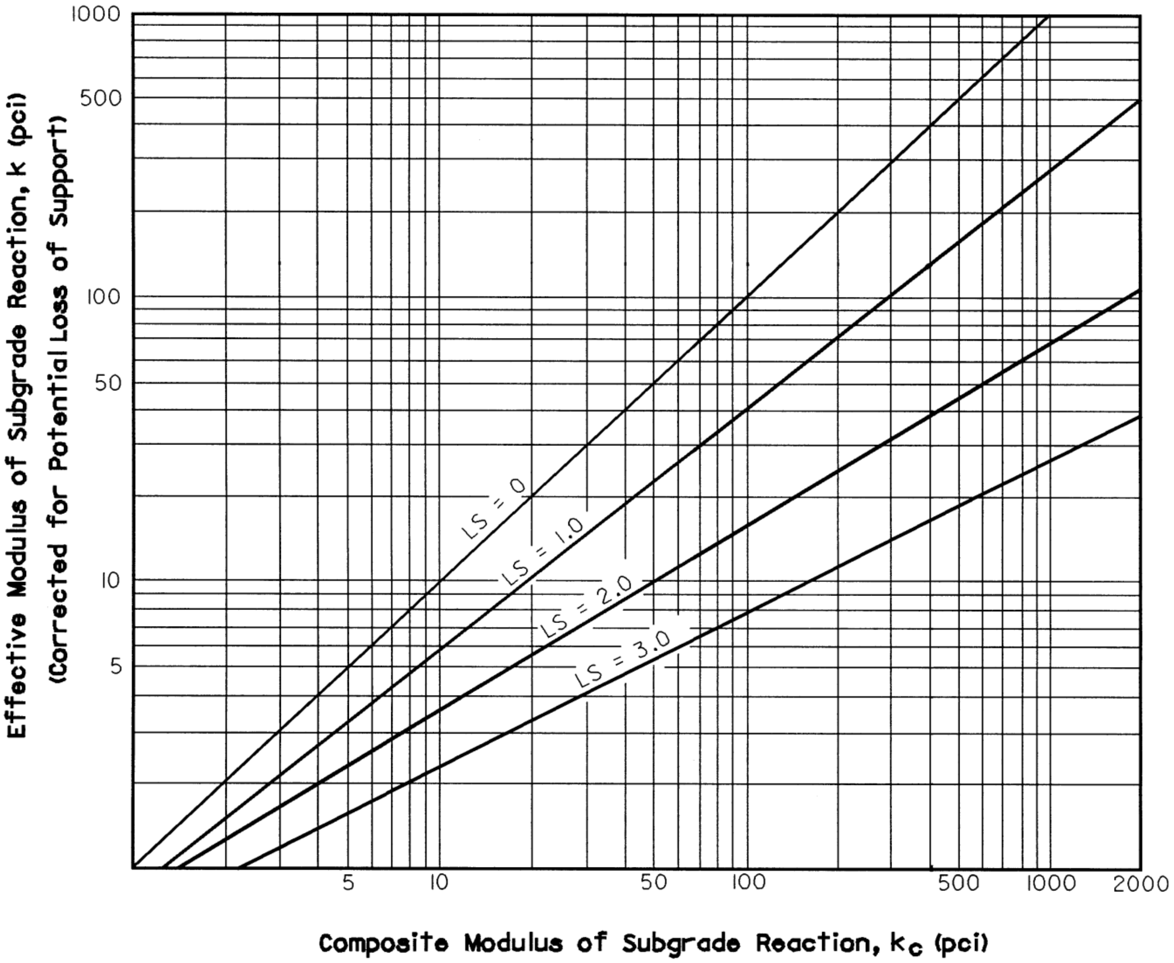
301.4, 302-1 (step 3)



Effective Modulus of Subgrade Reaction (k)

301-3
July 2008

Reference Section & Figure
301.6, 302-1 (step 4)



Rigid Pavement Design Example

Page 1

302-1

January 2024

Reference Section

302

Given:

- Pavement of choice: Doweled, jointed concrete
- Subbase: 6 inches Item 304 Aggregate Base
- Shoulders: Tied, jointed, concrete
- Number of Lanes: 4 (2 per direction)
- Functional Classification: Principal Arterial (Rural)
- 2018 Traffic: 15,800 ADT
- 2038 Traffic: 22,450 ADT
- 24 hour truck %: 18%
- Design Period: 20 years
- Open to Traffic: 2019
- Subgrade CBR: 5 (from Subgrade Analysis)

Problem: Solve for the thickness of the concrete slab.

Solution:

<u>Step 1</u> - Determine the 18-kip equivalent single axle loading (ESAL).

Since the project is expected to open to traffic in 2019, the ESAL projection should be for 2019 to 2039. Calculate the mid-year (2029) ADT, rounded to nearest ten:

2029 ADT = 15,800+(22,450-15,800)(11/20)
2029 ADT = 19,460

The equations in Section 202.2 are used with

Directional distribution, D = 50% (Figure 202-1)
Lane factor = 95% (Figure 202-1)
B:C ratio = 5:1 (Figure 202-1)
ESAL conversion factor for B trucks = 1.67 (Figure 202-1)
ESAL conversion factor for C trucks = 0.44 (Figure 202-1)

Using the equations given in Section 202.2:

ESAL's from B trucks = 19,460(0.18)(0.50)(0.95)(5/6)(1.67) = 2,315
ESAL's from C trucks = 19,460(0.18)(0.50)(0.95)(1/6)(0.44) = 122

Total daily ESAL's = 2,315+122 = 2,437 ESAL/day

Design period ESAL's = 2,437 ESAL/day * 365.25 days/yr. * 20 years = 17,802,285
use 17.8x10^6 ESAL’s

Step 2 - Determine the subgrade resilient modulus (M_r) using the formula given in Section 203.1.

M_r = 1200 * CBR
M_r = 1200 * 5
M_r = 6000 psi

Step 3 - Determine the composite modulus of subgrade reaction (k_c) using Figure 301-2.

Starting with the given subbase thickness (D_{SB}) of 6", a line is projected up to the subbase elastic modulus (E_{SB}) curve of 30,000 psi (Item 304 Aggregate Base from Figure 301-1). From this point on the 30,000 psi curve, a line is projected to the right for future intersection. Similarly, from the 6" subbase thickness (D_{SB}), a line is projected down to the subgrade resilient modulus (M_r) curve of 6000 psi. From this point on the 6000 psi curve, a line is projected to the right to the turning line and then projected up to intersect with previously projected line. This intersection results in a composite modulus of subgrade reaction (k_c) of 335 pci.

Step 4 - Determine the effective modulus of subgrade reaction (k) using Figure 301-3.

Using the composite modulus of subgrade reaction (k_c) determined in Step 3, enter the chart on the bottom. Project a line from 335 pci up to LS = 1.0 (from Figure 301-1 for Item 304 Aggregate Base). Then project a line straight across to the vertical axis. This results in an effective modulus of subgrade reaction (k) of 110 pci.

Step 5 - Determine the thickness of the concrete slab using Figures 302-2 and 302-3.

Figure 302-2 is used to solve for the match line number using the following information:

Effective modulus of subgrade (k) = 110 pci (Step 4)
Concrete elastic modulus (E_c) = 5,000,000 psi (Figure 301-1)
Concrete modulus of rupture (S'_c) = 700 psi (Figure 301-1)
Load Transfer Coefficient (J) = 2.7 (Figure 301-1)
Drainage coefficient (C_d) = 1.0 (Section 205.2)

The resulting match line number is then used on Figure 302-3, along with the following information, to solve for the design slab thickness (D).

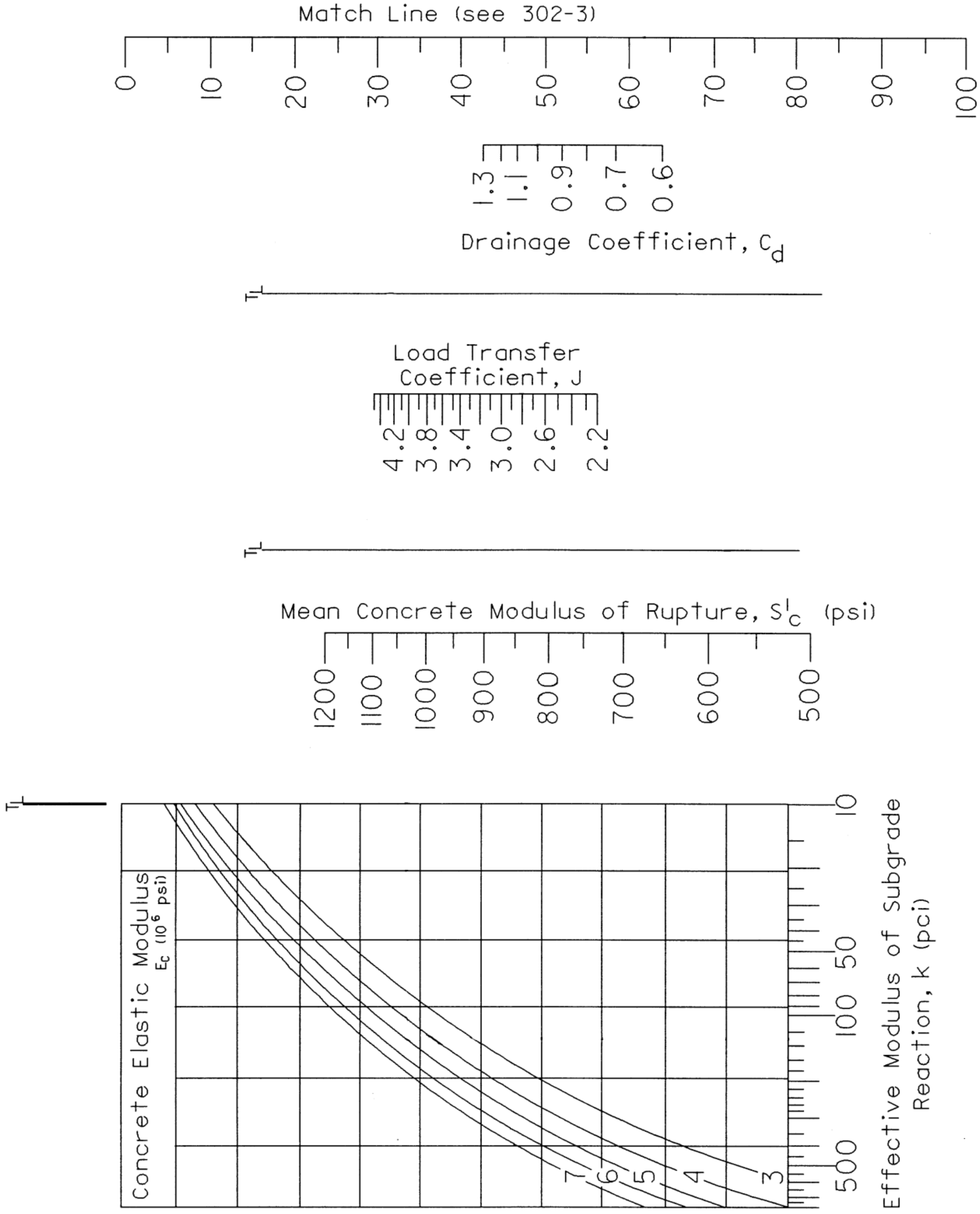
Design serviceability loss (PSI) = 1.7 (Figure 201-1)
Reliability = 85% (Figure 201-1)
Overall standard deviation = 0.39 (Figure 201-1)
18-kip equivalent single axle load = 17.8×10^6 ESAL (Step 1)

Therefore: design slab thickness (D) = 10 inches

Rigid Pavement Design Chart
Segment 1

302-2
July 2008

Reference Section & Figure
302, 302-1 (step 5)



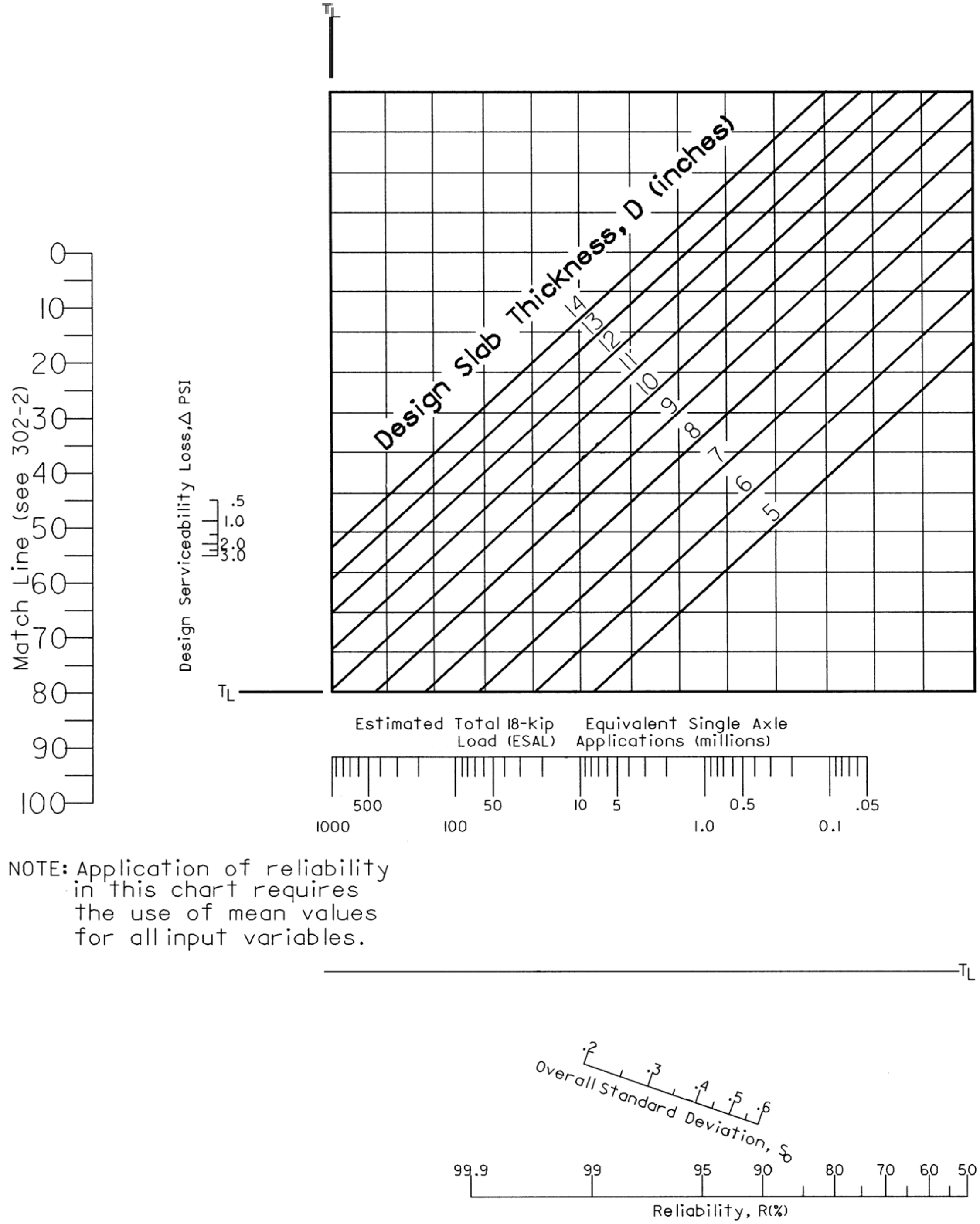
Rigid Pavement Design Chart Segment 2

302-3

July 2016

Reference Section & Figure

302, 302-1 (step 5)



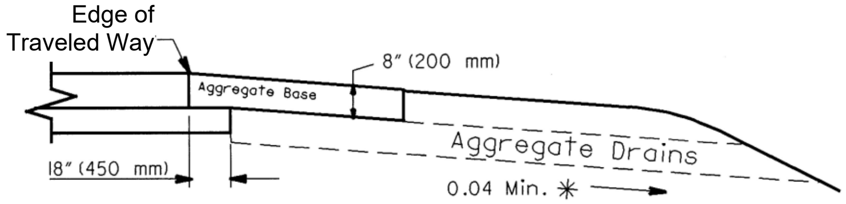
NOTE: Application of reliability in this chart requires the use of mean values for all input variables.

Surface Treated Shoulder and Stabilized Aggregate Shoulder Typical Sections

303-1
January 2024
Reference Section
205.1, 303.5, 303.6

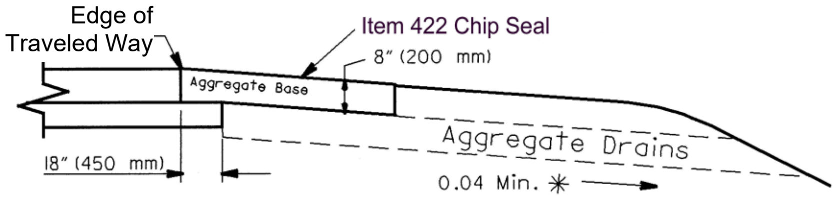
AGGREGATE SHOULDER

Less than 250 B & C Trucks in Design Year ADT



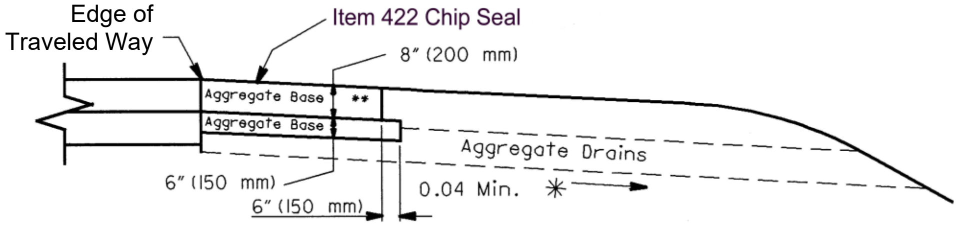
SURFACE TREATED

250 to 500 B & C Trucks in Design Year ADT

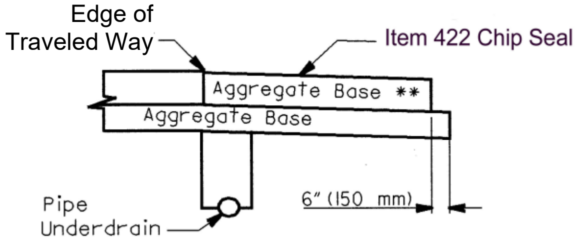


SURFACE TREATED

501 to 1000 B & C Trucks in Design Year ADT



WITH PIPE UNDERDRAIN



✳ 0.08 Desirable

✳ 0.08 Desirable

✳✳ A flexible shoulder (Item 301) could be used in lieu of the Bituminous Surface Treatment

Notes:

The bottom of the aggregate drains shall be at or below the bottom of the pavement 's aggregate base at the point of contact. The top of the aggregate drains shall be no higher than the bottom of the shoulder's aggregate base at the point of contact.

See Figure 403-1 for additional shoulder details.

Table of Contents

400 Flexible Pavement Design

400.1 Introduction

Flexible pavement design is based on the concept of structural number. The structural number is a regression coefficient expressing the structural strength of a pavement required for given combinations of soil support (M_r), traffic loading, and terminal serviceability. Flexible pavements can be constructed with Marshall mix designs, Superpave mix designs, stone matrix mixes, or legacy ODOT mixes; however, regardless of the mix design method used, the ODOT/AASHTO method of pavement design calculates the same required structural number. Once the structural number is determined, the flexible buildup is determined by using the appropriate structural coefficient for ODOT specification materials. Alterations to ODOT's Construction and Material Specifications (C&MS) for asphalt concrete may require adjustments to the procedures described herein.

The Construction Administration Manual of Procedures published by the Office of Construction Administration contains additional information on flexible pavement and proper construction practices.

401 Design Parameters

Flexible pavement design is based on relatively few input parameters. Serviceability, traffic loading (ESAL), subgrade stiffness (M_r), reliability, and overall standard deviation have all been discussed in Section 200. Structural coefficient is the only new parameter. Structural coefficients for ODOT asphalt concrete material specifications are found in Figure 401-1.

402 Structural Number Determination

All of the design input information is required prior to determination of design thickness. Structural number (SN) is determined using the nomographs found in Figures 402-2 and 402-3. An example flexible pavement design is provided in Figure 402-1.

402.1 Ramps and Interchanges

If traffic and soils data is available, ramps, collector-distributor lanes, directional roadways, etc., may be designed individually. More common is to use the same thickness as the mainline or reduce the mainline thickness by 1 inch (25 mm).

403 Typical Section and Buildup Considerations

403.1 Typical Section Design

Regardless of the SN required, a buildup that includes an aggregate base (Item 304) will generally provide better performance than an asphalt-on-subgrade buildup. The aggregate base is less sensitive to moisture than the subgrade and it separates the pavement further from the subgrade. An aggregate base is recommended under all flexible pavements and particularly when the thickness of a full depth flexible design is very thin, approximately 5 inches (130 mm) (SN ~ 1.8) or less.

All surface and intermediate courses should be specified in 0.25-inch (5 mm) increments. Items 301 and 302 should be specified in 0.5-inch (10 mm) increments. Item 304 is typically placed at 6 inches (150 mm) thick. The minimum thickness for Item 304 is 4 inches (100 mm) and it should be specified in 1-inch (25 mm) increments.

When designing a flexible pavement, some consideration should be given to reducing the total number of separate lifts required. This can be accomplished by keeping in mind the maximum and minimum lift thicknesses for all of the materials involved. A lift is the thickness of material placed in one pass. Maximum and minimum lift thicknesses can be found in the C&MS, or Section 406 or Figure 406-1 of this Manual.

403.1.1 Phase Joints

Full-depth longitudinal joints due to maintenance of traffic phasing on multi-lane pavement replacement projects known as phase joints or phase lines, require details in the plans to ensure proper construction. Ideally these joints would be lapped as shown in Standard Construction Drawing BP-3.1. In part-width construction operations, lapping is not possible and the asphalt placed near the existing pavement at the phase line generally does not receive the desired level of compaction. This location often ends up in or near a wheelpath in the final lane configuration. The maintenance of traffic plan needs to allow sufficient width for stepped joint construction.

It is recommended to have a detail in the plans showing cutting back 6 inches (150 mm) of the first (bottom) lift of asphalt concrete base at the phase line. Cut back any second lift of asphalt concrete base a sufficient amount to create a 6-inch (150 mm) horizontal step on the first lift. Show the edge of the intermediate course at least 3 inches (75 mm) away from what will be the trimmed edge of the asphalt concrete base lift immediately below. An example step detail is shown in the Traffic Engineering Manual Figure 698-14.

Consideration should be given to placing a construction underdrain at or near the phase joint to provide drainage during construction.

Two-lane roads, low volume roads, and short sections of replacement due to bridge, culvert, or intersection work generally do not require the details described in this section but adequate space for some stepping of the phase joint should be provided.

403.1.2 Longitudinal Joints in Surface Courses

Cold longitudinal paving joints in surface courses are often the first location to show distress and require maintenance. Item 447 acceptance and SS 872 VRAM are two separate methods available for improving cold longitudinal joint performance.

All priority system asphalt concrete surface course paving not using Item 424 and expected to remain as the surface for three years or more should include cold longitudinal joint improvement. Short sections of paving often associated with bridge, culvert, or intersection projects do not require cold longitudinal joint improvement, but it may be considered.

Limiting the number of cold longitudinal joints in multi-lane pavements is an option but may not be appropriate for all locations. Limiting cold longitudinal joints can add significant project cost due to the additional trucks, pavers, rollers, and anti-segregation equipment that may be required. Limiting the joints requires sufficient nearby asphalt plant capacity and trucking to provide enough material to keep multiple pavers or a single full width paver moving forward at sufficient ground speed to allow for compaction before the mix cools.

If it is desired to limit the number of cold longitudinal joints, the designer should indicate either the location(s) of the cold joints or the maximum number of cold joints allowed. Typically, two lanes and a shoulder are the widest that can be paved without a cold joint. Do not include any specific method for limiting cold joints, such as requiring full width paving or echelon paving, as it is the contractor’s choice how to achieve the requirements.

Projects using Item 447 acceptance may use SS 872 VRAM on joints excluded from the 447 joint density requirements. Do not place VRAM under joints that will be cored for Item 447 joint density acceptance. The most common place to use VRAM with Item 447 acceptance is when paving against existing pavement to remain in place. When using VRAM with Item 447 acceptance, include a plan note indicating that no joint density cores will be taken where SS 872 VRAM is placed.

403.2 Shoulder Buildups

Shoulders are used to provide an area for the accommodation of disabled vehicles, for the lateral support of the base and surface courses, to improve the safety of a highway, and for future maintenance of traffic operations during maintenance and rehabilitation work.

Shoulders for flexible pavements should be constructed using the same asphalt concrete pay items and thicknesses as the driving lanes' pavement whenever a paved shoulder is required. This provides for the ability to have a hot longitudinal joint at the pavement-shoulder interface, provides a stable temporary pavement for maintenance of traffic lane shifts, and reduces the complexity of construction. Using other types of shoulders, such as surface treated, stabilized aggregate, or turf shoulders should be in accordance with the Location & Design Manual, Volume One - Roadway Design. Regardless of the type of shoulder used, the base and subgrade should be designed to drain water away from the pavement, rather than towards it. Examples of typical sections depicting flexible pavement with different types of unpaved shoulders are located in Figure 403-1. Also, refer to the Location & Design Manual, Volume 3 - Sample Plan Sheets.

403.3 Edge Course Design

For proper quantity calculations, each lift of pavement and base below the intermediate course must be shown wider than the lift above, creating a stair step look. A lift is the thickness of material placed in one pass. Maximum lift thicknesses for the various materials are found in the C&MS, or Section 406 or Figure 406-1 of this Manual. When a layer of material exceeds the maximum lift thickness, it will be placed in two lifts. The designer should assume the two lifts will be approximately equal thickness. If a layer requires three lifts, it should be assumed that the lifts will be approximately equal thickness.

Surface and intermediate courses should be shown ending in a vertical plane at the outside edge of the surface course. The lift immediately below the intermediate course should be shown extending 4 inches (100 mm) beyond the edge of the intermediate course or a distance equal to the combined thickness of the surface and intermediate course, whichever is greater. An additional 4 inch (100 mm) step may be necessary if using multiple lifts of intermediate course. All other lifts of Items 301, 302, and 304 should be shown extending 6 inches (150 mm) beyond the overlying lift or extending the thickness of the overlying lift, whichever is greater.

For concrete curbed sections, the asphalt is paved to the face of the curb. Where the bottom courses of the asphalt pavement buildup lie below the depth of the curb base, those lifts should be placed as a foundation for the curb and should have the proper edge course design as discussed above.

404 Asphalt Concrete Acceptance

One of the most important concepts to understand when selecting asphalt concrete materials is the acceptance method used in construction. There are four different acceptance methods; 446, 447, 448, and 449. The acceptance method for all asphalt concrete items is specified by the number in parentheses in the pay item description. It is important that the designer understand the different acceptance methods and when they apply.

Items 446, 447, and 448 are density acceptance methods. Proper density is important to the long-term performance of the pavement. Items with density acceptance give ODOT more assurance that proper density will be achieved but there are differences in the requirements of 446, 447, and 448.

For all density acceptance methods, in order to give the contractor the opportunity to achieve proper density, the asphalt lift must be placed on a generally level surface, at a uniform thickness, and at the proper thickness based on nominal maximum aggregate size. If the surface is not level, the thickness not uniform, or the thickness not proper, it may not be possible to evenly compact the material and achieve the proper density. A level surface is a surface placed as part of the same contract or a surface planed under the same contract. An existing, aged surface may be a level surface but not if there is rutting, shoving, debonding, potholes, etc. Pavement planing is recommended for most existing, aged surfaces prior to density acceptance. A generally level surface is required to place a uniform thickness layer of asphalt.

The 446 acceptance method requires random cores be taken and measured for density. If the pavement is over or under compacted, the contractor is assessed a penalty or, in some cases, forced to remove and replace the material. Item 446 acceptance is available for surface and intermediate courses.

The 447 acceptance method is similar to 446 acceptance with respect to taking cores but with extra requirements for density along cold longitudinal joints. Item 447 acceptance is intended for limited access, multi-lane facilities with controlled grades and cross slopes, and is for 442 surface courses only. It is not for use on 2-lane facilities or any facility with numerous driveways or intersections, or anywhere the maintenance of traffic plan does not allow continuous paving. Item 447 acceptance requires a minimum of 10,000 feet (3000 m) of cold longitudinal paving joints after removing joints excluded by the specification. With 447 acceptance, SS 875 Longitudinal Joint Adhesive is required on all cold longitudinal joints and is incidental to the surface course pay item. Do not include SS 875 as a pay item when using 447 acceptance.

The 448 acceptance method includes asphalt binder content, gradation, and density acceptance measured with a nuclear or electromagnetic gauge. Item 448 acceptance is a less stringent density requirement than 446 and 447 acceptance. It assures the department of a minimum level of compaction but does not challenge the contractor to achieve optimum compaction or avoid over-compaction like 446 and 447 acceptance. Items with 448 acceptance are typically used in lower traffic volume situations where the risk of pavement distresses resulting from lack of density is not as great. Item 448 acceptance is available for surface and intermediate courses.

The 449 acceptance method includes asphalt binder content and gradation as well as specific roller types, sizes, and quantities but does not have any density requirement. Compaction is complete when it visually appears that the rollers are no longer having any effect. Item 449 acceptance is used for asphalt concrete bases, variable depth courses, lifts less than 1 inch (25 mm) thick, spot paving, and paving less than one continuous mile (1.6 km). Item 449 acceptance is available for surface, intermediate, and base courses.

404.1 Acceptance Guidelines

The following guidelines are provided to assist in selecting materials with the proper acceptance type. All asphalt concrete items require an acceptance method in parentheses in the pay item description. The 447 acceptance method is the highest standard of the available acceptance methods and is to be specified whenever the project criteria for use are met. The 446, 447, and 448 acceptance methods should not be used with variable depth courses except in the limited situations described below.

Specify 446 as follows except where 447 acceptance criteria are met:

- All surface and intermediate courses placed at a uniform thickness on a level surface on priority, general, and urban system projects using Item 442 with greater than 1500 trucks

in the opening day traffic and greater than 500 cubic yards (400 cubic meters) of surface course material (approximately two lane-miles [3.2 lane-km]).
- Surface and intermediate courses on all priority system minor rehabilitation projects structurally designed from deflection measurements where a uniform thickness is placed.
- All surface and intermediate courses placed at a uniform thickness on priority system projects where the combined surface and intermediate course quantities exceed 2000 cubic yards (1500 cubic meters).
- All surface and intermediate courses placed at a uniform thickness on general and urban system projects using Item 442 with greater than 1500 trucks in the opening day traffic and the combined surface and intermediate course quantities exceed 2000 cubic yards (1500 cubic meters).

Specify 447 acceptance for 442 surface courses meeting the criteria above for 446 acceptance and all of the following additional criteria:

- Limited access, multi-lane facilities with controlled grades and cross slopes.
- Few, if any, driveways and intersections.
- Maintenance of traffic operations that allow for continuous paving.
- A minimum of 10,000 feet (3000 m) of cold longitudinal paving joint(s) after removing joints excluded by the specification.
- Projects with late season completion dates may not be good candidates for 447 acceptance. Instead use SS 872 VRAM for cold longitudinal joints.

Specify 448 acceptance for surface and intermediate courses when 446 or 447 acceptance is not applicable and all of the following criteria are met:

- A uniform thickness of at least 1 inch (25 mm).
- At least one continuous mile (1.6 km) of paving in two or more adjacent lanes.

Specify 449 acceptance when any of the following apply and anytime 446, 447, or 448 acceptance is not appropriate:

- All asphalt concrete base courses, Items 301 and 302.
- All variable depth courses and all courses placed less than 1 inch (25 mm) thick.
- When the project consists of paving less than one continuous lane mile (1.6 km) in at least two adjacent lanes.

For projects that use 446, 447, or 448 acceptance, it is permissible to use variable thickness to form a butt joint or taper end according to SCD BP-3.1. ODOT construction and testing staff will test only the areas constructed as uniform thickness and skip testing the short areas with variable thickness. This eliminates any need for an additional pay item yet still allows the proper material with the proper acceptance to be used.

When 446 or 447 acceptance is specified for the surface course, it is recommended the intermediate course use 446 acceptance except where a uniform lift thickness is not possible such as a variable depth course for crown correction. It is permissible to use a variable depth course with 449 acceptance below a surface with 446, 447, or 448 acceptance, or below an intermediate course with 446 or 448 acceptance.

When choosing to use 446 acceptance on general and urban system projects, the recommended minimum quantities are 500 cubic yards (400 cubic meters) of surface course material or 2000 cubic yards (1500 cubic meters) of surface and intermediate course combined.

405 Superpave Asphalt Concrete

Superpave mixes, Item 442, are required on all projects with greater than 1500 trucks in the opening day traffic. Superpave mixes are not necessary on projects with lower truck traffic although some districts have been instructed to use Superpave mixes due to localized material problems.

Superpave Type A and B requirements are found in C&MS 442. They control gradation bands and aggregate angularity. Type A has higher crush requirements that may mean the importation of aggregate in some areas of the state but provides the most rut resistance. Type B has less restrictive crush requirements. Type A mixes are preferred except where superior rut resistance is not necessary and importation of aggregate would be cost-prohibitive. District testing and construction personnel knowledgeable in materials should be consulted prior to selection of Type A or B.

Pay item descriptions for Superpave items contain a reference to the nominal maximum aggregate size used in the mix. Accordingly, the 9.5mm, 12.5mm, and 19mm designations are used for Superpave mixes. This reference to the nominal maximum aggregate size replaces the reference to Type 1 and Type 2 used in Item 441 mixes, has nothing to do with any other measurement, and is used in English and metric plans.

The pay item descriptions for Superpave items indicate the acceptance method by the number in parentheses. The designer should follow the guidance in Section 404 to select the proper acceptance method.

406 Lift Thickness and Usage Guidelines

ODOT asphalt concrete specifications contain aggregate gradation requirements for all items. For optimum performance of the pavement system, it is important to design the various lifts of asphalt concrete items in order to achieve maximum smoothness, durability, and densification. In order to do this, some constraints are required regarding maximum and minimum lift thicknesses in relation to the gradation of the item specified. A lift is the thickness of material placed in one pass.

There are many different asphalt concrete specification items available. The differences between the items are sometimes subtle but always important. Understanding these subtleties and their importance can help the designer select the proper item for the proper application. The specifications themselves and any designer notes should also be consulted for additional guidance.

To select mixes for use in high stress locations the designer should refer to Appendix B: Pavement Guidelines for Treatment of High Stress Locations and Section 406.7. High stress locations occur where heavy vehicles are operating under low speed or stopped conditions.

406.1 Surface Courses

The designation of surface course refers to the layer's relative position in the pavement buildup. Surface courses are the top layer of asphalt concrete placed in a flexible pavement, with rare exceptions. In general, surface courses have the finest gradation, highest binder content, and strictest quality control requirements to provide a dense, smooth, durable surface. As a result, surface courses are typically the most expensive layer in the flexible pavement structure by unit cost.

All surface courses should be specified in 0.25-inch (5 mm) increments except Item 424 Type A that can be specified as thin as five-eighths inches (0.625" [16 mm]).

406.1.1 Item 441 Asphalt Concrete Surface Course, Type 1, (446, 448, & 449), PG64-22

This item is for roads with less than 1500 trucks in the opening day traffic. Lift thickness can be 1.25 inches (32 mm) or 1.5 inches (38 mm). A 1-inch (25 mm) lift may be used with 448 and 449 acceptance, however 1.25 inches (32 mm) is the preferred minimum. If 446 or 448 acceptance is specified, a uniform thickness is required.

406.1.2 Item 441 Asphalt Concrete Surface Course, Type 1, (446, 448, & 449), PG70-22M

This item is for districts that have been specifically instructed to use it on roads with less than 1500 trucks in the opening day traffic. Lift thickness can be 1.25 inches (32 mm) or 1.5 inches (38 mm). A 1-inch (25 mm) lift may be used with 448 and 449 acceptance, however 1.25 inches (32 mm) is the preferred minimum. If 446 or 448 acceptance is specified, a uniform thickness is required.

406.1.3 Item 442 Asphalt Concrete Surface Course, 9.5mm, Type A & B (446, 447, 448, & 449)

This item is a Superpave surface course for roads with less than 1500 trucks in the opening day traffic. This item exists for those districts required to use Superpave mixes on lower truck traffic routes due to localized material problems. The requirements of Section 406.1.1 apply. If 446, 447, or 448 acceptance is specified, a uniform thickness is required.

406.1.4 Item 442 Asphalt Concrete Surface Course, 12.5mm, Type A & B (446, 447, 448, & 449)

This item is for roads with greater than 1500 trucks in the opening day traffic. The gradation of this mix requires a minimum lift thickness of 1.5 inches (38 mm). When used with an intermediate course, the 12.5mm surface course is typically placed at 1.5 inches (38 mm). The 12.5mm surface course may be specified up to a maximum of 2.5 inches (65 mm). A 12.5mm surface course cannot be placed properly at a thickness less than 1.5 inches (38 mm); durability and constructability problems will result. If 446, 447, or 448 acceptance is specified, a uniform thickness is required.

406.1.5 Item 443 Stone Matrix Asphalt Concrete, 12.5mm, PG70-22M & PG76-22M (446)

Stone matrix asphalt (SMA) concrete is a highly rut-resistant mix intended as a surface course for high stress areas. SMA uses 446 acceptance therefore a uniform lift thickness is required. The minimum lift thickness is 1.5 inches (38 mm). Maximum lift thickness is 2 inches (50 mm). SMA is not recommended for intermittent paving. The minimum recommended placement is one mile (1.6 km) of continuous paving or 250 cubic yards (200 cubic meters) however, there may be situations where smaller quantities are justified.

406.1.6 Item 424 Fine Graded Polymer Asphalt Concrete, Type A & B, (448 & 449)

This item is intended primarily for use as a surface treatment. Use of this item should be in accordance with recommendations from the pavement management system. This item should not be placed over crack sealer that has aged less than one year.

Type A has the finer gradation and can be placed as thin as 5/8-inches (16 mm) up to 1-inch (25 mm) thick. Type A uses 449 acceptance exclusively and thus never has any density testing. Type A is not for use in any location with high friction demand or legal speed limit greater than 40 miles per hour. Type A should not be used in locations with greater than 1500 trucks per day regardless of friction demand or speed.

Type B can be placed at thicknesses from 0.75 inches (19 mm) to 1.25 inches (32 mm). If Type B is specified and the project contains multiple road sections, some with greater than 1500 trucks and some with less, the mix design criteria for all the sections will be for greater than 1500 trucks. Type B uses 448 or 449 acceptance. If using 448 acceptance, a uniform thickness of at least 1 inch (25 mm) is required.

Although both Type A and B can specify 449 non-density acceptance, because they are thin surface treatments, they are not recommended for use as variable depth courses. Both types can be placed on an existing, non-planed surface if the surface is reasonably free of ruts and other surface deviations. If pavement planing is performed prior to placing a 424 overlay, Item 897 Fine Planing is recommended.

406.2 Intermediate Courses

Intermediate courses are placed on top of base courses and below surface courses. Intermediate courses provide additional structural capacity and level the base course to allow a smooth surface course. Intermediate courses can be used for extended periods for maintenance of traffic but generally not more than two construction seasons and one winter. Contact the Office of Pavement Engineering if anticipating longer maintenance of traffic operations on an intermediate course.

Any time an intermediate course is used as a variable depth, scratch, or leveling course, the legend on the typical section sheets should include the word “variable” or “leveling” in parentheses at the end of the item description.

All intermediate courses should be specified in 0.25-inch (5 mm) increments.

406.2.1 Item 441 Asphalt Concrete Intermediate Course, Type 2, (446 & 448)

This item is for roads with less than 1500 trucks in the opening day traffic. The gradation of this mix requires a minimum lift thickness of 1.75 inches (45 mm). The maximum lift thickness is 3 inches (75 mm). Due to the density acceptance, a uniform thickness is required.

The PG binder is automatically designated in the C&MS and is not included as part of the pay item description.

406.2.2 Item 441 Asphalt Concrete Intermediate Course, Type 2, (449)

This item is for roads with less than 1500 trucks in the opening day traffic. This item is the same material as Item 441 Asphalt Concrete Intermediate Course, Type 2, (446 & 448) (Section 406.2.1) except it can be used as a variable thickness course. The minimum and maximum lift thicknesses Section 406.2.1 apply. When using this material as a leveling or wedge course, the maximum recommended thickness of the wedge is 4.5 inches (115 mm). This item can be tapered to 0 inches (0 mm) and placed at non-uniform thickness less than the minimum lift thickness.

For projects using density acceptance for the surface course but needing this type of a leveling or wedge, it is acceptable to use this item for the intermediate course. Use of this item should be avoided, if possible, for high traffic volumes to minimize pavement densification under traffic.

The PG binder is automatically designated in the C&MS and is not included as part of the pay item description.

406.2.3 Item 441 Asphalt Concrete Intermediate Course, Type 1, (448 & 449)

This item is intended primarily as a scratch course on roads with less than 1500 trucks in the opening day traffic. Uniform lift thickness for this item can be as thin as 1 inch (25 mm) and as thick as 1.5 inches (38 mm). When using 448 acceptance, a uniform thickness of at least 1 inch (25 mm) is required.

This item can be used as a variable thickness course with 449 acceptance. When using this material as a leveling or wedge course, it may be practical to stretch the lift thickness past the 1.5 inch (38 mm) limit. For situations where the variability of the course thickness is 2 inches (50 mm) or more, consideration should be given to pavement planing to allow for the use of a Type 2 intermediate course which provides more stability than a Type 1 mix. This item can be tapered to 0 inches (0 mm) and placed at non-uniform thickness less than the minimum lift thickness.

For projects using density acceptance for the surface course but need this type of a leveling or wedge, there is nothing wrong with placing an intermediate course with 449 acceptance under a surface course with density acceptance. This item is not to be used as uniform thickness layer for projects with greater than 1500 trucks in the opening day traffic.

The PG binder is automatically designated in the C&MS and is not included as part of the pay item description.

406.2.4 Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (446 & 448)

This item is for roads with greater than 1500 trucks in the opening day traffic. The gradation of this mix requires a minimum lift thickness of 2.25 inches (55 mm). The maximum lift thickness is 3.75 inches (95 mm). Due to the density acceptance, a uniform thickness is required.

406.2.5 Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (449)

This item is the same material as Item 442 Asphalt Concrete Intermediate Course, 19mm, Type A & B (446 & 448) (Section 406.2.4) except it can be used as a variable thickness course. The minimum and maximum lift thicknesses in Section 406.2.4 apply. When using this material as a leveling or wedge course, the maximum recommended thickness of the wedge is 4.5 inches (115 mm). This item can be tapered to 0 inches (0 mm) and placed at non-uniform thickness less than the minimum lift thickness.

For projects using density acceptance for the surface course but needing this type of a leveling or wedge, it is acceptable to use this item for the intermediate course. Use of this item should be avoided, if possible, for high traffic volumes to minimize pavement densification under traffic.

406.2.6 Item 442 Asphalt Concrete Intermediate Course, 12.5mm, Type A & B (446 & 448)

This item is for roads with greater than 1500 trucks in the opening day traffic. The gradation of this mix requires a minimum lift thickness of 1.5 inches (38 mm). The maximum lift thickness is 2.5 inches (65 mm). Due to the density acceptance, a uniform thickness is required.

406.2.7 Item 442 Asphalt Concrete Intermediate Course, 12.5mm, Type A & B (449)

This item is the same material as Item 442 Asphalt Concrete Intermediate Course, 12.5mm, Type A & B (446 & 448) (Section 406.2.6) except it can be used as a variable thickness course. The minimum and maximum lift thicknesses in Section 406.2.6 apply. When using this material as a leveling or wedge course, the maximum recommended thickness of the wedge is 3 inches (75 mm). This item can be tapered to 0 inches (0 mm) and placed at non-uniform thickness less than the minimum lift thickness.

For projects using density acceptance for the surface course but needing this type of a leveling or wedge, it is acceptable to use this item for the intermediate course. Use of this item should be avoided, if possible, for high traffic volumes to minimize pavement densification under traffic.

406.2.8 Item 442 Asphalt Concrete Intermediate Course, 9.5mm, Type A & B (448 & 449)

This item is intended primarily as a scratch course on roads with greater than 1500 trucks in the opening day traffic. The requirements of Section 406.2.3 apply.

406.3 Base Courses

Asphalt concrete base courses provide the majority of the structural capacity in most flexible pavement buildups. All asphalt concrete base courses should be specified in 0.5-inch (10 mm) increments.

406.3.1 Item 301 Asphalt Concrete Base, (449), PG64-22

This item is to be used in conjunction with both a surface and intermediate course.

The gradation of this mix requires the lift to be at least 3 inches (75 mm) thick. In special circumstances, it is possible to allow this lift to be as thin as 2.5 inches (65 mm), but this is discouraged. ODOT C&MS specifies a maximum compacted lift of 6 inches (150 mm). Layers thicker than 6 inches (150 mm) will automatically be placed in multiple lifts. This item may be placed in variable thicknesses.

For most situations, this material should have 304 underneath, and a minimum of 3 inches (75 mm) of surface and intermediate course above.

This material can be used for maintenance of traffic operations during construction but care should be taken to minimize high traffic volume contact. In high traffic volume situations, an intermediate course is preferred for maintenance of traffic, particularly over the winter.

406.3.2 Item 302 Asphalt Concrete Base, (449), PG64-22

This item is to be used in conjunction with both a surface and intermediate course. This mix was developed for use with thick flexible pavements where high volume truck traffic exists. The recommended minimum quantity for Item 302 is 2500 cubic yards (1900 cubic meters) per project. When lift thicknesses and maintenance of traffic operations allow, Item 302 is preferred over Item 301. Item 302 generally costs less than Item 301 and is a more stable, rut-resistant mix but is more susceptible to segregation problems during construction unless good construction practices are followed.

The gradation of this mix requires the lift to be at least 4 inches (100 mm) thick. ODOT C&MS specifies a maximum compacted lift of 7.75 inches (190 mm). Layers thicker than 7.75 inches (190 mm) will automatically be placed in multiple lifts. This item may be placed in variable thicknesses.

For most situations, this material should have 304 underneath, and a minimum of 3 inches (75 mm) of surface and intermediate course above. It is not necessary to put a 301 course above a 302 course. Placement of 301 below 302 is illogical.

Item 302 is not recommended for high speed maintenance of traffic operations. If it must be used for maintenance of traffic, even low speed conditions, the maximum is 60 days and never over the winter. If it is necessary to maintain traffic for more than 60 days or over winter, the top 3 inches (75 mm) of the 302 could be changed to 301, or preferably, the project should be phased to allow the intermediate course to be placed and used for maintenance of traffic.

406.4 Item 407 Tack Coat

A tack coat is used to bond pavement layers together to create a monolithic pavement structure. A tack coat is required between all lifts of asphalt concrete; surface and intermediate, intermediate and base, and between multiple lifts of asphalt concrete base (C&MS items 301 and 302). When following the small quantity guidelines (Section 410), a tack coat is required between all lifts, even if the same material is used for multiple lifts.

A tack coat is required anytime asphalt concrete is placed on pavement constructed by a previous project, even if the old pavement has been planed. The one exception is, when constructing an unbonded concrete overlay, tack coat should not be used under the bondbreaker layer unless traffic will be maintained on the bondbreaker.

A tack coat is required anytime asphalt concrete is placed on Portland cement concrete or brick with the exception of a bondbreaker layer mentioned above. When tack coat is placed on concrete or brick, C&MS automatically requires the use of rubberized asphalt emulsion conforming to 702.13. It is recommended the designer use the tack coat pay item that references 702.13 where the plans show placing tack on concrete or brick.

Tack coat application rates are specified in the C&MS. It is recommended that the designer use the mid-point of the application rate ranges shown in C&MS Table 407.06-1 for determining plan quantity. When multiple tack coats exist on a project, such as below an intermediate course and below a surface course, one total quantity for all the tack coat is listed in the general summary. It is not necessary to show in the plans the estimated application rate(s).

406.4.1 Non-Tracking Tack Coat

Non-tracking tack coat does not require as long of a cure time as standard tack coat to prevent tracking onto adjacent roadways. Non-tracking tack coat should be considered when project conditions do not allow for adequate cure time for standard tack coat. The designer should evaluate the potential for safety-related issues that would arise from tracking tack coat material onto adjacent roadways. Project conditions that may warrant the use of non-tracking tack include short construction zones, particularly in urban areas, and when night paving is required.

Non-tracking tack coat is not allowed on concrete or brick.

Non-tracking tack coat is not recommended for very small quantities. A minimum quantity of 800 gallons (3000 L) is recommended.

406.5 Item 408 Prime Coat

Prime coats are rarely used and are never required for asphalt pavements. Before specifying a prime coat, the designer should check with construction personnel to see if prime coats are routinely non-performed. A prime coat should not be included in the plans if it will be non-performed.

Prime coats are applied to Item 304 Aggregate Base to seal and protect the 304 during construction. Prime coats help control dust and damage caused by construction traffic. They can also help reduce water infiltration while the 304 is exposed. The designer should consider the construction phasing and how long the 304 will be exposed to the elements and construction traffic when determining the use of prime coat.

Estimated application rate for prime coat is always 0.4 gallons per square yard (1.8 L/m^2).

406.6 Anti-Segregation Equipment

Items 441 and 442 have a pay item for anti-segregation equipment. This item requires the contractor to provide equipment to remix the asphalt concrete after discharging from the trucks.

Anti-segregation equipment is to be specified for surface and intermediate courses of uniform thickness on all large-scale priority system paving projects. Large-scale paving projects generally consist of at least one mile (1.6 km) of paving. Other projects such as two-lane resurfacing, spot paving, and bridge projects that may include small amounts of paving do not need to specify anti-segregation equipment.

The cubic yards (cubic meters) calculated for this item should include the total quantity of surface and intermediate course on the priority system route driving lanes, collector-distributor lanes, ramps, etc., but not including shoulders. The anti-segregation quantity should not include median crossovers, turn lanes, and paving on non-priority system cross-roads.

406.7 Asphalt Binder Grades

ODOT uses the Performance Grade (PG) binder grading system to designate the grade of asphalt binder in all asphalt concrete items. Most asphalt concrete items contain a default binder grade given in the specification. Other items list the binder grade as part of the pay item description. The binder grades used and available in Ohio are: PG64-22, PG64-28, PG70-22M, PG76-22M, and PG88-22M.

The numbers in the PG designation relate to the temperature range the binder is expected to perform. A PG64-22 binder is expected to resist deformation at a high pavement temperature of 64 ºC and to resist cracking at a low pavement temperature of -22 ºC. PG64-22 is pronounced PG sixty-four minus twenty-two.

In most cases, the default binder grade is sufficient for normal traffic loading and patterns. In high stress locations (see Appendix B), the designer should consider using a binder with the ability to resist deformation at higher temperatures.

The most common binder for 441 items is PG64-22. Some districts are required to use PG70-22M in 441 surface courses. In high stress locations, PG64-22 surface course binders should be changed to PG70-22M and for districts already using PG70-22M for surface courses it should be changed to PG76-22M. In extreme conditions, all districts should use PG76-22M or even PG88-22M and the asphalt concrete should be changed to a 442 mix as well.

Item 441 intermediate courses use PG64-22 binder in all districts. If the surface course binder grade is changed due to a high stress location, the binder grade for any intermediate course may be changed to match the surface binder grade but this is usually not necessary.

The surface course binder for 442 items is PG70-22M. In high stress locations, the binder should be changed to PG76-22M or PG88-22M.

The intermediate course binder for 442 items is PG64-28. If the surface course binder grade is changed due to a high stress location, the binder grade for any intermediate course may be changed to match the surface binder grade but this is usually not necessary.

407 Warranty Asphalt Concrete

The use of warranty does not change the asphalt concrete thickness design in any way. The same inputs are used and the same SN determined regardless of whether warranty or conventional asphalt concrete will be used. To determine the thickness of a warranty asphalt pavement, the designer should assume conventional materials and lift thickness restrictions, then apply the appropriate structural coefficients. For asphalt pavements with a 7-year warranty, the entire thickness is specified as Item 880. For 3-year warranties, conventional items are specified for each layer and Supplement 1059 is added to the surface course pay item description.

More information on asphalt pavement warranties is available in the Warranty Application Guidelines in the Innovative Contracting Manual published by the Office of Construction Administration, in the Item 880 Asphalt Concrete (7 Year Warranty) specification, and in Supplement 1059 Asphalt Concrete Surface Course Warranty Requirements.

Use of Item 880 and Supplement 1059 currently require pre-approval from the Division of Construction Management.

408 Smoothness Specifications

Incentive/disincentive for smoothness is specified using Proposal Note (PN) 420 Surface Smoothness Requirements for Pavements. PN 420 is recommended for all eligible projects as described in the designer note.

The minimum smoothness requirements when PN 420 is not used are contained in C&MS 401.10.

Smoothness incentives generally result in better attention to detail by the contractor and higher quality pavement overall. Smooth, high quality pavements are expected to perform better for a longer time, potentially resulting in cost savings to the Department.

The designer should ensure the contractor has a reasonable opportunity to achieve the incentive. Projects that may otherwise be eligible but have numerous manholes, drainage structures, business or residential driveways, etc., may not be good candidates for smoothness incentive depending on the maintenance of traffic and sequence of operations.

409 Special Use Asphalt Concrete Items

The following items are used for surface treatments, high stress areas and other situations where specialized material is desired.

409.1 Item 803 Rubberized Open Graded Asphalt Friction Course

This item is intended for use in areas with poor skid resistance, where surface drainage is a concern, or where reduced tire-pavement noise is desired. Air-cooled slag is required, which may not be economically available in all areas of the state.

ODOT has had trouble with snow and ice removal on open graded friction courses (OGFC). According to FHWA Technical Advisory T 5040.31, an OGFC “requires special snow and ice control methods and generally remains icy longer.” An OGFC is effective in reducing potential for hydroplaning, reducing splash and spray, and reducing tire-pavement noise as much as 3 to 5 decibels.

An OGFC does not add any structural capacity and therefore should be considered on structurally sound pavements only.

409.2 Item 823 Light Traffic Asphalt Concrete, (448 & 449)

This item is intended for non-highway locations with little or no truck traffic, typically less than 50 trucks per day. Examples of locations where this item may be appropriate include state park roads, car parking lots, driveways, and shared use paths. This item is not permitted for use on any state highway. When using 448 acceptance, a uniform thickness of at least 1 inch (25 mm) is required.

409.3 Item 826 AC Surface and Intermediate Course, Type 1 & 2, (448 & 449), Fiber Type A, B, or C

These items are intended primarily for high stress areas to reduce the potential for rutting. Use of these items should be coordinated with the Offices of Pavement Engineering and Materials Management. When using 448 acceptance, a uniform thickness of at least 1 inch (25 mm) is required.

409.4 Item 859 AC with Verglimit

This item is intended as an anti-icing pavement. It is not recommended for roads with greater than 1500 trucks per day. Verglimit is a linseed oil-coated multi-component chemical deicer additive consisting of calcium chloride flakes and other chemicals. ODOT has very limited experience with this item. Use of this item should be coordinated with the Offices of Pavement Engineering, Maintenance Administration, Materials Management, and Structural Engineering if used on bridges.

410 Small Quantity Guidelines

Numerous asphalt concrete mixes exist for use in various situations on projects large and small. It is desirable to minimize the number of different mixes specified on a project to reduce complexity and receive the best price for the items specified. These guidelines are intended to simplify and reduce the cost of paving on bridge and culvert replacement projects, bridge deck overlays, turn lane additions, landslide repairs, and any project of less than 0.25 miles (0.5 km) of full depth pavement.

410.1 Transition to Structures

Bridge replacement and rehabilitation projects often include a small amount of paving to transition to the structure. Culvert replacement projects include a small quantity of asphalt to replace the pavement over the culvert. When these small quantities are the only asphalt paving on a project, the guidelines in this section should be used to select the proper asphalt concrete items.

If the road carries less than 1500 trucks per day, use Item 441 Asphalt Concrete Surface Course, Type 1, (449), PG64-22 for both the surface and intermediate courses. Include a plan note restricting the 441 to two-inch (50 mm) maximum lift thickness. Use either Item 301 Asphalt Concrete Base, (449), PG64-22 or Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

If there are more than 1500 trucks per day, use Item 442 Asphalt Concrete Surface Course, 12.5mm, Type A or B (449) for both the surface and intermediate courses. Include a plan note requiring PG64-22 binder and restricting the 442 to two-inch (50 mm) maximum lift thickness. If the project is on an interstate and the adjoining pavement is less than seven years old, use the standard PG70-22M binder for the 442. Use Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

If the transition area is a high stress location, the asphalt concrete should be selected in accordance with the High Stress Guidelines (Appendix B) and Section 406.7. Include a plan note restricting the asphalt concrete selected for the surface and intermediate courses to two-inch (50 mm) maximum lift thickness. Use Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

410.2 Overlaying Pavement and Bridges Simultaneously

When continuing a pavement overlay across a bridge, use the same asphalt concrete items on the bridge as used on the pavement. If a leveling course is needed on the bridge but not used on the pavement, use an additional lift of the surface course mix as the leveling course. Include a plan note restricting each lift of surface course on the bridge to two inches (50 mm) maximum.

410.3 Bridge Deck Overlays with Transitions

Some new bridges may include an asphalt concrete wearing surface. The items to be used for the wearing surface are specified in the Bridge Design Manual. Use the same items as used on the bridge for any required transition to the pavement. If a surface course mix is used for both the surface and intermediate course, include a plan note restricting each lift of surface course to two inches (50 mm) maximum. Use either Item 301 Asphalt Concrete Base, (449), PG64-22 or Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course, if needed.

410.4 Turn Lane Additions

These guidelines are to be used any time a turn lane is added or other minor widening is performed without a resurfacing project and the adjoining asphalt concrete surface is more than three years old. If the adjoining surface is less than three years old, the materials in the widening should match the adjoining pavement so the performance is similar. If the widening is greater than the equivalent of one lane wide and 0.25 miles (0.50 km) long, standard materials and lift thicknesses should be used.

If the road carries less than 1500 trucks per day, use Item 441 Asphalt Concrete Surface Course, Type 1, (449), PG64-22 for both the surface and intermediate courses. Include a plan note restricting the 441 to two-inch (50 mm) maximum lift thickness. Use either Item 301 Asphalt Concrete Base, (449), PG64-22 or Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

If there are more than 1500 trucks per day, use Item 442 Asphalt Concrete Surface Course, 12.5mm, Type A or B (449) for both the surface and intermediate courses. Include a plan note requiring PG64-22 binder and restricting the 442 to two-inch (50 mm) maximum lift thickness. If the project is on an interstate and the adjoining pavement is less than seven years old, use the standard PG70-22M binder for the 442. Use Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

If the widening is a high stress location, the asphalt concrete should be selected in accordance with the High Stress Guidelines (Appendix B) and Section 406.7. Include a plan note restricting the asphalt concrete selected for the surface and intermediate courses to two-inch (50 mm) maximum lift thickness. Use Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

410.5 Landslides, Washouts, Collapses, etc.

Repairing landslides, washouts or other collapses may require small quantities of new pavement. If the adjoining pavement is less than three years old, the materials used in the repair should match the adjoining pavement so the performance is similar. If the repair length is less than 0.25 miles (0.50 km), these guidelines apply; otherwise, standard materials and lift thicknesses apply.

If the road carries less than 1500 trucks per day, use Item 441 Asphalt Concrete Surface Course, Type 1, (449), PG64-22 for both the surface and intermediate courses. Include a plan note restricting the 441 to two-inch (50 mm) maximum lift thickness. Use either Item 301 Asphalt Concrete Base, (449), PG64-22 or Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

If there are more than 1500 trucks per day, use Item 442 Asphalt Concrete Surface Course, 12.5mm, Type A or B (449) for both the surface and intermediate courses. Include a plan note requiring PG64-22 binder and restricting the 442 to two-inch (50 mm) maximum lift thickness. If the project is on an interstate and the adjoining pavement is less than seven years old, use the standard PG70-22M binder for the 442. Use Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

If the repair is in a high stress location, the asphalt concrete should be selected in accordance with the High Stress Guidelines (Appendix B) and Section 406.7. Include a plan note restricting the asphalt concrete selected for the surface and intermediate courses to two-inch (50 mm) maximum lift thickness. Use Item 302 Asphalt Concrete Base, (449), PG64-22 for the base course.

400 Flexible Pavement Design

List of Figures

Flexible Pavement Structural Coefficients

401-1
July 2025
Reference Section
401

ASPHALT CONCRETE STRUCTURAL COEFFICIENTS		
Material	**English Coefficient**	**Metric Coefficient**
Items 424, 441, 442, 443, 823, 826, 859 AC Surface Courses	0.43	0.0169
Items 441, 442, 823, 826 AC Intermediate Courses	0.43	0.0169
Item 880 Warranty Asphalt - top 3" (75 mm)	0.43	0.0169
Items 301, 302 Asphalt Concrete Base Courses	0.36	0.0142
Item 880 Warranty Asphalt - below top 3" (75 mm)	0.36	0.0142
Item 321 Cracked & Seated Plain Concrete	0.27	0.0106
Existing Asphalt Concrete - old, oxidized, & weathered	0.23	0.0092
Item 304 Aggregate Base*	0.14	0.0055
Item 320 Rubblized Concrete	0.14	0.0055
Item 421 Microsurfacing	0.0	0.0
Item 803 Rubberized Open Graded Asphalt Friction Course	0.0	0.0
Item 822 Hot In Place Recycling	0.0	0.0

* When the entire subgrade is chemically stabilized (global chemical stabilization), the coefficient for Item 304 Aggregate Base is increased to 0.17 (0.0067). Include sample plan note G123 Chemically Stabilized Subgrade in the plans.

Asphalt Concrete Drainage Factor = 1.0

Flexible Pavement Design Example

Page 1

Given:

- Number of Lanes: 4 (2 per direction)
- Functional Classification: Principal Arterial (Rural)
- 2018 Traffic: 15,800 ADT
- 2038 Traffic: 22,450 ADT
- 24 hour truck %: 18%
- Design Period: 20 years
- Open to Traffic: 2019
- Subgrade CBR: 5 (from Subgrade Analysis)

Problem: Solve for the Structural Number and determine an acceptable flexible buildup

Solution:

Step 1 - Determine the 18 Kip Equivalent Single Axle Loading (ESAL)

Since the project is expected to open to traffic in 2019, the ESAL projection should be for 2019 to 2039. Calculate the mid-year (2029) ADT, rounded to the nearest ten:

2029 ADT = 15,800+(22,450-15,800)(11/20)
2029 ADT = 19,460

Directional distribution, D = 50% (Figure 202-1)
Lane factor = 95% (Figure 202-1)
B:C ratio = 5:1 (Figure 202-1)
ESAL conversion factor for B trucks = 1.06 (Figure 202-1)
ESAL conversion factor for C trucks = 0.33 (Figure 202-1)

Using the equations given in Section 202.2:

ESAL's from B trucks = 19,460(0.18)(0.50)(0.95)(5/6)(1.06) = 1470
ESAL's from C trucks = 19,460(0.18)(0.50)(0.95)(1/6)(0.33) = 92

Total daily ESAL’s = 1470+92 = 1562 ESAL/day

Design period ESAL’s = 1562 ESAL/day * 365.25 days/yr. * 20 years = 11,410,410
use $11.4\text{x}10^6$ ESAL

Step 2 - Determine the subgrade resilient modulus (M_r) using the formula given in Section 203.1.

M_r = 1200 * CBR
M_r = 1200 * 5
M_r = 6000 psi

Step 3 - Determine the design structural number (SN) using Figures 402-2 and 402-3. In Figure 402-2, solve for the match line number using the following information:

Reliability = 85% (Figure 201-1)
Overall Standard Deviation = 0.49 (Figure 201-1)
18-kip Single Axle Loads = 11.4x10^6 ESAL (Step 1)
Subgrade Resilient Modulus = 6,000 psi (Step 2)

The resulting match line number is then used in Figure 402-3, along with the design serviceability loss of 2.0 (Figure 201-1), to solve for the design structural number (SN).

Therefore: design structural number (SN) = 5.07

Step 4 - Design the typical section using the layer coefficients found in Figure 401-1. The structural number of each layer is determined by multiplying the thickness times the coefficient. The total structural number for the pavement buildup must equal or exceed the design structural number (SN) = 5.07 (Step 3).

Check the number of trucks in the opening day traffic.
2019 ADTT = (15,800+(22,450-15,800)(1/20))*0.18
2019 ADTT = 2900

Since the opening day truck traffic is greater than 1500, Item 442 Asphalt Concrete Surface Course, 12.5mm is required.

The following buildup is the recommended solution in accordance with the guidance in Section 406.

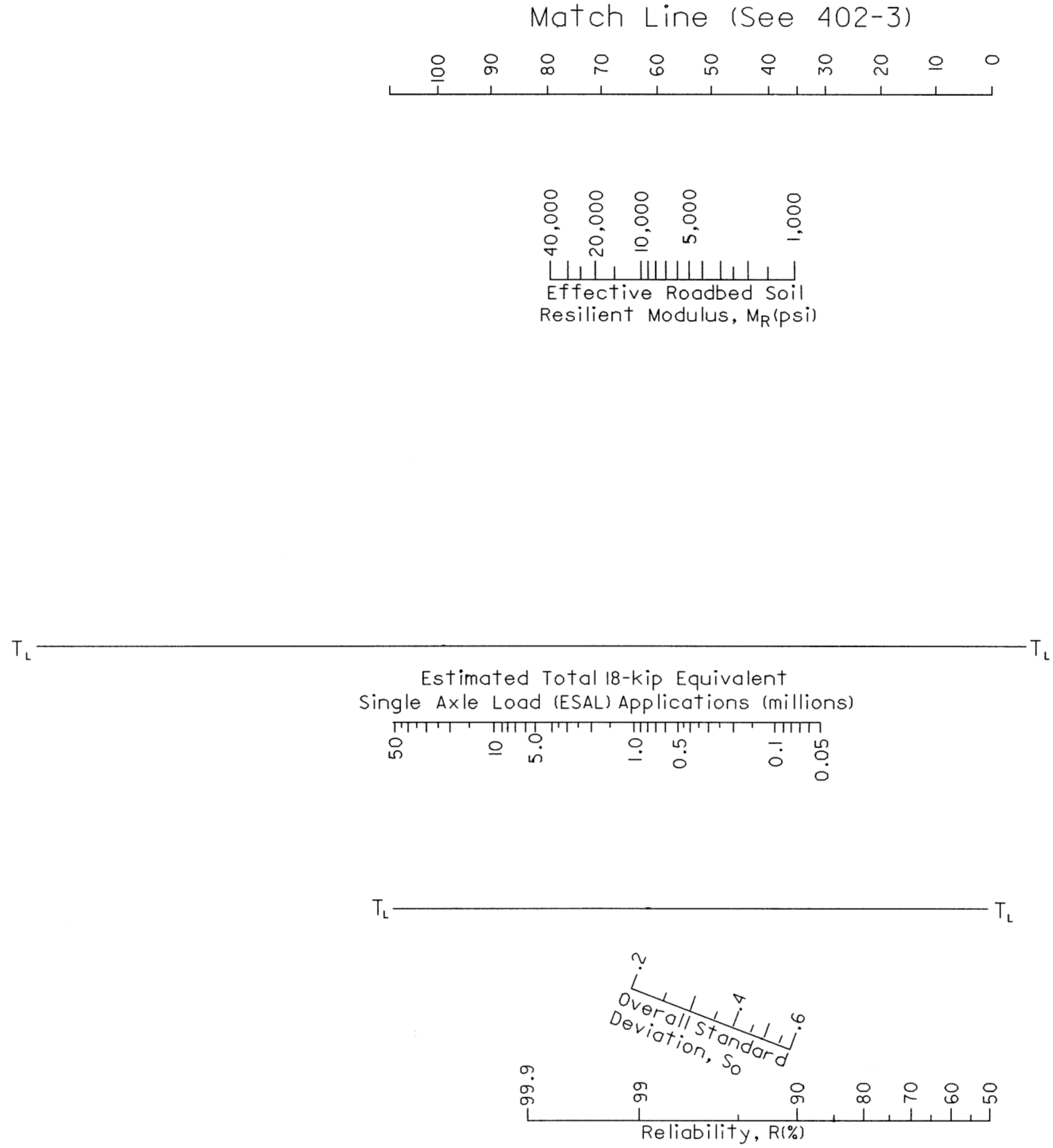
Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (447)	1.5"	0.43	0.65
442 AC Intermediate Course, 12.5mm, Type A (446)	1.75"	0.43	0.75
302 Asphalt Concrete Base, PG64-22, (449)	8"	0.36	2.88
304 Aggregate Base	6"	0.14	0.84
		Total SN =	5.12

Since the total SN equal to 5.12 of the proposed buildup is greater than the required SN of 5.07, the design is acceptable.

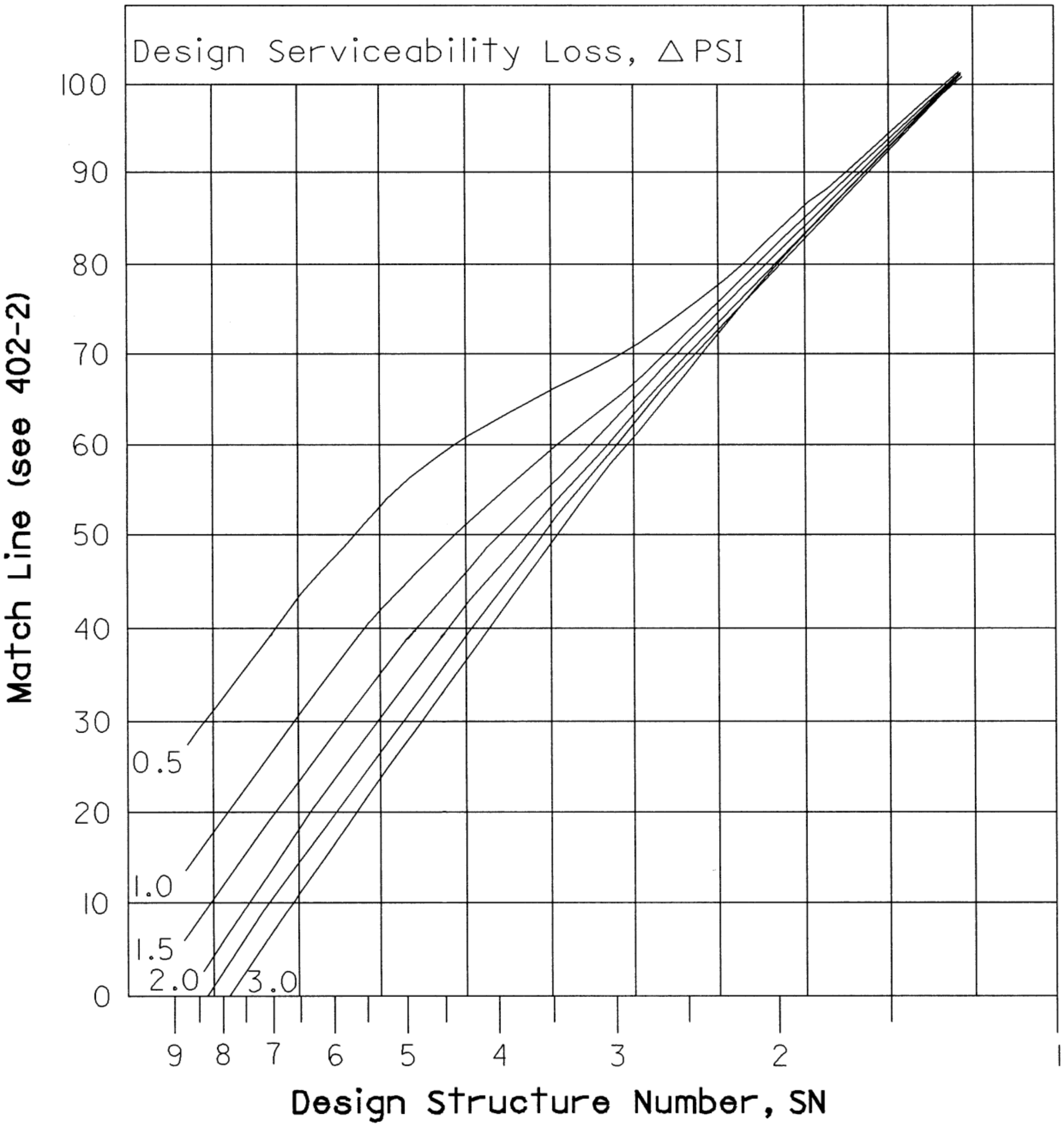
Flexible Pavement Design Chart Segment 1

402-2
July 2008

Reference Section & Figure
402, 402-1(step 3)



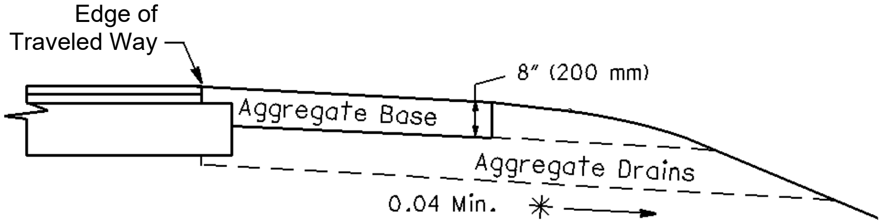
# Flexible Pavement Design Chart Segment 2	**402-3** July 2008
	Reference Section & Figure **402, 402-1(step 3)**



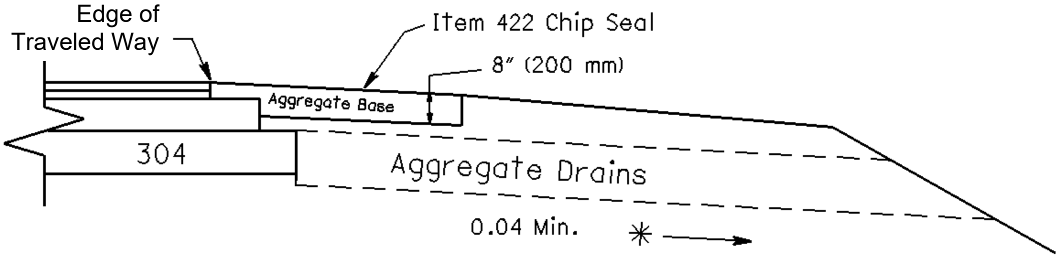
Surface Treated Shoulder and Stabilized Aggregate Shoulder Typical Sections

403-1
January 2024
Reference Section
205.1, 403.2

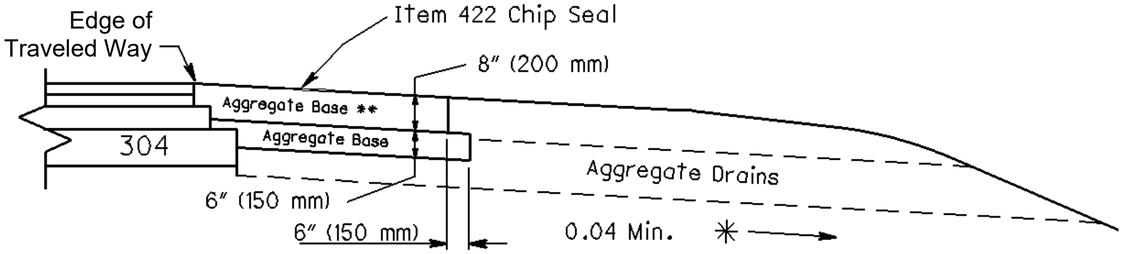
AGGREGATE SHOULDER



SURFACE TREATED



SURFACE TREATED (Greater than 500 trucks in Design Year ADT)



Notes:

The bottom of the aggregate drains shall be at or below the bottom of the pavement's aggregate base at the point of contact. The top of the aggregate drains shall be no higher than the bottom of the shoulder's aggregate base at the point of contact.

* 0.08 Desirable

** A flexible shoulder (Item 301) could be used in lieu of the Surface Treatment

Asphalt Concrete
Quick Reference Guide
Page 1

406-1
January 2024
Reference Section
406

Item	Minimum Lift	Maximum Lift	Taper to 0"*	Uniform Thickness Required
301 Asphalt Concrete Base (449)	3"	6"	No	No
302 Asphalt Concrete Base (449)	4"	7.75"	No	No
424 Fine Graded Polymer Asphalt Concrete, Type A (449)	0.625" (5/8")	1"	No	Yes
424 Fine Graded Polymer Asphalt Concrete, Type B (448 & 449)	0.75"	1.25"	No	Yes
441 AC Surface Course, Type 1 (446)	1.25"	1.5"	No	Yes
441 AC Surface Course, Type 1 (448)	1.25"	1.5"	No	Yes
441 AC Surface Course, Type 1 (449)	1.25"	1.5"	No	No
441 AC Intermediate Course, Type 1 (448)	1"	1.5"	No	Yes
441 AC Intermediate Course, Type 1 (449)	1"	1.5"	Yes	No
441 AC Intermediate Course, Type 2 (446 & 448)	1.75"	3"	No	Yes
441 AC Intermediate Course, Type 2 (449)	1.75"	3"	Yes	No
442 AC Surface Course, 9.5mm, Type A or B (446 & 447)	1.25"	1.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (448)	1.25"	1.5"	No	Yes
442 AC Surface Course, 9.5mm, Type A or B (449)	1.25"	1.5"	No	No
442 AC Surface Course, 12.5mm, Type A or B (446, **447** & 448)	1.5"	2.5"	No	Yes
442 AC Surface Course, 12.5mm, Type A or B (449)	1.5"	2.5"	No	No
442 AC Intermediate Course, 19mm, Type A or B (**446** & 448)	2.25"	3.75"	No	Yes
442 AC Intermediate Course, 19mm, Type A or B (449)	2.25"	3.75"	Yes	No
442 AC Intermediate Course, 12.5mm, Type A or B (**446** & 448)	1.5”	2.5”	No	Yes
442 AC Intermediate Course, 12.5mm, Type A or B (449)	1.5”	2.5”	Yes	No
442 AC Intermediate Course, 9.5mm, Type A or B (448)	1"	1.5"	No	Yes
442 AC Intermediate Course, 9.5mm, Type A or B (449)	1"	1.5"	Yes	No
443 Stone Matrix Asphalt Concrete, 12.5mm (446)	1.5"	2"	No	Yes

Items in **bold** indicate the most commonly used surface and intermediate courses.

Item	Minimum Lift	Maximum Lift	Taper to 0"*	Uniform Thickness Required
803 Rubberized Open Graded Asphalt Friction Course	0.75"	0.75"	No	Yes
823 AC Surface, Type 1, (448)	1	1.5	No	Yes
823 AC Surface, Type 1, (449)	1	1.5	No	No
823 AC Intermediate Course, Type 1, (448)	1	1.5	No	Yes
823 AC Intermediate Course, Type 1, (449)	1	1.5	Yes	No
823 AC Intermediate Course, Type 2, (448)	1.75	3	No	Yes
823 AC Intermediate Course, Type 2, (449)	1.75	3	Yes	No
826 AC Surface Course, Type 1, (448), Fiber A, B, or C	1"	1.5"	No	Yes
826 AC Surface Course, Type 1, (449), Fiber A, B, or C	1"	1.5"	No	No
826 AC Intermediate Course, Type 2, (448), Fiber A, B, or C	1.75"	3"	No	Yes
826 AC Intermediate Course, Type 2, (449), Fiber A, B, or C	1.75"	3"	Yes	No
826 AC Surface Course, 442 12.5mm, (448), Fiber A, B, or C	1"	1.5"	No	Yes
826 AC Surface Course, 442 12.5mm, (449), Fiber A, B, or C	1"	1.5"	No	No
826 AC Intermediate Course, 442 19mm, (448), Fiber A, B, or C	1.75"	3"	No	Yes
826 AC Intermediate Course, 442 19mm, (449), Fiber A, B, or C	1.75"	3"	Yes	No
859 AC with Verglimit	1"	2.5"	No	Yes

* A "Yes" value in this column indicates the material can be specified at a 0" minimum in variable depth applications such as a rut fill course or it can be tapered to 0" at the beginning and end of paving. A "No" value indicates the minimum lift thickness is required at all times and a butt joint is required at the beginning and end of paving. Intermediate courses may taper and end as shown in the butt joint detail in BP-3.1 even with a “No” value.

Table of Contents

500 Pavement Design Procedures for Minor Rehabilitation

500.1 Introduction

Minor rehabilitation occurs when the pavement has deteriorated beyond the point at which a surface treatment is cost effective or the pavement is structurally deficient for the anticipated ESALs but has not yet deteriorated to the point where major rehabilitation is required. Minor rehabilitation usually consists of some combination of planing, repair, and overlay. ODOT designs minor rehabilitation overlays using a non-destructive, deflection-based procedure.

501 Non-Destructive Testing

Non-destructive testing (NDT) is a means of analyzing pavement properties without causing damage. ODOT uses non-destructive deflection measuring equipment for pavement analysis. Deflection measuring equipment imposes a load on the pavement and measures the response. Deflections can be correlated to the structural condition of the pavement and the subgrade. Designers can interpret the deflections and provide recommendations for pavement rehabilitation. ODOT uses the Falling Weight Deflectometer to measure pavement deflections.

501.1 Falling Weight Deflectometer

The Falling Weight Deflectometer (FWD) is an impact load response device used to measure pavement deflection. The impact force is created by dropping a weight of 110, 220, 440, or 660 pounds (50, 100, 200, 300 kg) from a height of 0.8 to 15 inches (20 to 380 mm). By varying the drop height and weight, a peak force ranging from 1500 to 24,000 pounds (6.7 to 106.8 kN) can be generated. The load is transmitted to the pavement through a loading plate, 11.8 inches (300 mm) in diameter, to create a load pulse in the form of a half sine wave with a duration of 25 to 30 ms. The actual magnitude of the load applied depends on the stiffness of the pavement and is measured by a load cell. Deflections are measured by seven to nine velocity transducers (i.e. sensors), one located at the center of the loading plate with the remaining six to eight placed at locations up to 7.4 feet (2.25 m) from the center of the load plate. Deflection measurements are recorded on a computer located in the tow vehicle.

501.1.1 Sensor Setup

For minor rehabilitation analysis, ODOT typically collects seven sensors of measurements located at -12, 0, 12, 24, 36, 48 and 60 inches (-305, 0, 305, 610, 915, 1220, 1525 mm) from the load plate and these are noted as W(-12), W(0), W(12), W(24), W(36), W(48) and W(60) respectively.

501.2 Other Non-Destructive Testing

Ground Penetrating Radar (GPR) is another non-destructive testing method that may provide additional insight into the presence of pavement anomalies (i.e. air, water, or differences in material dielectric constant) as well as estimate in-place thicknesses. Pavement cores are required to correlate GPR scans to pavement thickness. ODOT has not had success correlating the GPR-identified pavement anomalies with scoping pavement repairs and rehabilitation strategies.

A Profilometer is another non-destructive testing method primarily used to obtain the international roughness index (IRI) otherwise known as smoothness. IRI may provide insight into determining if and where the ride needs improvement through planing or diamond grinding. This type of non-destructive testing is most often used by ODOT for smoothness acceptance in construction as specified in proposal note 420.

502 Deflection Testing and Analysis

502.1 Testing

Deflection measurements taken when the subgrade is frozen are meaningless for design. The testing season in Ohio runs approximately April through November. Deflection testing is completed by the Office of Pavement Engineering.

502.1.1 Annual Testing Program

Each year a testing program is established that consists of projects approximately two to three fiscal years in the future to encompass the construction season two years in the future. Testing requests need to include the county, route, begin log, end log, length, PID, fiscal year, pavement type, date needed, etc. All projects must include the exact limits of the project by straight line mileage. In conjunction with research needs, deflection testing is prioritized based on the date needed and scheduled accordingly.

Deflection testing requires a lane closure as the equipment must be stationary to run the test. The Office of Pavement Engineering coordinates with ODOT county forces to schedule traffic control for testing within a county.

502.1.2 Additional Testing Requests

Districts may need to add project sections during the testing season. Additional requests are honored on a first-come, first-served basis, subject to scheduling considerations. Requests made too late in the season may not be tested until the following year. Research testing needs take priority during many of the summer months. The best time to submit requests is just prior to and early in the testing season. Additional requests need to include the same project information described in Section 502.1.1.

502.1.3 Re-testing Requirements

Deflection measurements represent a snapshot of the pavement at the time of measurement. As the pavement continues to deteriorate, the snapshot changes. Deflection measurements should not be obtained more than four years prior to the anticipated construction year. If the project is delayed such that the data will be more than five years old, new deflection measurements should be requested and the design checked against the new measurements to ensure validity.

502.1.4 Testing Protocol

At each location where deflections are measured, the load plate and sensors are placed on the pavement before applying an approximate 9000 pound (40 kN) seating load. After the load plate is seated on the pavement surface, loads of approximately 9000, 12,000 and 15,000 pounds (40, 53.4, and 66.7 kN) are applied to rigid and composite pavements and loads of approximately 6000, 9000 and 12,000 pounds (26.7, 40, and 53.4 kN) are applied to flexible pavements.

The three load responses (deflections) are measured and recorded on the computer in the tow vehicle for each location. Some sections that do not have a uniform build-up for the length of testing may keep the same loading set-up. Measurements are ideally collected in the outside wheel path of the driving lane approximately every 100 to 500 feet (30.5 to 152.4 m) with every third test location a joint approach/leave measurement on composite and rigid pavements. Field restrictions may result in a different test pattern or spacing. For routine analysis and design, a minimum of 30 locations of mid slab type measured deflections is required.

502.2 Analysis

Deflection measurements yield a great deal of information about the pavement when properly interpreted. This Manual is not intended to make the reader an expert in analyzing deflection data. The Office of Pavement Engineering analyzes the deflection measurements and provides District pavement engineers with processed FWD measurements in Excel files and a pavement rehabilitation recommendation letter. The file contains deflection measurements normalized to a 1000 pound (4.4 kN) load, the Edwards Ratio, Design Modulus, Load Transfer, and Joint/Crack Support Ratios as discussed in Sections 502.2.1 to 502.2.4. Separate Excel files are provided for each direction of measurement (i.e. divided sections typically have two files, one for each direction while undivided sections typically have just one file corresponding to the direction collected).

502.2.1 Edwards Ratio

A useful parameter derived from the FWD measurements is called the Edwards Ratio; named after William F. Edwards, former Bureau Chief of Research and Development at ODOT. The Edwards Ratio states that if the W(0) sensor reading divided by the W(60) sensor reading is greater than three, the pavement is acting as a flexible pavement and should be analyzed as such. If it is less than three, the pavement is acting as a rigid pavement and should be analyzed as such. This is very useful when trying to decide how to analyze a brick pavement or a previous break & seat or crack & seat.

502.2.2 Design Modulus

The W(60) sensor can be used to estimate the subgrade support. The estimated subgrade design modulus is listed on the statistical summary tab in the Excel file provided to District pavement engineers.

502.2.3 Load Transfer

Load Transfer can indicate joints that have deteriorated and are no longer effectively transferring the load. Load Transfer less than 0.70 indicate poor load transfer however, Load Transfer greater than 0.70 does not necessarily indicate good joints. If the pavement is warm, the joints may be locked up and showing better load transfer than actually exists. Load Transfer is the W(12) sensor divided by the W(0) sensor, both from the joint approach reading.

When cracks are tested, Load Transfer from one side of a crack to the other is calculated and analyzed in the same manner as joints.

502.2.4 Joint Support Ratio

The Joint Support Ratio is another measure of a joint’s effectiveness. Joint Support Ratio is the W(0) sensor from the joint leave reading divided by the W(0) sensor from the joint approach reading. Joint Support Ratios between 0.50 and 1.50 are considered good. Ratios outside this range indicate probable voids under the joint. Voids are also likely anytime the W(0) sensor measurement is above 1.0.

When mid-panel transverse cracks are tested, a Crack Support Ratio is calculated and analyzed the same as the Joint Support Ratio.

502.3 Factors Affecting Deflections

The major factors that influence deflections include loading, climate, and pavement conditions. These factors must be carefully considered when conducting nondestructive tests and analyzing the results.

502.3.1 Loading

The magnitude and duration of loading have a great influence on pavement deflections. It is desirable that the NDT device applies a load to the pavement similar to the actual design load, e.g., a 9000 pound (4086 kg) wheel load. This is achieved with the FWD utilized by ODOT for deflection measurements.

502.3.2 Climate

Temperature and moisture are the two climatic factors that affect pavement deflections. For asphalt pavements, higher temperatures cause the asphalt binder to soften and increase deflections. For concrete pavements, temperature, whether ambient or thermal gradient within the slab, has a significant influence on deflections near joints and cracks. Concrete expands in warmer temperatures causing tighter joints and cracks and resulting in greater efficiency of load transfer and smaller deflections. Curling of the slabs due to temperature gradients can cause a large variation in measured deflections. Measurements taken at night or early morning, when the top of the slab is colder than the bottom, will result in higher corner and edge deflections than those taken in the afternoon, when the top of the slab is much warmer than the bottom.

The season of the year has a great effect on deflection measurements. In winter, when the subgrade is frozen, deflections are reduced. In the spring there may be increased moisture in the subgrade and deflections increase. ODOT attempts to mitigate the seasonal effects by testing in the summer and fall.

502.3.3 Pavement Conditions

Pavement conditions have significant effects on measured deflections. For asphalt pavements, deflections obtained in areas with cracking and rutting are normally higher than those free of distress. For concrete pavements, voids beneath the concrete slabs will cause increased deflections, and the absence or deterioration of load transfer devices will affect the deflections measured on both sides of the joint.

503 Overlay Design Procedure

503.1 Introduction

The overlay design procedure for minor rehabilitations requires a great deal of preparatory work before analyzing the deflection measurements. The FWD measurements must be available (Section 502), traffic projections must be completed (Section 202), and the history of the pavement must be known.

The pavement history is required to determine the actual buildup of the pavement at the time the FWD measurements were collected. Sources for pavement history include such things as the pavement management system or looking up historical plans. On past overlay projects where the asphalt surface was planed, it is necessary to determine the depth of planing as deflection analysis requires the total thickness of asphalt and/or concrete at the time the measurements were taken. If the thickness or pavement type changes within the project, the deflection measurements will be analyzed separately for each of the different thicknesses or pavement types.

Once all the required information is collected, the Office of Pavement Engineering will process and analyze the deflection measurements. Most of the overlay design inputs for deflection analysis are common to all pavement types: the design traffic input comes from the ESAL11 program (Section 202.3), reliability factors are given in Figure 201-1, the traffic standard deviation is always 0.10, and initial and terminal PSI are always 4.5 and 2.5, respectively. Overlay design inputs specific to each pavement type are discussed in the following sections. The information given here is not intended to fully explain the deflection measurement and analysis procedure.

All of the overlay design inputs and outputs are exclusively in English units.

503.1.1 Design Period

The design period is the number of years over which the pavement is expected to deteriorate from its initial condition to its terminal serviceability. It is the number of years the ESALs are predicted for. The design period is established in Section 102.

503.2 Rigid Pavements

Rigid pavement refers to all types of exposed concrete pavement with no asphalt on top. The minimum overlay thickness for rigid pavements is three inches. Pavements that require an overlay of about one inch or less are candidates for diamond grinding instead of an overlay.

Most of the rigid pavement overlay design inputs for deflection analysis use recommended default values, such as Poisson's Ratio, elastic modulus, initial PSI, terminal PSI, modulus of rupture, and the drainage coefficient shown in Figure 503-1. The thickness of the existing pavement is obtained from the history. The load transfer coefficient (J) is dependent on the specifics of the existing pavement. A list of J-factors for existing pavements is given in Figure 503-1. A rigid pavement with the majority of the joints replaced with flexible repairs should use a J-factor for a pavement with no load transfer at the joints (i.e. undoweled).

503.3 Flexible Pavements

Flexible pavements are made up entirely of asphalt with or without an aggregate or macadam base. Previously rubblized pavements are considered flexible pavement. Previous break & seat and crack & seat projects may be flexible pavement but are more likely acting as composite pavement. The Edwards Ratio can help in determining the appropriate pavement type for analysis in questionable cases.

Most of the overlay design inputs for flexible pavement require project specific values. Overlay design requires the whole thickness of flexible pavement above subgrade including any aggregate base, macadam base, or rubblized concrete, plus the entire thickness of asphalt.

Overlay design requires the surface asphalt layer thickness for temperature adjustment. It is not a sensitive input and may use a default value of 3.5 inches (90 mm). Best practice is to use the thickness of the existing surface and intermediate courses combined. Pavement surface temperature is recorded during FWD testing and stored on the computer in the tow vehicle. Where fluctuating temperatures were recorded for the same data, a weighted average should be used.

Overlay design also requires the 5-day mean air temperature. This should be obtained from meteorological records available on the internet. If temperature records cannot be obtained, the morning pavement surface temperature should be used as the basis for the 5-day mean temperature. Some adjustment is allowed if the designer is aware of specific temperature conditions in the days just prior to the FWD measurements.

503.4 Composite Pavements

Composite pavements are concrete overlaid with asphalt. Most in-service break & seat and crack & seat pavements should be analyzed as composite pavements. Any asphalt-surfaced road with concrete underneath that is acting like a rigid pavement according to the Edwards Ratio, should be analyzed as a composite pavement.

The overlay design inputs for composite pavement are nearly identical to rigid pavement with the addition of asphalt on top (Section 503.2). The thickness of the existing asphalt concrete layer on top of the concrete is required for overlay design. Overlay design uses recommended default values for Poisson's Ratio, resilient modulus of the asphalt, new concrete elastic modulus, initial PSI, terminal PSI, new concrete modulus of rupture, and drainage coefficient. The thickness of existing PCC slab used for overlay design is obtained from the pavement history or coring. The load transfer coefficient (J) is dependent on the specifics of the existing pavement. A list of J-factors for existing pavements is given in Figure 503-1. A composite pavement with the majority of the joints replaced with flexible repairs should use a J-factor for a pavement with no load transfer at the joints (i.e. undoweled).

503.4.1 Brick Base Pavements

Most brick pavements in Ohio were built on a concrete base and have since been overlaid with asphalt and thus are a special kind of composite pavement. The Edwards Ratio can help the user decide which pavement type to use to analyze the brick.

Since brick base pavements occur mostly in urban areas, there are likely to be geometric constraints such as curb reveal, driveways, etc. One method to increase the structural capacity while possibly minimizing elevation changes involves removing the bricks. This should be considered only if the section has been cored to determine the condition and thickness of the underlying concrete. A crack and seat design (see Section 600) is used to determine the new thickness of asphalt to be placed after the old asphalt and bricks have been removed. The actual cracking and seating operation should not be performed as the concrete is likely already well cracked. This method eliminates the need for deflection analysis on a brick base pavement.

504 Minor Rehabilitation Strategies

As stated before, minor rehabilitations generally consist of some combination of planing, repair, and overlay. The structural overlay thickness needed for priority system routes is determined from the FWD measurements by the Office of Pavement Engineering. Even if no additional structure is needed, an overlay may still be required to correct functional deficiencies. The thickness of a functional overlay is selected based on factors such as planing depth, lift thickness requirements, vertical clearance, curb reveal, etc. A functional overlay with planing should never result in thinner pavement than existed beforehand. The other minor rehabilitation actions are at the designer’s discretion based on the condition of the pavement. The actions selected should be those required to reach the full design period for minor rehabilitation projects.

For all minor rehabilitation projects within 300 feet (100 m) of an ODOT permanent traffic count station, include the Traffic Engineering Manual plan note 1342-14 in the plans.

504.1 Asphalt Considerations

All asphalt items used in minor rehabilitation overlays should conform to the guidelines given in Section 400. High stress areas should be identified and treated in accordance with the guidelines in Appendix B. Prior to completion of the plans, all asphalt items specified should be discussed with the District Engineer of Tests or designee. This is important to ensure proper binder grades and mix specifications are specified.

A minimum of 3 inches (75 mm) of asphalt is required over any concrete or brick surface.

504.1.1 Longitudinal Joints in Surface Courses

Cold longitudinal paving joints in surface courses are often the first location to show distress and require maintenance. Item 447 acceptance and SS 872 VRAM are two separate methods available for improving cold longitudinal joint performance.

All priority system asphalt concrete surface course paving not using Item 424 and expected to remain as the surface for three years or more should include cold longitudinal joint improvement. Short sections of paving often associated with bridge, culvert, or intersection projects do not require cold longitudinal joint improvement, but it may be considered.

Limiting the number of cold longitudinal joints in multi-lane pavements is an option but may not be appropriate for all locations.

Limiting cold longitudinal joints can add significant project cost due to the additional trucks, pavers, rollers, and anti-segregation equipment that may be required. Limiting the joints requires sufficient nearby asphalt plant capacity and trucking to provide enough material to keep multiple pavers or a single full width paver moving forward at sufficient ground speed to allow for compaction before the mix cools.

If it is desired to limit the number of cold longitudinal joints, the designer should indicate either the location(s) of the cold joints or the maximum number of cold joints allowed. Typically, two lanes and a shoulder are the widest that can be paved without a cold joint. Do not include any specific method for limiting cold joints, such as requiring full width paving or echelon paving, as it is the contractor’s choice how to achieve the requirements.

Projects using Item 447 acceptance may use SS 872 VRAM on joints excluded from the 447 joint density requirements. Do not place VRAM under joints that will be cored for Item 447 joint density acceptance. The most common place to use VRAM with Item 447 acceptance is when paving against existing pavement to remain in place. When using VRAM with Item 447 acceptance, include a plan note indicating that no joint density cores will be taken where SS 872 VRAM is placed.

504.2 Pavement Planing

Item 254 Pavement Planing, Asphalt Concrete is always recommended prior to placing a new asphalt overlay on an old asphalt surface. A planed surface allows for mechanical interlock between the old pavement and the overlay which helps prevent rutting and debonding. Planing removes the old, raveled, oxidized asphalt which, if left in place, would be a weak layer in the pavement structure and would tend to hold water due to the lower binder content. Planing reduces the overall elevation increase and thus helps reduce geometric problems. Planing removes ruts, top-down cracking, and other irregularities and provides a level surface for the contractor to achieve proper density when 446 or 447 acceptance is specified. When specifying planing in the vicinity of an ODOT permanent traffic count station or weigh-in-motion, always include the Traffic Engineering Manual plan note 1342-13 in the plans.

When planing to remove an entire layer or layers of asphalt, state in the plans the layer(s) to be removed, along with the expected depth. It is recommended the planing depth be specified 0.25 inches (6 mm) deeper than the layer(s) to be removed. Item 254 also allows the planing depth to be increased as much as 3/8 inches (10 mm) during construction without additional compensation. Following these recommendations increases the likelihood of fully removing the intended layer(s) without scabbing or other issues.

When old asphalt is removed, it is necessary to replace the structure removed with an equivalent structure of new asphalt. The structural ratio of new asphalt to old asphalt used in Ohio is 2:3. For example, if 3 inches (75 mm) of asphalt are removed, 2 inches (50 mm) of asphalt are required to replace the lost structure. Any required structural overlay from deflection analysis is then placed in addition to the 2 inches (50 mm). This ratio should not be used to make major reductions in the pavement thickness. In virtually all cases, the pavement thickness after rehabilitation should be equal to or greater than the thickness prior to rehabilitation.

On composite pavements, including brick bases, if all the asphalt is removed down to the concrete or bricks, the minimum overlay thickness for rigid pavements of 3 inches (75 mm) applies.

When planing down to a concrete surface, scarifying the top of the concrete is recommended if the total overlay to be placed is less than 5 inches (125 mm) thick. The scarification should be specified by plan note. The roughened surface increases the bond between the asphalt and the concrete and helps reduce the chances of rutting and debonding.

504.2.1 Brick Base Pavements

When planing asphalt over a brick base, it is recommended to leave about two inches (50 mm) of asphalt on the bricks. Planing any closer can easily dislodge the bricks and pull them up with the asphalt. Dislodged bricks should be quickly repaired, preferably using asphalt concrete (Items 301 or 441 Type 2), to prevent adjacent bricks from moving. Repairs should be made prior to running any traffic over the area, including construction traffic.

504.2.2 Fine Planing

Supplemental Specification 897 Pavement Fine and Micro Planing, Class A for fine planing is available for use with single course thin asphalt concrete overlays to allow for proper compaction. Thicknesses of planing need to be carefully considered to minimize any scabbing. Scabbing occurs when the planing depth is slightly above the interface of two pavement layers and the entire top layer is pulled up in random spots. Fine planing is primarily for surface treatment projects and will not typically be used for minor rehabilitation projects.

504.2.3 Micro Planing

Supplemental Specification 897 Pavement Fine and Micro Planing, Class B for micro planing is available for short term friction remediation and is not intended to be used for minor rehabilitation projects.

504.3 Full Depth Pavement Repair

504.3.1 Rigid and Composite Pavements

Full-depth repairs in rigid and composite pavements most often occur at transverse joints and cracks. Repairs can be made using either concrete or asphalt. The repairs can be at transverse joints, transverse cracks, or any other place that requires full-depth repair.

Rigid repairs according to BP-2.5 using Item 255 Full Depth Pavement Removal and Rigid Replacement are recommended in almost every case. Prior to performing rigid repair, coring is recommended to determine if solid concrete exists to dowel into. Where solid concrete does not exist, flexible repairs using Item 252 Full Depth Rigid Removal and Flexible Replacement are an option. Only coring can reveal if the concrete is solid, FWD analysis and visual inspection of the surface cannot reveal this. Cores should be extracted a minimum of three feet from the joint or crack, near the location of the expected saw cut for the repair.

There are two types of Item 255 repairs. For Type 1 repairs, the surface of the concrete in the repair matches the surface elevation of the existing adjacent concrete, either exposed or composite. Type 2 repairs are exclusively for composite pavements and the surface of the concrete matches the surface elevation of the existing asphalt wearing surface. Exposed concrete always uses Type 1 repairs. The choice of Type 1 or Type 2 for composite pavements depends on the district preference, MOT plans, lane closure times, and other factors.

Three classes of concrete exist for rigid repairs; QC 1, QC MS, and QC RS. Class QC 1 is recommended if the repairs are in a closed lane and adequate time, typically 3 to 7 days, exists for curing. When quicker opening to traffic is needed, one of the other classes may be used. Class QC MS allows opening to traffic in 24 to 28 hours. . Class QC RS allows opening to traffic in 4 to 6 hours. Use of class QC MS, and previously QC FS, has led to problems due to the rapid and significant drying shrinkage. Class RS was developed to overcome these problems and. is recommended whenever a faster setting time is needed.

Full depth repairs are considered economical for quantities up to ten percent of the pavement surface area. When more than ten percent repair is needed, a more thorough investigation is warranted. If not already done, the pavement should be cored to better determine exact repair needs. The required overlay thickness needs to be examined and the possibility of major rehabilitation should be considered. It should be remembered that minor rehabilitations are intended to last twelve years, not twenty. It may not be necessary to repair every joint or crack, especially if the pavement is to receive a thick overlay.

When estimating repair quantities, it is important to correctly calculate the pavement sawing quantities. Transverse saw cuts are required across the pavement at the limits of the repair. A saw cut is also required along any tied longitudinal joint. For a typical six foot (1.8 m) repair in one twelve foot (3.6 m) wide lane on a four-lane divided highway with an asphalt overlay or tied concrete shoulders, the total sawing quantity would be 12 feet + 6 feet + 12 feet + 6 feet = 36 feet (3.6 m + 1.8 m + 3.6 m + 1.8 m = 10.8 m). In limited rare situations where the limits of repair encounter untied side(s), each untied side does not require a saw cut and the calculated quantity should exclude these lengths from the total sawing quantity. For example, a typical six foot (1.8 m) repair in one twelve foot (3.6 m) wide lane on a four-lane divided highway with concrete lanes and asphalt shoulders, the total sawing quantity would be 12 feet +12 feet +6 feet = 30 feet (3.6 m +3.6 m +1.8 m = 9 m).

If the existing concrete has skewed joints, best practice is to make the saw cuts perpendicular to the center line and spaced to encompass the skew and the dowels.

In the past, due to concerns over pressure in concrete pavements, Type D pressure relief joints (see BP-2.4) were sawed at approximately 1000-foot (300 m) intervals in many concrete pavements. This not only relieved the pressure in the pavements but allowed the mid-panel cracks to open up and lose aggregate interlock required for load transfer. These Type D joints should be repaired full depth with rigid repairs whenever they are encountered. As long as a method to relieve pressure exists at the bridges, there is rarely a need for any additional pressure relief joints in a concrete pavement.

Some concrete pavements have had joints and cracks repaired with full depth flexible repairs. These asphalt repairs tend to hump up as the concrete expands, forming mini speed bumps which can be very detrimental to the ride and can be a maintenance headache. When a large number of asphalt repairs exist, it is generally impractical to re-repair them with concrete. However, if there are only a few flexible repairs or if the concrete is in excellent condition except for the flexible repairs, it may be practical to replace all the flexible repairs with rigid repairs.

When replacing two or more consecutive slabs, best practice is to specify the individual items of work, such as 202 Pavement Removed and 452 Non-Reinforced Concrete Pavement, rather than specifying a long 255 repair. The plans should include notes to match the transverse joint spacing and location with the transverse joints in any adjacent, tied concrete pavement.

504.3.2 Flexible Pavements

Flexible pavements may require full-depth repair due to potholes, wheel track cracking, transverse thermal cracks, etc. Full-depth repairs in flexible pavements are done using Item 253 Pavement Repair. As with rigid and composite pavements, when full-depth repair quantities exceed about ten percent, further investigation is warranted and major rehabilitation should be considered. For construction purposes, the minimum practical repair size is 2 feet by 2 feet (0.6 m x 0.6 m), however it is best if the repairs are sized such that hand placement and compaction is avoided.

Transverse thermal cracks are similar to transverse joints in concrete pavement. As flexible pavements expand and contract with temperature, if the binder is too stiff the pavement will crack. These cracks can be random or can be regularly spaced just like joints in concrete. Thermal cracks are full-depth cracks through the entire thickness of the pavement and, if they are to be repaired, must be repaired full depth to correct them.

504.3.3 Brick Base Pavements

Brick base composite pavements built on a concrete base typically do not have joints but often require full-depth repair. Full-depth repairs should be made using Item 305 Concrete Base, As Per Plan to the top of the bricks. A plan note needs to be written to handle all project specific concerns. In general, the note should eliminate the need for dowels, tie bars, joint forming, joint sealing, and texturing requirements. This assumes the brick has an asphalt overlay or is going to receive one.

Full-depth repair of brick base composite pavements built on a flexible base should be made Item 253 Pavement Repair. Alternatively, the repairs may specify the depth of Item 304 Aggregate Base and/or Item 301 Asphalt Concrete Base to be placed.

As many brick pavements occur inside municipalities, the agency responsible for maintenance should be contacted regarding their repair standards. This is particularly true for exposed brick pavements that will remain exposed. ODOT does not have standards for building or repairing exposed brick pavements.

504.3.4 Pavement Coring

Coring is completed with a drill rig capable of extracting a minimum of 4 inch (100 mm) diameter cores the depth of the pavement layers. Cores are used primarily to determine or confirm in-place layer thicknesses and conditions before finalizing a repair strategy. Coring can be completed by either District forces where available or the Office of Pavement Engineering. Requests are handled on a first-come, first-served basis, subject to scheduling considerations.

504.4 Partial Depth Pavement Repair

504.4.1 Concrete Pavement

Partial depth repairs in exposed concrete pavement are specified using Item 256 Bonded Patching of Portland Cement Concrete Pavement. Bonded patches are most commonly used to repair surface spalling along transverse and longitudinal joints. Item 256 patches are very dependent on good workmanship, a clean patch area, and proper bonding grout installation. ODOT has limited experience with bonded patches in concrete.

Bonded patches are not recommended on projects that will overlay the concrete. Any spalls or distresses needing repair prior to overlay should be filled with asphalt prior to the overlay. Minor spalls can be paved over and filled in with the first lift of the overlay. If there are a large number of minor spalls, a small quantity of asphalt may be added to the quantity for the first lift to account for the additional material.

504.4.2 Asphalt Surfaces

Asphalt surfaces include both full depth flexible and composite pavements. Partial depth repairs in asphalt surfaces are specified using Item 251 Partial Depth Pavement Repair. Repairing all the asphalt down to the concrete on a composite pavement is a partial depth repair. Partial depth repairs are most successfully used to correct areas of debonding or localized severe raveling.

Partial depth repairs are not an effective way to fix most cracking. Top down cracking is unlikely to reflect through an overlay and can be cost effectively removed by planing off the surface. Bottom up cracking will reflect through partial depth repairs and any overlay. Partial depth repairs will not stop reflective cracking on composite pavements. Coring can help determine the type of cracking.

Stripped layers deep in the pavement structure are better addressed with full depth repairs rather than partial depth. Partial depth repairs must extend below the stripped layer to be effective.

Specify 441 or 442 partial depth repairs to match the overlay material being used on the project, or whichever material is appropriate when the project does not include an overlay. For construction purposes, the minimum practical repair size is 2 feet by 2 feet (0.6 m x 0.6 m), however it is best if the repairs are sized such that hand placement and compaction is avoided.

504.5 Reflective Crack Control

Composite pavements develop reflective cracks in the asphalt over transverse or longitudinal joints or cracks in the concrete below. Reflective cracks are inevitable with composite pavements. Reflective cracks may also occur in flexible pavements, particularly over thermal cracks and the longitudinal joint formed when a pavement is widened. Other reflective crack control options may be available, however only details regarding sawing and sealing, fabrics and geogrids, and interlayers are discussed.

504.5.1 Sawing and Sealing

Sawing and sealing asphalt concrete pavement joints, Item 409, consists of making a partial-depth saw cut in the asphalt overlay finished surface directly over transverse joints in the underlying concrete pavement immediately after paving. After the saw cuts are made, they are filled with a hot applied joint sealer. Sawing and sealing can be effective in controlling the location and deterioration of reflective cracks. Properly locating and aligning the saw cuts is critical for the treatment to have any chance of success. Sawing and sealing should be considered anytime the concrete is exposed, either because it has never been overlaid or because any overlay has been removed.

504.5.2 Fabrics and Geogrids

Paving fabrics and geogrids have not been found to be cost effective in reducing transverse reflective cracking. Studies have shown that fabrics can delay and sometimes reduce reflective transverse cracking, but not to the extent that future maintenance needs are less costly or come at a later time. Paving fabrics effectiveness in reducing reflective cracks over longitudinal joints was monitored for 10 years and compared to control sections. The results were inconclusive on the ability of the fabrics to delay the appearance or reduce the severity of longitudinal cracking.

Fabrics may be considered for longitudinal joints, particularly widening joints and joints at concrete/asphalt interfaces however, these types of applications should include a control section approximately one mile (1.6 km) long to monitor performance. Notify the Office of Pavement Engineering of the location of the fabric and control section. A minimum overlay thickness of 1.5 inches (38 mm) should be placed above fabric installations.

Due to each proprietary material having different specifications and a lack of cost effectiveness data for Ohio, a generic specification has not been developed.

504.5.3 Interlayers

Interlayers are intended as stress relieving layers to reduce or delay reflective cracking. ODOT conducted a study of chip seal interlayers and concluded they were not a cost-effective solution to reduce or delay reflective cracking on composite pavements..

Interlayers can be constructed using a chip seal or void reducing asphalt membrane (VRAM). Chip seal interlayers consist of placing an Item 422 Single Chip Seal, Type A on a planed or unplaned surface prior to placing an asphalt concrete overlay. Wait at least 24 hours before placing the asphalt concrete overlay. Apply tack coat prior to the overlay. Use the new asphalt application rate for estimating the tack coat quantity. When planing prior to a chip seal interlayer, SS 897 Fine Planing is recommended.

VRAM interlayers consist of an application of Item 872 Void Reducing Asphalt Membrane at a rate of 0.25 to 0.30 gallons per square yard (1.13 to 1.36 L/m^2) prior to placing an asphalt concrete overlay. VRAM interlayers are more easily constructed as part of a standard paving operation.

504.6 Concrete Pavement Restoration

Concrete Pavement Restoration (CPR) generally consists of some combination of full- and partial-depth repair, load transfer retrofit, cross stitching, diamond grinding, joint resealing, undersealing, etc. Experience has shown that adding tied concrete shoulders where they don’t already exist is not cost effective and is not recommended as part of a CPR project. CPR is recommended as the first rehabilitation action for most exposed concrete pavements. CPR maintains the concrete surface and avoids the reflective cracking that comes with composite pavements. CPR is not recommended for pavements built with slag aggregate as they tend to deteriorate from the surface down and diamond grinding can speed this deterioration.

504.6.1 Load Transfer Retrofit

Load transfer can be established across transverse cracks by retrofitting dowel bars or deformed bars. Dowel bars are recommended when the crack extends across all tied concrete lanes and shoulders. Deformed bars are recommended when the crack exists in one lane but not the adjacent tied lane or shoulder. The choice of dowel or deformed bars should be shown in the plans or marked by the Engineer. It should never be left to the contractor to choose. All the bars across a crack are required to be the same type, never a mixture of dowels and deformed bars.

Dowel bar retrofit can be used to establish load transfer at undowelled joints however, most pavements in Ohio were constructed with dowels. Details on load transfer retrofit can be found in C&MS Item 258 and SCD BP-2.6.

504.7 Geometric Issues

Many times there are geometric deficiencies with the roadway such as vertical clearance, curb reveal, cross-slope, etc., that need to be addressed. Some geometric deficiencies can be easily corrected as part of the pavement rehabilitation. Cross-slopes can be adjusted with either variable depth planing or a layer of asphalt with variable thickness or in extreme cases a combination of the two. Other problems are not fixed so easily.

To meet at-grade bridges and provide minimum clearance requirements under overhead bridges, the overlay is often thinned down or the planing depth increased. The minimum overlay thickness on concrete must still be maintained. If the minimum overlay thickness cannot be maintained, pavement must be removed or bridges raised. These areas with thinner pavement structure may exhibit more extensive and severe distresses as they age and will require more maintenance than the surrounding pavement. In some cases where a thick structural overlay is required, thinning down is not recommended and the pavement should be replaced or bridges raised.

Curb reveal is often a problem in urban areas. The structural needs of the pavement should not be compromised to save old curb. Where there is insufficient curb height for the required overlay, the curbs should be replaced. When only a functional overlay is needed, then it may be practical to increase the planing depth at the face of the curb to provide the full overlay thickness while still maintaining the curb height.

504.8 Pavement Widening

When widening a pavement, the best practice is to design the widening for the traffic and soils conditions present. When traffic and soils information is not available, the designer should match the in-place pavement type, materials and thicknesses. Best practice is for the old pavement and the widening to meet at the same subgrade elevation. If necessary, the widening may be built thicker than the abutting pavement but should not be built thinner. The base under the widening should slope away from the old pavement and drainage should be provided for the widening. Drainage can be achieved with pipe underdrains or possibly aggregate drains. Pipe underdrains should be tied into the existing outlets, if any.

Pavement widening in this section refers to additional driving lane width, additional lanes, turn lanes, etc. Widening projects in excess of four lane-miles must follow the Pavement Type Selection process in Section 104.

When adding or widening paved shoulders only, asphalt pavement is typically used regardless of the driving lanes pavement type. Matching subgrade elevation and providing drainage is recommended.

504.8.1 Rigid Pavement

When widening rigid pavement with concrete, if the widening is tied to the existing, the new pavement should be the same type as the old (reinforced or non-reinforced). Prior to specifying tying the widening, the existing concrete should be cored to determine soundness. Where coring discloses unsound pavement; cutting back to sound concrete, performing pavement repairs, replacing the pavement, or widening with an untied longitudinal joint should be considered. Widening of concrete pavement without tying longitudinally may create separation or longitudinal faulting depending on traffic. The plans need to show if the widening is tied or untied. Details for widening are shown in BP-8.1.

The most important consideration when widening and tying rigid pavement is that transverse joints in the widening must be of the same type, placed at the same location, and in the same alignment as the old concrete joints. Mismatched transverse joints will induce cracking. Longitudinal joints are to be located at lane lines however, in a widening situation this may not be possible. The worst location for a longitudinal joint is in the wheel path. If necessary, remove part of the old pavement to prevent locating a longitudinal joint in the wheel path.

Rigid pavements to be overlaid as part of the widening project should be considered composite pavements and follow the widening guidelines given in Section 504.8.3.

When widening a rigid pavement with another pavement type, the widening should be designed for the conditions at hand. If necessary, the base under the widening should be thickened so that the subgrade elevations will match. If the widening is thicker than the abutting pavement, the subgrade should be sloped away from the old pavement and drainage provided.

504.8.2 Flexible Pavement

When widening flexible pavement with asphalt, the best practice is to make a saw cut at the edge of a lane and remove the outside edge of the old asphalt. This not only removes the uncompacted asphalt at the edges, but ensures there will not be a longitudinal construction joint in the wheel path. When matching thickness with the in-place buildup, the exact buildup and lift thicknesses should follow the guidelines given in Section 406. Details for widening are shown in BP-3.1.

When widening a flexible pavement with another pavement type, the widening should be designed for the conditions at hand. If necessary, the base under the widening should be thickened so that the subgrade elevations will match. If the widening is thicker than the abutting pavement the subgrade should be sloped away from the old pavement and drainage provided.

504.8.3 Composite Pavement

When widening composite pavement with composite pavement, not only should the subgrade elevations match but the surface of the concrete must match as well. Because it will be overlaid immediately, use Item 305 Concrete Base for the concrete regardless of what type the old concrete is.

Prior to widening with composite pavement, the existing pavement should be cored to determine the condition of the existing concrete. If the existing concrete is sound, the widening should be tied to the existing pavement as shown in BP-8.1. When tying, if the existing concrete is reinforced, include a plan note requiring the 305 Concrete Base to be reinforced. Where coring discloses unsound pavement; cutting back to sound concrete, performing pavement repairs, replacing the pavement, or widening with an untied longitudinal should be considered. Untied widening may lead to more rapid and severe distress along the longitudinal joint. The plans need to show if the widening is tied or untied. Details for widening are shown in BP-8.1.

The longitudinal joint between the old and new concrete is to be located at a lane line however, in a widening situation this may not be possible. It is recommended that some of the old pavement be removed rather than placing the longitudinal joint in a wheel path.

When widening a composite pavement with another pavement type, the widening should be designed for the conditions at hand. If necessary, the base under the widening should be thickened so that the subgrade elevations will match. If the widening is thicker than the abutting pavement the subgrade should be sloped away from the old pavement and drainage provided. Widening composite pavement with flexible pavement should follow the details in BP-3.1.

504.8.4 Wheel Path Location

The location of the wheel path varies depending on lane width and traffic wander. Where the wheel path location is known, use known limits for these locations. In lieu of project specific details of traffic wander and wheel path location, typical lane widths of 10, 11 and 12 feet (3.05, 3.35, 3.66 m) have corresponding wheel paths assumed to be located at 42 to 60 inches (1.07 to 1.53 m), 41 to 61 inches (1.04 to 1.55 m) and 40 to 62 inches (1.02 to 1.58 m), respectively, from the center of lane. Generally, the wider the lane the more traffic wander and the larger the wheel path. If the longitudinal widening joint must be placed in the lane, locate it in the center of the lane or a maximum of 3 feet (0.91 m) from the center.

504.9 Shoulder Use for Maintenance of Traffic

When minor rehabilitation requires the use of shoulders for maintenance of traffic operations during construction, the structural integrity of the shoulders should be verified. Verification may include pavement history, coring, non-destructive testing, empirical calculations etc., to determine the feasibility of use. Shorter duration maintenance of traffic operations, typical of minor rehabilitations, may not require as detailed an investigation as required for longer operations.

504.9.1 Pavement for Maintaining Traffic

When the shoulders are deemed structurally inadequate for maintenance of traffic operations during construction, they may require replacement. The replacement pavement is typically constructed in accordance with Item 615 Roads and Pavements for Maintaining Traffic. If the replacement pavement will be left in place, design calculations should be performed to confirm that the proper thicknesses and materials are specified.

500 Pavement Design Procedures for Minor Rehabilitation

List of Figures

Overlay Design Inputs

503-1
July 2015
Reference Section
503

Parameter	Recommended Default Value
Reliability - All	see Figure 201-1
Standard Deviation of Traffic - All	0.10
Initial PSI - All	4.5*
Terminal PSI - All	2.5
Poisson's Ratio - Asphalt	0.35
Resilient Modulus - Asphalt	450,000 psi
Poisson's Ratio - Concrete	0.15
Elastic Modulus - Concrete	5,000,000 psi
Modulus of Rupture - Concrete	700 psi
Drainage Coefficient - Concrete	1.0
Load Transfer Coefficient - Concrete	See below

* New rigid pavement design uses 4.2 as the Initial PSI, however when analyzing an exposed rigid pavement for overlay design an initial PSI of 4.5 should be used.

Load Transfer Coefficient (J)

Existing Pavement	Edge Support**	No Edge Support
Jointed Doweled	2.7	3.2
Jointed Undoweled	3.8	4.2
Continuously Reinforced	2.4	3.0

** Edge support includes tied concrete shoulders, integral curb, widened lane, etc. Widened lane refers to concrete slabs built 14 feet (4.2 m) wide or wider, but striped for a standard 12-foot (3.6 m) lane, leaving 2 feet (0.6 m) outside the traveled lane to provide edge support.

550 Surface Treatments

Table of Contents

550 Surface Treatments

550.1 Introduction

Pavement surface treatments require a planned approach to extend the service life of existing pavements. Surface treatments should be used on structurally sound pavements to reduce the infiltration of water through the surface, retard oxidation, arrest top down cracking, and enhance friction, thus preserving the structure. Surface treatments include crack sealing, chip sealing, microsurfacing, fine graded polymer asphalt concrete overlays, and asphalt rejuvenation for asphalt surfaces; or diamond grinding for concrete surfaces. Details concerning asphalt concrete material specifications and lift thicknesses can be found in Section 400.

551 Crack Sealing

Crack sealing is the placement of hot applied material in or over cracks in the pavement. Types I, II, and IV crack sealing uses a neat or modified binder, such as a PG64-22, which may be mixed with polyester fibers. Type V crack sealing uses an asphalt mastic mixed with aggregate. Crack sealing is used to minimize the intrusion of water into the pavement. By keeping water out of the pavement, erosion of the mix is kept to a minimum, deterioration of the crack is slowed, and less water is available to deteriorate the underlying materials.

551.1 Project Selection

There is not a crack seal decision tree in the pavement management system and therefore the system does not provide recommended crack seal candidates. Although the performance effectiveness of crack sealing both flexible and composite pavements has been established, cost effectiveness occurs within a very tight band of pavement condition. Only flexible and composite pavements are considered for crack sealing. Crack sealing rigid pavements is not considered cost effective.

Pavements selected for crack seal should have sufficient cracking for mobilization to be worthwhile but not be excessively cracked. Research has found the most effective and practical time to crack seal is in the PCR range of 65 to 80. In addition to the PCR range, the Office of Pavement Engineering has placed additional constraints on individual distresses and combinations of distresses for determining appropriate candidates. In general, cracks that display significant raveling of the crack face and secondary branch cracking (Figure 551-1) need more than a Type I, II, or IV crack seal and should be considered for Type V crack seal or some other treatment. Furthermore, pavements that require more than 5000 pounds of Type I, II, or IV crack seal material per lane mile (1400 kg per lane km) are questionable candidates for crack sealing.

551.2 Design Considerations

Crack Sealing is specified using Item 423. The following pay items are available:

Item	**Unit**	**Description**
423	Pound	Crack Sealing, Type I
423	Pound	Crack Sealing with Routing, Type I
423	Pound	Crack Sealing with Sawing, Type I
423	Pound	Crack Sealing, Type II
423	Pound	Crack Sealing, Type IV
423	Pound	Crack Sealing, Type V
423	Square Yard	Crack Sealing, Type I
423	Square Yard	Crack Sealing with Routing, Type I
423	Square Yard	Crack Sealing with Sawing, Type I
423	Square Yard	Crack Sealing, Type II

423	Square Yard	Crack Sealing, Type IV
423	Square Yard	Crack Sealing, Type V

The different “Type” crack seal descriptions refer to differences in material, equipment, mixing, and application of the sealant. The specification also includes dimensions for the sealant reservoir when routing or sawing is used.

Choosing the proper crack seal material type is very important. Type I and Type IV materials are **not** appropriate for pavements that will be microsurfaced within 2 years. The option of routing or sawing cracks prior to crack sealing is also provided with Type I, however it should be considered only when pavements are not expected to be treated for several years and where cracks are newly formed. Type II material should be specified for preparing pavements just prior to microsurfacing or chip sealing. All types of crack sealing should be aged at least a full 12 months prior to any type of asphalt overlay to prevent tearing of the overlay during the rolling process.

Crack seal may be specified by either square yard or pound. Square yard pay items tend to reduce the amount of crack sealer placed and prevent excessive amounts of crack seal. Paying by the pound is more likely to result in all the cracks being sealed but can lead to excessive sealant on the surface, which can reduce friction. Regardless of the pay item selected, good inspection is critical to a successful crack seal project.

551.2.1 Type I, II, and IV Crack Seal

Figure 551-2 contains a table showing the estimated pounds of crack seal material required for various crack widths and depths. The table is based on a unit weight of material of 63 pounds per cubic foot (1009 kg/m^3) and does not account for waste or spillage. The table is applicable for Type I, II, and IV crack seal pay items.

Crack sealing with Type I, II, or IV is not an acceptable treatment for cracks wider than one inch (25 mm), regardless of the material or unit of measurement. Cracks one inch (25 mm) and wider should be addressed with full or partial depth repairs or Type V crack seal.

551.2.2 Type V Crack Seal

Type V crack seal is an aggregate and asphalt mastic sealant intended for cracks wider than one inch (25 mm), preferably wider than 1.5 inches (38 mm). It is primarily intended for sealing wide longitudinal cracks, usually along longitudinal paving joints, but can be used on any wide cracks and even as a pothole filler.

Figure 551-3 contains a table showing the estimated pounds of Type V crack seal material required for various crack widths and depths. The table is based on a unit weight of material of 105 pounds per cubic foot (1682 kg/m^3) and does not account for waste or spillage.

552 Chip Sealing

Chip seal is the sprayed application of a polymer-modified asphalt binder covered immediately by a washed aggregate and rolled with a pneumatic roller. Chip seals are best placed as single course applications. Double chip seals have had multiple problems when used on ODOT projects and their use is discouraged. Chip seal is intended for low volume roadways to provide a new wearing surface as well as to eliminate raveling, retard oxidation, reduce the intrusion of water, and improve surface friction.

552.1 Project Selection

The pavement management system provides a yearly list of recommended chip seal candidates based on the optimized solution. The system also contains all possible chip seal candidates, even those not selected in the optimized solution. Further investigation of any chip seal is recommended however, since the candidates are identified based on projected PCR distresses only and a field visit will further differentiate good candidates from bad.

Chip seal is restricted to pavement sections with low traffic volumes and low truck traffic. The exact limits of traffic and truck traffic are set in the pavement management system decision trees. Results from ODOT sponsored research indicate the most appropriate PCR range for cost effective chip sealing is between 65 and 80. In addition to the PCR range, the Office of Pavement Engineering has placed additional constraints on individual distresses for determining appropriate candidates. The pavement management system decision trees show the exact levels of allowable/not allowable distress for chip seal.

Pavements that exhibit debonding, bleeding, or rutting (>3/8-inch [9.5 mm]) problems are not eligible for chip seal. Furthermore, allowable levels of wheel track cracking, potholes, and edge cracking require repair prior to placing a chip seal if they indicate structural deficiencies.

552.2 Design Considerations

Chip seal is specified using Item 422. The specification includes a project review 25 to 35 days after placement and a two year warranty. The warranty provides for remedial action of surface defects such as surface patterns, bleeding, flushing, and loss of cover aggregate.

The aggregate and emulsion for chip seal are paid separately. Aggregate is paid by the square yard. The emulsion is paid by the gallon. The estimated application rate of emulsion for determining plan quantities is 0.4 gallons per square yard (1.8 L/m^2).

The specification requires separate payment for removal of all pavement markings.

Single and double chip seals require removal of raised pavement markers paid separately under Item 621 Raised Pavement Markers Removed.

The specification includes two gradations, Type A and Type B. The Type A gradation is recommended for single chip seals. The Type B gradation is not recommended for single chip seals. For double chip seals, the specification requires Type A for the first course and Type B for the second course.

Where repairs are needed prior to a chip seal they should be performed approximately one year prior to the chip seal to ensure uniform absorption of the seal coat.

Chip seals have been used successfully on shoulders where inlays were used on the driving lanes. Where rumble strips or rumble stripes are covered with a single chip seal, they remain functional for the life of the chip seal.

553 Microsurfacing

Microsurfacing is a thin (1/4 – 3/8 inches [6 – 9.5 mm] thick) surface coat of cold applied paving mixture composed of polymer-modified asphalt emulsion, 100 percent crushed aggregate, mineral filler, water, and other additives. Microsurfacing is used to retard raveling and oxidation, fill ruts, reduce the intrusion of water, improve surface friction, and remove minor surface irregularities.

Microsurfacing is best placed using a self-propelled, continuous loading machine to proportion and mix the materials and apply the mixture to the pavement surface. This continuous loading machine can pave for a full production day without a transverse construction joint. The machine holds a sufficient amount of material to continue operating between truckloads.

Another method to place microsurfacing is with a truck-mounted microsurfacing paver. In this process, the mix is batched at a central plant, transferred to the site, and connected to the truck-mounted machine. Each time a truck is emptied, the machine is stopped, unhooked and the new truck is hooked up. The process of changing trucks creates a transverse construction joint in the surface. The specifications limit the use of truck-mounted machines to projects of less than 15,500 square yards (13,000 m^2), projects with multiple routes where every route is less than 15,500 square yards (13,000 m^2), or where specified in the plans. If there is any uncertainty or the designer wants to specifically allow or dis-allow the truck mounted machines, a note should be put in the plans.

553.1 Project Selection

The pavement management system provides a yearly list of recommended microsurfacing candidates based on the optimized solution. The system also contains all possible microsurfacing candidates, even those not selected in the optimized solution. Further investigation of any microsurfacing project is recommended however, since the candidates are identified based on projected PCR distresses only and a field visit will further differentiate good candidates from bad.

Results from the most recent ODOT sponsored research indicates the most appropriate PCR range for cost effective microsurfacing is between 65 and 80. In addition to the PCR range, the Office of Pavement Engineering has placed constraints on individual distresses for determining appropriate microsurfacing candidates. The pavement management system decision trees show the exact levels of allowable/not allowable distress for microsurfacing.

There are no traffic volume restrictions for microsurfacing. Localized wheel track cracking or edge cracking should be repaired full depth with Item 253. Any potholes must be repaired full depth with Item 255 for composite pavements or Item 253 for flexible pavements. Areas that exhibit debonding must be patched with Item 251. All existing patches must be in good repair prior to microsurfacing. All existing cracks must be sealed prior to microsurfacing. In general, cracks that indicate areas of structural weakness such as wheel track and edge cracking need full depth repair prior to microsurfacing. Figure 553-1 shows examples of cracks requiring repair.

Microsurfacing is not recommended on bridge decks that have been sealed with high molecular weight methacrylate (HMWM).

553.2 Design Considerations

Microsurfacing is specified using Item 421. The specification includes a two year warranty. The warranty provides for remedial action of surface defects such as debonding, raveling, and bleeding.

Where rutting greater than 3/8 inches (9.5 mm) is present, a microsurfacing rut fill course is recommended. For the rutting condition, it is advisable to ensure the rutting is arrested and the rutted layer is no longer deforming. Microsurfacing will not stop an unstable mix from continuing to deform.

A single course microsurfacing can be used to cover light raveling and improve skid resistance on a structurally sound pavement. A multiple course microsurfacing is used to correct other minor pavement surface deficiencies, such as medium severity raveling, medium severity bleeding, or rutting as deep as 1.5 inches (38 mm). Rutting less than 3/8 inches (9.5 mm) can be filled using a leveling course, whereas rutting 3/8 inches (9.5 mm) or greater should be filled using the rut fill course.

Item 421 includes Microsurfacing, Surface Course (FR) that requires a blend of high polish resistant aggregate (i.e. traprock) for use in areas of high friction demand. Surface Course (FR) is intended for use as part of a friction remediation plan and should not be used unless there is need for enhanced polish resistance.

A tack coat is placed prior to the application of the microsurfacing material. The cost of the tack coat is incidental to the microsurfacing.

The specification requires separate payment for removal of all pavement markings. The specification also requires removal of raised pavement markers paid separately under Item 621 Raised Pavement Markers Removed.

Due to the brittle nature of microsurfacing it is a poor crack sealer. Surface preparation for microsurfacing includes crack sealing. The cost of crack sealing is incidental to the microsurfacing.

Microsurfacing has been used successfully on shoulders with rumble strips. Single application microsurfacing can be placed on rumble strips without loss of functionality. A double application microsurfacing placed on shoulders will fill in the rumble strips. A separate operation to pre-fill the rumble strips prior to a double application microsurfacing is not necessary. New rumble strips can be installed after a double application microsurfacing.

It is believed that rumble stripes can be treated the same as rumble strips but there have been few, if any, applications to date

554 Fine Graded Polymer Asphalt Concrete

Fine Graded Polymer Asphalt Concrete (Item 424) is a thin surface, asphalt concrete paving mixture composed of polymer modified asphalt cement mixed with aggregate. A conventional asphalt plant and asphalt-paving machine is used to mix and place the material. This mixture is used to retard raveling and oxidation, reduce the intrusion of water, improve surface friction, and improve minor surface irregularities.

554.1 Project Selection

The pavement management system provides a yearly list of recommended candidates for fine graded polymer asphalt concrete based on the optimized solution. The system also contains all possible candidates, even those not selected in the optimized solution. Further investigation of any fine graded polymer asphalt concrete candidate is recommended however, since the candidates are identified based on projected PCR distresses only and a field visit will further differentiate good candidates from bad.

Results from the most recent ODOT sponsored research indicates the most appropriate PCR range for cost effective thin overlays, including fine graded polymer asphalt concrete, is between 65 and 80. In addition to the PCR range, the Office of Pavement Engineering has placed additional constraints on individual distresses for determining appropriate candidates. The pavement management system decision trees show the exact levels of allowable/not allowable distress for fine graded polymer asphalt overlays.

There are no traffic volume restrictions for fine graded polymer asphalt concrete. It may not be cost effective for pavements with excessive, cracking, potholes, rutting, or debonding. Localized wheel track cracking or edge cracking should be repaired full depth with Item 253. Any potholes must be repaired full depth with Item 255 for composite pavements or Item 253 for flexible pavements. Areas that exhibit debonding must be patched with Item 251. All existing patches must be in good repair prior to placing a fine graded polymer asphalt concrete overlay.

554.2 Design Considerations

Two mix gradations are available for this specification. Type A uses 8.5 percent polymer modified asphalt binder, has the finer mix gradation, uses a recipe-type design, and is accepted using Item 449 requirements. Type A is not for use in any location with high friction demand or legal speed limit greater than 40 miles per hour. Type A should not be used in locations with greater than 1500 trucks per day regardless of friction demand or speed. Type B uses a minimum of 6.4 percent polymer modified asphalt binder, has aggregate as large as a 3/8-inch sieve, and uses the Marshall mix design method. Type B may be used with any traffic level but is required for locations with 1500 trucks per day or more. Type A mixes are accepted using Item 449 requirements. Type B mixes are accepted using Item 448 or 449 requirements.

The appropriate treatment when overlaying shoulders with rumble strips is to use a scratch course to repair/fill the rumble strips prior to overlay. Once overlaid, new rumble strips can be cut into the fine graded polymer asphalt concrete.

555 Rejuvenating Agents

ODOT conducted research on the use of penetrating sealers to extend asphalt pavement service life. The research showed an immediate and significant reduction in skid number after the sealers were applied, however it did improve over time. Also, the research did not show any improvement in pavement performance or extension of pavement life based on the PCR. As a result of this research, ODOT does not consider penetrating sealers a cost effective treatment. and no standard specifications exist.

556 Diamond Grinding

Diamond grinding is used to provide a smooth driving surface on exposed concrete pavements that have become rough due to faulting or cracking. It can also be used to restore or improve surface friction but should not be used with polishing aggregate. Diamond grinding is often performed in combination with repairs or load transfer retrofit as a minor rehabilitation project rather than a surface treatment.

556.1 Project Selection

The pavement management system provides a yearly list of recommended diamond grinding candidates based on the optimized solution. The system also contains all possible diamond grinding candidates, even those not selected in the optimized solution. Further investigation of any diamond grinding project is recommended however, since the candidates are identified based on projected PCR only and a field visit will further differentiate good candidates from bad.

There are no traffic volume restrictions for diamond grinding. It is not recommended for pavements built with slag aggregate as they tend to deteriorate from the top down and the diamond grinding can speed the deterioration.

556.2 Design Considerations

Diamond grinding is specified using Item 257. Shoulders are not ground except as necessary to provide positive lateral drainage. Diamond grinding is not likely to affect any shoulder rumble strips.

550 Surface Treatments

List of Figures

Poor Crack Seal Candidates

551-1

July 2024

Reference Section

551

Poor candidates for Type I, II, and IV crack sealing

Crack Seal Quantity Estimate

551-2
July 2024
Reference Section
551

Crack Seal Quantity Estimate[1,2]

Depth of Crack (inches)	Average width of crack opening (inches)					
	1/4	**3/8**	**1/2**	**5/8**	**3/4**	**7/8**
3/4	8.2	12.3	16.4	20.5	24.6	28.7
7/8	9.6	14.4	19.1	23.9	28.7	33.5
1	10.9	16.4	21.9	27.3	32.8	38.3
1-1/8	12.3	18.5	24.6	30.8	36.9	43.1
1-1/4	13.7	20.5	27.3	34.2	41.0	47.9
1-38	15.0	22.6	30.1	37.6	45.1	52.6
1-1/2	16.4	24.6	32.8	41.0	49.2	57.4
1-5/8	17.8	26.7	35.5	44.4	43.3	62.2
1-3/4	19.1	28.7	38.3	47.9	57.4	67.0
1-7/8	20.5	30.8	41.0	21.3	61.5	71.8
2	21.9	32.8	43.8	24.7	65.6	76.6

[1] Pounds required per 100 linear feet of crack for Types I, II, and IV crack seal
[2] For Type II overband treatments, add 29 pounds per 100 linear feet

Type V Crack Seal Quantity Estimate

551-3
July 2024
Reference Section
551

Crack Seal Quantity Estimate[1]

Depth of Crack (inches)	Average width of crack opening (inches)						
	1	**1.5**	**2**	**2.5**	**3**	**3.5**	**4**
1	75	110	150	180	220	250	300
1.5	110	160	220	275	330	380	440
2	150	220	300	360	440	510	580
2.5	180	275	360	460	550	640	730
3	220	330	440	550	660	770	875
3.5	250	380	510	640	770	890	1020
4	300	440	580	730	875	1020	1170

[1] Pounds required per 100 linear feet of crack for Type V crack seal

Cracks Requiring Repair Prior to Microsurfacing

553-1
July 2015

Reference Section
553

Microsurfacing Rut Fill Quantity Estimate

553-2
July 2016
Reference Section
553

Rut Depth	Quantity (lb/SY)
0.5” - 0.75”	20 - 30
0.75” - 1.0”	25 - 35
1.0” -1.25”	28 - 38
1.25” - 1.5”	32 - 40

600 Major Rehabilitation Design

Table of Contents

600 Major Rehabilitation Design

600.1 Introduction

Major rehabilitations are performed when the pavement condition is such that minor rehabilitation is no longer feasible or when geometric or capacity improvements require major work. Sometimes minor rehabilitation projects need to be elevated to major rehabilitation because of specific project conditions. For example, project level analysis may reveal excessive repair quantities that make minor rehabilitation a poor choice economically. However, funding is not always available to elevate a project to major rehabilitation.

The design period for major rehabilitations is established in Section 100. Most major rehabilitations require a life-cycle cost analysis using the procedures in Section 700 and a pavement selection according to Section 100. Major rehabilitations include the techniques given here, as well as complete removal of the existing pavement and replacement with either concrete or asphalt. The design of new concrete and asphalt is given in Sections 300 and 400 respectively.

600.2 Subgrade Determination

To design all major rehabilitations, including complete replacement, it is necessary to know the strength of the subgrade under the existing pavement. Prior to requesting pavement design for a major rehabilitation, soil borings should be taken and analyzed according to guidance from the Office of Geotechnical Engineering. If necessary for a preliminary design, subgrade strength can be estimated from historical subsurface investigations or by using the W(60) sensor readings from the FWD. The processed FWD data provides the subgrade design modulus for each direction tested.

601 Unbonded Concrete Overlay

An unbonded concrete overlay is a new concrete pavement placed on top of an old, deteriorated concrete pavement with a thin layer of asphalt or nonwoven geotextile in between to act as a bond-breaker. The thickness of an unbonded concrete overlay is derived from the required thickness for a new concrete pavement reduced by an amount based on the effective thickness of the existing concrete.

The design of an unbonded concrete overlay begins with the design of a new rigid pavement according to the procedures in Section 300. Next an asphalt overlay is designed using deflection analysis described in Section 500. The equation for determining the thickness of an unbonded concrete overlay, developed by the U.S. Army Corps of Engineers, is given below:

$$T_{UCO} = \sqrt{(T_N)^2 - (T_E)^2}$$

where:

T_{UCO} = Required thickness of the unbonded concrete overlay.
T_N = Required thickness for a new concrete pavement.
T_E = Effective thickness of the existing concrete.

The effective thickness of the existing concrete comes from the analyzed FWD measurements and a manual average of the effective thickness of the existing concrete, Deff (PCC). Best practice dictates averaging all the readings for the entire project, both directions, rather than averaging each direction separately and using the smaller or larger number. The design period used in deflection analysis does not matter as the Deff (PCC) does not change with different traffic inputs. The effective thickness of the existing concrete can also be estimated using Figure 5.13 in the AASHTO ’93 design guide when FWD measurements are not available. An example of an unbonded concrete overlay design is given in Figure 601-1.

To minimize the elevation increase of an unbonded concrete overlay, removal of any existing asphalt overlay using Item 202 Wearing Course Removed prior to placing the bondbreaker is recommended. Item 202 Wearing Course Removed may also be specified for removing adjacent asphalt shoulders down to the elevation of the concrete. Deteriorated joints and cracks do not need to be repaired prior to the overlay. New concrete pavement should be placed wherever pavement must be removed to meet the elevation of mainline bridges or to provide clearance at overhead bridges. The thickness required for the new pavement is the thickness calculated for new pavement when designing the unbonded concrete overlay, T_N. A base of at least 6 inches (150 mm) of Item 304 should be placed under the new concrete.

Item 452 Non-Reinforced Concrete Pavement is recommended for all unbonded concrete overlays and the replacement areas. Because of the dowels and the required concrete cover, the minimum thickness is 8 inches (200 mm).

Asphalt bondbreaker layers should consist of 1 inch to 1.5 inches (25 - 38 mm) of Item 442 Asphalt Concrete Intermediate Course, 9.5mm, Type A (448), As Per Plan. Include a note in the plans instructing the contractor to use a PG64-22 binder, design the mix at 2% air voids, and use an N_{DES} of 50 gyrations. The asphalt bondbreaker **should not** be tacked down unless it will be used for maintenance of traffic operations. Nonwoven geotextile bond breakers should be placed according to the manufacturer’s recommendations.

602 Fractured Slab Techniques

Fractured slab techniques are a method of rehabilitating rigid or composite pavements. They involve impacting the concrete to break it into smaller pieces. The intent being to retard or eliminate reflective cracking in a new asphalt overlay. Fractured slab techniques involve placement of a thick asphalt overlay. The increased elevation due to the thick overlay requires full-depth replacement to meet mainline bridges and possibly to provide clearance at overhead bridges. The pavement in these replacement areas should be designed as full-depth flexible pavement on an aggregate base.

The design of fractured slab techniques begins with the design of a new flexible pavement as described in Section 400. The structural number required for the new flexible pavement is the basis for all the fractured slab designs.

Because these techniques turn a rigid pavement into a flexible pavement, subgrade conditions take on increased importance. Weak or wet subgrade can hamper the fracturing operation and may make the seating or rolling operation ineffective. Prior to designing a fractured slab technique, the W(60) sensor readings from the FWD should be carefully reviewed to try and determine local areas of soft subgrade that may require undercutting and replacement. Prior to constructing a fractured slab technique, soil borings should be taken and specific replacement and undercut quantities should be set up in the plans.

A fractured slab technique called break and seat was used extensively in Ohio in the past. While some sections had good performance, others performed very poorly. Break and seat is not approved for use as a major rehabilitation strategy.

602.1 Crack & Seat

Crack and seat, Item 321, is for use on non-reinforced concrete pavements only. It is not for use on reinforced pavements whether jointed or continuous. The cracks induced are very light and are visible only with the application of water. Prior to cracking, any asphalt overlay must be removed using Item 202 Wearing Course Removed. Item 202 Wearing Course Removed may also be specified for removing adjacent asphalt shoulders down to the elevation of the concrete.

To design a crack and seat, the thickness of the cracked concrete is multiplied by a structural coefficient, given in Figure 401-1. Asphalt layers are then added until the total structural number is equal to or greater than the structural number required for a new flexible pavement. Any existing subbase under the concrete is neglected. An example is shown in Figure 602-1.

602.2 Rubblize & Roll

Rubblize and roll, Item 320, can be used on all concrete pavements although it is primarily intended for reinforced concrete. The rubblizing process does just what the name implies; it reduces the concrete to rubble. All slab action is destroyed and the concrete is transformed into an aggregate base. Prior to rubblizing, any asphalt overlay must be removed using Item 202 Wearing Course Removed. Item 202 Wearing Course Removed may also be specified for removing adjacent asphalt shoulders down to the elevation of the concrete.

Subgrade support is even more important for rubblize and roll than for crack and seat. The Office of Geotechnical Engineering has established conditions when rubblizing is not allowed (see Geotechnical Design Manual). Soil borings are strongly encouraged as early as possible in the design phase. Where subgrade conditions are very poor, analysis of the soil borings may reveal such large areas requiring replacement and undercutting that the decision to rubblize should be reconsidered. As a rule of thumb, areas three percent or more above optimum water content will require undercutting and replacement. Another rule of thumb was developed to estimate optimum water content: the optimum water content is the Plastic Limit minus four. Plastic Limit is not to be confused with the Plasticity Index. The Plastic Limit is equal to the Liquid Limit minus the Plasticity Index.

Minor settling or depressions may occur in the rubblized layer. Include a quantity of filler aggregate with rubblize projects equal to ten percent of the rubblized area at a one inch (25 mm) depth to fill the depressed areas.

To design a rubblize and roll, the thickness of the rubblized concrete is multiplied by a structural coefficient, given in Figure 401-1. Asphalt layers are then added until the total structural number is equal to or greater than the structural number required for a new flexible pavement. Any existing subbase under the concrete is neglected. An example is shown in Figure 602-1.

603 Whitetopping

Terminology regarding whitetopping is not universally consistent. The whitetopping referred to here is the construction of a conventional new rigid pavement on top of an old asphalt pavement. It is not to be confused with any type of thin or ultra-thin whitetopping which is a thin layer of concrete bonded to an old asphalt surface to prevent rutting and shoving.

Whitetopping is designed as a new rigid pavement using the existing asphalt pavement as the base for determining the modulus of subgrade reaction. The requirements of Section 500 apply, including the minimum thickness.

604 Shoulder Use for Maintenance of Traffic

When major rehabilitation requires the use of old shoulders for maintenance of traffic operations during construction, the structural integrity of the shoulders should be verified. Verification may include pavement history, coring, non-destructive testing, empirical calculations etc., to determine the feasibility of use. Shorter duration maintenance of traffic operations may not require as detailed an investigation. Shoulders originally built thinner than the driving lanes that have never been rebuilt, even if they have been overlaid, can almost never be used for maintenance of traffic regardless of duration.

604.1 Pavement for Maintaining Traffic

When the shoulders are deemed structurally inadequate for maintenance of traffic operations during construction they may require replacement. The replacement pavement is typically constructed in accordance with Item 615 Roads and Pavements for Maintaining Traffic.

Longer duration maintenance of traffic operations may warrant a new pavement design of either concrete or asphalt given in Sections 300 and 400, respectively. Critical, high volume locations, such as interstate cross-overs where failure could shut down the entire road, should always be checked for a new pavement design rather than relying on the buildups in Item 615. If the replacement pavement will be left in place, design calculations should be performed to confirm that the proper thicknesses and materials are specified.

600 Major Rehabilitation Design

List of Figures

Unbonded Concrete Overlay Example

601-1
January 2022
Reference Section
601

Given:

- Rigid Pavement Design Example, Figure 302-1
- Existing pavement buildup: 3" Asphalt
  9" Reinforced Concrete
  6" Subbase
- Deflection Analysis, Average Deff = 8.69”

Problem:

Design an unbonded concrete overlay.

Solution:

Obtain required thickness for new rigid pavement.
T_N = 10" (from Figure 302-1)

Obtain effective thickness of existing concrete.
T_E = 8.7" (from deflection analysis or AASHTO method from condition survey)

Calculate required thickness of unbonded concrete overlay.

$$T_{UCO} = \sqrt{(10)^2 - (8.7)^2}$$
$$T_{UCO} = \sqrt{100 - 75.69}$$
$$T_{UCO} = \sqrt{24.31}$$
$$T_{UCO} = 4.9"$$

Minimum thickness of unbonded concrete overlay = 8"

Items of work:

452	8"	Non-Reinforced Concrete Pavement, Class QC 1P with QC/QA
442	1"	Asphalt Concrete Intermediate Course, 9.5mm, Type A (448), As Per Plan
202		Wearing Course Removed

Include a plan note requiring PG64-22 binder, for the mix to be designed at 2% air voids, and an N_{DES} of 50 gyrations.

Fractured Slab Examples

602-1
January 2022
Reference Section 602

Crack & Seat Example

Given:

- Flexible Pavement Design Example, Figure 402-1
- Existing pavement buildup: 3" Asphalt
  9" Non-Reinforced Concrete
  6" Subbase

Problem:
Design a Crack & Seat project.

Solution:
Obtain required structural number for a new flexible pavement.
SN = 5.04 (from Figure 402-1)

Determine the required buildup using the structural coefficients given in Figure 401-1

Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (447)	1.5"	0.43	0.65
442 AC Intermediate Course, 12.5mm, Type A (446)	1.75"	0.43	0.75
301 Asphalt Concrete Base, PG64-22, (449)	3.5"	0.36	1.26
321 Cracked & Seated Concrete	9"	0.27	2.43
	Total Structural Number =		5.09

Rubblize & Roll Example

Given:

- Flexible Pavement Design Example, Figure 402-1.
- Existing pavement buildup: 4" Asphalt
  9" Reinforced Concrete
  6" Subbase

Problem:
Design a Rubblize & Roll project.

Solution:
Obtain required structural number for a new flexible pavement.
SN = 5.04 (from Figure 402-1)

Determine the required buildup using the structural coefficients given in Figure 401-1.

Material	Thickness	Coefficient	SN
442 AC Surface Course, 12.5mm, Type A (447)	1.5"	0.43	0.65
442 AC Intermediate Course, 19mm, Type A (446)	2.25"	0.43	0.97
302 Asphalt Concrete Base, PG64-22, (449)	6"	0.36	2.16
320 Rubblized Concrete	9"	0.14	1.26
	Total Structural Number =		5.04

700 Life Cycle Cost Analysis

Table of Contents

700 Life-Cycle Cost Analysis

701 Introduction

Life-Cycle Cost Analysis (LCCA) is a process for evaluating the economic worth of a pavement segment by analyzing initial costs and discounted future costs such as surface treatment, resurfacing, rehabilitation, and reconstruction costs over a defined analysis period. This section outlines some of the requirements for preparing an LCCA. Other details about the LCCA are given in Section 100.

701.1 Discount Rate

ODOT uses the discount rate provided by the Office of Management and Budget (OMB) in Circular A-94. Specifically, the 30-year real interest rate is used. The current discount rate can be found on the OMB website at http://www.whitehouse.gov/omb/.

702 Initial Construction

All alternatives for initial construction are designed using the procedures outlined in this Manual. Initial construction is considered to take place in year zero.

All differential pavement items are to be included in the analysis such as excavation, stabilization, pavement removed, base, and pavement. Non-pavement items and items common to all alternatives can be neglected. Items such as striping, signing, lighting, guardrail, barrier, underdrains, culverts, bridges, embankment, etc., are not pavement items, are essentially equal for all alternatives and are not to be included in the analysis. On new locations, earthwork items including stabilization are common to all pavement alternatives and are essentially equal and are not to be included.

For rehabilitations that raise the elevation of the existing pavement, a cost needs to be included for maintaining clearance under overhead structures and for meeting elevations of at-grade bridges. This cost can be calculated in various ways, most common is to calculate the cost to remove the existing pavement, excavate down, and build back up with new pavement. Another way is to calculate the cost of jacking the bridges, including any approach work necessary on overheads. A third option could be a combination of the two.

It is not important which method is selected for computing cost of maintaining clearance. What is important is that the costs are included in the analysis. The same method of calculating the costs is to be used for all alternatives. The method used in the LCCA for computing cost of maintaining clearance does not have to be the actual method used in the plans and in construction.

703 Future Rehabilitation

703.1 Introduction

The future rehabilitation required to keep the pavement in serviceable condition for the next 35 years must be predicted. Routine and reactive maintenance performed by ODOT forces are not included in the analysis due in part to lack of dependable data. Only contract rehabilitation projects are considered.

ODOT does not use salvage value. The rehabilitation schedules listed below result in approximately equal condition at the end of the analysis period. The salvage values are considered equal and are not included in the analysis.

703.2 Rehabilitation Schedules

The rehabilitation schedules given below were developed from an analysis of ODOT pavement performance data. The analysis will be updated periodically and the rehabilitation schedules updated accordingly. The schedules below are to be used without deviation.

The schedules list only major items of work. The LCCA should include the specification items needed to complete the work described such as tack coats and pavement sawing.

703.2.1 Flexible Pavement

Flexible pavement includes new pavement on a new alignment and complete replacement of existing pavement.

Year 14: 1.5" overlay with planing (driving lanes only).

Year 24: 3.25" overlay with planing (driving lanes and shoulders) with 1% patching planed surface.

Year 34: 1.5" overlay with planing (driving lanes only).

703.2.2 Rigid Pavement

Rigid pavement includes new pavement on a new alignment and complete replacement of existing pavement.

Year 22: Diamond grinding (driving lanes plus one foot of each shoulder) and full depth rigid repairs of 4% of the driving lanes surface area.

Year 32: 3.25" asphalt overlay and full depth rigid repair of 2% of the driving lanes surface area.

703.2.3 Composite Pavement

Composite pavement includes new pavement on a new alignment and complete replacement of existing pavement. The performance of newly constructed composite pavements has not been studied as relatively few have been constructed. Since composite pavement is a hybrid of rigid and flexible pavements, a hybrid rehabilitation schedule may be derived from the rigid and flexible schedules.

The timing, width, and thickness of each rehabilitation shall be the same as the flexible pavement schedule given in Section 703.2.1. A quantity of full depth rigid repairs equal to 2% of the driving lanes surface area shall be included with the overlay at years 14 and 34, and 3% at year 24.

703.2.4 Unbonded Concrete Overlay

An unbonded concrete overlay is a new concrete pavement built on top of an old concrete pavement with a bondbreaker layer in between. The future rehabilitation schedule is the same as rigid pavement given in Section 703.2.2.

703.2.5 Fractured Slab Techniques

Fractured slab techniques include crack & seat, and rubblize & roll. The future rehabilitation schedule for all fractured slab techniques is the same as flexible pavement given in Section 703.2.1.

703.2.6 Whitetopping

Whitetopping is a new concrete pavement built on an old flexible pavement. The future rehabilitation schedule is the same as rigid pavement given in Section 703.2.2.

704 Total Cost

Once all the costs for initial construction and future rehabilitation have been calculated, they are summed to determine the net present value of each alternative. Future rehabilitation costs are discounted to account for and the time value of money.

704.1 Discounting

Discounting is a simple yet effective way to account for the time value of money. The discount rate can be thought of as the difference between market interest rates and the general rate of inflation. For example, if one-year Certificates of Deposit (CD) are paying 5.5% while inflation is running 2.0% per year, the discount rate would be 3.5%. Similarly, if CDs are paying 8.0% and inflation is running 4.5%, the discount rate is still 3.5%. Using a discount rate eliminates the need to predict what inflation will do for the next 35 years or what return one might get on an investment.

The formula for applying the discount rate is as follows:

$$(P/F,i\%,n) = \frac{1}{(1+i)^n}$$

where:

$(P/F,i\%,n)$ = discount factor

i = discount rate from OMB Circular A-94

n = year costs occur

An example of how to use the discount rate and calculate total cost is shown in Figure 703-1.

705 Results Presentation

The Office of Pavement Engineering prepares all LCCAs and pavement selection packages. A standard format for presenting the information is still evolving. Once a standard is established, a general description will be added to this Manual.

700 Life-Cycle Cost Analysis

List of Figures

Discounting Example

704-1
July 2014
Reference Section
704.1

Given:

- Initial Construction (Year 0): $16,000,000
- First Rehabilitation (Year 14): $1,400,000
- Second Rehabilitation (Year 24): $2,300,000
- Third Rehabilitation (Year 34): $1,400,000

Problem:

Solve for the net present value using a discount rate of 1.9%.

Solution:

Calculate the discount factor for each year using the equation given in Section 704.1.

$$(P/F,1.9\%,0) = \frac{1}{(1+0.019)^{0}} = 1.0$$

$$(P/F,1.9\%,14) = \frac{1}{(1+0.019)^{14}} = 0.7684$$

$$(P/F,1.9\%,24) = \frac{1}{(1+0.019)^{24}} = 0.6365$$

$$(P/F,1.9\%,34) = \frac{1}{(1+0.019)^{34}} = 0.5273$$

Multiply costs by discount factors and sum to find Net Present Value (NPV).

NPV = (16000000)*(1)+(1400000)*(0.7684)+(2300000)*(0.6365)+(1400000)*(0.5273)
= $19,300,000

Appendix A

Pavement Surface Friction Treatments

January 2022

PAVEMENT SURFACE FRICTION TREATMENTS

BACKGROUND:

Surface friction is an important pavement property for vehicle control and stopping. Wet pavement surfaces are of specific interest as they exhibit lower friction than when the pavement is dry. There are many factors that determine the amount of friction required at each location such as; speed limit, geometrics, surface drainage, texture, and aggregate properties. Standard pavement items, with approved aggregates, generally provide adequate wet friction for most locations. As pavements age the surface friction properties may change by loss of texture, aggregate polishing, or non-pavement issues such as changes in speed limits, traffic patterns or drainage issues. Corrections must be made at locations where it has been determined there is a lack of wet friction. The treatments listed here represent potential remedies.

A surface friction treatment may not be the best long-term solution for correcting geometric conditions. Straightening a curve, flattening a hill, providing additional signing, or removing vegetation to improve sight distance may eliminate the need for future surface friction treatments. Providing a surface friction treatment in response to poor geometric conditions may result in increased speed that reduces or negates the benefit of the treatment.

The treatments outlined here may lose effectiveness as they wear over time and all pavement surfaces will be candidates for repair, grinding, overlay, or replacement eventually.

Assistance with the application of these surface friction treatments is available from the Office of Pavement Engineering, the Office of Construction Administration, and the Office of Materials Management.

DEFINITIONS:

Friction: The force that resists relative motion between two objects in contact. For pavements, it is the force between the tire and the pavement that allows acceleration, deceleration, and directional control.

Friction Demand: The amount of friction needed at a given location to safely maintain vehicle control.

Macrotexture: The observable surface finish of the pavement, i.e. smooth and tight vs. rough and open.

Microtexture: The fine-scale texture of the individual aggregate particles. Microtexture is not necessarily visible to the naked eye.

Polishing: The loss of microtexture.

INTRODUCTION:

Long-term pavement surface friction treatments are categorized into tiers 1, 2, or 3 with the higher numbered tier expected to provide higher wet friction. Short term treatments are not assigned a tier. The purpose of the tiers is to help guide the designer toward an appropriate long-term treatment. Not all treatments within a tier are equal so it may not always require moving to a higher tier to provide the needed frictional properties. The exact treatment selected for a location is based on engineering judgement of the friction demand, existing pavement conditions, needed longevity of treatment, cost, etc.

Tier 1: Tier 1 treatments are standard specification items using standard materials. These treatments are appropriate when there is no expectation of higher friction demand, but the existing surface no longer possesses adequate friction.

Tier 2: Tier 2 treatments add special aggregate or aggregate blends to provide enhanced friction or reduced polishing potential. These treatments are appropriate for locations where there is higher friction demand or where tier 1 treatments may not provide the needed friction based on experience or engineering judgement.

Tier 3: Tier 3 consists only of Supplemental Specification 888 High Friction Surface Treatment (HFST) and chip seals using slag aggregate. Tier 3 treatments provide the highest level of friction resistance and are appropriate for the most demanding locations.

SURFACE FRICTION TREATMENTS:

I. Short Term Treatments

When there is the need to improve the frictional properties of the pavement as soon as practical or a temporary improvement is needed before a long-term treatment is applied, micro planing using Supplemental Specification 897 Pavement Fine and Micro Planing may be used. SS897 is for asphalt surfaces only. It may be possible to perform this work using in-house forces. Similar work could be performed on concrete surfaces but diamond grinding, diamond grooving, or both is preferred for concrete.

Micro planing mechanically abrades the surface to provide increased macrotexture. Micro planing may also improve microtexture by exposing new aggregate surfaces, but polishing aggregates will continue to polish after micro planing.

The surface resulting from micro planing typically deteriorates at a faster rate and aggregate polishing is accelerated after planing. These surfaces normally need to be removed or covered up in one to three years. The abraded surface also increases tire-pavement noise and may be objectionable in noise sensitive areas.

II. Long Term Treatments

A. Tier 1

Tier 1 treatments consist primarily of a new surface using standard specification items. Tier 1 treatments are appropriate as the first long-term treatment for most locations. Tier 1 treatments are also appropriate, in many cases, in locations where a tier 2 or 3 had been applied previously but, because of pavement deterioration, a new surface is being placed. When repaving tier 2 and 3 locations, the designer should review the sites to ensure the location does not have increased friction demand that necessitates another tier 2 or 3 treatment or if tier 1 is sufficient.

Below are brief discussions of each of the tier 1 treatments.

1. Asphalt pavements (C&MS Items 424, 441, 442, and 443)

A new asphalt surface using any of the standard specification items with proper construction techniques and approved materials is expected to provide the necessary wet weather friction for most locations.

A new asphalt surface may be placed with or without planing the old surface. Placing a new asphalt surface by contract, with or without planing, is more cost effective as part of a larger project rather than a spot treatment.

Items must be properly specified based on the section’s traffic counts and other considerations. Refer to PDM Section 400 for more information on asphalt pavements. Refer to PDM Sections 400 and 550 for more information on Item 424 Fine Graded Polymer Asphalt Concrete.

2. Concrete pavements (C&MS Items 451 and 452)

A new concrete pavement using either of the standard specification items with proper construction techniques and approved materials is expected to provide the necessary wet weather friction for most locations.

Replacing the existing pavement with concrete pavement for no other reason than to provide wet weather friction is unlikely to be a cost-effective solution. There may be other considerations such as a high stress area that would make this a more attractive solution.

Refer to PDM Section 300 for more information on concrete pavements.

3. Microsurfacing (C&MS Item 421)

Standard microsurfacing is widely known to provide good wet weather friction. Microsurfacing may be placed along an entire roadway section or at spot locations if there are enough locations in reasonable proximity to make a viable project.

Refer to PDM Section 550 for more information on microsurfacing.

4. Chip Seal (C&MS Item 422)

Properly constructed chip seals with approved materials provide more macrotexture for wet weather friction than most other treatments. Chip seals may be placed along an entire roadway section or at spot locations if there are enough locations in reasonable proximity to make a viable project. Spot locations may be more suitable for chip sealing using in-house forces rather than by contract.

Refer to PDM Section 550 for more information on chip seal. The traffic level restrictions for chip seals still apply when used as a friction treatment.

5. Diamond Grinding (C&MS Item 257)

Diamond grinding may be used on concrete surfaces to remove a thin layer of the existing surface, expose new aggregate surfaces, and provide a new texture. Diamond grinding is not recommended with polishing aggregates.

Diamond grinding may be used on asphalt surfaces but is typically a shorter-term treatment in these applications.

Diamond grinding may be performed as a stand-alone treatment or in combination with diamond grooving. Because of the equipment mobilization costs, diamond grinding is more appropriate for longer applications.

Refer to PDM Section 550 for more information on diamond grinding.

6. Diamond Grooving (SS 889)

Diamond grooving may be used on asphalt or concrete surfaces to improve macrotexture. Diamond grooving has no effect on microtexture. It may be used as a stand-alone treatment or in combination with diamond grinding. Diamond grooving may be used a spot treatment or in longer applications.

Refer to the supplemental specification and designer notes for more information on diamond grooving.

B. Tier 2

Tier 2 treatments are primarily new surfaces using traprock or slag aggregates. Traprock and slag are hard, durable aggregates that resist polishing. Slag aggregates also exhibit high microtexture. Tier 2 treatments are appropriate for documented locations where tier 1 treatments have been tried, where polishing is a known issue, or other locations determined by engineering judgement. Locations identified for tier 2 treatments may also be candidates for geometric changes.

Below are brief discussions of each of the tier 2 treatments.

1. Asphalt with 60% slag

This item requires that 60 percent of the coarse aggregate and 50 percent of the fine aggregate consist of air cooled blast furnace slag (ACBFS). ACBFS may not be economically available throughout the state. There are no standard specifications for this item, but example plan notes are available. This can be used with asphalt items 441 and 442 only. This has been used as an option with traprock when polishing was the primary concern.

A new asphalt surface may be placed with or without planing the old surface. Placing a new asphalt surface by contract, with or without planing, is more cost effective as part of a larger project rather than a spot treatment.

2. Asphalt with 60% traprock

This item requires that 60 percent of the coarse aggregate and 50 percent of the fine aggregate consist of igneous diabase trap rock from Ontario. Traprock may not be economically available throughout the state. There are no standard specifications for this item, but example plan notes are available. This has been used as an option with ACBFS when polishing was the primary concern.

A new asphalt surface may be placed with or without planing the old surface. This can be used with asphalt items 441 and 442 only. Placing a new asphalt surface by contract, with or without planing, is more cost effective as part of a larger project rather than a spot treatment.

3. Microsurfacing with 50% traprock (C&MS Item 421)

   Item 421 Microsurfacing, Surface Course (FR) requires that 50 percent of the aggregate consist of igneous diabase trap rock from Ontario. The percentage of traprock is limited to 50 percent in order to have the proper limestone fines to react with the emulsion. Traprock may not be economically available throughout the state.

   Microsurfacing with traprock may be placed along an entire roadway section or at spot locations if there are enough locations in reasonable proximity to make a viable project.

4. Asphalt with 100% slag

   This item requires that 100 percent of the coarse aggregate and 50 percent of the fine aggregate consist of ACBFS. ACBFS may not be economically available throughout the state. There are no standard specifications for this item, but example plan notes are available. This can be used with asphalt items 441 and 442 only. This has been used as an option with traprock when polishing was the primary concern.

   A new asphalt surface may be placed with or without planing the old surface. Placing a new asphalt surface by contract, with or without planing, is more cost effective as part of a larger project rather than a spot treatment.

5. Asphalt with 100% traprock

   This item requires that 100 percent of the coarse aggregate and 50 percent of the fine aggregate consist of igneous diabase trap rock from Ontario. Traprock may not be economically available throughout the state. There are no standard specifications for this item, but example plan notes are available. This can be used with asphalt items 441 and 442 only. This has been used as an option with ACBFS when polishing was the primary concern.

A new asphalt surface may be placed with or without planing the old surface. Placing a new asphalt surface by contract, with or without planing, is more cost effective as part of a larger project rather than a spot treatment.

6. Rubberized Open Graded Friction Course (SS 803)

While rubberized open graded friction course is specifically designed to provide wet weather friction, ODOT has had difficulty with snow and ice removal and does not recommend its use. Refer to PDM Section 400 for more information on rubberized open graded friction course.

C. Tier 3

Tier 3 treatments are appropriate for documented locations with high friction demand, particularly spot locations where only isolated areas require treatment. Locations identified for tier 3 treatments may also be candidates for geometric changes.

Below are brief discussions of each of the tier 3 treatments.

1. High Friction Surface Treatment (SS 888)

A high friction surface treatment (HFST) consists of an epoxy resin and calcined bauxite aggregate. As the name implies, HFSTs are a proven treatment to provide high wet pavement friction. An HFST is a relatively expensive but long-lasting treatment and is recommended for pavements in good condition only. HFSTs are most appropriate in spot locations such as curves, ramps, or intersection approaches.

Do not place an HFST on any pavement scheduled for rehabilitation within three years or any pavement exhibiting surface debonding.

Locations scheduled for rehabilitation where a previous HFST exists may or may not require re-installation of the HFST. The reasons for the initial installation should be considered and engineering judgement applied to determine the appropriate tier treatment for the rehabilitation.

Refer to the supplemental specification and designer notes for more information on HFST.

2. Chip seal with slag

Chip seal using slag aggregate is an experimental treatment with promising but very limited results. It may become an option for longer segments needing a tier 3 treatment. The traffic level restrictions for chip seals still apply when used as a friction treatment.

D. Other Options

As mentioned previously, geometric improvements may reduce the friction demand and eliminate the need for any other treatment. New or additional signage or removing vegetation to improve sight distances may also be effective in some situations.

In some locations the problem may be excessive speed rather than lack of wet friction. These locations are better suited to additional warning signs or other measures to reduce speed rather than a surface friction treatment. Full lane transverse rumble strips in accordance with the Traffic Engineering Manual Section 1400 are an option to alert drivers to slow down.

SEGMENT LIMITS OF SURFACE FRICTION TREATMENTS

The segment limits of a pavement surface friction treatment depend in part on the treatment selected. Some treatments are more appropriate for longer sections of roadway while others are spot treatments. Whatever treatment is selected, it is important to ensure the treatment encompasses the area of inadequate friction and extends through the area of higher friction demand.

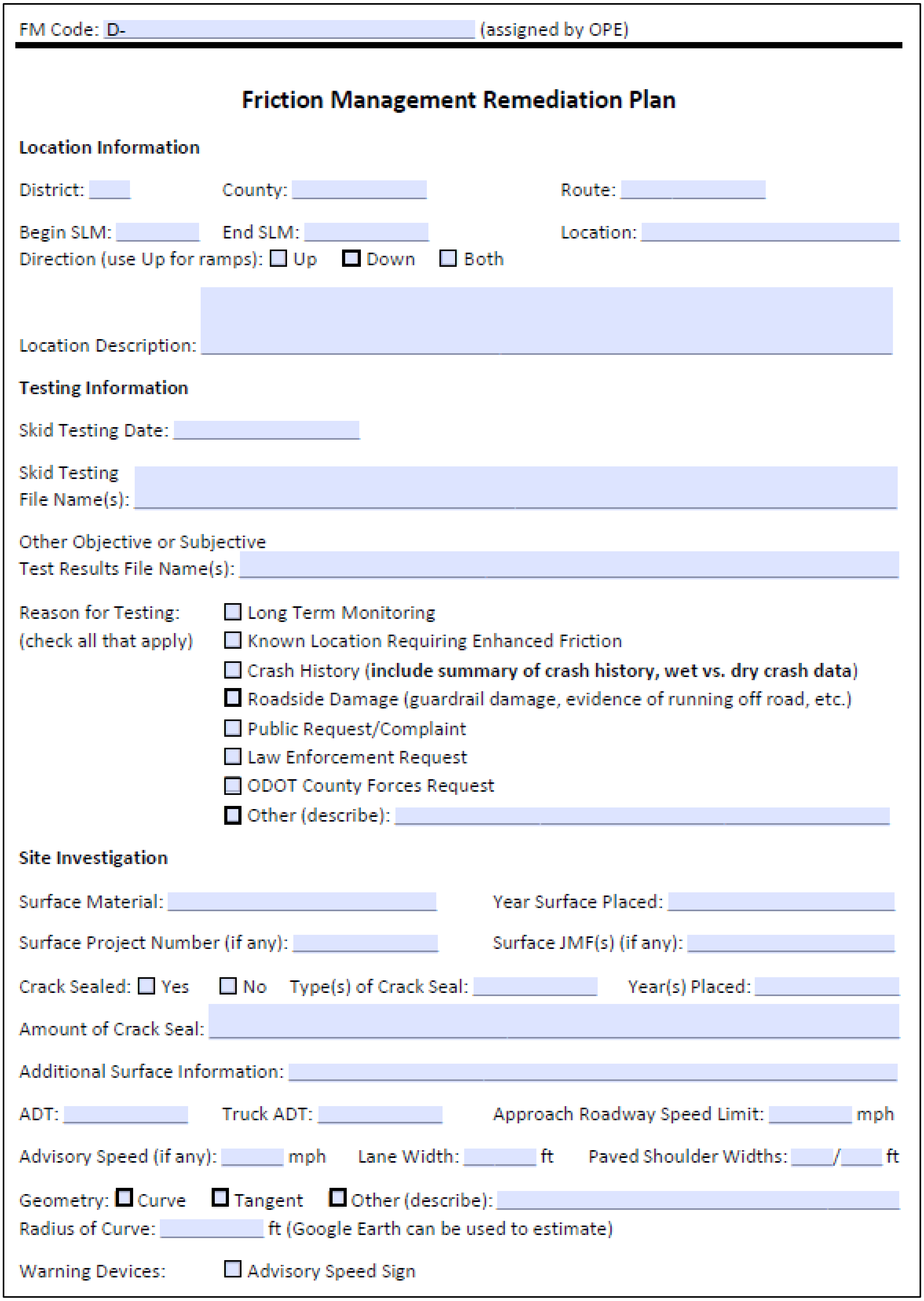
SUMMARY AND FUTURE DIRECTION

ODOT has tools to objectively measure available wet pavement friction. Friction demand, however, is subjective and requires engineering judgement. The tiers and treatments listed here are intended to assist in the subjective analysis and help the designer determine an appropriate treatment for the needed friction demand.

ODOT is collecting data to possibly determine the expected wet pavement friction provided by the various treatments and researching ways to objectively determine friction demand ranges. Future updates to this appendix may relate treatments or tiers with ranges of friction demand.

The ODOT Highway Friction Management Program document is available at O:\Planning\Highway Friction Management Program. Questions about the friction management program should be directed to the Office of Technical Services.

The form shown on the following pages is for submitting friction management remediation plans to the Office of Pavement Engineering for approval. The form is available electronically at O:\Pavement\Friction. Questions about the form or any of the pavement friction treatments should be directed to the Office of Pavement Engineering.



FM Code: D- (assigned by OPE)

Friction Management Remediation Plan

Location Information

District: County: Route:

Begin SLM: End SLM: Location:

Direction (use Up for ramps): ☐ Up ☐ Down ☐ Both

Location Description:

Testing Information

Skid Testing Date:

Skid Testing File Name(s):

Other Objective or Subjective Test Results File Name(s):

Reason for Testing: (check all that apply)

- ☐ Long Term Monitoring
- ☐ Known Location Requiring Enhanced Friction
- ☐ Crash History (**include summary of crash history, wet vs. dry crash data**)
- ☐ Roadside Damage (guardrail damage, evidence of running off road, etc.)
- ☐ Public Request/Complaint
- ☐ Law Enforcement Request
- ☐ ODOT County Forces Request
- ☐ Other (describe):

Site Investigation

Surface Material: Year Surface Placed:

Surface Project Number (if any): Surface JMF(s) (if any):

Crack Sealed: ☐ Yes ☐ No Type(s) of Crack Seal: Year(s) Placed:

Amount of Crack Seal:

Additional Surface Information:

ADT: Truck ADT: Approach Roadway Speed Limit: mph

Advisory Speed (if any): mph Lane Width: ft Paved Shoulder Widths: / ft

Geometry: ☐ Curve ☐ Tangent ☐ Other (describe):

Radius of Curve: ft (Google Earth can be used to estimate)

Warning Devices: ☐ Advisory Speed Sign

☐ Yellow Flashers
☐ Full Lane Rumble Strips
☐ Other (describe):

Any other site investigation information:

Remedial Action Plan

Treatment(s): ☐ Microplaning/Diamond Grinding
☐ Microsurfacing
☐ Asphalt
☐ High Friction Surface Course
☐ Improved signing, striping, lighting, etc. (any non-pavement treatments)
☐ Other (describe):

Surface Course Pay Item: Pay Item Description:

Special Aggregate: ☐ Trap Rock
☐ Slag
☐ Other (describe):

Geometric Improvement: ☐ Yes ☐ No Describe:

Approximate date for applying remedial action:

Any other information, description or clarification of the remedial action:

Remedial Action – Short Term

If the remedial action above is a long-term fix that may not be initiated for months or years, describe any plans for an immediate or short-term fix:

OPE Notes:

Appendix B

Pavement Guidelines for Treatment of High Stress Locations

January 2021

PAVEMENT GUIDELINES FOR TREATMENT OF HIGH STRESS LOCATIONS

BACKGROUND:

These guidelines are intended to be used to reduce or eliminate rutting or shoving problems associated with the use of asphalt concrete pavement surfaces in high stress locations.

These guidelines are intended to be used by district office staff in making best practice decisions regarding pavement resurfacing and design considerations. Technical assistance with these guidelines is available by contacting the Offices of Pavement Engineering, Materials Management, or Construction Administration.

DEFINITIONS:

Rutting: Rutting is visually identified by vertical depressions in the pavement surface along the wheel tracks. Rutting is measured transversely across the depression using a string line or straight edge. Rutting is generally considered significant when it approaches 0.4 inches (10 mm) in depth. The presence of significant rutting may or may not indicate a high stress location. Problems such as poor mix design, production, or placement could contribute to rutting in locations that are not high stress.

Shoving: Shoving is longitudinal displacement of a localized area of the pavement surface. It is generally caused by braking or accelerating vehicles and is usually located on hills, curves, or intersections. Shoving may also include vertical displacement. Shoving is generally considered significant when it affects ride quality. The presence of shoving may or may not indicate a high stress location. Problems such as poor mix design, production or placement could contribute to shoving in locations that are not high stress.

High Stress Location: High stress locations are found at areas of high acceleration and braking, at intersections, sharp curves, ramps, and where heavy vehicles frequent at slow speeds. High stress locations occur at intersections with forced stop control and one or more of the following criteria:

- The approach grade to the stop control is greater than or equal to 3.5 percent.
- Current Design Designation of 500 trucks per day or greater in the design lane.
- Current Design Designation of 250 trucks per day or greater in a turn lane.

High stress locations occur in locations with or without forced stop control, such as ramps, roundabouts, or sharp curves, that have greater than 250 trucks per day or have exhibited repeated rutting problems in the past. As truck counts on ramps are often unknown and the definition of a sharp curve depends upon the speed of the curve, some judgment is required on new locations.

High stress locations occur on stretches of roadway that continue to exhibit significant rutting after several trials of standard mixes. These stretches of roadway generally exhibit rutting due to some combination of long or steep grades; trucking/traffic patterns, counts, or weights.

High stress locations occur at standard bus stops on bus routes or at park and ride lots.

High stress locations occur at all truck and bus lots located in the Department's rest areas.

TREATMENT OF HIGH STRESS LOCATIONS:

I. RIGID PAVEMENT:

No special treatment is needed for high stress locations where rigid pavement exists or is proposed. When replacing a composite or flexible pavement with a rigid pavement at a high stress location, the following needs to be considered:

A. When new pavement is being constructed, the designer should try to match subgrade elevation at the high stress termini. For most situations, the rigid pavement should be placed on a minimum of 6 inches (150 mm) of Item 304 Aggregate Base; however, if the surrounding flexible or composite pavement is constructed on subgrade, it would be acceptable to do the same with the rigid pavement. The thickness of the rigid pavement should be a minimum of 8 inches (200 mm). The exact thickness should be determined by design calculations in accordance with the procedures specified in Section 300 of the Pavement Design Manual. Additional thickness of Item 304 may be used, if necessary, to match subgrade elevations.

B. For composite pavements where clearance requirements are not a concern, an unbonded concrete overlay may be placed. Unbonded concrete overlays should be constructed a minimum of 8 inches (200 mm) thick with standard dowels using Item 452. If dowels are not used or non-standard smaller diameter dowels are used, the thickness may be reduced to 6 inches (150 mm).

C. For flexible pavements where clearance requirements are not a concern, conventional whitetopping may be used. Conventional whitetopping should be constructed a minimum of 8 inches (200 mm) thick with standard dowels using Item 452. If dowels are not used or non-standard smaller diameter dowels are used, the thickness may be reduced to 6 inches (150 mm).

II. FLEXIBLE PAVEMENT:

A. There are several options available for the use of flexible pavement in high stress locations. For cost consideration, a “next step” type of approach is recommended.

In some locations it may be necessary to take multiple steps as the first treatment. Next Step approaches are as follows:

1. In a high stress area with less than 1500 trucks that would normally use Item 441, specify a Superpave mix design using Item 442. All high stress areas using Item 442 shall use 446 acceptance regardless of the quantity limitations given in Section 404.1. Consideration may also be given to changing the surface course binder to PG76-22M or PG88-22M.

2. In a high stress area that would normally require a Superpave mix design, change the surface course binder to PG76-22M or PG88-22M, or specify a non-standard modified asphalt concrete pavement mix design. A list of all available modified asphalt concrete mixes is on file with the Office of Materials Management. Contact the Asphalt Materials Section for a current list of available options. Item 443 Stone Matrix Asphalt Concrete may also be considered but not for small quantity applications.

B. For all high stress locations where rutting is evident, pavement planing should be specified to remove all deformed material.

   1. For flexible pavement, planing should be specified to the bottom of the material responsible for the rutting. In order to determine the responsible layer, the comparison of pavement cores taken in the rutted area with cores taken outside of the rut may be helpful. Where this information is not available, best practice is to remove 3 inches (75 mm) below the deepest portion of the rut. Standard practice concerning tack coat should be followed prior to the placement of the Next Step asphalt mixes.

   2. For composite pavement, planing should be specified according to II.B.1. Where the surface of the rigid base pavement is within 2 inches (50 mm) of the required planing depth, best practice is to take the planing down to the concrete and possibly include a layer of Asphalt Concrete Base (301 or 302) in the overlay buildup.

C. Lift combinations and thickness requirements will generally be the same as would be required for a standard flexible pavement or overlay.

LIMITS OF HIGH STRESS LOCATIONS:

The limits of the high stress treatment should be determined as follows:

A. A minimum of 250 feet (75 m) back from the location of stop termini, traffic signal, or roundabout entrance.

B. The length of the turn lane.

C. The limits of the existing problem condition.

D. The entire roundabout.

In urban areas where several intersections exist within close proximity to each other and meet high stress criteria, best practice is to specify the required high stress mix the length of the section bounded at the outermost limits of the high stress locations.

Appendix C

Simplified Pavement Design for Short Projects

Simplified Pavement Designs for Short Projects

Many projects, such as bridge replacement projects, include a short stretch of new pavement or pavement replacement. For projects in which the total length of new pavement or pavement replacement is less than 300 feet (100 m), the chart on the following page may be used in lieu of a complete pavement design according to Sections 200, 300 and 400 of this Manual. The buildups given on the chart are conservative and based on the amount of truck traffic expected for the opening day. The following procedures and precautions should be recognized:

1. The length of pavement replacement is exclusive of bridge length, where applicable.
2. The buildups given here are in accordance with the small quantity guidelines Section 410.
3. The designer should first evaluate the buildup of the existing pavement. If the structural buildup or thickness of the existing pavement exceeds the chart value, then the existing design should be perpetuated.
4. Where opening day truck traffic exceeds 800, this chart is not to be used and the procedures described in Sections 200, 300 and 400 of this Manual are to be followed.
5. If it is known in advance that poor soils may be encountered at subgrade level or if the designer is unsure of proper subgrade or slope treatments, review by the Office of Geotechnical Engineering is recommended.
6. The designer is always welcome to do a complete design according to Sections 200, 300 and 400 rather than using the chart.

Simplified Pavement Designs for Short* Projects

Pavement Composition	Pavement Course Thicknesses														
	Number of Trucks in Opening Day ADT (ADT x T24)														
	<=10		11-25		26-50		51-100		101-200		201-400		401-800		>800
	in	mm	**in**	mm	**in**	mm	**in**	mm	**in**	mm	**in**	mm	**in**	mm	
Flexible Design															
441 AC Surface, Type 1, (449), PG64-22**	**1.25**	32	**3**	75	**3**	75	**3**	75	**3**	75	**3**	75	**3**	75	n/a
301 Asphalt Concrete Base, (449), PG64-22	**4**	100	**4**	100	**5**	125	**6**	150	**7**	180	**8**	200	**9**	230	n/a
304 Aggregate Base	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	n/a
Alternate Flexible Design															
441 AC Surface, Type 1, (449), PG64-22**	**3**	75	-	-	-	-	-	-	-	-	-	-	-	-	n/a
304 Aggregate Base	**12**	300	-	-	-	-	-	-	-	-	-	-	-	-	n/a
Rigid Design															
452 Non-Reinforced Concrete Pavement, Class QC 1P	**7*** **	180	**7*** **	180	**7*** **	180	**7*** **	180	**8**	210	**9**	230	**10**	260	n/a
304 Aggregate Base	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	**6**	150	n/a

* Less than 300 linear feet (100 m) of total pavement replacement.

** Include a plan note restricting the 441 to 2-inch (50 mm) maximum lift thickness.

*** 7-inch (180 mm) concrete is allowed for short projects only. All other projects require 8-inch (200 mm) minimum in accordance with Section 302.