Best Practices for Design and Construction of Low Volume Roads

MnPAVE Training, 2002

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Best Practices for Design and Construction of HMA Pavements

Sponsored by :

- Minnesota Local Road Research Board
- Minnesota Department of Transportation

Pavement Thickness Design

1. Traffic
2. Subgrade (Embankment)
   - Design
   - Construction
3. Pavement Layers
   - Design
   - Construction

Minnesota Thickness Design Procedures

- Soil Factor
- R-Value
- Mechanistic-Empirical (MnPAVE)

Soil Factor Thickness Design

1. Traffic ; 2-way AADT & HCADT
   projected 20 years
2. Embankment Soil ; Soil Factor
   Clay Loam A-6 100%
   Granular Soils 50 – 75%
   Heavy Clays 120 – 130%

(50% = ½ thickness of subbase)

Soil Factor Thickness Design (cont.)

3. Design Thickness

Granular Equivalent (GE)

HMA $a_1 = 2.00\text{-}2.25$

Class 5 $a_2 = 1.0$

Class 3/ 4 $a_3 = 0.75$

Select Gran $a_3 = 0.50$

$GE = a_1 D_1 + a_2 D_2 + a_3 D_3$ .....

R-Value Thickness Design

Subgrade Soil R-Value

- Measured in laboratory
- Predicted from soil classification (correlations in Table 1.)

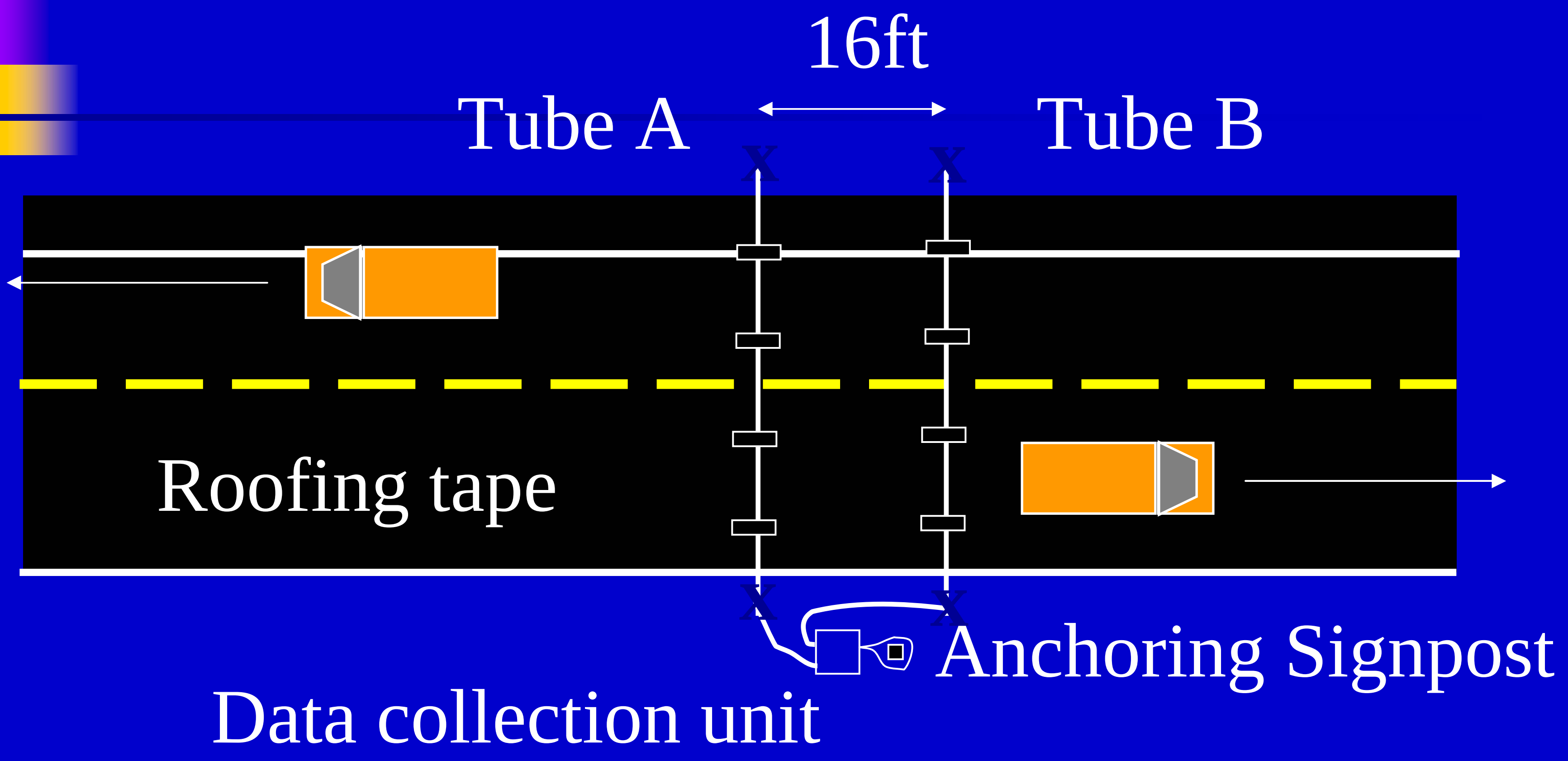
ESAL Calculations

- Total Traffic – AADT
- Vehicle Type Distribution
- Axle Weight (type) Distribution (by vehicle type)
- Lane Distribution
- Growth
- Spreadsheet Software (MNESAL’s)

Assumed Vehicle Distribution

Class #	Description	Percentage
1	Cars & Pickups	94.1
2	2-Axle S.U.	2.6
3	3-Axle S.U.	1.7
4	3-Axle Semi	0.0
5	4-Axle Semi	0.1
6	5-Axle Semi	0.5
7	Bus/Truck Trailers	1.0
8	Twin Trailers	0.0

Data Collection



Vehicle Classification Measurements

- 25,000 Vehicles, Maximum
- 48 Hours, Minimum
- One Week
  - Summer
  - Fall

Data Storage by Mn/DOT Transportation Data & Analysis

- Individual County Identification Numbers

  Mille Lacs County 5526-5550

- Statewide Database –

  Melissa Thomatz – Mailstop 450

  melissa.thomatz@dot.state.mn.us

Load Spectrum

- Definition – distribution of axle weights by axle type (single, tandem, tridem)*
- Related to structural deterioration
  1. HMA Fatigue
  2. Subgrade Rutting

     *need same traffic data as for ESAL's calculations

Design Traffic (Chapter 3)

- Soil Factor

  Two-way AADT and HCADT

- R – Value

  Design lane ESAL's

- MnPAVE

  Design lane ESAL's or Load Spectrum

R-Value Design Thickness

- Granular Equivalent Thickness (same formula as Soil Factor Design)

  a_1 2.00 – 2.25 for HMA

  a_2 1.00 for class 5 or 6

  1.25 to 1.50 for stabilized bases

  a_3 0.75 for Class 3

  0.50 for Select Granular

R-Value Minimum Thicknesses

- Minimum Surface plus Base GE
- Minimum Surface GE
- Depend on Traffic

MnPAVE
Mechanistic – Empirical Design

- Embankment Soil
- Traffic
- Pavement Section

MnPAVE – Embankment Soil Resilient Modulus (M_r)

- Like Elastic Modulus
- Varies throughout the year
- Depends on:
  - soil type
  - density
  - moisture content

MnPAVE – Embankment Soil Determination

- Measurement in laboratory

  LTPP P-46   standard triaxial test

- Correlations from Table 1
  - Soil Classifications
  - R - Value

Embankment Soil – M_r Variatons*

- Annual Variation – 5 seasons
  - Early Spring (frozen)
  - “Late” Spring (weakest)
  - Summer (recovering)
  - Fall (recovered)
  - Winter

*based on Mn/ROAD

Soil Resilient Modulus Correlations (Table 1)

- Soil Classification
  - AASHTO
  - Unified
- Strength Tests
  - R – Value
  - DCP

Soil Classification			Strength Tests				MnPAVE Design Moduli							
Textural Class	AASHTO	Mn/DOT Soil Factor	R-Value (240 psi Exudation Pressure)		CBR Percentage	DCP mm/blow	Winter & Early Spring		Late Spring		Summer		Fall	
			Estimated	Measured	Estimated	Estimated	MPa	ksi	MPa	ksi	MPa	ksi	MPa	ksi
Gravel (G)	A-1	50-75	70	ND	21	12	350	50	62	9.0	78	11	78	11
Sand (Sa)	A-1 A-3	50-75	70	ND	21	12	350	50	62	9.0	78	11	78	11
Loamy Sand (LSa)	A-2	50-75	30	46 - 74	6.2	22	350	50	33	4.8	41	6.0	41	6.0
Sandy Loam (SaL)	A-2 A-4	100-130	30	17 - 49	4.4	27	340	50	27	4.0	34	5.0	34	5.0
Loam (L)	A-4	100-130	15	14 - 26	4.2	27	330	48	27	3.9	33	4.8	33	4.8
Silt Loam (SiL)	A-4	100-130	12	10 - 40	3.9	28	320	46	26	3.7	32	4.6	32	4.6
Sandy Clay Loam (SaCL)	A-6	100-130	17	14 - 27	4.5	26	350	50	28	4.0	35	5.0	35	5.0
Clay Loam (CL)	A-6	100-130	13	13 - 21	4.1	28	330	48	26	3.8	33	4.8	33	4.8
Silty Clay Loam (SiCL)	A-6	120-130	10	11 - 21	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Sandy Clay (SaC)	A-7	120-130	14	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND	ND
Silty Clay (SiC)	A-7	120-130	8	ND	3.4	30	300	43	24	3.5	30	4.3	30	4.3
Clay (C)	A-7	120-130	12	10 - 17	3.9	28	320	47	26	3.7	32	4.7	32	4.7

Design and Construction Embankment – Chapter 4

- Design
  - Drainage
  - Uniformity
  - Frost protection

Design and Construction Embankment Chapter 4 (cont.)

- Soil Sampling
- Mix Soils minimize high moisture pockets
- Layer Construction UNIFORMITY

Design and Construction Embankment – Chapter 4 (cont.)

- Construction
  - Specifications:
    - 2105 – Specified Density or *Quality* Compaction
    - 2111 – Proofrolling
    - 2123 – Equipment Requirements

Design and Construction Pavement Section – Chapter 5

- Granular base / subbase
  - Drainage
  - Uniformity
- Construction
  - Specifications

    Materials: 3138, 3149

    Construction: 2211

Design and Construction Pavement Section - HMA

- Design

  Volumetrics, Air Voids, VMA, VFA,

  1.2350 Spec.-Marshall hammer compaction

  (Number of blows)

  2.2360 Spec.- Gyratory compaction

  (Number of gyrations)

HMA Construction - Specifications

- Asphalt – PG grading and quality
- Aggregate
  - Quality
    - Crushing; fractured faces for CA
    - FAA for sand
    - Moisture Susceptibility
  - Gradation – Spec 3139

HMA Construction Specifications (cont.)

- Construction
  - 2350 (Marshall Hammer)
  - 2360:(Gyratory Compactor)
    - DENSITY – Specified or *Quality*
    - UNIFORMITY – QC/QA
    - RIDE

Best Practices Report

Chapter 1. Summary (distributed)

2. Design Procedures

3. Traffic Calculations

4. Embankment Design and Construction

5. Pavement Section Design and Construction

6. Summary

Design Comparisons

- 1. Current Design Procedure
  - Soil Factor Design
  - R – Value Design
- 2. Mn/PAVE Design
- Submit MnPAVE Design Summary which is part of output and also current design results to
  - Gene Skok, skokx003@tc.umn.edu
  - Or Shongtao Dai, shongtao.dai@dot.state.mn.us

Low Volume Road Performance