Seal Coats in Manitoba

F. YOUNG, A. ROBINSON, AND B. ROWLEY

Pavement seal coats of asphalt and aggregate have been used in Manitoba, Canada, for many years. They are employed as both a dust-free surface on low-volume roads and a wearing surface on pavement. In the latter application, the subject of this paper, seal coats are applied to seal out moisture, provide a lighter colored surface for nighttime visibility, improve skid resistance, and reduce pavement oxidation. A side benefit is the improvement in appearance by covering sealed and unsealed cracks and any patching that had been required. More than 300 miles of seal coats are placed annually by two permanent summer crews. Application and cost data relative to Manitoba's program are presented.

Asphalt aggregate seals have been used in Manitoba since petroleum and natural asphalts became available. Until the 1950s, a common usage was in the form of a double-prime surface on low-volume roads. These early treatments usually consisted of an application of MC-30 (MC-0) on the traffic gravel surface, with excess asphalt blotted by an application of sand. This was followed by an MC-500 (MC-3) spray with either sand or chips for final cover aggregate.

As traffic volumes increased in the post World War II period, it became apparent that the existing double-prime surface lacked the structural integrity required to provide satisfactory surface for an acceptable period of time. Investigation revealed that this type of construction could provide a suitable surface if properly supported by an adequate base. Such surfaces are termed asphalt surface treatment.

In 1959 an alternate surface to provide an all-weather surface on light traffic roads, at a cost lower than that of hot or cold mixed pavement, was introduced. Some of these structures have provided good service for more than 20 years and are routinely included as part of Manitoba's seal coat program.

This paper therefore includes such surface treatments as part of the overall maintenance works performed by the two permanent summer crews. The experience gained during the days of double-prime, the long experience with asphalt surface treatment, as well as the continual work with sealing pavement have resulted in the successful maintenance program described in this paper. The two maintenance crews, when available, apply the final chip or sand seal on newly laid base courses as part of the construction program; this topic is also included in this paper.

PROGRAM DESCRIPTION

Most of the seal coat work is planned well before the summer season, which usually provides only 4 to 5 months of suitable weather. Stockpiles of chips, sand, or both are prepared by the Manitoba Department of Highways and Transportation forces or by contract, sometimes more than a year in advance. The asphalt is also ordered during the winter and early spring.

F. Young and A. Robinson, 1181 Portage Ave. Annex, Winnipeg, Manitoba R3G 0T3, Canada. B. Rowley, 215 Garry St., Winnipeg, Manitoba R3C 1H1, Canada.

TABLE 1 SIX-YEAR SEAL COAT PROGRAM

Year	Lane Miles	Lane Kilometers	Total Expenditure ($ Canadian)
1980–1981	599.4	964.4	1,709,708
1981–1982	686.4	1,104.6	2,365,759
1982–1983	759.4	1,222.4	2,897,010
1983–1984	735.4	1,183.5	2,766,136
1984–1985	692.0	1,113.7	2,935,457
1985–1986	652.6	1,050.0	2,868,445
Avg	687.6	1,106.4	2,590,419

Warrants for inclusion in the sealing program include input from department district personnel, the maintenance director's office, and the maintenance management group. Special cases may occur that require or result from input by others in the Department, including safety considerations, special material problems causing surface distress, and so forth.

The work is put in priority order from these inputs with attention to budget constraints, previous years' maintenance costs, capacity of the application crews, availability of aggregate, and level of service that has to be maintained.

Table 1 presents the length of roads on which seal coats were applied for the past 6 years and associated gross expenditures.

Table 2 presents the seal coat program carried out, by the same crew, on capital works. Increased emphasis on the seal program in 1985–1986 resulted in a major expansion.

The expenditures given in Table 2 are estimated from average costs of seal coat application. This was necessary for the preparation of this paper because aggregate production and application did not always occur during the same construction year. Additional funds provided for patching and crack sealing before the sealing under this program are not included.

MATERIALS

Although occasionally there are a few miles of seal placed by using sand cover and some incorporate cut back asphalt

TABLE 2 SEAL COATS OTHER THAN MAINTENANCE

Year	Lane Miles	Lane Kilometers	Total Expenditure ($ Canadian)
1984–1985	169	272	395,511
1985–1986	368	593	862,273

TABLE 3 SPECIFICATIONS FOR COVER AGGREGATE

Passing Sieve	Class A Chips	Class B Chips
16 mm (5/8")		100
12.5 mm (1/2")	100	80 - 100
4.75 mm (No. 4)	0 - 60	0 - 65
425 mm (No. 40)	0 - 15	0 - 15
75 mm (No. 200)	0 - 4	0 - 5
% Crushed Particles	30 Min	30 Min
L.A. Soundness (% Loss)	35 Max	35 Max
Shale (%)	3 Max	4 Max
Ironstone (%)	5 Max	5 Max

(MC-500), these are now uncommon and are usually done by local district forces.

Most of the seal coat program makes use of crushed aggregate (chips) and a high float emulsified asphalt. The specifications for the materials are given in Tables 3 and 4.

AGGREGATE

The cover aggregate is produced mainly from local gravel deposits. The material is a combination of limestone and granite in most sources, with the ratio of the two depending on location in the province. Cover aggregate produced from a limestone quarry is currently being experimented with and early trials indicate satisfactory results.

In general, the Class A chip is used for cover. Care must be exercised to ensure meeting of specifications, particularly with respect to the #200 sieve fines. Sometimes chips require washing to reduce adhered fines but this is uncommon. The use of fans and proper screening during the crushing operation can largely eliminate the problem. On a few occasions, water has been sprayed on loads in the tilted truck box to remove fines but this has not been necessary lately. One must also be aware that snow melt and rain on a stockpile will concentrate fines toward the lower portions of the pile. Excess fines and chips coated with fines can absorb the asphalt and reduce the bond to the chip.

The spreader applies an average of 140 tons/lane-mi (127 tonnes/lane-km) of chips immediately behind the asphalt distributor. (This represents about 75 yd^3 of 140 lb/ft^3 aggregate/lane-mi.)

ASPHALT

An average of 1,750 gal/lane-mi (4944 L/km) of asphalt is applied by pressure distributor immediately before the chip spreader. The experienced operators may vary the rate slightly, depending on the condition of the surface, size, and gradation of the chip and the results of previous applications.

The asphalt type is chosen on the basis of traffic volume on the roadway. Because of excellent performance in the past few years, it is the authors' practice to use high float emulsions, HF-150 for high-volume roads and HF-250 for moderate- to low-volume roads. High volume of traffic for Manitoba's conditions would include annual average daily traffic of more than 2,000 total vehicles per day in each direction.

This rule of thumb is a general guide. Conditions of high temperature and/or greater than normal traffic volume (because of vacation traffic, etc.) can dictate that a harder base asphalt is

TABLE 4 ASPHALT EMULSION SPECIFICATIONS

Test	ASTM	Emulsified Asphalt Product HF-100	HF-150	HF-250
Flash point (°C)	D 1310	–	–	–
Consistency test at 50°C (saybolt furol seconds)	D 88	35–150	35–150	35–150
Residue by distillation (%)	D 244	62 min	62 min	62 min
Oil distillate by volume (%)	D 244	0.5–4	0.5–4	0.5–4
Storage stability				
24 hr (%)	D 244	1.5 max	1.5 max	1.5 max
5 days (%)	D 244			
Sieve test (%)	D 244	0.1 max	0.1 max	0.1 max
Coating test	D 244	–	–	–
Tests on residue by distillation to 260°C				
Penetration at 25°C (mm)	D 5	100–175[a]	150–250[a]	250–500[a]
Solubility (%)	D 2042	97.5 min	97.5 min	97.5 min
Ductility at 25°C (mm)	D 113	–	–	–
Float test at 60°C (sec)	D 139[b]	1,200 min	1,200 min	1,200 min

[a]The penetration at 25°C, 100 gm, 5 sec shall be estimated by performing the test using 50 gm and multiplying the average of three values by $2^{1/2}$ and reporting the value as the estimated penetration at 25°C, 100 gm, 5 sec.

[b]ASTM D 139 except the residue at 260°C directly into the float collar and not through a No. 50 sieve, and after the regular cooling procedures is placed in a float bath at 60°C rather than 50°C.

required. Therefore, the time of year and day of the week have an influence on binder selection.

APPLICATION PROCEDURE

One of the most important features of these operations is the significant amount of attention paid to traffic control. In addition to signs, barricades, and flagpersons, one or more pilot vehicles are used to convey traffic through the project. In the authors' experience, speed must not exceed 30 mph (45 km/hr) or there is a risk of losing cover aggregate, at least during the initial 6 to 8 hr of life.

Warm, dry days are essential to the success of the operation, which restricts Manitoba to a season generally from May 24 to September 15. A temperature of higher than 4°C (39°F) is required, with moderate winds and low risk of rain within 24 hr.

The two crews are supplied with aggregate by trucks of the Manitoba Department of Highways and Transportation or rental trucks. The number of trucks depends on the length of the haul and the rate of progress.

Asphalt is picked up from nearby suppliers, department storage yards, or portable storage tanks accompanying the crew. Living accommodations in the form of trailers are employed in remote areas.

It should be noted that both applications, asphalt and chips, are carefully calibrated and controlled to ensure uniformity. Careful nozzle placement, both vertically and horizontally, as well as attention to pressure, temperature, and speed, are essential. Paper is placed at the start and end of each run to ensure a neat, square finish. Material application rates are as noted previously in the section on Materials.

A pressure distributor applies the asphalt at a temperature of 70°C (160°F). A self-propelled aggregate spreader applies the chips to the fresh asphalt immediately behind the distributor. The spreader is continually supplied with material during the application.

The chips are rolled almost immediately by a steel-wheeled roller, which is followed closely by four self-propelled rubber-tired rollers. On high-volume roads, an additional steel- and rubber-tired roller is employed.

After the asphalt has set, one or more drag brooms remove most of the loose chips before traffic is permitted on the new seal.

The application has a success rate of higher than 95 percent on an average year. There is seldom a complete loss of chips, but partial loss has been experienced in cases in which high volumes of fast traffic accompanied by fairly heavy rains have stripped the chips in the wheelpaths as many as 3 days after placement.

The 6-yr average of aggregate and asphalt consumption is given in Table 5. Overall costs for the seal coat program are given in Table 6.

PERFORMANCE

Both the Class A (maximum size of ½ in. or 12.5 mm) and the Class B (maximum size of ⅝ in. or 16 mm) chips provide increased night visibility. The higher limestone content chips have the higher reflectivity.

Because of the coarse texture, tire noise increases but this seldom results in motorist complaints. Noise levels have not been measured.

Because of stringent traffic control measures, use of sufficient rolling equipment, removal of excess chips by brooming, and, perhaps most important, the fairly low traffic volumes in Manitoba, there are few claims for vehicle damage by flying stones. This is also true on low-volume roads where it is deemed unnecessary to perform the brooming.

Skid resistance is not routinely measured in Manitoba. Because accidents attributable to lack of surface friction are rare, it has not been considered essential—and might be a disadvantage—to collect such data.

A combination of low traffic volumes, moderate speeds, generally good geometrics, and low rainfall all contribute to fewer skid accidents. Daily routine patrol by maintenance and other personnel provides input on surface condition that is influential in determining priorities for seal coat. Minor flushed or rutted sections are usually corrected within a few days by local crews. The development of longer sections of potentially low friction provides strong influence in the larger surface treatment program, but reaction time is longer. In the authors' opinion, routine surface inspection as part of the overall maintenance activity provides input adequate to ensure motorist

TABLE 5 MATERIAL QUANTITIES

Year	No. of Gallons Used	No. of Litres Used	No. of Tons of Chips Used	No. of Tonnes of Chips Used
1980–1981	1,048,950	4 768 527	84,969	77 058
1981–1982	1,201,200	5 460 655	97,308	88 236
1982–1983	1,329,300	6 042 998	107,676	97 659
1983–1984	1,286,950	5 850 475	104,247	94 554
1984–1985	1,211,000	5 505 206	98,091	88 965
1985–1986	1,142,050	5 191 759	92,506	83 903
Avg	1,203,242	5 469 936	97,466	88 396

TABLE 6 UNIT COSTS FOR SEAL COAT APPLICATION

			Cost ($ Canadian)			
			Labor		Equipment	
Year	No. of Lane-Mi	No. of Lane-Km	per Lane-Mi	per Lane-Km	per Lane-Mi	per Lane-Km
1980–1981	599.4	964.4	325	202	543	337
1981–1982	686.4	1,106.4	305	189	587	365
1982–1983	759.6	1,222.4	355	221	679	422
1983–1984	735.4	1,183.5	365	227	668	415
1984–1985	692.0	1,113.7	365	227	711	442
1985–1986	652.6	1,050.0	388	241	743	462
6-yr avg	687.6	1,106.4	351	218	655	407

safety. It is also noted that many agencies have used accident statistics to help formulate corrective action programs *(1)*.

For special study purposes, some skid testing has been undertaken. The skid numbers indicate a slight decrease in wet friction as a result of seal coat application. On average, the ASTM E-274 friction number was 49 for chip-sealed surface and 54 for unsealed pavement. These friction levels would generally be considered satisfactory *(2)*.

DISCUSSION OF RESULTS

Thirty years ago, seal coating was planned for new pavements from 2 to 5 years after initial paving and thereafter at 5-yr intervals. With current equipment and materials, it is common for a reseal on an asphalt surface treatment to last 7 years, while chip seals on hot mix asphalt last from 10 to 12 years.

The longer life is attributable in part to the possibility of applying high float emulsions more heavily because they do not flow as readily as cut backs or regular emulsion grades. Increased care in production of good-quality chips is also important.

Another major factor in achieving success with seal coat is a competent, closely supervised crew that has been provided with all the necessary equipment. The freedom to vary application rates, within reason, and to use judgment about existing and forecast weather suitability is also important. Systems are available to predict or design for rates of asphalt and chip application, but in the long run experience is essential *(3,4)*. Seal coating, perhaps unfortunately, requires the constant attention of the applicators and is as much an art as it is a science.

Traffic control cannot be overemphasized. The higher the vehicle speed permitted, the greater is the damage to fresh seal coat. Pilot vehicles are a necessity on most projects to protect the public, the crew, and the road surface.

A final note is necessary about aggregate and climate. Most chips in Manitoba are produced from gravel and generally are more than 70 percent carbonate (limestone). The climate is fairly arid because of average precipitation of about 20 in./yr. The high float emulsions suit these conditions. Other agencies located in areas of heavier rainfall and/or where different chip sources are used should consider the use of cationic emulsions for faster setting times and adequate bond to roadway and chip surfaces.

Cutback asphalts can also be used successfully, but they appear to be more sensitive to weather. They are also losing favor because of concerns of air pollution and this type of use of potential fuel products.

Warrants for seal coating may be

- To reduce pavement oxidation,
- To improve appearance,
- To improve nighttime visibility, and
- To improve skid resistance.

It should be noted that, in Manitoba's experience, skid resistance of a flushed or bleeding pavement can be improved by use of a surface chip seal. However, severely overasphalted pavements are only improved for 2 or 3 yr, after which time the bleeding generally begins to reach the surface again. Also, in such cases it is difficult to determine asphalt application rates, sometimes resulting in early flushing.

Whether skid testing, accident records, or appearance provides the warrant for some action, considerable lead time is required before the work can be accomplished. This poses a serious problem in case of litigation because many roads cannot be closed, and signing (Slippery When Wet, etc.) is not always considered to cover the agency's responsibility. Perhaps steps should be taken to increase public awareness that remedial action takes time and money.

CONCLUSIONS

Several conclusions can be made about seal coats.

1. Seal coat application does extend pavement life.
2. Satisfactory performance of seal coats depends on several factors:
   a. Good-quality material,
   b. Adequate labor and equipment,

Oil		Chips		Overhead Expenses		Total	
per Lane-Mi	per Lane-Km	per Lane-Mi	per Lane-Km	per Lane-Mi	per Lane-Km	per Lane-Mi	per Lane-Km
1,221	759	583	362	179	111	2,851	1,772
1,702	1,057	692	430	162	100	3,447	2,142
1,680	1,044	885	550	215	134	3,814	2,370
1,621	1,007	880	545	227	141	3,761	2,337
1,887	1,172	985	612	294	183	4,242	2,636
2,100	1,305	907	564	257	414	4,396	2,732
1,702	1,057	822	511	222	181	3,752	2,332

c. Careful design of material quantities and/or thorough exploitation of experience,
d. Strict control of application quantities and operational methods,
e. Sufficient traffic control to ensure minimum loss of aggregate, and
f. Suitable weather.

3. In areas of high-volume traffic, high speeds, and heavy rainfall, attention to aggregate polishing is necessary because chip seals do not necessarily provide high skid resistance.

4. Of all factors influencing seal coat application, inclement weather (cold, wet), particularly in combination with high-volume traffic, can be the most damaging.

REFERENCES

1. *NCHRP Synthesis of Highway Practice 14: Skid Resistance.* TRB, National Research Council, Washington, D.C., 1972, 66 pp.
2. *NCHRP Synthesis of Highway Practice 104: Criteria for Use of Asphalt Friction Surfaces.* TRB, National Research Council, Washington, D.C., 1983, 41 pp.
3. N. W McLeod. *Basic Principles for the Design and Construction of Seal Coats and Surface Treatments with Cutback Asphalts and Asphalt Cements.* Association of Asphalt Paving Technologists, Minneapolis, Minn., 1960.
4. N. W. McLeod. *Seal Coat and Surface Treatment Design and Construction Using Asphalt Emulsion.* Asphalt Emulsion Manufacturers Association, Washington, D.C., 1974.

Publication of this paper sponsored by Committee on Characteristics of Bituminous-Aggregate Combinations to Meet Surface Requirements.