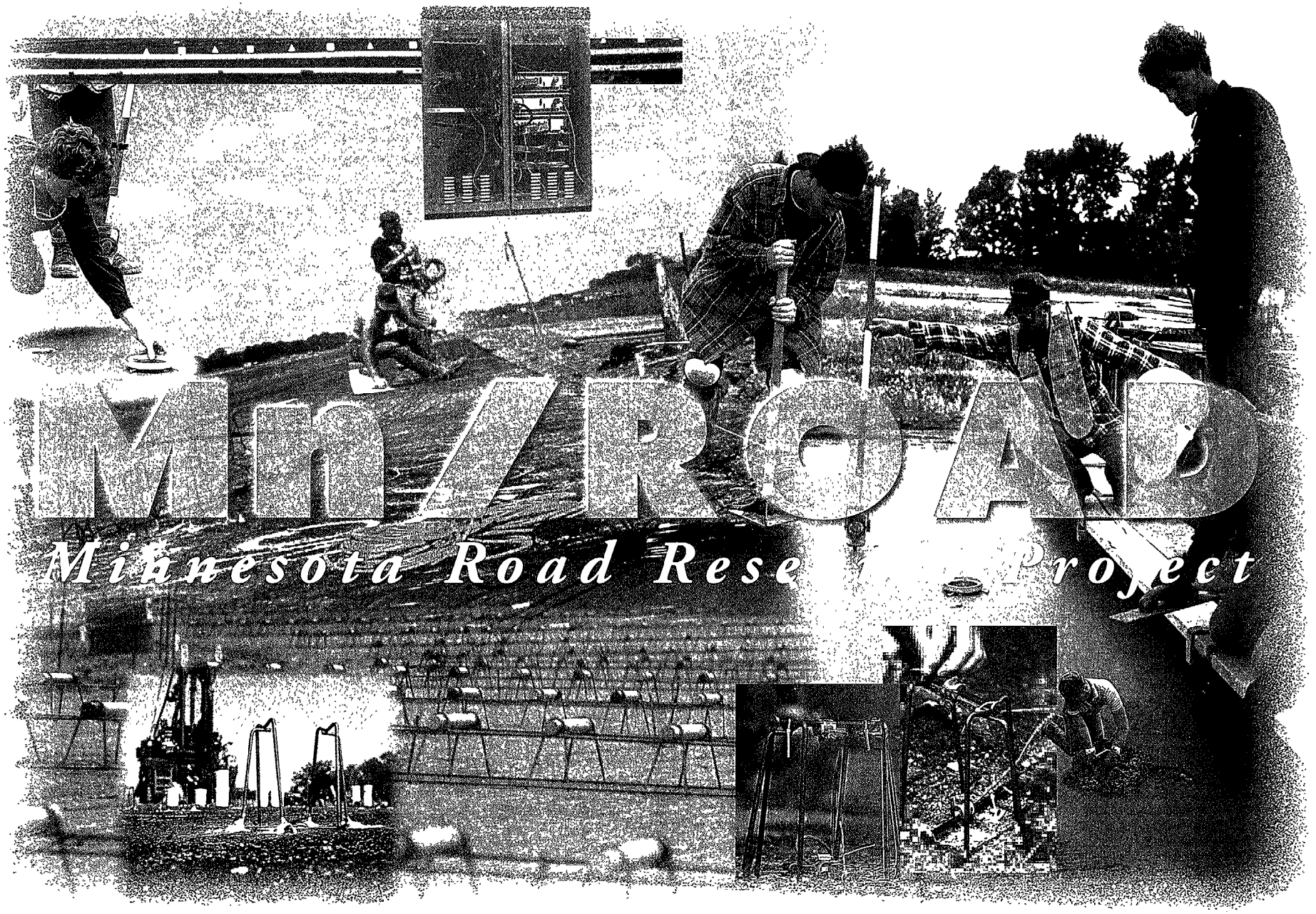


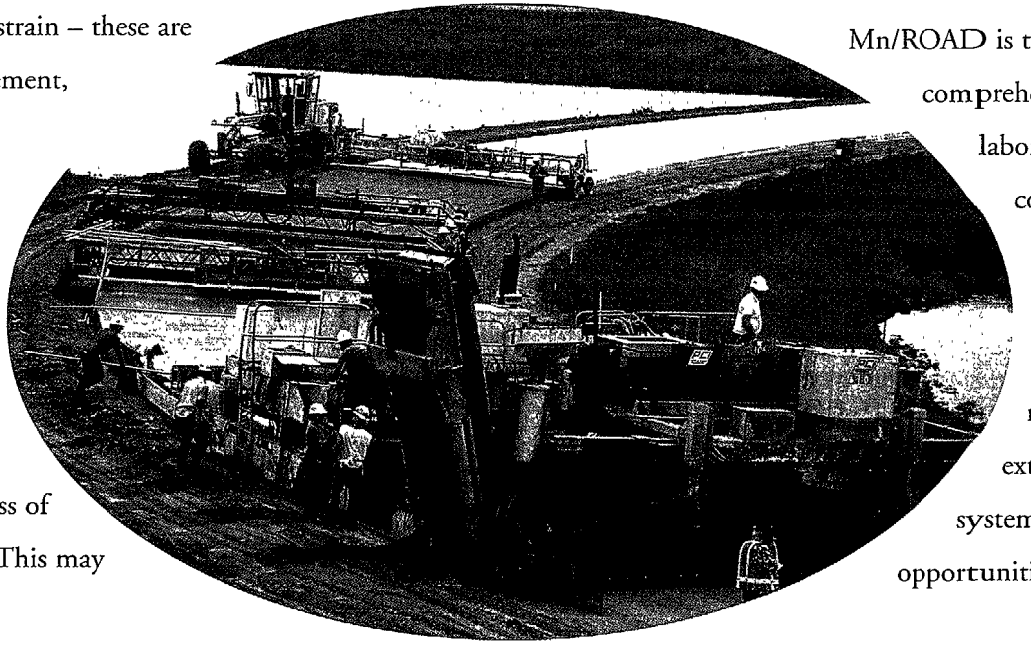
MN/ROAD PURPOSE

"To build a research facility for the development and testing of more cost effective pavement designs."

INTRODUCTION

Roads don't last as long as they should. Potholes, cracks, crumbling, stress and strain – these are all symptoms of a failing pavement, and they're more frequent nowadays as the weight and volume of traffic on our roads continues to rise. And in cold climates, like Minnesota experiences, roads freeze solid in winter and then they endure the stress of a spring thaw year after year. This may cause the roads to fail even faster than in warmer climates.

Now, thanks to Mn/ROAD, the Minnesota Road Research Project, we are learning more than ever before about the causes of road failure. This extraordinary new pavement test facility promises to change the way roads are constructed, leading to better, safer, longer-lasting highways around the world.



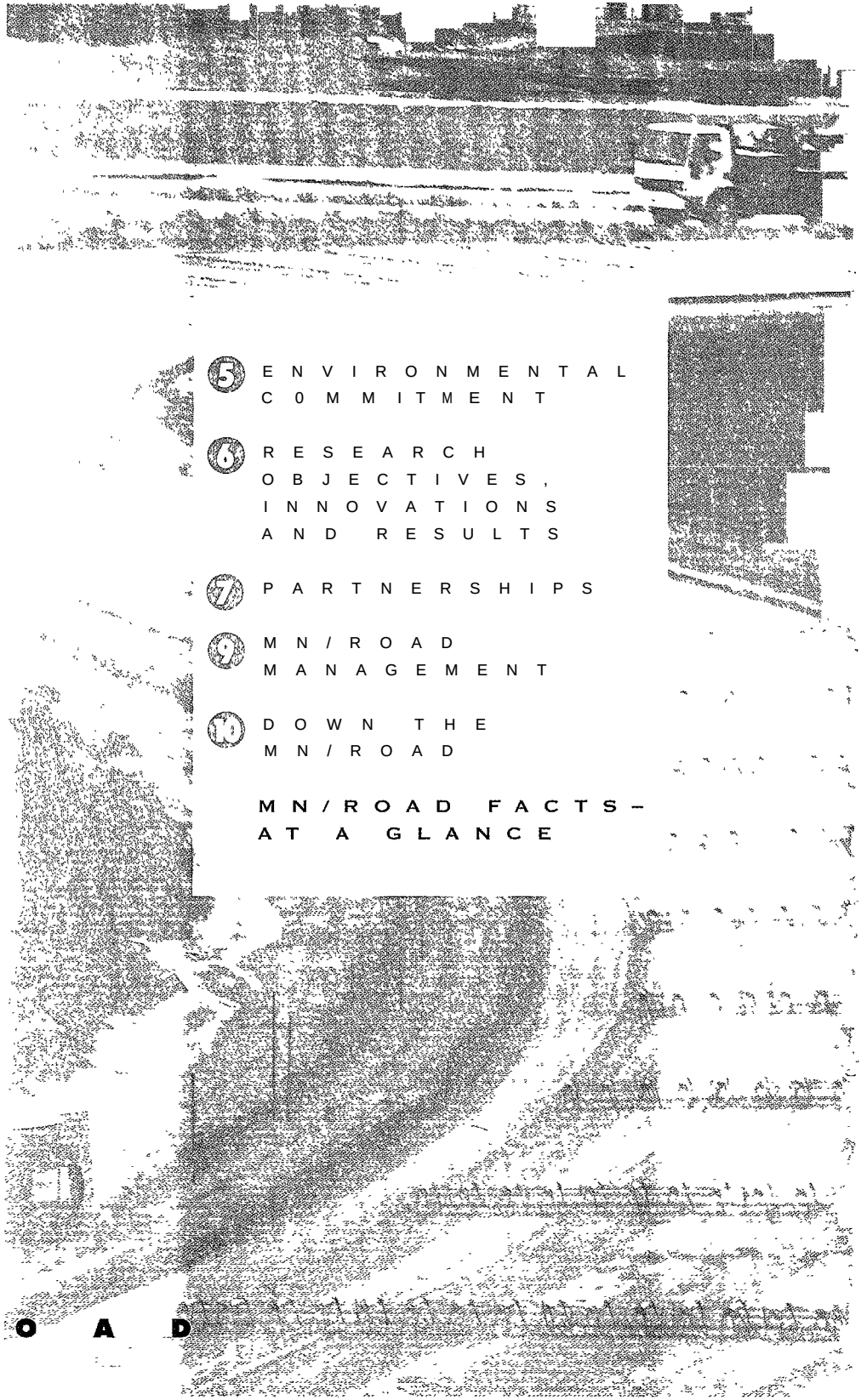
Mn/ROAD is the world's largest and most comprehensive outdoor pavement laboratory, distinctive for its complex web of more than 4,500 electronic sensors embedded within six miles of pavements. The sensor network, combined with an extensive data collection system, provides long-needed opportunities to study how heavy

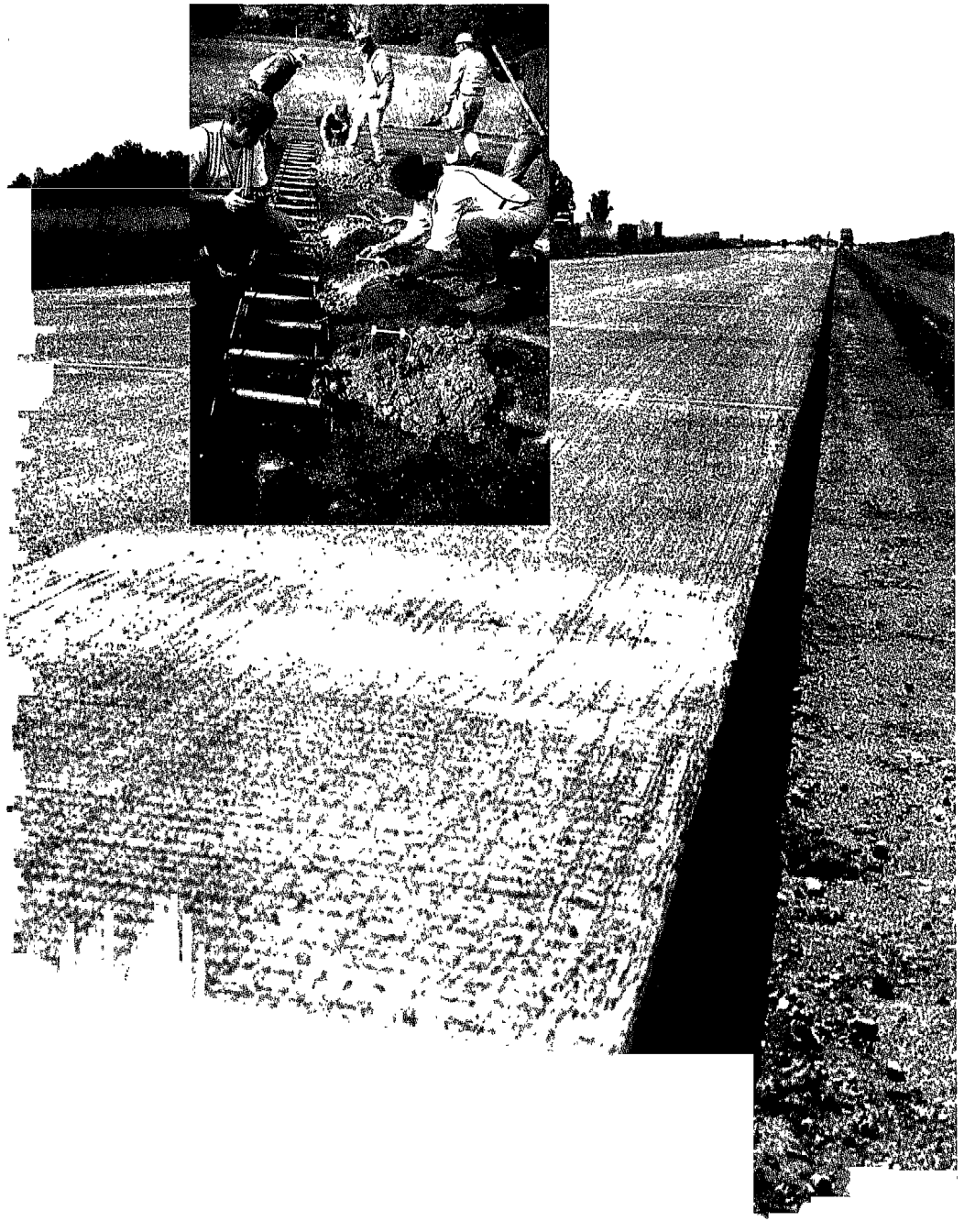
commercial truck traffic and the annual freeze/thaw cycle affect pavement materials and designs.

The Minnesota Department of Transportation (Mn/DOT) developed Mn/ROAD in partnership with the University of Minnesota. Built over four years at a cost of $25 million, Mn/ROAD opened in August 1994 and now generates millions of bytes of live data daily. Over its projected lifespan -- at least twenty years --researchers in industry, government and universities can partner with Mn/ROAD to explore new ground in pavement materials, design, instrumentation and other research areas.

WHAT IS MN/ROAD?

Mn/ROAD is currently the world's most advanced outdoor pavement research facility, located 40 miles northwest of Minneapolis/St. Paul, in Otsego, Minnesota. In a first-of-its-kind design, Mn/ROAD incorporates 4,572 electronic sensors





strategically placed within multiple layers of 500-foot sections of test roadway, called "cells." The cells represent a variety of types and depths of pavement surfaces, bases, subgrades, drainage and compaction. A total of forty test cells are divided between two types of roadway:

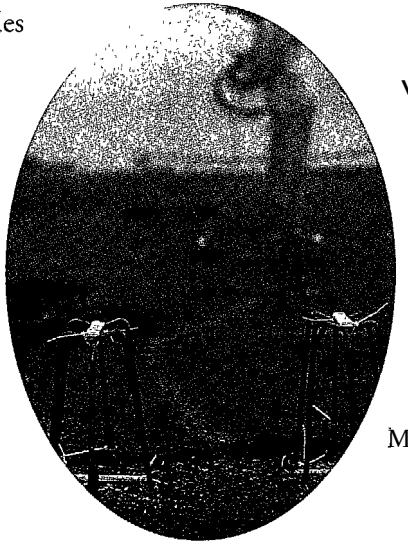
- **A 3.5-mile mainline "live roadway" located on westbound Interstate 94.** This roadway is used by approximately 21,000 vehicles daily, of which 15 percent are heavy commercial trucks. It contains 23 test cells, nine with concrete surfaces and 14 with bituminous surfaces. The sections are designed to have five- and ten-year lives, depending on the materials used in the surface, base, and subbase layers. Research focuses on the effects of heavy truck traffic and the environment on these different pavement designs.

- **A 2.5-mile closed-loop, low-volume road.** This road incorporates 17 test cells with bituminous, concrete, and aggregate surfaces. Research focuses on the effects of controlled loadings on the

types of pavements typically found on city, county, and township roads.

The sensor network is the key tool that enables researchers to pursue their objectives, which include evaluating the effects of heavy vehicles on pavement, investigating seasonal changes in paving materials, and improving design and performance on low-volume roadways. Seventeen types of sensors are peppered through the layers of bituminous and concrete pavement surfaces, as well as gravel base and subbase soil layers. The sensors measure variables such as pavement pressure, strain and movement due to truck loads, as environmental conditions such as temperature, moisture and frost depth. The Mn/ROAD site also incorporates an Automated Weather Station to measure temperature, humidity and solar radiation, and a Weigh-In-Motion scale which determines vehicle type, speed, weight and axle spacing as vehicles pass over the roadway.

A stream of live data flows from the sensors and other instrumentation to an extensive data collection network. Data signals are cabled first to 26 roadside cabinets containing 38 data acquisition computers. From there, data is routed by fiber-optic cable to the site computer, then to the Mn/DOT Research Laboratory in Maplewood, Minnesota, and the University of Minnesota. Eventually, the information will flow around the world via Internet for cooperative research and design planning.

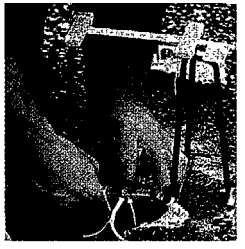


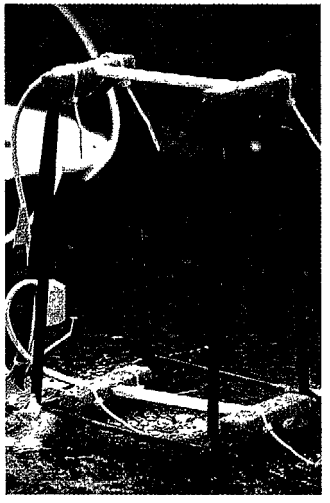
WHY MN/ROAD?

Mn/DOT's formal goal for MN/ROAD is "to extend pavement life, thereby improving the quality of the Minnesota road system and its value to the state economy while reducing future taxpayer costs." But the need for this kind of research extends far beyond Minnesota, as do the benefits.

Old Standards, New Needs

Current pavement standards in the United States were developed through tests conducted in the late 1950s and early '60s. But since then, construction techniques, available materials, snd the volume and weight of traffic have changed significantly. Mn/ROAD's breakthrough technology allows close investigation into these new circumstances.





Furthermore, road building has shifted away from Interstate construction toward system rehabilitation. Officials project that Mn/ROAD research will lead to more cost-effective rehabilitation and reconstruction through the development 0ε better, longer-lasting pavement designs.

Cold Weather and Pavement Life

Minnesota and other cold regions have particular concerns about the effects of cold weather on pavements, because the freezing ənd thawing process, combined with heavy truck traffic, accelerates pavement damage. The Mn/ROAD site was chosen partially for its higher water table, enabling researchers at the U. S. Army Corps of Engineers/Cold Regions Research and Engineering Laboratory (CRREL) to develop research plans for Mn/ROAD. The Finnish National Road Administration (FinnRA) is also conducting research on pavement technologies at the research facility.

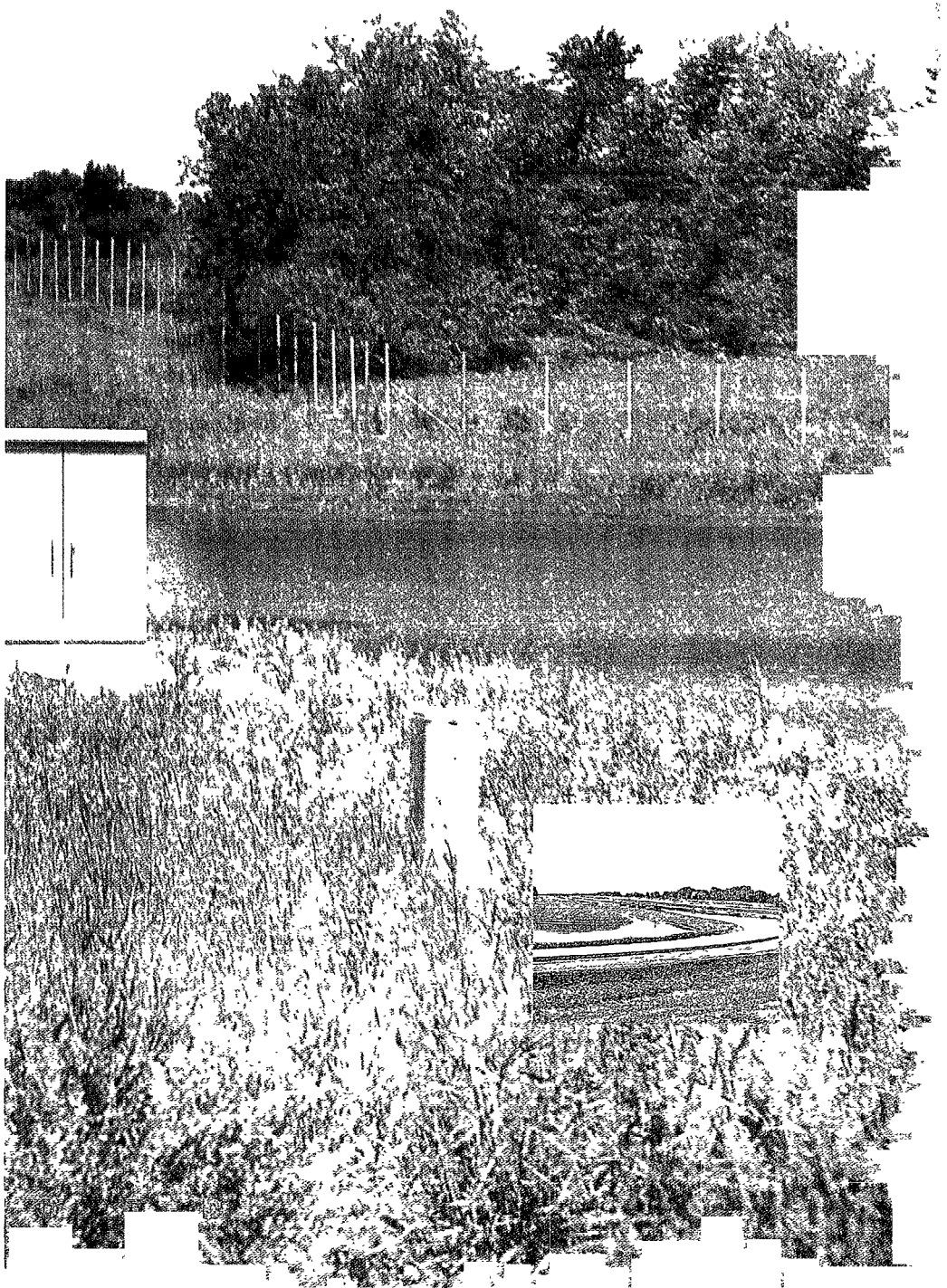
Who Benefits?

Information gathered from Mn/ROAD will help us design safer, more cost-effective roadways which will ultimately benefit the entire transportation community. Better performance and longer life from roads and highways means more cost-efficient roads, with the potential for substantial tax savings on road building and rehabilitation. Reducing the need ɛos routine maintenance will lessen

inconvenience to motorist improve reliability to industry and increase safety for system users and workers.

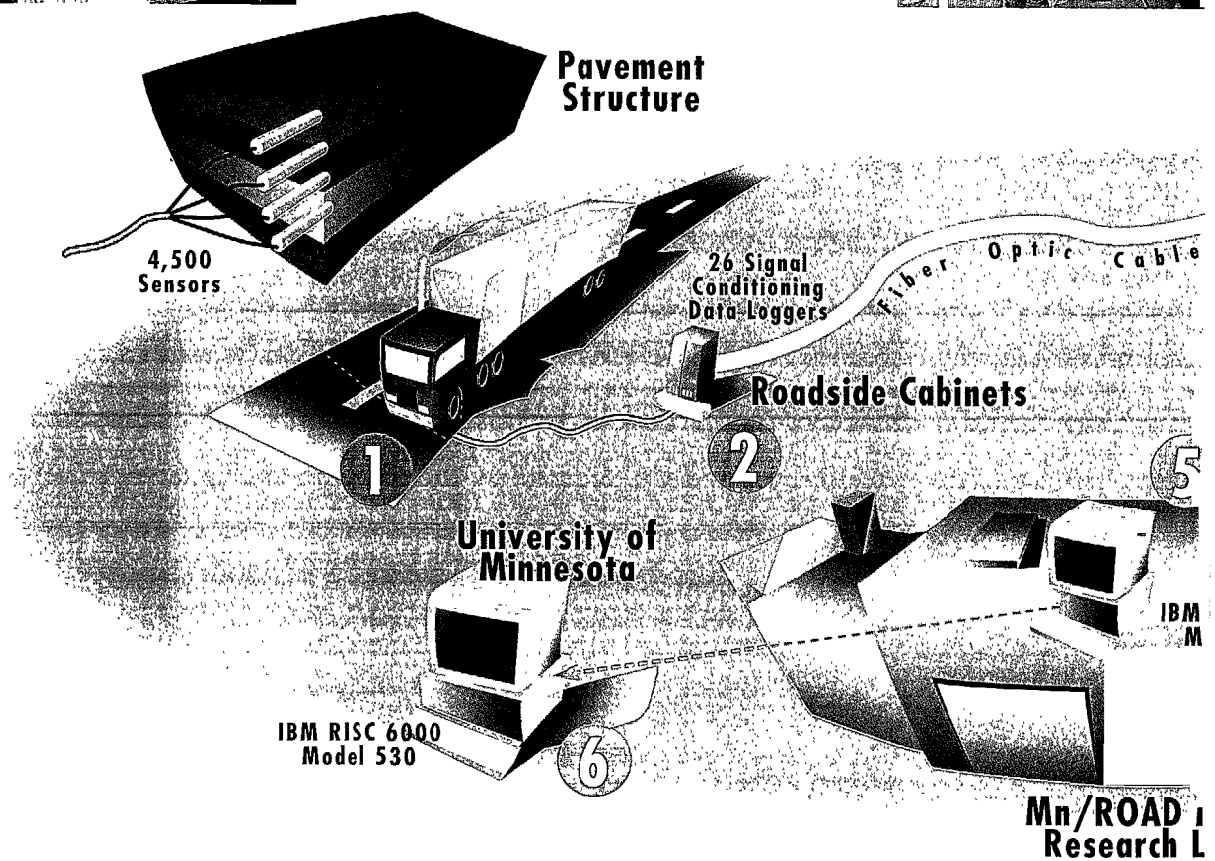
ENVIRONMENTAL COMMITMENT

More than 40 potential sites were evaluated against criteria set to ensure environmental responsibility as well as research suitability. The selected site lies in a rural area and has easy, open access. Surrounding farmland affected by the construction was restored to its former condition. Nineteen acres of ponds and designated wildlife areas around the test areas were expanded after construction to cover twenty-two acres. restored ponds were designed with irregular shorelines and bottoms to encourage wildlife to remain in the area. Whitetail deer, blue herons, ducks, geese and other types of wildlife are seen regularly at the site.



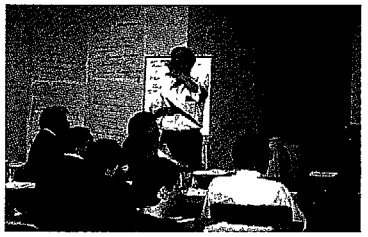
RESEARCH OBJECTIVES, INNOVATIONS AND RESULTS

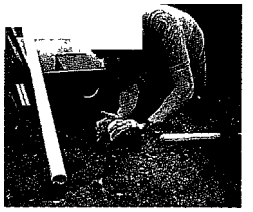
Mn/DOT, in cooperation with the University of Minnesota's Department of Civil Engineering, has defined 14 initial research objectives at Mn/ROAD, following input from a wide range of professionals from Mn/DOT, industry and universities. These objectives consider the effects of design procedures, materials, traffic loadings and climatic conditions on pavement performance.

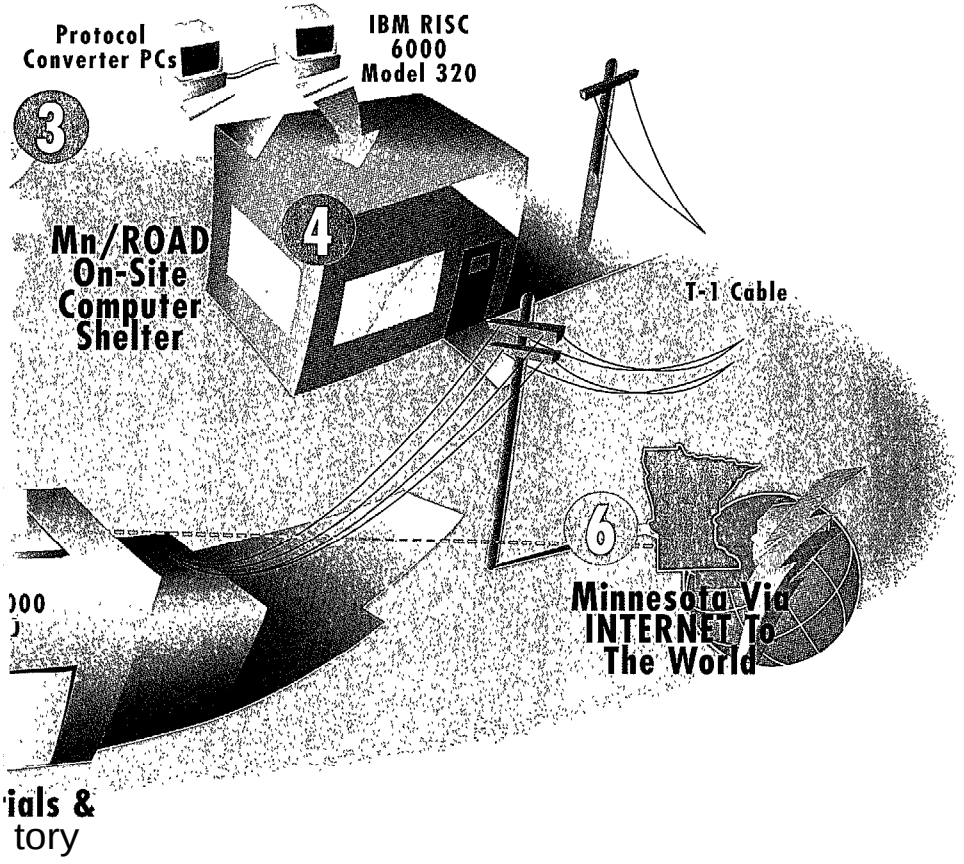


The sensor network designed and built exclusively for Mn/ROAD is giving researchers an unprecedented look at how roads perform under real weather and traffic conditions. Some of Mn/ROAD's research uses newly developed sensors that have been specially modified for Mn/ROAD. Researchers can now test and verify existing pavement design models, analyze factors that affect pavement performance, develop new design models and analyze the performance of the sensors and other instrumentation.

Some of these innovations are already leading to results beyond the laboratory. For instance, approximately 103 resistivity probes,







customized for Mn/ROAD by CRREL, are built into the pavements to measure the freeze/thaw depth changes as they occur. This information will replace current estimations of thaw dates, playing a major role in improving how and when weight restrictions for trucks are implemented on the nation's roads each spring.

PARTNERSHIPS

Mn/ROAD owes its success to a solid team of experts from Mn/DOT, the University of Minnesota, consultants, contractors, and other agencies and partners. In fact, partnerships are vital to Mn/ROAD's activities, involving universities, industry and governments, whether local, national or international. Here are a few of the partnerships that have pooled resources with Mn/ROAD:

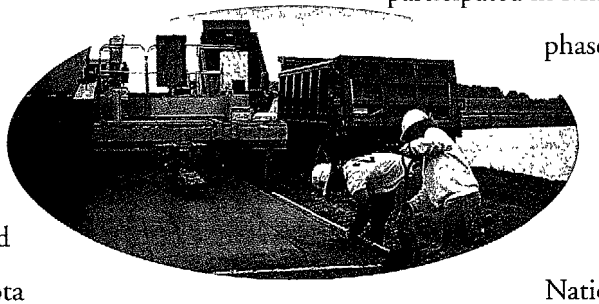
- The University of Minnesota was a key partner with Mn/DOT during Mn/ROAD's design and construction. Various federal government agencies fund contracts for soil and pavement testing at Mn/ROAD, coordinated by Dr. David Newcomb at the University's Department of Civil Engineering. The University's Center for Transportation Studies also provides funds for research and development. Also, Dr. Matthew Witczak from the University of Maryland designed the test sections based on information generated by the Mn/ROAD Task Force and several working

committees. As a top expert in sensor design, Dr. Witczak continues to provide key information to the Mn/ROAD researchers.

- **The Federal Highway Administration (FHWA) funded a major portion of construction, sensors, data acquisition equipment and computer costs.** It currently provides research funding and representation on key research committees.

- **The Minnesota Local Road Research Board (LRRB),an organization represented by various Minnesota transportation professionals, including county and city engineers,** provided funding for research contracts and for some of the administrative and operational costs at Mn/ROAD.

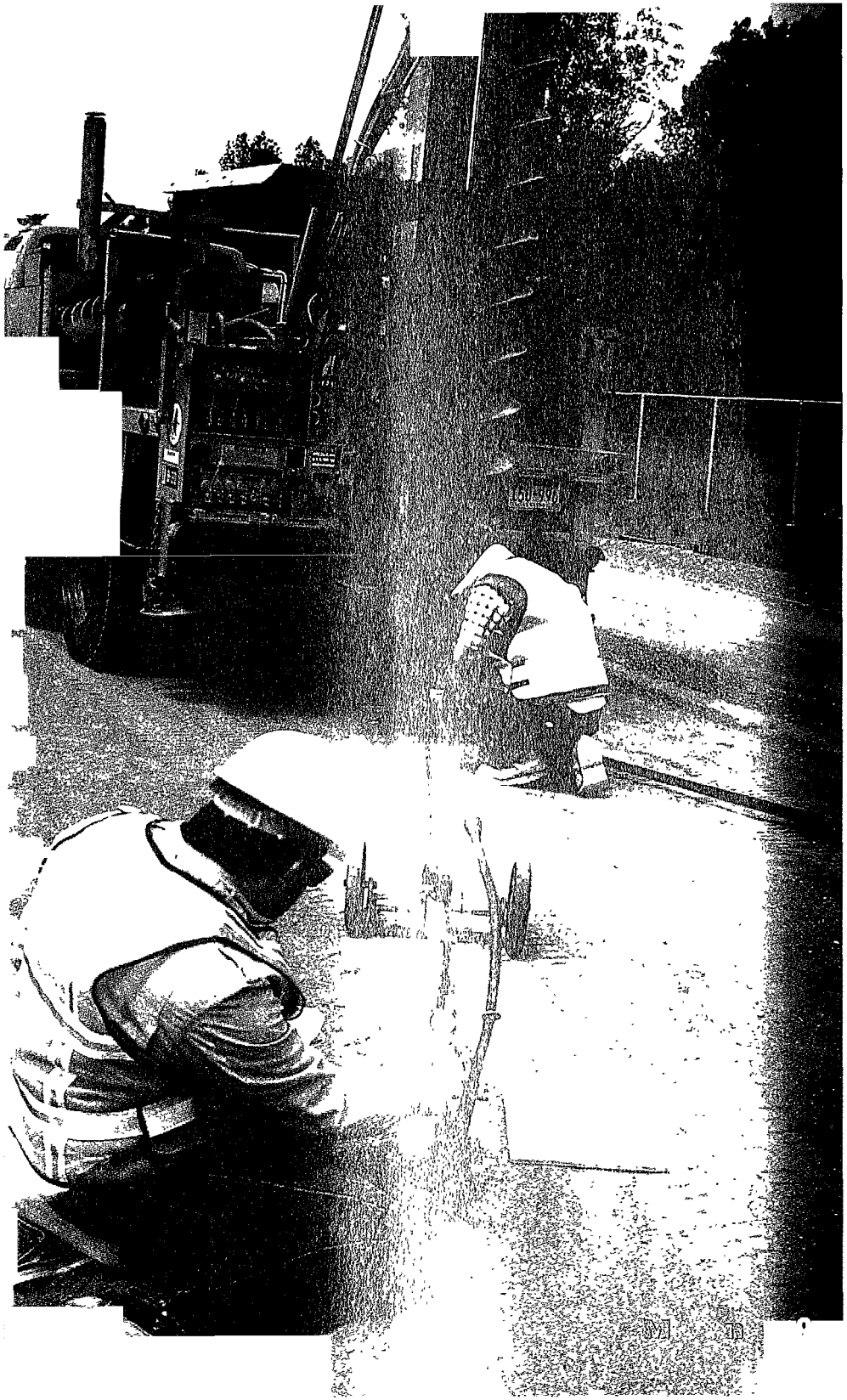
- **The Strategic Highway Research Program (SHRP) provided direction on testing methods and materials testing to Mn/ROAD engineers.** In turn, Mn/ROAD engineers and Dr. David Newcomb, University of Minnesota Department of Civil Engineering, provide sensor expertise to SHRP for its sensor installations. Mn/ROAD sections are included in the Long Term Pavement Performance (LTPP) Studies.



- **The U. S. Army Corps of Engineers/Cold Regions Research and Engineering Laboratory (CRREL), contracts to test and analyze materials,** and incorporates resulting research into the CRREL Mechanistic Pavement Design Procedures.

- **Private industry has been involved throughout the life of the project.** Organizations such as the Minnesota Asphalt Pavement Association and the Concrete Pavers Association of Minnesota participated in Mn/ROAD's planning, design and construction phases and are now represented on key committees.

- **International partners are expected to play increasingly visible roles.** For instance, since 1991 representatives from the Finnish National Road Administration (FinnRA) and the



Technical Research Centre of Finland have exchanged visits and technical information with Mn/ROAD engineers. As a result, seven areas of cooperative research with FinnRA are currently underway at Mn/ROAD.

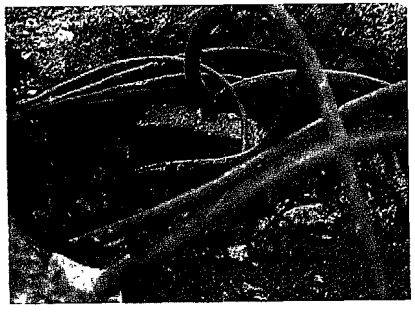
MN/ROAD MANAGEMENT

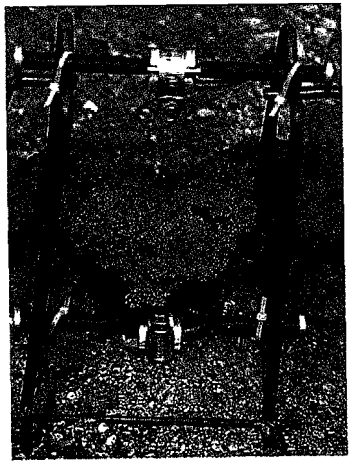
The Board of Directors of Mn/ROAD is comprised of top representatives from Mn/DOT, the Center for Transportation Studies, University of Minnesota, the local Road Research Board, Federal Highway Administration, bituminous and concrete paving industries, and the Wisconsin Department of Transportation. It operates as a high level goal setting and decision making entity for Mn/ROAD. The Board functions in the areas of overall goals and strategic directions, governance, funding, entrepreneurship, management accountability and research implementation.

DOWN THE MN/ROAD

Mn/ROAD will provide the key to unlocking the future of pavement design and technology, well into the next century. Looking ahead, we envision ongoing opportunities such as:

- Additional partnership opportunities involving a wide array of government agencies, universities, private industries and other countries;
- Enhanced site operations and administration;
- Rehabilitation strategies for experimental roadways;
- Automation of controlled loading experiments on the low-volume road;
- Other improvements, expansions, discoveries and partnerships.





MN/ROAD FACTS–AT A GLANCE

- Mn/ROAD is the largest and most heavily instrumented pavement testing facility in the world, with 4,572 sensors (of 17 different types) embedded within a total of six miles of test road.
- Mn/ROAD is located about 40 miles northwest of Minneapolis/St. Paul in Otsego, Minnesota, alongside Interstate 94

- Built over four years at a cost of $25 million by the Minnesota Department of Transportation, in partnership with the University of Minnesota, Mn/ROAD opened in August 1994 and is expected to generate data for at least the next 20 years.

- Mn/ROAD consists of forty 500-foot test cells distributed over a 3.5 mile road segment of "live" traffic diverted from Interstate 94, and a 2.5 mile low-volume loop simulating city and county roads.

- 30 megabytes of data flow daily from Mn/ROAD to the Mn/DOT research facility in Maplewood, Minnesota, as well as to researchers at the University of Minnesota and eventually, the world via Internet.

- Mn/ROAD includes an Automated Weather Station for environmental readings such as temperature, moisture and solar radiation, as well as a Weigh-In-Motion scale which determines vehicle type, speed, weight and axle spacing.

- Mn/ROAD technology uses 26 miles of fiber optic cable, 245 miles of wire, 26 roadside data collection cabinets, 38 acquisition computers, 5 protocol computers and an on-site RISC 6000 computer.

Mn ROAD

Office** of **Minnesota Road Research

Mn/ROAD – the Minnesota Road Research Project - stands at the frontier of pavement research, attracting international attention and positioning Minnesota on the leading edge of innovation, technology and research accomplishments.

Many other states, provinces and countries will benefit from this research and join with us at Mn/ROAD, as we find ways to "Build a Better Foundation for the Future."

M N 11 R O A D

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