MnROAD's Future Vision

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ABSTRACT: Minnesota Department of Transportation constructed the Minnesota Road Research Project (MnROAD) between 1990-1994. This paper reviews MnROAD's existing resources, seven key research topics, current test cells avalible for reconstruction, and the expected actions needed to accomplish the key topics for MnROAD's next phase. The MnROAD site is located 40 miles northwest of Minneapolis/St. Paul and is an extensive pavement research facility consisting of two separate roadway segments containing 51 500-foot long distinct test cells. The 3 ½-mile Mainline Test Roadway (Mainline) is part of westbound interstate 94 and contains 31 test cells and carries an average of 20,000 vehicles daily. Parallel and adjacent to the Mainline is a Low Volume Roadway that is a 2 ½-mile-closed loop that contains the remaining 19 test cells. Traffic on the LVR is restricted to an MnROAD operated 18 wheel, 5-axle, tractor/trailer with two different loading configurations of 102kips and 80kips. Subgrade, aggregate base, and surface materials, as well as geometric design methods vary from cell to cell. Daily information is gathered via a computerized data collection system that monitors more than 4500 mechanical and environmental sensors.

KEY WORDS: MnROAD, Mechanistic Design, Low Temperature Cracking, Recycled Materials, Quiet Pavement Design

1 EXISTING RESOURCES

The Minnesota Road Research Project (MnROAD) facility is completing Phase-I of its life and Phase-II is being planned. Opportunities are numerous for colaborative research during Phase-II of this unique transporation research facility.

Minnesota Department of Transportation (Mn/DOT) constructed the Minnesota Road Research Project (MnROAD), shown in Figure 1, between 1990-1994. MnROAD, located near Albertville, Minnesota (40 miles northwest of Minneapolis-St. Paul) is one of the most sophisticated, independently operated pavement test facility of its type in the world. Mn/DOT invested $25 million in regular state construction funds to build the original 40 test cells. More detailed information can obtained by visiting the MnROAD web page at *http://mnroad.dot.state.mn.us/research/mnresearch.asp*

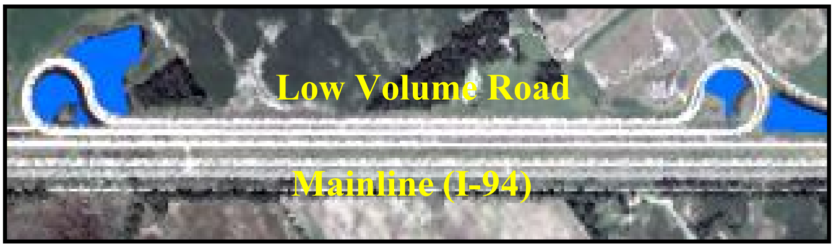


Figure 1 – MnROAD Mainline and Low Volume Road

1.1 MnROAD Mainline

The mainline consists of a 3.5-mile 2-lane interstate roadway carrying "live" traffic. Cell design/layout can be found in Appendix-B. 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 HMA cells and 9 Portland Cement Concrete (PCC) test cells. Since then a number of activities have taken place on the mainline, which is summerized in Table-1.

Traffic on the mainline comes from the traveling public on westbound I-94. Typically the mainline traffic is switched to the old I-94 westbound lanes once a month for three days to allow MnROAD researchers to safely collect data. The mainline ESALs are determined from an IRD hydraulic load scale was installed in 1989 and a Kistler quartz sensor installed in 2000. Currently the mainline has received roughly 5 million flexible Equivalent Single Axle Loads (ESALS) and 7.8 million Rigid ESALS as of December 31, 2004.

Table 1 MnROAD Cell Timeline/History

Year	Activity (Cell number)
1990	Earthwork begins on mainline (1-23) and LVR (24-40)
1992	Mainline 5-year cells paved
1993	Mainline 10-year and LVR paved
1994	Opened to traffic August 1994
1997	Mainline Superpave (50-51), Whitetopping (92-97)
1999	Chip Seal (27), Oil Gravel (28), Superpave (33-35)
2000	Slurry Seal (20,23), Oil Gravel (26-27), PCC (32,52-53), Culverts (54)
2003	Slurry Seal (1-2,4,14-16,18-22)
2004	Slurry Seal (15-17), Superpave (26,31), PCC (54), Whitetopping (60-63)

1.2 MnROAD Low Volume Road (LVR)

Parallel and adjacent to the mainline is the Low Volume Roadway (LVR). The LVR is a 2-lane, 2½-mile-closed loop that contains 20 test cells. Cell design and layout can be found in Appendix-A. A number of test cells have been reconstructed on the low volume road and is also explained in Table-1.

Traffic on the LVR is provided by a MnROAD operated vehicle, which is a typical 18-wheel, 5-axle, tractor/trailer with two different loading configurations. The ""heavy"" configuration consists of a gross vehcile weight of 453.7 kN (102 kips) and the the "legal" load configuration consists of 355.9 kN (80 kips). The driver averages 80 laps a day in his eight hours of work. On Wednesdays the tractor/trailer operates in the 453.7 kN (102K) configuration in the outside lane and the rest of the week the 355.9 kN (80K) configuration is used for the inside lane. This results in a similar number of ESALs being delivered to both lanes.

1.3 MnROAD Instrumentation and Performance Database

Data collection at MnROAD is accomplished with a variety of methods to help describe the layers, the pavement response to loads and the environment, and actual pavement performance. Layer data is collected from a number of different types of sensors located throughout the pavement surface and sub-layers, which initially numbered 4,572. Since then we have added to this total with additional installations and sensors types. Data flows from these sensors to several roadside cabinets, which are connected by a fiber optic network that is feed into the MnROAD database for storage and analysis. Data can be requested from the MnROAD database for each sensor along with the performance data that is collected thought the year. This includes ride, distress, rutting, faulting, friction, forensic trenches, material laboratory testing and the sensors measure variables such as temperature, moisture, strain, deflection, and frost depth in the pavement along with so much more.

1.4 Current Operations Structure

The MnROAD project for this first phase has been funded primarily by the Minnesota Department of Transporation (Mn/DOT) and Minnesota's Local Road Research Board (LRRB) since 1990. Mn/DOT has been operating the facility with 3 employees at the MnROAD site (Supervisor, Electronic Tech, Truck Driver), plus 6 full time equavalant staff from the Office of Materials (9 total) based in Maplewood Minnesota. The Office of Materials, commonly referred as the Maplewood Lab employees 124 people and is responsible for providing technical assistance our customers (districts, counties, cities), central laboratory testing, geotechnical investigations, and research. MnROAD is also supported part time by a database manager, programmer and web designer, and desktop support, along with Mn/DOT's District-3 personnel who provide traffic switches for the mainline and help with routine maintenance (labor and equipment) when required.

A independent governence study was completed in March 2004. This study stated that MnROAD should continue to operate under Mn/DOT staffing but partnerships should be developed with other states, FHWA, and private industry to help direct the research efforts and assist with the funding. The study also recommended that a alliance be formed to assist in the future direction of the project.

1.5 Transportation Engineering & Road Research Alliance (TERRA)

A independent governess study was completed in March 2004. This study stated that MnROAD should continue to operate under Mn/DOT staffing but outside funding should be developed with other states, FHWA, and private industry to help direct the research efforts and assist with the funding. The study also recommended that a alliance be formed to assist in the future direction of the project.

TERRA is a new research governance structure that partners private industry with national, state, and local road authorities. Its mission is to develop, sustain and communicate a comprehensive program of research on pavement, materials, and related transportation engineering challenges including issues related to cold climates. While the primary focus will be to expand pavement related research opportunities, other compatible research will be pursued in order to diversify funding.

Current TERRA partners include the Aggregate & Ready Mix Association, Asphalt Pavement Association, Associated General Contractors, Concrete Paving Association, Federal Highway Administration, Local Road Research Board, Minnesota Department of Transportation, University of Minnesota.

1.6 Minnesota Pavement Research Institute

The Pavement Research Iinstitute (PRI) has also been developed to help promote and coordinate the research activities at Mn/DOT and the University of Minnesota. The PRI goals are to help facilitate the development of research utilizing the resources of Mn/DOT, MnROAD, the University of Minnesota, and other research universities.

1.7 Phase-1 Accomplishments

MnROAD has been very successful in its initial phase-I experiment. Nationally we have provided data to a number of national studies inlcludeing the design guide and locally provided Minnesota with an updated method for spring load restrictions and a new flexible pavement design (MnPAVE). A more detailed list of accomplishments can be optained from our web site.

2 MNROAD FUTURE RESEARCH TOPICS

The proposed Phase II research program will center on the reconstruction of a majority of the MnROAD test sections. Each test section will be specifically designed toward improving the performance or life cycle cost of pavements in cold weather climates. Transportation research is needed now more than ever to help provide the safe, efficient and cost-effective movement of people, goods and services on the highway system that is the backbone of our national economy. The potential benefits of road research are tremendous. Even small increases in performance and pavement life result in a reduction in costs for maintenance, repairs, user delays, and congestion. These pavement research activities improve our national productivity and quality of life.

2.1 Development and calibration of new design methods for new and rehabilitated pavements.

Objective: Mechanistic-Empirical procedures need to be verified with field measured response data and calibrated to real world conditions.

Current pavement designs use an experience-based, empirical design process. Empirical designs followed the logic that what we did in the past will tell us what will work in the future. This approach does not account for ongoing changes in the transportation field including: increased tire pressures, tire design advancements, potential increased axle weights, modified axle configurations, pavement material improvements and construction advancements.

Mechanistic-empirical (M-E) procedures are being created to address these shortcomings by including the mechanics of pavement materials, pavement-load interactions and environmental factors. These factors are modeled and then related to actual pavement performance. Mn/ROAD data was used to develop the National Cooperative Highway Research Program project 1-37 M-E design procedure. This project, project produced a product called thet Mechanistic-Emperical Pavement Design Guide (M-E PDG), which provides M-E design procedures for HMA and PCC. MnROAD will provide the perfect platform to verify this Guide.

2.2 Improved pavement preventive maintenance and rehabilitation techniques.

Objective: Agencies need a system that will match pavement age and condition with the correct preventative maintenance strategy.

Pavement preventative maintenance encompasses products and techniques that maximize the service life of a pavement. Surface treatments, crack sealing, joint resealing, thin overlays and minor PCC repairs are examples of pavement preventative maintenance products. Each product extends pavement life resulting in longer periods between major reconstruction and few user delays. Questions exist regarding the application of the right product at the right time to create the optimal program.

2.3 Effective use of recycled materials through out the pavement structure.

Objective: Performance based specifications for waste materials need to be developed that account for the engineering properties and environmental impacts.

The highway construction industry has embraced the use of recycled materials for decades. This recycling has been limited primarily to reuse of construction waste streams back into the same or similar products. Most of the removed pavements are reused into new pavements or are incorporated into base material. The base materials often have enhanced performance characteristics depending upon the type and content of recycled materials, however little is known about their true engineering properties.

Waste owners from outside the highway construction industry often view road building as a potential market for their recyclables. Tires, scrap shingles, and waste glass are among the products that have shown promising applications. These recycled materials provide a great potential for cost savings, but need to be characterized by their engineering properties.

2.4 Quiet Pavement Designs – Tire/Pavement interface

Objective: Develop test new designs that will reduce the tire-pavement noise levels and reduce the need for noise walls.

Tire/pavement noise issues typically have not been the main focus for construction or maintenance practices in many of the roadways in our system. Long-term pavement research needs to be initiated at MnROAD to review a number of different pavement designs relating to the tire/pavement noise along with its effect on friction, texture, and ride over time.

2.5 Thermal Cracking - Examine the ability of pavements to resist low temperature cracking

Objective: Better methods to predict the ablility of an HMA pavement to resest thermal cracking are needed.

The most common distress to flexible pavements in cold regions is thermal cracking. As temperatures decrease, the pavement contracts and the asphalt cement becomes brittle. In northern climates, these two factors commonly result in thermal cracks. All of the initial HMA test sections at MnROAD experienced thermal cracking, much of it initiated during the low temperatures encountered during the winter of 1996 when the air temperature reached (-39.5 F). Advancements in asphalt specifications occurred from the development and implementation of the Performance Grade system that is part of Superpave. Five years of experience with this system in Minnesota has revealed limitations. New test methods and materials will be used at MnROAD to help in the elimination of thermal cracking.

2.6 Intelligent compaction technology.

Objective: Develop guidelines/specifications to take advantage of new technology that is currently being introduced in North America.

Compaction equipment is becoming available that can measure the stiffness of grading materials during compaction at the construction site. Some of these compactors also adjust their compactive energy while compacting. This optimizes resources by allowing the specified stiffness to be achieved without over compaction. This equipment is available in Europe, but only a few compactors are believed to be present in the United States. The FHWA and several DOTs are currently working to organize demonstrations of this new equipment.

2.7 Continued support for on-site non-pavement research.

Objective: Continue to promote the use of the MnROAD facility to provide a test location for future ITS (intelligent transportation systems) and other copatible efforts.

MnROAD's low volume road is an ideal location for working on intelligent transporation systems since its closed to public transporation, access can be controled, detailed layout information, and can provide shelter to work on vehicles and trucks. Examples of sucessful research performed at MnROAD include pavement marking evaluation, drainage research, environmental effects on not only the roadway but also from runoff and on roadside vegitation, plastic culvert response measurements.

3 MNROAD TEST CELLS AVALIBLE FOR RECONSTRUCTION

Now that MnROAD has been in service for 10 years, it is now ready to move into its next phase of major construction of new researh cells. This will involve both new reconstruction and rehabilitation techniques. MnROAD cell layout maps are attached in Appendix A and B, showing the design features for each test cells up to now. The following is a summary of the current test cells condition and research availability for MnROAD's next phase.

3.1 Condition of MnROAD 's Flexible Pavements

The condition of the flexible test cells for the mainline and LVR have deriorated primarily due to low temperature cracking. MnROAD was built as a structural experiment that, however for the most part, it has deteriorated due to materials and environmental effects. Low temperature thermal cracks developed, deteriorated, cupped, causing a deterioration in ride. Rehabiliation of these cells will be required in 2006. Some of the thin LVR cells (built less than 4") have failed due to loadings, but for the most part it's the low temperature cracking causing the reduction in ride, as shown in Figure 2 and 3.

3.2 Condition of MnROAD's Rigid Pavments

The condition of the rigid mainline and LVR test cells are still performing well at MnROAD as shown in Figure-2 and 3. These rigid cells have not deteriorated to a point where any rehabilitation or reconstructed is needed, but they may not have a strong research need to continue. To optimize rigid research we may considure other research opportunities for cells 8, 10, 11, 13 which currently have features that are not germane to concrete practice for this climate at this time. These include 20 and 24 foot panels as well as the use of permeable asphalt stabilized bases.

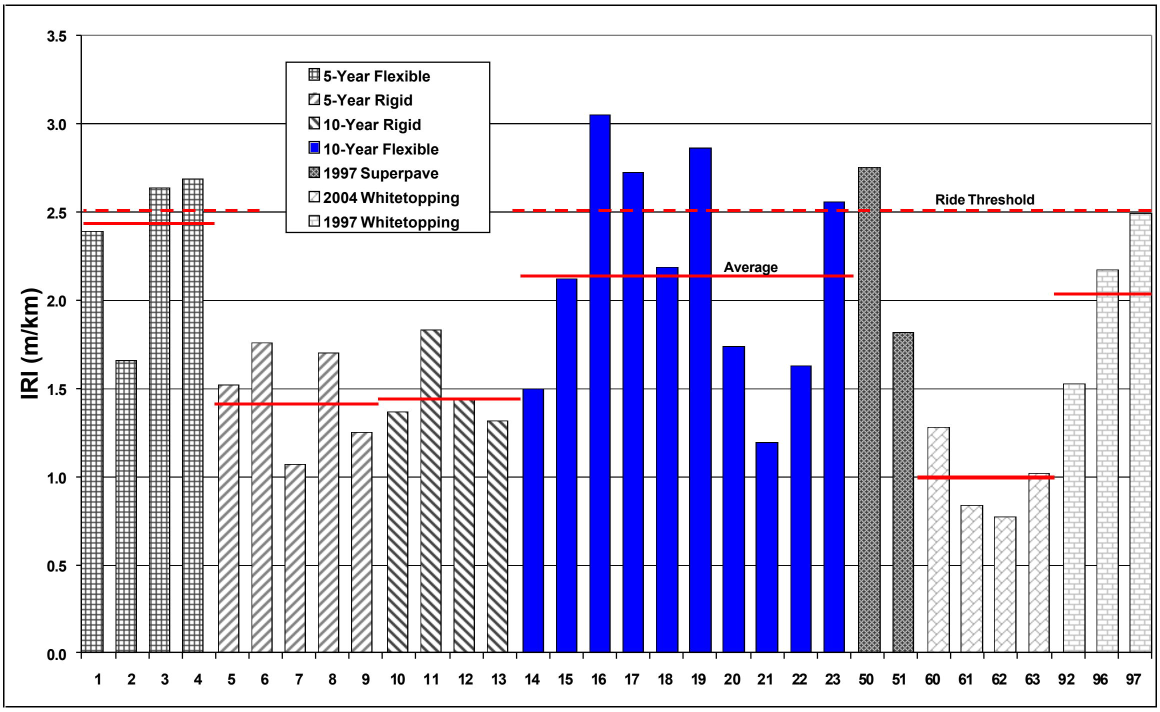


Figure 2 – MnROAD Mainline Ride (IRI m/km)

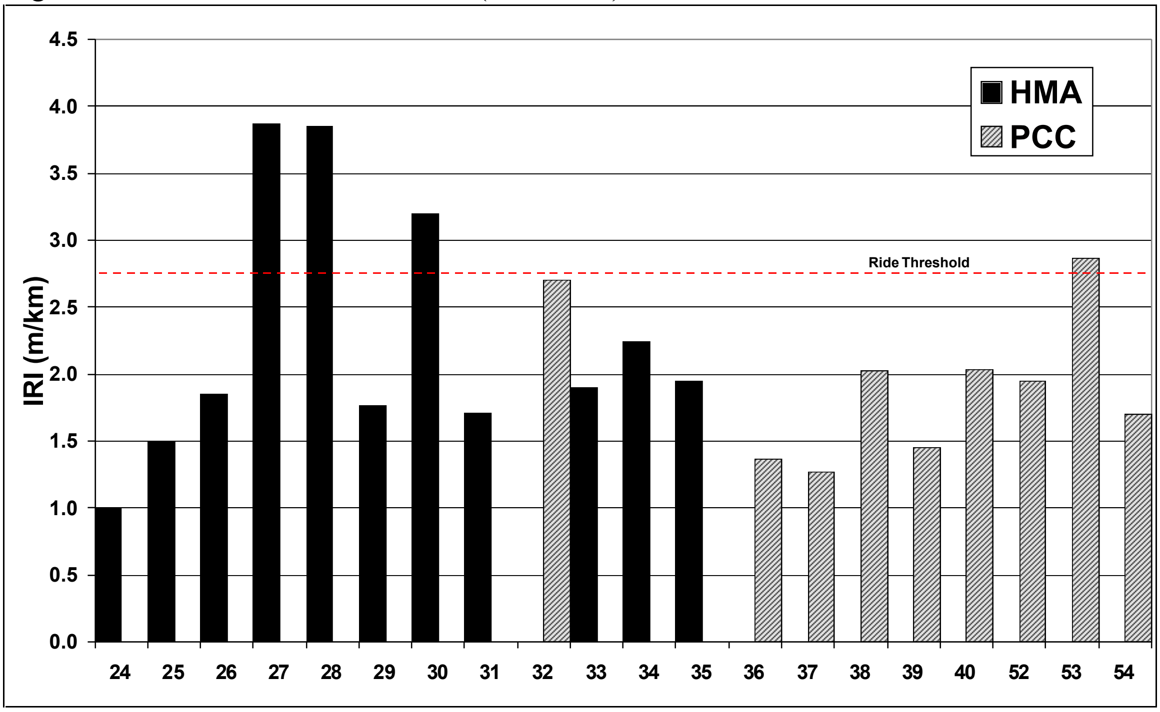


Figure 3 – MnROAD Low Volume Ride (IRI m/km)

3.3 Recommendations for possible reconstuction

In summary MnROAD mainline has 18 mainline test cells available (14 flexible and 4 rigid) and 7 low volume road cells available for reconstruction in 2006. Committees are being formed to help guide MnROAD's reconstruction plan. These committees will consist of leaders from government and the private sector at the local, state, and national level. Table-2 outlines the test cells and their condition and avalibility.

MnROAD also may provide the opportunity to use the existing 3.5 mile eastbound I-94 (flexible) and the 3.5 mile westbound I-94 (rigid) lanes for additional test cells. This would allow more research possibilities. It would also be easy to divert I-94 traffic on and off the three separtate roadways for a safe work zone and could easly be tied to MnROAD's sensor network. Other projects other than at MnROAD also maybe utilized to help develop research project needs including any work done on SHRP/LTPP test sections in the state.

Table 2 MnROAD Low Volume Road (LVR) Test Cells Condition

Cells	Design Group	AVG–Ride IRI (m/km) (Driving or 80K)	Mainline Cell Assessment
ML 1-4	5-Year Flexible	2.54	Work Required in 2006 - Note IRI reflects the 2003 and 2004 slurry seal treatments
5-9	5-Year Rigid	1.46	No work required till 2015 but cells 11,8,10,13 are Available for work in 2006
10-13	10-Year Rigid	1.49	
14-23	10-Year Flexible	2.16	Work Required in 2006 - Note PSR reflects the 1999, 2003 and 2004 slurry seal treatments
50-51	1997 Superpave Flexible	2.61	Too close to transition Do not include in next phase
93-95 60-63	1997 & 2005 Whitetopping Rigid	2.06 (1997) 0.93 (2005)	No work expected till 2010
LVR 24-31	LVR Flexible	1.87 1.85 3.86 1.71	Cells 24,25,29,30 - 2006 construction opportunities Cell 26 – 2006 construction opportunity Cells 27-28 – 2006 construction opportunities Cells 31 2004 Mesabi Hard Rock Superpave
33-35	1999 LVR Superpave	2.03	No work required till 2010 other than cell-35 may need some repairs before then
36-40	LVR Rigid	1.68	No work required till 2015
32, 52-53	2000 LVR Rigid	2.51	Constructed in 2000 east of cell 32 No work required till 2015
54	2004 Mesabi Rigid	1.70	No work required till 2015

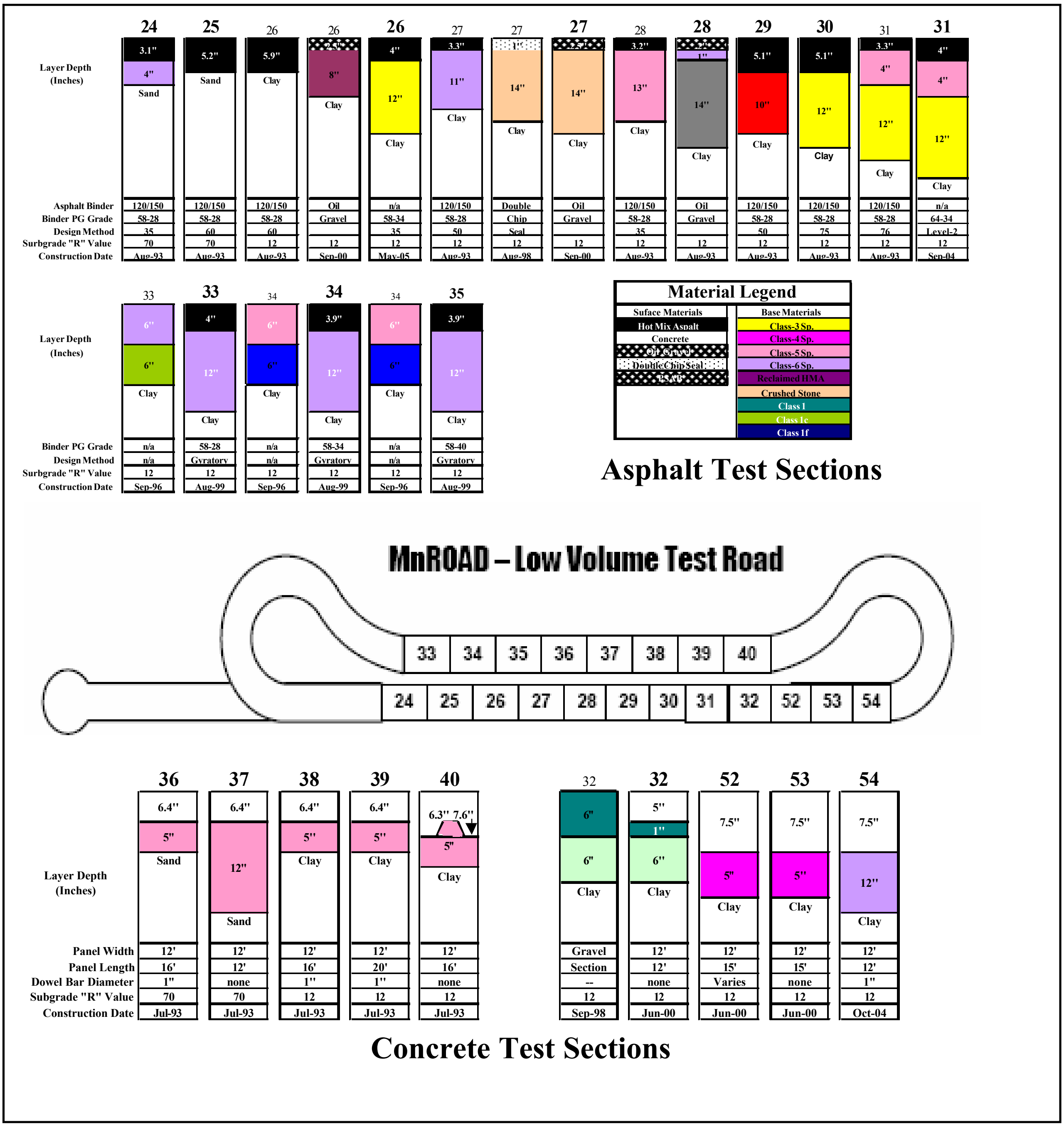
4 CONSTRUCTION AND RESEARCH FUNDING

MnROAD is expecting to fund both its construciton and operatons in a number of ways. Mn/DOT and the Minnesota Local Road Research Board will continue to support MnROAD but will not be the sole supporters. Funding will also be developed from private/public partnerships, state research pooled fund studies, name of NCHRP, and possible earmarked federal funding relating to the seven research topics discussed. Currently the governing alliance TERRA seeks $15 million in federal funds over six years for the research and technology transfer program. The federal funding will be supplemented with $5 million of matching funds from local partners. It is expected that reconstruction costs will run $100,000 to $300,000 per cell depending on the fix and sensors required. Typical operations costs will equal $20,000/year at the current level of effort. Future program areas include core research studies, join ventrure studies, technology transfer, innovative products, operations, and reconstruction.

5 CONCLUSION

MnROAD is successfully wrapping up its first phase and working towards its second phase. We have 15 years of experience in designing, constructing, and operating a test track and have the resources to successfully develop and procede with the next phase. The initial seven research topics have been developed (list out) and will guide us on our future direction and partnerhips. We are looking for and welcome input into our plans and for participation in the the next phase of MnROAD.

Appendix A – Low Volume Road Test Sections

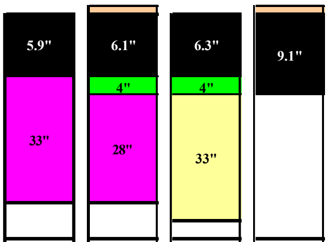


Appendix B – Mainline Test Sections

Asphalt Test Sections

5-Year

Layer Depth (Inches)



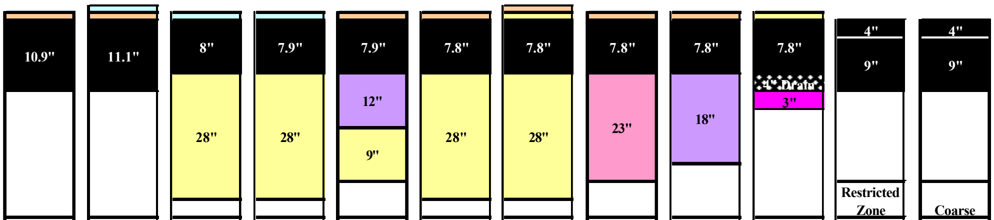
	1	2	3	4
Asphalt Binder	120/150	120/150	120/150	120/150
Binder PG Grade	58-28	58-28	58-28	58-28
Design Method	75	35	50	Gyratory
Surbgrade "R" Value	12	12	12	12
Construction Date	Sept-93	Sept-93	Sept-93	Sept-93

Material Legend

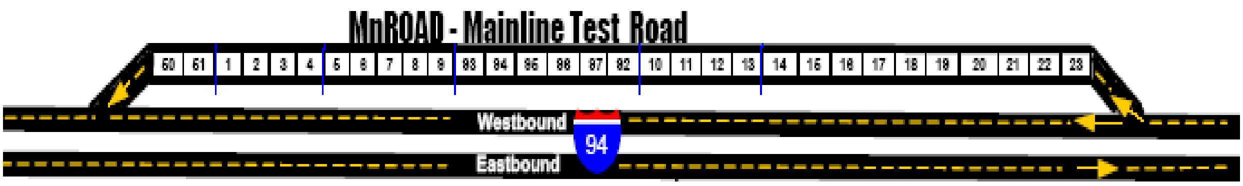
Suface Materials	Base Materials
Hot Mix Aspalt	Class-3 Sp.
Concrete	Class-4 Sp.
Oil Gravel	Class-5 Sp.
Double Chip Seal	Class-6 Sp.
PSAB	Reclaimed HMA
	Crushed Stone
1999 Micro	Class 1
2003 Micro/MiniMac	Class 1c
2004 Micro	Class 1f

10-Year

Layer Depth (Inches)



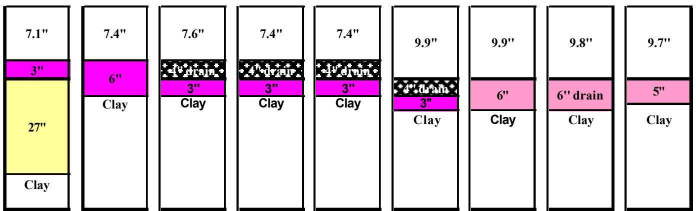
	14	15	16	17	18	19	20	21	22	23	50	51
Asphalt Binder	120/150	AC-20	AC-20	AC-20	AC-20	AC-20	120/150	120/150	120/150	120/150	Overlay	Overlay
Binder PG Grade	58-28	64-22	64-22	64-22	64-22	64-22	58-28	58-28	58-28	58-28	58-28	58-28
Design Method	75	75	Gyratory	75	50	35	35	50	75	50	35	35
Surbgrade "R" Value	12	12	12	12	12	12	12	12	12	12	12	12
Construction Date	Jul-93	Jul-93	Jul-93	Jul-93	Jul-93	Jul-93	Jul-93	Jul-93	Jul-93	Sept-93	Jul-97	Jul-97



Concrete Test Sections

5-Year Test Sections / 10- Year Test Sections

Layer Depth (Inches)



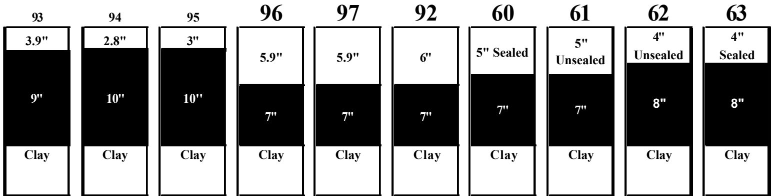
	5	6	7	8	9	10	11	12	13
Panel Width	13'/14'	13'/14'	13'/14'	13'/14'	13'/14'	12'/12'	12'/12'	12'/12'	12'/12'
Panel Length	20'	16'	20'	15'	16'	20'	24'	15'	20'
Shoulders	HMA	HMA	HMA	13' PCC	13' PCC	HMA	HMA	HMA	HMA
Dowel Bar Diameter	1"	1"	1"	1"	1"	1 1/4"	1 1/4"	1 1/4"	1 1/4"
Subgrade "R" Value	12	12	12	12	12	12	12	12	12
Construction Date	Sep-92	Sep-92	Sep-92	Sep-92	Sep-92	Sep-92	Sep-92	Sep-92	Sep-92

Material Legend

Suface Materials	Base Materials
Hot Mix Aspalt	Class-3 Sp.
Concrete	Class-4 Sp.
Oil Gravel	Class-5 Sp.
Double Chip Seal	Class-6 Sp.
PSAB	Reclaimed HMA
	Crushed Stone
1999 Micro	Class 1
2003 Micro/MiniMac	Class 1c
2004 Micro	Class 1f

Panel Width (Passing lane / Driving lane widths)

Layer Depth (Inches)



	93	94	95	96	97	92	60	61	62	63
Panel Width	4'	4'	6'	6'	12'	12'	6'	6'	6'	6'
Panel Length	4'	4'	6'	6'	10'	10'	5'	5'	5'	5'
Fibers	Polypro	Polypro	Polyolefin	Polypro	Polypro	Polypro	n/a	n/a	n/a	n/a
Dowels	none	none	none	none	none	Yes	none	none	none	none
Subgrade "R" Value	12	12	12	12	12	12	12	12	12	12
Construction Date	Oct-97	Oct-97	Oct-97	Oct-97	Oct-97	Oct-97	Oct-04	Oct-04	Oct-04	Oct-04