Blue Earth County
Finn / Oil Gravel Project
C.S.A.H. No. 24 from T.H. 30 to C.S.A.H. 25

Local Road Research Board
In 1996, Blue Earth County paved a rural, two-lane County State Aid Highway using Finn Road or Oil Gravel technology to explore its potential for providing an economical, easy to maintain, and improved all-weather driving surface for the County's 300 miles of gravel road.

Koch Oil designed the mix, and Loveall Construction of Winnebago, Minn., constructed the mix, with construction inspection and contract administration by Blue Earth County. Separate pay items for gravel, quartzite, asphalt, and produce and lay gave the County the flexibility to modify the mix design based on design information and to conduct construction tests for the highest quality pavement. High Float Emulsion 3010 asphalt binder was used. The pavement was constructed in two demonstration sections: one with 100 percent quartzite and one with 50 percent gravel and 50 percent quartzite.

Significant segregation of the mix occurred during construction, which was repaired by spray injection and seal coating. The County reports performance after one winter as good, with initial construction cost about 33 percent less than a traditional 7-ton hot mix bituminous pavement design. No maintenance experience is available to date.
Blue Earth County
Finn Road/Oil Gravel Project
CSAH 24 from TH 30 to CSAH 25

Final Report

Prepared by:
Alan Forsberg, PE
Blue Earth County
Public Works Department
35 Map Drive
Mankato, Minnesota 56001

April 1997

Published by:
Minnesota Local Road Research Board
Office of Research Administration
200 Ford Building
Mail Stop 330
117 University Avenue
St. Paul, Minnesota 55155

The opinions, findings, and conclusions expressed in this publication are those of the authors and do not necessarily those of the Minnesota Local Road Research Board or the Minnesota Department of Transportation.
Acnowledgments

The author on the behalf of Blue Earth County wishes to express his sincere thanks to the following people and organizations for their participation in this demonstration project:

• The Local Road Research Board for its support by funding the asphalt used to construct the project and remedial seal coating.

• Dan Wegman and Dan Staebel of Koch Materials for providing the mix design and technical assistance.

• Roger Olson and the Office of Minnesota Road Research at the Minnesota Department of Transportation (Mn/DOT) for technical assistance.

• Larry LaPoint and Jack Hermer of the Blue Earth County Highway Department for providing the plans, specifications, construction administration, and construction inspection.

• H.R. Loveall Construction for their cooperation and support for new paving technologies during construction of the project.
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Executive Summary

Blue Earth County has over 300 miles of gravel roads to maintain. This requires regular gravel surfacing replacement and blading. Our sources of good gravel surfacing material are also being depleted. Although they provide an all weather road for the public, they are frequently dusty, bumpy and muddy, even with good maintenance. They are also weight posted at 5 tons per axle in the spring, severely limiting goods movement. Placing a high level bituminous pavement on all these low traffic volume roads is not economically feasible—either in initial costs or future maintenance overlays.

The purpose of this project was to test the feasibility of the Finn Road technology by providing a hard surface which is more economical to construct and maintain than the traditional high level bituminous pavement.

In the summer of 1996 Blue Earth County in cooperation with the Minnesota Local Road Research Board constructed two Finn Road test sections—one with 100 percent crushed quartzite aggregate and one with 50 percent quartzite and 50 percent gravel. The two sections compare the cost and performance characteristics of the more costly 100 percent crushed quarry rock recommended for Finn Road pavements.
The following was found:

- Segregation of the mix was a problem—perhaps due to the coarseness of the mix and fluidity of the low asphalt content heated emulsion binder.

- Rutting of the mix during construction was a problem—but could be avoided by not allowing construction traffic on the mat. It is not necessary to close the centerline joint everyday because the mix stays soft for days. Rutting damage during construction was readily removed by rolling.

- The mix was susceptible to edge and rutting damage for several weeks until the binder hardened.

- The Finn Road technology has potential for reduced construction and maintenance costs. However, performance needs to be observed for several years and the segregation problem resolved.
I. Introduction

A. Project Purpose

Blue Earth County has about 300 miles of aggregate surfaced roads. These roads can be bumpy, dusty, and muddy depending on the season and weather conditions. They also are weight posted in the spring at 5 tons per axle substantially reducing their utility for moving goods. Maintaining the roads requires regular replacement of surfacing material and blading. Figure 1 shows the location of the project.

The purpose of the project was to test the feasibility of providing a hard surface which would be economical to construct and maintain using the Finn Road/Oil Gravel technology.

B. Pavement History

CSAH 24 was graded and about 2 inches of gravel surfacing applied in 1988. Since then, additional gravel surfacing was placed as part of maintenance operations. In addition, aggregate was placed to reinforce weak areas after being used by the public as a detour for TH 30 work. Test cores indicated about 3 to 4 inches of gravel surface in place on the average.

C. Traffic Conditions

Traffic ranges from an ADT of 91 south of TH 30 to 81 north of TH 30. Traffic consists predominantly of auto and light truck traffic.
However, the road must also carry occasional heavy agricultural loads of fertilizer, agricultural machinery and crops during planting and harvest seasons. There is the potential of heavy loads for the developing hog feedlot industry.
BLUE EARTH COUNTY HIGHWAY DEPARTMENT
COUNTY STATE AID HIGHWAY No. 24
FINN ROAD / OIL GRAVEL PROJECT

BETWEEN 1ST NO. 30 & CSAH No. 25
FROM SW COR. SEC. 18-105-29
TO NW COR. SEC. 6-105-29

GROSS LENGTH 15,860.3 FEET 3.004 MILES
BRIDGE LENGTH 45.0 FEET 0.009 MILES
NET LENGTH 15,815.3 FEET 2.995 MILES

GRADED IN 1988 UNDER SAP 07-624-01

END SAP 07-624-03
STA 316 + 91.6

BRIDGE EXCEPTION 45.0'
STA 196 + 25 TO STA 196 + 70

BEGIN SAP 07-624-03
STA 158 + 21.3

PROJECT LOCATION

BLUE EARTH COUNTY

DESIGN DESIGNATION
ADT (Current Year) 81 1996
ADT (Future Year) 130 2016
7 TON DESIGN
DESIGN SPEED 50 MPH
SOIL FACTOR 1.50
SHOULDER WIDTH 4.0'
II. Demonstration Project Design

A. Test Sections

Three fairly uniform sections of road were defined for the test. The trial section from the south County line to TH 30 was maintained as an aggregate surface for comparison of costs and performance. The section from TH 30 to 1.5 miles north was paved with a 50 percent quartzite and 50 percent natural gravel aggregate mix. The section from here north to CSAH 25 was paved with a 100 percent quartzite aggregate mix. These two sections were established to test the performance and cost implications of using a larger percentage of more costly quartzite material.

B. Bridge and Drainage Considerations

The three sections are straight and flat except for the Perch Creek crossing. The crossing has hills leading down to the bridge on both sides of the creek. As is typical in our area, it was found the road embankment was wet and soft on these hills. To counter this affect, earth embankment was subcut and replaced with gravel base to match the bridge grade. Four inch agricultural drain tile was installed along both edges of the future pavement on both hills.

C. Pavement Structural Section

An additional 7 inches of Mn/DOT class 5 base was added to the existing 3 to 5 inches of gravel base. The gravel base was trimmed using
string line control in order to ensure a pavement with uniform thickness and good ride. The Finn Road mix was laid in one 2.5 inch lift. Based on Minnesota Department of Transportation (Mn/DOT) gravel equivalency design methods, a soil factor of 130, 11 inches of class 5 gravel base, 100 ADT traffic, and 2.5 inches of Finn Road bituminous mix (GE assumed to be 1.5 per inch), the finished road has a design strength of about 7 tons. See figure 2 for a typical cross section.
III. Bituminous Mix Design

The bituminous mix design was done by Koch Materials Company. Finn Road design technology, experience gained previously in St. Louis County and Stearns County, and cold mix technology was the basis for the design.

A. Aggregate Selection, 100 Percent Quartzite North Section

Three bins of coarse, medium and fine quartzite materials were combined to provide the design gradation. The material was 100 percent crushed, very hard quartzite from the New Ulm Quarry. The binder was High Float Emulsion 300 (HFE 300). The asphalt content was 6 percent emulsion, 4.1 percent added AC. Figure 3 is mix design data; figure 4 is gradation tabular and curve information. The mix design sheet noted the mix was “very prone to segregation.”

B. Aggregation Selection, 50 Percent Quartzite, 50 Percent Gravel Section

Two bins of coarse and fine quartzite and two bins of medium and fine gravel were combined to provide the design gradation. The quartzite material was 100 percent crushed, the gravel percent crushed was not measured but would probably be low. The binder was HFE 300. The asphalt content was 5 percent emulsion, 3.4 percent added AC. Figure 5 is mix design data; figure 6 is gradation tabular and curve information. The mix design sheet noted the mix was “not as prone to segregation.”
C. Asphalt Binder Selection

At the recommendation of Koch and Mn/DOT Research, HFE 300 (high float emulsion) was chosen as the binder. This product was also used for the Stearns and St. Louis County projects.
TYPICAL SECTION

SEG. "A" STA. 158 + 21.3 TO STA. 237 + 51.5 100% QUARTZITE
SEG. "B" STA. 237 + 51.5 TO STA. 316 + 81.6 50% QUARTZITE - 50% GRAVEL

SEE DETAIL "A"

DETAIL "A"

2 1/2" OIL GRAVEL

7" AGGR. BASE CL-5 (2211)

INPLACE 3" AGGR. BASE CL-5 (2211)
S.A.P. 07-624-03 CSAH NO. 24 OIL GRAVEL PROJECT

SEGMENT "A" STA 158+21 TO STA 237+52 100% QUARTZITE

1. Aggregate Gradations:

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<th>Percent Passing SRP 3/4</th>
<th>Percent Passing NU No. 8</th>
<th>Percent Passing NU No. 4</th>
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Blend % | 55 | 10 | 35 | 100.0

2. Aggregate Portions and Source:
55% Sioux Rock Products Jeffers MN 3/4"
10% New Ulm Quartzite New Ulm MN No. 8 Sand
35% New Ulm Quartzite New Ulm MN No. 4 Sand

3. Emulsion HFE-300
   % Emulsion 6.0
   % Added AC 4.1
   % Total AC 4.1

4. Mix Density 148.2 Lbs/ft³

Figure 3
S.A.P. 07-624-03  CSAH NO. 24  OIL GRAVEL PROJECT
SEGMENT "B" STA 237+52 TO STA 316+82  50% QUARTZITE -- 50% GRAVEL

1. Aggregate Gradations:

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Blend % 40 10 10 40 100.0

2. Aggregate Portions and Source:
40% Sioux Rock Products Jeffers MN 3/4"
10% New Ulm Quartzite No. 8 Sand
10% Cedar Grove Fine
40% Cedar Grove Medium

3. Emulsion HFE-300
% Emulsion 5.0
% Added AC 3.4
% Total AC 3.4

4. Mix Density 133.9 Lbs/ft3

Figure 5
BITUMINOUS GRADATION CURVE

0.45 POWER OF PARTICLE SIZE

Percent Passing

0 10 20 30 40 50 60 70 80 90 100 110

0 1 2 3 4 5

0.45 Power of Sieve Size

- SRP 3/4 CL.
- No.8 MESH
- COMPOSITE
- MAX. DEN.
- OIL GRAVEL MIN.
- OIL GRAVEL MAX.
- CG FINE
- CGMED

1996 Demo Oil Gravel Project  Figure 6
IV. Contracting Method

A. Procurement

Public advertisement and low bid procurement under Minnesota law and County State Aid requirements for local governmental agencies was followed.

B. Pay Items and Agency Control

The contract included separate pay items for quartzite, gravel, asphalt emulsion, and produce and lay. The contract also provided the County with the authority to require changes in the relative quantities of these materials depending on construction tests to ensure the highest quality product and value for the County. Ordinary compaction was specified with a nuclear density gauge used to establish the optimum rolling pattern. The contractor was required to provide a steel vibratory and rubber tire roller.

C. Construction Quality Control

County forces regularly took gradation and asphalt content measurements. These tests were all within specifications. No changes from design gradation or asphalt content were made.
V. Construction

H.R. Loveall Construction of Winnebago was awarded the construction contract.

A. Equipment

A continuous drum plant was set up in the McMartin pit about 9 miles from the construction site. Piles of aggregate appeared to be uniform and non-segregated. The aggregate and asphalt emulsion were fed into the drum and heated to 150 degrees F. to ensure uniform mixing and coating. The mix was transferred by conveyor into a silo for storage and weighing before being dropped into "Flo boy" conveyor type truck trailers in three piles. The silo was kept partially full and included a baffle at the top to reduce segregation effects. The production rate was about 2,000 tons per day.

The mix was trucked to the construction site and conveyed from the rear of the trailers into a Cedar Rapids brand paver. The paver used a long ski automatic grade control to ensure uniform paving depth.

The mix was compacted with a break down steel vibratory roller, intermediate rubber tire roller, and final steel non-vibratory roller.
B. Construction Observations

Segregation of the mix became apparent almost immediately. Each step of production was reviewed to isolate the source of this problem. The County coordinated with the contractor, Mn/DOT and Koch to resolve the problem. No firm conclusions were reached on how to avoid the segregation. The mix was probably susceptible to segregation due to the coarseness of the aggregate, low asphalt content and low viscosity of the heated asphalt emulsion. Some segregation may have been occurring each time the mix was handled. Candidates for reducing segregation include not emptying the paver wings and designing a more uniformly graded aggregate structure. Perhaps the best solution, although requiring additional cost, would be a remixing device at the paver.

On the first day of paving, the mix was very stable for construction traffic until about 2:00 p.m. when air temperatures reached over 80 degrees Fahrenheit. The pavement then became very unstable and severe rutting was observed behind the hauling trucks. All truck traffic was then removed from the pavement and the pavement successfully rolled smooth.

With traditional hot mixes, it is important to close up full width paving each day to ensure a good centerline joint. With Finn Road, this is not necessary since the emulsion stays soft for several days. The
rutting problem could have been avoided by recognizing this difference and not allowing haul trucks on the new pavement.

Figures 7 and 8 are photos of construction. Figure 9 is contract cost information.
VI. Repair of Segregated Areas

We considered removing and replacing all severely segregated areas. However, this was rejected due to the cost and uneven surface which would result. Instead, these areas were “blow patched.” A mixture of asphalt and pea rock size crushed quartzite was blown into the void areas using rented proprietary equipment. However, other large areas with less voids but still significant segregation remained. It was not practical to blow patch these large areas. After consultation with the contractor, Koch, and Mn/DOT Research, it was determined these areas should be seal coated. Two five hundred foot long sections were not seal coated for control and comparison purposes.

The blow patching and seal coating repair was done by County forces. Seal coating costs were reimbursed under the Local Road Research Board policy on repairing failed demonstration sections. Although the pavement had not failed, the seal coating was seen as a remedial action to prevent more costly future repair.
## CONTRACT COST

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Production rate average for "good" day 2000 ton per day.
VII. Conclusions

A. Performance

The pavement remained soft for several weeks after placement and was susceptible to damage, especially at the edge of the pavement. However, the pavement did harden sufficiently by the end of the summer to resist edge damage. No rutting damage occurred during this period.

The pavement has gone through one winter season without snow plow damage and appears to be in good condition. Ride and overall appearance are excellent.

B. Cost

The Finn Road bituminous mix cost $21.87 per ton for the 50 percent quartzite and 50 percent gravel section and $24.55 per ton for the 100 percent quartzite section. The Finn Road pavement including 7 inches of additional gravel base and 2.5 inches of pavement cost about $112,000 per mile (average of both sections). This compares to a traditional 2331 bituminous mix design consisting of 12" of gravel base and 3.5 inches of bituminous pavement of about $168,000 per mile. The Finn Road pavement is about 33 percent less costly to construct than a traditional 7 ton bituminous pavement in Blue Earth County.
Assuming the Finn Road pavement is structurally able to accommodate the occasional heavy agricultural loads without failure, it should be more economical to maintain and repair. This would result in future reduced maintenance costs.

C. Future Projects

The project showed adequate potential with lower initial construction costs and potentially lower maintenance costs to consider additional applications. However, before additional applications, the pavement should be observed several years for performance and the segregation problem addressed.