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SUMMARY OF DRAINAGE ANALYSIS IN SISIMIUT, GREENLAND

Demonstration Project Report

ABSTRACT

Drainage is one of the most important factors to be kept in mind in road design and maintenance projects. It is accepted generally that road structures work well and last longer in dry conditions. Researches have shown that that poor drainage is often the main cause of road damages and problems with long term road serviceability. This knowledge however has not always been applied in practice with the result that the general drainage condition of the road networks is not good. Previous ROADEX projects have reported that poor drainage is the one of the biggest problems for Northern European rural roads, and parts of the main road network.

Drainage analysis was developed to locate those critical sections, needing improvement and after that regular attention and maintenance. Usually a drainage analysis is done visually from a moving car and later from digital videos with input from road historical performance data (roughness and rutting). In Greenland case roughness and rutting data was not available which caused limitations for the statistical analysis.

This report "Summary of Drainage Analysis in Sisimiut, Greenland" describes the results of the ROADEX drainage demonstration project in the Sisimiut area of Greenland. The Sisimiut demonstration project was the first project to use the ROADEX drainage analysis solely in an urban area. In addition to visual evaluations a laser scanner was also used. Overall the surveyed drainage sections proved to be in moderate condition. Mainly the problems were related to a side sloping street profile and/or clogged access road culverts. Other specific reasons for poor drainage were also detected. The data collected by the laser scanner was useful for detecting the depth and form of the ditches, and changes in road cross sections. The report concludes with recommendations on road sections that should receive immediate maintenance attention and sections that will need attention eventually.

KEYWORDS

Drainage, analysis, urban area, pavement, life time, laser scanner

PREFACE

This task “Summary of drainage analysis results in Sisimiut, Greenland” was carried out in ROADEX IV work package 3, Local demonstrations.

The field measurements were performed by Seppo Tuisku with the help of Arctic Technology Centre (ARTEK). Arne Villumsen from Danmarks Tekniske Universitet (DTU) and Rasmus Nielsen from Arctic Technology Centre (ARTEK) helped with the arrangements of the survey. Nils Hoedeman from Danmarks Tekniske Universitet (DTU) arranged accommodation and the flights to Greenland. Rasmus Lind Jensen and Lucie Gros participated in the field surveys and Rasmus Lind Jensen later implemented the survey in Nuuk with the same equipment. Processing and analysis of the measured data was carried out by Seppo Tuisku. The report was written jointly by Seppo Tuisku and Annele Matintupa. Rasmus Lind Jensen subsequently carried out a drainage analysis for the Nuuk area and this work is presented in a separate report. Timo Saarenketo steered the demonstrations as lead manager of the ROADEX D1 “Drainage Maintenance Guidelines” group. Ron Munro helped with the demonstration arrangements and checked the language. Mika Pyhähuhta from Laboratorio Uleåborg designed the report layout.

Finally the authors would like to thank the ROADEX IV Project Steering Committee for their guidance and encouragement in the work.

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1. INTRODUCTION

1.1 THE ROADEX PROJECT

The ROADEX Project is a technical co-operation between road organisations across northern Europe that aims to share road related information and research between the partners. The project was started in 1998 as a 3 year pilot co-operation between the districts of Finland Lapland, Troms County of Norway, the Northern Region of Sweden and The Highland Council of Scotland and was subsequently followed and extended with a second project, ROADEX II, from 2002 to 2005, a third, ROADEX III from 2006 to 2007 and a fourth, ROADEX IV from 2009 to 2012.



Figure 1: The Northern Periphery Area and ROADEX IV partners.

The Partners in ROADEX IV “Implementing Accessibility” comprised public road administrations and forestry organisations from across the European Northern Periphery. These were The Highland Council, Forestry Commission Scotland and Comhairle Nan Eilean Siar from Scotland, The Northern Region of The Norwegian Public Roads Administration, The Northern Region of The Swedish Transport Administration and the Swedish Forest Agency, The Centre of Economic Development, Transport and the Environment of Finland, The Government of Greenland, The Icelandic Public Road Administration and The National Roads Authority and The Department of Transport of Ireland.

The aim of the Project was to implement the road technologies developed by ROADEX on to the Partner road networks to improve operational efficiency and save money. The lead partner for the project was The Swedish Transport Administration and the main project consultant was Roadscanners Oy of Finland.

A main part of the Project was a programme of 23 demonstration projects showcasing the ROADEX methods in the Local Partner areas supported by a new pan-regional “ROADEX Consultancy Service” and “Knowledge Centre”. Three research tasks were pursued as part of the project: “Climate change and its consequences on the maintenance of low volume roads”, “Road Widening” and “Vibration in vehicles and humans due to road condition”.

All ROADEX reports are available on the ROADEX website at www.ROADEX.org.

1.2 THE DEMONSTRATION PROJECTS

Twenty three demonstration projects were planned within the ROADEX IV project. Their goal was to take selected technologies developed by ROADEX out on to the local road networks to have them physically used in practice to show what they could achieve. The projects were funded locally by the local Partners, designed and supervised by local staff, and supported by experts from the ROADEX consultancy.

The demonstrations were managed in 6 groups by a nominated lead manager from ROADEX:

- D1 - "Drainage Maintenance Guidelines"
- D2 - "Road friendly vehicles and Tyre Pressure Control"
- D3 - "Forest Road policies"
- D4 - "Rutting, from theory to practice"
- D5 - "Roads on Peat"
- D6 - "Health and Vibration"

This report deals with the demonstrations project in the D1 "Drainage Maintenance Guidelines" group carried out in Greenland.

2. STREETS SURVEYED

The drainage demonstration project was carried out in the city area of Sisimiut. The streets for survey were chosen by the Arctic Technology Centre (ARTEK). Overall 17,240 metres in 20 streets were surveyed in Sisimiut. The length of the surveyed streets varied from 130m to 3710m, the longest section was the road to Sisimiut airport (Asummiunut). One gravel road section was also included (Aqqusinersuaq gravel). The streets surveyed are shown in Figure 2 and a summary of their lengths is given in Table 1.



Figure 2: The surveyed street network in the Sisimiut area, Greenland

The terrain in Sisimiut area is mostly dry, and bedrock is close to the surface. Problems with the drainage condition are mostly due to lack of maintenance, or in some cases the absence of a drainage system altogether.

Table 1. The surveyed street sections and their lengths.

Street	From (Survey Direction)	Length m
Adammip	Karl Sivertssenip	740
Aggartarfik	Aqqusinersuaq	130
Aqqaluartaap	Eggaavimmut	325
Aqqusinersuaq	Umiarsualisimmut	2000
Aqqusinersuaq gravel	Aqqusinersuaq	1990
Asummiunut	Bridge	3710
Eggaavimmut	Aqqaluartaap	935
Fahlip	Aqqusinersuaq	480
Glahnip	Aqqusinersuaq	365
Guutaap	Aqqusinersuaq	185
Jooruaqqap	Umiarsualisimmut	420
Kaaliikassaap	Eggaavimmut	655
Karl Sivertssenip	Aqqaluartaap	300
Muunup	Aqqusinersuaq	1500
Nikkorsuit	Glahnip	950
Paamap Kuua	Aqqusinersuaq	245
Qiviarfik	Nikkorsuit	475
Saamualip	Aqqusinersuaq	250
Ulkebugt	Muunup	1225
Umiarsualisimmut	Aqqusinersuaq	360

3. DATA COLLECTION, FIELD SURVEYS

3.1. GENERAL

The data collection surveys for the Sisimiut drainage demonstration were carried out in August 2011. The weather during the surveys was mostly dry but some drizzle occurred and also fog impaired visibility at times. Traffic in the urban area caused some delays to the surveys at times.

All of the surveyed street sections commenced at an intersection, the only exception being the road to the airport (Asummiunut) which was started after the Bridge. The surveyed sections also ended at intersection in most cases.

3.2. VIDEO AND GPS

Drainage analysis in the field was carried out on one street section at a time and both sides of the street were analyzed separately. The Arctic Technology Centre (ARTEK) provided the survey vehicle and CamLink video-logging system by Roadscanners Oy was installed on the van roof (Figure 3). Driving speed during the data collection varied due to the traffic on the street but was mostly between 10-30 km/h. The GPS device model used for positioning was an APD Communications INCA 2. All of the data was linked to GPS using Road Doctor™ CamLink software.



Figure 3. ARTEK provided the survey vehicle used in the project. Video cameras were placed in the orange CamLink box for shelter from the rain and dust. A laser scanner was attached to the trailer hitch and to the roof rack.

Two video cameras in a CamLink box were used in the survey, one camera to record the view of the street and the second camera to record the edge of the street and the ditch, where a ditch was present.

Two laptops were used to record the video and laser scanner data at the same time. The preliminary classifications were recorded by using the laptops keyboard (Figure 4). Audio comments were additionally recorded to help the office work. These audio comments were mainly

about the drainage condition and to correct any mistakes with classification entered through the keyboard. The preliminary analysis was adjusted later in the office. This was done mainly with the help of data from the street camera, but the side camera view was also very useful in having a closer look to the ditches where they existed.



Figure 4. Two laptops were used for data collection on the road.

3.3. LASER SCANNER

In recent years the greatest developments in all of the NDT techniques used in road surveys have been made with laser scanners, and it is a fact that these systems will fast become a standard tool for a variety of tasks in road condition management. More detailed information regarding the use of laser scanners is available in the ROADEx report “New Survey Techniques in Drainage Evaluation” by Annele Matintupa and Timo Saarenketo.

Laser scanning is a technique where the distance measurement is calculated from the travel time of a laser beam from the laser scanner to the target and back. When the laser beam angle is known, and beams are sent out to different directions from a moving vehicle with known position, it is possible to make a 3d surface image, or “point cloud”, from the road and its surroundings. In the point cloud with millions of points, every point has an x, y and z coordinate and a number of reflection, or emission characteristics.

The accuracy of the laser scanner survey can be reduced by different factors reducing visibility, such as dust, rain, fog or snow. Also high vegetation can prevent information being obtained from the ground surface.

A laser Scanner is composed of three parts, the laser canon, a scanner and a detector. The laser canon produces the laser beam, the scanner circulates the laser beam, and the detector measures the reflected signal and defines the distance to the target. The distance measurement is based on the travel time of light, or phase shift, or a combination of both.

The quality and price of mobile laser scanner survey systems vary but they can be roughly classified into two categories a) highly effective high accuracy systems and b) cheaper “everyman’s” laser scanner systems that have reduced distance measurement capability and accuracy.

Laser scanner results can be used in several different ways in low volume road surveys. A road cross section profile can provide good information on the shape of rutting and if there are verges preventing water flowing away from the pavement. A map showing surface levels in colour codes can be prepared to identify the places with debris filled ditches and clogged culverts. The changes in width of the road can also be easily seen from the maps. When other road survey data is combined with laser scanner data it can provide excellent basic information for analysing permanent deformation and road diagnostics.

In this project the data collection was carried out using a SICK LMS151 laser scanner (Figure 5). The laser scanner was mounted to the back of the survey van (seen in Figure 3).



Figure 5. The SICK LMS151 laser scanner in close-up.

The data analysis was carried out with the new Road Doctor™ Laser Scanner (RDLS) module of Road Doctor™ software. This module facilitates integrated analysis of the laser scanner data and other road survey data.

4. DRAINAGE ANALYSIS

4.1. GENERAL

The Greenland drainage demonstration project in Sisimiut was the first ROADEX drainage project to be implemented solely in an urban area. The circumstances in Sisimiut differed significantly however from the Nordic countries where the ROADEX drainage survey method was originally developed. It was not possible to carry out rutting and roughness analyses, as in previous projects, as the data was not available for Sisimiut streets.

Sisimiut town is located in a hilly area which naturally causes height changes to the streets in both longitudinal and lateral directions. A major difference from previous drainage surveys was the presence of ditches made of concrete. Most of these drains worked well and seemed to be a good solution. Flooding events cannot flush material from paved ditches unlike excavated ones.

4.2. TYPICAL DRAINAGE DEFICIENCIES IN SISIMIUT

4.2.1. Drainage Deficiencies in Side Sloping Street Profiles

In the earlier ROADEX drainage analysis projects it was found out that the upper side of the side sloping road profile could pose problems. This appeared to be the case also in the urban area of Sisimiut. In some side slopes the ditch was found to be too shallow or otherwise ineffective and in other cases there was no drainage system at all. Figures 6-9 show some typical drainage deficiencies in side sloping street profiles.



Figure 6. Adammip; Shallow concrete ditch on the upper side of the slope, with damages in the edge of the pavement (marked with red circle).



Figure 7. Jooruaqqap; No drainage system on the upper (right) side of the side slope, problems also on the lower (left) side



Figure 8. Muunup; No drainage system on the upper side (right) of the steep side slope, damages in the edge of the pavement (marked with red circle).



Figure 9. Saamualip; No working drainage on the upper (right) side of the side slope

4.2.2. Clogged Culverts on Access Roads

The drainage surveys also revealed that some of the accessing road culverts were clogged with soil and rubbish. In most cases these culverts just need cleaning out, but it is recommended that the condition of the culvert should be checked at the same time, and the culvert replaced if necessary. Typical examples of clogged access road culverts are shown in Figures 10-11.



Figure 10. Clogged access road culvert on Jooruaqqaap. Note the water trapped on the upper side of the culvert.



Figure 11: Eggaavimmut; Soil and rubbish in an access road road culvert.

4.2.3. Other Drainage Deficiencies

Some street sections did not have drainage system at all. In these cases the road surface water did not have proper exit way from the pavement and this could cause problems over time. This was the case especially in some road sections located in cuttings. Some of the old concrete ditches were in a poor condition. It is recommended that these should be repaired or, if this is impossible, that they are replaced with an open ditch or some other drainage system. Examples of other drainage deficiencies are shown in Figures 12-19.



Figure 12. Adammip; no existing drainage system, potholes in the middle of the lane.



Figure 13. No ditches on both sides of the street in Eggaavimmut



Figure 14. No room for a ditch in Glahnip.



Figure 15. Jooruaqqap; No drainage system in a road cut.



Figure 16. No drainage system in Qiviarfik in a road cut.



Figure 17. Nikkorsuit; No drainage system



Figure 18. Saamualip; No ditch on the right, the ditch on the left needs cleaning.



Figure 19. Partly destroyed concrete ditch in Glahnip street.

4.2.4. Drainage Deficiencies on the Road Outside the Urban Area

The road to the airport, Asummiunut, was the only road section surveyed outside the urban area. Asummiunut lies on a hillside which makes the road profile mostly side sloping (57%). The general circumstances of the road were the closest to Nordic countries roads and the drainage was found to be in good condition. A total of 81% of the section was classified as being drainage Class 1 and the only drainage deficiencies that were found were partly blocked ditches in the upper side of the slope. Examples of typical drainage deficiencies on the road are shown in Figure 20.



Figures 20. Stones are slowing down the water flow in Asummiunut.

4.2.5. Gravel Road Drainage Deficiencies

Drainage analysis has also been used on gravel roads in Nordic countries and one gravel road section, Aqqusenersuaq, was selected as a demonstration section for drainage analysis in Greenland circumstances.

The selected section was mostly in side sloping road profile (81%) and the drainage deficiencies found were fairly typical for the road conditions. This road had long sections without existing drainage system on the upper side of the slope which could cause erosion risks in some circumstances.



Figures 21. Aqqusenersuaq gravel road; No ditch on the upper side of the side slope.

4.3. DRAINAGE CLASSIFICATION

The drainage classification of the surveyed roads was carried out using the principles outlined in this chapter. A complete description of the ROADEX drainage analysis classification is given in the ROADEX report “Drainage Survey Method Description”. The main difference in the Greenland demonstration project from that of the earlier drainage projects was that the surveyed sections were located in the urban area.

The drainage classification in Sisimiut was based on the following ROADEX drainage descriptions:

4.3.1. Class 1; Drainage in Good Condition

Drainage Class 1 means that the drainage condition is faultless. The cross-section of the road has preserved its form well and water flows unrestricted from the pavement to the ditch. Water has also a clear passage in the ditches.



Figures 22. Example photographs of drainage Class 1 in Sisimiut.

4.3.2. Drainage Class 2; Drainage in Adequate Condition

In drainage Class 2 there can be some visible changes to the road cross-section. The road shoulder has narrow verges or vegetation growth that is preventing the free flow of surface water from the road surface into the ditch. There is some vegetation in the ditch that restricts water flow

and creates damages. Some soil is sliding from the road side slope into the ditches and raising the bottom of the ditch.



Figures 23. Example photographs of drainage Class 2 in Sisimiut.

4.3.3. Drainage Class 3; Drainage in Poor Condition

Drainage Class 3 covers those road sections with severe drainage problems. The road shoulder has a high verge and/or dense vegetation that are causing ponding on the traffic lane or on the shoulder. Vegetation is growing in the ditches and restraining the flow of water creating dams in the ditches. Unstable soil is flowing from ditch slopes into the bottoms of ditches and blocking the flow of water. Clogged culverts or outlet ditches is preventing the flow of water in the ditch. In the Sisimiut urban area many of the drainage Class 3 sections did not have a drainage system at all in some locations and clearly needed one. This was seen to be causing deformation and damages at the time of the surveys.



Figures 24. Example photographs of drainage Class 3 in Sisimiut.

5. DRAINAGE ANALYSIS RESULT

5.1. DRAINAGE CONDITION IN AVERAGE

The drainage condition in Sisimiut was examined statistically, and in general the drainage was found to be in moderate condition. The distribution of the assessed drainage classes is summarised in Figure 25. The distribution of average drainage classes in each road section surveyed is presented in Figures 26-29. The gravel road section (Aqqaluartaap) has not been included in the summary as the map material available only covered part of the road.

The drainage condition in the Sisimiut urban area was found to be variable. Umiarsualisimmut Street was in the best condition and was rated as drainage Class 1. Ulkebugt appears to be in poor condition statistically but this was mainly due to maintenance work being carried out at the time of the field survey. Saamualip, Eggaavimmut and Glahnip were the worst street sections for drainage condition statistically.

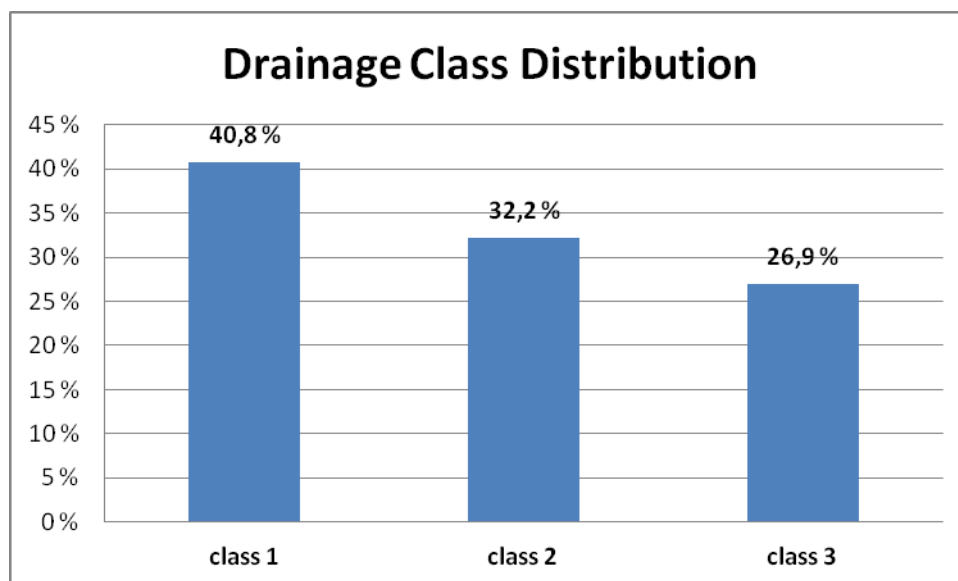


Figure 25. Distribution of the drainage classes on the surveyed streets



Figure 26. Distribution of average drainage classes in north-west part of the surveyed area.

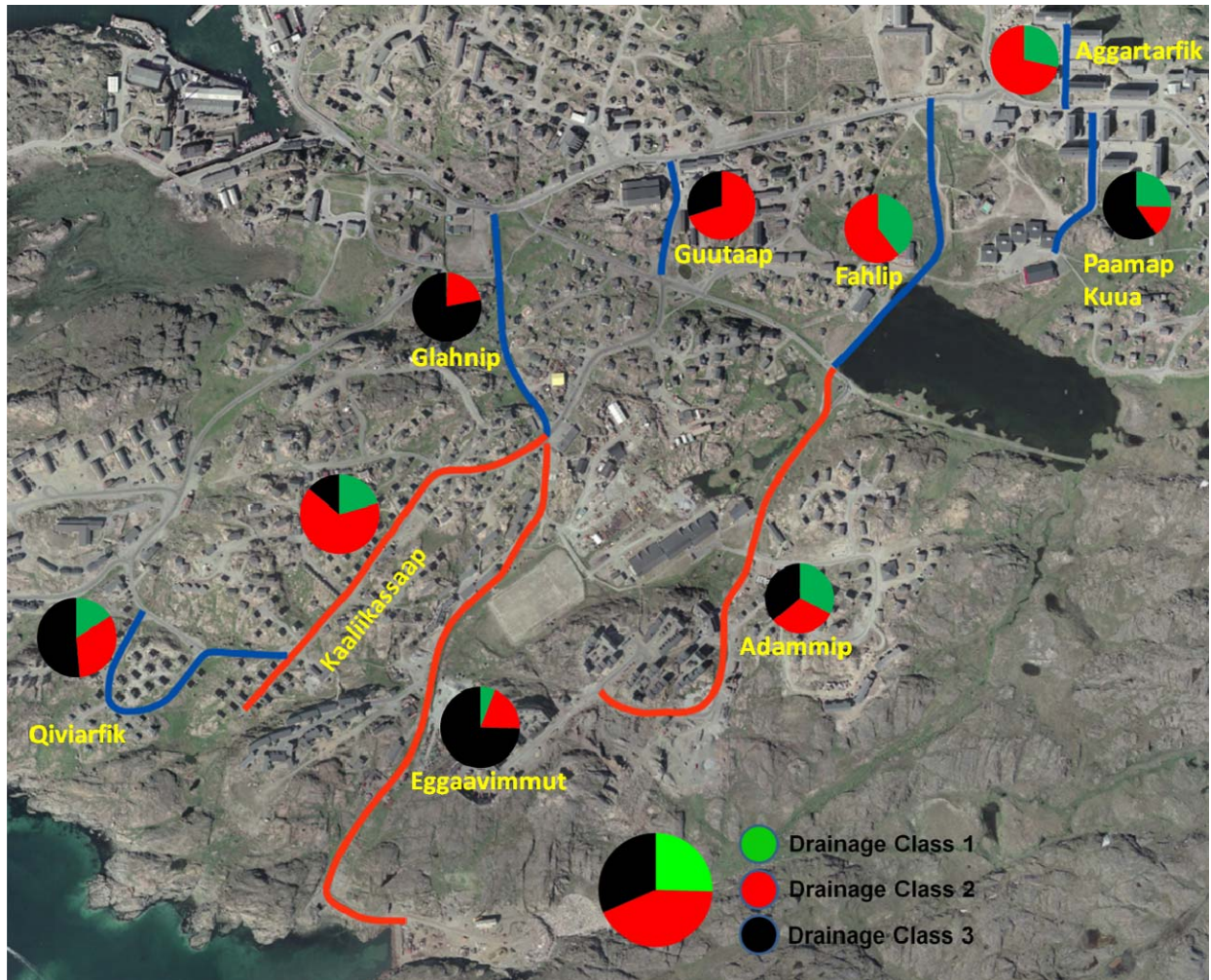


Figure 27. Distribution of average drainage classes in the south of the area.

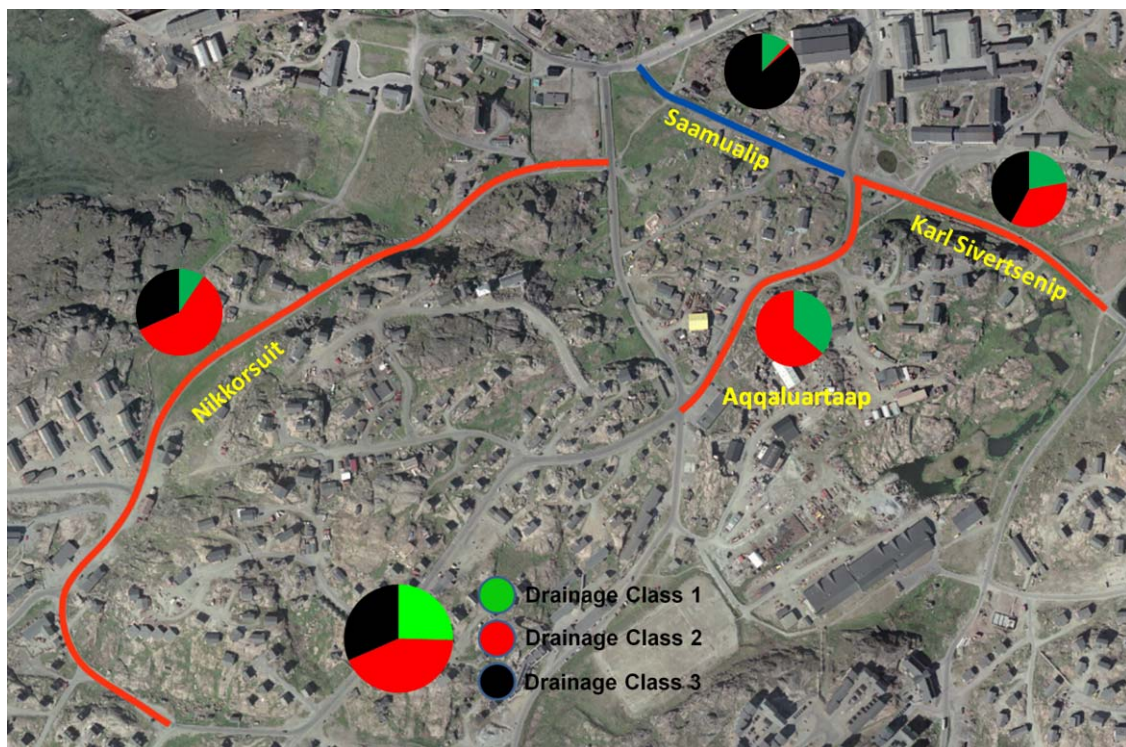


Figure 28. Distribution of average drainage classes in the north-east part of the area.

A GIS map showing the drainage classification of the Asummiunut road abstracted from Road Doctor™ is given in Figure 29. From this it can be seen that the Asummiunut drainage was in generally good condition. The road profile classification (in the middle) shows that most of the road had a side sloping road profile. Asummiunut was also longest road section surveyed.

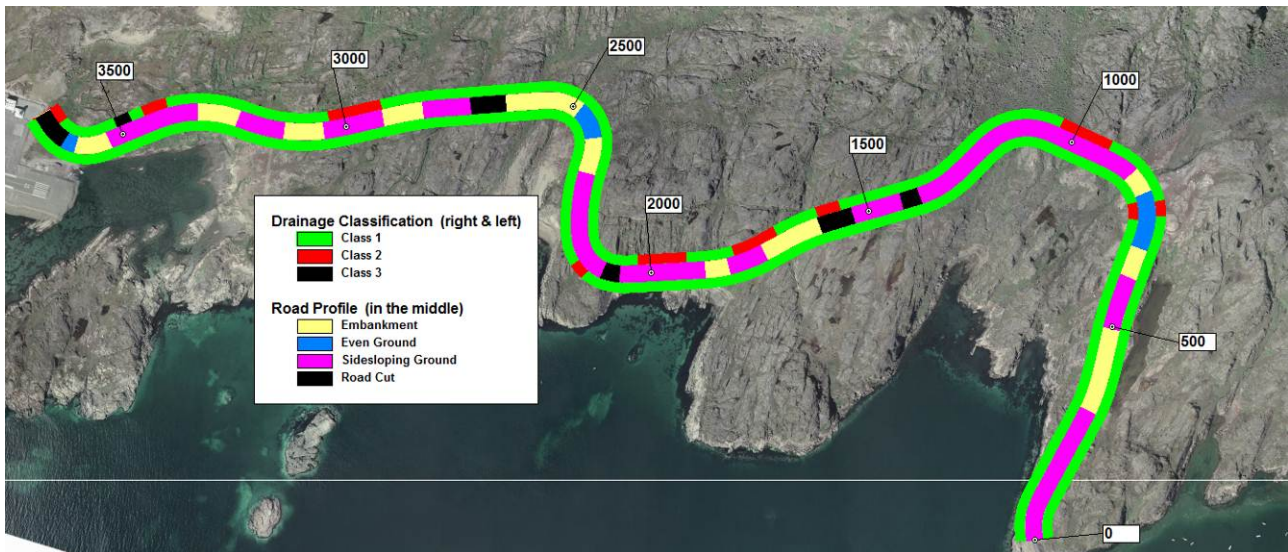


Figure 29. Asummiunut drainage and road profile map. The middle coloured line indicates the road profile. The drainage classes of the roadside ditches are given on the outside.

The distribution of the road profiles of all the surveyed paved roads in Sisimiut is presented in the Figure 30. This shows that a little less than two thirds (64.9%) of the surveyed area were located in side sloping road profile. Only 8.2% of the surveyed roads was located on embankment.

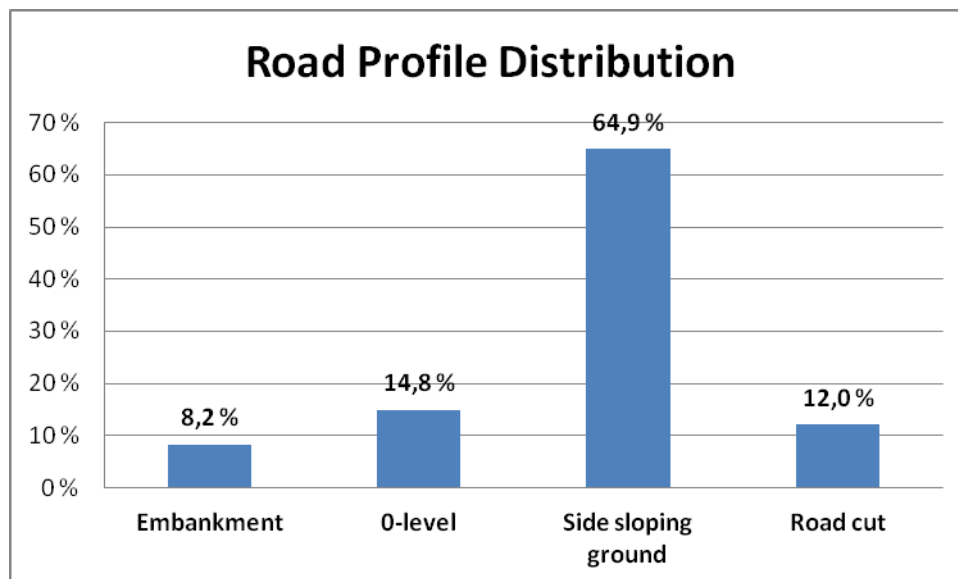


Figure 30. Distribution of the road profiles of surveyed roads

The variation of drainage class between the different road profiles is similar to the results of the earlier ROADDEX demonstration projects in the Nordic countries. Road cuts have on average the poorest drainage condition and embankment have the best drainage condition (Figure 31).

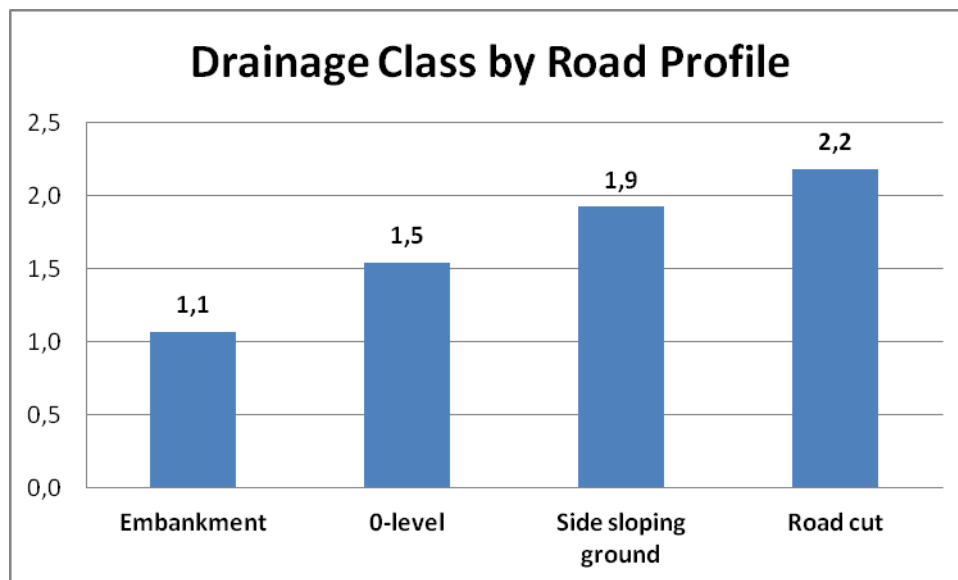


Figure 31. Average drainage classes by road profile.

6. LASER SCANNER RESULTS

The Greenland project was the first ROADEX demonstration project to trial the use of a laser scanner in a drainage analysis of an urban area. The circumstances in Sisimiut were challenging for the laser scanner survey as many of the surveyed streets did not have open ditches. A laser scanner survey is at its best for drainage analysis in an environment of open ditches where it can measure the depths of the ditches. It is even better if the ditch depth information can be integrated with layer thickness data from a ground penetrating radar survey.

Nevertheless some interesting observations were found from the laser scanner data. A couple of interesting examples are presented in the following figures.

An example from Adammip street, where the rutting on the right is clearly visible in the laser scanner data. The ditch can be seen to be shallow on the road cut side of the cross section (Figure 32).

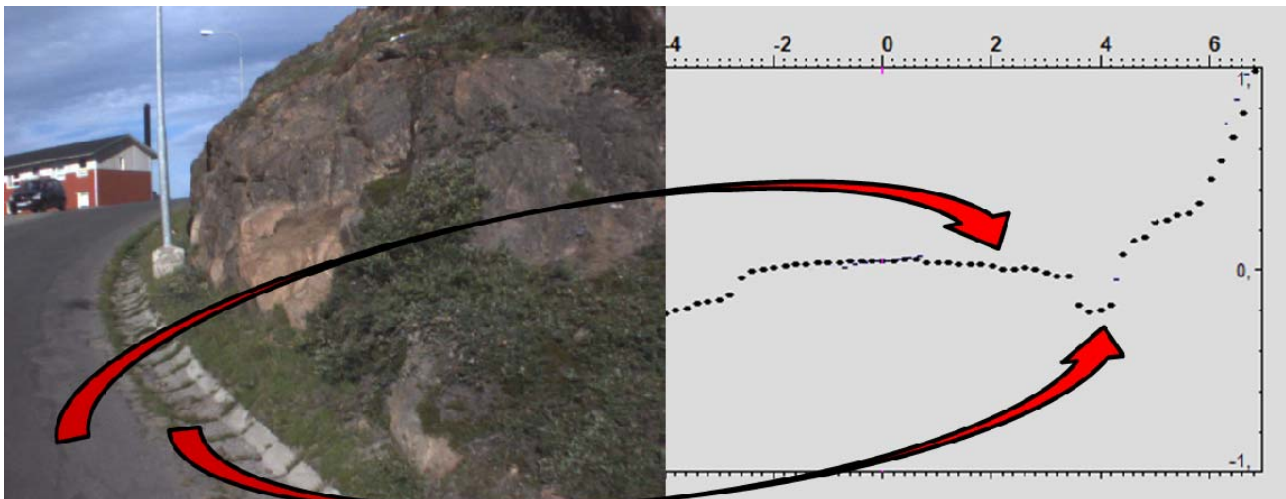


Figure 32. Cross-section showing laser scanner data from Adammip. The upper red arrows indicates ruts on the right edge of the street and the lower arrow indicates the shallow ditch. Both features can be clearly seen in the output from the laser scanner.

On Aqqaluartaap Street the road profile slopes mainly from right to left. The ditch on the right side is deep enough and the shape of the shoulder is good. The ditch is made of concrete (Figure 33).

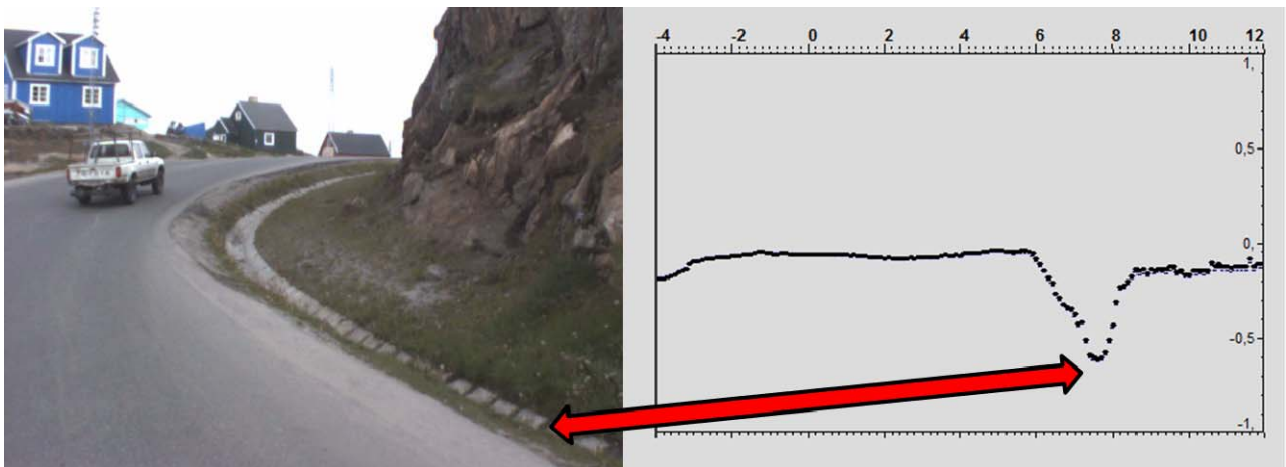


Figure 33. Cross-section showing laser scanner data from Aqqaluartaap. The red arrow indicates the ditch which is in good condition and deep enough. The ditch bottom can also be clearly seen in the output from the laser scanner.

Verges were not a significant problem on the surveyed street sections. Some street sections with verges were detected and they could also be seen in the laser scanner data. Figure 3 shows an example of a high verge from Glahnip Street.

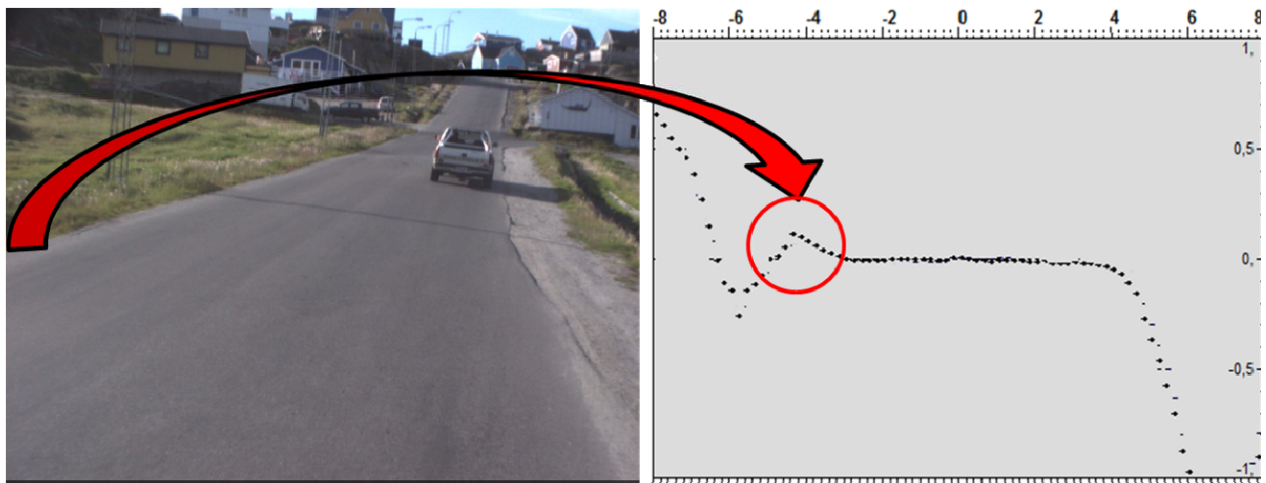


Figure 34. Cross-section showing laser scanner data from Glahnip; The high verge on the left edge can also be clearly seen in the output from the laser scanner.

On Kaaliikassaap the road profile comprised a road cut and on the right bend there was deep rutting. The ditch on the right hand side was in acceptable condition.

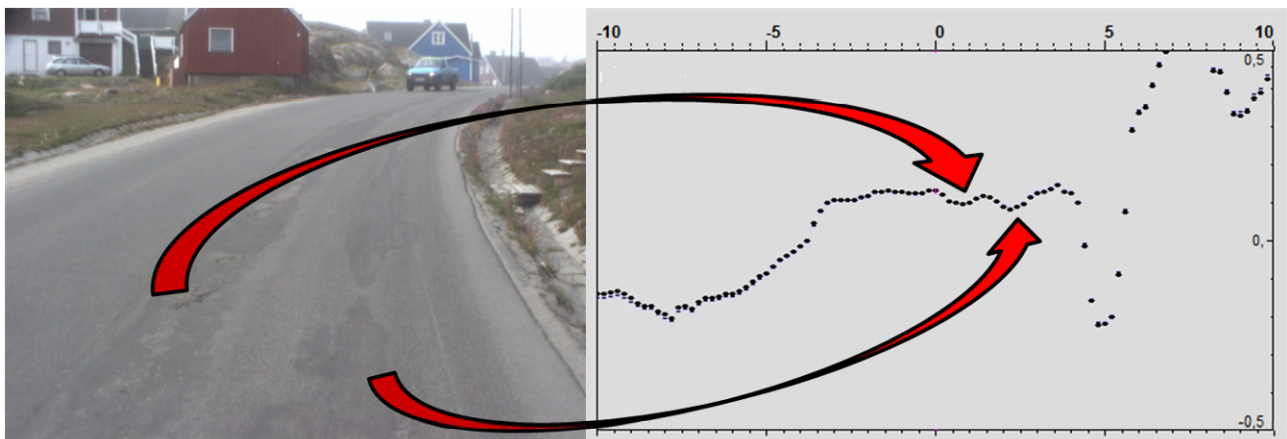


Figure 35. Cross-section showing laser scanner data from Kaaliikassaap. Major rutting is present and can be clearly seen both in the output from the laser scanner and the digital video.

On the street sections where an open ditch was present, it was possible to calculate the depth of the ditch from the laser scanner data and present it in an analysis field to be compared with other road data. The red line in Figure 36 presents the depth of the left ditch and blue line presents the depth of the right ditch.

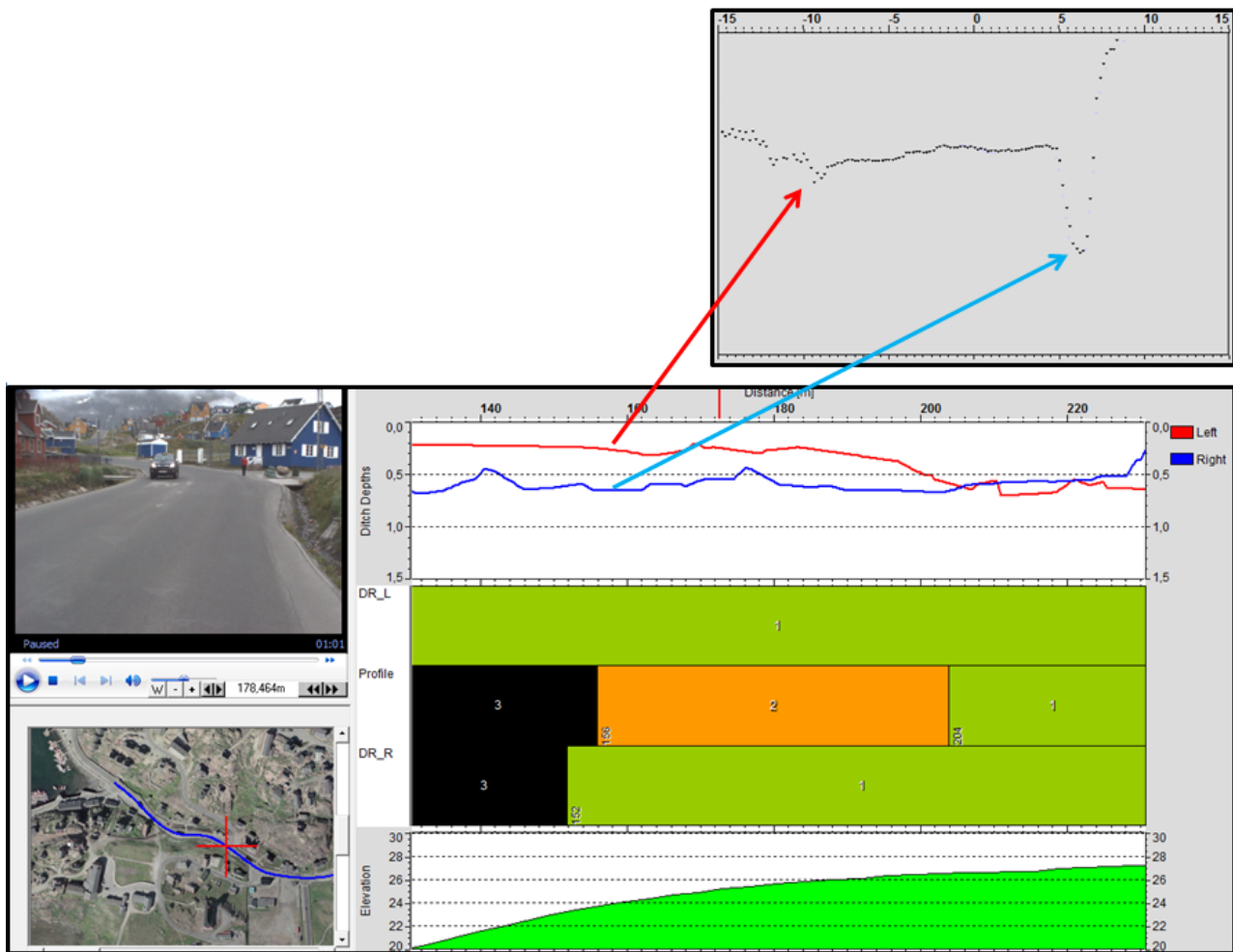


Figure 36. Ditch depth presented in Road Doctor™ analysis view. The example shown is from Akqusinersuaq. The top panel shows the ditch depths, the middle panel shows the drainage class and road profile, and the bottom panel gives an indication of the elevation of the road. A video and map is on the left side. All of the data on the screen can be reviewed integrated. The cross-section has been prepared from laser scanner data. The ditch bottoms are marked with arrows.

Changes in the topography of the pavement surface can give a good indication of those areas of the road with deformation or frost problems. The use of a “rainbow” map of the road surface makes it considerably easier to visualize these deviations. These maps show the road surface topography and its deviations and damage.

Figure 37 shows a section from Fahlip street as a rainbow map. Overall the Fahlip Street pavement is relatively new and in good condition. In the foreground of the photograph there is an unevenness in the street surface (dotted white circle) which is clearly visible in the surface topography rainbow map (upper white dotted circle). The cross section at the point is shown on the right side, and it is also marked on the surface map with a black dotted line.

The continuity of the surface topography map breaks at the point where the unevenness occurs. Once the unevenness ends the continuity in the topography map returns (from 380m chainage).

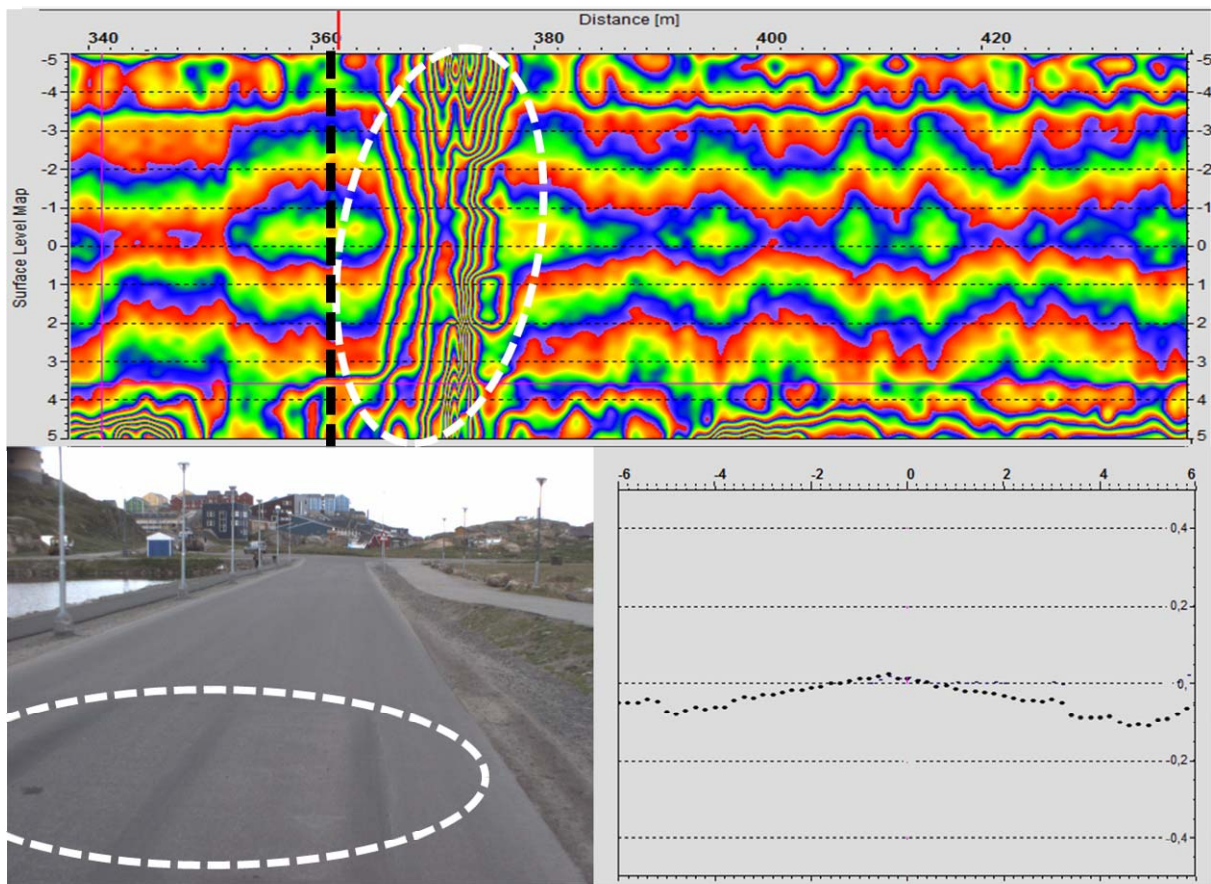


Figure 37. Pavement surface topography map from Fahlip street shown as a rainbow map together with a still photograph and cross section

7. DRAINAGE IMPROVEMENT DESIGN

7.1. GENERAL

In many ROADEX countries drainage, and drainage improvement, has a low priority despite research proving that it is important that road drainage should be kept in a good working condition. Nowadays a number of issues have to be considered when planning drainage work. What is the best way to organize it? Should the work be the responsibility of the maintenance contractor or pavement contractor? Etc.

It is not just enough that problematic sites are improved, it is vital that the improved sections are also kept in a good condition. Constant monitoring and maintenance of the improved drainage is vital to ensure that good drainage work remains effective. The ROADEX II project has shown that if the drainage can be kept in good condition, the pavement lifetime can be increased by 1.5-2 times.

7.2. IMPROVEMENT DESIGN IN SISIMIUT URBAN AREA

The demonstration project in Sisimiut, Greenland, set out to demonstrate the ROADEX drainage analysis and prepare a design for future maintenance sections. However as already mentioned, roughness (IRI) and rutting data was not available for Sisimiut and as a result, the sections for maintenance improvement were selected by visual observation based on experience from previous drainage projects.

The sections to be improved were divided into two categories. “Category 1” comprised maintenance work that should be done as soon as possible. “Category 2” comprised those sections that needed improvement but were not critical. The selected sections were printed on to aerial maps using Road Doctor™ software. These are shown in figures 37-39.

A road in an urban environment normally has a larger range of drainage elements than road in a rural environment and for this reason recommended drainage measures are not specified in detail. As an example, what should be done with broken concrete ditches? Most of the concrete ditches are in good condition, but should the broken sections be removed, replaced or repaired?

Saamualip, Eggaavimmut and Glahnip streets have the highest percentage of Category 1 maintenance sections where the maintenance work should be done as soon as possible.

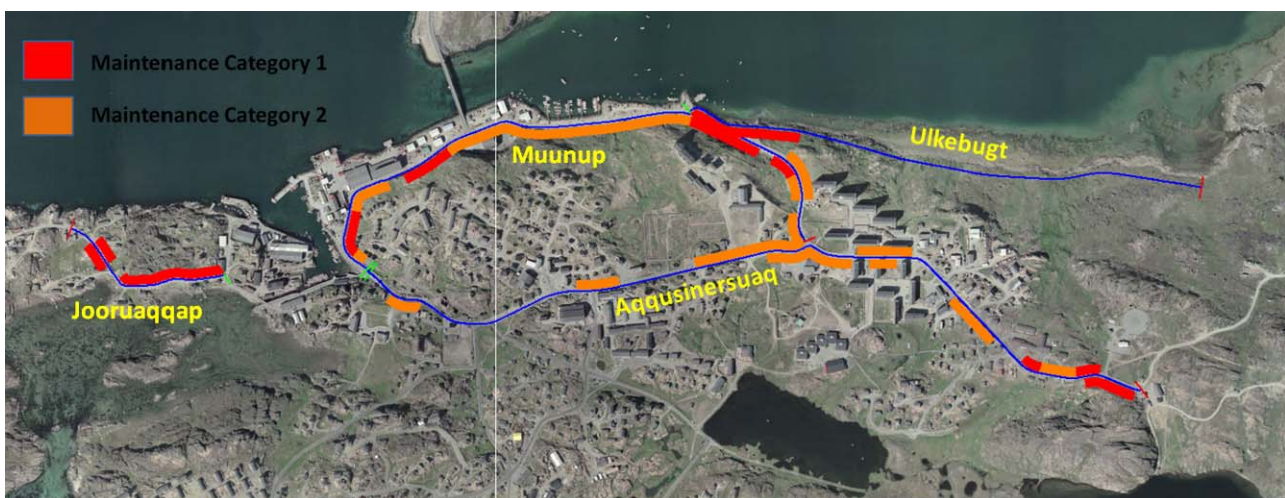


Figure 38. Sections for maintenance in the north-west part of the surveyed area.

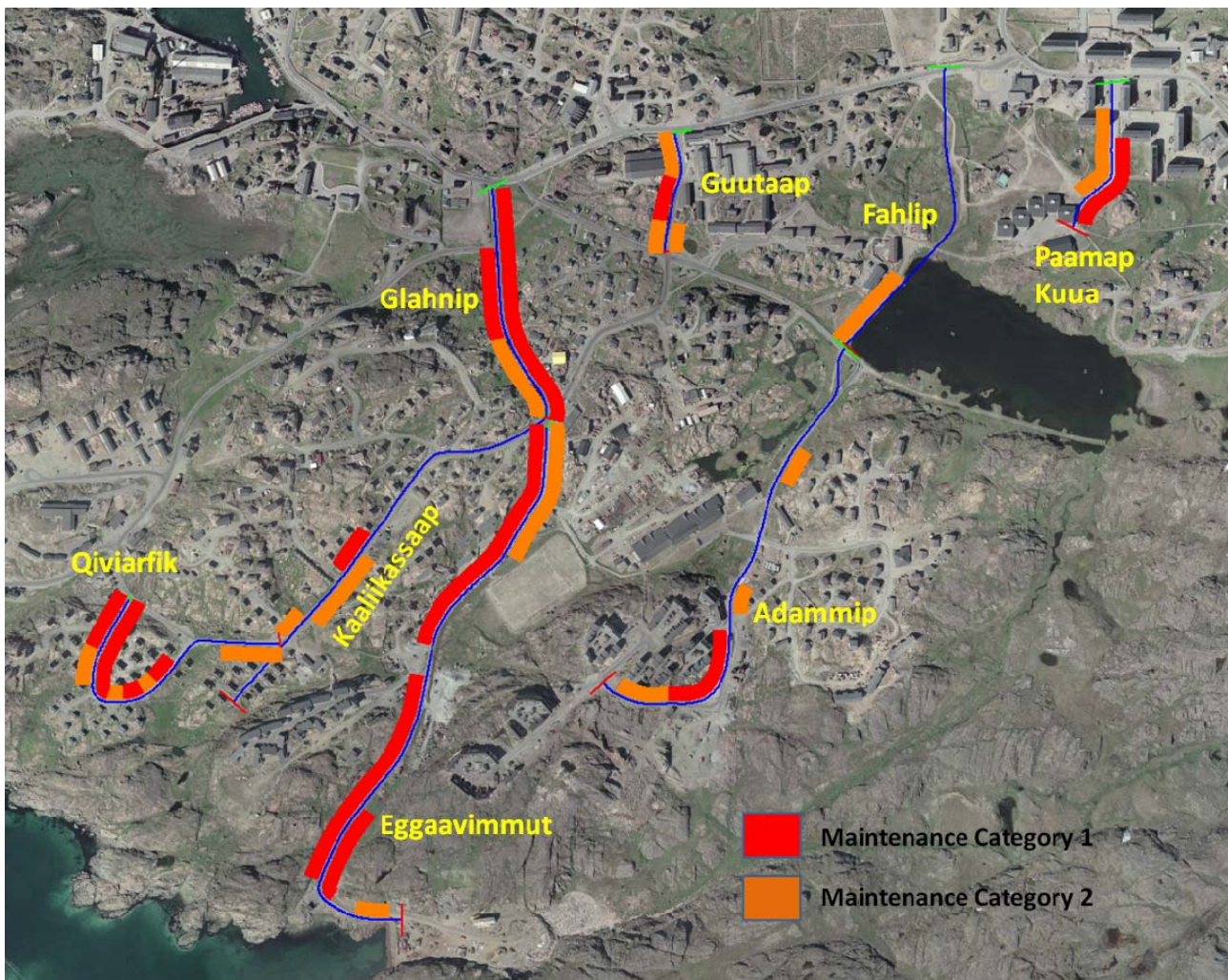


Figure 39. Sections for maintenance in the south part of the surveyed area.

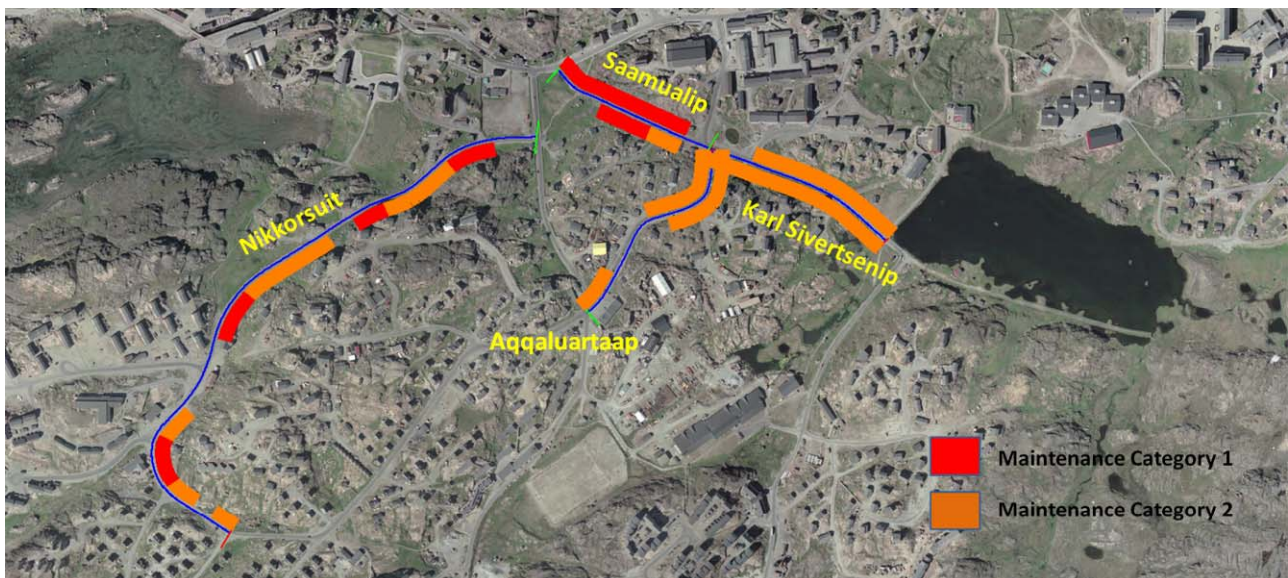


Figure 40. Sections for maintenance in north-east part of the surveyed area.

8. CONCLUSIONS

A ROADEX drainage demonstration project was conducted on 18 street sections and two road sections in Sisimiut, Greenland. This included a section on a gravel road. The lengths of the surveyed street sections varied from a few hundred metres to two kilometres, and the longest was the road to the airport (Asummiunut) which was 3700m. The field measurements were carried out in August 2011.

It was found that in general the road drainage in Sisimiut was in moderate condition. Roughly 41% of the surveyed chainage was classified as drainage Class 1, but on the other hand 27% was classified as drainage Class 3 (severe drainage deficiencies). The road to the airport was in good condition with 80.9% of the chainage classified as drainage Class 1. The only gravel road surveyed, the gravel part of Aqqusinersuaq, had severe drainage problems and 70.3% of the road was classified as drainage Class 3.

Typically the poorest drainage sections were located in side sloping ground, as was the case in previous ROADEX drainage demonstration projects. Clogged access road culverts were also seen to present drainage problems. Few verges were detected in the Sisimiut area. These were not a source of major problems.

A laser scanner was used for the first time in an urban area. This enabled road features to be detected that affected drainage condition. The laser scanner could even have been more useful if the data could have been combined with ground penetrating radar data. This would have made it possible to compare the bottom of road structure to the bottom of the ditch depth. Drainage guidelines generally specify that the bottom of the ditch should be 20cm lower than the bottom of road structure to assure that drainage functions well.

The experiences and results of the demonstration project confirm that the ROADEX drainage analysis can be applied to urban street areas. However it has to be remembered that urban areas can have different kinds of features than rural roads. These features have to be taken into account when designing future maintenance works.



ROADEX PROJECT REPORTS (1998–2012)

This report is one of a suite of reports and case studies on the management of low volume roads produced by the ROADEX project over the period 1998-2012. These reports cover a wide range of topics as below.

- Climate change adaptation
- Cost savings and benefits accruing to ROADEX technologies
- Dealing with bearing capacity problems on low volume roads constructed on peat
- Design and repair of roads suffering from spring thaw weakening
- Drainage guidelines
- Environmental guidelines & checklist
- Forest road policies
- Generation of 'snow smoke' behind heavy vehicles
- Health issues raised by poorly maintained road networks
- Managing drainage on low volume roads
- Managing peat related problems on low volume roads
- Managing permanent deformation in low volume roads
- Managing spring thaw weakening on low volume roads
- Monitoring low volume roads
- New survey techniques in drainage evaluation
- Permanent deformation, from theory to practice
- Risk analyses on low volume roads
- Road condition management of low volume roads
- Road friendly vehicles & tyre pressure control
- Road widening guidelines
- Socio-economic impacts of road conditions on low volume roads
- Structural innovations for low volume roads
- Treatment of moisture susceptible materials
- Tyre pressure control on timber haulage vehicles
- Understanding low volume pavement response to heavy traffic loading
- User perspectives on the road service level in ROADEX areas
- Vehicle and human vibration due to road condition
- Winter maintenance practice in the Northern Periphery

All of these reports, and others, are available for download free of charge from the ROADEX website at www.ROADEX.org.

