DEPARTMENT OF TRANSPORTATION

FLEXIBLE PAVEMENT DESIGN GUIDANCE

INTRODUCTION

Under State Aid guidelines, there are several options available to cities and counties when designing flexible pavements. Historically Minnesota cities and counties have designed pavements using Soil Factors (S.F.) to represent subgrade soil type and strength along with Gravel Equivalency (G.E.) values and 20-year projected Average Daily Traffic (ADT) loading. More recently, R-value and Equivalent Single Axle Loads (ESAL's) have been used with Mechanistic-Empirical (ME) based calculations and computer software programs being recommended. Within State Aid all of these methods of pavement design are permissible. State Aid Operations Chapter 8820 requires all pavements to be designed meeting minimum structural design strengths. These are defined in sections 8820.9920 to 8820.9986. Although allowance is made to design seven and nine ton strength roadways, new or reconstructed pavements should be designed to have ultimate structural design strengths of ten tons. This requires the geometric typical sections be designed wide enough to accommodate a thicker future structural pavement section.

Before preparing a pavement design, a minimum of two primary parameters are required to be defined. These are subgrade soil strength and traffic loading.

Subgrade Soil Strength

Select from the table below a Soil Factor or an assumed R-value to represent the subgrade soil strength for the road segment being designed. If an actual R-value was determined through a soil investigation program, use it.

Stabilometer R-values by Soil Type

SOIL PROPERTIES				
MnDOT Textural Classification	AASHTO Classification	ASTM Unified Classification	MnDOT Soil Factor	R-value (assumed)
Gravel	A-1	GP-GM	50	75
Sand	A-1, A-3	SP-SM	75	70
Loamy Sand	A-2	SM, SC	75	70
Sandy Loam Slightly Plastic (<10% clay)	A-2	SM, SC	75	30
Sandy Loom Plastic (10-20% clay)	A-4	SM, SC	100	20
Loam	A-4	ML, MH	100	20
Silt Loam	A-4	ML, MH	100	20
Sandy Clay Loam	A-6	SC, SM	100	20
Clay Loam	A-6	CL	100	12
Silty Clay Loam	A-6	ML/CL	120	12
Sandy Clay	A-7	SC	120	12
Silty Clay	A-7	ML/CL	120	12
Clay	A-7	CL, CH	130	10

NOTE: 1. Soil Factors from State
2. R-values from Table 299.2 of the MnDOT Pavement Design Manual
3. R-values based on data collected by MnDOT through 1974.

When using the subgrade soil strength Soil Factors or R-values from this table for bituminous pavement design, it is essential that the subgrade be constructed of uniform soil at a moisture content and density in accordance with MnDOT Specification 2105 and be capable of passing test rolling, MnDOT Specification 2111. To minimize frost heaving and thaw weakening, it is also essential that finished grade elevation be suitably drained or placed an adequate distance above the water table. This distance should be at least equal to the depth of frost penetration. In the case of silty soils, the distance should be significantly greater because of capillary action.

Table 299.3 - Approximate Equivalent Classifications

MnDOT Triangular Textural	AASHTO (Group Index)	Unified (USCS)
Gravel	A-1-a(0)	GW, GP
Sand	A-1-b(0)	SW, SP
Coarse Sand	A-1-a, A-1-b(0)	SW, SP
Fine Sand	A-1-b, A-3(0)	SW, SP
Loamy Sand	A-2-4, A-2-5(0)	SM, SC
Sandy Loam (Slightly Plastic)	A-2-4, A-2-6, A-2-7(0)	SM, SC
Sandy Loam (Plastic)	A-4(0-4)	SM, SC
Loam	A-4(0-4)	ML, OL, MH, OH
Silt Loam	A-4(0-4)	ML, OL, MH, OH
Silt	A-4	ML, OL, MH, OH
Sandy Clay Loam	A-6, A-5(0-16)	SC, SM
Clay Loam	A-6(0-16)	ML, OL, CL, MH, OH, CH
Silty Clay Loam	A-6, A-5(0-16)	ML, OL, CL, MH, OH, CH
Sandy Clay	A-7, A-7-6(0-20+)	SC, SM
Silty Clay	A-7, A-7-5(0-20+)	OL, CL, OH, CH
Clay	A-7(0-20+)	CL, CH, OH, OL

NOTE: MnDOT Pavement Manual, Chapter 2
Granular – MnDOT Spec 3149.2B1
Select Granular – MnDOT Spec 3149.2B2
AASHTO Soil Types – A-1-a, A-1-b and A-3

Traffic loading

Traffic loading is represented either as ADT, Heavy Commercial ADT (HCADT) or total ESAL's calculated over the design life of the pavement. Current ADT values for cities and counties can be obtained from the MnDOT Traffic Forecasting and Analysis webpage. It is always encouraged to do a special traffic count when reconstructing or overlaying a roadway to obtain the most current and accurate traffic loading information. ESAL's can be calculated using the State Aid ESAL Calculator. When designing ten ton roadways, the calculated 18 kip ESAL loading must be multiplied by 1.12 (10 Ton ÷ 9 Ton = 1.11) to obtain the 20 kip ESAL loading for use in the design charts or programs.

FLEXIBLE PAVEMENT DESIGN

Using the subgrade soil strength value and either ADT or ESAL's you can now use one of the following State Aid Pavement Design Charts or MnDOT Pavement Design programs (located at: www.dot.state.mn.us/stateaid/pavement.html) to design your road pavement section.

Design Charts:

- Ultimate 10 Ton Staged Flexible Pavement Design Using Soil Factors
- 7 & 9 Ton Flexible Pavement Design Using Soil Factors

- 7 Ton National Preservation Routes Flexible Pavement Design Using Soil Factors
- MnDOT R-value Bituminous Pavement Design Chart

MnDOT Flexible Pavement Design (R-value)

MnPAVE

Ultimate Ten Ton Staged Flexible Pavement Design

Ultimate ten ton staged pavement designs are permissible for all new and reconstructed rural and suburban undivided roadways having a projected ADT of 150 to 1,499. Staged design allows the initial pavement to be designed for a minimum nine ton structural strength. Typical section dimensions required to accommodate a future bituminous overlay (typically two inches) to be placed to achieve the ultimate ten ton design strength without compromising the minimum design standards. Roadways having a projected ADT of 1,500 or more and rural divided roadways must be designed having ten ton minimum pavement design strengths. An exception has been allowed for roadway pavements within municipal corporate limits where minimum structural pavement design must support nine ton axle strength.

If you have any questions concerning pavement design, please contact:

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