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ABSTRACT

The Novachip process, also known as ultrathin friction course, was developed in France in 1986. The process utilizes a single piece of equipment to place a thin, gap-graded hot mix asphalt (HMA) onto a relatively thick layer of polymer modified asphalt emulsion tack coat. Two Novachip projects were constructed in Alabama in 1992 to achieve the following objectives: (a) Document the materials and the construction procedures utilized in the construction of the Novachip surface course, and (b) monitor and evaluate the performance of the Novachip test sections at regular intervals for a period of three years.

This paper gives the construction details and performance of Novachip after 4½ years in service. Since this was the first Novachip project in the U.S. with the machine imported from France, some equipment related problems were encountered. The surface texture of Novachip is very similar to that of a typical open-graded friction course. No significant raveling was observed on the two projects after about 4½ years' service, which indicates very good bond between Novachip and underlying surface. Novachip surface has significantly higher pavement surface friction numbers compared to dense-graded HMA wearing course. It appears to be a potential alternate for chip seals, micro surfacing, and open-graded friction course.

KEY WORDS: ultrathin friction course, Novachip, construction, performance, hot mix asphalt

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INTRODUCTION

The Novachip process, also known as ultrathin friction course, was developed by SCREG Routes Group in France in 1986 and has been utilized successfully in Europe (*1*, *2*). The process was demonstrated in 1990 during a European Asphalt Study Tour undertaken by U.S. engineers (*3*). The procedure utilizes a single piece of equipment to place a thin, gap-graded HMA (hot mix asphalt) onto a relatively thick layer of polymer modified asphalt emulsion tack coat. The Novachip process appears to have promise in pavement surface rehabilitation, and in providing the maintenance engineer with a cost-effective alternative for chip seals, micro-surfacing, plant mix seals, or thin dense-graded HMA overlays. The main advantages of Novachip touted by the manufacturer are:

- excellent adhesion (no chip loss);
- reduced rolling noise (urban use);
- rapid application; and
- quick opening to traffic.

Novachip can be used as a surface seal for HMA pavements to reduce deterioration caused by weathering, raveling, traffic, and oxidation. It can seal small, “non-working” cracks and provides a wearing surface with excellent frictional resistance when proven non-polishing aggregates are used for the coated chips. 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. In addition, Novachip enlivens an aged HMA pavement surface and provides a uniform appearance. Novachip does not, however, significantly increase the structural capacity of the pavement.

A general concept for using Novachip would be to use it in place of conventional chip seal (surface treatment) when the traffic volume is too high for a chip seal or where vehicles perform turning and stopping maneuvers that may damage a chip seal. Novachip appears to be a direct competitor of micro-surfacing. In fact, the selling price of Novachip in France is about the same as micro-surfacing and just a little more than a polymer modified asphalt chip seal.

The Alabama Department of Transportation (ALDOT), along with the state highway agencies in Mississippi and Texas, is evaluating the Novachip process in the United States. Test sections were constructed in these states in the fall of 1992 using the Novachip equipment imported from France (*4*, *5*).

The National Center for Asphalt Technology (NCAT) of Auburn University monitored the construction and performance of the Novachip process in Alabama.

OBJECTIVES

This research project was undertaken to achieve the following objectives:

1. Document the materials and the construction procedures utilized in the construction of the Novachip surface course in Alabama, and
2. Monitor and evaluate the performance of the Novachip test sections at regular intervals for a period of three years.

NOVACHIP PROCESS

As mentioned earlier, the Novachip process utilizes a single piece of equipment to place a thin, gap-graded HMA onto a relatively thick layer of modified asphalt emulsion tack coat. The paving machine (as shown in Figures 1 and 2) for Novachip placement consists basically of:

1. A receiving hopper to accept the gap-graded HMA from trucks.
2. Two auger conveyors that elevate the coated chips into an insulated storage bin.
3. An insulated emulsion storage tank.
4. Delivery conveyor which delivers the coated chips from the storage bin to the screed box.
5. An emulsion spray bar for tack coat application.
6. Distribution auger and a vibratory screed to place and level the coated chips.

The following advantages are claimed in utilizing this equipment:

1. One piece of equipment making a single pass to apply the tack coat and thin HMA course.
2. In addition, this equipment includes a screed that immediately orients the aggregate particles in the HMA to a uniform position into the freshly applied tack coat. This positioning of the aggregate particles provides for a free drainage pavement, increases frictional resistance, and also decreases the tire noise that is predominant with conventional chip seals.
3. The immediate application of the HMA to the freshly applied tack coat assures good bonding characteristics of the two materials, and also reduces the common occurrence of abrasion and erosion of individual pieces of aggregate under traffic.
4. The use of this equipment and procedure provides for a cleaner job site in that it eliminates having construction equipment and other vehicles trafficking in the freshly placed tack coat, and tracking it onto adjacent surfaces.
5. An additional desirable aspect of the Novachip equipment and procedure is that the one piece of equipment used for tack coat application and placement of the HMA minimizes the areas that have to be closed to traffic during construction. Following rolling of the HMA and a short period of time for cooling and curing of the emulsion, traffic can be turned onto the Novachip surface.

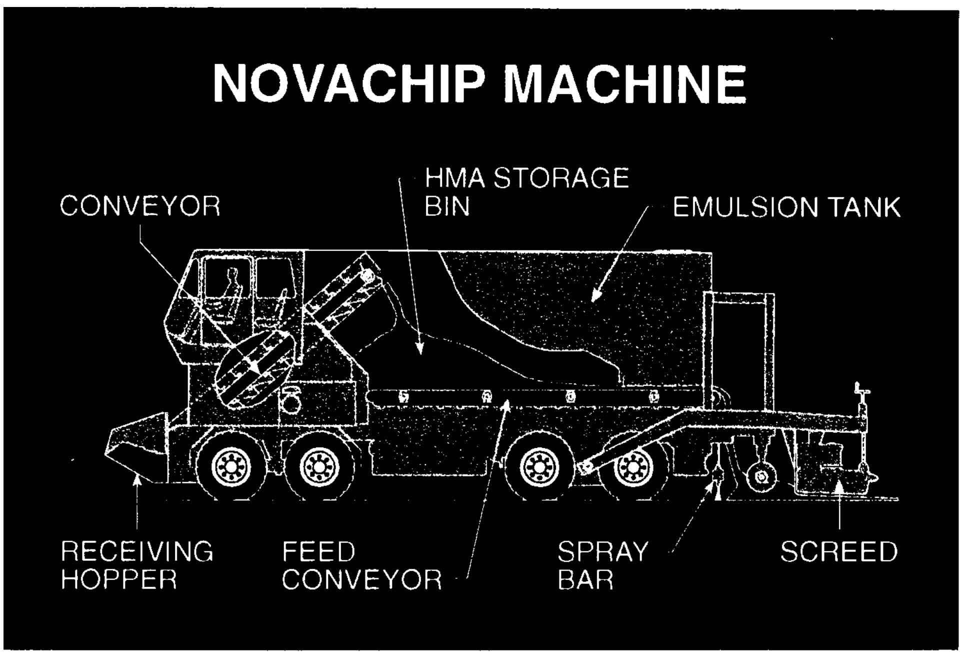

Figure 1. Schematic of Novachip Paving Machine

Figure 2. Novachip Paving Machine Used in Alabama

Project Location

Originally, only one Novachip test section was to be placed on an older, aged, weathered secondary pavement. Due to the scheduling of the arrival of the Novachip paving equipment and some contractual problems, the first Novachip test section was placed as a wearing surface on the newly overlaid pavement (binder course) of the two eastbound lanes of US 280 (AL 38) in ALDOT Division 4, Tallapoosa County. The test section was placed in October, 1992 from mile post (MP) 63.90 to 66.60 just north of the intersection between US 280 and AL 22 near Alexander City. This will be hereinafter called the Tallapoosa Project.

The second Novachip project was constructed in November 1992 on AL 21 (an existing two-lane highway) just north of the town of Talladega from MP 236 to 239 in Talladega County (ALDOT Division 4). This project will be hereinafter called the Talladega Project.

Construction Details

Tallapoosa Project
Two different aggregates were used for the gap-graded HMA (Novachip) on this project. Crushed gravel was used from MP 63.90 to MP 64.85. The mix consisted of 70% 3/8" crushed gravel, 27% sand, and 3% mineral filler.

Crushed granite aggregate was used from MP 64.85 to MP 66.60. The mix consisted of 75% 3/8" granite coarse aggregate, 20% granite screenings, and 5% mineral filler.

The gradation of the job mix formulas (JMF) for the two gap-graded HMA mixtures are given in Table 1.

Table 1. Job Mix Formula for Tallapoosa Project

Sieve (mm)	% Passing Crushed Gravel	% Passing Granite
½" (12.5 mm)	100	100
3/8" (9.5 mm)	88	95
4 (4.75 mm)	36	35
8 (2.36 mm)	28	24
16 (1.18 mm)	21	18
30 (0.6 mm)	15	12
50 (0.3 mm)	11	9
100 (0.15 mm)	8	7
200 (0.075 mm)	5.0	5.2
% Asphalt Content	4.8	5.2

An AC-20 asphalt cement was used in preparing the HMA mixtures. The specified mixing temperatures were between 143ºC (290ºF) and 168ºC (335°F). The materials were mixed and coated in a drum mixing plant operating at 90-135 Mg (100-150 tons) per hour. The HMA plant was located approximately 13 km (8 miles) from the project.

A CRS-2P SBR latex modified asphalt emulsion was used for the tack coat on both test sections. The specified application rate was 1±0.2 L/m^2 (0.22±0.05 gal. per sq. yd).

Novachip paving equipment (Figure 2) was imported from France. Primary operating personnel also came from France to demonstrate the equipment and place the test section. Figure 2 shows the receiving hopper at the left end of the machine, and tack coat spraying mechanism at the right end of the Novachip equipment.

The equipment that was used to smooth and seat the HMA into the tack coat consisted of a 9-Mg (10-ton) double drum case roller. An 11-Mg (12-ton) double-drum Hyster roller was used for smoothing or final rolling. Both mixtures were stable under the rollers. Rolling of the two sections was performed in the static mode during Novachip construction.

Novachip paving on this project was accomplished on October 1-2, 1992. The granite Novachip was placed on October 1 followed by the gravel Novachip on October 2. The ambient temperature ranged from 14 to 27°C (58 to 80°F). The machine traveled at a rate of 24-27 m (80-90 feet) per minute. Figure 3 shows a truck discharging mix into the hopper of Novachip machine. The Novachip surface after rolling appeared similar to an open-graded friction course (OGFC). Average rate of the Novachip mix used was 30 kg/m^2 (55 lbs./sq. yd). The following observations were made during the construction.

1. The emulsion spray bar, pumping, and storage system created significant problems during the test section construction. The spray bar did not have positive closure at each spray nozzle. Whenever the emulsion distribution system was shut off, the material remaining in the spray bar drained (leaked) onto the pavement, creating a large puddle of excess emulsion (Figure 4). In some locations where this situation occurred, excess emulsion was visible on the surface of the finished pavement. In addition, the system's emulsion storage tank did not have provisions for heating the emulsion. Therefore, maintaining the desired temperature of the tack coat was dependent on the Novachip paver's insulated tank's efficiency. These factors, in conjunction with the opening size of spray bar nozzles, and the equipment's speed of travel had an influence on the varying rates of tack coat application.

Figure 3. Truck Discharging Mix into Hopper

Figure 4. Tack Coat Puddles Where the Machine Stopped

2. The Novachip paving machine's receiving hopper did not mate satisfactorily to the delivery trucks' tail gates, and the auger elevators did not remove the HMA fast enough to prevent spillage of material over the hopper's sides. In the areas where this situation occurred and was not corrected, the tack coat was applied onto the spilled HMA and not onto the intended pavement surface. The absence of tack coat on the pavement's surface creates an area for possible delamination of the Novachip (HMA) and the underlying pavement.
3. The equipment's two outer screed extensions were not heated and properly adjusted, which had a tendency to pull or drag the HMA. This resulted in the outer edges of the pavement having a coarse, more open texture, and the area of the wheel path having a smoother, richer appearance.
4. The overall size and configuration of the Novachip spreading equipment required that oversized hauling and weight permits be obtained for transportation on U.S. highways.
5. A possible environmental or public concern would be the steam or vapor cloud that is created when the hot mix asphalt comes in contact with the polymer modified asphalt emulsion.
6. Communication problems between the French equipment operators, contractor, and ALDOT staff made it difficult to determine if the Novachip spreader lacked the ability to place a uniform quantity of material. Constant manipulation by the screed operator resulted in varying rates of application of the material being placed on the test sections.

Most of the preceding problems occurred because this was the first Novachip job in the United States.

No existing pavement condition survey was performed on the Tallapoosa Project because the Novachip was placed on a new binder course overlay. There is no control section in the eastbound lanes. The westbound lanes of US 280 just across from the Novachip section were constructed two months later. The conventional dense-graded wearing course (AL 416 mix) on these westbound lanes has been considered as a control section for this project. The mix in the control section contained granite aggregate.

Talladega Project

The second Novachip paving was accomplished in Talladega County on November 9-11, 1992, as mentioned earlier. The Novachip mixture was made in a batch plant. It consisted of 72% granite coarse aggregate, 22% granite screenings, and 6% aggregate lime mineral filler. The gradation of the job mix formula (JMF) for the mixture is given in Table 2. AC-20 asphalt cement was used for coating the mixture. A CRS-2P SBR latex modified asphalt emulsion was used for the tack coat material. The existing road surface was slightly raveled and had some transverse cracks which were partially sealed.

Notes from the Project Engineer reveal that the planned rate of placement was 30 kg/m^2 (55 lbs/sq. yd). However, the rates varied from 34 to 45 kg/m^2 (63 to 83 lbs/sq.yd.) averaging at 38 kg/m^2 (70.5 lbs/sq.yd). The variance was attributed to the crown or high area in the traffic lane, which caused the screed to drag the aggregate in these locations. The placement of the mix did not have leveling qualities because of the thin layer placed. Some spray bar leakage was also noted by the Project Engineer.

Observations made on December 18, 1992, revealed that there was a decided difference in the surface texture. The center of the traffic lane had an open texture whereas the wheel paths had a closed or much more dense appearance. It was difficult to determine if this was caused by the aforementioned screed drag or by the excessive tack coat in the depressions of the wheel paths.

The control section in this project consisted of conventional dense-grading wearing course (AL 416 mix) containing granite aggregate.

Table 2. Job Mix Formula for Talladega Project

Sieve (mm)	% Passing
½" (12.5 mm)	100
3/8" (9.5 mm)	99
4 (4.75 mm)	40
8 (2.36 mm)	25
16 (1.18 mm)	15
30 (0.6 mm)	13
50 (0.3 mm)	10
100 (0.15 mm)	8
200 (0.075 mm)	5.3
% Asphalt Content	5.2

PERFORMANCE EVALUATION

Both Tallapoosa and Talladega projects have been visually inspected annually since construction in 1992. The following observations were made during the last inspection on July 3, 1996, about 3-3/4 years after construction.

Tallapoosa Project

The 1996 average daily traffic (AADT) on this road is 13,044 with 10-1/2% trucks. No significant loss of Novachip or raveling has taken place in both granite and gravel test sections. This indicates very good adhesion between the Novachip and the underlying surface. As reported earlier, excessive emulsion tack coat puddles had resulted during construction from the leakage of spray bar wherever the machine stopped during paving. The excess emulsion was visible on the surface of the pavement within a year, and it was still evident after 3-3/4 years (Figure 5). This leakage problem was later rectified.

The granite section which was placed first shows moderate flushing in the wheel tracks of eastbound travel lane and slight flushing in the wheel tracks of the eastbound passing lane as shown in Figure 6. The gravel section which was placed on the following day shows slight flushing in the wheel tracks of the traffic lane and no flushing in the wheel tracks of the passing lane as shown in Figure 7. It is possible that the tack coat application rate was reduced and was just adequate for the gravel section. It appears that in future work the application rate should be maintained lower for the traffic lane compared to that for the passing lane. It was observed in both granite and gravel sections that worn aggregate was visible at the surface and was not covered by flushed asphalt binder. Therefore, frictional resistance of the flushed areas should not be adversely affected much.

Figure 8 shows a close-up of gravel Novachip surface which appears like the surface of a typical open-graded friction course (OGFC). Figure 9 shows a comparatively dense surface of the control section which used dense-graded wearing course mix (AL Designation 416) consisting of granite aggregate.

Pavement surface friction numbers were obtained by Alabama DOT annually for gravel Novachip, granite Novachip, and granite control sections. Table 3 gives the range and mean of the yearly friction numbers. The comparison of granite Novachip section with granite control

Figure 5. Tallapoosa Project - Flushing Due to Spray Bar Leakage

Figure 6. Tallapoosa Project - Granite Section Showing Moderate Flushing in Travel Lane (Left) and Slight Flushing in Passing Lane (Right)

Figure 7. Tallapoosa Project - Gravel Section Showing Slight Flushing in Travel Lane (Left) and no Flushing in Passing Lane (Right)

Figure 8. Tallapoosa Project - Closeup of Gravel Novachip Surface After 3-3/4 Years

Figure 9. Tallapoosa Project - Closeup of Dense-Graded Wearing Course Mix After 3-3/4 Years

Table 3. Pavement Surface Friction Numbers (Tallapoosa Project)

Date Measured	Novachip				Control (416 Granite Mix)	
	Travel Lane		Passing Lane		Travel Lane	Passing Lane
	Gravel	Granite	Gravel	Granite		
January 4, 1993						
Mean	48	43	43	43	48	47
Range	45-52	40-46	42-44	40-46	44-49	44-50
August 26, 1993						
Mean	42	44	50	50	44	48
Range	38-46	39-46	47-52	49-52	41-48	46-50
April 26, 1994						
Mean	42	39*	46	46	39	44
Range	38-45	35-41	46-47	44-48	37-42	41-46
May 10, 1995						
Mean	43	40	49	49	41	45
Range	40-46	37-44	47-50	47-51	37-43	44-47

*Bleeding spots had lower friction numbers (mean = 31) section indicates that the Novachip surface has generally higher friction number than the control section in the passing lane, and about equal friction number in the travel lane, although the Novachip surface has some flushing in the wheel tracks. Therefore, a properly designed Novachip surface should exhibit significantly higher friction numbers compared to a dense-graded HMA surface, both using the same aggregate.

Talladega Project

The 1996 average daily traffic (AADT) on this road is 7,534 with 11-1/2% trucks. This project also does not show any loss of Novachip or raveling after about 3-3/4 years' service. Some transverse cracks have reflected through the Novachip surface. The puddles of excessive tack coat are minimal on this project compared to Tallapoosa project. After the Tallapoosa project, the machine had been to Mississippi and Texas before this project was started. Obviously, the tack coat spray bar was repaired. This project does show some excessive tack coat bleed through the Novachip mix in wheel tracks and scattered areas at some places. This two-lane highway has a high crown and uneven surface. It appears that tack coat puddles in the wheel tracks and scattered depressions have caused the flushing problem. Obviously, Novachip cannot effectively remove large surface irregularities. It is also possible that the existing surface was non-uniform in surface texture and, therefore, absorbed the emulsion tack coat to different degrees. However, the Novachip surface is reasonably uniform and generally acceptable on this project (Figure 10). Even in scattered flushed areas, the worn granite aggregate is visible at the surface and, therefore, slight flushing should not adversely affect the surface affect the surface friction. The surface appears much more uniform after 3-3/4 years' service compared to the surface just after construction.

Table 4 gives the pavement surface friction numbers for this project. After about 2-1/2 years Novachip surface has significantly higher friction numbers compared to dense-graded ALDOT 416 mix.

Figure 10. Talladega Project - General Uniform Appearance of Novachip Surface

Table 4. Pavement Surface Friction Numbers (Talladega Project)

Date Measured		Northbound Lane		Southbound Lane	
		Novachip	Control (416)	Novachip	Control (416)
April 26, 1994					
	Mean	42	40	44	40
	Range	41-45	37-43	42-45	39-43
May 10, 1995					
	Mean	50	41	48	41
	Range	47-52	38-46	47-49	38-44

CONCLUSIONS

The following conclusions can be drawn from this study:

1. Spotty flushing of emulsion tack coat through the Novachip mix was caused from equipment related problems. The nozzles in the spray bar did not have a positive shut off and leaked when the machine stopped.
2. The amount of tack coat should be lower in a travel lane as compared to a passing lane to minimize flushing in the wheel tracks of the travel lane.
3. The surface texture of Novachip is very similar to that of a typical open-graded friction course.
4. No significant raveling was observed on these two projects after about 3-3/4 years, which indicates very good bond between Novachip and underlying surface.
5. Novachip surface had significantly higher pavement surface friction numbers compared to dense-graded HMA wearing course on the Talladega project. Novachip's friction numbers were about the same as the dense-graded HMA wearing course on the Tallapoosa project in the travel lane which experienced some flushing in the Novachip section.
6. Novachip appears suitable for high traffic roads based on its performance on the Tallapoosa project (ADT = 13,044; 10.5% trucks). It is a potential alternate for chip seals, micro surfacing, and open-graded friction courses.

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