Non-pavement Research at MnROAD
MnROAD Lessons Learned – December 2006
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1 Abstract

Since opening for operations in 1994, MnROAD has produced a considerable amount of pavement response and environmental data on its many test sections, and the research and reports resulting from this data are evidence of MnROAD's lasting influence in pavement engineering. The MnROAD facility, however, is capable of experiments, demonstrations, and research outside of pavement engineering, and products from the first ten years of its operation support its use as a non-pavement research facility. The brief describes these non-pavement products, the ability and flexibility of MnROAD staff in adapting the facility to non-pavement research, and the potential of MnROAD to host non-pavement research.

2 Background

Though non-pavement research is not included in the fourteen original research objectives as set out in MnDOT Report 1990-03, a quick review of the MnROAD-related reports and briefs to come out of MnROAD's first ten years illustrates the volume and extent of non-pavement research done at MnROAD. These non-pavement topics include investigations into data acquisition for test track instrumentation, environmental biology, so-called smart truck (GPS guided) technology, and many others.

Though MnDOT Report 1990-03 did not explicitly detail non-pavement topics, it is hard to imagine that MnROAD's initial planners did not anticipate this kind of research. In devising MnROAD, MnROAD's planners sought to create an environment in which the variables in a given experiment in pavements could be restricted to those under consideration. This kind of controlled environment is equally useful to non-pavement experiments, perhaps even more useful for non-pavement topics as areas of concern for pavement topics (how different bases and thicknesses influence observed results) do not factor into non-pavement experiments. For non-pavement topics, the controlled environment of MnROAD means that important variables, such as environmental changes, are monitored and that the experimental setup itself is left undisturbed by unaccounted for influences.

It is MnROAD's staff and their efforts that make MnROAD an outstanding facility for non-pavement research. Over MnROAD's first ten years of operation, MnROAD engineers have become acquainted with experiments that require a wide variety of conditions. The flexibility gained through accommodating these experiments make MnROAD staff uniquely qualified to handle both pavement and non-pavement topics. As MnROAD staff monitor the test cells and experiments conducted on those test cells on a full-time basis, these engineers can provide immediate feedback to researchers if circumstances arise that compromise a given experiment. This response allows adjustments in experiments that can make the difference between adjusting an experiment

to yield useful data and ignoring an experiment only to find out it has yielded unusable data after the fact.

Though the remainder of this brief will detail specific non-pavement research conducted at MnROAD, it is important to remember that none of this research would have been possible without the controlled environment of MnROAD and its experienced, flexible personnel.

3 Non-Pavement Research Conducted at MnROAD

The establishment in 1991 of the Minnesota Guidestar program, a cooperative initiative between MnDOT, the Federal Highway Administration, UM, and other members, ensured that work in intelligent transportation systems (ITS) would become a key area of interest for engineers in transportation-related fields in Minnesota throughout the 1990s. As the creation of Guidestar coincided with the early construction stages of MnROAD, it was only a matter of time before these two major MnDOT interests became related in some measure.

Some of the more noticeable non-pavement issues investigated at MnROAD have been assistive or autonomous vehicle guidance systems and the technologies associated with those systems. These issues arose out of MnDOT and MnROAD's combined need for driver-assist technologies to ensure the safety of the operator of the truck that provides the load repetitions on the low-volume road at MnROAD. This simple need expanded into an ongoing project that aims to provide similar assist and guidance systems for operators of MnDOT's many snowplow operators and eventually all operators of heavy vehicles.

In addition to the impetus for this project coming from a specific MnROAD need, MnROAD's ability to control traffic flow to maintain a safe testing environment made it an ideal site for this project. As a result, the work vehicle guidance systems, spearheaded by researchers at the University of Minnesota (UM) Department of Mechanical Engineering with the support of MnDOT, resulted in numerous published reports over MnROAD's first ten years of operation. Furthermore, the nature of the reporting on these issues allows the reader to view the progression of the research over the decade.

The earliest research in this work (between 1994 and 1997) involved investigating different radar sensing systems and global positioning systems (GPS) guidance systems to create a semi-tractor capable of preventing crashes and controlling the vehicle if the driver were to become incapacitated. In this time, UM researchers modified a Navistar 9400 truck tractor (called SAFETRUCK) to meet their specifications. In addition to SAFETRUCK, during this time period UM researchers also developed and tested a heads-up display (HUD) prototype that provides a driver with lane boundaries in conditions of poor visibility. Though the illustration is from a much later report, Figure 1 provides an idea of the HUD perspective.

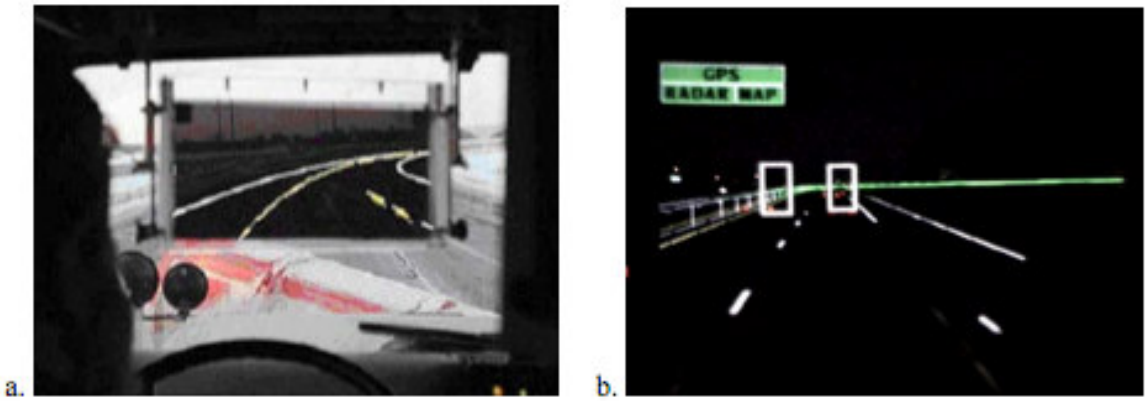

Figure 1. a. Typical view of roadway and b. HUD view of roadway (from MnDOT 2004-09)

SAFETRUCK was first successfully demonstrated for the public in April 1997 at the MnROAD facility. Furthermore, local media outlets featured this technology—and MnROAD along with it—in articles and reports. A valuable summary of the work accomplished in these first years of research can be found in MnDOT Report 1998-29, "SAFETRUCK – Sensing and Control to Enhance Vehicle Safety."

Later work under the Guidestar aegis used the MnROAD as a testing facility to refine the GPS in sensing the position of the vehicle and the controls of the truck in responding to the GPS feedback (these modifications comprised the Differential Global Positioning System, or DGPS). Other work modified the so-called Virtual Bumper first alluded to in MnDOT Report 1998-29. The Virtual Bumper is a series of radar and laser sensors that detect potential collisions. In the event of a possible collision, this system then assists the operator in avoiding those collisions through automated feedback to the vehicle control, which can modify the vehicle's trajectory. The sum of SAFETRUCK, the HUD, the Virtual Bumper, and later additions and modifications to these systems was the driver assistive system (DAS). A MnDOT snowplow equipped with the above technologies is shown in Figure 2.

Figure 2. MnDOT snowplow equipped with DAS technologies (from MnDOT 2004-09)

In 2004, UM researchers published MnDOT Report 2004-09, "System Performance and Human Factors Evaluation of the Driver Assistive System (DAS)." This report is an excellent bookend to the work done in ITS at MnROAD during MnROAD's first ten years of operation.

A number of experiments have been conducted at MnROAD that deal with issues in environmental biology. MnROAD is an especially attractive test site for experiments that require an awareness of environmental conditions. The constant monitoring of temperature and moisture provide data for the biologist to use as a reference in validating field data. Furthermore, the close monitoring of the site itself and the controlled traffic prevent the experimental setup from becoming disturbed or damaged.

Two notable experiments in biology-related issues that were conducted at MnROAD resulted in MnDOT reports. In MnDOT Report 2004-11, "Improving the Design of Roadside Ditches to Decrease Transportation-Related Surface Water Pollution," the authors detail a field-monitoring program that monitors the ability of roadside plants and a check dam in removing pollutants from storm water that ran off a pavement. In the drainage ditch, the authors installed a strip of vegetation (or "swale") that was followed by a check dam (both illustrated in Figure 3), and then monitored the water at both ends of the constructed filtration system.

Figure 3. Vegetative swale (at left) and completed check dam (at right) (from MnDOT 2004-11)

It should be noted that MnROAD was more than a simple site for this experiment: MnROAD engineers assisted in the installation of the check dam. The authors monitored the site from June 2000 to June 2002, and found that the vegetation and check dam reduced pollution in the water tested by as much as 54 percent. This study in road runoff is a transportation-related experiment made much more accessible by the existence of MnROAD in terms of setting up the experiment, monitoring the conditions to which the experiment is exposed, and protecting the experiment from being disturbed.

In MnDOT Report 2004-41, "The Effect of Novel Soil Amendments on Roadside Establishment of Cover Crop and Native Prairie Plant Species," the authors discuss the use of MnROAD as a facility to conduct an experiment in methods to establish vegetation on the near inslopes of roadsides. The study examines the use of three different soil treatments: two different erosion control materials and the amendment of the soil with

organic materials. Along the roadside, the researchers installed a wide variety of plants. The use of MnROAD as a testing facility helped protect and control the experiment, and for this reason the soil treatments went undisturbed and performed as expected. However, the authors found that the use of these treatments did not improve the establishment of the plants within two meters of the road.

Another interesting non-pavement experiment conducted at MnROAD was the installation of larger culverts, made of corrugated polyethylene, under test sections in the low-volume loop. In this report, MnDOT 2000-22 "Performance of Themoplastic Pipe Under Highway Vehicle Loading," the authors detail the installation of the culverts and the various modeling and loading tests investigated to track the performance of the culverts over 3.5 years. Thanks to the MnROAD facility, the authors were able to conduct both static and dynamic loading tests using strain gauges and LVDTs. (All of the data was acquired by the authors [a private consulting firm] through an internet connection provided by MnDOT. In this case, the dataloggers used to collect data could have been triggered to collect data using the internet connection. This example suggests another possibility for researchers around the world in need of a suitable facility for their experiments.) The authors found that the culverts performed well and showed no signs of increased deflections over that time. Furthermore, the authors were able to provide recommended minimum depth covers for the culverts based on their experience at MnROAD.

4 MnROAD Contributions to Non-Pavement Research

Though MnROAD has a fairly passive role in the non-pavement projects that have been conducted at the MnROAD facility, it is important to note the opportunity that MnROAD provides to the researchers conducting these non-pavement research projects. An overwhelming number of the researchers involved in these projects are UM professors and students working on MnDOT-sponsored research. This small contribution—MnROAD's role as a facilitator of non-pavement research—is another way in which has strengthened its relationship with UM (see the technical brief "Educational Benefits" for more).

Also, throughout MnROAD's operation it has been the burden of MnROAD engineers alone to devise methods of acquiring data, calibrating sensors, and maintaining a database. The amount of effort put and number of reports written on this topic make it worthy of notice as a different kind of non-pavement research at MnROAD. With the help of researchers in the computer science and electrical engineering departments at UM, MnROAD engineers have participated in developing data flow query languages to retrieve and visualize data (MnDOT 1996-02) and calibrating the Megadac data acquisition system ("Dynamic Megadac Calibration Procedure and Development Manual"). Furthermore, MnROAD engineers have developed their own "peak picking" programs to process pavement response data at MnROAD (MnDOT 1996-09). These efforts are difficult to categorize, but are worth notice here as "non-pavement topics" simply as a way of recognizing another of MnROAD's intangible products from its first ten years of operation.

5 Recommendations

Though this brief does not provide a comprehensive overview of the non-pavement projects in which MnROAD has participated, it is hoped that this brief provides an idea of the expanse of projects MnROAD engineers have encountered in MnROAD's first ten years of operation. A recommendation for MnROAD is to use its web site and brochures to "advertise" two things:

1. MnROAD's controlled environment makes it an outstanding facility for non-pavement research
2. MnROAD engineers are familiar with a wide range of projects, and their flexibility and expertise makes them uniquely qualified collaborators.

It would also be useful to encourage researchers to mention MnROAD in their presentations and publications. If possible, these researchers should highlight the beneficial features of MnROAD as a staging facility for non-pavement experiments.

Furthermore, another kind of non-pavement knowledge only touched upon briefly in the fourth section of this brief is the test track expertise of MnROAD engineers. Though this will be discussed further in other technical briefs, it is important for MnROAD to recognize the scope of its own work in non-pavement research. Writing programs to pick peaks from data or calibrate sensors, for example, may appear to employees to be "just another day at the office," but the work resulting from this is unique to MnROAD in many cases and could potentially provide lessons to other test tracks. It is important for MnDOT and MnROAD to continue to mention and push in public presentations not only MnROAD's status as premier cold regions test track, but MnROAD's accomplishments as 1st major test track since AASHO Road Test. Were this fact more acknowledged, MnROAD might see an increase in data requests and publicity.

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