Local Projects Pavement Design Guidance (2018)

Date: review 2018
Source: Varilek/Soula

NDOT is required by the Code of Federal Regulations (CFR) Title 23 to review all pavement designs for federally funded projects administered by the state. NDOT requires different levels of documentation for different types of pavement projects. Below are the required documentation requirements for:

Maintenance projects (2" or less of HMA), pavement repairs, minor intersection modifications (matching or exceeding existing pavement depths), preventative maintenance projects (micro-surfacing, armor coats, etc.)

- See 2.5 – First page of Local Projects Pavement Determination Data Sheet

Resurfacing, Restoration, and Rehabilitation (3R) Structurally enhance and extend the service life of an existing pavement and improve load carrying capacity (typical fill depth is greater than 2" and up to and including 6" of Asphaltic Concrete or Portland Cement Concrete.) Types of Improvements Include – Resurfacing, addition of auxiliary lanes, lane and shoulder widening, vertical and horizontal curves, and base repairs, etc.

New and Reconstruction (Resurfacing with >6" of HMA or PCC, new build HMA or PCC)

- Pg 1 & 2 or 1 & 3 of Local Projects Pavement Determination Data Sheet as applicable
- Appropriate tables, figures and nomographs

All design assumptions and calculations - See Nebraska Administrative Code Title 428, Chapter 2, pg. 39 for more information. https://dot.nebraska.gov/media/5593/nac-428-rules-regs-nbcs.pdf

Reference:

- AASHTO Guide For Design of Pavement Structures 1993 (Referenced as **AASHTO** below, may be purchased on-line.) NDOT uses and recommends the AASHTO design method. Other nationally accepted design methods may be acceptable.

AASHTO 93 Pavement Design Common Errors:

- Utilizing a 24.3 Growth Factor from Pavement Design Workshop example for all design scenarios
  - GF = 24.3 is only applicable for a 20 year performance period with 2% Growth Rate
- Assuming traffic projection time period (yrs.) must be the same as performance period (n).
  - The performance period (n) is independent of the traffic projection (yrs.) and can represent any design life the designer chooses. Typical values include 20 years for full depth HMA and 35 yrs. for full depth PCC.
- Not using direction or lane factors in ESAL calculation typically resulting in 2X the appropriate ESALs.

Summary of AASHTO 93 Pavement Design Process for *Local Projects*

Input values are based on specific project details and in accordance with the *1993 AASHTO Guide for Design of Pavement Structures.*

Any nationally recognized design method, such as PaveXpress, StreetPave, or WinPASS are acceptable.

Calculating Equivalent Single Axle Load (ESAL):

1. Calculate Traffic Growth Rate: **GR = ((Future ADT/Present ADT)$^{(1/yrs)}$ -1)*100 =**
2. Calculate Traffic Growth Factor: **GF = ((1+g)^{n}-1)/g =** **g = GR/100**
    a. GF equation may be used in lieu of interpolation of *Table D.20 pg D-24 AASHTO*
    b. n = Analysis Period also known as Performance Period or Design Life. This variable (n) is independent of the time period associated with the traffic projection (yrs).
3. Calculate ESALs: **ESALs = Present ADT x 365 days/yr x HT x GF x TF x D_D x D_L**
    a. HT = Heavy Trucks (%/100)
    b. GF = Traffic Growth Factor calculated above
    c. TF = Truck Factor
        i. Use single Truck Factor and ESAL calculation based on National Functional Classification, **OR**
        ii. Multiple Truck Factors if detailed traffic distribution is known or assumed *pg D-25 AASHTO*
    d. D_D = Directional Distribution Factor (%/100) *pg II-9 AASHTO*
    e. D_L = Lane Distribution Factor (%/100) pg *II-9 AASHTO*

Flexible Pavement Design (New Build)

1. Calculate ESALs as shown above
2. Calculate Effective Roadbed Soil Resilient Modulus (M_R) *pg II-14 Fig. 2.3 AASHTO*
    a. Opt, wet, dry M_R values for NE soils available
    b. Frozen and chemically stabilized M_R values available
    c. Note: nomograph can be replaced by $u_f = 1.18 \times 10^8 \times M_R^{-2.32}$ *pg II-14 AASHTO*
3. Estimate Design Structural Number (SN) *pg II-32 Fig. 3.1 AASHTO*
4. Identify desired materials and required depths to meet SN through iterative process. There are numerous potential solutions to any given SN *pg II-35 AASHTO* **$SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \ldots$**
    a. a_1, a_2, a_3 = layer coefficients of surface, base and subbase
        i. typical coefficients available
    b. D_1, D_2, D_3 = depths of surface, base and subbase
    c. m_2, m_3 = drainage coefficients of base and subbase
        i. coefficients available *pg II-25 Table 2.4 AASHTO*

*Flexible Pavement Design Example available in *Appendix H AASHTO*

Rehabilitation of Flexible Pavement – Condition Survey Method:

(Used for HMA overlay, mill and overlay, recycle and overlay, etc.)

1. Calculate required Structural Number; Steps 1-3, Flexible Pavement Design (New Build)

2. Identify desired material(s) and required depth(s) to meet SN through iterative process *pg II-35 AASHTO*

   $SN = a_1D_1 + a_2D_2m_2 + a_3D_3m_3 + \ldots$

   a. Process similar to Step 4, Flexible Pavement Design (New Build). Primary difference is rehabilitation typically only involves HMA surface, leaving existing HMA, base, subbase, etc. below.
      i. Age and condition of existing underlying materials must be taken into consideration when assigning layer coefficients.
      ii. Typical coefficients available
   b. A shorter performance period may be appropriate depending on scope of rehabilitation

Rigid Pavement Design (New Build):

1. Calculate ESALs as shown above
2. Calculate Effective Modulus of Subgrade Reaction (k) *pg II-38 Table 3.2 AASHTO*
   a. Estimate Roadbed Resilient Modulus (M_R) for each season
      i. Opt, Wet, Dry M_R values for NE soils available
      ii. Frozen and chemically stabilized M_R values available
   b. Estimate Subbase Elastic Modulus (E_{SB}) **ONLY IF** design includes foundation course for each season
   c. Calculate Composite Modulus of Subgrade Reaction (k) *pg II-39 Figure 3.3 AASHTO* for designs with foundation course **OR** $k = M_R/19.4$ for slab on grade *pg II-44 AASHTO* for each season
   d. Modify k-value for effect of rigid foundation if bedrock within 10' *pg II-40 Fig 3.4 AASHTO* for each season if necessary. This step typically not applicable in NE.
   e. Calculate Relative Damage to pavement *pg II-41 Fig 3.5 AASHTO* for each season based on Composite k value calculated in step c (unless step d was used).
   f. Calculate Average Relative Damage by completing *pg II-38, Table 3.2 AASHTO*
   g. Back calculate composite k value using Average Relative Damage *pg II-41 Fig 3.5 AASHTO*
   h. Correct k value for loss of support *pg II-42 Fig 3.6 AASHTO*
3. Estimate required pavement thickness *pg II-45 Fig 3.7 AASHTO*
   a. This is the minimum required thickness based on project inputs. Local minimum design policies, engineering judgment, constructability issues, etc. may dictate additional depth.

*Rigid Pavement Design Example available in *Appendix I AASHTO*

Rehabilitation of PCC – PCC Condition Survey Method:

(Used for HMA overlay of PCC)

1. Calculate required slab depth for future traffic (D_f).; Steps 1-3, Rigid Pavement Design (New Build)
2. Calculate the effective depth of existing PCC based on condition **$D_{eff} = F_{jc} \times F_{fat} \times F_{dur} \times D_{ex}$** *pg III-121 AASHTO*
   a. D_{eff} = Effective slab depth (in)
   b. F_{jc} = Joints and Cracks adjustment factor
   c. F_{fat} = Fatigue Damage adjustment factor
   d. F_{dur} = Durability adjustment factor
   e. D_{ex} = Existing slab depth (in)
      i. Recommended factors *pg III-123 AASHTO*
3. Calculate A factor **$A = 2.2233 + 0.0099(D_f - D_{eff})^2 - 0.1534(D_f - D_{eff})$** *pg III-115 AASHTO*
   a. D_f = Slab depth for future traffic (in)
4. Calculate depth of overlay required (D_{ovl}). **$D_{ovl} = A(D_f - D_{eff})$** *pg III-115 AASHTO*

Local Projects Pavement Determination Data Sheet

Pavement Determination Data Sheet

Project Name _____
Project No. _____
Control No. _____
Letting Date _____
Prepared by _____
Date _____

Scoping Information

Pavement Determination

Mainline-

Shoulder-

Patching-

Pavement History

Top Layer	
Intermediate	
Intermediate	
Base layer	
Subgrade	

Pavement Management System or Field Visit Information

HMA	
Rutting (mm)	
Cracking (%)	
Rating	

PCC	
Cracking(%)	
Faulting	
Rating	

Cores

Location	Depth	Comments
1		
2		
3		
4		
5		
6		
7		
8		

Soils	
Classification	
Optimum Modulus	
Wet Modulus	
Dry Modulus	
Frozen Modulus	

Traffic	
Current ADT	
yr Forecast ADT	
% Heavy Trucks	
Predicted ESAL's	

Design Method Used:	AASHTO

Structure Number (HMA) or Thickness (PCC) Required for ESAL's	
Structure Number or Thickness Designed *(must be ≥ required)*	

Flexible Design Inputs

Structure Number based on ESAL's

Use this method for New Build design or for establishing required structure number for comparison to Rehabilitation design.

Performance Period (Yrs)	
Number of Lanes in Design Direction	
% of Trucks in Design Lane	
% of Trucks in Design Direction	
Average Initial Truck Factor (ESALS/Truck)	
Traffic Growth Rate (GR)	
Traffic Growth Factor (GF)	
Initial Serviceability	
Terminal Serviceability	
Reliability Level	
Overall Standard Deviation	
Structure Number Required	

Use these inputs & the Flexible Pavement Nomograph (Figure 3.1, pg. II-

HMA Condition Survey Method (Rehabilitation)

Use this method for Rehabilitation of existing asphalt roadways or for Bituminous Recycling Strategies

Surface Course

Type	
Depth (D_1, inches)	
Layer Coefficient (a_1)	
Structure No. for Layer (SN_1)	$SN_1=D_1 \times a_1$

Base Layer

Type	
Depth (D_2, inches)	
Layer Coefficient (a_2)	
Drainage Coefficient (m_2)	
Structure No. for Layer (SN_2)	$SN_2=D_2 \times a_2 \times m_2$

Sub-Base Layer

Type	
Depth (D_3, inches)	
Layer Coefficient (a_3)	
Drainage Coefficient (m_3)	
Structure No. for Layer (SN_3)	$SN_3=D_3 \times a_3 \times m_3$

Total Structure Provided ($SN_1 + SN_2 + SN_3 + \_$)

Add or Subtract Layers as

Comments:

Rigid Design Inputs

Thickness based on ESAL's

Use this method for New Build design or for establishing Required thickness for comparison to Rehabilitation design.

Performance Period (Yrs)		Base Type	
Number of Lanes in Design Direction		Base Thickness	
% of Trucks in Design Lane		Depth to Bedrock	
% of Trucks in Design Direction		Projected Slab Thickness	
Average Initial Truck Factor (ESALS/Truck)		Loss of Support	
Traffic Growth Rate (GR)		Reliability Level	
Traffic Growth Factor (GF)		Overall Standard Deviation	
		Load Transfer Coefficient	
Initial Serviceability		Drainage Coefficient	
Terminal Serviceability			
28-Day Mean PCC Modulus of Rupture		Thickness Required (D_r)	
28-Day Mean PCC Elastic Modulus of Slab			

Use these inputs & the Rigid Pavement Nomograph (Figure 3.7, pg.II-45)

PCC Condition Survey Method (Rehabilitation)

Use for Rehabilitation(HMA overlay) for existing concrete roadways

$$D_{ovl} = A\left(D_r - D_{eff}\right)$$

$$A = 2.2233 + 0.0099\left(D_r - D_{eff}\right)^2 - 0.1534\left(D_r - D_{eff}\right)$$

$$D_{eff} = F_{jc} \times F_{fat} \times F_{dur} \times D_{ex}$$

Definitions:

D_{ovl} = HMA overlay thickness (inches)
D_r = PCC required thickness (inches) based on ESAL's
D_{eff} = Condition Survey or factor of existing PCC as thickness (inches)
D_{ex} = Existing PCC Depth
A = Conversion number for PCC to HMA
F_{jc} = Joint & Crack adjustment factor (1.0 - 0.5)
F_{fat} = Fatigue Damage adjustment factor(1.0 - 0.9)
F_{dur} = Durability Factor (1.0 - 0.8)

F_{jc}=	
F_{fat}=	
F_{dur}=	
D_{ex}=	
D_{eff}=	

A=	

D_{ovl}=	

Comments:

Date: 2018
Source: Local Projects

NEBRASKA
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DEPARTMENT OF TRANSPORTATION

Design

Preliminary Pavement Design

Checklist # 06-12 page 1 of 3

Instructions for Use: Sections of this form are to be completed by the LPD PC before forwarding to NDOT M&R Pavement Design Section to check the Pavement Design related items on the 30% Plan Set. The NDOT LPD PC will submit a copy of the 30% PIH Plan set and the Pavement Determination to NDOT M&R to conduct this review.

Local Public Agency *(LPA)*:	LPA Responsible Charge:	
State Project No.:	Project Name and Location:	
State Control No.:	Date of Review:	This Form was Completed By:

This section to be completed by the LPD PC:

Item #	Task Description or Questions	Completed			If No, Define Corrective Action	Details or Information Used to Verify Content	Additional Comments
		Yes	No	N/A			
1.	Have the 30% PIH plans been submitted and are they ready for review?	☐	☐	☐			A pavement design analysis is not required for maintenance projects.
2.	Has the Pavement Determination Data Sheet *(PDDS)* been submitted?	☐	☐	☐			Sheet 1 required for maintenance projects *(<2" HMA)*. Sheets 1 & 2 or 1 & 3 required for resurfacing and new build projects. Appropriate nomographs required for new build.
3.	Will a Permit to Occupy State ROW be required and has that been noted on the submittal memo?	☐	☐	☐			Only if applicable.
4.	Has the LPA notified the PC of any known relaxation of design standards?	☐	☐	☐			

Remaining sections to be completed by Materials and Research.

Remaining Pavement Design

Item #	Task Description or Questions	Completed			If No, Define Corrective Action	Details or Information Used to Verify Content	Additional Comments
		Yes	No	N/A			
5.	Has a copy of the pavement design analysis been received?	☐	☐	☐			A pavement design analysis is not required for maintenance projects.
6.	Was the pavement design developed using a nationally recognized method? *(AASHTO, Asphalt Institute Method, Portland Cement Association)*	☐	☐	☐			
7.	Are all of the necessary inputs for the pavement design included? (ADT, %HT, expected life, layer coefficients…)	☐	☐	☐		Design Analysis Input and Output	
8.	Does the pavement strategy seem reasonable for the project scope? *(Check for constructability issues, material availability, etc.)*	☐	☐	☐		Existing Pavement Information, existing pavement determination, material testing information.	
9.	Have all the pavement mix types been pre-approved?	☐	☐	☐		All asphalt or concrete must be a current NDOR mix.	

Plans

Item #	Task Description or Questions	Completed			If No, Define Corrective Action	Details or Information Used to Verify Content	Additional Comments
		Yes	No	N/A			
10.	Do the project plans have typical sections or details that address all of the necessary pavement work?	☐	☐	☐			
11.	Have all the pavement related items been properly labeled in the typical section or detail? *(Depth of strategy, shouldering, preparation, inlays).*	☐	☐	☐			
12.	Is the existing pavement depth shown or described on the plans? (Needed for all removal, rehabilitation, repair or recycling sections of the project)	☐	☐	☐			