Modified bitumen for surface dressing

Questionnaire – testing - full scale experiments

Accumulated by Pétur Pétursson
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1 FOREWORD

Surface dressing with polymer modified bitumen had not been used in Iceland and there was an interest in doing some research in that direction in the effort to increase the lifetime of surface dressing and to prevent early failure. With increased traffic volume on the roads, especially heavy vehicles, the stresses on the surface dressing have increased considerably and premature defects have occurred to more extent than before, both fretting (chipping loss) and bleeding. By using modified binders the surface dressing will have increased service life and that applies both for bitumen softened with ethylester from fish oil and bitumen emulsions.

The project Modified bitumen for surface dressing was initiated by the Icelandic delegation of the NVF committee „Road surfacings“ (Belegninger) at the annual meeting of the committee in 2010\(^1\). The research fund of the Icelandic Road and Coastal Administration has provided generous funds for this research project since it started in 2012. The first step of the project included composing a questionnaire and receiving answers from Nordic contact persons on issues related to the use of surface dressing. The second step involved laboratory testing of surface dressing samples with and without SBS modification. The third step, which is still in progress, was to lay experimental road sections of surface dressing with and without modification. The main purpose of the project as a whole was to gather information from the three steps mentioned above to be able to evaluate the benefits of using modified binders for surface dressings.

In this final report to NVF Surfacings committee the main findings of the project are gathered. The project group members were Ingvi Árnason IRCA, project leader, Gunnar Bjarnason IRCA, Lars Peter Jensen Hlaðbær-Colas and Pétur Pétursson PP-Consult.

\(^1\) The members of the Icelandic delegation are or have been in the period: Halldór Torfason, chairman, Ingvi Árnason, secretary, Ásberg K. Ingólfsson, Baldur Einarsson, Bergbóra Kristinsdóttir, Lars Peter Jensen, Pétur Pétursson, Sigursteinn Hjartarson and Pórbjörg Hólmgeirsdóttir.
2 INTRODUCTION

The Icelandic Road and Coastal Administration has been aware of how polluting it is for the environment to use white spirit as a solvent in cutback surface dressing. As far back as 1998 some experiments were made with a different and more environmentally friendly solvent in cutback (Shellsol D60). The solvent proved to be equally suitable for the cutback bitumen, but workability was not satisfactory (too much airborne spray onto vehicles passing). Therefore it was not a successful solution to the environmental problem, besides being considerably more expensive than white spirit.

Experimental road sections of single surface dressing with bitumen emulsions have been laid occasionally in Iceland, first in 1993, then 1994, 2003 and 2006. All these experiments were without bitumen modification and some were successful and others not. The main defects occurring were fretting (random loss of chippings) and tearing (excessive fretting) and in some cases remedial work needed to be made the next year after laying. In 2007 it was decided to stop experiments with bituminous emulsion surface dressing for the time being, even though some sections proved to last for years, even longer than normal cutback surface dressing in some cases. Yet it was concluded that taking risks of early failures of emulsion surface dressings was not acceptable, especially on roads with high volume traffic.

Experiments with using rapeseed oil to soften bitumen instead of white spirit took first place in 2006 in the effort to reduce environmental impacts. Surface dressing with rapeseed oil softened bitumen continued until 2010, but bleeding and chipping loss occurred in many cases. Apparently, the poor quality of the rapeseed oil was blamed for some early defects of surface dressing and new softeners were tried in the following years. Since 2010 the use of etylester extracted from fish oil has increasingly been used as a softener for bitumen for surface dressing. Still it has proven to be unsatisfactory for roads with high traffic volume as the risk of bleeding is considerable under heavy traffic. Therefore, it was decided to try out surface dressing with bitumen emulsions modified with Latex, as well as surface dressing with etylester softened bitumen modified with SBS.

The first experimental road sections with bitumen emulsions modified with Latex and surface dressing with etylester softened bitumen modified with SBS were laid in 2013, as well as sections without modification. There have been some technical problems regarding the production of bitumen emulsions, but experiments are still taking place, some being successful and others with defects, mainly chipping loss. Washing of aggregates for bitumen emulsions is now becoming mandatory in Iceland and rules about traffic control at the working place are being tightened. It is hoped that these actions, as well as further guidelines concerning materials, equipment, design, construction, records, quality control, inspection and remedial work will increase the quality and lifetime of surface dressing with bitumen emulsions in Iceland.
Concerning the experiments with surface dressing with ethylester softened bitumen modified with SBS, it was decided to postpone further experiments as equipment to properly mix the SBS with the binder does not exist in the country.

3 QUESTIONNAIRE

As mentioned in Foreword, a part of this project, in fact the only part involving the Nordic countries, was to compose and send out a questionnaire concerning the use of surface dressing in each country. Answers were received from all the Nordic contact persons on issues related to the use of surface dressing. The questionnaire was mostly composed at meetings of the Icelandic NVF Surfacings committee, but Lars Peter Jensen, a member of the committee finalized the questionnaire and sent it to Nordic contact persons of the NVF Surfacing committee. Table 1 shows the main answers received from each country. The table is slightly simplified from the original questionnaire for clarity reasons.

Table 1 Clarified, English version of answers received from the Nordic countries in 2012

<table>
<thead>
<tr>
<th>Question</th>
<th>Finland</th>
<th>Norway</th>
<th>Sweden</th>
<th>Denmark</th>
<th>Iceland</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Surface dressing (m²) per year</td>
<td>630,000 m² 2012</td>
<td>500,000 m²</td>
<td>12,000,000 m²</td>
<td>5 – 6,000,000 m²</td>
<td>2,570,000 m²</td>
</tr>
<tr>
<td>A Single surface dressing</td>
<td>100%</td>
<td>100%</td>
<td>99%</td>
<td>85%</td>
<td>100%, Two layers on unbound base</td>
</tr>
<tr>
<td>B Double surface dressing</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10%</td>
<td>0</td>
</tr>
<tr>
<td>C Other types</td>
<td>0</td>
<td>0</td>
<td>1%</td>
<td>5%</td>
<td>0</td>
</tr>
<tr>
<td>2 Chipping sizes</td>
<td>6/8 og 6/12 mm</td>
<td>8/11 mm</td>
<td>8/11 and 4/8 mm</td>
<td>5/8 and 8/11 mm</td>
<td>8/11, 11/16, also 8/16, 4/16 mm to some extent</td>
</tr>
<tr>
<td>3 Chippings washed</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>A Bitumen emulsion of total (%)</td>
<td>0%</td>
<td>100%</td>
<td>100%</td>
<td>20%</td>
<td>0%</td>
</tr>
<tr>
<td>B Cutback of total (%)</td>
<td>100%</td>
<td>0</td>
<td>0</td>
<td>70%</td>
<td>0%</td>
</tr>
<tr>
<td>C Other types of total (%)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>10% f.ex. PG 330/430</td>
<td>100% softened bitumen with fish oil esther</td>
</tr>
<tr>
<td>5 Do you use modified cutback bitumen?</td>
<td>No, too small quantities to pay off</td>
<td>Yes, always modified bitumen</td>
<td>Yes, „Racked-In“ 8/11 mm, small quantity</td>
<td>Yes, about 30% of cutback bitumen is modified</td>
<td>No, trials will start in 2013</td>
</tr>
<tr>
<td>6 Type of polymer used</td>
<td>Trials with SBS</td>
<td>Latex</td>
<td>SBS and Latex 3-4 %</td>
<td>SBS</td>
<td>Trials with 3 % SBS in cutback and 2 % Latex in emulsion</td>
</tr>
<tr>
<td>7 Why use modified bitumen</td>
<td>Reduce risk of failures, sweeping can start earlier and prolonged season</td>
<td>Where heavy traffic is, prolonged season, better breaking of emulsions and better spraying properties</td>
<td>Prolonged service life where climatic conditions are severe</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Finland</td>
<td>Norway</td>
<td>Sweden</td>
<td>Denmark</td>
<td>Iceland</td>
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<tr>
<td>-------------------------------------------------------------------------</td>
<td>-------------------------------------------------------------------------</td>
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<td>--------------------------</td>
<td>---------------------------</td>
</tr>
<tr>
<td>8 Increased cost when using modified bitumen</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A Direct cost</td>
<td></td>
<td></td>
<td>1.000 SEK/tonne</td>
<td>1 – 2 DKK/m²</td>
<td>10 % more expensive</td>
</tr>
<tr>
<td>B Life Cycle Cost (LCC)</td>
<td></td>
<td>Same</td>
<td></td>
<td>Prolonged by at least 2 years</td>
<td></td>
</tr>
<tr>
<td>C Other cost related issues</td>
<td></td>
<td>Surface dressing is too expensive compared with warm mixed ultra thin asphalt concrete</td>
<td>Modified bitumen is a very competitive material</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9 Environment / working conditions</td>
<td></td>
<td>To get rid of solvents on site</td>
<td></td>
<td>Estimate about 50 % emulsions in 2014.</td>
<td>To get rid of solvents on site, best solutions are always sought concerning durability of surface, environmental matters and health issues on site</td>
</tr>
<tr>
<td>10 Pros and cons regarding handling and spreading modified binder</td>
<td>The storage time is limited</td>
<td>More effective usage of equipment as the season is longer</td>
<td>More difficult to handle emulsion when spreading by hand, more quantity is needed and viscosity can be too high for good result</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11 Test method suitable for modified binder</td>
<td></td>
<td>Vialit plate test at different temperatures</td>
<td>Visual assessment of cohesion</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A On surface dressing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>B On bitumen</td>
<td></td>
<td>Bitumen tested with softening point and penetration before emulsification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>12 How is the bitumen modified?</td>
<td>Mixed in a tank before emulsification</td>
<td>Mixed in a tank before or at emulsification</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 Storage of modified bitumen</td>
<td>Needs constant stirring</td>
<td>Has a shorter storage period than unmodified binder</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Although answers were not received to all questions asked, some interesting observations can be made in general. Note that Finland and Iceland have little or no experience of modifying bitumen for surface dressing at the time the questionnaire was sent out. In Norway, surface dressing is not very common, but all they lay seems to be with modified bitumen. They state that “surface dressing is too expensive compared with warm mixed ultra thin asphalt concrete”.
The table shows the use of surface dressing in the Nordic counties. The most quantity of surface dressing is laid in Sweden each year and Denmark comes second. Both countries seem to have a vast experience according to answers to the questionnaire. Apparently, only a small quantity of modified binder is used for surface dressing in Sweden. In Denmark, 70% of surface dressings are cutback, there of 30% with modified binder, but at the time of the answers received Denmark aimed at 50% bitumen emulsions by 2014. It is interesting that both Sweden and Denmark require that aggregates for surface dressing shall be washed, which is not a requirement in Finland, Norway and Iceland. They have a positive attitude toward modified bitumen and mention in their answers that surface dressing with modified binder can endure heavy traffic better than unmodified, there is less danger of early failure, the construction season can be extended, sweeping can be earlier and the breaking behaviour of the emulsion is better. Drawbacks mentioned are shorter storage time, as well as higher viscosity at a given temperature which makes it more difficult to lay the surface dressing by hand.

Regarding the cost of using modified binder Denmark mentions that the cost is increased by 1-2 DKK/m² (~ 0.15 to 0.25 EUR), but on the other hand the service life of the surface dressing is increased by at least two years. Sweden estimates that modified bitumen is about 1.000 SEK (~ 100 EUR) more expensive than unmodified per tonne.

4 LABORATORY TESTING

4.1 Influence of adding SBS on the viscosity of the bitumen
A small part of the project was to measure the effect of adding 3% SBS into softened PG 160/220 bitumen with 7% ethylester and 0.9% TPH adhesion agent on the viscosity compared to the same binder without SBS. Figure 1 shows the results of these measurements.

![Figure 1](image_url)

Figure 1 The effect of adding 3% SBS into softened bitumen on the viscosity on the binder
The figure shows that the addition of 3 % SBS increases the viscosity at a given temperature considerably, more than doubles the viscosity compared to the reference softened bitumen. At 135°C the normal softened binder has a viscosity close to 100 cSt, which is thought to be a suitable spraying viscosity. On the other hand the SBS modified binder has a viscosity around 250 cSt at 135°C, which is probably too viscous for spraying. Therefore, it should be considered if the spraying temperature of the SBS modified binder should be increased when laying experimental road sections.

4.2 Tensile test – influence of SBS on the force needed to pull aggregate out of the bitumen

It was decided to do some further laboratory testing with added SBS to the softened binder, in the same portions as described in chapter 4.1. First, a metal frame was fixed on four 50 x 50 cm concrete slabs, standing 1 cm above the surface. The binder with and without SBS was then spread on the concrete surface at 130°C, approximately 2,0 l/m², two slabs with and two slabs without SBS. Two types of 11/16 mm aggregate chippings were then added onto the binder and rolled with a cylindrical concrete block. The intention to swipe excessive chippings off the day after was abandoned as the binder was too soft. Instead, the concrete slabs were turned so that excessive chippings fell off. The samples were kept at room temperature for a couple of months before the actual pulling took place. Before the pull off process each sample was cut into two identical samples. The following photos, figure 2 a) to h), show the process of preparing the samples, step by step.

![a) Concrete slabs ready for preparation](image1.jpg)
![b) Metal frame glued on the sides of the slabs](image2.jpg)
c) Closeup of concrete slab with frame

d) Hot binder poured on the surface

e) Binder spread with a spatula

f) Chippings rolled with a concrete block

g) SBS modified binder has increased tensile strength

h) Cut slabs, ready for testing

Figure 2 a) to h) Preparation of samples
Before the actual pulling took place a cylindrical steel plate with 100 mm diameter was glued on each of the 8 specimens with epoxy glue. It was decided not to try to separate the chippings outside the glued area by core drilling as the binder was soft and displacement would have occurred. Instead it was decided to pull off without cutting, even though chippings partially glued under the plate and partially outside the plate would also be pulled up. Therefore, the surface area pulled off was not exactly the same as the steel plate (78,5 cm²), but when measured, the surface area varied from 103,3 to 124,7 cm². It was anticipated that the spread in values would be considerable.

Figure 3 a) and b) show how the tensile test was performed.

![Figure 3 a) and b) Tensile test on surface dressing samples](image)

In this report it would not be meaningful to go into details of this “homemade” tensile test. In fact most measurements did not seem to be significantly different, especially when testing at temperatures +5°C and +17°C. The binder was relatively soft at temperatures above freezing, both with and without SBS, as the softener (ethylester from fish oil) does not evaporate from the binder. The tensile force was approximately 800 to 1000 N at +17°C and 3500 to 5000 N at +5°C for both types of binder. However, at -5°C there seems to be a significant difference in the tensile force needed for modified and unmodified binders, see figure 4.
Figure 4 Tensile test results at -5°C with and without SBS modification

It is interesting to see that the tensile force is considerably higher for the SBS modified sample than for the unmodified sample. Also, the deformation before the sample is fully pulled off is much more (about 4 mm) for the modified sample than the unmodified (about 1 mm). This gives an indication that SBS modified, softened binder might be more resistant to brittle failure, which might be applied by for example snow-ploughs, when temperatures are below 0°C.

4.3 Testing of surface dressing squares

To make sure that the aggregates used in bitumen emulsion surface dressing would adhere properly to the bitumen emulsion, some squares of 32 cm each side were laid at the production site of the emulsion. Chippings from four sources were used, some 8/11 mm and some 11/16 mm. The quantity of emulsion for each aggregate was based on the chipping size and flakiness. The emulsion used was with latex.

The bitumen emulsion was poured onto the marked surface and evened and then chippings were shovelled into the emulsion as soon as possible. It should be stated that the temperature of the emulsion was about 30°C when the chippings came in contact. After all the squares had been laid the tire of a jeep was driven over them, about 6 times.

Figure 5 a) and b) show the preparation and compaction of bitumen emulsion surface dressing trials.
Figure 5 a) and b) Preparation and compaction of bitumen emulsion surface dressing

Figure 6 shows the 8 squares (two of a kind) after compaction.

Figure 6 The 8 squares (two of a kind) after compaction

Three days later, excessive and loose chippings were removed by sweeping them off, see figure 7. There was no difference in the amount of loose chippings noted and it was concluded that all the squares had been successful.
The next step was to spray water (about 5°C) with some pressure onto the squares with a water hose for 30 seconds to see if chipping loss occurred. This action was not harmful to any of the squares, as no or very little chipping loss occurred. Therefore, it was decided to increase the agitation and place a car tire on top of one square of each chipping source and turn the wheel all the way to the right and all the way to the left while constantly spraying water onto the surface see figure 8. This agitation led to some chipping loss of all the squares, which is not surprising as the force was considerable, bearing in mind that the squares had not been compacted with a roller and traffic and the binder was still rather soft.

Figure 7 Excessive chippings swept off the squares

Figure 8 Agitation with a turning car tire and water on top of the squares
It was concluded from this testing of surface dressing squares with bitumen emulsion with latex and four different chippings that the production of the emulsion might be considered satisfactory and suitable for all the chipping sources tested.

5 EXPERIMENTAL ROAD SECTIONS WITH MODIFIED BITUMEN

5.1 Road sections in North Iceland in 2013

Two experimental road sections, about 1 km each, were laid in the northern part of Iceland in 2013, one normal softened surface dressing with 6.5% ethylester and 0.9% TPH adhesion agent and the other one exactly the same, but with the addition of 3% SBS modification. The SBS was mixed into the bitumen in the binder distributor by the pumping system as there was no suitable asphalt mixing plant available in the country. The mixing took several days and was not apparently complete after mixing over weekend. Still the sections were laid in July 2013 and no problems occurred during the process. In early winter some chipping loss was noted, both in the sections with and without SBS modification, slightly more in the section without SBS. However, this did not call for repairs and since then, both sections are undamaged. It has been noted at inspections that the effect of the SBS modification on the tensile behaviour of the binder is quite noticeable, when pulling individual chippings out of the surface, see figure 9.

![Figure 9](image)

**Figure 9** The effect of the SBS modification on the tensile behaviour of the binder

The aggregate used in these sections is a very cubical, 8/11 mm basalt with a Flakiness Index of 2%, about 6% undersizes, more than 30% oversizes and 0.8% fines. The chippings are obviously coarser than 8/11 mm, but does not reach 16 mm. The fines content was within limits, which were at that time <1%. So, generally speaking, this experiment with using SBS modified bitumen was successful, even though there was not a very distinct difference between the section with and the section without SBS. Still, there was a chipping loss during the first winter, even more when not using SBS modification, but not to such amount that it damaged the sections.
5.2 Road sections in West Iceland in 2013

Four experimental road sections, about ½ to 1 km each, were laid in the western part of Iceland in 2013. One section was normal softened surface dressing with 6,5 % ethylester and 0,9 % TPH adhesion agent and another one exactly the same, but with the addition of 3 % SBS modification. Those two sections are quite similar to those laid in the north, but the aggregate source was different. As in the north, the SBS was mixed into the bitumen in the binder distributor by the pumping system as there was no suitable asphalt mixing plant available in the country. The mixing took several days and was not complete after mixing over weekend.

The other two sections laid in the west were bitumen emulsions with and without latex. Those were the first bitumen emulsion sections for several years and in fact the first emulsion sections in Iceland with latex modified bitumen. All the sections were laid in one day in late August 2013 and no problems occurred during the process. Figures 10 a) to d) show a part of the laying process and need no further explanation.

![Figure 10 a) to d) Photos of the laying process in west Iceland](image)

All the sections were in good condition when inspected two days after sweeping in August. Still, it was noted that some streaking had occurred between lanes on the bitumen emulsion
section without latex. In October scabbing had occurred at the end of the bitumen emulsion section with latex, but in both cases the defects can be related to mistakes when laying the sections.

In January 2014, fretting and scabbing in the bitumen emulsion section without latex had occurred, especially near both ends, both between lanes and between wheel tracks. The bitumen emulsion with latex was in a much better condition and the tensile strength of the modified bitumen was observed. The sections with ethylester softened bitumen, with and without SBS were mostly in good condition and no defects reported.

In March 2014 it was noted that bitumen emulsion section without latex had more defects, both fretting and scabbing, than when inspected in January, two months earlier. The other three sections had minor fretting here and there, besides all sections being very thin, especially the wheel tracks. Figures 11 a) to d) show the general condition of each of the four sections when inspected in March 2014.

![a) Bitumen emulsion without latex](image1.png) ![b) Bitumen emulsion with latex](image2.png) ![c) Softened bitumen with SBS](image3.png) ![d) Softened bitumen without SBS](image4.png)

Figures 11 a) to d) A view over each of the four sections when inspected in March 2014

It was evident as early as in the spring 2014 that the sections in west Iceland that were laid in August 2013 would have a very short service life, having in mind that the traffic rate was about
2500 AADT. That became evident in 2015 when all the wheel tracks had been abraded through by studded tires.

The chippings used for this experiment was supposed to be 8/11 mm with less than 1 % fines. Evidently, these requirements were not fulfilled, as apparently 35 % of the chipping were under 8 mm (undersize) and the fines were measured 1 %. Additionally, the chippings were quite flaky, with Flakiness Index above 20 %. For those reasons, the surface dressing coat was very thin from the beginning and not likely to withstand the studded tires and snow ploughs used for winter maintenance.

5.3 Road sections laid in 2014 and 2015
Even though the experimental road sections laid in 2013 were not a total success, it was decided to keep the research project going and sections were laid in 2014 and 2015. In 2014 some 18 surface dressing road section with a total length of 15 km were laid with bitumen emulsion, most of them with latex modification. Further experiments with SBS modification were not laid in 2014 and 2015 and the focus set on bitumen emulsions with and without latex.

In 2015 about 30 sections of surface dressing with bitumen emulsion were laid of a total length of 33 km mostly modified with latex. There of about 20 sections were defined as a part of the research project and were specially inspected.

It would be too detailed to go through all the experiments of the years 2014 and 2015, but in general it can be stated that some sections were successfull and others not. This means that either materials, design, construction, aftercare, conditions and/or other factors are not always correct. The defects that have occurred are mostly fretting and streaking, but also the breaking behavior of the emulsion in some cases, especially in relatively hot and sunny conditions. Figures 12 a) to b) show surface dressing shortly after it was laid and again after one winter.

![Figure 12 a) and b)](image-url)Surface dressing with emulsion after it was laid and after one winter
The surface dressing on figure 12 was laid in hot weather conditions on a significantly sloping road with a bend and with heavy traffic. It was noted in the middle of the construction that the emulsion started to flow up on top of the chippings and to prevent this it was decided to lower the quantity of emulsion. After one winter the problem area on the photo to the right was undamaged (red arrow), but where the quantity of emulsion had been lowered (in the front on the photo to the right), serious fretting and scabbing had occurred.

Other common defects were connected with wrong construction practice, such as early streaking between lanes (lack of overlap) and mistake in the spraying of emulsion, see figure 13 a) and b).

![Defects connected with wrong construction practice](image)

a) streaking – insufficient overlap  
b) gap in binder distribution

**Figure 13 a) and b)** Defects connected with wrong construction practice

The defect that is of most concern is the fretting problem (random loss of chippings from the mosaic), either soon after construction or in early winter, see figure 14.

![Early fretting of a surface dressing with bitumen emulsion and latex](image)

**Figure 14** Early fretting of a surface dressing with bitumen emulsion and latex
This defect may be related to insufficient binder or cold weather after operation which results in poor stabilisation of the chippings to form a mosaic. Another cause might be the hardness of the underlying surface which does not allow a proper embedment of the chippings. In either case, if the fretting is recognised at an early stage, the remedial work of fog sealing has proven to save the surface dressing from further fretting in several cases.

6 CLOSING REMARKS

After receiving answers to a questionnaire from the Nordic countries concerning their use of surface dressing, the effort of the project has been to introduce surface dressing with modified binders in Iceland. Some of the experimental road sections have been successful and others have failed, but the project has led to many positive changes, both in the production process of aggregates and bituminous binder and in the laying process and aftercare. The project is not finished in Iceland and experiments with surface dressing with modified bitumen will continue, even though this NVF project (Belegninger) has now finished. The experiments so far have led to a number of improvements, such as:

The answers to the questionnaire from the Nordic countries gave valuable information on how the countries practice the use of surface dressing.

Fines requirements have been lowered from <1 % to <0,5 % in the IRCA guidelines and for the most trafficked roads a requirement of washing the aggregate has now been added in the bid documents.

Producers are required to keep close control of over- and undersizes as well as fines quantity when producing surface dressing aggregates.

The producer of the bitumen emulsion in Iceland (MHC) has built up a laboratory to be able to test the production, for example bitumen content, breaking value, viscosity and sieving residue.

Traffic control on site at construction and after construction has been tightened and the use of speed control vehicles has been introduced where traffic volume is high.

Racking small chippings into coarser chippings in single surface dressing is becoming more common as a part of the operation, not only to prevent damage caused by heavy rain soon after construction.

The Irish guidelines for surface dressing in Ireland have been translated into Icelandic and are at present being reviewed by a group of experts and will be adopted to suit Icelandic materials and practice. Those guidelines address materials, equipment, design, construction practice, records, quality control, inspection and remedial work. It is hoped that the Icelandic translation of the guidelines will improve all the aspects concerning successful laying of surface dressing in Iceland.