Chip Sealing in New Brunswick

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As an economic alternative to asphaltic concretes, the New Brunswick Department of Transportation has been placing surface treatments and chip seals on its highway system for more than 45 years. Surface treatments placed over granular or soil-stabilized bases on low-traffic-density roads have provided excellent dust-free riding surfaces for the province's rural population; chip seals, considered only for maintenance functions, have been successfully employed to extend pavement life, rejuvenate oxidized surfaces, seal cracks, and improve surface friction. A variety of cover aggregates from more than 100 sources as well as many grades of liquid asphalt are used to construct seal coats in New Brunswick. The particular combination of materials ultimately decided on for any seal project is dictated by field conditions and the type of riding surface required. The construction procedures and materials used by the department today for constructing this type of surface have evolved over nearly one-half century of trial and error. Some of that history is related in this paper, and present-day applications of surface treatments and reseals in the region are discussed.

This is not meant to be a technical paper but a brief outline and description of the practical applications of the chip seal and surface treatment processes in New Brunswick.

The province of New Brunswick is located on the East Coast of Canada adjacent to the state of Maine. New Brunswick has an area of 27,750 mi^2, approximately that of West Virginia, and a population of 750,000 people, 50 percent of whom live in rural areas.

As early as the 1930s government officials realized that, to provide a dust-free, relatively smooth, secondary road system for the widely dispersed rural population, a method that was more economical than placing expensive asphaltic concrete had to be developed. In 1939 this realization resulted in the New Brunswick Department of Transportation embarking on its first surface treatment program. This program consisted of contracting out 20 mi of provincial highway for surface treatment. That meager beginning has grown to the stage where the province now has a surface-treated road inventory of approximately 5,000 mi.

In 1957 senior management, thinking that it would be more economical and that better control could be exercised over the program, opted to field their own seal crews instead of contracting this work. This result of this decision was the establishment of five divisional crews, each responsible for carrying out the work in 3 of New Brunswick's 15 counties. That organizational format is still in existence today.

A typical crew consists of approximately 27 employees and the following equipment.

New Brunswick Department of Transportation, P.O. Box 6000, Fredericton, New Brunswick E3B 5H1, Canada.

- One tank car heater,
- One power broom,
- One service truck,
- Six tandem gravel trucks,
- Two asphalt pressure distributors,
- One self-propelled aggregate spreader,
- One pneumatic-tired roller,
- One rubber-coated steel drum vibratory roller,
- One mobile field office,
- One dining trailer,
- One 20-man lodging trailer,
- Two equipment floats, and
- One minibus.

The province's chip seals and surface treatments are placed almost entirely by its five highly mobile crews.

No public tenders have been called by the department to place these types of surfaces since 1974, although contractors have been hired occasionally on a rental basis to assist in completing the programs when the work load has been too great for departmental crews.

The New Brunswick Department of Transportation has jurisdiction over a 10,600-mi highway network, 4,550 mi of which are chip sealed. (This term is used colloquially to describe two entirely different processes that will be defined later in this paper.) The following table gives a more detailed breakdown of the department's highway inventory.

Type	*Miles*
Dirt or gravel road	3,700
Asphaltic concrete highways	2,350
Chip-sealed highways	4,550
Total	10,600

Although cover aggregate gradations have varied, new asphalt binders have been developed, and equipment has become much more sophisticated, the basic principles of constructing surface treatments and chip seals have remained essentially the same, and so has their greatest adversary—the weather.

Because of climatic conditions, it has been found necessary to establish September 15 as the date when the placement of all seal coats in the province is to cease. Experience has shown that seals placed after this date run a high risk of failing. Even with the asphalt binders available today, chip seals and surface treatments cannot be placed with any degree of confidence after the established cutoff date.

Experience has proven that to construct economical and durable chip seals and surface treatments three factors must be considered:

- Materials,

TABLE 1 COVER AGGREGATE SPECIFICATIONS

U.S. Standard Sieve Series	Percentage (by weight passing) of Cover Material				
	3/8 in.	1/2 in.	5/8 in. (A)	5/8 in. (B)	3/4 in.
3/4 in.	–	–	–	–	100
5/8 in.	–	–	100	100	–
1/2 in.	–	100	0–90	0–95	40–80
3/8 in.	100	40–90	0–60	0–80	20–62
No. 4	0–5	0–20	0–20	0–50	0–20
No. 8	–	0–8	0–8	0–45	0–10
No. 200	0–2	0–3	0–3	0–5	0–3

- Design, and
- Construction.

Each of these topics will be addressed individually.

MATERIALS

In New Brunswick a wide variety of cover aggregates from more than 100 different sources is used. Aggregates range from a basically single-sized 3/8-in. crushed quarried rock to a 3/4-in. crushed bank gravel that contains as much as 50 percent fines passing the No. 4 sieve; however, use of very sandy cover material is the exception rather than the rule and is limited to New Brunswick's Northeast where quality aggregate is nonexistent. Sources in that area contain very little crushable material so reducing the sand fraction of cover aggregates to 20 percent or less would mean wasting large quantities of sand and accelerating pit depletion.

By calling contracts for the supply of cover aggregates, the department maintains a province-wide inventory valued at $2 million. This inventory is supplemented by purchasing some material from approved commercial sources.

All cover aggregates must meet the department's specified grading limits (Table 1) and have a Los Angeles abrasion loss of less than 30 percent; however, consideration is being given to accepting aggregates with a higher abrasion loss for roads that have very low traffic volumes.

Members of a quality control field staff, equipped with mobile testing laboratories, are assigned to every crushing job. These inspectors exercise stringent control over aggregate producers to ensure that all materials fall within specification.

Various grades of emulsified and cutback asphalt binders are also used in New Brunswick. In general, emulsions are used for high-traffic-volume roads and cutbacks for roads with low traffic densities. One exception would be the use of high-float emulsions with sandy aggregates on roads with a traffic count of less than 500 vehicles per day (vpd).

A typical construction season, lasting four months (May 15–September 15), would see 7 million U.S. gallons of asphalt binder sprayed. Approximately 50 percent of that total would be cutbacks although the department intends to use more emulsion products in the future because of increasing traffic volumes and the impact cutbacks have on the environment.

Table 2 gives the amount of asphalt binder used in New Brunswick's seal coat programs for the seasons of 1981–1984. Table 3 gives the various types of liquid asphalt binder most commonly employed in New Brunswick and their principal uses.

In 1985, 3.5 million U.S. gallons of PMC-3 were used. This was by far the largest quantity of any single type of binder used that year. For that reason and because this binder is peculiar to New Brunswick, its particular specifications are set out in Table 4.

Departmental specifications covering the manufacture and delivery of asphalt binders allow the placement of quality control technicians at the manufacturer's plant or refinery to monitor testing of materials slated for delivery to the chip seal crews. In addition, random field samples are taken and tested in the department's regional laboratories as a cross-check.

TABLE 2 ASPHALT CONSUMPTION 1981 THROUGH 1984, INCLUSIVE

Year	Asphalt Usage (U.S. gal)		
	Cutback	Emulsion	Total
1984	2,932,781	3,149,782	6,082,563
1983	2,793,728	3,420,048	6,213,776
1982	2,813,293	4,788,209	7,601,502
1981	3,082,581	2,707,548	5,790,083

DESIGN

When chip seals are considered by the New Brunswick Department of Transportation for high-traffic-volume collector and arterial highways as an alternative to recapping with an asphaltic concrete seal mix, an aggregate average least dimension design is used to determine asphalt and cover aggregate application rates. This method was developed in New Zealand and introduced to New Brunswick in the early 1960s by Norman W. McLeod, a highly respected authority in asphalt circles around the world *(1)*.

Average least dimension design has been adopted by numerous highway boards and agencies in North America to help take the guesswork out of constructing chip seals and surface treatments. This method of design is also recognized by the Asphalt Institute as an acceptable practice *(2)*.

The department's central laboratory, located in Fredericton, the capital city, compiles information on the characteristics of cover aggregates and asphalt binders, such as

TABLE 3 ASPHALT TYPES AND USES

Type of Construction and Conditions	Type of Asphalt					
	Cutbacks		Emulsions			
	N.B. Prime	PMC-3	RS2K	HF100s	HF150s	HF250s
Chip seal		X	X	X	X	X
Surface treatment		X			X	X
Prime	X					
Over open-graded aggregate	X					X
Over dense-graded aggregate		X			X	X
Over soil stabilization		X				
With sandy cover aggregate					X	X
With clean cover aggregate		X	X	X		
Low traffic volumes[a]		X			X	X
Moderate traffic volumes[b]		X		X	X	
High traffic volumes[c]			X			

[a]Fewer than 500 vpd.
[b]500 to 2,000 vpd.
[c]More than 2,000 vpd.

- Average least dimension,
- Aggregate bulk specific gravity,
- Loose unit weight, and
- Residual asphalt of binder.

Field crew technicians armed with this information plus the traffic count and surface condition of projects to be chip sealed can calculate quite accurate application rates of cover aggregate and asphalt binder.

A vast majority of chip seals placed in New Brunswick are on rural roads that have traffic volumes of less than 500 vpd. A formal design procedure for these roads has been found unnecessary; relying on experienced field technicians to establish application rates for binder and aggregate has produced excellent results.

CONSTRUCTION

Even though a great deal of consideration may be given to materials and design, acceptable chip seals and surface treatments can only be achieved by employing proven construction techniques, skilled workmen, and reliable equipment.

Before getting too deeply into construction practices, the terms used for the two basic types of seals placed on New Brunswick highways, surface treatments and chip seals, should be defined.

A surface treatment can be defined as the uniform application of an asphalt binder to a prepared gravel, crushed-stone, or soil-stabilized base followed by a uniform application of cover aggregate and compaction.

A chip seal is the uniform application of an asphalt binder to an existing paved surface followed by a uniform application of cover aggregate and compaction.

Typically, a road designated to be surface treated is first upgraded or constructed in accordance with departmental standards. In most cases a 6-in. layer of 1¼-in. crushed gravel or rock is placed as a top course. The top course is then shaped and compacted before the initial application of asphalt binder. The binder is applied at a predetermined rate (usually between 0.45 and 0.60 U.S. gallons per square yard) by a pressure asphalt distributor. Cover aggregate (usually ¾ in.) is then applied with a self-propelled aggregate spreader. The layer is then compacted. If rain is not threatening and the traffic volume

TABLE 4 SPECIFICATIONS FOR PMC-3 LIQUID ASPHALT, 1986

Characteristics	ASTM	Min	Max
Flash point (Cleveland open cup) (°F)	D 92-78	100	–
Viscosity (kinematic at 140°F)	D 3170-83	550	750
Distillation test	D 402-82		
Percentage of total distillate to 680°F			
At 374°F			30
At 437°F		25	50
At 500°F		40	68
At 600°F		70	
Distillation residue (% by volume)		78	
Penetration at 77°F	D 5-83	90	160
Ductility at 77°F	D 113-85	100	
Solubility in trichloroethylene	D 2042-81	99.5	
Water (%)	D 95-83		0.2
Pumping temperature (°F)		165	250
Spraying temperature (°F)		225	250

TABLE 5 COST DATA FOR 1985

Type of Work	Lane Miles Completed	Average Cost per Lane Mile ($ U.S.)	Average Cost per Square Yard ($ U.S.)
Reseal	804.4	4,780.00	0.68
Second seal	313.3	5,037.00	0.72
Surface treatment	444.2	10,495.00	1.49
Leveling ahead of reseals	804.4	3,110.00	0.44

is low, this type of surface is immediately opened to the motoring public.

In the case of multicoat surface treatments, which are usually the case in New Brunswick, best results are achieved when the first layer is given a week or more to cure and any imperfections are corrected before the next coat is applied.

A variation of this type of treatment is to spray the top course with N.B. primer, a penetration primer similar to R.C. 30, then compact with a steel-wheeled roller and allow a minimum of 72 hr curing time before applying a conventional surface treatment.

This type of application is not as common as it once was in the province for a number of reasons:

1. N.B. primer contains 50 percent naptha gas and in times of energy conservation fuel can be put to much better use.
2. Environmentalists frown on the naptha gas being allowed to evaporate off into the atmosphere.
3. Motorists will not tolerate the inconvenience of driving over such a surface while it cures when an alternate route is unavailable.

All surface treatments receive a chip seal the year after construction and this layer is termed "second seal" by local work crews. In essence, a surface treatment consists of three coats: a prime and seal or double seal the first year and a single application the second year.

A chip seal application is considered by the department to be a maintenance function and is intended to be applied to existing surface-treated roads every 5 years; however, budget restraints and rising costs have caused the resealing cycle to be extended to 10 or 11 years.

Before a chip seal is begun, it is most critical that the surface to be sealed is well patched and leveled with premix, for a chip seal application adds little or no strength and does not change surface contours. Chip seals do, however, extend pavement life, rejuvenate oxidized surfaces, seal cracks, and improve surface friction.

After the surface repairs are completed, the area to be sealed is thoroughly cleaned with a power broom to enhance the bond between the old surface and the new seal. The chosen asphalt binder is then applied to the surface at a predetermined rate. Cover aggregate is then placed with a self-propelled aggregate spreader. It has been observed that spreader hoppers equipped with aggregate placement screens improve embedment of graded aggregates. The mat is then compacted with a pneumatic-tired roller and a rubber-coated, steel drum, vibratory roller. On low-traffic-volume roads, the surface is opened to traffic immediately; however, on high-speed collector and arterial highways, traffic control is essential. It may even be necessary to convoy or reroute traffic for a few hours while these newly placed chip seals are in their most tender condition.

COST

In addition to the chip sealing and surface treatment of the highway network, New Brunswick transportation officials have found chip-sealed surfaces an economical alternative to hot-mix paving of parking lots, rural subdivisions, and shoulders on arterial highways. Table 5 gives the average cost incurred by the province for the various seal coat functions during the 1985 season.

The fastest escalating cost by far is that of preparing old surfaces for chip seal. This cost is directly attributable to the extended period a surface treatment is asked to perform without a reseal, from the recommended 5 years to the present 10 to 11 years.

OBSERVATIONS AND CONCLUSIONS

It has been observed that, when careful consideration is given to materials, design, and construction of chip seals and surface treatments, quality road surfaces will result 98 percent of the time in New Brunswick.

If chip-sealed surfaces, the subject of this paper, where not used in New Brunswick, undoubtedly many residents who now enjoy dust-free roadways would, for economic reasons, still live and drive on dirt and gravel roads.

One important aspect of chip seals and surface treatments must be understood: Seals in themselves have little or no strength and contribute very little to the bearing capacity of highways. This type of surface is only as good as the base on which it is placed.

REFERENCES

1. N. W. McLeod. Basic Principles for the Design and Construction of Seal Coats and Surface Treatments with Cutback Asphalts. *Proc., Association of Asphalt Paving Technologists,* supp. to Vol. 29, 1960.
2. *Asphalt Surface Treatments and Asphalt Penetration McAdam.* FS-13. The Asphalt Institute, College Park, Md., 1979.

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