Pavement Performance Evaluation
Burlington-Northern & Santa Fe Railroad
Intermodal Facility
Denver, Colorado

Prepared for:

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NICKOLAS SAVKO & SONS, INC.
CONTRACTORS

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Attention: Mr. Bob Thompson

Job Number 02-0182

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GROUND
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PURPOSE AND SCOPE OF STUDY

This report presents the results of an evaluation of the pavement surface in use at the Burlington-Northern & Santa Fe Rennick Yard Intermodal railroad facility located at 53rd Avenue and Fox Street in Denver, Colorado. The roller compacted concrete pavement was installed at the facility in 1986 and the purpose of this limited study is to evaluate the long term performance of the pavement after 16+ years of service. The general project site is shown in Figure 1.

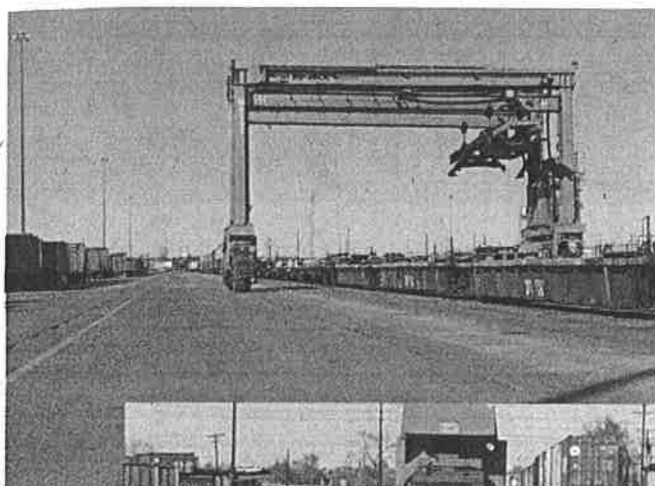
This evaluation includes a review of original laboratory mix information regarding the roller-compacted concrete, recovering cores from the pavement, performing laboratory tests on a portion of the recovered cores to determine unit weight, compressive strength and splitting tensile strength and a field review of the pavement surface. This report has been prepared to summarize the observations and test data.

PROJECT BACKGROUND

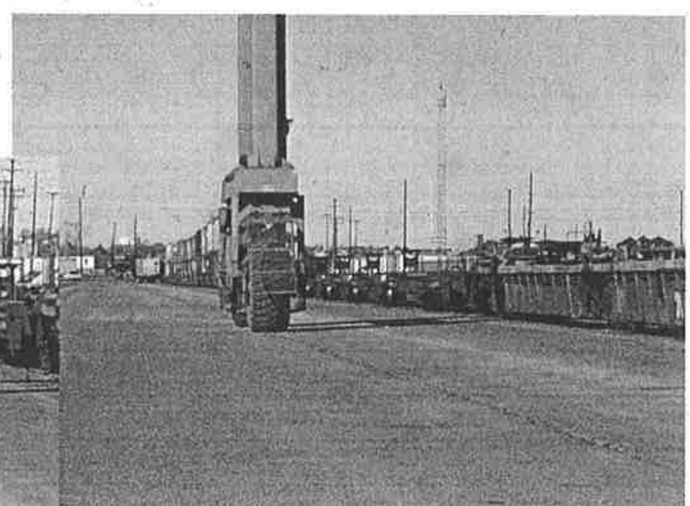
The Rennick Yard Intermodal Facility roller-compacted concrete (RCC) pavement was constructed in the spring of 1986. The owner, Burlington Northern, required a very high durability pavement able to withstand high turning stresses, heavy loading and static loading from steel trailer supports. The size of the yard, roughly 28 acres, also required a cost effective solution. The climate in Denver is highly varied with hot summers and numerous freeze-thaw cycles in winter. GROUND Engineering provided mix design recommendations and testing, as well as construction observation and materials testing during construction. Civil engineering design was provided by Centennial Engineering, Inc. and the Contractor was Judd Brothers Construction Company.

The Rennick Yard is a hub between two modes of transportation – rail and highway trucking. Containers are switched in the yard between the trucks and rail cars using heavy duty loading and unloading equipment. Conventional over-the-road tractor trailer loading, parked trailers with steel landing gear, heavy tire loading from the transfer loaders (up to 110 kips) and high turning stresses result in an extreme loading environment for a pavement structure.

A transfer loader is pictured at right.



The large loader transfer device shown at left and below exerts high tire stress and also runs directly on an original paving joint as shown.



Denver, Colorado experiences numerous freeze-thaw cycles per year combined with sunshine most of the year resulting surface warming and re-freezing frequently throughout the winter months.

ORIGINAL ROLLER COMPACTED CONCRETE MIX DESIGN

The mix used at the Rennick yard consisted of the following:

Description	Quantity/yd3
Cement, Type I-II	475 lbs
Fly Ash, Type C	75 lbs
Aggregate CDOH Class C (3/4 inch max. crushed with 3 to 12 percent passing No. 200 sieve)	3390 lbs
Water, Potable	217 lbs

Age	Compressive strength (psi)	Splitting Tensile Strength (psi)
7-day	1,980	295
14-day	3,560	390
28-day	4,280	545

Maximum dry density of the mix based on ASTM D-1557: 142.2 pcf

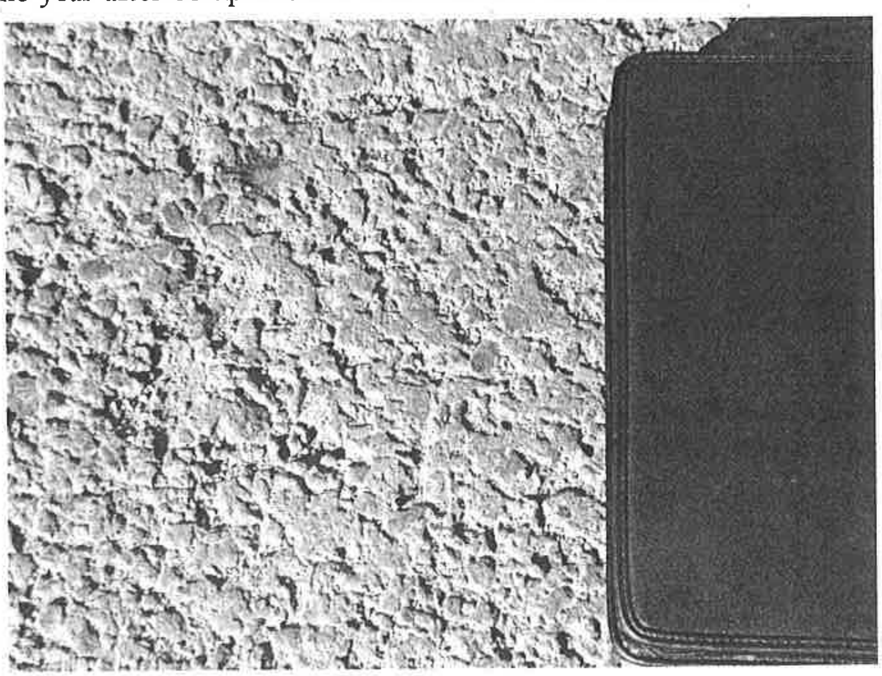
Optimum Moisture Content ASTM D 1557: 5.4%

PLACEMENT METHODS

The RCC was mixed at the site using a pug mill fed from site stockpiles using conveyors. Cement and fly ash were fed with hoppers and water was added 30 seconds after aggregate introduction. The maximum output of the mill was 265 cubic yards per hour. Dump trucks were used to transport the mix to two ABG pavers with vibrating screeds and double tamp bars. String line control was used to achieve a design thickness of 15 inches in two lifts. Steel drum rollers were used to obtain at least 95 percent of the maximum dry density (ASTM D1557). Given the length of the project, the longitudinal joints resulted in cold joints. Some raveling was noted shortly after construction at joints and free edges. Testing performed during placement averaged approximately 97 percent of the maximum dry density near optimum moisture content. Compressive strength tests performed on samples during construction averaged approximately 5,000 psi at 28-days.

CURRENT SURFACE CONDITION

The current condition of the RCC pavement surface at Rennick yard appears very similar to the surface observed about one year after completion of construction. The surface has a rough texture that is still generally impervious as shown in the photo on the right. A notebook placed on the pavement surface provides scale. This texture is very similar to that observed after final compaction.



One area of concern shortly after completion of construction was the condition of the longitudinal joints. These cold joints showed some raveling and segregation at the top corners after construction and look very similar now, after almost 17 years. Maintenance on the pavement has been very minimal and the surface is still providing excellent service. These photos show the current joint condition.

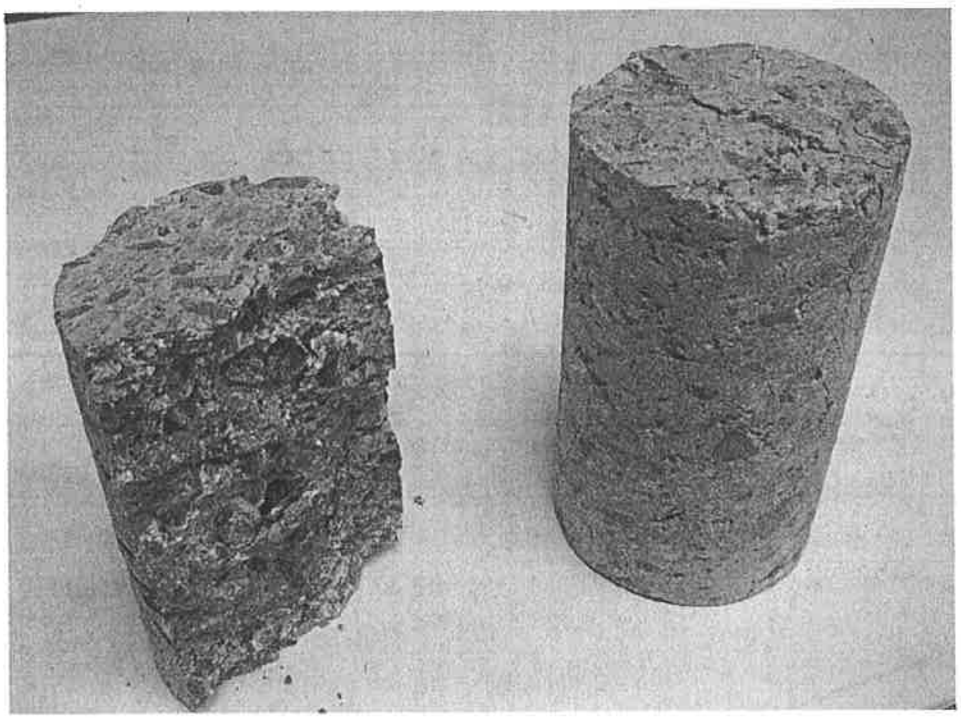
The smaller transverse cracks seen are due to initial shrinkage after placement.

CORE SAMPLING AND TESTING

Four-inch diameter cores were cut at four locations in the yard as shown in the attached Figure. Areas of high traffic were sampled, particularly the entrance area. A portion of the cores recovered were tested in our laboratory to determine compressive strength, splitting tensile strength and other parameters. Remaining core specimens were shipped at the client's request to the

Portland Cement Association laboratory in Skokie, Illinois for further testing. The results of tests performed on a limited number of the recovered cores are tabulated below:

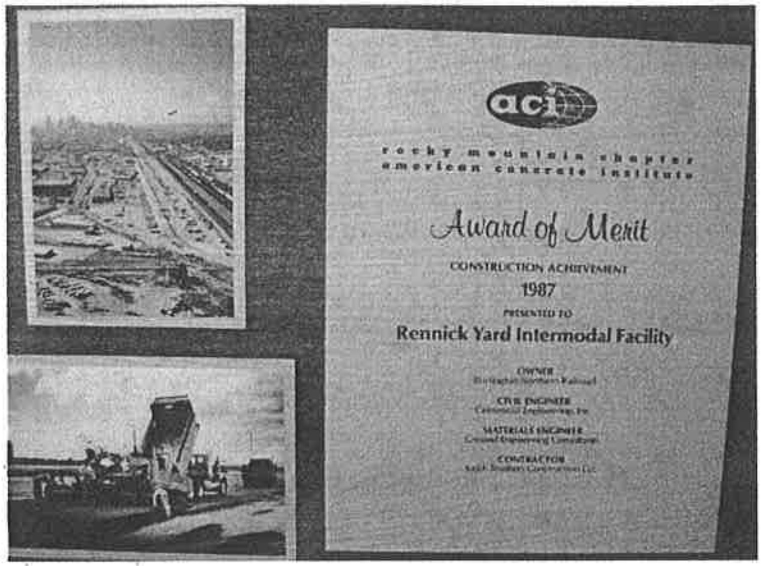
Core Identification	Layer	Compressive Strength (psi)	Splitting Tensile Strength (psi)	Density (pcf)
4-2	Top		535 psi	149.1 pcf
4-2	Bottom	7,240 psi		139.2 pcf
5-1	Top		575 psi	145.1 pcf
5-1	Bottom	5,310 psi		138.5 pcf
Entrance	Top	6,230 psi		140.2 pcf
Entrance	Bottom		590 psi	141.7 pcf
3-1	Top	7,940 psi		140.1 pcf
3-1	Bottom		740 psi	145.7 pcf



The core on the right in the photo was taken after the splitting tensile test and the right core was taken after the compressive strength test.

CONCLUSIONS

The performance of the RCC pavement since it was placed in 1986 has been excellent. A combination of flat grades, constant traffic, high stresses and repeated freeze-thaw has not significantly degraded the pavement. Very little maintenance has been necessary and the Owner's expectations for the pavement have been met and exceeded. Laboratory testing indicates a gain in compressive and tensile strength based on recent core tests when compared to strengths determined during placement. Such a gain is not unexpected for this material. Surface texture and joint quality, normally the first areas of difficulty after years of service, do not look significantly changed from their condition shortly after completion of the project. As noted previously, these areas were somewhat raveled after installation but have not significantly degraded. The yard is still in near-continuous service. The photo at right is of a local American Concrete Institute (Rocky Mountain Chapter) award for construction achievement on the project in 1987.



LIMITATIONS

This report has been prepared for the Client pertaining to evaluation of the project described. It may not contain sufficient information for other parties or other purposes. This report was prepared in accordance with generally accepted pavement engineering practice in the area at the time of preparation and our proposal to the Client. GROUND makes no other warranties, either express or implied, as to the professional data, opinions, or recommendations contained herein.

Sincerely,
GROUND ENGINEERING CONSULTANTS, INC.

James B. Kowalsky, P.E.

REFERENCES

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Erosion and Abrasion Resistance of Soil-Cement and Roller Compacted Concrete, Research & Development Bulletin RD 126, K.D. Hansen, Schnabel Engineering Associates, 2002

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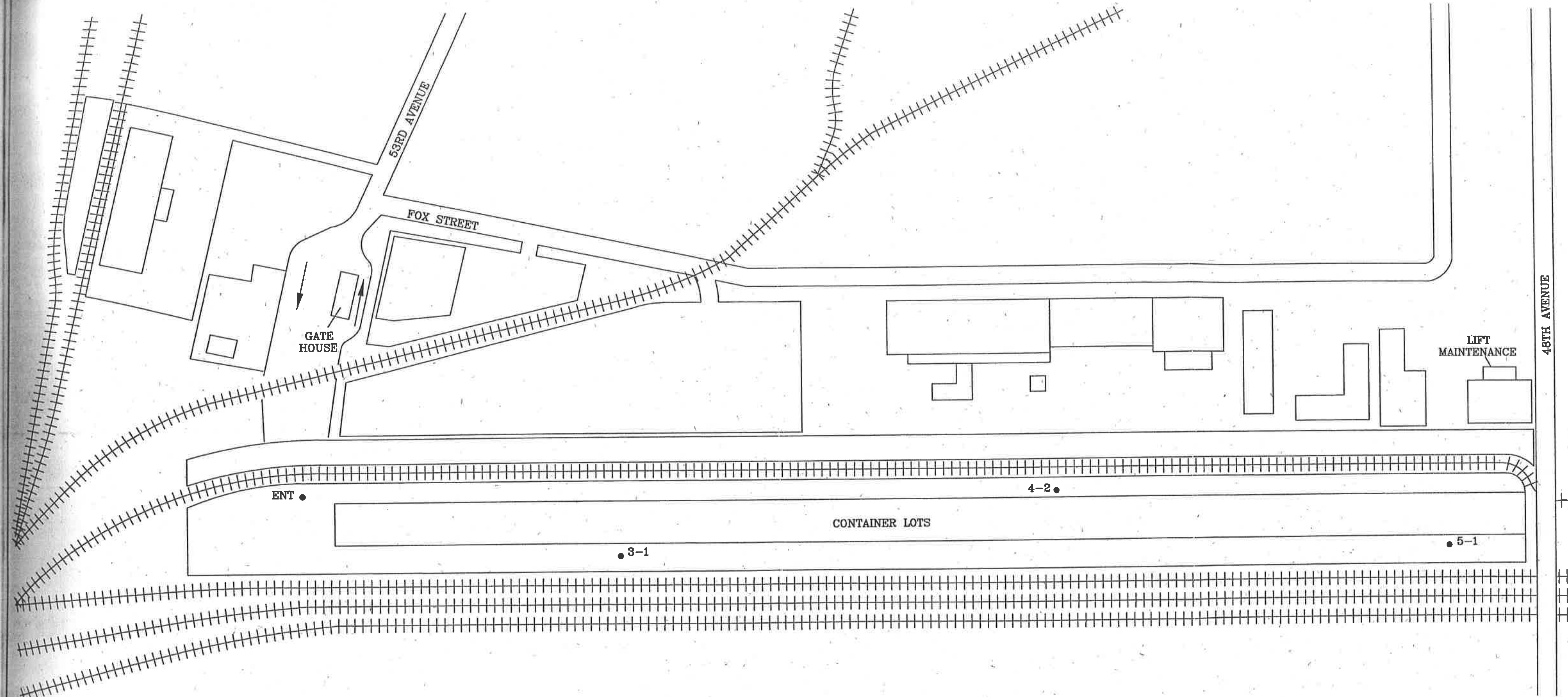

1
• Indicates test hole number and approximate location.

(Not to Scale)

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LOCATION OF TEST HOLES

JOB NO. 02–0182	DRAWN BY: HS
FIGURE: 1	APPROVED BY: JK
CADFILE NAME: 0182SITE.DWG	