



Mn/ROAD Aggregate Profile

Introduction

Four different aggregate materials were used as base and subbase materials in the construction of the MnROAD project. These materials are referred to as Class 3sp, Class 4sp, Class 5sp and Class 6sp and are labeled “special” due to the fact that they are used for MnROAD exclusively, this is shown in Appendix A. The Minnesota DOT uses Class 3, Class 4, Class 5, and Class 6, not labeled "special", as base materials on a regular basis. A simple interpretation of the base materials consistency and strength can be determined with a series of tests including, gradations, Proctor tests, rapid shear strength tests and frost susceptibility tests. Gradations, Proctor and shear strength tests were run on all four base materials, while frost susceptibility tests were run on Class 5sp and Class 6sp material exclusively. Testing agencies responsible for the various tests include:

- ◆ Minnesota DOT, gradations and Proctor tests
- ◆ University of Illinois at Urbana-Champaign (Thompson 1998), rapid shear tests
- ◆ US Army Cold Regions Research and Engineering Laboratory (Bigl+Berg,1990), frost susceptibility



Results

Gradation tests, conducted by the Minnesota Department of Transportation, were run on all four classes of base material and are used to determine the Unified Soil Classification System (USCS) Classification. The tests show that the materials appear to be classified by the USCS as:

- Class 3sp: a gravely sand with the highest percentage of fines at approximately 12.3% to 13.2%.
- Class 4sp: a gravely sand with about 7.3% fines.
- Class 5sp: a sandy gravel with approximately 5.7% fines.
- Class 6sp: a sandy gravel with the lowest percentage of fines at about 4.7%.

Gradation test results are found on the Table 1 and Graphs 1 through 4.

Material	Class 3sp	Spec.	Class 4sp	Spec.	Class 5sp	Spec.	Class 6sp	Spec.
Gradation								
Passing 1" (25mm)	100	100	100	95-100	100	100	100	100
Passing 3/4" (19mm)	99.5		98	90-100	96	90-100	97.7	85-100
Passing 3/8" (9.5mm)	97.7	95-100	91	80-95	81	70-85	69.7	50-70
Passing #4 (4.75mm)	90.5	85-100	80	70-85	69	55-70	46	30-50
Passing #10 (2mm)	79.6	65-90	67	55-70	54	35-55	27.8	15-30
Passing #20 (0.85mm)	61.9		46		34		15.1	
Passing #40 (0.425mm)	39.6	30-50	28	15-30	20	15-30	10.4	5-15
Passing #60 (0.225mm)	26.2						8.1	
Passing #100 (0.15mm)	18.3		11		8		6.3	
Passing #200 (0.075mm)	13.2	8-15	7.3	5-10	5.7	3-8	4.7	0-5

Table 1: Gradation results

Proctor tests, conducted by the Minnesota Department of Transportation, are used to determine the materials maximum dry density and optimum moisture content. These tests show that the materials appear to be:

- Class 3sp: the least dense material, of the materials tested, with maximum dry density of about 127.9 pounds per cubic foot.
- Class 4sp: the highest optimum water content at approximately 10% of the total dry weight.
- Class 5sp: the densest of the four materials tested with a maximum dry density of approximately 132.7 pounds per cubic foot.
- Class 6sp: the lowest optimum water content at approximately 6.8%.

Proctor test results are found on Table 2.

Material	Class 3sp	Class 4sp	Class 5sp	Class 6sp
Max. Dry Density, pcf	127.9	126	132.7	128.7
Opt. Mois. Cont., %	8.8	10	8.1	6.8

Table 2: Proctor results

Rapid shear strength tests, conducted by the University of Illinois at Urbana-Champaign (Thomson, 1998), were run on all four classes of base. This test uses the friction angle ‘ ϕ ’ and cohesion ‘ c ’ to develop a Mohr-Coulumb failure envelope, which, after more testing, is used to determine the materials peak shear strength. The rapid shear strength tests run on the four classes of base suggest that:

- Class 3sp material is the weakest material of the four materials tested.
- Class 6sp material is the strongest material of the four bases tested and the least susceptible to changes in moisture content.

Frost susceptibility tests, conducted by the US Army Cold Regions Research and Engineering Laboratory (Bigl+Berg, 1990), were only run on the Class 5sp and Class 6sp materials due to equipment problems while testing the Class 3sp material. Frost susceptibility tests use the rate of heave during the test to determine a relative index of frost susceptibility, which is rated from negligible to very high.

- Class 5sp material appeared to have a low to medium frost susceptibility.
- Class 6sp material’s frost susceptibility appeared to be negligible.
- The tests also suggest that frost susceptibility of the base material may increase with increasing freeze-thaw cycles.

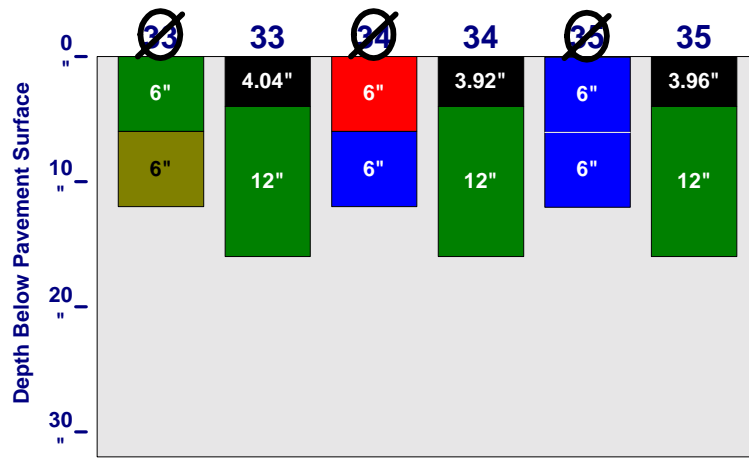
Frost susceptibility tests are found on Table 3.

	1 st Freeze Cycle		2 nd Freeze Cycle		CBR Tests		Overall Rating
	H _v rate (mm/day)	Rating	H _v rate (mm/day)	Rating	CBR (%)	Rating	
Subgrade							
1171(563)	1	V. Low	7.5	Medium	2	High	Medium
1193(564)	9.3	High	22.5	V. High	<1	V. High	V. High
1206(565)	9.3	High	16	High	<1	V. High	V. High
1232(566)	1	V. Low	7.5	Medium	2	High	Medium
Class 5							
Sample 1	3	Low	3	Low	7	Medium	Low
Sample 2	NF	-	4.3	Medium	11	Low	Medium
Sample 3	5.5	Medium	5.4	Medium	11	Low	Medium
Sample 4	5.3	Medium	5.3	Medium	12	Low	Medium
Class 6							
Blended	<1	Negl.	<1	Negl.	29	Negl.	Negl.

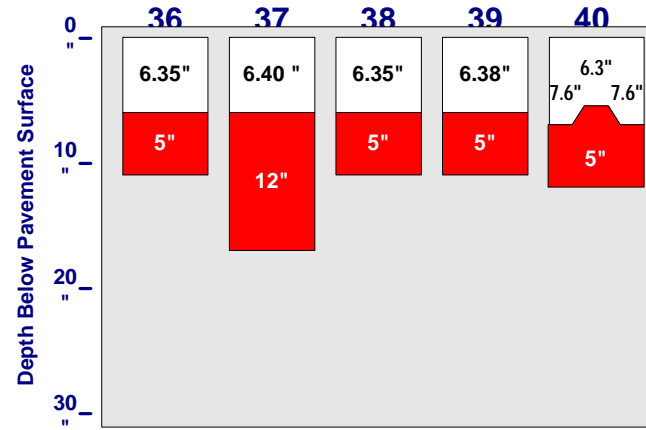
Table 3: Frost susceptibility tests (Bigl+Berg, 1990)

Appendix A

MnROAD Test Sections



Asphalt Binder	PG 58-28	PG 58-34	PG 58-40
Subgrade "R" Value	12	12	12
Construction Date	Sep 96	Sep 96	Aug 99

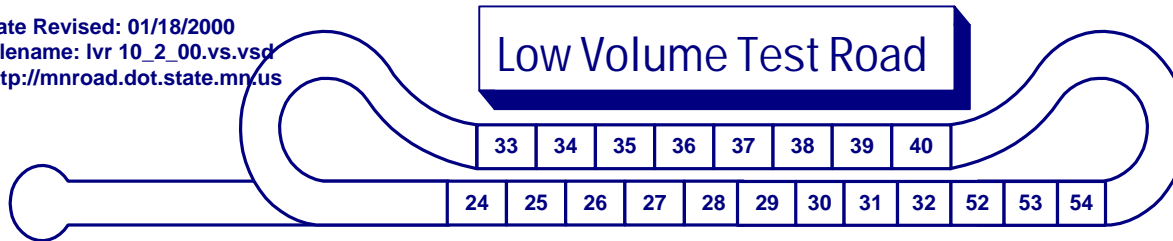


Panel Width**	12' / 12'	12' / 12'	12' / 12'	12' / 12'	12' / 12'
Panel Length	15'	12'	15'	20'	15'
Dowel Diameter	1"	None	1"	1"	None
Subgrade "R" Value	70	70	12	12	12
Construction Date	Jul 93	Jul 93	Jul 93	Jul 93	Jul 93



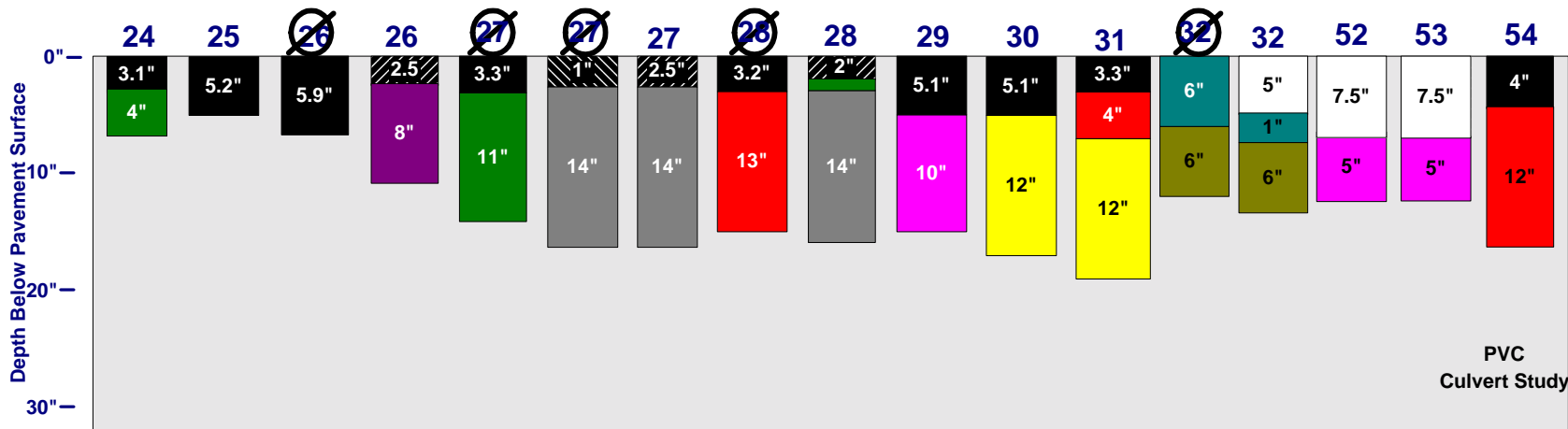
∅ Cells that have been re-constructed with new materials

Date Revised: 01/18/2000
 Filename: lvr 10_2_00.vs.vspd
 http://mnroad.dot.state.mn.us



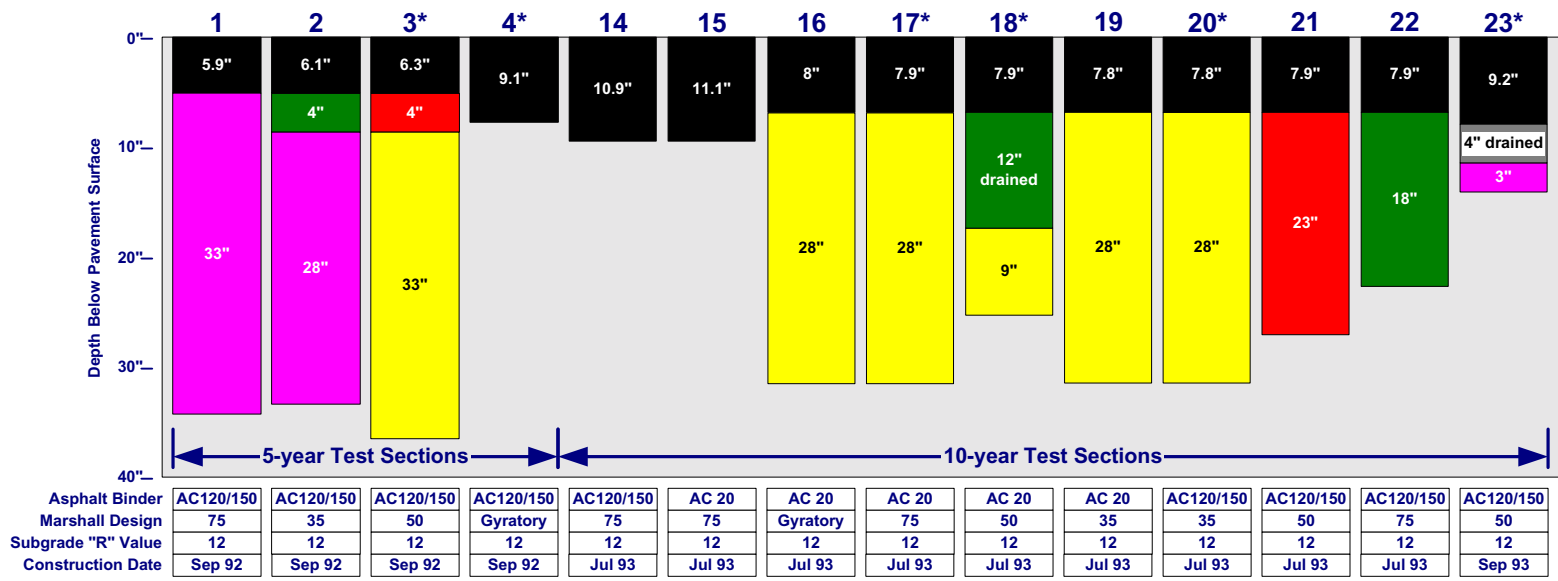
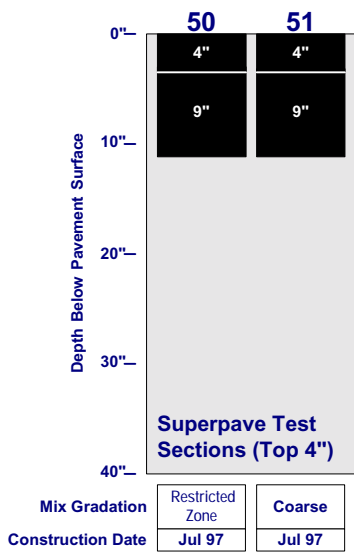
Legend

- Oil / Gravel
- Hot Mix Asphalt
- Concrete
- Crushed Stone Base
- Class 1
- Class 1c
- Class 1f
- Class 3 Sp.
- Class 4 Sp.
- Class 5 Sp.
- Class 6 Sp.
- Reclaimed HMA
- Double Chip Seal



Asphalt Binder	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150	AC 120/150
Marshall Design	35	50	50	50	50	50	75	75	75	75	75	75	75	75	75
Subgrade "R" Value	70	70	12	12	12	12	12	12	12	12	12	12	12	12	12
Construction Date	Aug 93	Aug 93	Aug 93	Sept 00	Aug 99	Aug 99	Sep 00	Aug 93	Aug 99	Aug 93	Aug 93	Aug 93	Aug 93	Aug 93	Oct 00

PVC
Culvert Study

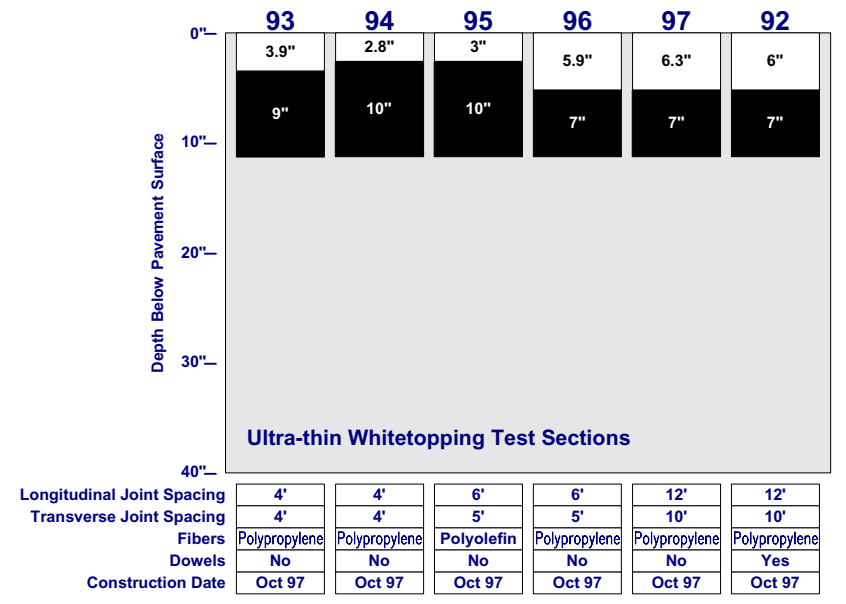
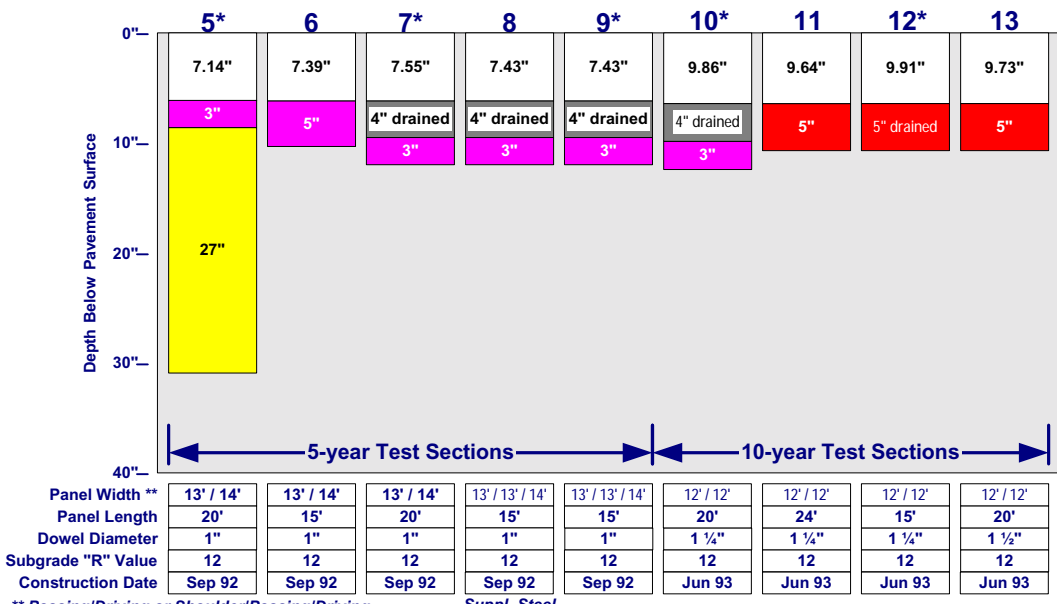
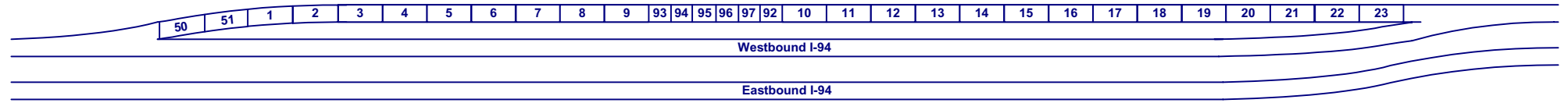


Legend

- Hot Mix Asphalt
- Concrete
- Class 3 Sp.
- Permeable Asphalt Stabilized Base
- Class 4 Sp.
- Class 5 Sp.
- Class 6 Sp.

Mainline Test Road

Date Revised: 01/18/2000
 Filename: mainline co
<http://mnroad.dot.state.mn.us>
 * Cells that are LTPP Sections - GPS Database



** Passing/Driving or Shoulder/Passing/Driving

Suppl. Steel