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MAINTENANCE AND REHABILITATION OF LOW COST SURFACE DRESSING FOR LOW VOLUME ROADS – EXPERIMENTAL ROAD SITES –

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Abstract: Two experimental road sections were laid in 2003 in the northwestern part of Iceland to compare different aggregate sources and their suitability for low cost and low traffic surface dressing. The third set of experimental road sections was laid in the year 2005. The laying process was a traditional surface dressing procedure for all test sites. The project focused on comparing aggregates for surface dressing in a district where the traffic volume is generally low and climatic conditions are harsh. Comparison of surface conditions and test results indicate that abrasive strength of aggregates is most important where the traffic rate is relatively high (i.e. over 1.000 AADT). On the other hand frost resistance proves to be a ruling factor regarding service life of surface dressing where the traffic rate is relatively low. Other important factors recognized are the condition of the underlying surface as well as good practice when laying surface dressing.

1 INTRODUCTION

In general, Iceland is a scarcely populated country, with a total population of 300.000 while the surface area of the island is about 100.000 km^2. This fact results in a long road network, where the total road system is about 13.000 km. Approximately 5.000 km of the road network in Iceland is paved, mostly with surface dressing, and 8.000 km are unpaved gravel roads. It is worth mentioning that a considerable proportion of the unpaved roads are highland summer roads which will probably not be paved in the near future. Still, it is obvious that since the road system is long and the traffic rate on urban roads is relatively low, costly roads with high quality materials which are transported long-distances are not economically feasible. However, asphalt concrete is increasingly being used in the surroundings of major towns with increasing traffic rate.

There are several factors that predominantly affect the durability of the surface dressing road network in Iceland. Firstly, it has to be secured that the adhesion between aggregates and binder is satisfactory, otherwise the laying of surface dressing is bound to be a failure. Secondly, the use of studded tires has major influence on the road surface, causing abrasion (and impact) and consequently rutting in the wheel tracks, especially where the traffic volume is relatively high. Good abrasive strength of aggregates is therefore important under these circumstances. Thirdly, the climatic conditions also have a great influence on road surfaces as frequent freezing and thawing occurs in most places of the island. Durability (resistance to freezing and thawing) is therefore an important characteristic of aggregates.

A side effect regarding the durability against freezing and thawing is the saline environment caused either by sea-spray or de-icing chemicals which drastically increase the deterioration of poor quality aggregates against freeze/thaw cycling. Another side-factor is the potential damage caused by winter maintenance of the roads which makes good adhesion, durability and resistance to abrasion all the more important. Heavy steel blades of snow ploughs often damage the surface coat by cutting the surface dressing, especially in areas outside the wheel tracks themselves.

2 ROAD SITES AND MATERIALS

It was decided in the summer of 2003 to lay some experimental road sections in the northwestern part of Iceland, the West fjords, to compare different aggregate sources and their suitability for low cost and low traffic surface dressing. The sections were laid on top of older surface dressing which were due for maintenance. The main purpose of the project was to find the relationship between aggregate quality and performance under prevailing circumstances, i.e. relatively low traffic volume and harsh climatic conditions. There is lack of high quality aggregates in the area so the aggregates are in some cases of medium to rather poor quality.

It must be emphasized here that the traffic volume is very low in the area of concern and therefore costly solutions were not considered. The research project which started in 2003 can be divided into two parts;

a. All-in surface dressing, 0-16 mm, where the traffic rate is about 300 AADT. Nine sections were laid, the aggregate mostly originated from gravel pits, but also a few from crushed rock sources.
b. Eleven sections were laid where the traffic volume is about 600 AADT. Here, most sections were of single sized 11-16 mm surface dressing, two were 8-11 mm and two were all-in 0-16 mm.

The third set of experimental road sections was laid in the year 2005, using single sized aggregates from four different sources, including imported high quality aggregate from Norway. Both 8-11 and 11-16 mm aggregates were used for this experiment, six sections altogether. In this case the traffic rate is approximately 1.200 AADT which is considerably higher than for the sections from 2003. It should be stated here that the underlying surface dressing was severely damaged in places, with potholes and rutting in wheel tracks, which were not repaired properly prior to the experimental surface dressing.

The laying process was a traditional surface dressing procedure for all test sites, see figure 2. The monitoring of the experimental road sections has been ongoing since they were laid. General description has taken place with mapping of overall conditions, close up description of aggregates, photographs and quality estimation. Figure 3 gives an example of photographs taken and figure 4 shows a typical mapping of an experimental road section

Figure 2 Laying of Vadall section

Figure3 Overview at Vadall section

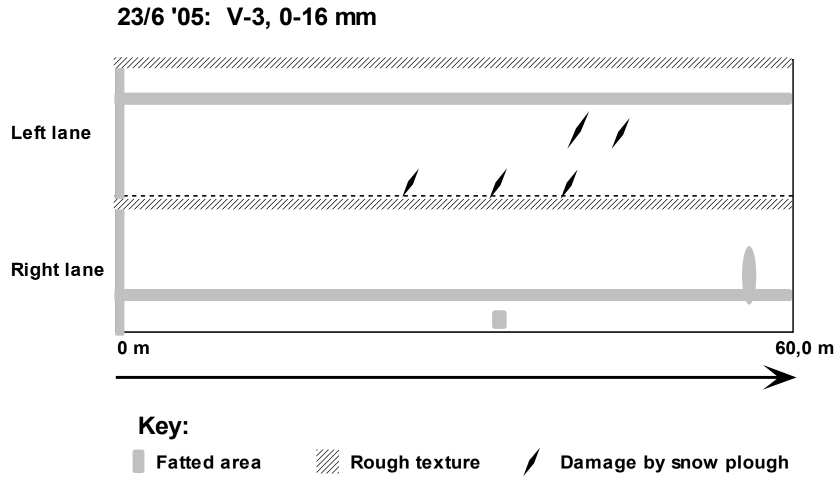

Figure 4 Example of mapping of road section

3 MONITORING OF ROAD SECTIONS AND LABORATORY TEST RESULTS

3.1 Vadall site, traffic rate 300 AADT

All the 9 experimental road sections at this site were all-in surface dressing with 0-16 mm aggregates. This is perhaps the simplest and most economic type of surface dressing where the aggregate is simply crushed to a certain extent. Often, there is no need to process the aggregate further except washing to take out most of the fines. Five of the aggregates used at Vadall were from crushed rock quarries and four from gravel deposits. Each road section is 60 m long. The bitumen was cutback with 10 % white spirit and 0,7 % amine as an adhesive agent. The quantity of bitumen was 1,8 l/m^2 on all sections and the rate of spread of chippings was approximately 18 kg/m^2. The main test results are as follows, see table 1:

Table 1 Main test results for the Vadall aggregates

No.	Size mm	Fines %	<0,02 mm	<0,002 mm	C&B %	FI %	STT %	LA %	F-Th %	Adh %	Petrogr. %
V-1	0-16	3,1	2,4	0,5	-	25,1	11,1	11,1	0,3	100	67/33/0
V-2	0-16	4,7	3,2	0,5	29/53	8,4	19,5	14,0	13,4	<50	18/72/10
V-3	0-16	7,3	4,7	0,9	-	15,0	20,3	14,7	4,7	86	100/0/0
V-4	0-16	3,9	2,8	0,5	44/46	10,6	16,1	16,2	7,7	97	28/71/1
V-5	0-16	4,8	3,7	0,8	89/3	14,4	17,8	15,9	5,1	88	54/41/5
V-6	0-16	7,0	4,4	0,8	-	12,5	16,9	24,9	0,8	90	99/1/0
V-7	0-16	7,2	4,9	0,9	52/25	7,7	15,2	17,8	5,2	84	80/20/0
V-8	0-16	4,7	3,4	0,7	-	21,0	14,2	11,1	0,8	100	16/84/0
V-9	0-16	2,5	2,1	0,5	-	12,2	13,8	14,9	10,6	67	74/9/16

Legend (see also tables 2 and 3):
Fines passing 0,063 mm, %
C&B Crushed and broken surfaces, % crushed/totally rounded
FI Flakiness Index, %
STT Studded Tire Test, % passing a specified sieve after test
LA Los Angeles test, % passing a specified sieve after test
F-Th Freeze/thaw test with salt, % passing a specified sieve after10 cycles
Adh Adhesion, wet mix test, % coating after mixing in water for one hour
Petrogr Simplified petrographic analysis, % 1st, 2nd and 3rd class

Table 1 shows that the amount of fines is considerably high in some cases (more than 7 % fines in three cases) and clay-sized particles up to 1 %. It also shows that laboratory test results give a wide range, from good to poor results for different test methods.

The following broad conclusions can be drawn from the Vadall site:

a) Abrasion by studded tires (measured with the STT method) does not reflect the performance of the 0-16 mm all-in surface dressing where the traffic rate is only about 300 AADT.
b) Relatively high LA value does not reflect performance under the conditions at Vadall, as V-6 shows good performance.
c) Poor frost resistance according to testing is generally in harmony with poor performance.

3.2 Tungudalur site, traffic rate 700 AADT

As the traffic rate is considerably higher in Tungudalur than in Vadall, it was decided to have most of the experimental road sections with single sized aggregates of 11-16 mm. However, two sections were made with 8-11 mm aggregate size and two with 0-16 mm all-in for comparison. The quantity of bitumen was between 1,7 and 2,0 l/m^2 (depending on size of aggregate) and the rate of spread of chippings was approximately 16 to 20 kg/m^2.(depending on aggregate size). The main test results are as follows, see table 2:

Table 2 Main test results for the Tungudalur aggregates

No.	Size mm	Binder l/m^2	Fines %	C&B %	FI %	STT %	LA %	F-Th %	Adh %	Petrogr. %
T-1	8-11	1,7	3,8	-	12,2	-	14,6*	5,5	94	66/34/0
T-2	0-16	1,8	5,3	-	19,3	13,5	11,2	0,3	100	6/94/0
T-3	0-16	1,8	2,4	-	21,5	10,3	10,9	0,1	100	63/36/1

T-4	11-16	2,0	0,9	-	12,4	17,0	12,6	0,7	100	18/81/2
T-5	11-16	2,0	1,6	80/2	5,6	12,3	18,3	2,8	100	68/25/6
T-6	11-16	2,0	4,2	-	13,3	19,6	14,3	4,5	86	100/0/0
T-7	11-16	1,9	1,4	-	18,9	10,2	10,7	0,3	100	86/13/0
T-8	11-16	2,0	1,5	-	14,5	13,4	15,0	9,9	67	74/12/14
T-9	11-16	2,0	1,0	-	18,0	15,1	10,7	0,3	100	28/72/0
T-10	8-11	2,0	0,7	-	14,4	-	10,2	0,1	100	0/100/0
T-11	11-16	2,0	1,8	-	9,7	23,7	16,3	2,4	99	72/28/0

The general observation concerning the Tungudalur sections are as follows:

a) Sections with 8-11 mm aggregate are generally almost fully worn in the wheel tracks. This is without doubt related to the small size of chippings.
b) Sections T-2 and T-3 are on the poor site, although T-2 appears to be surprisingly good, bearing in mind that it is 0-16 mm all-in. Still, this relatively good performance of T-2 (and perhaps T-3 also) must be related to the overall good properties as observed in the laboratory, as well as the 16 mm maximum aggregate size. T-3 may suffer from the flaky appearance (FI = 22 %) as other factors measured in the laboratory are generally good.
c) The sections that make the best performance of the Tungudalur test site have in common that the aggregate has a reasonable abrasive strength, good impact resistance and excellent frost resistance.

3.3 Hnifsdalur site, traffic rate 1.200 AADT

This site was laid in the summer of 2005 between two towns where the traffic rate is considerably higher than at the previous sites. Also, this road is kept open at all times and therefore winter maintenance (snow ploughs and de-icing) is frequent. Aggregates from four sources were used single sized 11-16 mm and additionally two of them single sized 8-11 mm. The main test results are as follows, see table 3:

Table 3 Main test results for the Hnifsdalur aggregates

No.	Size mm	Binder l/m^2	Fines %	<0,02 mm	<0,002 mm	FI %	STT %	LA %	F-Th %	Petrogr. %
H-1	11-16	1,9	3,9	2,5	0,6	11,4	21,8	15,8	3,9	20/79/1
H-2	8-11	1,7	3,3	2,1	0,5	12,2				
H-3	11-16	1,9	0,7	0,5	0,1	9,4	6,8	11,2	2,2	92/6/2
H-4	11-16	1,9	1,7	1,3	0,3	6,4	6,3	10,1	0,0	0/0/0*
H-5	8-11	1,7	1,5	1,1	0,2	11,4				
H-6	11-16	1,9	1,1	0,7	0,2	11,5	17,3	12,0	0,6	11/86/3

** Durasplitt not classified according to petrographic analysis*

It was evident after the first winter that H-1 and H-2 had suffered severely, especially in the wheel-tracks, and H-3 was also badly rutted in two of the four wheel tracks. In all these cases, the underlying surface was clearly visible through the experimental road sections. H-4, H-5 and H-6 were in a much better condition, although apparently material loss is clearly visible between wheel-tracks and between lanes. The damage detected on the Hnifsdalur road after one winter is thought to be caused by three factors:

a) The underlaying surface was not adequately repaired prior to laying the test sections. Deep rutting in the wheel-tracks result in material loss on the crest between wheel-tracks which is caused by snow ploughs.
b) There was a blockage in one of the slot jets of the spray bar, resulting in inadequate binder content in one of the inner and one of the outer wheel tracks in the first three sections (not detected earlier).
c) Different quality of aggregates. The aggregate in sections H-1 and H-2 (local basalt 11-16 and 8-11 mm) is clearly the poorest one with severe damage in all wheel tracks after one winter. The poor abrasive strength of that aggregate (STT = 22 %) is thought to be the main cause for failure although the blocked jet obviously supplemented to the damage in two of the wheel tracks. The frost resistance of this aggregate is also the poorest of the four aggregate types used in the H-sections. Aggregates H-3 to H-6 are more or less of equal quality, according to test results, although H-6 has the highest abrasion value (STT = 17 %). No obvious difference is detected between the aggregate sources.

4 CONCLUSIONS AND DISCUSSION

This project has focused on comparing aggregates for surface dressing maintenance in a district where the traffic volume is generally low and climatic conditions are harsh. Also, transportation distances for good quality aggregates are long and too costly. Although this project can not be described as a large scale project, it has given valuable information about various factors affecting the service life of surface dressing laid for maintenance purposes under these circumstances.

Abrasive strength of aggregates is most important where the traffic rate is relatively high (i.e. over 1.000 AADT) and winter maintenance is frequent with snow ploughs and de-icing chemicals, as is the case in the Hnifsdalur test road.

Frost resistance proves to be an increasingly ruling factor regarding service life of surface dressing when the traffic rate gets relatively lower. Abrasive strength of aggregates is of minor importance at least when the traffic rate is lower than approximately 500 AADT.

Condition of underlying surface to be maintained needs to fulfill minimum criteria regarding evenness. Otherwise, rutted wheel tracks reflect up through the new layer and can result in failure caused be snow ploughs on crests between the wheel tracks. Winter maintenance is an external factor which needs to be taken strongly into account under these circumstances.
Good practice (including pre-checking of equipment to be used) when laying surface dressing is an important factor for a successful surface layer.

It is very important to make the best use of local materials as possible, especially where hauling distances are long and the traffic volume is low. Therefore, knowledge of the potential of local aggregates will help road designers to evaluate their use, and calculate the cost effectiveness of such use.