Minnesota Road Research Project

2006 Cell 1 Construction Report

MnROAD Mainline

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ABSTRACT

The purpose of this report is to provide details on the 2006 reconstruction of Cell 1 on the MnROAD Mainline. The condition of Cell 1 was deteriorating rapidly, primarily in the driving (right) lane. Top down cracking, transverse cracking, rutting, and ride quality have reached or are approaching levels that require extensive repair. A dense array of instrumentation was placed in the right wheel path in the vicinity of station 1105 + 50 during initial construction in 1993. The pavement was significantly weakened around these sensors and was becoming badly damaged by traffic. The driving lane required rehabilitation in the form of a 1.5-inch mill and overlay, which was performed as part of State Project No. 8680-152, in which two test sections on the MnROAD Low Volume Road were reconstructed. The asphalt mixture type was selected to complement a Local Road Research Board (LRRB) study entitled "Performance of PG 52-34 Oil on Local Roads." The objective of this study was to determine at which traffic level PG 52-34 could be used as an effective binder grade without being susceptible to rutting. The use of this binder on the Mainline under interstate traffic will provide an accelerated test and be a benefit for the LRRB study. This report documents the previous pavement condition, HMA mix design, and field construction activities.

INTRODUCTION

MnROAD Facility

The Minnesota Department of Transportation (Mn/DOT) constructed the Minnesota Road Research Project (MnROAD) between 1990 and 1993. MnROAD is located 40 miles northwest of Minneapolis/St. Paul and is an extensive pavement research facility consisting of two separate roadway segments containing 52 distinct test cells. Each MnROAD test cell is approximately 500 feet long. Subgrade, aggregate base, and surface materials, as well as, roadbed structure and drainage methods vary from cell to cell. All data presented herein, as well as historical sampling, testing, and construction information, can be found in the MnROAD database and in various publications. Layout and designs used for the Mainline and Low Volume Road are shown in Appendix A. Additional information on MnROAD can also be found on its web site at http://mnroad.dot.state.mn.us/research/mnresearch.asp.

Mainline

The MnROAD Mainline is a 3.5-mile 2-lane interstate roadway carrying “live” traffic. The Mainline consists of both 5-year and 10-year pavement designs. The 5-year cells were completed in 1992 and the 10-year cells were completed in 1993. Originally, a total of 23 cells were constructed consisting of 14 hot mix asphalt (HMA) cells and 9 Portland cement concrete (PCC) test cells. Superpave and whitetopping cells were added in 1997 and 2004.

Traffic on the Mainline comes from the traveling public on westbound I-94. Typically the Mainline is closed for three days per month and the traffic is rerouted to the original interstate highway to allow MnROAD researchers the ability to safely collect data and record test cell performance. The traffic volume has increased dramatically since the test facility first opened, from an estimated 14,000 vehicles per day in 1994 to over 26,000 vehicles per day today. The Mainline equivalent single axle loads (ESALs) are determined from two weigh-in-motion (WIM) devices located at MnROAD. An IRD Inc. hydraulic load scale was installed in 1989 east of the mainline test cells, and a Kistler quartz WIM was installed in 2000 between PCC cells 10 and 11. Over time the mainline has received roughly 6 million flexible ESALs and 10 million rigid ESALs as of December 2005.

Low Volume Road

Parallel and adjacent to the Mainline is the Low Volume Road (LVR). The LVR is a 2-lane, 2 ½-mile closed loop that contains 20 test cells. Traffic on the LVR is restricted to an MnROAD operated vehicle, which is an 18-wheel, 5-axle, tractor/trailer with two different loading configurations. The "heavy" load configuration results in a gross vehicle weight of 102 kips (102K configuration). The “legal” load configuration has a gross vehicle weight of 80 kips (80K configuration). On Wednesdays the tractor/trailer operates in the 102K configuration and travels in the outside lane of the LVR loop. The truck travels on the inside lane of the LVR loop in the 80K configuration on all other weekdays. This results in a similar number of ESALs being delivered to both lanes even though the number of passes differs. Several pavement sections on the Low Volume Road have been reconstructed since 1993.

MnROAD Instrumentation and Performance Database

Data collection at MnROAD is accomplished with a variety of methods to help describe the pavement response to loads and the environment and the actual pavement performance. Layer data is collected from a number of different types of sensors (initially numbering 4,572) located throughout the pavement surface and sub-layers. The sensors measure variables such as temperature, moisture, strain, deflection, and frost depth. Data flows from these sensors to several roadside cabinets, which are connected by a fiber optic network that is fed into the MnROAD database for storage and analysis. MnROAD staff also monitor pavement performance on a regular basis, and the data is input into the database. Monitoring

data includes ride, distress, rutting, faulting, friction, FWD, forensic trenches, and material laboratory testing. Data from the sensors or monitoring activities can be requested from the MnROAD database by contacting Mn/DOT researchers.

CELL HISTORY

Materials

Cell 1 was originally constructed in 1993. The cell was designed with a 5-year design life (approximately 3 million ESALs) following Mn/DOT 2350 specifications for hot mix asphalt. The cell, one of 14 original Mainline HMA test cells, was constructed on a 33-inch base of Class 4 over a clay subgrade. The subgrade design R-value was 12. The average HMA thickness was 5.9 inches, and the mix used a 75-blow Marshall design. The asphalt binder had a penetration grade of 120/150, which through laboratory testing was later graded as a PG 58-28.

Traffic Loading

Traffic was applied to the test cell beginning in 1994 in the form of live interstate vehicles. Traffic is typically run on the MnROAD mainline for all but three days per month – during these days the traffic is switched over to the old Westbound I-94 to facilitate any testing and repair work needed by researchers. Through the summer of 2005, the number of ESALs applied on the driving lane totaled 5.8 million, and those on the passing lane totaled 1.4 million (see Figure 1).

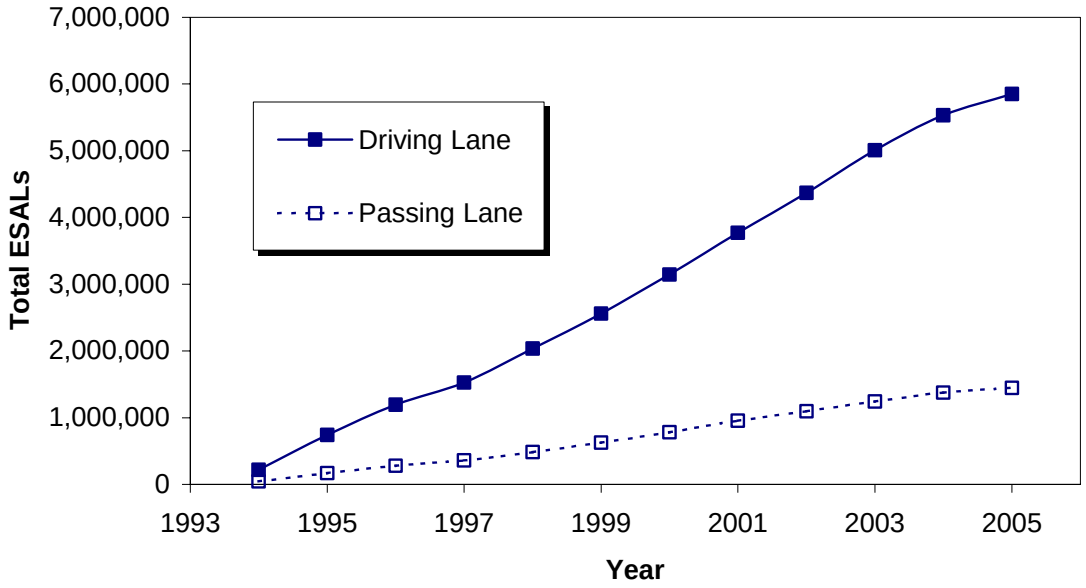

Figure 1. Cell 1 ESAL Accumulation over Time

Pavement Condition

The condition of Cell 1 was deteriorating rapidly, primarily in the driving (right) lane. Top down cracking, transverse cracking, rutting, and ride quality have reached or are approaching levels that require extensive repair. A dense array of instrumentation was placed in the right wheel path in the vicinity of station 1105 + 50 during initial construction in 1993. The pavement was significantly weakened around

these sensors and was becoming badly damaged by traffic, as shown in Figure 2. Several cores were taken in this area to investigate the integrity of the pavement structure. Figure 3 shows that beneath the surface, the HMA pavement is still intact. It was determined that the driving lane required rehabilitation in the form of a 1.5-inch mill and overlay.

Figure 2. Cell 1 Pavement Condition

Figure 3. Cores Showing Cell 1 Structural Integrity

Table 1 shows the Cell 1 ride quality measured prior to the mill and overlay. Data was collected with the Pathways van by Mn/DOT Pavement Management staff and converted into International Roughness Index (IRI). The IRI of the driving lane was 2.97, and the Present Serviceability Rating (PSR) was 2.0, which corresponds to "poor" condition. Video logs also enabled the calculation of a Surface Rating (SR) to quantify pavement distress – the lower the number, the more cracking is present.

Table 1. Cell 1 Ride Quality Data

Lane	IRI, m/km	PSR	SR
Driving	2.97	2.0	1.7
Passing	2.65	2.2	3.2

Table 2 shows the average rutting conditions measured before the rehabilitation. Rutting data was collected using an automated laser profile system (ALPS). The rutting in the driving lane is approaching ½ inch, which is the common trigger for rehabilitation.

Table 2. Cell 1 Rutting Data (inches)

Lane	LWP	RWP	Average
Driving	0.39	0.46	0.42
Passing	0.16	0.34	0.25

Cell 1 exhibits a fair amount of cracking, and this is the primary reason that the mill and overlay is required. The low temperature (transverse) cracks show the typical pattern and are spaced about 50 feet apart (Table 3). Top down cracking extends the entire length of the section in both wheelpaths of both lanes, and the severity level is mostly medium to high (Table 4). A forensic coring operation in 2005 determined that the crack depth progressed significantly since an earlier investigation, in many cases extending throughout the entire pavement depth. The cracks were sealed in 1998 and again in 2000.

Table 3. Cell 1 Transverse Cracking Data

Lane	Low Severity		Medium Severity		High Severity	
	Number	Length, ft	Number	Length, ft	Number	Length, ft
Driving	1	2	3	26	17	181
Passing	1	4	0	0	14	161

Table 4. Cell 1 Top Down Cracking (Total Length, ft)

Lane	Low	Medium	High
Driving	0	850	150
Passing	50	950	0

CELL 1 RECONSTRUCTION

The mill and overlay of the driving lane of Cell 1 was performed as part of State Project No. 8680-152, in which two test sections on the MnROAD Low Volume Road were reconstructed. The goal of this larger project was to evaluate the effectiveness of a geocomposite capillary barrier drain (GCBD) for pavement drainage. This 3-layer geotextile system explicitly targets and provides for unsaturated flow and will potentially result in greater drainage efficiency compared to conventional drainage methods. The milling and paving operations performed on Cell 1 were simply done as overruns on this project.

The asphalt mixture type was selected to complement a Local Road Research Board (LRRB) study entitled "Performance of PG 52-34 Oil on Local Roads." The objective of this study was to determine at which traffic level PG 52-34 could be used as an effective binder grade without being susceptible to rutting. The use of this binder on the Mainline under interstate traffic will provide an accelerated test and be a benefit for the LRRB study.

Construction Field Notes

Table 5 is a summary of Mn/DOT's field notes taken during construction. The notes basically reflect the main activities that occurred each day. Figure 4 shows the bituminous mix design report for Cell 1.

Table 5. Cell 1 Construction Field Notes

Date	Notes
June 19	*7:00 a.m.* – CAT PM 465 cold planer on the job. Hardrives began milling Cell 28 on LVR. *7:30 a.m.* – Traffic was switched from the MnROAD Mainline to old Westbound I-94. Traffic will remain off the Mainline for approximately 8 weeks until the overlay is paved. *1:30 p.m.* – Finished milling LVR, walked down to Cell 1. Milled 1.5" in driving (right) lane. The milling machine was careful to avoid several in-pavement LED markers along the edge stripe. Completed milling by 2:45 p.m. Cleaned up surface with a skid steer loader.
August 7	Tom Wood was on site to assist with Mn/DOT field inspection. Hardrives equipment included CAT AP-1055B paver, Ingersoll Rand DD-130HF vibratory (breakdown) roller, and Dynapac CC622VHF steel wheel (finish) roller. Steve Weis (paving foreman) called and said PG 52-34 oil was having trouble passing the specifications at Flint Hills Resources. Paving began with the bottom lift on Cells 27-28, moved onto Cell 1 (the paver broke down for about an hour before starting Cell 1), then moved back to place the top lift on Cells 27-28. Tack coat was sprayed on Cell 1 at a rate of 0.10 gal/sq yd before paving. A total of 84 tons of HMA was placed on Cell 1. 16 5-gallon buckets of loose mix (PG 52-34) was sampled from the paver wings for later research and stored in the MnROAD polebarn.
August 10	Ted Snyder was on site early in the morning to take HMA cores from Cells 27-28 for QC/QA testing. A Hardrives representative took cores from 4 random locations (2 each lift) along with 2 companion cores for Mn/DOT.
August 16	Traffic was switched back to the MnROAD Mainline at 8:00 AM CDT.

BITUMINOUS PLANT MIX DESIGN REPORT

Minnesota Department of Transportation
Office of Materials
1400 Gervais Avenue
Maplewood, MN 55109
Phone (651) 779-5614
FAX: (651) 779-5580

 # 0-2006-193

Date: 8/11/2006

THIS MIX DESIGN REPORT IS NOT VALID UNTIL PLANT NO. INDICATED BELOW IS CERTIFIED.

TO BE FILLED IN BY CONTRACTOR	
ENGINEER	**FOR**
PROJECT NUMBER	
CONTRACTOR SIGN.	
FOR ALL STATE, COUNTY, AND CITY PROJECTS, CONTRACTORS MUST FAX A COPY TO MN/DOT TWO WORKING DAYS PRIOR TO PRODUCTION AT (651) 779-5580	

SPEC	**2360**
SPEC YEAR	**2006**
MIX TYPE	**SPWEB340**
AC GRADE	**PER PROPOSAL**

THIS MIXTURE HAS BEEN REVIEWED FOR VOLUMETRIC PROPERTIES ONLY, IT DOES NOT ASSURE THAT FIELD PLACEMENT AND COMPACTION REQUIREMENTS HAVE BEEN MET.

PLANT NO. **901208** - **2006A** JOB MIX FORMULA

Begin With Test Number		
SP	**WE**	**301**
- -	- -	- - -

Sieve Size (mm)	(in.)	Composite Formula	JMF LIMITS			For Information Only Virgin Formula
37.5	(1 1/2)			-		PERCENT PASSING
25.0	(1)			-		
19.0	(3/4)	100	100	-	100	
12.5	(1/2)	94	87	-	100	
9.5	(3/8)	80	73	-	87	
4.75	(#4)	62	55	-	69	
2.36	(#8)	53	47	-	59	
0.075	(#200)	2.4	2.0	-	4.4	
Spec. Voids		4.0	3.0	-	5.0	
Spec. VMA		14.0	13.7			
% AC		5.7 (TOTAL)	5.3			%AC (NEW)

TM # 2006-083 **Indicates a Gyratory Density of** 147.6 **(lbs/ft3) at** 60 **Design Gyrations**
Use of anti-strip agent required: N

Proportions		Pit	Source of Material	Sp.G
48	%	71059	BARTON ELK RIVER #2 BA 3/4"	2.644
24	%	19106	KRAEMER BURNSVILLE 9/16" CHIP (LIMESTONE)	2.675
20	%	71041	AGG IND ELK RIVER CLASS D MAN. SAND	2.651
8	%	71002	BARTON ELK RIVER #1 WASHED SAND	2.656
	%			
	%			
	%			
	%			

Mix Aggregate Specific Gravity at the Listed Percentages = 2.654

This Mix Design Report supersedes MDR/REC # 0-2003-224 **Dated:** 9/25/2003

Remarks MINUS #4 AGGREGATE SPG AT THE LISTED PERCENTAGES = 2.640

Mix Design Reviewed by:

cc:
Contractor - COMMERCIAL ASPHALT #8
Metro Inspection

Figure 4. Bituminous Mix Design Report

CONSTRUCTION SUMMARY

Researchers will continue to monitor the performance of Cell 1 with respect to the PG 52-34 binder grade. Early results indicate that the soft binder is holding up quite well under Interstate traffic, with little or no noticeable rutting. It worked well to include the mill and overlay of Cell 1 in the larger construction project on the Low Volume Road.

APPENDIX A

MNROAD TEST SECTION LAYOUTS

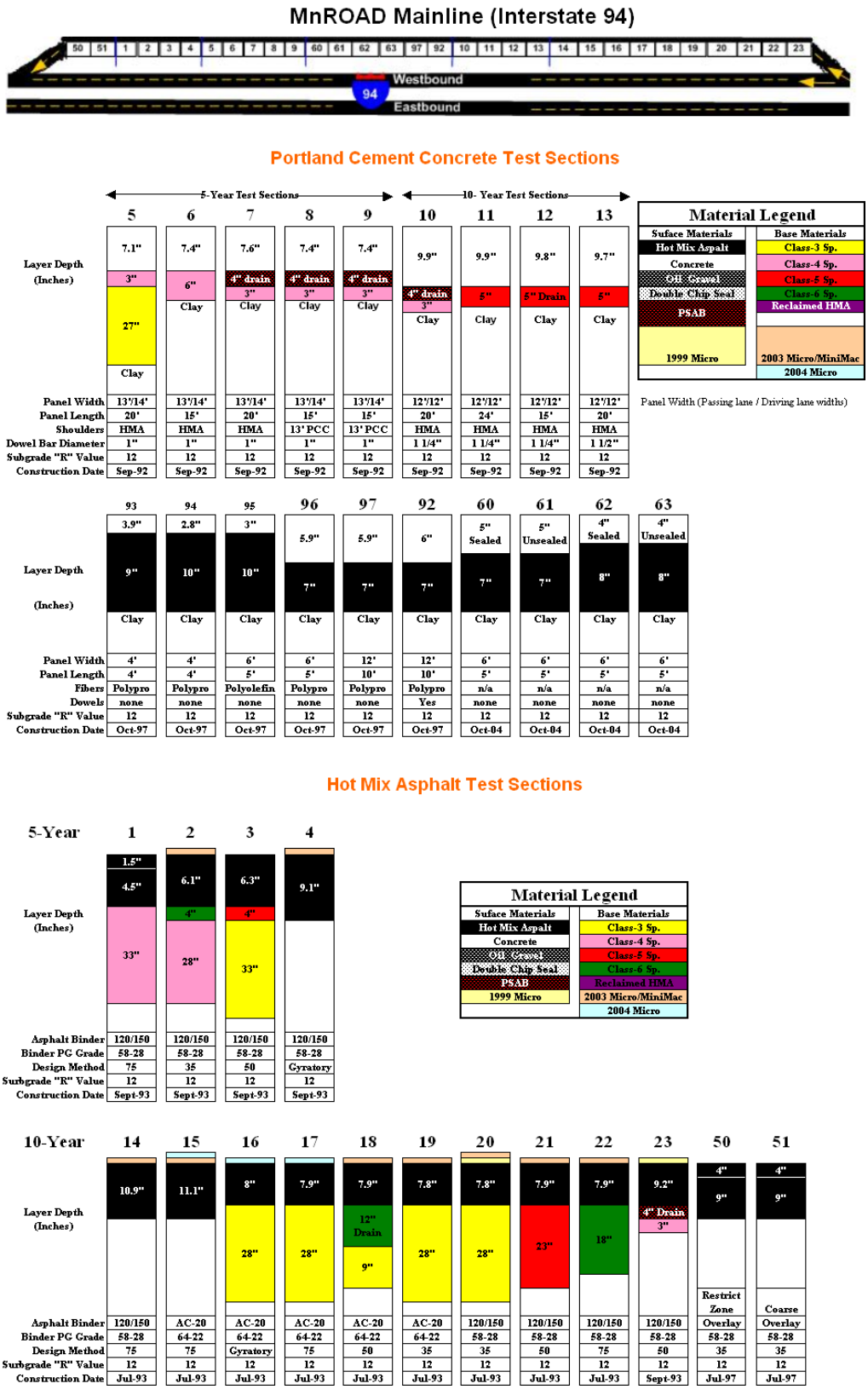

Figure A-1. MnROAD Test Cell Layout (Mainline)

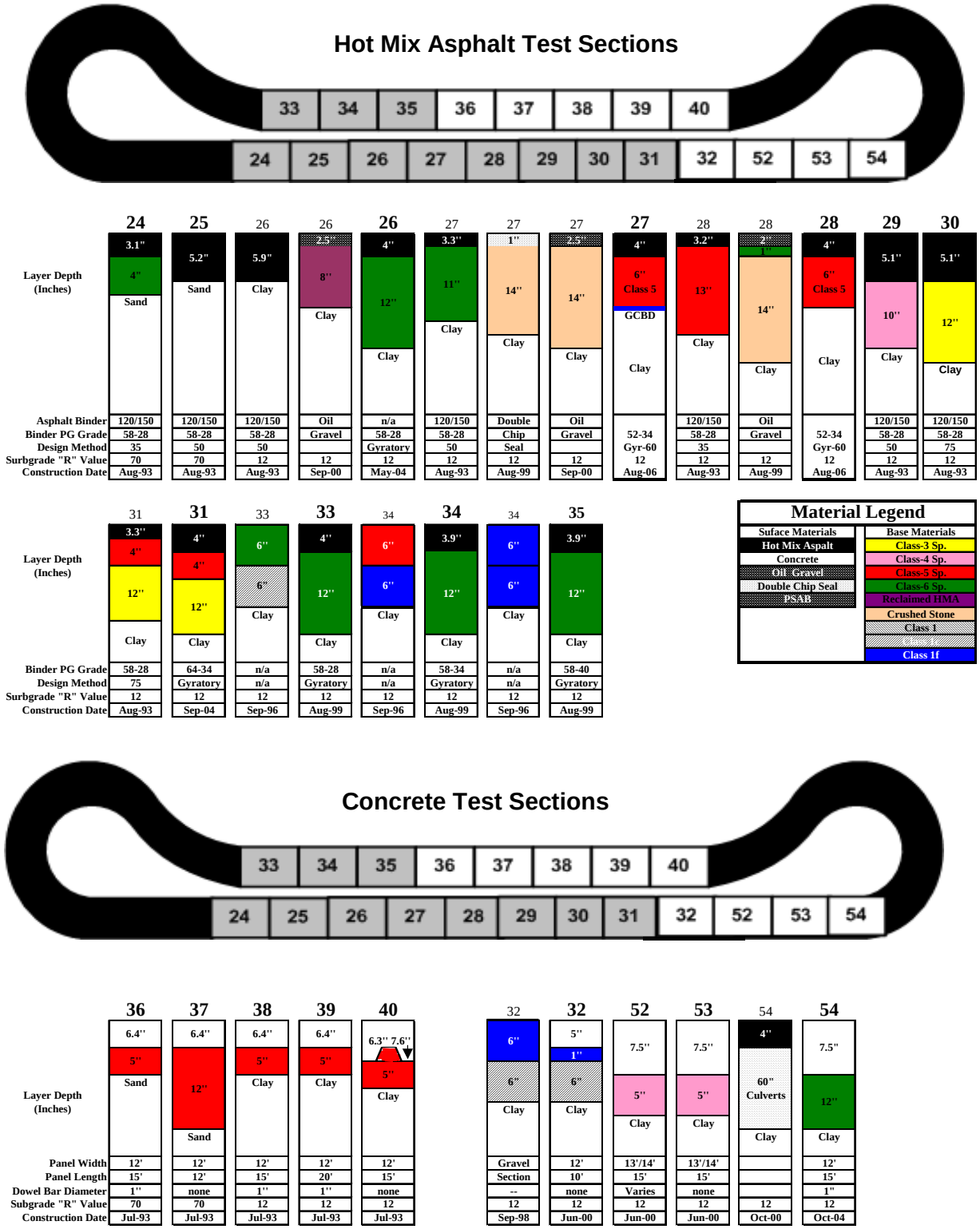

Figure A-2. MnROAD Test Cell Layout (Low Volume Road)