Pavement Design Guidance for LPAs

The NDOR is required by the Code of Federal Regulations (CFR) Title 23 to review all pavement designs for federally funded projects administered by the state. The NDOR 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, bike paths, minor intersection modifications (matching or exceeding existing pavement depths), preventative maintenance projects (microsurfacing, armor coats, etc.)

- Pg 1 only of Pavement Determination Data Sheet

New and Reconstruction (Resurfacing with >2" of HMA, new build HMA or PCC)

- Pg 1 & 2 or 1 & 3 of Pavement Determination Data Sheet as applicable
- Appropriate tables, figures and nomographs
- All Design assumptions and calculations

Useful References:

- AASHTO Guide For Design of Pavement Structures 1993 (Referenced as **AASHTO** below)
  May be purchased at: https://bookstore.transportation.org/
- Nebraska Department of Roads Pavement Design Manual (Referenced as **NDOR PDM** below)
  http://www.dor.state.ne.us/mat-n-tests/
- 2011 Pavement Design Workshop Presentation (Power Point)
  http://www.dor.state.ne.us/mat-n-tests/divisionPresentations.htm
- 2011 Pavement Design Workshop Presentation (Video)
  http://campus.extension.org/user/view.php?id=11400&course=487
- Summary of AASHTO 93 Pavement Design Process (See Below)
  - NDOR uses and recommends the AASHTO design method. Other nationally accepted design methods may be acceptable.

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. See equation below.

Summary of AASHTO 93 Pavement Design Process

Calculating Equivalent Single Axle Load (ESAL):

1. Calculate Traffic Growth Rate: **$GR = ((\text{Future ADT}/\text{Present ADT})^{(1/yrs)} - 1)*100 =$**
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: **$ESALs = \text{Present ADT} \times 365 \text{ days/yr} \times HT \times GF \times TF \times D_D \times D_L$**
    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, *Pg 18 & 19 NDOR PDM* **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 *pg 72 NDOR PDM*
    b. Frozen and chemically stabilized M_R values available *pg 16 & 17 NDOR PDM*
    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 *pg 45 NDOR PDM*
    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 *pg 45 NDOR PDM*
    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 *pg 72 NDOR PDM*
        ii. Frozen and chemically stabilized M_R values available *pg 16 & 17 NDOR PDM*
    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*