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 Design Reference Resource Center on the ODOT website at http://www.dot.state.oh.us/drrc. 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 Design Reference Resource Center. The online manual is 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 Design Reference Resource Center with notification through the e-mail subscription list. Revisions will be issued as necessary on the quarterly 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.

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Ohio Counties

No.	County	Code	District	No.	County	Code	District
01	Adams	ADA	9	45	Licking	LIC	5
02	Allen	ALL	1	46	Logan	LOG	7
03	Ashland	ASD	3	47	Lorain	LOR	3
04	Ashtabula	ATB	4	48	Lucas	LUC	2
05	Athens	ATH	10				
06	Auglaize	AUG	7	49	Madison	MAD	6
				50	Mahoning	MAH	4
07	Belmont	BEL	11	51	Marion	MAR	6
08	Brown	BRO	9	52	Medina	MED	3
09	Butler	BUT	8	53	Meigs	MEG	10
				54	Mercer	MER	7
10	Carroll	CAR	11	55	Miami	MIA	7
11	Champaign	CHP	7	56	Monroe	MOE	10
12	Clark	CLA	7	57	Montgomery	MOT	7
13	Clermont	CLE	8	58	Morgan	MRG	10
14	Clinton	CLI	8	59	Morrow	MRW	6
15	Columbiana	COL	11	60	Muskingum	MUS	5
16	Coshocton	COS	5				
17	Crawford	CRA	3	61	Noble	NOB	10
18	Cuyahoga	CUY	12				
				62	Ottawa	OTT	2
19	Darke	DAR	7				
20	Defiance	DEF	1	63	Paulding	PAU	1
21	Delaware	DEL	6	64	Perry	PER	5
				65	Pickaway	PIC	6
22	Erie	ERI	3	66	Pike	PIK	9
				67	Portage	POR	4
23	Fairfield	FAI	5	68	Preble	PRE	8
24	Fayette	FAY	6	69	Putnam	PUT	1
25	Franklin	FRA	6				
26	Fulton	FUL	2	70	Richland	RIC	3
				71	Ross	ROS	9
27	Gallia	GAL	10				
28	Geauga	GEA	12	72	Sandusky	SAN	2
29	Greene	GRE	8	73	Scioto	SCI	9
30	Guernsey	GUE	5	74	Seneca	SEN	2
				75	Shelby	SHE	7
31	Hamilton	HAM	8	76	Stark	STA	4
32	Hancock	HAN	1	77	Summit	SUM	4
33	Hardin	HAR	1				
34	Harrison	HAS	11	78	Trumbull	TRU	4
35	Henry	HEN	2	79	Tuscarawas	TUS	11
36	Highland	HIG	9				
37	Hocking	HOC	10	80	Union	UNI	6
38	Holmes	HOL	11				
39	Huron	HUR	3	81	Van Wert	VAN	1
				82	Vinton	VIN	10
40	Jackson	JAC	9				
41	Jefferson	JEF	11	83	Warren	WAR	8
				84	Washington	WAS	10
42	Knox	KNO	5	85	Wayne	WAY	3
				86	Williams	WIL	2
43	Lake	LAK	12	87	Wood	WOO	2
44	Lawrence	LAW	9	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 GB1 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, 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

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)

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

Geotechnical Bulletin GB1: Plan Subgrades (ODOT - Current Revision)

Guide for Design of Pavement Structures (AASHTO - 1993)

Highway Engineering Handbook (McGraw-Hill - 1996)

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)

Manual of Operation and Use of Dynaflect for Pavement Evaluation (ODOT - 1983)

Pavement Condition Rating System (ODOT - Current Revision)

Principles of Pavement Design (Wiley-Interscience - 1975)

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)