SEEDING CEMENT CONCRETE PAVEMENT
AUTOROUTE 40 QUEBEC - TROIS-RIVIERES

Ministère des Transports
direction expertises et normes
service des sols et chaussées

BROCHU, Paul-A., Eng.

Ministère des Transports du Québec

SEEDING CEMENT CONCRETE PAVEMENT

AUTOROUTE 40 QUÉBEC - TROIS-RIVIÈRES

SUMMARY

SEEDING CONCRETE PAVEMENT

In order to overcome rutting and skidding problems on concrete pavements exposed to high volumes of traffic, a new technique called «seeding» has been used in Québec in the last year on three different projects.

Originally developed by Belgium's Centre des Recherches routières, the technique has been used very successfully in that country for many years. It consists in spreading uniformly small quantities of a high quality aggregate on the surface of a newly poured concrete pavement and embedding the rock fragments into the fresh mix in order to obtain a durable wear-resistant and anti-skid surface. This result is obtainable even if local aggregates that do not stand up to polishing are used in the bulk of the concrete.

The seeding equipment is easily mounted on the back of a slip form paver and has non influence on the rate of production of the contractor.

TABLE OF CONTENTS

	PAGE
INTRODUCTION	1
SURFACE TEXTURE	2
SIZE AND OTHER PROPERTIES OF SEEDING AGGREGATES	3
SPRINKLING RATE	3
CHARACTERISTICS AND EQUIPMENT: AUTOROUTE 40	4
JOB EVALUATION	7
LABORATORY TESTS	7
Grinding tests	8
Dorry test (modified)	8
Durability tests	12
Aggregate distribution	15
CONCLUSION	15

INTRODUCTION

In view of the increase in the cost of highway construction, it is becoming more and more important to develop new techniques enabling us to build higher quality, more durable highways at a better price.

To this end, we had to find a way to reduce excessive wear of cement concrete slabs, eliminate rutting and increase the anti-skidding properties of the pavement in order to provide greater safety for drivers.

There were two ways of reaching these objectives. The first consisted in using a method developed in Denmark in which the slab is made of high-performance aggregate which is resistant both to wear and to polishing. In order to increase traction, the aggregates are stripped by removing the surface mortar of the conrete. This is done by spraying a retarder on the surface of the fresh concrete. The following day, after the concrete has hardened, the surface is brushed in order to remove the mortar. Unfortunately, this technique, known as stripping, requires high-performance aggregates throughout the slab and therefore adds considerably to the cost, since high-quality aggregate must often be brought in from far away.

The second possible way of increasing resistance to wear and skidding is the technique used on Highway 40 at Batiscan, called seeding. This technique, developed by Belgium's Centre de Recherches Routières, consists in distribution high-performance aggregates of a given size uniformly over the surface of the fresh concrete and embedding them with a tamping beam in such a way that they form a rough surface on the concrete.

SURFACE TEXTURE

This process is flexible and the surface texture of the concrete slab can therefore be adapted to the type of traffic, the weather conditions and the environment. In Belgium, for instance, where there is a high volume of heavy traffic, a mild climate and not much concern over noise pollution, a coarse texture with a high sideways force coefficient was adopted. It should be noted, however, that the Belgian projects have generally been carried out in sparsely populated rural areas. In France, where traffic noise is considered an important factor, the texture of the pavement is denser. In Québec, the hard climate and the consequent use of large quantities of de-icing agents prompted us to opt for a dense texture which, in addition to maintaining a high sideways force coefficient, considerably reduces traffic noise and prevents snowploughs from tearing the aggregates out during winter maintainance operations, which could otherwise have posed a problem.

SIZE AND OTHER PROPERTIES OF SEEDING AGGREGATES

The size of the aggregates generally used for seeding in 0/25 mm concrete is 12,5/19 mm. Larger aggregates are difficult to embed and smaller ones tend to disappear into the fresh concrete. Aggregates must be clean and wet to facilitate embedding and make the chips stick in the concrete.

Well chipped, cube-shaped aggregate is best for seeding. It must also meet the requirements set out in the ministère des Transport's cahier des charges et devis généraux for class I aggregates:

- the petrographic number must be less than 120
- the loss in the magnesium sulphate test must be less than 5%
- the loss in the Los Angeles test must be less than 18%
- the coefficient of abrasive wear must be less than 8%

According to a recent compilation of data by the Laboratoire central of the ministère des Transports, several quarries thoughout Québec could supply this type of aggregate. There would thus be no problem in obtaining it.

THE SPRINKLING RATE

The rate a which the aggregates are sprinkled over the surface depends on their size. For 12,5/19 mm chips, a rate between 6 and 8 kg/m² is recommanded. The aggregate size in the

Autoroute 40 project was 9,5/19 mm and the rate of sprinkling varied between 5 and 6 kg/m².

CHARACTERISTICS AND EQUIPMENT: AUTOROUTE 40

Table 1 gives the main characteristics of the seeded cement concrete project for Autoroute 40 at Batiscan. The concrete slab was made by a CMI autograde slip-form paver. A chip-sprinkling machine drawn behind the paver not only sprinkled but also embedded the chips in the fresh concrete. Its main components were a storage hooper for the chippings, a spreader drum with a speed regulator for adjusting the sprinkling rate and a vibrating tamping beam for embedding the aggregates into the concrete. All the seeding operations were carried out within the sliding forms of the paver.

TABLE 1

SEEDED CEMENT CONCRETE PAVEMENT

AUTOROUTE 40 QUÉBEC - TROIS-RIVIÈRES

CHARACTERISTICS

A. GENERAL

Project leader	- Ministère des Transports Gouvernement du Québec
Contractor	- G.G. Construction Ltée
Length	- 8,11 km
Width	- 2 X 7,30 km
Paving period	- September-October 1981 July-August-September 1982

B. PROJECTS

Sub-base	- 300 to 450 mm sand
Base	- 150 mm 0-19a crushed aggregate
Concrete surface	- 200 mm
Length of slabs	- 5 m
Transversal joints	- dowelled sawn contraction joints
Longitudinal joint	- sawn joint with tie bars between the lanes

C. MATERIALS

Concrete	- Class 6, 25 mm, 30 MPa
Aggregates	- Pax quarry - Deschambault crystalline limestone - Trenton group
Sand	- Brouillette bank - Saint-Narcisse high fluvial terrace
Cement	- normal CSA-A5 Portland
Admixture	- air-entraining agents ASTM-C-260, 6% TCDA - Dispersant
Paving train	- CMI type, 2 vibrating finishers
Curing material	- Sealtight WP 60 - white, type 2, class A

D. SEEDING

Seeding stone	- 51% granitic gneiss, 27% granite, 9% anorthosite, 6% syenite, 6% diorite
Size	- 12,5/19 mm
Sprinkling rate	- 5 to 6 kg/m²
Pre-treatment	- washing on loading
Embedding method	- continuous forward movement tamping

JOB EVALUATION

In order to obtain an objective evaluation of the results of the Batiscan pilot project on seeded concrete, a committee of six people was created to note every defect found on each of the 740 5-meter slabs. Table 2 gives the result of these inspections. Unanchored chips, variation from true grade, slumping at the edge of slabs, cracks, patches, low spots and surface segregation are considered major defects, while poorly formed pavement edges, an irregular surface appearance, joints requiring repair work, incompletely sawn joints and a poor vertical line in the slab edge are minor defects.

During the first four days of paving, the seeding was the overall major problem. As of the fifth day, seeding was well under control and the only defects were minor.

In the light of these findings, we may conclude that seeding is possible with modified equipment and that the defects are those normally encountered when building a road with cement concrete.

LABORATORY TESTS

Laboratory tests on concrete slab cores taken on the Autoroute 40 construction site at Batiscan have proven the important effect of the rate of chip sprinkling on the resistance to wear of the pavement.

Grinding tests

Figure 1 gives the results of grinding tests. With no chips, it takes 9,7 minutes to grind 1 mm off a core with a diameter of 100 mm, compared to 19 minutes when the core is 13,2% chips, that is, results from a sprinkling rate of 5 kg/m². The resistance to wear of the concrete slab core more than doubled when it contained high-performance aggregates. If the rate of sprinkling is increased to 21,1 %, or 8 kg/m2, grinding time jumps to 25 minutes, almost three times the resistance of a core with no chips. It is therefore advantageous to maintain as high a rate of sprinkling as possible if we wish to reduce rutting and wear over a period of time.

Dorry test (modified)

The results obtained with the Dorry test, which also measures abrasive wear, were about the same. Figure 2 gives the losses observed in the tests by chip-sprinkling rate. With no chips, losses amount to 0,54 gr/cm² compared to 0,38 gr/cm², almost double the wear.

TABLE 2

AUTOROUTE 40 - BATISCAN

SEEDED CEMENT CONCRETE PAVEMENT

PAVING DAY	MAJOR DEFECTS			MINOR DEFECTS	
	Number of slabs	%	Type	Number of slabs	%
1	13/30	43,4	seeding	1/30	3,3
	1/30	3,3	other		
2	21/91	23,1	seeding	11/91	12,1
	4/91	4,3	other		
3	26/114	22,8	seeding	8/114	7,0
	1/114	0,3	other		
4	35/75	46,6	seeding	7/75	9,3
	7/75	9,4	other		
5	6/95	6,3	seeding	12/95	12,6
	3/95	3,2	other		
6	1/179	0,55	seeding	46/179	25,6
	1/179	0,55	other		
7	0/153	0	seeding	8/153	5,2
	0/153	0	other		
8	0/3	0	seeding*	3/3	100
	0/3	0	other		

*unseeded slab

FIGURE 1

GRINDING TESTS

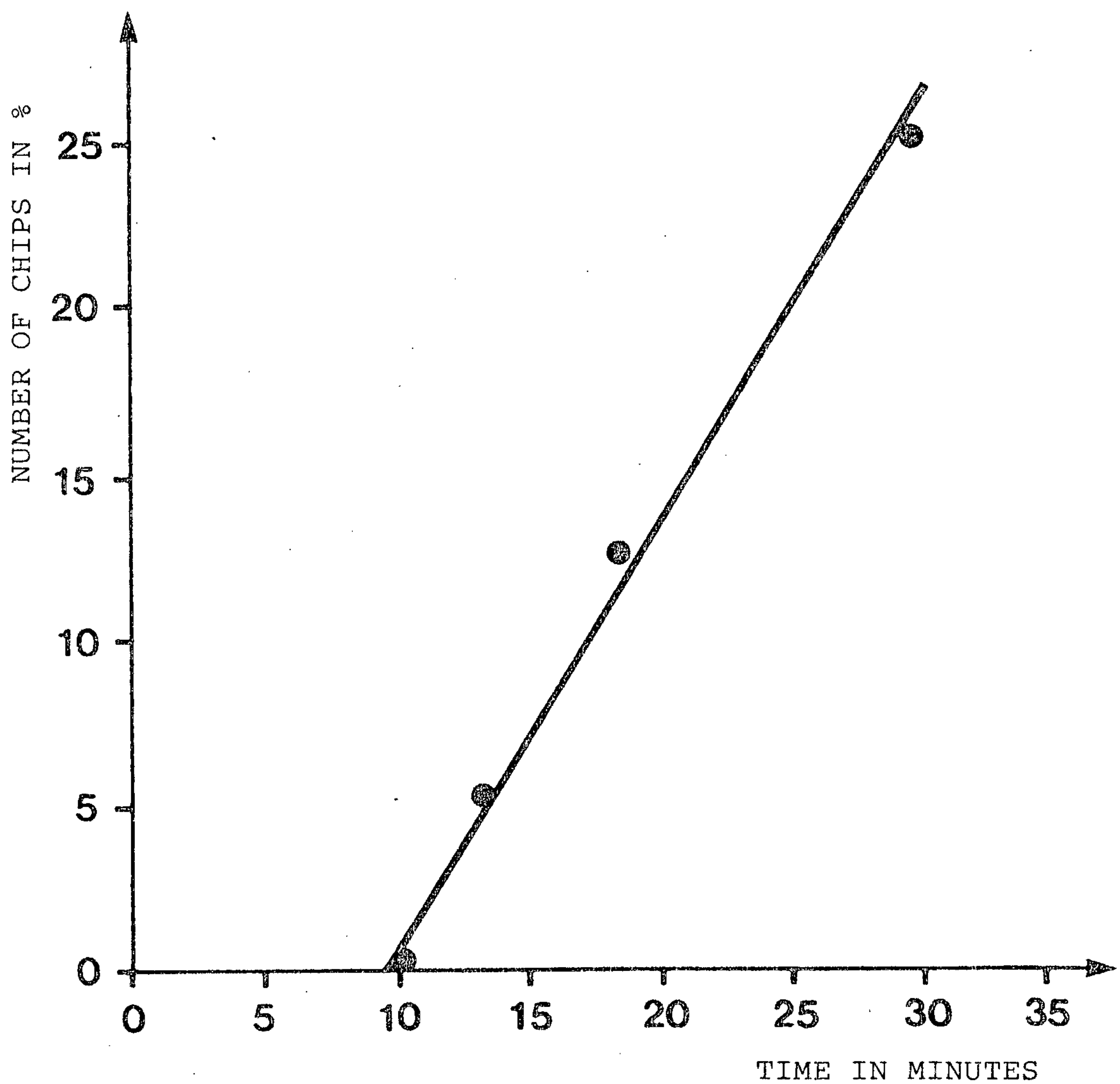
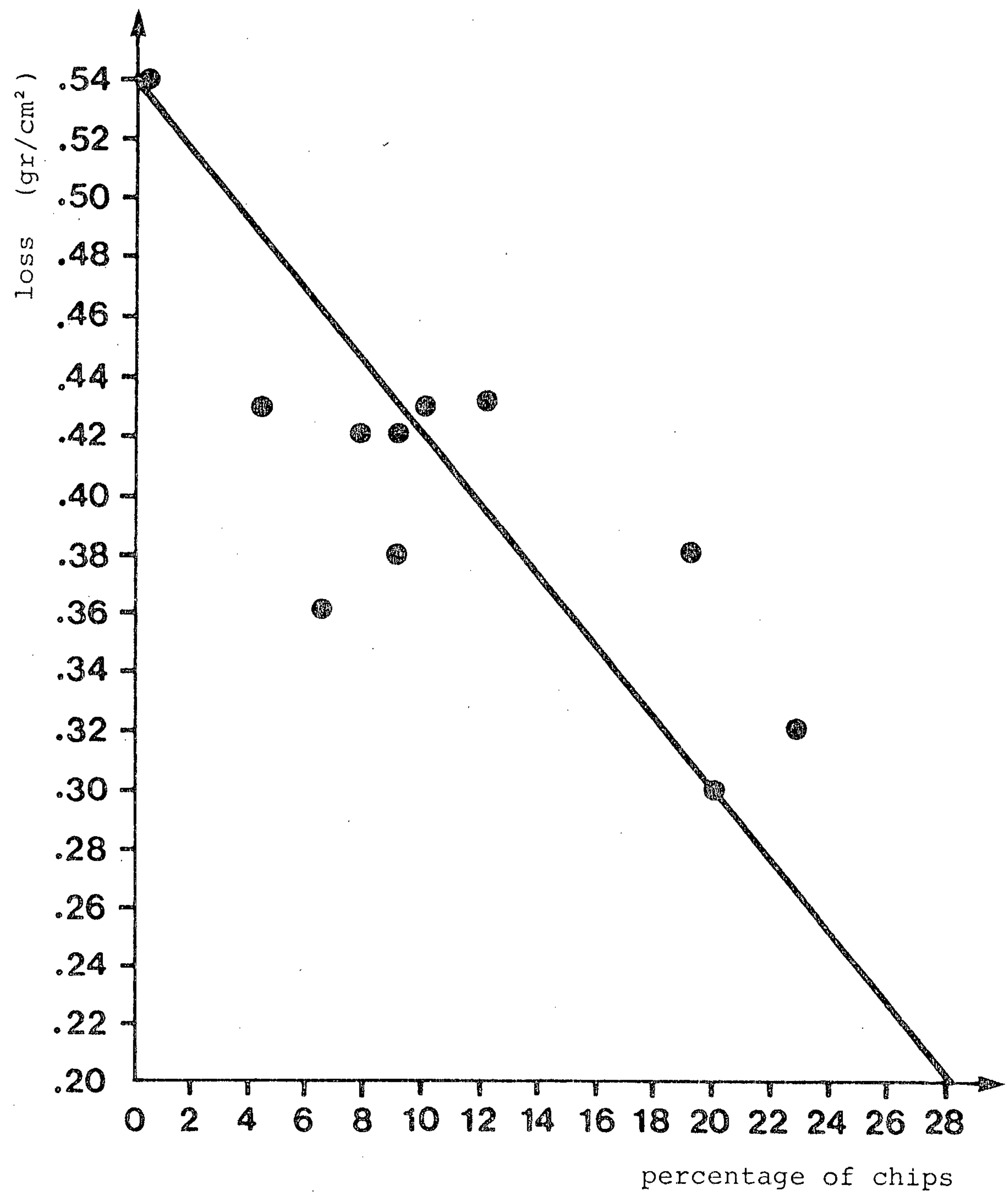


FIGURE 2

DORRY TEST (modified)



These laboratory tests do no necessarily reflect the performance of the cement concrete on Autoroute 40 at Batiscan under traffic conditions, but they do give us a good idea of the increased resistance to wear obtained by the use of high-performance aggregates in the pavement.

Table 3 is a compilation of test results on aggregates from different quarries in Québec. If we compare the Dorry wear coefficient for the L/G Ltée bank (4,7) used in the Batiscan project with that for the St-Bruno quarry, for instance (2,0), we observe that we could have more that doubled the results given in the preceding figures by using this type of aggregate for seeding.

Durability tests

We also had the Laboratoire central carry out freeze and thaw tests on samples 150 mm in diameter taken from the Autoroute 40 project. These tests consist in submitting samples covered in calcium chloride to 50 cycles of 16 hours of freezing -18°C temperatures and 8 hours of 23°C temperatures for thaw conditions. The results showed that only one chip in two samples with very exposed aggregates was torn out.

Cores with no chips visible on the surface were submitted to 695 freeze-thaw cycles in keeping with the ASTM-C-666 standard, without any noticeable deteriotation.

TABLE 3

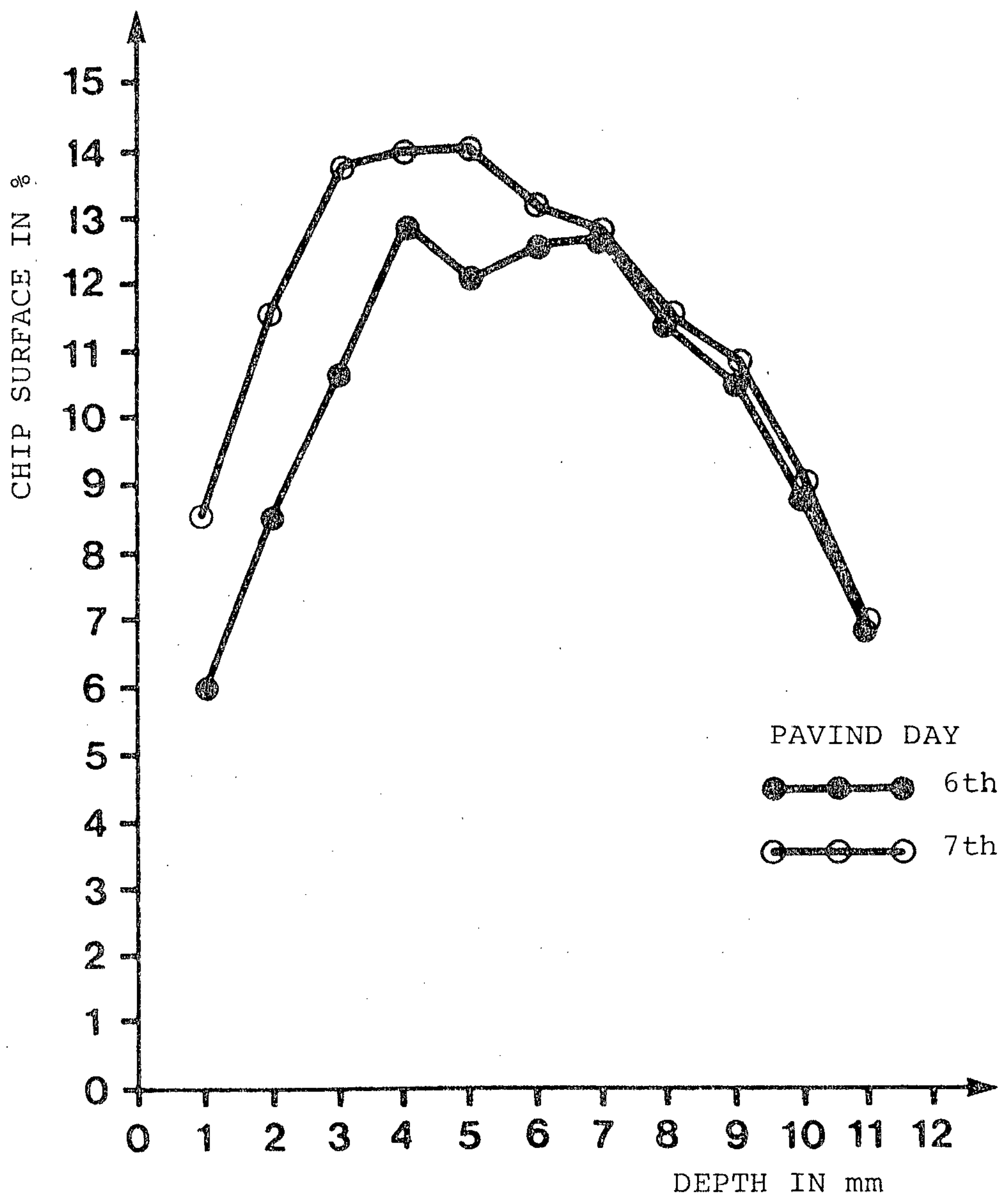
HIGH-PERFORMANCE AGGREGATES

SOURCE	NATURE	PETROGRAPHIC NUMBER	LOSS IN $MgSO_4$	LOS ANGELES	DORRY COEFFICIENT OF ABRASIVE WEAR
Demix Quarry Varennes	100% phonolite	100	0,7	15	3,9
Saint-Bruno Quarry Saint-Bruno	100% basalt	100	0,2	11	2,0
Intercomtés Quarry Bromont	100% pelite	100	1,4	13	3,9
Saint-Flabien Quarry	55% andesite 30% amygdaloid andosite 15% altered andesite	123	3,0	12	3,8
Sable L/G Ltée	51% granitic gneiss 27% granite 9% anarthosite 6% syenite 6% diorite	102	0,6	18	4,7

Analyses made by the Laboratoire central of Québec's ministère des Transports

FIGURE 3

CHIP DISTRIBUTION



These tests clearly demonstrated that seeded cement concrete reacts very well to freezing and thawing.

Aggregate distribution

Since the surface texture of our pavement was very dense, we took core samples from slabs on the construction site and examined them for chips at each millimeter of thickness in order to determine whether aggregate distribution was good and to check that the chips had no completely disappeared into the fresh concrete. Figure 3 represents the chip surface found fromm 1 mm to 11 mm below the surface of the slab. We observed that chips are found as of 1 mm from the surface and that the largest surface of chips is found at 4, 5 and 6 mm below the surface of the slab. This is normal since our seeding aggregates vary from 9,5 mm to 19 mm in size and their largest surface is at their midpoint. Moreover, 13 and 14 percent corresponds to the 5 kg/m^2 sprinkling rate we recommended.

CONCLUSION

Seeding cement concrete pavements definitely reduces aggregate wear and polishing. High-performance aggregates at the surface of the pavement maintain the physical properties of the pavement in the long term while promoting the use of local aggregates of inferior quality in the bulk of the concrete.

Finally, given the small quantities of aggregate required, a pavement with high skid resistance and wear resistance may be obtained at a very low cost.

The Batiscan experiment on Autoroute 40 has proven that the seeding technique is now well controlled. Other contracts using the same technique are currently under way on autoroute 40 and 440 at Sainte-Anne-de-la-Pérade and Montréal. The results are most satisfactory and production high: over one kilometer 7,30 meters wide a day. The minor and major defects mentioned in the section on evaluation are, for all practical purposes, non existent.

REFERENCES

Dussine M. - «Une structure nouvelle de chaussée. La dalle épaisse de béton calcaire cloutée en surface» Revue générale des routes et des aérodromes, décembre 1981

Fuchs F. - «Nouveaux développements en matière de béton de ciment clouté» Centre de Recherches Routières Belge, TRB janvier 1981

Larrivée J.C. et Brochu P.A. - «Autoroute 40, Donnacona - Trois-Rivières» Ministère des Transports, février 1980

Van Heystraeten G. - «Connaissances acquises en matière de béton de ciment clouté» Centre de Recherches Routières Belge, janvier 1974