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ROADEX ROAD REHABILITATION REVIEW

**Road AC 1093 Morkan – Dikanäs
Västerbotten, Sweden**

ROADEX Road Rehabilitation Review
ROAD AC1093 MORKAN – DIKÄNAS
VÄSTERBOTTEN, SWEDEN
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PREFACE

This report discusses the results found due the rehabilitation works completed as part of the ROADEX IV project. It aims to show how successful certain methods that were used on the road were on reducing the amount of permanent deformation.

This report is not intended to replace the reference works available on the subject but it is hoped that the summaries shown and the results found will give the reader a greater understanding of the issues and solutions for each situation.

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ABSTRACT

A series of rehabilitation works were carried out on road AC 1093 Morkan – Dikanäs during the summer of 2009 as part of pilot trials of the design method contained in the ROADDEX report “Managing rutting in low volume roads”. This report gives a brief introduction into the techniques used in the rehabilitation works and the results seen of the road to date (October 2010).

For sections suffering from Mode 1 rutting (deformation in aggregates close to the surface), the ROADDEX method was used as the rehabilitation procedure. However, problems arose during the milling process due to the large amount of stones, boulders and solid rock found near the surface of the road. Consequently only 28% (1509m of 5352m) of these sections were milled and the remaining proportions were provided with 80mm of a new base course.

For sections suffering from Mode 2 rutting (deformation in the subgrade) the ROADDEX method was found to be inadequate and the Odemark – method was used in these sections. In the worst cases the sections were reinforced with steel net reinforcement without removing the existing superstructure. Consequently the increased thickness in the superstructure caused settlement of the road and cracks can be found crossing the road on the edges of the steel net.

In October 2010 the road was re-examined to see how successful each of the rehabilitation methods used were with over a year of the original traffic loading. It was clear that the permanent deformation of the road structure had been dramatically reduced and that the road suffered from Mode 2 rutting in only one area but with a few cases of Mode 1 rutting occurring. The majority of the wearing course had been damaged with varying degrees of deformations including potholes and longitudinal indentations. These longitudinal indentations may have occurred due to freeze thaw or the flow of water in the wheel paths of the road which took the fines in the wearing course off the road. However, apart from rutting and frost heave the deformations visible were related to maintenance and are not considered relevant to this ROADDEX project.

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 the present day.



Figure 1.1 The Northern Periphery Area and ROADEX IV Partners

The partners in ROADEX IV “Implementing Accessibility” comprise of public road administrations and forestry organisations from across the European Northern Periphery. These were The Highland Council, Forestry Commission Scotland and the Western Isles Council 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 Road Administration and The National Roads Authority and The Department of Transport of Ireland.

The aim of this project is 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 is The Swedish Transport Administration and the main project consultant is Roadscanners Oy of Finland.

The project was awarded NPP funding in September 2009 and held its first steering Committee meeting in Luleå, November 2009.

A main part of the project is 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 will also be pursued as part of the project: D1 “Climate change and its consequences on the maintenance of low volume roads”, D2 “Road Widening” and D3 “Vibration in vehicles and humans due to road condition”. All of the reports are available on the ROADEX website at www.ROADEX.org.

1.2. BACKGROUND ON THE ROAD

Road AC 1093 is a 20km long low volume road in the western part of Västerbotten County, Sweden. The road suffered from permanent deformations close to the surface, in the subgrade and was in need of strengthening. It was chosen by the Swedish Transport Administration as a pilot project to evaluate the ROADEX method as a suitable method to design a new pavement as part of the “Managing Rutting in Low Volume Roads”.

When the road was chosen as a pilot project by the Swedish Transport Administration a rehabilitation plan was made. The plan was created by the following companies and organisations: Roadscanners Oy, DMC projektering and Tampere University of Technology, Earth and Foundation structures.

This rehabilitation plan was used as a basis for the construction document that the contractor used while reinforcing the road. An employee from the Swedish Transport Authority was on site during the work to document the more critical parts of the operation.

1.3. MEASURES

A series of different rehabilitation measures were decided based on calculations from the ROADEX method (Mode 1 rutting) and the Odemark method (Mode 2 rutting). Some of Mode 1 rutting areas had problems with the milling due to boulders and rocks in the superstructure close to the surface. Consequently only 28% (1509m of 5352m) of these sections were milled and the remaining proportion was provided with 80mm of a new base course (Hjelm, 2009). Also, sections that had no deformation had there wearing course removed and a new wearing course applied.

As a final measure, the project manager ordered a new 100mm thick wearing course over the whole trial distance to allow a good tolerance for future maintenance works. The following are the different measures taken which were related to the condition of the road (Hjelm, 2009).

1.3.1. Mode 1 rutting sections

Section type 1: New wearing course 100mm

Milling 200mm

80mm new 8-32 macadam

Regulating layer

Removing 30-50mm of old wearing course with a road grader

Section type 2: New wearing course 100mm

Milling 200mm

100mm of new 8-32 aggregates

Regulating layer

Removing 30-50mm of old wearing course with road-grader

Section type 3: New wearing course 100mm

New base course 100mm

Regulating layer

Removing 100-150mm of old layers with a road-grader

1.3.2. Mode 2 rutting sections

Section type 4: New wearing course 100mm
New base course 200mm
Regulating layer
Removing 50-90mm of old layers with a road-grader

Section type 5: New wearing course 100mm
New base course 250mm
Regulating layer
Removing 40-90mm of old layers with a road-grader

Section type 6: New wearing course 100mm
New base course 200mm
Steel –net reinforcement
New base course 50mm
Removing 250mm of old layers

1.3.3. Sections without rutting

Section type 7: New wearing course 100mm
Regulating layer
Removing 30-50mm of old layers with a road-grader

2. DEFORMATIONS

This project focused on looking at two modes of rutting which are described in detail in previous reports (Andrew Dawson, 2006). The following is a brief reminder on the two modes being focused on as well as another form of deformation that was visible on the road known as frost heave. Apart from these modes of rutting there is Mode 0 which deals with compaction, Mode 3 which looks at partial damage as well as combined modes which can be seen in greater detail in the referenced reports.

2.1. MODE 1 RUTTING

In weaker granular materials, local shear close to the wheel may occur. This gives rise to heave immediately adjacent to the wheel path which can be seen in the following figure. This rutting is mostly consequence of inadequate shear strength in the aggregate relatively close to the pavement structure. In this mode, ideally there would be no deformation at the subgrade surface. This type of rutting is frequently observed in the Nordic area that is affected by seasonal frost.

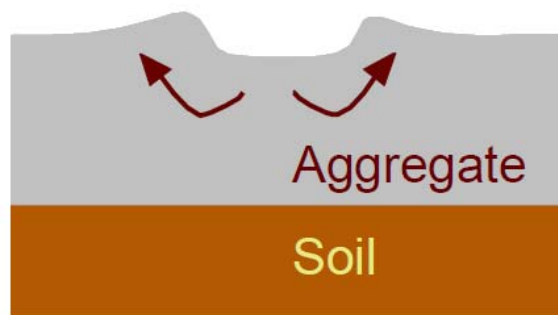


Figure 2.1 Mode 1 Rutting - Shear deformation within the granular layers of the pavement, near the surface

2.2. MODE 2 RUTTING

When the aggregate quality is better, then the pavement as a whole may rut. The following figure shows an idealized view of the subgrade deforming, while the granular layer(s) deflect bodily on it (i.e. without any thinning).

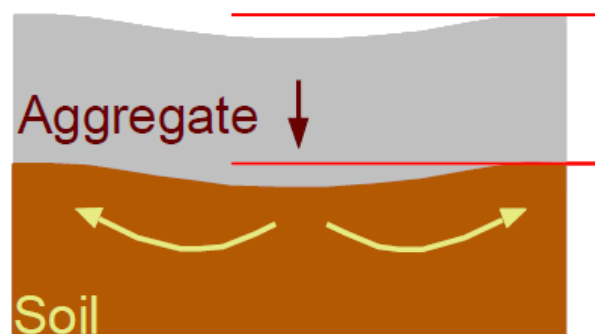


Figure 2.2 Mode 2 Rutting - Shear deformation within the subgrade with the granular layer following the subgrade

2.3. FROST HEAVE

Frost heave is a phenomenon where the ground surface may rise due to frost action. When water freezes it can increase in volume by approximately 9%. As a result, in a saturated soil the void volume above the level of freezing will increase by the same amount, representing an overall increase in the volume of the soil by 2.5-5% depending on the void ratio. However, the volume of soil can increase by a much greater amount if ice lenses are formed within the soil.

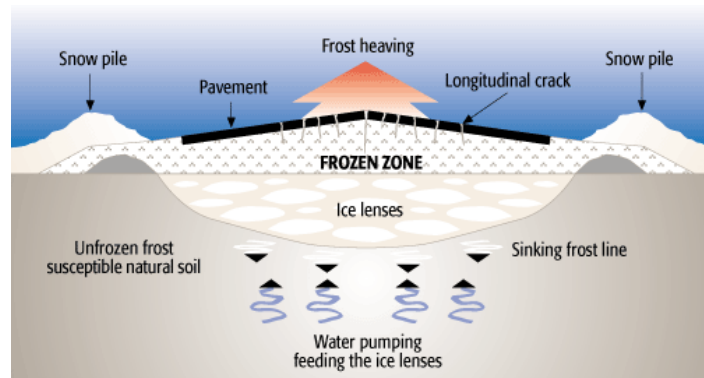


Figure 2.3 Effects of freeze and thaw cycles on a road

The temperature at which the water freezes in the pores of a soil depends on the pore size. The smaller the pores the lower the freezing temperature, therefore water freezes initially in the larger pores when the smaller pores remain unfrozen. As the temperature continues to fall below zero, higher soil suction develops and water migrates to the ice in the larger voids where it freezes and increases the volume of the ice. Continued migration can therefore create ice lenses and the ground surface will rise as seen in figure 2.4 (Quebec n.d.).

When the thawing takes place the soil that was previously frozen will now have an excess of water and due to this, the soil will be soft and its strength will be reduced. The worst conditions for water migration occur in soils having a high percentage of silt-size particles due to its small pores however, the permeability is not too low (Craig, 2004).

3. CONDITION OF THE GRAVEL ROAD

Looking at the road one year after rehabilitation works will show if the methods used were an appropriate remedy for the permanent deformations that the road had suffered from. Looking at figures 3.1 and 3.2 it can be seen that the percentage of rutting has been dramatically reduced looking at the statistics prior to the rehabilitation works (Matintupa, 2009).

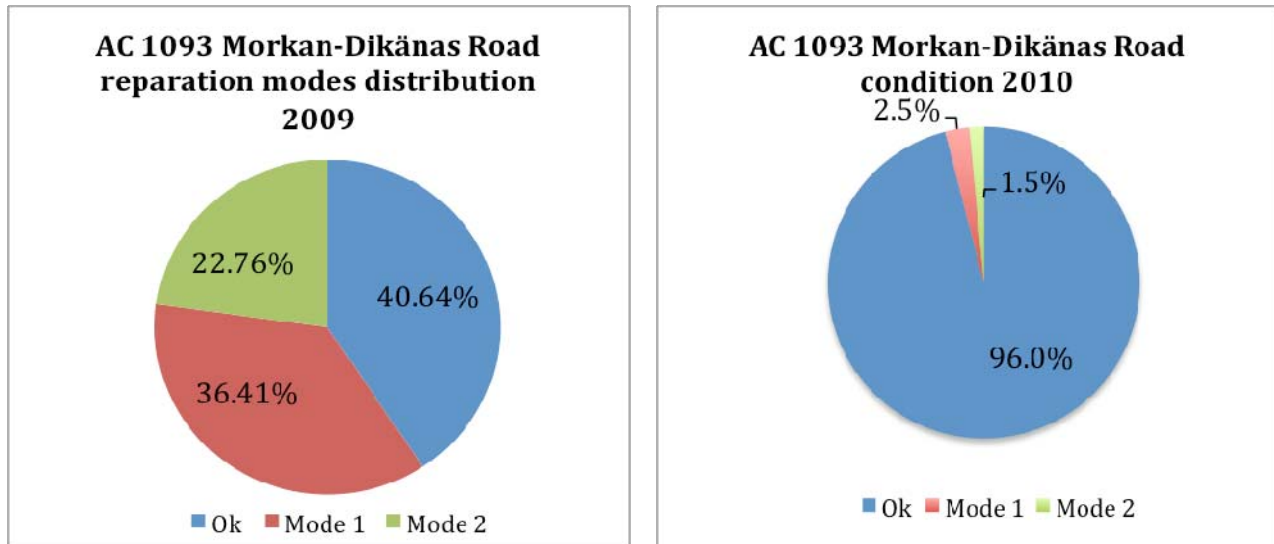


Figure 3.1 Road repair modes 2009

From this, the modes of deformation evident in the road can be delved into further to examine their causes and possible remedies as well as looking at the areas that suffered from frost heave.

3.1. VISIBLE MODE 1 RUTTING

Throughout the entire road, Mode 1 rutting was apparent in approximately 500 meters of the road surface. However, the rutting was seen to occur due to a build of potholes resulting in the failure of the aggregates close to the road surface, which can be seen in figure 3.3. A probable cause of this is the high level of fines in the top layers, which can then hold an excess amount of water that can weaken the layers and the load is not distributed throughout the road evenly.



Figure 3.3 Section 2\170 with visible Mode 1 Rutting

From figure 3.4 it can be seen that, the road type that this mode of rutting was most evident in was where there were problems with the milling and mixing. Instead of milling and mixing the road was given a new base course of thickness 80mm which was estimated on the original price of the rehabilitation works of these sections. Consequently, the road that had suffered from Mode 1 rutting, probably had a high level of fines below the 80mm new base course which may have had a high moisture content that migrated in to the top layer thus resulting in further deformations.

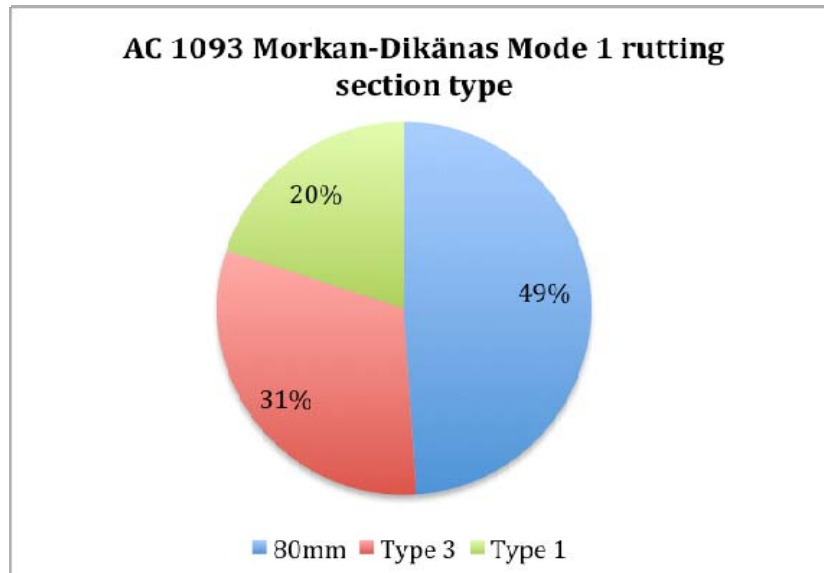


Figure 3.4 Mode 1 Rutting section type

A misleading factor from this pie chart is that there is approximately 4km of road with section type 3 compared to only 424m of road type 2, 3843m of 80mm base course and 1085m of road type 1. As a result, over 9% of section type 1 shows deformation compared to only 4% of section type 3 showing that type 3 was a more effective section. This may be a result of removing more of the old layers or adding a new 100mm base course rather than adding 80mm new 8-32 macadam and milling it by 200mm. A remedy for such rutting is to improve the aggregate or by reducing the tire imposed stresses (Andrew Dawson, 2006).

3.2. VISIBLE MODE 2 RUTTING

Mode 2 rutting occurred in only one area and section type. Close to where the road stops there is a large peat land area where the subgrade of the road was found to be very poor (Hjelm, 2009). As a result, section type 6 was chosen as the appropriate rehabilitation works. Out of the 1050m of section type 6, 28% of it was found to suffer from Mode 2 rutting after the rehabilitation works. From a visual inspection of the topography of the area it is assumed that the rutting and transversal cracks in the road surface become most prominent in the middle of a sloping peat area. Here, the peat area may be at its deepest therefore the subgrade is at its weakest here. Figure 3.5 shows the road section where Mode 2 rutting is apparent.



Figure 3.5 Section 20\250 with visible Mode 2 Rutting



Figure 3.6 Section 20\175 Transversal cracks visible

A remedy for this type of rutting would be to improve or thicken the aggregate so that the wheel loads are spread better. This will result in less stress on the subgrade. Another solution would be to put a load restriction on the road during the thawing seasons (Andrew Dawson, 2006).

As mentioned previously, transversal cracks are visible along the edges of the steel nets, which can be seen in figure 3.6. These cracks came shortly after the construction of the road and there are many possible scenarios for their occurrence such as:

- Increased thickness of the superstructure that causes settlements (Hjelm, 2009)
- Joint between the nets is insufficient due to skidding (Hjelm, 2009)
- Increased volume due to excess water during construction
- Frost heave occurring at steel net connections thus pushing up at the weakest point in the reinforcement.

Possible solutions to reduce the forming of these cracks would be similar to the mMode 2 rutting remedial actions. Also, if the steel nets were overlapped by a greater amount and the connections made stronger it may reduce the risk of the crack formations.

3.3. VISIBLE FROST HEAVE

Longitudinal indentations in the road appeared quite frequently throughout the entire road which can be seen in the inventory in Appendix A. However, not all can be directly correlated to frost heave. In figures 3.7 and 3.8 the difference between the frost heave and longitudinal indentations can be seen. Here it can be seen that the frost heave does not act in a straight line compared to the longitudinal indentations. These longitudinal indentations are thought to occur on sloping surfaces where the water runs down the road in the wheel tracks and takes the fines in the road surface away with it. Therefore they are of no concern in relation to the structural integrity of the road and are more of a maintenance issue and should be dealt with accordingly.



Figure 3.7 Section 1\626 with visible frost heave



Figure 3.8 Section 1\854 with longitudinal indentations

Looking at figure 3.9 it is thought that there is a high level of silt in the road surface that is been washed off with the flow of water. This high level of fines may also be in the road structure which in turn can give rise to frost heave as mentioned previously. Therefore a possible remedy for this defect would be to reduce the level of fines, especially silt in the road structure.



Figure 3.9 Section 0\640 with silt visible in the drainage

3.4. ADDITIONAL OBSERVATIONS

Throughout the entire road there was a significant amount of potholes considering that this road had rehabilitation works done the previous year. Figure 3.10 shows how bad the condition of the road gets in a localised area. This potholing is seen frequently at the bottom of sloping roads and it is due to the buildup of the water on the road, which may also be related to high fines content in the road structure. However, this is also only a maintenance issue, which does not alter the structural integrity of the road.



Figure 3.10 Section 19\190 with severe pothole conditions

It is also important that trees and other flora are kept at an appropriate distance from the road. Without this the road is provided with shade which in turn reduces the speed of evaporation and thawing of water from the road. A good example of this can be seen in figure 3.11.



Figure 3.11 Section 0\520 with visible shading of road surface by flora

4. CONCLUSION

As it can be seen the road has performed considerably well in relation to rutting and permanent deformations after a year of its original loading. Therefore the techniques and section types used were sufficient enough to reduce rutting considerably. However, slightly altering the section type 1 so as to remove more of the old structure may improve the results found in these rehabilitation works. The frost heave visible on the road surface may become an issue if moisture continues to be present in the superstructure of the road and the ice lenses are allowed to grow in the cold winter conditions.

When looking at the drainage, the entire road showed good quality drainage, culverts and outlet ditches with most sections being class one apart from places that were mentioned in the inventory, which can be found in the appendix A. This high standard of drainage can greatly affect the integrity of the road by keeping the moisture out of the road superstructure where the strength can be reduced greatly due to excess water.

Overall the road continues to function efficiently with some maintenance issue which may be addressed accordingly.

5. REFERENCES

- 1) Dawson, A. & Kolisoja, P.. *Managing rutting in low volume roads*, ROADDEX III project, 2006.
- 2) Craig, R.F. *Craig's soil mechanics*. 7th. Taylor & Francis, 2004.
- 3) Hjelm, R. "Summary of rehabilitation works." Swedish Transport administration, 2009.
- 4) Matintupa, A. *AC 1093 Morkan - Dikanäs*. Roadscanners Oy, 2009.
- 5) Quebec, Transports. www.mtq.gouv.qc.ca.

6. APPENDICES

Appendix A..... Morkan – Dikanäs Report inventory
Appendix B..... Morkan – Dikanäs Photos



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.

