

THE IMPORTANCE OF WINTER MAINTENANCE FOR CYCLISTS

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ABSTRACT

Single bicycle accidents represent more than 70% of all bicycle accidents in Sweden and the biggest influencing factor is slippery surfaces, mainly caused by ice and snow. In addition, the winter maintenance service level is significant for the accessibility of cyclists and for their decision to cycle or not. According to road maintenance administrators the most difficult conditions to manage in cycleway maintenance is thawing and freezing, resulting in slush followed by icy ruts and slipperiness. In this paper, winter maintenance of cycleways will be discussed from various perspectives, based on several studies performed at VTI. The effects on safety related to winter maintenance is estimated using accident data based on reports from hospital emergency rooms. In total, almost 18000 bicycle accidents were analysed. The paper will also present the opinion of cyclists concerning the importance of the winter road condition for their perceived safety, their travel time, etc. The results are based on focus group studies performed in two Swedish cities with different climate and daylight conditions. The cyclists' opinion will also be compared to the perception of road maintenance administrators. Road maintenance administrators from 13 different municipalities in Sweden have been interviewed.

KEYWORDS

CYCLISTS / CYCLEWAYS / WINTER MAINTENANCE / SAFETY / ACCESSIBILITY

1. INTRODUCTION

To be able to meet the environmental goals concerning energy consumption, carbon dioxide emissions, the impacts on health, of air pollution and noise, etc., it is important that environmentally-sound ways of transportation, such as cycling, increases at the expense of car-based transport.

In Sweden, bicycles are used not only for recreational purposes but is a common transport mode, e.g. for commuting. In total, about 10% of all passenger journeys are made by bicycle [1]. For commuting the modal split of cycling is considerably higher, up to 30% in certain cities [2]. Even in the wintertime cycling is considerable, although it decreases to about a third compared to that during the summertime [3]. Although cycling frequency is rather high compared to many other countries, more than half of all passenger trips in Sweden less than 5 km are made by car. According to Nilsson [4], between 9 and 48% of these short car trips could be transferred to bicycle (in total over the year). By improving the winter maintenance service level of cycleways, it could be possible to increase the number of bicycle trips during winter by approximately 18% [5].

In Sweden, about 35 cyclist are killed and 400 are severely injured every year (average for the 21st century, including police reported accidents only) [6]. According to the official accident statistics [6], the number of lightly injured cyclists is about 2000 every year. However, only a small proportion of the bicycle accidents come to the knowledge of the

police, which is especially true for accidents causing no casualties or severe injuries. This is a problem when trying to analyse the causes of bicycle accidents. Therefore, the magnitude of the safety problem related to winter maintenance of cycleways is unclear. Earlier studies have been limited to data based on reports from hospital emergency rooms from one [7] or a few [3] cities only. With the introduction of the Swedish Traffic Accident Data Acquisition (STRADA), where reports from hospital emergency rooms are gathered in the same database as police reports, the official statistics are gradually being improved.

In this paper winter maintenance of cycleways in Sweden will be discussed from various perspectives including the effects on safety and accessibility of cyclists. The results presented summarize several studies [8, 9, 10] performed at VTI, the Swedish Road and Transport Research Institute, concerning cyclists and winter maintenance. The studies performed are supplementing my PhD-project [11], which was summarised at PIARC XIth International Winter Road Congress in Sapporo, in 2002 [12].

2. METHOD

At VTI research is carried out on how to improve cycleway maintenance in order to promote cycling. A project has been carried out regarding the standard of cycleways, with the objective to provide information for road management authorities as to what characterises an attractive cycleway from the standpoint of infrastructure maintenance. In this paper, the winter maintenance related results from this research are summarised. The results are based on literature reviews, accident analysis [8], focus group studies [9], and interviews with road management authorities [10].

2.1. Accident analysis

The effects on safety related to winter maintenance was estimated using accident data based on reports from hospital emergency rooms, gathered in the Swedish Traffic Accident Data Acquisition (STRADA). The data obtained from STRADA was from 2003 to 2006 and came only from hospitals that were directly linked to the database during these years. The total number of accident reports used in the analysis was 17,989. The reports concerned cyclists who had been injured in a traffic environment only. In addition to the standard accident variables, descriptions and details of the events leading up to the accidents were also used in the analysis. This enabled a more detailed description of the accident and injury situations associated with cyclists, including winter maintenance related accidents. A full report of the accident study is available in Swedish, including a summary in English [8].

2.2. Focus group studies

Cyclists' opinions of the significance of various road related factors for their perceived safety, their travel time, and the decision to cycle or not were gathered in focus group studies. Four focus group meetings were held in 2006, in two Swedish cities with different climate and daylight conditions, Linköping and Umeå. In each city two focus groups, with about 10 participants in each group, were summoned, with the relative distinction being the participants cycling distance from residence to work. The first group included cyclists with a cycling distance of 5 km or less, and the second group cyclists with a longer cycling distance.

The participants were recruited on the assumption that they would cycle to and from work. The sample was therefore restricted to people of working age, and the ages of the

participants ranged from 23 to 64. The aim had been to have an even distribution regarding sex and age, but more than 60% were women and the 51-60 age group was over-represented. For most of the participants the distance between home and work was between 3 and 7 km, and they stated that they cycled every day during the summer months. A majority also cycled at least 3 days a week during the winter.

During the focus group meetings, an interview guide with six principal areas was used: avoidance of obstacles etc, the cycle ride takes longer than necessary, the cycle ride takes longer than usual/ planned, increased stress, safety risk, and the decision whether or not to cycle. Discussions were initiated by a moderator who asked questions relating to the participants' comments etc. The results are based on a simple content analysis, i.e. only what the group participants had said was analysed. Apart from the principal areas in the interview guide, the participants' comments were grouped under the categories maintenance, geometric design, other road users, traffic rules, and other matters. This paper will focus on the results related to winter maintenance of cycleways. A full report of the focus group study is available in Swedish, with a summary in English [9].

2.3. Interviews with road management authorities

To get an insight into the management problems related to cycleway maintenance, road maintenance administrators from 13 different municipalities in Sweden were interviewed in 2005. The municipalities included in the study all had a relatively high volume of bicycle traffic and a large separate cycleway network. The interviews also gave an overview of current routines, policies and regulations for cycleway maintenance. The interviews were supplemented with relevant documentation provided by the municipalities, such as bicycle plans, technical descriptions of road operation service levels, etc. Only the results related to winter maintenance are included in this paper. A full report of the study is available in Swedish, with a summary in English [10].

3. RESULTS

3.1. Accident analysis

The analysis of the data obtained from STRADA showed that the most common accidents among cyclists were single bicycle accidents (figure 1). Next most common, with 17%, were accidents involving cyclists and motor vehicles. Normally, collisions with motor vehicles are considered to be the most serious type of bicycle accident, as the consequence of such an accident is often severe. However, the analysis showed that single bicycle accidents accounted for more than 50% of the severely injured cyclists.

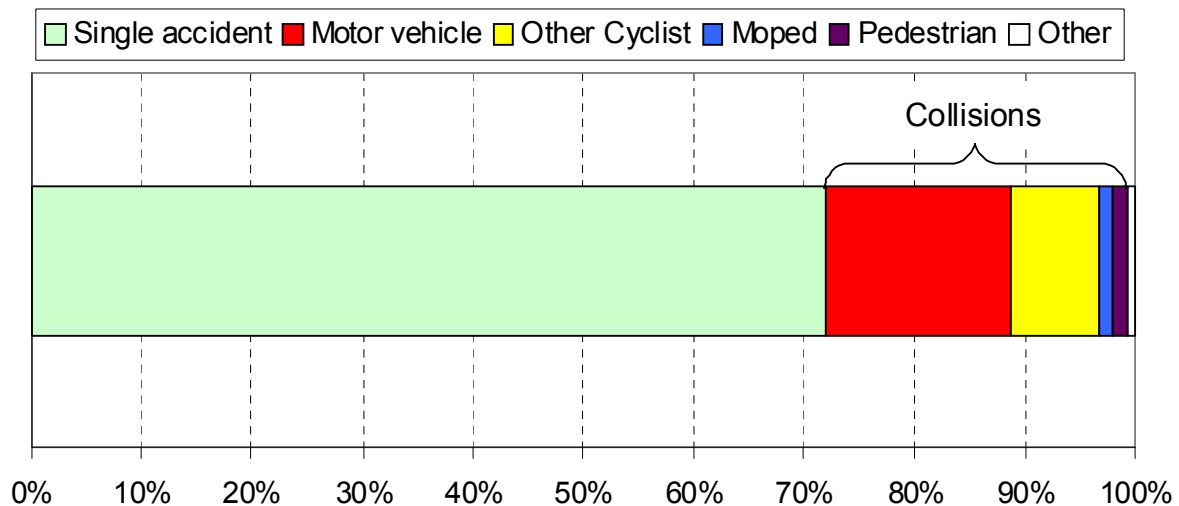


Figure 1 – The accident types of the injured cyclists analysed

In one third of the single bicycle accidents, the cause of the accident was not specified in the accident description. Among the reasons stated, the biggest influencing factor was slippery surfaces or impaired grip. On average, over a whole year, slippery surfaces were stated as a contributory cause in 23% of the single bicycle accidents. Snow and ice were undoubtedly the main cause, but loose gravel/grit (from winter maintenance) was also frequently given as a reason (table 1). All types of causes generating a slippery surface were more frequent in contributing to a single bicycle accident on separated cycleways than in crossings and on roadways. This could indicate that the road condition in general is worse on separated cycleways than on roadways.

Table 1 – Percentage of injured in single bicycle accidents due to impaired grip

Cause of impaired grip	Roadway (N=5,592)	Cycleway (N=4,815)	Crossing or other location (N=2,515)	Total (N=12,922)
Ice/snow	11.9%	13.5%	10.2%	12.2%
Grit	6.0%	6.9%	4.2%	6.0%
Wet	3.2%	4.7%	2.7%	3.7%
Other	0.8%	0.8%	0.8%	0.8%
Total	22.0%	25.9%	17.8%	22.6%

During the wintertime, December to February, impaired grip caused by snow and ice was a contributory cause in more than half of the single bicycle accidents that occurred (figure 2). Figure 2 shows the situation for all kinds of traffic environments, i.e. crossings, in traffic cycling, and separated cycleways. On separated cycleways only, impaired grip caused by snow and ice contributed to an even higher amount of the accidents (e.g. 71% in January). Note that impaired grip due to left over grit from winter maintenance and stated as a contributory accident cause, accounts for 15% of the single bicycle accidents in the month of April. On separated cycleways the corresponding amount is 19%.

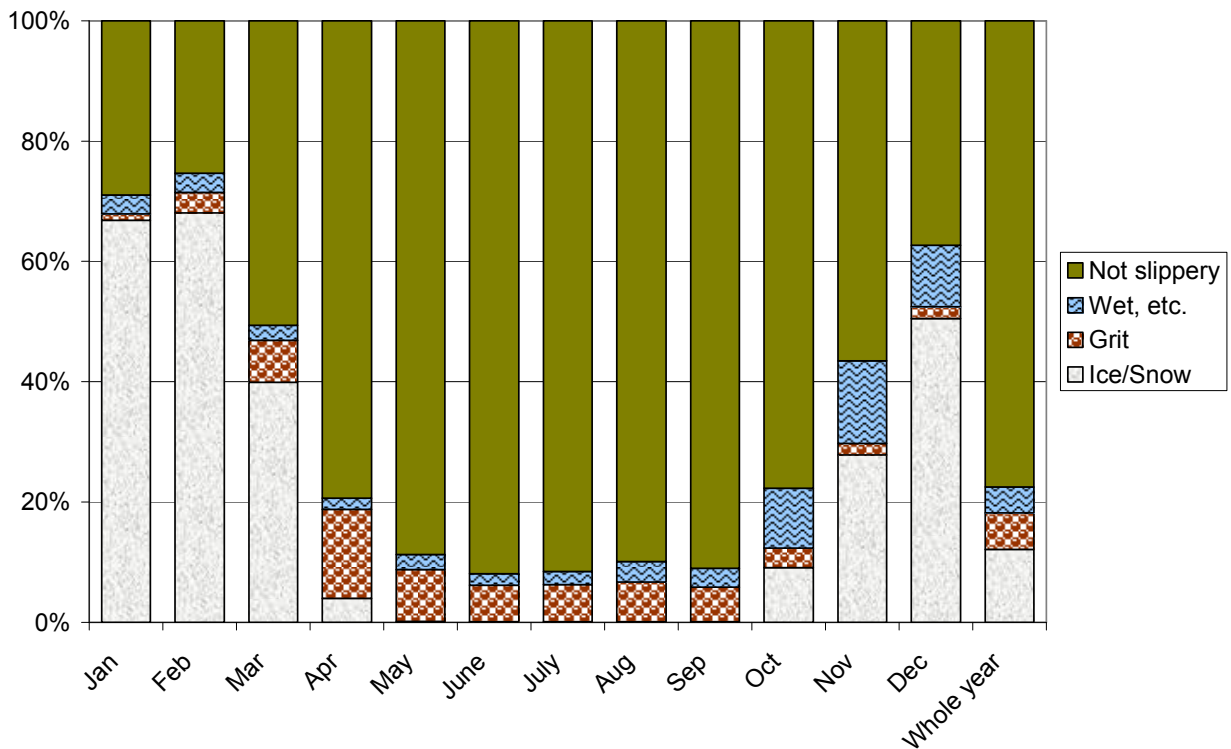


Figure 2 – The contribution of slippery surfaces to single bicycle accidents, over the year.

3.2. Focus group studies

There was a tendency that problems related to snow banks and street-lighting were more emphasized in the focus group discussions in Umeå. Otherwise, there was no significant difference in the results from the different focus groups. The results are therefore not presented separately group by group, but all together.

The issue of safety risk created the liveliest discussion in the focus groups. What appeared to have the greatest significance were other road users and geometric design. Shortcomings in winter maintenance were also often mentioned. The participants in the focus groups perceived a considerable increase in the accident risk during winter, mainly due to slipperiness and darkness. The increase in perceived accident risk was said to be compensated with a lower speed during winter. Certain places where freezing occurs first, such as bridges and tunnels, were considered to be the most dangerous. Insufficient street-lighting makes it difficult to see deficiencies in the road surface creating a safety hazard when cycling. Street-lighting was also said to be important for the cyclists feeling of security. Especially the females expressed a fear of assault.

Snow banks, which reduce the visibility in crossings, were also said to affect the perceived safety when cycling. This also applied to snow on the road surface which makes it difficult to cycle and distracts the cyclists' attention from other road-users. Another winter maintenance related factor mentioned was grit used for de-icing, but causing an impaired grip on bare road surfaces during mild weather conditions. The grit was also said to create a problem with punctured tyres. Some of the participants also perceived the method using grit for de-icing to be ineffective. This is exemplified with the following comment by one of the participants: *"It is always icy. You see the grit through the ice, but it's never on the*

surface where you want it. Then, in the spring, you realise how much they are actually spreading - there can be a several centimetre thick layer of grit on the surface."

Snow banks, not only in crossings but also on the sides of a cycleway, decrease the width available for cyclists and reduce the visibility. This was said to create conflict situations with other cyclists and pedestrians. In addition, the possibility to take evasive action to avoid obstacles or conflict is impaired due to slipperiness caused by ice and snow. On the other hand, conflicts with other cyclists decrease in the wintertime since cycling frequency is relatively low. The participants in the focus groups also perceived cycling during winter to be more stringent, with more correct behaviour and less violations of traffic rules, which contributes to decrease the number of conflicts with other cyclists. One of the participants expressed this with the following: *"During winter, only experienced cyclists are out. We know how to handle our bicycles and the number of unexpected events decrease"*.

The participants in the focus groups perceived cycling during winter, in general, to be more time consuming and physically demanding than cycling in the summertime. By creating an impaired grip, snow and ice decrease energy efficiency when cycling. There is also a need to proceed more cautiously in order to avoid falls and conflicts with other road-users. In addition, low temperatures affecting bearings and gears of the bicycle, the use of studded tyres, and friction caused by bicycle light dynamos, make it heavier to pedal. Periods with temperature fluctuations above and below freezing, typically at the beginning and end of the winter season, are perceived to be the most problematic. Snow melting and then freezing creates icy tracks that are difficult to negotiate. Darkness also increases cyclists' travel time. Bicycle lights are seldom sufficient for lighting up the road surface and only the most central areas of the cities were perceived to have sufficient street-lighting.

According to the focus groups, shortcomings in winter maintenance were the prime reason for a cycle journey to take longer than usual or planned, especially, if a cycleway is not cleared from snow. *"In worst cases you need to get off your bike and walk"*, is a comment from one of the focus group participants. After a cycleway has been cleared from snow, cyclists can also be hindered by snow thrown up by a snowplough clearing an adjacent roadway.

Most of the participants in the focus group studies almost always used their bicycle when travelling to work, even during the winter. Exercise and wellbeing were the chief reasons for their decision to cycle. Reasons not to cycle were mainly: *"when needing the car to do errands or for work purposes"*. Due to the perceived increase in accident risk, a few of the participants in the focus groups stated that they chose not to cycle during winter. This was particularly true for those with longer cycling distances. Longer distances were often associated with the absence of separated cycleways. Cycling in mixed traffic in darkness and poor visibility on slippery road conditions, was considered too dangerous by some of the participants – mainly among the females.

Although many of the participants said that they cycled during any weather condition, very low temperatures, and snowfall combined with strong winds were said to affect their mode choice and reject use of the bicycle. Minus 20°C seemed to be the lower temperature limit for most of the participants. The winter maintenance service level was also significant for their daily decision to cycle. Cycleways not cleared from snow or covered with icy tracks, were reasons mentioned to choose another transport mode. However, it was pointed out that it was not always possible to predict weather or road conditions when leaving home in the morning. When discussing the decision whether or not to cycle, the participants said that when choosing another transport mode they often regretted doing so, as they missed their daily bicycle ride.

3.3. Interviews with road management authorities

For cycleway construction, all the municipalities interviewed follow the technical description of road constructions from the Swedish Road Administration. However, for maintenance and operation of cycleways, including winter maintenance, the municipalities have their own requirements. The local conditions are considered to vary to a degree demanding specific requirements for each municipality. For example, during a “normal winter”, snow clearance is needed on 11 occasions in the city of Gothenburg compared to 22 in the municipality of Luleå.

Usually, budget restrictions determine maintenance requirements and when measures are taken. In the winter maintenance requirements for cycleways, there are usually two quality classes - high priority cycleways and low priority cycleways. In all the municipalities interviewed, high priority cycleways are snow cleared before and at a higher winter maintenance service level than roads and streets. For snow clearance of cycleways, the starting condition is usually 3-5 cm of snow, and the maximum time to operate from 3 to 12 hours. Some of the municipalities, mainly in the north of Sweden, consider temperature and snow quality in their requirements. In addition, in four of the municipalities interviewed, the requirements stipulate that cycleways should be cleared from snow before the morning peak of cycling, i.e. before 6.30 or 7 a.m.

In the municipalities interviewed, the requirements for de-icing are not specified in detail. Normally, de-icing should be done after each occasion of snow-clearance or “when needed”. Malmö is the only municipality solely using salt for de-icing of cycleways. The others are using grit, normally a crushed stone-material of a granular size between 2 and 8 mm. In four of the municipalities, the stone-material is being tumbled to round off the sharp edges in order to decrease the problem with punctured tyres. In Linköping, salt is used for de-icing on a selection of the high priority cycleways and grit is used on the rest of the cycleway network.

Cyclists’ problems associated with grit is realised by the road management authorities. Therefore, the aim is to sweep it up as soon as possible after the winter season. In addition, one of the municipalities sweeps the grit to the side during mild weather periods in the winter, on parts of their high priority cycleways. According to the municipalities interviewed, it takes about one to one and a half month to sweep up left over grit from winter maintenance.

Thawing and freezing, resulting in slush followed, alternately, by icy ruts and slipperiness, is considered to be the most difficult condition to manage in cycleway maintenance. The difficulty to uphold an even winter maintenance service level on bicycle routes alternating between separated cycleways and cycling on roadways, was also emphasised. Many of the interviewed stated that limited means is the largest problem and makes it increasingly difficult to provide a high maintenance service level.

In general, cycleway surface conditions are monitored by visual inspections only. The public is considered to be an important resource in detecting and reporting potholes, cracks and other cycleway defects, and the municipalities systematically register reports from the public. The most common complaints, from the public concerning cycleway maintenance, are regarding broken glass or slipperiness.

4. DISCUSSION

The introduction of STRADA has greatly improved the official statistics concerning traffic accidents involving cyclist. However, almost one third of the Swedish hospital emergency rooms are not yet linked to STRADA [6]. Further improvements of the database are needed, for example the quality of the accident descriptions and event details varied from case to case. It seems that no standard template was used for recording such information. Even after improving STRADA, many bicycle accidents will never be recorded since not all injured cyclists are being treated at hospitals. This is probably even more true for cyclists injured in single bicycle accidents, and hence, winter maintenance related accidents are probably underestimated.

The accident analysis, in particular figure 2, reveal cyclists' sensitivity to impaired grip and the importance of a high winter maintenance standard aiming to reduce the time with slippery surfaces. The traditional method using grit for de-icing needs to be reconsidered, in view of the number of accidents caused by the grit at dry road conditions. A more restricted use of the grit, and routines to sweep it up early in the spring and at periods of mild weather during winter, are some possible solutions. Using warm-wetted sand in northern regions, or to substitute gritting with chemical methods for de-icing [13] are other suggestions. However, the equipment for these methods needs to be further developed for a more effective use on cycleways. In addition, winter maintenance methods and equipment better adapted to the conditions of cycleways are needed to avoid damaging the cycleway construction.

When comparing the cyclists' opinion from the focus group studies to the perception of road maintenance administrators, there seems to be a pretty good understanding of cyclists' situation among the road maintenance administrators. The winter maintenance policy in the municipalities is to give priority to cycleways. However, budget constraints usually determine the maintenance service level. By supporting the municipal road administrators with cost-benefit arguments presenting the total cost of bicycle accidents, travelling time, etc., they might get increased funding for maintenance measures. On the other hand, it is possible to improve the winter maintenance service level with limited means, through good organization, by choosing the appropriate service level considering the use of a cycleway, and by taking measures at the right time. This demands a good knowledge about bicycle traffic flows, accidents, the location of problematic cycleway segments, the desires of cyclists as well as their assessment of comfort, travelling time, etc.

What was not realised by the road maintenance administrators, but was clear from the focus group study, was the in-sufficient lighting along cycleways affecting accessibility, safety, as well as the feeling of security of cyclists. Even small adjustments, such as choosing the right type of lamps and having the appropriate distance between the lighting poles might improve the situation considerably. According to Nygårdhs [14], lighting with the luminous points placed low with a dim natural light, spreading light to the sides, has many security advantages, for example less shadows and an increased identification capacity. Disadvantages are the risk of vandalism, risk of glare and that the extension of the road can be more difficult to see.

If a road management authority wants to promote cycle traffic it is essential to enhance the competitiveness of the bicycle as a transport mode by improving accessibility and making travel times shorter for cyclists. What this mainly requires is a direct and continuous cycleway network, preferably with grade separated intersections that do not necessitate

detours by cyclists. A cycleway network separated from car traffic is even more important during winter, since cycling on a roadway in darkness and poor visibility in combination with a slippery road surface is not to recommend. A high maintenance service level is also an important measure in order to promote cycling and simultaneously improve cycling safety. The maintenance service level has an immediate effect on accessibility during short periods, but an improved winter maintenance service level is not likely to recruit new cyclists. It is, however, important in retaining the existing cyclists and demonstrating that they are a prioritised group of road users, and to raise the status of the bicycle as a mode of transport.

5. CONCLUSIONS

The biggest influencing factor in single bicycle accidents was impaired grip mainly caused by snow and ice. Loose grit from winter maintenance was another frequent cause, particularly in the month of April.

Slippery surfaces, especially in combination with darkness, also affected the perceived safety of cyclists. For the accessibility and comfort of cyclists, a cycleway properly cleared from snow is the most important. Icy tracks formed when wet snow freezes also has a negative effect on the accessibility and comfort of cyclists.

Major obstacles for road management authorities in cycleway maintenance were:

- Limited funding
- Thawing and freezing, resulting in slush followed by icy ruts and slipperiness
- Lack of knowledge about effects, current state and effective measures

6. RECOMMENDATIONS

For the safety and accessibility of cyclists, the following recommendations should be considered by road management authorities responsible of winter maintenance:

- Snow clearance of cycleways should be started at a snow depth of 3 cm of loose snow, at the latest.
- Cycleways should be cleared from snow before the morning peak of cycling, i.e. before 6.30 a.m.
- To prevent the formation of icy tracks, snow clearance is also needed during mild weather periods when packed snow is melting.
- Problematic cycleway segments, for example where snow often is thrown up by a snowplough clearing an adjacent roadway, should be identified and attended to.
- Avoid building snow banks in cycleway crossings.
- Consider measures to decrease the amount of grit spread for de-icing.
- Sweep up the grit as soon as possible at the end of the winter season.
- Sweep the grit to the side of the cycleway during mild weather periods in the winter, especially in downhill slopes.
- Pay attention to bridges and tunnels where freezing occurs first.
- Enhance the winter maintenance service level on roadways with bicycle traffic.
- Improve the methods and equipment used in winter maintenance in order to be better adapted to the conditions of cycleways.

- For an effective use of funding, careful planning, clear strategies and a good organisation is needed.
- Improve the cycleway network comprehension, i.e. where accidents occur and where cycle frequency is high, in order to make the right priorities.
- Develop programmes and methods for follow-up and evaluation.

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