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EVALUATION OF ULTRATHIN FRICTION COURSE

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ABSTRACT

NOVACHIP™, sometimes known as ultrathin friction course, was successfully constructed on two highways in the San Antonio District of Texas. The French process, NOVACHIP™, is a new technology for Texas and the United States and this research study was initiated by the Federal Highway Administration in cooperation with the Texas Department of Transportation to provide a means for evaluation and documentation of the process and resulting performance.

After ten months of service, the NOVACHIP™ pavement surfaces are in excellent condition. The pavements appear to be in essentially the same condition as immediately after construction. The pavements will be monitored for a period of three years and performance documented.

In general, NOVACHIP™ appears to have promise as a preventive maintenance treatment or surface rehabilitation technique for asphalt concrete pavements. It should provide the engineer with an alternative for chip seals, micro-surfacing, open-graded friction courses, or thin asphalt concrete overlays.

INTRODUCTION

The San Antonio District of the Texas Department of Transportation (TxDOT) included the NOVACHIP™ process on a surface rehabilitation project in Comal County (US 281 and SH 46) during October of 1992. These locations are shown in Figure 1. This experimental installation was one of three in the United States. Others were constructed by Mississippi DOT and Alabama DOT. Because this is a new technology for Texas and the United States, this research study was created to provide evaluation and documentation of the process and resulting performance.

BACKGROUND

The NOVACHIP™ process was developed in France in 1986 by a company known as SCREG ROUTES and TRAVAUX PUBLICS and is marketed by that company. NOVACHIP™ has been utilized successfully in Europe. (1) The process has promise in pavement surface rehabilitation and provides the engineer with alternatives for chip seals, micro-surfacings, plant-mix seals, or thin overlays. NOVACHIP, sometimes called ultrathin friction course, was developed to be used for preventive maintenance or surface rehabilitation. (2) Its primary function is to restore skid resistance and surface impermeability.

Some of the advantages of NOVACHIP™ touted by the manufacturer are:

- excellent adhesion (no chip loss)
- reduced rolling noise (particularly for urban use)
- rapid application
- quick opening to traffic
- reshaping of existing pavement (drainage, ride quality).

NOVACHIP™ can be used as a surface seal for bituminous pavements to reduce deterioration caused by weathering, ravelling, traffic, and oxidation. It can seal small, "non-working" cracks and provides a wearing surface with excellent skid resistance. NOVACHIP™ can also be used to restore pavement surface smoothness to a limited extent, e.g., rut-filling and smoothing corrugations and other surface irregularities. NOVACHIP™ does not, however, increase the structural capacity of the pavement.

DESCRIPTION OF NOVACHIP™

A NOVACHIP™ friction course consists of a layer of hot-mix material placed over a heavy tack coat. The course thickness ranges from 3/8 to 3/4-inch, depending on the maximum size of the stone. Layer thickness is generally about 1 1/2 times the diameter of the largest stone. (2)

The hot-mix material is a gap-graded mixture which includes a large portion (70 to 80 percent) of single-sized crushed aggregate which is bound with a mastic composed of sand, filler (if needed) and binder. (2) This mixture is sometimes described as "hot, coated chippings".

The binder content ranges from 5.3 to 6.0 percent, depending on the traffic, climate and peculiarities of the existing pavement as determined by SCREG ROUTES engineers.

The heavy tack coat is generally a polymer-modified emulsified asphalt and the application rate commonly varies between 0.15 and 0.22 gallons per square yard.

NOVACHIP™ is placed with a specially designed paving machine which combines the functions of an asphalt distributor and a laydown machine. The paver applies the tack coat and the hot asphalt mixture in a single pass. This heavy application of tack helps to ensure adhesion of the friction course to the underlying pavement and reduce the possibility of the intrusion of surface water into the pavement structure.

DESCRIPTION OF PAVING EQUIPMENT

Application equipment for the NOVACHIP™ process was designed to accommodate the following operations: (1)

- collection of the mixture from the transport trucks,
- storage of the mixture,
- storage of sufficient tack emulsion for at least 3 hours of operation,
- distribution of the tack coat with servo-controled application rate,
- immediate covering of the tack with the mixture,
- smoothing of the applied mixture into a virtual monogranular layer with respect to the 2 or 3 highest points of the existing pavement surface.

The NOVACHIP™ paving machine, as it was developed, includes the following components (listed here from the front to the rear of machine): (1)

- A hopper for the collection of the mix with a coupling for attachment to the hook of the truck supplying the mixture. The design of this hopper was changed several times to prevent the mixture of hot, coated chippings from sticking together. Because of the tendency of the "chippings" to stick together, their manipulation, storage and collection is not easy. The hopper is now fitted with two transfer screws.
- A screw or rake conveyor which lifts and feeds the mix into a hopper.
- A heated compartment where the mixture is stored having a total capacity of about 4 to 6.5 cubic yards.
- A heated tank for the tack binder (16 cubic yards).
- A conveyor serving to transfer the mixture to the forward part of the smoothing assembly where the mixture is deposited onto the road.
- A spray bar for the distribution of the tack coat. The nozzles on the spray bar are at a large distribution angle and are very closely spaced. The transverse displacement of the spray bar is servo-controlled so as to ensure that it lines up with the boundary of the hot mix.
- A continuously, or nearly continuously, heated assembly for screeding the hot mix layer. The width of the screed can be varied from 8 to 15 feet.

PRECONSTRUCTION INFORMATION

EXISTING PAVEMENT CROSS-SECTIONS

The existing pavement surface of US 281 prior to construction consisted of a seven-year old double chip seal: Grade 5 (No. 4) over Grade 3 (1/2-inch). Underneath the double chip seal, most of US 281 is a three-inch layer of hot-mix asphalt concrete preceded by a Grade 3 (1/2-inch) surface treatment on eight inches of flexible base which was constructed in 1972.

SH 46 was surfaced with a one-inch thick layer of asphalt concrete pavement (ACP) which was about eight years old at the time of this construction project. The cracks in the pavement surface were sealed with asphalt-rubber crack sealant the previous spring. Beneath this ACP surface is a series of chip seals preceded by a one-inch thick layer of ACP. This lower layer of ACP was built in about 1958. Underneath this layer is the original pavement which was built in about the mid 1930's and is thought to be a double surface treatment on a limestone base.

Limestone bedrock is at or very near the surface in this portion of Texas; therefore, on much of the pavement, the subgrade is a limestone bedrock providing excellent support.

TRAFFIC DATA

Traffic data on US 281 and SH 46 near the time of construction as provided by D-10 Research of TxDOT is as follows:

US 281

Weighted Average Daily Traffic (ADT) = 20,300 vehicles per day (vpd) with 6.0 percent trucks,

SH 46

Weighted ADT = 4,200 vpd with 6.4 percent trucks.

PRECONDITION SURVEYS

Prior to construction, precondition surveys were performed on US 281 and SH 46. An index of pavement condition has been described which quantifies all forms and levels of pavement distress. (3) Based on maintenance costs, this index, or Pavement Rating Score (PRS), allows numerical comparison of pavement condition. A PRS value of 100 describes a pavement with no distress. Progressively lower PRS values describe pavement condition with more severe forms of distress. The form shown in Figure 2 is used to catalog distress observed on the pavement. Deduct values are assigned to each type and level of distress according to Table 1. The sum of deduct values is subtracted from 100 resulting in the pavement rating score (PRS).

US 281 was in good condition at the time prior to construction. Pavement Rating Scores were obtained at several stations along the pavement and are shown in Table 2. US 281 had an overall PRS of 93 prior to construction. The surface was a double chip seal which was in relatively good condition. The primary types of distress observed were some slight to moderate bleeding in places and slight ravelling.

Pavement Rating Scores for SH 46 are shown in Table 3. This pavement had an overall PRS of 85. The primary surface distress was longitudinal cracking and some slight ravelling. The cracks had been sealed the previous spring; however, at the time of the survey, they were observed to be partially sealed.

US 281 PAVEMENT TEST SECTIONS

Eight test sections were designated on US 281 as shown in Figure 3. These were 120-foot sections of the pavement which were chosen for more detailed pavement evaluation. Data collected on these test sections prior to construction of the NOVACHIP™ surface consisted of visual evaluations, photographs, rutting measurements, and surface texture measurements.

A portion of US 281 at the south end of the job will serve as a control test section. The pavement surface and cross-section at the south end of the US 281 job is essentially the same as the pavement underlying the NOVACHIP™ surface. A two-mile section of US 281 beginning at the south end of the NOVACHIP™ pavement will serve as a control (no treatment) throughout the monitoring process.

SH 46 PAVEMENT TEST SECTIONS

Seven 120-foot test sections were designated on SH 46 as shown in Figure 4. In addition to the type of data collected on US 281, crack maps of these test sections were also developed. This was unnecessary for US 281 as there was no cracking observed.

RIDE QUALITY DATA

One of the claims to be investigated in this study is that NOVACHIP™ can be used to restore pavement surface smoothness to a limited extent, e.g., rut-filling and smoothing corrugations and other surface irregularities. TxDOT's SIometer was used to measure ride quality of the pavement surface before and after application of NOVACHIP™. A SIometer has an accelerometer, a processing computer, and a data storage computer, all mounted in a vehicle. SIometer data is converted into a Ride Score based on a user panel rating, that ranges from 0.1 (very rough) to 5.0 (very smooth). Ride Score Classes are shown below. A Ride Score below 3.0 indicates a rough road to the average person.

Ride Score	Description
4.0 - 5.0	Very Smooth
3.0 - 3.9	Smooth
2.0 - 2.9	Medium Rough
1.0 - 1.9	Rough
0.1 - 0.9	Very Rough

US 281 had an overall average ride score of 4.5 and SH 46 had an average ride score of 4.0 prior to construction.

CONSTRUCTION

Construction of the NOVACHIP™ pavement surfaces began October 15, 1992 on US 281 and the job was completed on SH 46, October 31, 1992. The weather was favorable throughout construction with morning temperatures usually at 65°F and afternoon high temperatures at about 85°F.

SPECIFICATIONS

Some of the specification requirements for the NOVACHIP™ mixture which are somewhat more stringent than what is normally required in Texas for hot-mix asphalt concrete are discussed below.

Materials

The NOVACHIP™ process requires that the coarse aggregate in the mix be a high-quality, 100 percent crushed material. Coarse aggregate (+ No. 10) must have a polish value of >35. This requirement eliminates many of the aggregate sources in Texas. The Los Angeles Abrasion Test loss shall be less than 35 percent, and the magnesium sulfate soundness test loss shall not exceed 25 percent.

The fine aggregate (- No. 10) must also be 100 percent crushed material. It must be supplied from a source where coarse aggregate meets the Los Angeles abrasion and magnesium sulfate soundness loss requirements shown above. It must also have a sand equivalent value of not less than 60.

The asphalt material used for the paving mixture was required to meet TxDOT's standard specifications for AC-20.

Paving Mixture

The NOVACHIP™ contractor was required to provide the mixture design for the project. The gradation requirement for the aggregate in the mix follows:

	Percent by Weight
Retained on the 1/2" sieve	0
Retained on the 3/8" sieve	0 - 15
Retained on the No. 4 sieve	65 - 75
Retained on the No. 10 sieve	73 - 81
Retained on the No. 40 sieve	87 - 92
Retained on the No. 80 sieve	91 - 94
Retained on the No. 200 sieve	93 - 96

Specification Changes Prior to Construction

At the preconstruction conference held on October 13, 1992, it was revealed that the aggregate which was to be used for the mixture did not meet the specifications. The aggregate was out of specification on the No. 4 and No. 40 sieve and was very close to the lower end of the specification limits on other screens as shown in the following gradation:

	Percent by Weight
Retained on the 1/2" sieve	0
Retained on the 3/8" sieve	9.4
Retained on the No. 4 sieve	62.0
Retained on the No. 10 sieve	74.6
Retained on the No. 40 sieve	86.7
Retained on the No. 80 sieve	91.2
Retained on the No. 200 sieve	94.2

The sand equivalent value was measured to be 54 instead of the required 60.

Engineers from SCREG Routes stated at the meeting that it was of primary concern that the percent retained on the No. 10 be below 75 and the percent passing the No. 200 be a minimum of 5.5. SCREG Routes engineers stated that the above gradation and the sand equivalent value of 54 was acceptable for the NOVACHIP™ process.

A fundamental objective in this construction was to provide the opportunity for SCREG ROUTES to showcase the NOVACHIP™ pavement; therefore, it was the decision of TxDOT engineers that if these material properties were acceptable to SCREG ROUTES, then the specifications would be changed to reflect this. The mixture gradation specifications were changed to the following:

	Percent by Weight
Retained on the 1/2" sieve	0
Retained on the 3/8" sieve	0 - 15
Retained on the No. 4 sieve	60 - 70
Retained on the No. 10 sieve	70 - 78
Retained on the No. 40 sieve	85 - 92
Retained on the No. 80 sieve	90 - 94
Retained on the No. 200	93 - 96

These gradation limits are plotted in Figure 5. The sand equivalent specification was changed from a minimum value of 60 to a minimum value of 50.

JOB MATERIALS

US 281

The coarse aggregate for US 281 was a traprock (basalt) provided by Vulcan Materials from the plant at Knippa, Texas. Typical properties of the traprock as provided by Vulcan are shown in Table 4. This traprock is a very hard, durable, and dark-colored aggregate with a polish value of 38. The fine aggregate used on the job consisted of dry, limestone screenings from Gifford Hill. The aggregate portion of the NOVACHIP™ mix was comprised of 68 percent of the coarse traprock aggregate and 32 percent of the dry, limestone screenings.

The design asphalt content was 5.0 percent of an AC-20 grade. A liquid antistripping agent (PERMATAC) was also used at a rate of 1/2 percent by weight of the binder.

SH 46

It was decided by TxDOT engineers, material suppliers and contractors, that the existing supply and projected production rate of the traprock was insufficient to yield sufficient mix to keep up with the paving machine for SH 46. According to the rock supplier, the gradation was difficult to produce and cut production rates by 50 percent.

For SH 46, a new mixture design was developed by SCREG ROUTES engineers. The new design mixture contained 34 percent traprock, 34 percent limestone from Helotes, and 32 percent dry limestone screenings. The asphalt content was increased to 5.3 percent.

Tack Coat

As mentioned previously, the tack coat was a polymer-modified emulsion designated CRS-2p. It was to be applied at a design application rate of 0.20 gallons per square yard.

CONSTRUCTION SEQUENCE (US 281 and SH 46)

Prior to placement of the NOVACHIP™, the traffic buttons were removed from the existing pavement and the pavement surface was broomed. The NOVACHIP™ paving machine as described previously is capable of applying the tack coat and the paving mixture in one pass. A nurse truck was used to periodically fill the NOVACHIP™ emulsion tank with the CRS-2p. Trucks transported hot-mix material from the drum-mix plant which was approximately 10 miles from the US 281 job and 20 miles from SH 46. Trucks backed up to the paving machine and dumped the mix into the hopper located at the front of the NOVACHIP™ paver which augered the mixture to the back of the paver where it was placed onto the pavement. The tack coat was applied to the pavement about 2 seconds prior to placement of the mix.

Two 10-ton, steel-wheel rollers (66-inches wide and 54-inches wide) were used for a total of 4 passes. The first roller was immediately behind the paver. Traffic was allowed onto US 281 about four hours after construction and on SH 46 about 2 hours.

Traffic control on US 281 was accomplished through lane closure and on SH 46 pilot vehicles were used.

The hot-mix plant operated at a temperature of 315°F; however, SCREG ROUTES engineers would have preferred the plant to be operated at 330°F. The higher temperature improves workability of this "harsh" mixture but it was not possible to operate the plant at 330°F and stay within the air quality limits.

CONSTRUCTION NOTES - US 281

Construction of US 281 began on Thursday, October 15. US 281 is a four-lane, divided highway and the job was approximately four miles long for a total of 16 lane miles. US 281 was completed in four working days. Production rates and job yields are shown in Table 5.

The construction of US 281 went very well with only some minor problems noted. The most notable problem for the US 281 job can be attributed to the equipment. Whenever the paving machine was stopped for any length of time on the pavement, the distributor nozzles continued to leak emulsion causing excessive puddling. Sometimes the excess emulsion was washed off the pavement but often it was paved over. TxDOT engineers were concerned that this excess emulsion would eventually lead to a flushed surface in these areas. Therefore, after the second day of production, the equipment was repaired.

Another problem noted with the NOVACHIP™ process also occurs when the paver is stopped for an extended time period. Generally, there were two reasons for the paver to be stopped during the construction operation: (1) to wait for trucks supplying hot-mix or (2) to refill the emulsion tank on the paver with the tack material. In the locations where the paver was stopped for an extended period, there is a very slight hump in the NOVACHIP™ surface which is noticeable when passing over the surface at normal driving speed. When the paver stopped, it appeared that the mix in front of the screed cooled excessively causing the screed to ride up over the mix leaving a slight hump in the mat.

CONSTRUCTION NOTES - SH 46

Construction of SH 46 began in the eastbound lane on Wednesday, October 21, 1992. SH 46 is a two-lane highway, and the job was approximately 9.5 miles long for a total of 19 lane miles plus several climbing lanes dispersed throughout the length. The main travel lanes of SH 46 were constructed in six working days and another three days was devoted to construction of the climbing lanes. Production rates and job yields for the main travel lanes are shown in Table 6.

The eastbound lane of SH 46 was constructed without incident; however, problems began to develop with the mix during the construction of the westbound lane. Excessive tearing of the mat began to occur. Material appeared to be building up in front of the screed and then dragging along the pavement causing tears in the mat anywhere from 6-inches wide to 4-feet wide. This required a significant amount of handwork to repair the mat. The NOVACHIP™ mixture is 100 percent crushed material and lacks workability; therefore, it does not lend itself to handwork. This tearing in the mat occurred frequently for two days until the problem was resolved.

The problem was attributed to variability which was present in the dry screenings. There was only a half-day supply of screenings on hand throughout this period; therefore, the stockpile was changing constantly making quality control testing of the stockpile difficult.

Once this problem was discovered, SCREG ROUTES engineers redesigned the mixture replacing the dry screenings which comprised 32 percent of the aggregate portion to 22 percent dry screenings and 10 percent washed screenings. This resolved the problem and the remainder of the job was completed without difficulty.

In the numerous locations where the mat required handwork, an unattractive "blemish" remained visible on the pavement surface which was also noticeable by a slightly rougher ride in these areas. It was hoped that these "blemishes" would fade with time and traffic; however, at ten months after construction, they still remained quite evident.

COMMENTS AND OPINIONS OF ENGINEERS ON CONSTRUCTION SITE

Some of the comments which were noted by engineers visiting the construction site are listed below.

TxDOT Area Engineer: "For a pavement where I am very concerned about sealing the surface from the intrusion of water, the NOVACHIP™ pavement appears to be a good choice."

FHWA Engineer: "I am pleased with the way the NOVACHIP™ pavement looks, but the real issue is life-cycle cost. It has its place, but I'm not yet sure where -- maybe in urban areas. I would like for NOVACHIP™ to be a success in this country so that we have more paving options available to us."

FHWA Engineer: "NOVACHIP™ pavement looks very good - it's a very tough-looking mix. The NOVACHIP™ paving operation appears to be a lot quicker than a laydown machine. NOVACHIP™ may be a good alternative to microsurfacing as there is no waiting time to allow traffic on surface. This pavement surface would be good to use anywhere ride quality and frictional characteristics need improvement."

EARLY PERFORMANCE

The NOVACHIP™ pavement surfaces on US 281 and SH 46 were evaluated for performance in August of 1993 and were observed to be in excellent condition. The pavements appeared to be in essentially the same condition as immediately after construction.

RIDE QUALITY

Ride quality measurements were made on the projects prior to construction and again about three weeks after construction. These data are shown in Figures 6 and 7 for US 281. Prior to construction, US 281 had an excellent overall average ride score of 4.5. After construction of the NOVACHIP™ surface the overall average ride score was also measured to be 4.5; therefore, no additional improvement in ride quality was detected.

Ride quality data for SH 46 is shown in Figure 8. The average ride score for SH 46 prior to construction was 4.0. The NOVACHIP™ surface improved the ride score to 4.4.

FRICTIONAL CHARACTERISTICS

Skid resistance data was collected on the project using TxDOTs locked-wheel skid trailer (ASTM E274). The skid unit travels at a constant speed with the left trailer wheel locking at periodic intervals on a wetted surface. Classes of Skid Numbers are shown below:

Skid Number	Description
50 - 100	Very good
40 - 49	Good
30 - 39	Fair
20 - 29	Poor
1 - 19	Very poor

Skid resistance data were obtained from the district prior to construction of the NOVACHIP™ surfaces. These data were obtained in May of 1992. The average skid number for both US 281 and SH 46 was 31. (See

Figures 9 and 10.)

After construction of NOVACHIP™, skid data were collected again on November 17, 1992. On US 281, the skid number increased to 40 and on SH 46 the number increased to 46.

Skid data were collected again on March 17, 1993 at which time the NOVACHIP™ surface of US 281 had a skid number of 48 and SH 46 had a skid number of 53. This increase in skid resistance from soon after construction is likely due to the action of traffic and weather wearing or eroding away the asphalt binder on the aggregate surface.

SUMMARY AND GENERAL COMMENTS

NOVACHIP™ was successfully constructed on two highways in the San Antonio District of the Texas Department of Transportation: US 281 and SH 46 in Bexar County. The French process, NOVACHIP™, is a new technology for Texas and the United States and this research study was created to provide evaluation and documentation of the process and the resulting performance.

After ten months of service, the NOVACHIP™ pavement surfaces are in excellent condition. The pavements appear to be in essentially the same condition as immediately after construction. The pavements will be monitored for a period of three years and performance will be documented.

Total cost of the NOVACHIP™ pavements in this project were excessive due to the small number of jobs constructed here in the U.S. The equipment was transported to the U.S. from France to perform these jobs on a demonstration basis. The selling price of NOVACHIP™ in France is the same as micro-surfacing and just a little more than a polymer modified asphalt chip seal. In general, NOVACHIP™ appears to have promise as a preventive maintenance treatment or surface rehabilitation technique for asphalt concrete pavements. It should provide the maintenance engineer with an alternative for chip seals, micro-surfacing, plant-mix seals, or thin asphalt concrete overlays. This research study cannot provide a direct comparison of NOVACHIP™ to other maintenance treatments since no comparable test sections were constructed involving other maintenance treatments. Some of the advantages NOVACHIP™ may have over these maintenance treatments are listed below (not quantified in this study):

Advantages NOVACHIP™ May Have Over Chip Seal

1. Excellent chip retention.
2. Reshaping of existing pavement to a limited degree, e.g. rut-filling and smoothing corrugations and other minor surface irregularities.
3. Less rolling noise (not measured in this study).
4. Suitable for use on high traffic volume roads.
5. More resistant to damage caused by turning and stopping maneuvers.
6. Higher probability of success in cool, wet weather.

Advantages NOVACHIP™ May Have Over Micro-Surfacing

1. Quick reopening to traffic.
2. May have better adhesion to underlying surface due to heavy tack coat.
3. Greater surface macrotexture.
4. Better drainage -- Reduced splash and spray due to open surface texture.

Advantages NOVACHIP™ May Have Over Open-Graded Friction Courses

1. May have better adhesion to underlying surface due to heavy tack coat.
2. Better protection of underlying pavement from surface water which is often a problems with OGFCs.

Advantages NOVACHIP™ May Have Over Dense-Graded Thin Overlay

1. May have better adhesion to underlying surface due to heavy tack coat.
2. High-quality crushed materials should be more rut-resistant.
3. Greater surface macrotexture.
4. Improved surface drainage.
5. Better protection of underlying pavement from surface water.

Some preliminary conclusions regarding NOVACHIP™ as a result of construction observations and early performance data are listed below.

1. NOVACHIP™ is a high quality mixture, consisting of 100 percent crushed materials. This type of mixture ,however, does not lend itself to a significant amount of handwork and raking.
2. It is very important that the mixture be placed at 280°F or above. Due to the openness of the aggregate gradation, the mixture loses heat quickly. If the mixture gets too cool, the paver must operate at a slower-than-optimum speed. Excess mixture may also back up in front of the screed causing tears in the mat which are not as easy to repair as dense-graded hot mix. The plant temperature should be 315°F or more. Trucks which are transporting the mix should be covered with tarps, if possible.
3. NOVACHIP™ significantly increased the skid resistance of the pavement.

4. No improvement in ride quality was measured on US 281 resulting from NOVACHIP™; however, the existing pavement had a very good ride score. An improvement in ride quality on SH 46 was measured (ride score increased from 4.0 to 4.4).
5. Quality control procedures used for conventional hot-mix asphalt concrete jobs may not be acceptable for NOVACHIP™. The mixture is noticeably sensitive to changes mixture proportions. A performance-based specification regarding workmanship quality may be appropriate for this type of surfacing.

6. NOVACHIP™ provides a uniform, attractive appearance; however, the mixture lacks workability, therefore, excessive handwork and raking of the mix is very noticeable and detracts from the appearance and sometimes ride quality. No raking is required when a paving project is proceeding as it should.

REFERENCES

1. "NOVACHIP™, A New Type of Pavement Surfacing", SCREG ROUTES.

2. Serfass, J. P., Bense, P., and Samanos, J., "Performance Assessment of Ultrathin Friction Courses," Preprint of paper presented at the Transportation Research Board Meeting, Washington, D.C., January, 1993.

3. Epps, J. A., Meyer, A. H., Larrimore, I.E., Jr. and Jones, H. L., "Roadway Maintenance Evaluation User's Manual," Texas Transportation Institute Research Report 151-2, September, 1974.

Table 1. Pavement Rating Deduct Values.

Type of Distress	Degress of Distress	Extent or Amount of Distress (1)	(2)	(3) *
Rutting	Slight	0	2	5
	Moderate	5	7	10
	Severe	10	12	15
Raveling	Slight	5	8	10
	Moderate	10	12	15
	Severe	15	18	20
Flushing	Slight	5	8	10
	Moderate	10	12	15
	Severe	15	18	20
Corrugations	Slight	5	8	10
	Moderate	10	12	15
	Severe	15	18	20
Alligator Cracking	Slight	5	10	15
	Moderate	10	15	20
	Severe	15	20	25
Patching	Good	0	2	5
	Fair	5	7	10
	Poor	7	15	20

Deduct Points for Cracking

Longitudinal Cracking

	Sealed (1)	Sealed (2)	Sealed (3)	Partially Sealed (1)	Partially Sealed (2)	Partially Sealed (3)	Not Sealed * (1)	Not Sealed * (2)	Not Sealed * (3)
Slight	2	5	8	3	7	12	5	10	15
Moderate	5	8	10	7	12	15	10	15	20
Severe	8	10	15	12	15	20	15	20	25

Transverse Cracking

	Sealed (1)	Sealed (2)	Sealed (3)	Partially Sealed (1)	Partially Sealed (2)	Partially Sealed (3)	Not Sealed * (1)	Not Sealed * (2)	Not Sealed * (3)
Slight	2	5	8	3	7	10	3	7	12
Moderate	5	8	10	7	10	15	7	12	15
Severe	8	10	15	10	15	20	12	15	20

* Numbers in parentheses refer to quantity of distress observed as indicated on Figure 1.

Table 2. US 281 Preconstruction Pavement Rating Scores.

Station	Northbound Lanes Inside	Northbound Lanes Outside	Southbound Lanes Inside	Southbound Lanes Outside
730 + 00	95	85	93	90
710 + 00	95	95	95	90
690 + 00	100	92	100	92
670 + 00	95	95	95	85
640 + 00	100	95	95	85
620 + 00	100	88	100	85
600 + 00	100	85	100	92
580 + 00	100	85	100	85
560 + 00	100	88	100	85
540 + 00	100	88	100	88
526 + 85	100	88	100	88

Table 3. SH 46 Preconstruction Pavement Rating Scores.

Station	Eastbound Lane	Westbound Lane
1060 + 00	88	88
1030 + 00	88	88
1000 + 00	83	83
970 + 00	83	73
940 + 00	83	88
910 + 00	88	88
880 + 00	88	92
850 + 00	88	78
820 + 00	88	85
790 + 00	89	81
760 + 00	90	83
730 + 00	90	83
700 + 00	90	90
670 + 00	90	93
640 + 00	90	90
610 + 00	88	88
580 + 00	88	90

Table 4. Physical and Chemical Properties of Knippa, Traprock.

Physical Properties	
Specific Gravity (g/cc)	3.0
Absorption (24 hr, Water), %	0.8
L.A. Abrasion, % loss	9.0
$MgSO_4$ Soundness, % loss	< 7
Mohs Hardness	6

Chemical Analysis	
Silicon dioxide	38%
Iron oxides	14%
Aluminum oxide	12%
Titanium dioxide	4%
Calcium oxide	13%
Magnesium oxide	14%
Potassium oxide	1%
Sodium oxide	3%
Phosphorous oxide	<1%

Table 5. US 281 Job Production Rates.

Date	CRS-2p Tack Rate	Mix Produced, tons	Area Paved, yd^2	Yield, lb/yd^2
10/15/92 Th.	0.20 gsy	828.85	25,835	64.2
10/16/92 Fri.	0.18 gsy	1246.45	40,466	61.4
10/19/92 Mon.	0.16 gsy	1081.60	32,852	65.8
10/20/92 Tue.	0.18 gsy	814.40	25,646	63.5

Table 6. SH 46 Job Production Rates.

Date	CRS-2p Tack Rate	Mix Produced, tons	Area Paved, yd^2	Yield, lb/yd^2
10/21/92 Wed.	0.17 gsy	574.80	21,003	54.7
10/22/92 Th.	0.18 gsy	828.05	25,989	63.7
10/23/92 Fri.	0.18 gsy	847.05	30,215	56.1
10/26/92 Mon.	0.21 gsy	736.80	23,074	66.2
10/27/92 Tue.	0.21 gsy	486.80	15,069	64.6
10/28/92 Wed.	0.19 gsy	800.55	24,336	65.8

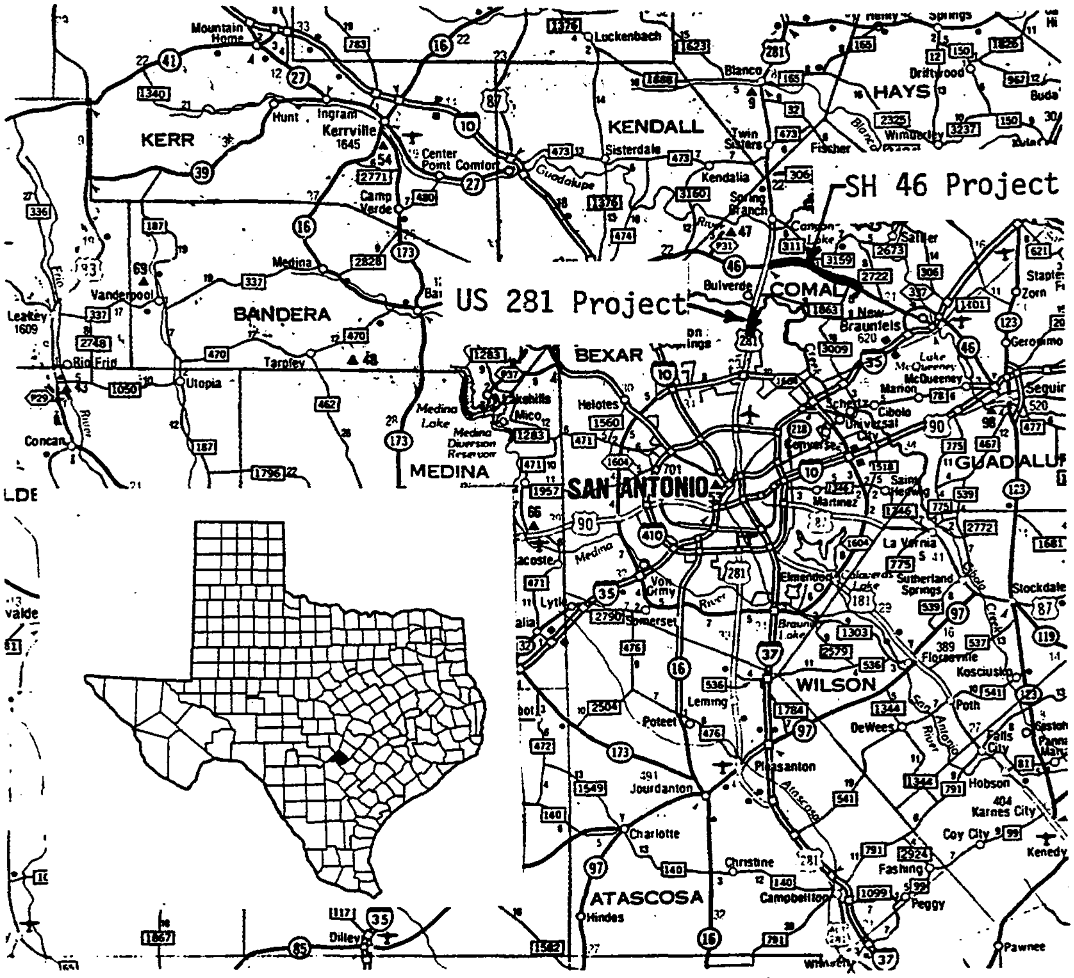


Figure 1. NOVACHIP Paving Project Locations.

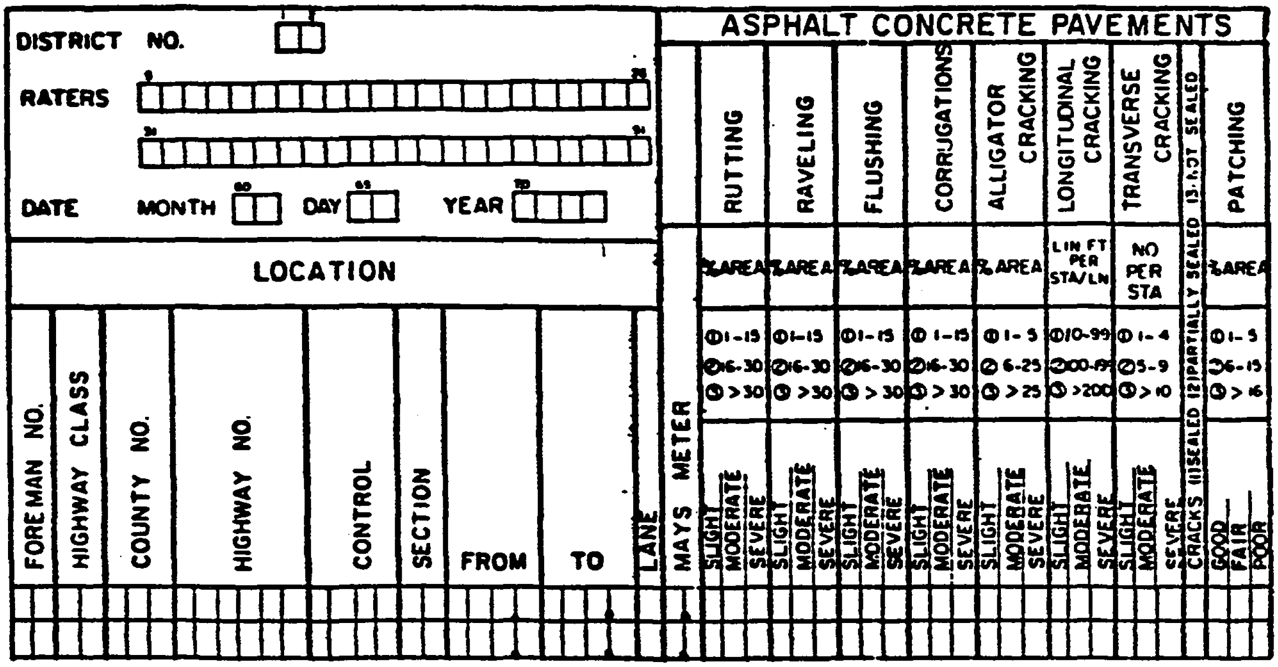

DISTRICT NO.
RATERS
DATE MONTH DAY YEAR
LOCATION
FOREMAN NO. | HIGHWAY CLASS | COUNTY NO. | HIGHWAY NO. | CONTROL | SECTION | FROM | TO | LANE
MAYS METER
ASPHALT CONCRETE PAVEMENTS
RUTTING — % AREA — ① 1-15 ② 16-30 ③ >30 — SLIGHT MODERATE SEVERE
RAVELING — % AREA — ① 1-15 ② 16-30 ③ >30 — SLIGHT MODERATE SEVERE
FLUSHING — % AREA — ① 1-15 ② 16-30 ③ >30 — SLIGHT MODERATE SEVERE
CORRUGATIONS — % AREA — ① 1-15 ② 16-30 ③ >30 — SLIGHT MODERATE SEVERE
ALLIGATOR CRACKING — % AREA — ① 1-5 ② 6-25 ③ >25 — SLIGHT MODERATE SEVERE
LONGITUDINAL CRACKING — LIN FT PER STA/LN — ① 10-99 ② 100-199 ③ >200 — SLIGHT MODERATE SEVERE
TRANSVERSE CRACKING — NO PER STA — ① 1-4 ② 5-9 ③ >10 — SLIGHT MODERATE SEVERE
CRACKS (1) SEALED (2) PARTIALLY SEALED (3) NOT SEALED
PATCHING — % AREA — ① 1-5 ② 6-15 ③ >16 — GOOD FAIR POOR

Figure 2. Pavement Rating Form.

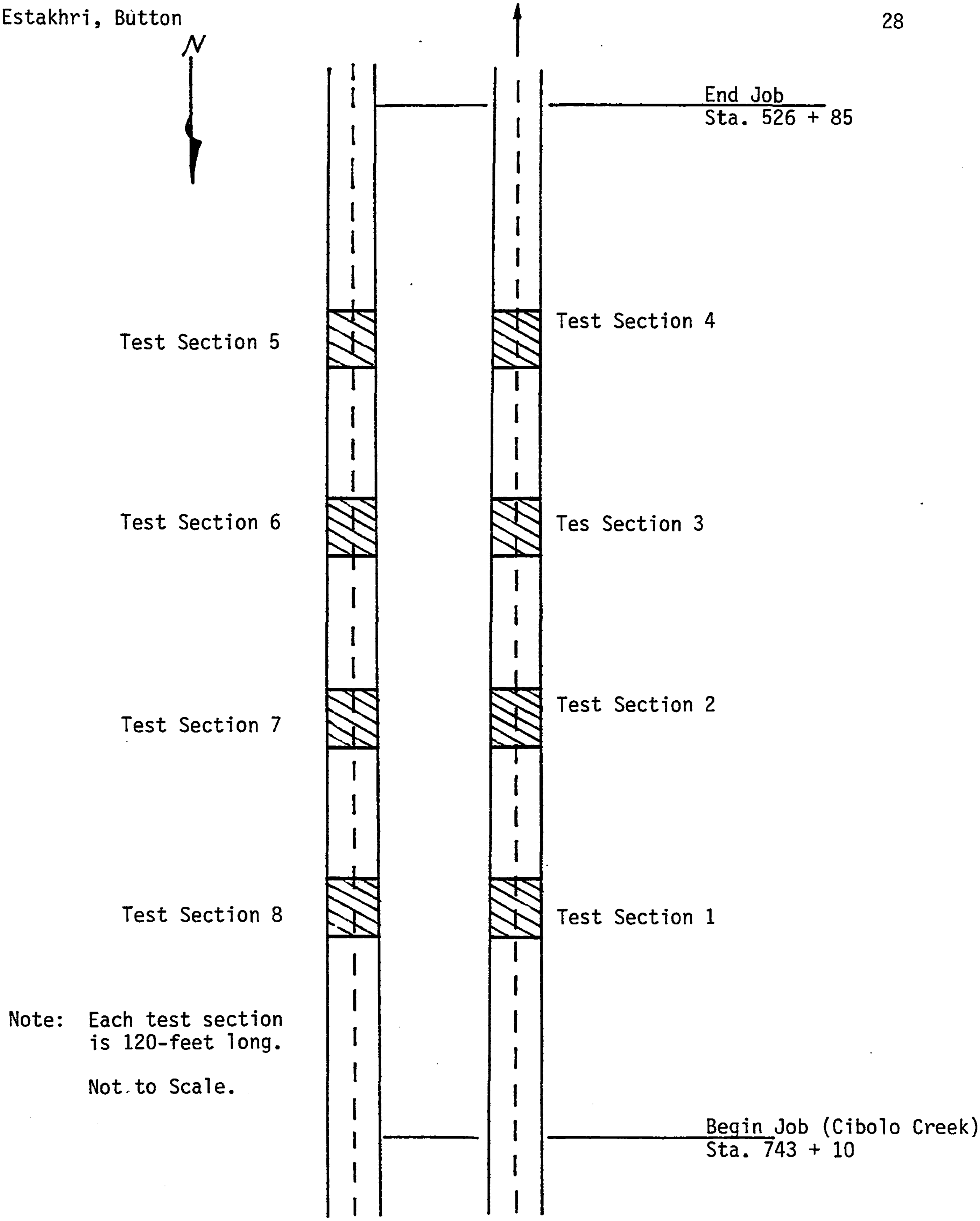
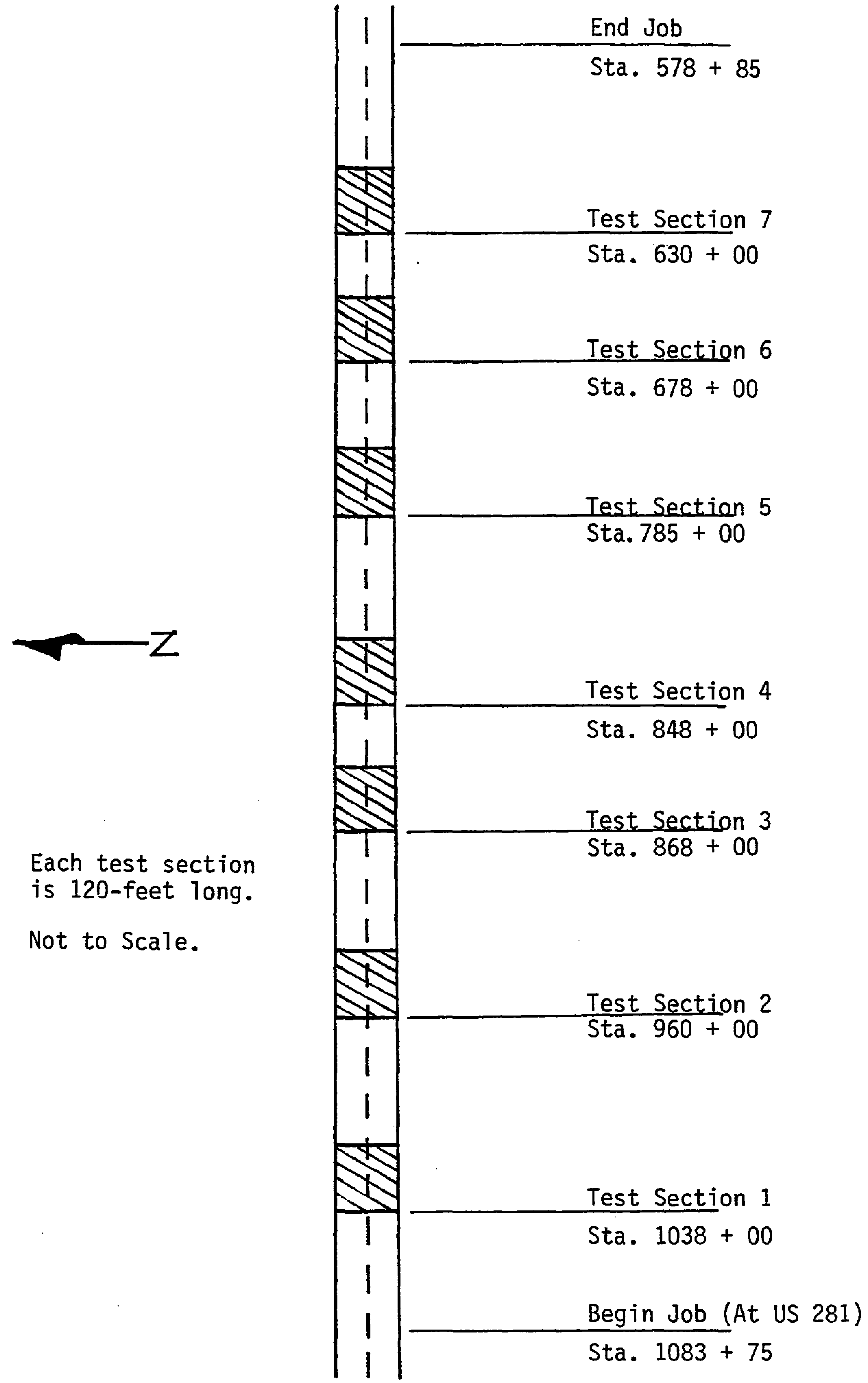


Figure 3. US 281 Test Section Layout.



Note: Each test section is 120-feet long.

Not to Scale.

Figure 4. SH 46 Test Section Layout.

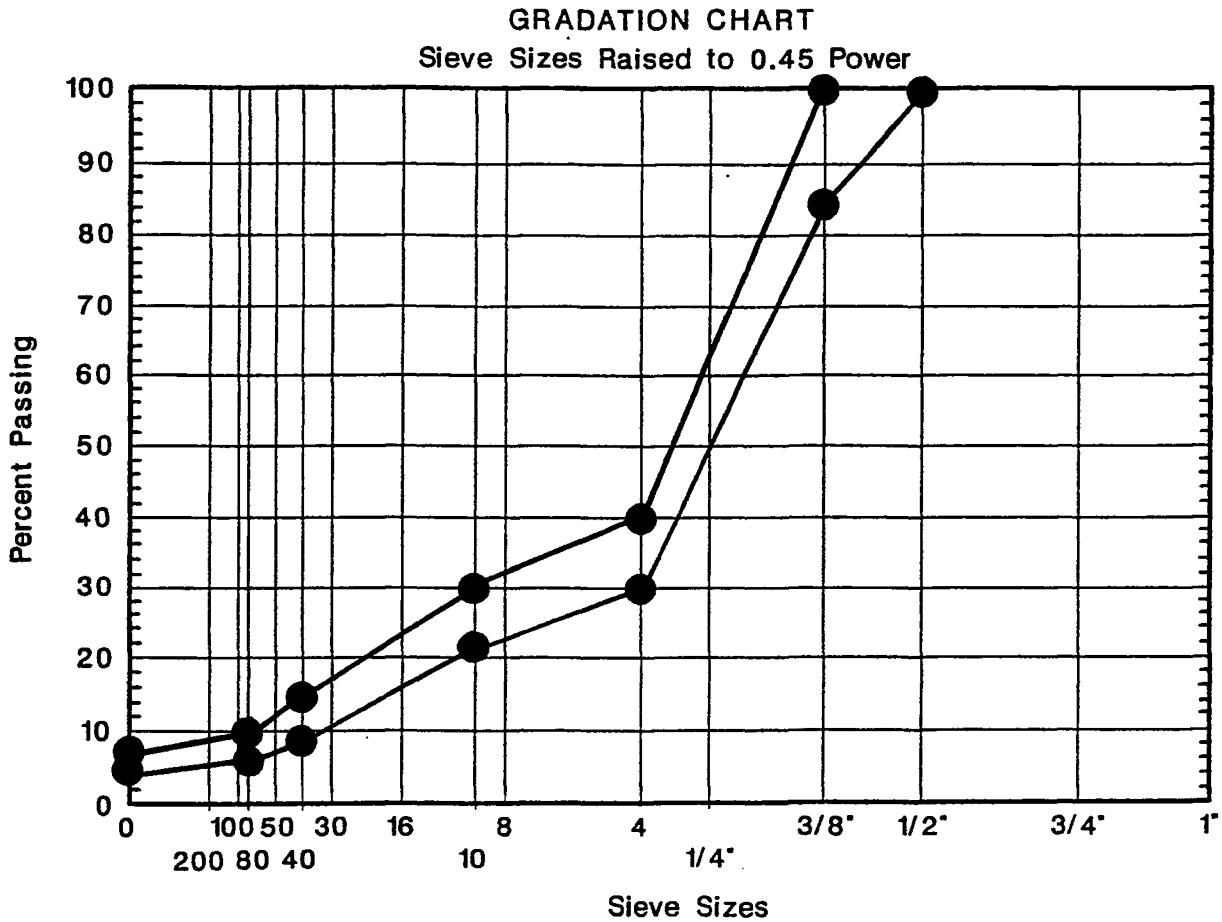
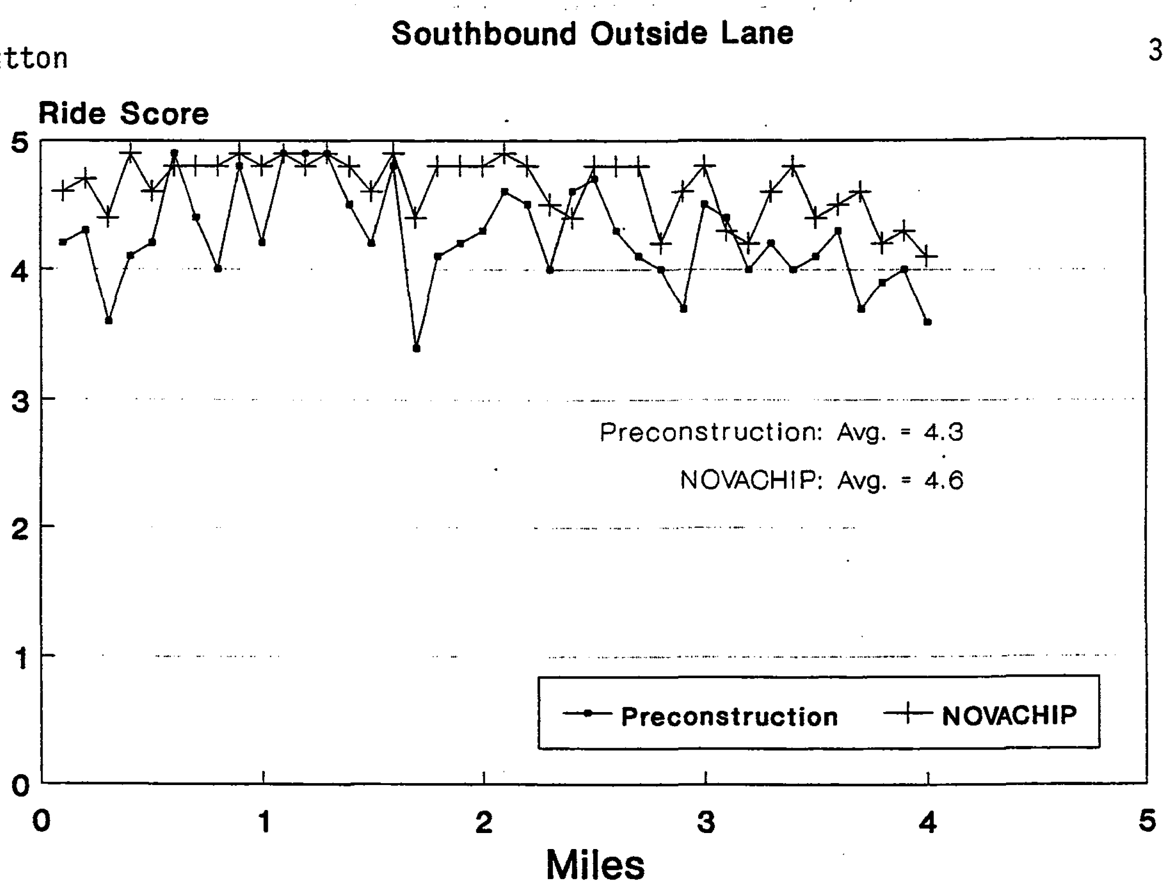


Figure 5. NOVACHIP Aggregate Gradation Job Specification Limits.



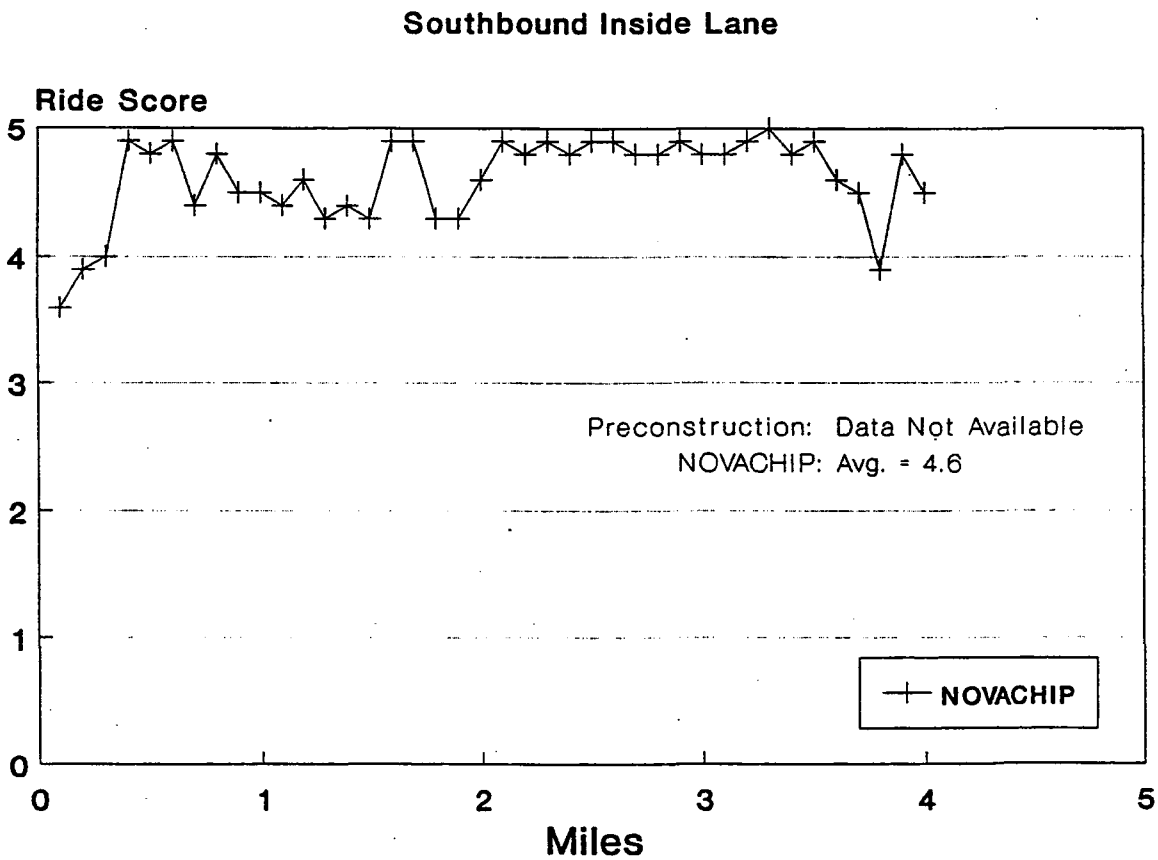
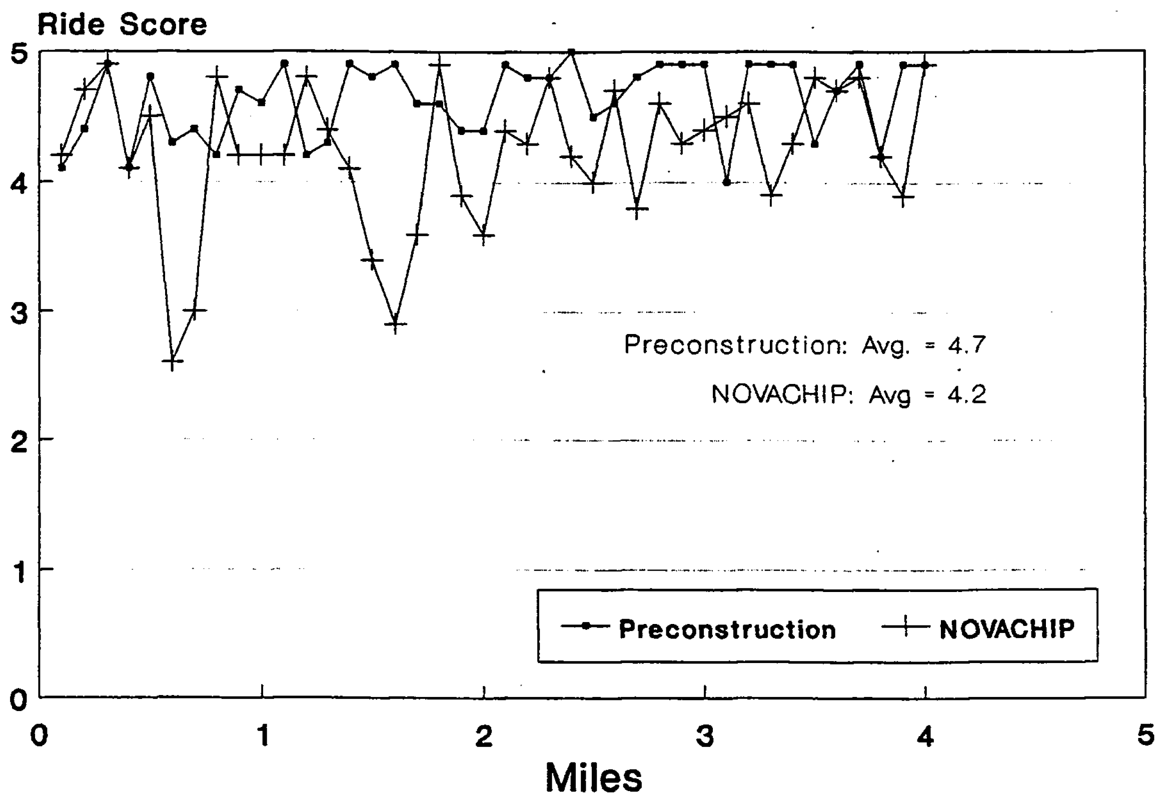


Figure 6. US 281 Ride Quality Data for the Southbound Lanes.

Northbound Outside Lane



Northbound Inside Lane

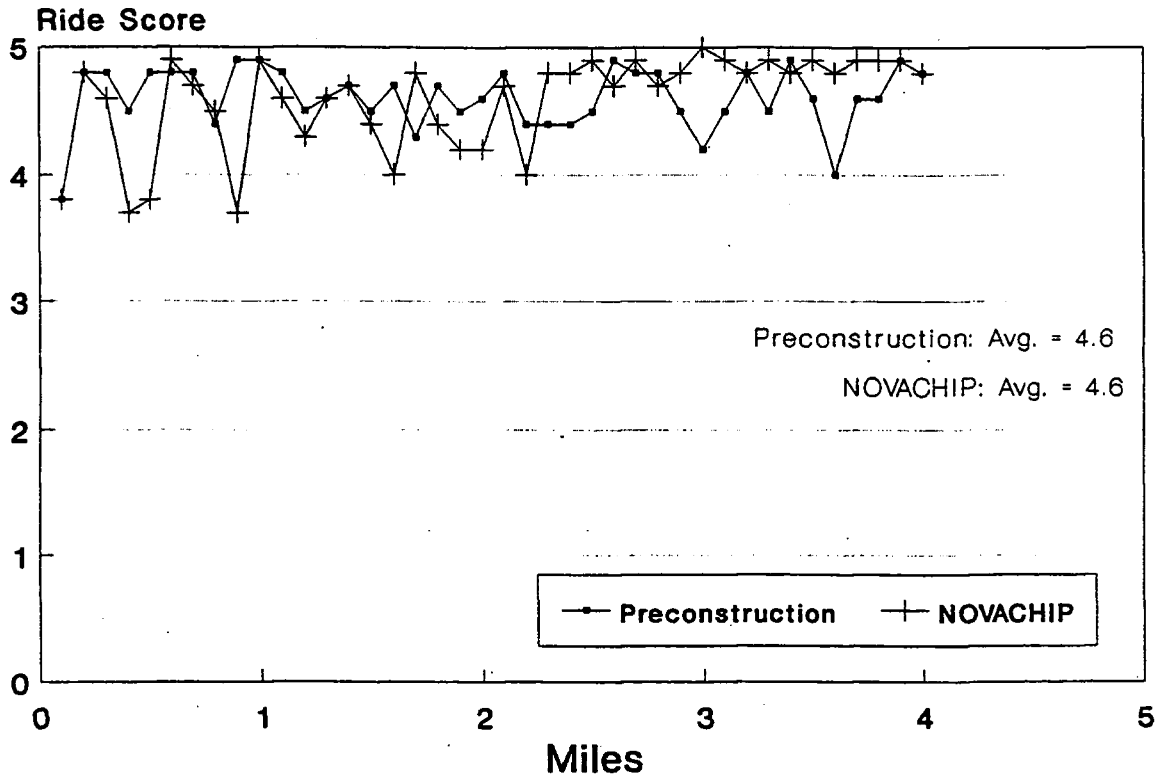
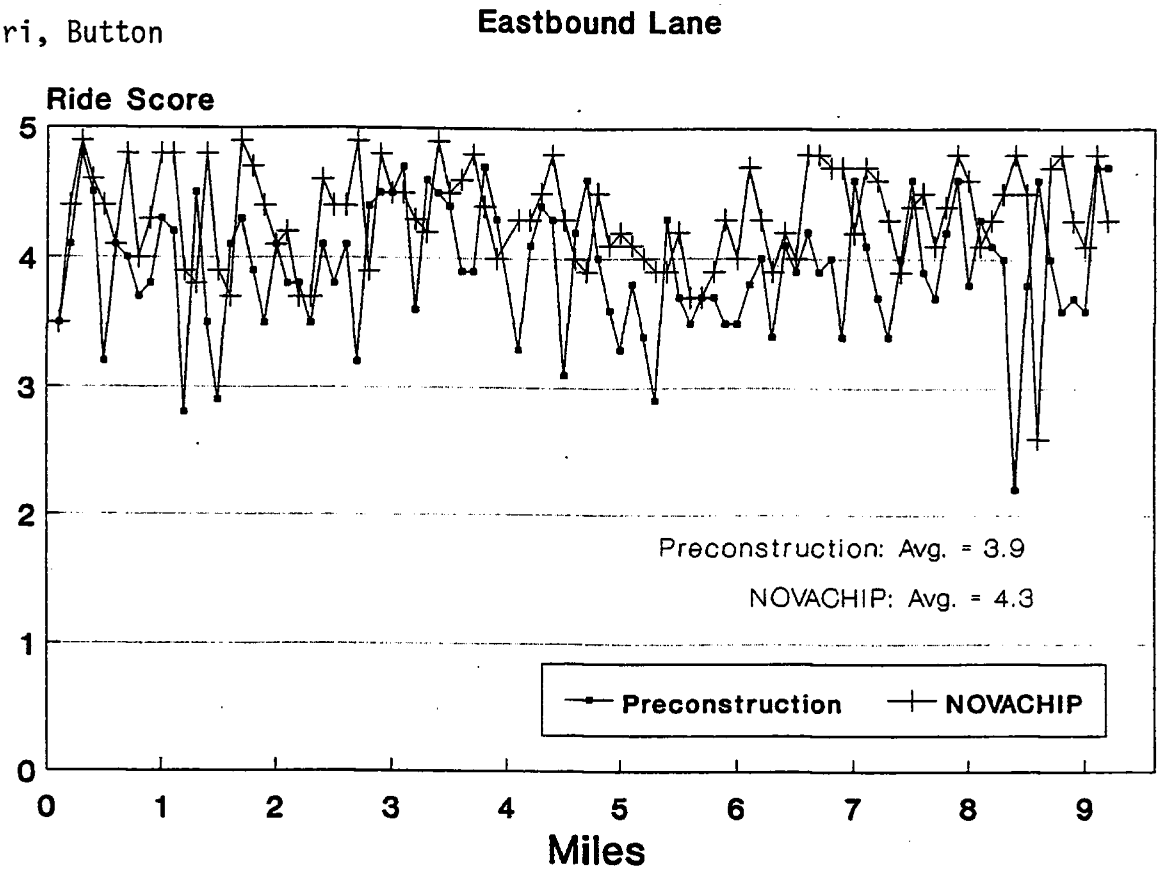


Figure 7. US 281 Ride Quality Data for the Northbound Lanes.



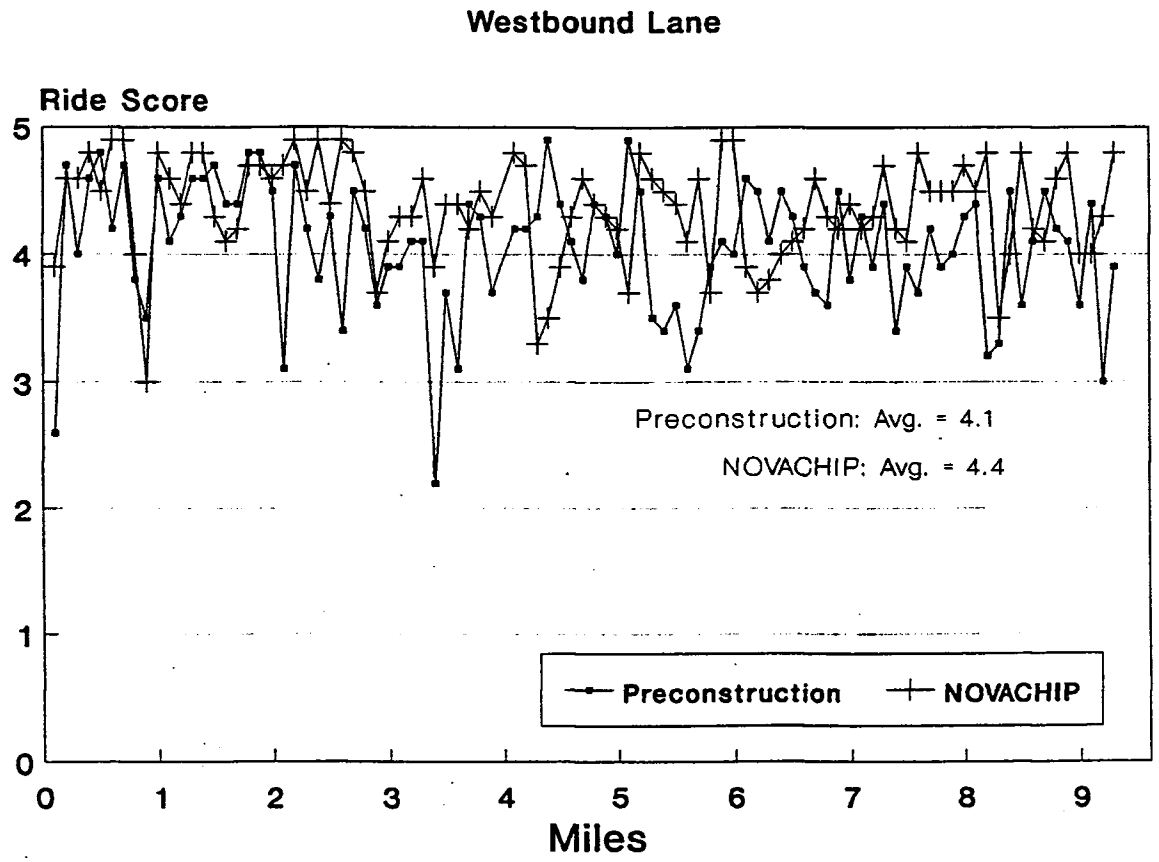


Figure 8. SH 46 Ride Quality Data.

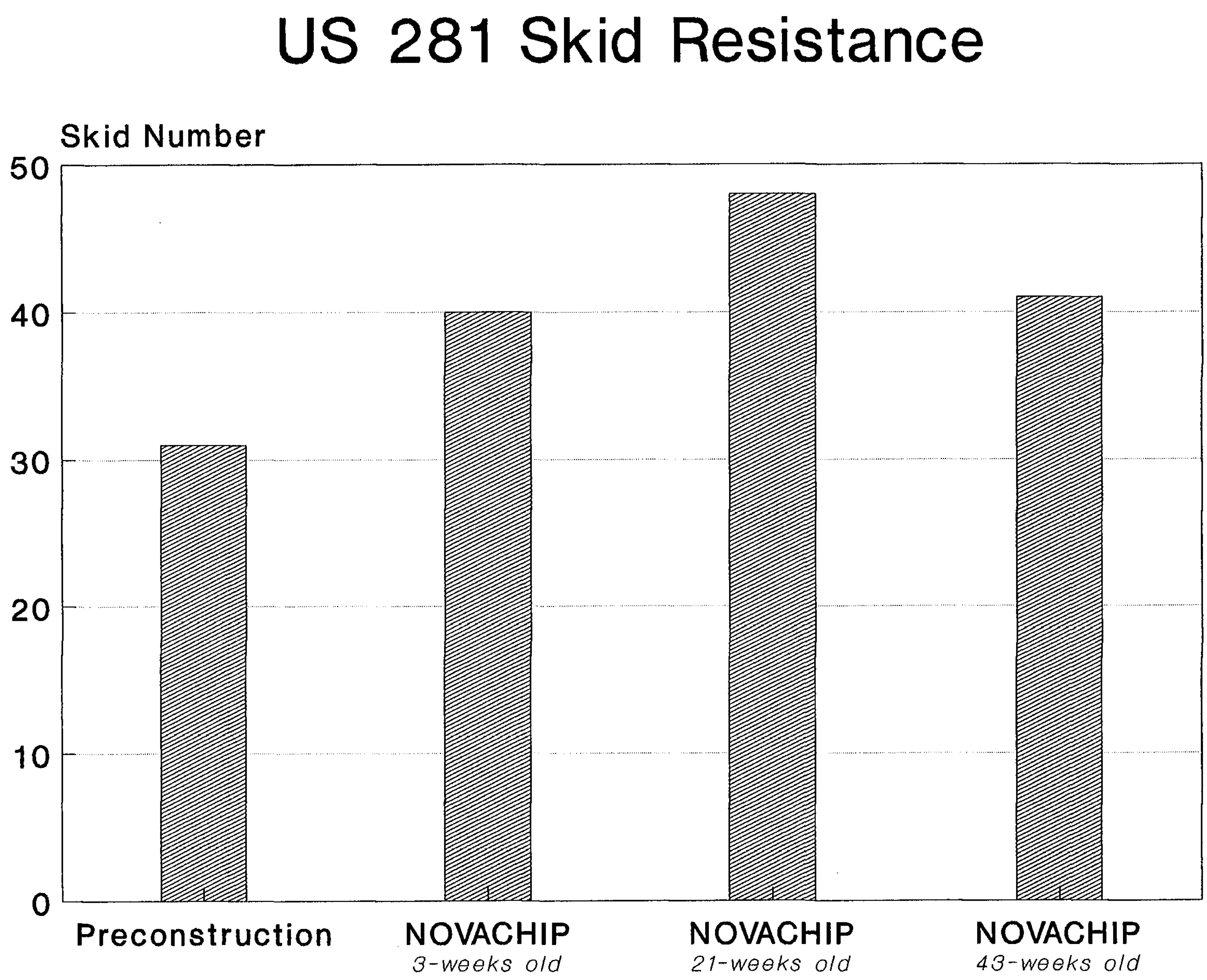


Figure 9. US 281 Skid Resistance Data.

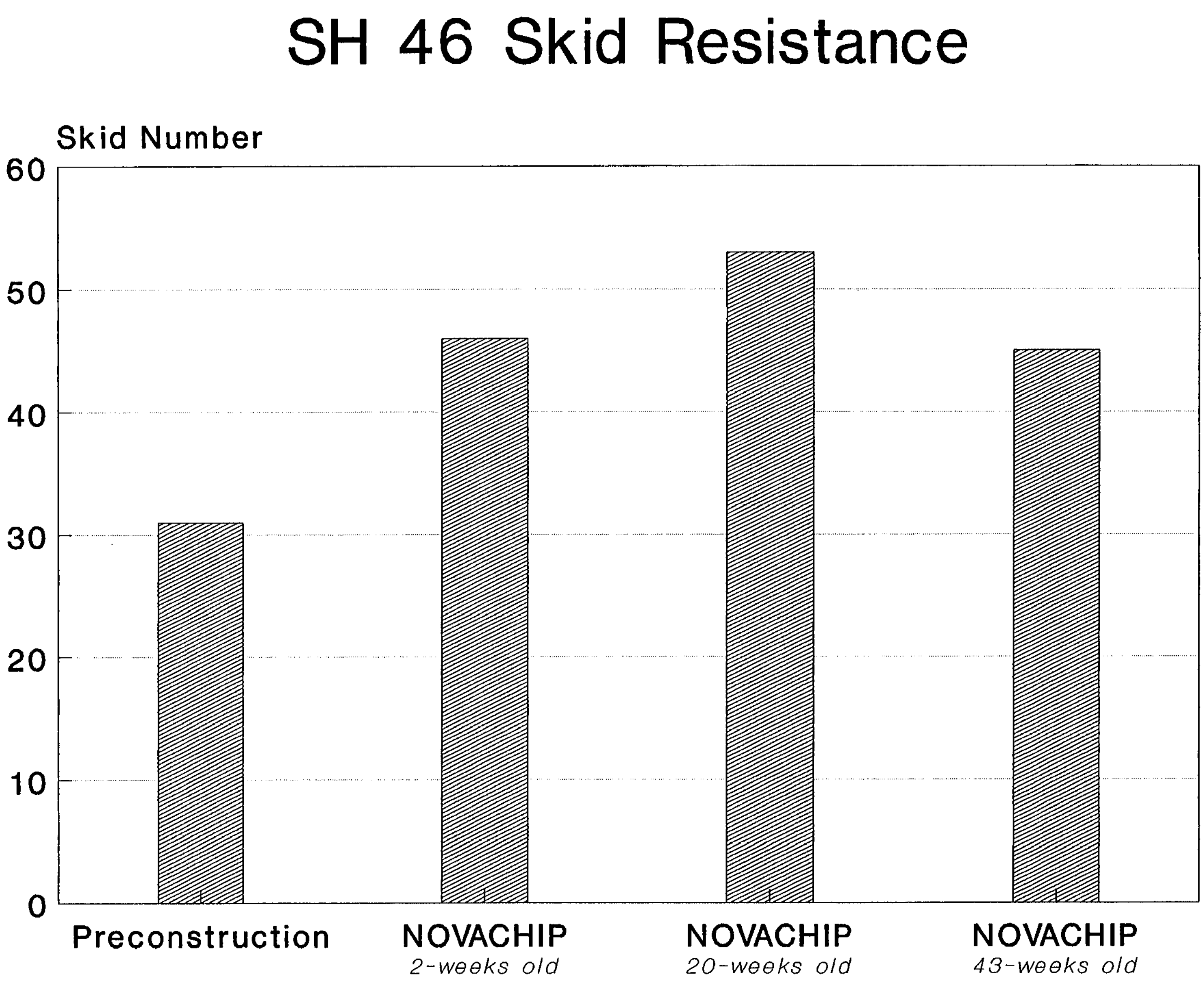


Figure 10. SH 46 Skid Resistance Data.