Saimaa University of Applied Sciences
Technology Lappeenranta
Double Degree Programme
Civil and Construction Engineering

Ivan Pukhlov

ROAD MAINTENANCE IN RUSSIA AND FINLAND

Thesis 2014
Abstract

Ivan Pukhlov
Road maintenance in Russia and Finland, 70 pages
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Technology Lappeenranta
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Instructor: Lecturer, Eija Mertanen, Saimaa University of Applied Sciences

The purpose of the research was to compare the approaches in the question of road maintenance in two neighboring countries, Russia and Finland.

The information about road classifications, lengths of road networks, traffic volumes, weather conditions, organizations, implementation, requirements of road maintenance and equipment for maintenance was included in the composition of this work.

The thesis comprises theory about both winter and summer maintenance requirements for the road surface.

The data was presented in the form of text, tables, figures and charts. It was gathered from the Internet and relevant literature such as books, tutorials, normative documents, manuals and methodical guidelines that are directly related to the maintenance of roads.

On the basis of the found material after each title a conclusion was made by comparing.

Keywords: road maintenance, road, requirements, weather conditions, traffic volumes, winter maintenance
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1 INTRODUCTION

Roads are complex engineering structures, designed for continuous, convenient and safe movement of vehicles with the design loads and speeds. This complex includes the subgrade, road pavement, bridges, pipes, and other engineering structures, equipping of roads and protective structures, service stations and road services. Characteristics and condition of the road elements and road structures determine its technical level and operational status.

Given the shortage of funds, the preservation of existing roads and maintaining the level of their transportation and operational condition is a priority for the road sector. Therefore, each state pays great attention to the maintenance of the roads and structures.

Experience shows that the economic returns of the funds, invested in the repair and maintenance of the roads, are two-three times more than the economic effect of each euro invested in the construction of the new roads.

Road organizations fulfill a huge amount of work for the maintenance and repair of roads which ensure traffic safety. Up to 85 % of all costs are spent annually for the development of road infrastructure. It is impossible to maintain the required level, as well as to improve transportation and the operational conditions of the road network without performing these works.

Road maintenance is a range of works to care for roads and structures during the whole year (subject to season) all over the road, for the prevention and elimination of constantly arising small damages, for the organization of traffic safety, as well as winter maintenance and landscaping roads.

The maintenance works include:

- Investigation and analysis of operating conditions of the roads and vehicle traffic;
- Permanent care of roads and structures, keeping them clean and tidy;
- Periodic repairs of roads and structures;
- Landscaping, architectural and aesthetic decoration;
Implementation of measures to increase the level of technical and operational condition of the roads, bringing them in line with the growing requirements of traffic safety.

The existing road network is the national wealth of the country, and it must be protected, multiplied and used effectively.

2 THE ROAD NETWORKS

Roads are of strategic importance for any country. Together, they are combined into the road network, which links the vast territory of the country, provides vital functions of all cities and towns, and largely determines the possibility of regional development, as the roads carry the most massive transportation of goods and passenger flows. The meaning of roads is constantly increasing due to changes in people's lifestyle, with a significant increase in demand for road transport, in terms of growth of industrial and agricultural production, expansion of international trade and development of services.

The road network generally forms the most basic level of transport infrastructure within urban areas, and will link with all other areas, both within and beyond the boundaries of the urban area.

A road network has many important goals such as mobility, social and economical functions. By connecting geographic locations, the road network facilitates the transport and movement of people, goods, and services, creating welfare. Road networks play a crucial role in the economic development. It is essential not only for connecting key urban centres but also for improving connectivity of more isolated local communities for whom many public transport options are limited or not available. (Wikipedia website)

In the development and maintenance of the highways network, attention shall be paid to the road transport system as part of the overall transport system promoting the realization of national land use goals and regional development as well as the achievement of goals set on community structure and the environment in land use planning.
The highways network shall provide access to safe and functional mobility and transport throughout the nation at a reasonable cost, taking into account the mobility needs of different population groups and the transport needs of the various sectors of business and industry. Attention shall be paid to the economical use of natural resources and to minimising the adverse impacts on the environment of the highways network and of traffic. (Highways Act 503/2005)

2.1 Russia

The basis of the country's road network consists of federal roads, which provide communications between subjects of Russian Federation and Moscow. The network density is more in the European part of Russia and decreases to the north and east. About 10% of the population lives in regions. There is no access to the year round operated road network.

![Figure 2.1 Roads map of the Russian federal highways. (Wikipedia website)](image)

Configuration of the federal highways network has a pronounced radial structure oriented to the Russian capital - Moscow. This network topology is a consequence of the weak horizontal linkages between cities and regions of the country with an insufficient number of connecting and chordates roads, which causes increasing in mileage, transportation costs and overload of roads.
The total length of the road network including roads of federal, regional and local levels in Russia is estimated at 1.3 million km. The length of the federal highways is 50.7 thousand km. (Federal Road Agency of the Ministry of Transport of the Russian Federation (RosAvtoDor))

2.1.1 Classification of roads in Russia

In accordance with the Law about highways, roads are divided into the following categories:

- Federal roads. A list of these roads shall be approved by the Government. Owned by the Russian Federation.
- Roads of regional and intermunicipal importance. Criteria for inclusion in this category of roads approved by the Subject of the Russian Federation. Owned by regional governments.
- Local roads. Roads within the boundaries of settlements (municipal district, urban district), not falling within any other category. Owned by settlements.
- Private roads. Roads owned by individuals and legal entities.

The total length of roads by their importance in different federal districts of Russia is shown in Table 2.1, and the division of the country by districts can be seen in Figure 2.2.

Table 2.1 The length of the public roads in Russia. (Federal State statistics service of Russia 2014 (Rosstat))

<table>
<thead>
<tr>
<th></th>
<th>Overall length – total, km</th>
<th>including on the importance:</th>
<th>Density of the paved public roads, km per 1000 km²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Federal roads, km</td>
<td>Roads of regional and intermunicipal importance, km</td>
</tr>
<tr>
<td>The Russian Federation</td>
<td>1 283 387,4</td>
<td>50 749,2</td>
<td>504 020,0</td>
</tr>
<tr>
<td>Central Federal District</td>
<td>297 919,0</td>
<td>10 438,8</td>
<td>112 885,2</td>
</tr>
<tr>
<td>Northwestern Federal District</td>
<td>121 282,2</td>
<td>5 979,6</td>
<td>66 565,2</td>
</tr>
<tr>
<td>Southern Federal District</td>
<td>100 569,4</td>
<td>4 249,5</td>
<td>31 197,8</td>
</tr>
<tr>
<td>North Caucasian Federal District</td>
<td>76 294,1</td>
<td>2 593,3</td>
<td>21 358,1</td>
</tr>
</tbody>
</table>
2.1.2 Categories of the roads

Roads in the Russian Federation are divided into three classes, depending on traffic conditions and access to them:

- Highway - category IA;
- Speedway - category IB;
- The road of conventional type (not speedway) - Category IB, II, III, IV, V.

Roads are divided into categories based on transportation and operational qualities and the properties of consumer, depending on:

- The number and width of traffic lanes;
- The presence of a central lane;
- The type of intersections with the roads, railways, tram tracks, cycling and walking paths;
- Access conditions to the road with the adjacencies in one level

The main parameters of the cross profile elements of carriageway and roadbed can be seen in Table 2.2 depending on their category.

Table 2.2 Characteristics of the cross profile elements of the carriageway and roadbed (GOST R 52398, 2005)

<table>
<thead>
<tr>
<th>Parameters of road elements</th>
<th>Highway</th>
<th>Speedway</th>
<th>The road of conventional type</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>IA</td>
<td>IB</td>
<td>IВ</td>
</tr>
<tr>
<td>Total number of lanes, pcs</td>
<td>4 or more</td>
<td>4 or more</td>
<td>4 or more</td>
</tr>
<tr>
<td>Width of lanes, m</td>
<td>3,75</td>
<td>3,75</td>
<td>3,75</td>
</tr>
<tr>
<td>Width of shoulders, m</td>
<td>3,75</td>
<td>3,75</td>
<td>3,75</td>
</tr>
<tr>
<td>The width of the edge strip at a roadside, m</td>
<td>0,75</td>
<td>0,75</td>
<td>0,75</td>
</tr>
<tr>
<td>Width of paved part of the shoulders, m</td>
<td>2,5</td>
<td>2,5</td>
<td>2,5</td>
</tr>
<tr>
<td>The smallest width of a central lane without road barriers, m</td>
<td>6,0</td>
<td>6,0</td>
<td>5,0</td>
</tr>
<tr>
<td>The smallest width of a central lane with road barriers, m</td>
<td>2 m + width of road barriers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The width of the safety band at a central lane, m</td>
<td>1,0</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
The network of paved public roads is distributed in the following order:

Category I: share in the network of paved roads 0.9 %;

Category II: share in the network of paved roads 5.1 %;

Category III: share in the network of paved roads 20.0 %;

Category IV: share in the network of paved roads 59.0 %;

Category V: share in the network of paved roads 15.0 %

(Federal State statistics service of Russia 2014 (Rosstat))
2.2 Finland

Figure 2.3 Map of the roads in Finland (Centre for Economic Development, Transport and the Environment of Finland)
The Finnish road network comprises highways, municipal street networks and private roads. The Finnish road network is approximately 454,000 kilometers long in total. It includes around 350,000 kilometers of private and forest roads and 26,000 kilometers of municipal streets. It should be noted that there are absolutely no toll roads in Finland unlike in Russia.

Highways and main roads comprise more than 13,000 kilometers, 810 kilometers of which are motorways. Most of the total road length of 78,000 kilometers consists of local and connecting roads. However, these represent just over a third of all traffic. (Finnish Transport Agency)

64% of all traffic on public roads takes place on main roads which are divided into class I (valtatie/riksväg) and class II (kantatie/stamväg) main roads. (Wikipedia website)

2.2.1 The classification of the roads in Finland

A highway is defined as a road assigned for general traffic and maintained by the State. Highways are classified as main roads Class I and Class II, regional roads or connecting roads depending on their transportational significance. A highway is defined as a road assigned for general traffic and maintained by the State. (Highways Act 503/2005)

The classification and numbering system of state-maintained roads of Finland is as follows:

- Main roads Class I (Finnish: valtatiet): road number 1–39 (between major cities)
- Main roads Class II (Finnish: kantatiet): road number 40–99 (between regional centers)
- Regional roads (Finnish: seututiet): road number 100–999 (between large municipalities or alternate routes)
- Connecting roads (Finnish: yhdystiet): road number 1000–9999 (connecting to a larger road)
- Local roads (Finnish: paikallistiet): road number 11000–19999 (between villages cf. farm-to-market road)

All main roads and almost all regional roads are paved. They are generally wider than 7 metres (23 ft). About half of the connecting and local roads are paved. (Wikipedia website)

Finland is divided into nine districts (the Regional Centres) which are responsible for the ordering of the road maintenance of their own area under guidance of the central unit. The territorial division of Finland is illustrated in Figure 2.4. The total length of roads by their class in different districts of Finland is shown in Table 2.3. (Centre for Economic Development, Transport and the Environment of Finland)

Table 2.3 The lengths of the roads in Regional Centres (Finnish Road Statistics 2013)

<table>
<thead>
<tr>
<th>Regional Centres</th>
<th>Class I Highways (km)</th>
<th>Class II Highways (km)</th>
<th>Regional Roads (km)</th>
<th>Connecting Roads (km)</th>
<th>Total 1.1.2013</th>
</tr>
</thead>
<tbody>
<tr>
<td>UUS</td>
<td>1 067</td>
<td>402</td>
<td>1 439</td>
<td>6 231</td>
<td>9 139</td>
</tr>
<tr>
<td>SWF</td>
<td>708</td>
<td>329</td>
<td>1 038</td>
<td>5 845</td>
<td>7 920</td>
</tr>
<tr>
<td>SEF</td>
<td>555</td>
<td>87</td>
<td>626</td>
<td>2 808</td>
<td>4 076</td>
</tr>
<tr>
<td>PIR</td>
<td>544</td>
<td>318</td>
<td>771</td>
<td>3 436</td>
<td>5 070</td>
</tr>
<tr>
<td>NSA</td>
<td>1 357</td>
<td>872</td>
<td>2 918</td>
<td>10 868</td>
<td>16 015</td>
</tr>
<tr>
<td>CEF</td>
<td>687</td>
<td>348</td>
<td>894</td>
<td>3 398</td>
<td>5 328</td>
</tr>
<tr>
<td>SOB</td>
<td>922</td>
<td>577</td>
<td>1 368</td>
<td>5 802</td>
<td>8 670</td>
</tr>
<tr>
<td>NOK</td>
<td>1 497</td>
<td>775</td>
<td>2 367</td>
<td>8 149</td>
<td>12 788</td>
</tr>
<tr>
<td>LAP</td>
<td>1 265</td>
<td>1 021</td>
<td>2 141</td>
<td>4 662</td>
<td>9 088</td>
</tr>
<tr>
<td>Whole country</td>
<td>8603</td>
<td>4 728</td>
<td>13 561</td>
<td>51 201</td>
<td>78 093</td>
</tr>
</tbody>
</table>
Figure 2.4 Map of regional centers in Finland (Centre for Economic Development, Transport and the Environment of Finland)
2.3 Summary

There are significant differences in comparison of the road network of Russia and Finland. The differences are related not only with the length, but with the density of roads per km². Thus the road network in Finland consists of 78,093 km while in Russia the road network is more in 16 times and consists of 1,283,000 km. This is not surprising as the sizes of the countries are different. Noteworthy is the fact that according to the data provided by the World Bank, the density of the road network in Finland is more than the Russian in 3.6 times. It is 23.1 km/100km² with a population density of 16 persons/km². In Russia, the density of the road network is 6.4 km/100 km² with a population density of 8.4 persons/km². Thus, it can be concluded that the road network in Russia needs to be expanded to ensure communication with all settlements, reducing the load on the existing road network and to improve the quality of movement.
3 CLIMATIC CONDITIONS

The conditions of roads and safety of driving greatly depend on weather. Therefore it is very important to understand the climatic conditions of the region for the implementation of road maintenance activities.

Climate, of course, with an area the size of Russia, it is difficult to give any sort of general advice about the climate and weather. The climate of Russia is formed under the influence of several determining factors. The enormous size of the country and the remoteness of many areas from the sea result in the dominance of the continental climate, which is prevalent in European and Asian Russia except for the tundra and the extreme southeast. Mountains in the south obstructing the flow of warm air masses from the Indian Ocean and the plain of the west and north makes the country open to Arctic and Atlantic influences. (Wikipedia website).

Finland's climate is so-called intermediate climate, combining characteristics of both a maritime and a continental climate. Weather in Finland depends very much on the prevailing wind direction and on how weather disturbances, i.e. low and high pressures, are situated. Finland is located in the zone of prevailing westerly winds on medium latitudes where tropical and polar air masses meet, where weather types vary rapidly particularly in winter. The prevailing air flow in Finland comes from the south-west. (Finland's weather and light website).

The climates of the two countries are considered in more detail in chapters 3.1 and 3.2.

3.1 Russia

Due to the huge size of the country, Russia has almost all climate zones of the world, excepting the tropical climates. Figure 3.1 shows a map that indicates the average temperature in Russia annually. And the next figure shows the average annual uncorrected precipitation. These maps illustrate a great difference in climate throughout Russia.
In general, the climate of Russia can be described as highly continental influenced climate with warm to hot dry summers and (very) cold winters with temperatures of \(-30^\circ\text{C}\) and lower and sometimes heavy snowfall. Sometimes very strong easterly winds called Buran can occur, bringing freezing cold temperatures and snow-
storms. Precipitation varies from region to region; the Western parts of Russia have the most rain (up to 750 mm), the southern and southeastern areas in the Russian steppes are the driest with an annual average below 200 mm.

In this study, the Northwest region of Russia is the most interesting, since it has a common border with Finland. The climate of this region is approximately aligned with the climate of the southern part of the neighbor country.

Northwestern Federal District of Russia is located in the area of two climatic zones: temperate and subarctic. The climate of the area is greatly influenced by the proximity of the sea. The climate is temperate continental humid. It is characterized by comparatively cold winters and warm summers. Relative humidity is high - 75-85 %. Humidity deficit is negligible and the annual average is 1-2 mm. The eastern part of the district is characterized more of a continental climate, where the winters are long and severe. In the direction of the west, and especially in the south-west - to the Baltic Sea - the climate is milder and wetter.

In the northwestern part of Russia warm (summer) and cold (winter) periods are clearly distinguished during the year. Transitional forms - spring and autumn, are also expressed. Annual precipitation in the region is about 600-800 mm. Figure 3.3 shows the main indicators of the average values of the weather conditions during the year (the measurement period 1971-2000). Results are shown in the example of Saint Petersburg - the administrative center of the North-West region. Figure 3.4 shows the amount of precipitation in 2013 in St. Petersburg. This is the mean monthly precipitation, including rain, snow, hail etc.
Figure 3.3 The main indicators of the average values of the weather conditions during the year (the measurement period 1971-2000). (Wikipedia website)

Figure 3.4 Average monthly precipitation over the year (rainfall, snow) in Saint-Petersburg in 2013. (World weather and climate information website)
Humidity in the region increases from the east (the dry air in the Komi Republic) to the west (the moist air on the Baltic coast, relative humidity 90-95 %).

The average annual temperature is 2.4 °C in the northeast; in the south-west rises to 6.8°C. This is explained by a mild winter in the south-west, where the average temperature in the coldest month - January - ranges from -2.7 °C to -4.3 °C; in the north-east of the district average January temperatures reach -8, 4°C and even to -10.0°C. The average air temperature in July, the warmest month of the year, is about the same within the entire area. It is about 17.0-17.5°C both in the north-east and south-west. In comparison with other parts of European Russia, in this area falls a relatively large amount of precipitation. Snow cover decreases in the direction from north-east to south-west. In the extreme south-west, with frequent thaws, snow cover is unstable.
3.2 Finland

The main factor influencing Finland's climate is the country's geographical position on high latitudes on the edge of a big continent. Weather in Finland varies greatly depending on the direction from which air flow and moving low and high pressures come at each time.

Finland's climate is so-called intermediate climate, combining characteristics of both a maritime and a continental climate. Weather in Finland depends very much on the prevailing wind direction and on how weather disturbances, i.e. low and high pressures, are situated. Finland is located in the zone of prevailing westerly winds on medium latitudes where tropical and polar air masses meet, where weather types vary rapidly particularly in winter. The prevailing air flow in Finland comes from the south-west.

Finland's mean temperature is several degrees higher than in most other continental areas located in the same latitudes. For instance, in comparison with the eastern part of Canada, Greenland and Siberia, the difference in the winter months can be 20-30 degrees. The primary reason for Northern Europe being this warm is the Gulf Stream and its extension, the warm North Atlantic current that transmits warmth from around the equator all the way up to the Arctic Sea. Finland's climate is warmed and balanced also by the Baltic Sea with its bays and numerous inland water bodies.

The annual mean temperature varies from more than +5 degrees in southwestern Finland to a couple of degrees below zero in Northern Lapland. Due to the warming effect of the Arctic Sea, Finland's coldest spot is not located in northernmost Lapland but in the north-western corner of the country.

The coldest time of the year is typically well after perihelion, i.e. in late January, except in maritime islands and coastal regions, where the slower cooling of the sea delays the coldest time until the first or second week of February. The lowest winter temperatures in Lapland and Eastern Finland are -45... -50 degrees, in other parts of the country usually between -35 and -45 degrees, in coastal regions and maritime islands, however, usually -25... -35 degrees.
The annual amount of precipitation in Finland varies between 500 and 650 millimetres. Lapland has the least precipitation, while inland areas in the southern and central parts of the country get the most downpours.

Figure 3.5 Average annual air temperature (°C) and average annual uncorrected precipitation sum (map to the right, unit millimeter), reference period 1981-2010. (Climate guide website)

The spring months see the least precipitation, while the amounts of precipitation increase towards summer so that July-August are typically the rainiest months. This is clearly seen in Figure 3.6. It shows the average monthly precipitation values for example Lahti. This city is the administrative center of the province Päijänne Tavastia which is located in the north of the Southern Finland. In the autumn, the amounts of precipitation begin to decrease again, but days with precipitation are more frequent in the autumn and winter. Usually, the number of days with precipitation per month is lowest in summer, but daily amounts of precipitation are highest in summer rain showers. (Climate guide website).
Snow cover

In Central and Northern Lapland, and the Koillismaa District, winter typically lasts for around seven months, and snow stays on the ground for more than six months every year. The number of days with snow cover decreases gradually towards the south and southwest. On the southwestern coast, the ground is covered with snow for a total of 3-4 months a year on average. Snow cover is deepest in late winter, typically in March, but in Lapland, not until April. Quite soon after, the snow begins to melt quickly. Snow is deepest in Lapland, more than 150 cm at most, but in the southern parts of the country, too, snow has been over one metre deep during snowiest winters. (Climate guide website).

The southwestern part of the country and the coastal areas receive a permanent snow cover during December on average, and it arrives earlier inland than by the open sea. The Åland Islands and the Turku archipelago are the areas with the shortest period of snow cover. In both areas the snow comes at the turn of the year and the final remnants melt away at the beginning of March at the latest.

In a typical winter the greatest snow depth is only 10-30 cm in southwestern Finland, in the western province of Ostrobothnia and on the coast. In southeastern and eastern Finland the snow cover is between 40-70 cm in the middle of March. In the hilly areas of eastern Finland, in the region of Kainuu and in most of Lapland the snow cover amounts to 60-100 cm early in April. The depth of the snow cover depends on the type of winter weather and it can vary greatly from the long-term average. Snowfalls and the depth of snow cover are decreasing as the climate
becomes warmer. The duration of the snow cover is gradually shortening at both ends. (Finland's weather and light website).

In this study, southern parts of Finland are the more interesting ones. In Southern Finland the average winter temperature is about -2 °C. The annual rainfall is about 600-700 mm. Permanent snow falls usually in December in the South. The Baltic Sea and especially the Gulf Stream are making the climate warmer. Weather conditions can change quickly in winter time. (Snow and Ice Databook 2010)

4 TRAFFIC VOLUMES

One of the most important uses for determining funding for the maintenance and improvement of highways is annual average daily traffic, abbreviated AADT.

AADT is a measure used primarily in transportation planning and transportation engineering. AADT is considered as one of the most important raw traffic datasets. Traditionally, it is the total volume of vehicle traffic of a highway or road for a year divided by 365 days. AADT is a useful and simple measurement of how busy the road is. (Wikipedia website)

4.1 Russia

To solve the problems of maintenance and repair of highways, road service should systematically study, collect and analyze traffic data at sites in different periods of the year. The study comes down to collecting information by intensity, composition and speed of traffic flow, distribution of vehicles on the road in different periods of the year, week and day complete details about the regularities of traffic obtained by special surveys of the roads. Road service leads the systematic integration of intensity and traffic composition.

In designing of the roads in Russia, the composition of the traffic flow is taken into account. The more trucks are in the traffic composition, the more difficult driving conditions are, and the wear of the road is coming faster. Statistics show that the number of trucks on the Russian roads, as a part of the traffic flow, is about 50 %, which is much higher than in European countries.
To take into account the composition of traffic, there is a notion, that traffic intensity is reduced to the passenger cars. That is all trucks and buses are replaced by passenger cars, using coefficient of reduction (ratio of the vehicle impact on surface of the road with a certain axial load, to the estimated impact from passenger car). (SNIP 2.05.02-85, 2004)

Reduced traffic for each type of vehicle is calculated by Formula 4.1:

$$N_{\phi, np} = \sum_{i=1}^{n} N_{\phi, np,i} = \sum_{i=1}^{n} N_{\phi, u3m,i} \cdot k_{np,i}$$

where:

- $n$ - number of vehicle types, units;
- $N_{\phi, u3m}$ - actual measured i-type vehicles traffic intensity, vehicles / h;
- $k_{np}$ - ratio for replacing the i-type vehicle traffic to a passenger car (Table 4.1)

Formula 4.1 Reduced traffic for each vehicle type. (SNIP 2.05.02-85, 2004)

Table 4.1 Ratio for replacing the different vehicles to a passenger car. (SNIP 2.05.02-85, 2004)

<table>
<thead>
<tr>
<th>Types of vehicles</th>
<th>Coefficient, $k_{np}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cars</td>
<td>1</td>
</tr>
<tr>
<td>Tricar</td>
<td>0,75</td>
</tr>
<tr>
<td>Motorcycles and mopeds</td>
<td>0,5</td>
</tr>
<tr>
<td>Trucks with carrying capacity, t:</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1,5</td>
</tr>
<tr>
<td>6</td>
<td>2</td>
</tr>
<tr>
<td>8</td>
<td>2,5</td>
</tr>
<tr>
<td>14</td>
<td>3</td>
</tr>
<tr>
<td>more than 14</td>
<td>3,5</td>
</tr>
<tr>
<td>Autotrails with carrying capacity, t:</td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>3,5</td>
</tr>
<tr>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>30</td>
<td>5</td>
</tr>
<tr>
<td>more than 30</td>
<td>6</td>
</tr>
</tbody>
</table>
Based on the design reduced traffic, the road must meet all the characteristics of the conformity category (see Table 4.2).

**Table 4.2** The division of the roads into categories according to the reduced traffic (SNIP 2.05.02-85, 2004)

<table>
<thead>
<tr>
<th>Importance of the road</th>
<th>Road category</th>
<th>Design reduced traffic. pcs. / day</th>
</tr>
</thead>
<tbody>
<tr>
<td>Federal highways</td>
<td>I-а</td>
<td>more than 14 000</td>
</tr>
<tr>
<td></td>
<td>I-б</td>
<td>more than 14 000</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>more than 6 000</td>
</tr>
<tr>
<td>Other federal roads</td>
<td>I-б</td>
<td>more than 14 000</td>
</tr>
<tr>
<td></td>
<td>II</td>
<td>more than 6 000</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>2 000 to 6 000</td>
</tr>
<tr>
<td>Republican, territorial, regional roads and roads of autonomous entities</td>
<td>II</td>
<td>6 000 до 14 000</td>
</tr>
<tr>
<td></td>
<td>III</td>
<td>2 000 to 6 000</td>
</tr>
<tr>
<td></td>
<td>IV</td>
<td>200 to 2 000</td>
</tr>
<tr>
<td>Local roads</td>
<td>IV</td>
<td>200 to 2 000</td>
</tr>
<tr>
<td></td>
<td>V</td>
<td>to 200</td>
</tr>
</tbody>
</table>

Consider the more detailed information on the traffic intensity on the example of one of the most important and busiest routes of Russian North-West: road M-10 "Russia". The M10 is a federal highway in Russia connecting the country's two largest cities, Moscow and Saint Petersburg, and continuing to the border with Finland. Other than in the vicinity of Moscow and Saint Petersburg, the M10 is basically a two-lane highway (one lane for each direction), with an occasional third centre lane to allow overtaking or for left-turning traffic at intersections.

The distance from Moscow to St. Petersburg by M10 is approximately 700 km. From Saint Petersburg city center to the Finnish border the distance is approximately 210 km. The route section between Saint-Petersburg and the border with Finland is known as the "Scandinavia" highway and is officially renamed to route A181, but the designation M10 is valid also. (Wikipedia website)
The traffic intensity throughout the road is extremely high - from 60 to 100 thousand cars per day in the Moscow region and from 60 to 20 thousand in the rest of its length. The road is overloaded against current standards in 2 - 5 times. 30-40% of the total number of vehicles is cargo vehicles.

Graph of the traffic intensity of road M-10 "Russia"

Figure 4.1 The average annual daily traffic volume according to the automated account on the road M-10 "Russia" in 2012 (Anokhin B., 2012)
4.2 Finland

The large number of cars and heavy trucks on the roads has negative impact on road conditions and safety. The average daily number of automobiles on all highways was about 1 283 in 2013. On main roads the AADT was from 2 700 to 5 900 automobiles, on regional roads 1 386 and on connecting roads about 340. In Uusimaa the AADT was 3 285 automobiles, in the rest of southern Finland from 1 400 to 1 500. The annual average daily traffic in regions is shown in Table 3.1.

Table 4.3 Average daily traffic (Finnish Road Statistics 2013)

<table>
<thead>
<tr>
<th>Regional centre (ELY)</th>
<th>Class I main roads</th>
<th>Class II main roads</th>
<th>Regional roads</th>
<th>Connecting roads</th>
<th>All highways</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uusimaa</td>
<td>13 902</td>
<td>12 352</td>
<td>4 132</td>
<td>686</td>
<td>3 285</td>
</tr>
<tr>
<td>Southwest Finland</td>
<td>7 368</td>
<td>4 701</td>
<td>2 263</td>
<td>491</td>
<td>1 512</td>
</tr>
<tr>
<td>Southeast Finland</td>
<td>6 597</td>
<td>2 390</td>
<td>1 541</td>
<td>302</td>
<td>1 395</td>
</tr>
<tr>
<td>Pirkanmaa</td>
<td>9 834</td>
<td>2 959</td>
<td>1 980</td>
<td>387</td>
<td>1 805</td>
</tr>
<tr>
<td>North Savo</td>
<td>4 779</td>
<td>1 833</td>
<td>820</td>
<td>191</td>
<td>783</td>
</tr>
<tr>
<td>Central Finland</td>
<td>5 445</td>
<td>1 297</td>
<td>1 133</td>
<td>313</td>
<td>1 177</td>
</tr>
<tr>
<td>South Ostrobothnia</td>
<td>4 197</td>
<td>2 232</td>
<td>1 376</td>
<td>354</td>
<td>1 049</td>
</tr>
<tr>
<td>Northern Ostrobothnia and Kainuu</td>
<td>3 738</td>
<td>1 410</td>
<td>775</td>
<td>245</td>
<td>822</td>
</tr>
<tr>
<td>Lappland</td>
<td>1 837</td>
<td>1 011</td>
<td>414</td>
<td>144</td>
<td>541</td>
</tr>
<tr>
<td>Whole country</td>
<td>5 938</td>
<td>2 774</td>
<td>1 386</td>
<td>336</td>
<td>1 283</td>
</tr>
</tbody>
</table>

During recent years the traffic situation in south-eastern Finland has changed essentially because of increased heavy traffic directed to Russia. Transit volumes of Finnish harbors and general cargo export to Russia have increased significantly. A proportion of the heavy traffic in south-eastern Finland has been exceptionally high reaching 25 % of everyday traffic on the main roads.

The majority of export and import freight traffic between Finland and Russia runs through the south-eastern part of Finland. (Bernitz O., Kinttula M., Pitkänen J-P., Jarkko Niittymäki J., 2009).

4.3 Summary

The growth of the traffic produced problems and revealed rehabilitation needs of the existing road network. Also it requires increased attention to road mainte-
nance. The heavy traffic is a significant factor producing noise impacts and increasing problems of road structural condition. Obviously the large-scale volume of the heavy traffic creates risks to traffic safety.

Summing up here are some interesting characteristics in comparison between the two countries.

In the list of countries by the number of road motor vehicles per 1,000 inhabitants, Finland stands in the 17th place and has 612 motor vehicles per 1,000 inhabitants. Russia has only 293 motor vehicles per 1,000 inhabitants and ranks place 53. (Wikipedia website)

Figure 4.2 shows a comparison by vehicles per kilometer during the years. Vehicles per kilometer of road include cars, buses, and freight vehicles but do not include two-wheelers. Roads refer to motorways, highways, main or national roads, secondary or regional roads, and other roads. Figure 4.3 and Figure 4.4 show a comparison of volumes of freight and passenger traffic in Finland and Russia.
Figure 4.3 The volume of goods transported by road vehicles, measured in millions of metric tons times kilometers traveled. (World Development Indicators (WDI), 2014)

Figure 4.4 The number of passengers transported by road times kilometers traveled. (World Development Indicators (WDI), 2014)
5 ORGANIZATION OF ROAD MAINTENANCE

5.1 Russia

The Federal Road Transport Agency, also known as Rosavtodor, is the Russian government agency which is responsible for overseeing the road transport industry and Transport engineering in Russia.

Federal Road Agency is a state body responsible for initiating of special federal, scientific and technical and innovation programs and projects including the “Roads” subordinate program of the “Modernization of Russian road system (years 2002-2010)” program.

Federal roads management is carried out by Federal Road Agency directly as well as through the system of federal state establishments and their branches, responsible for efficient federal roads management and for organizing of road construction, reconstruction, repair and maintenance works.

The organizational structure of road management and road organizations in every region of the Russian Federation is varied and periodically changed. In the subjects of the Russian Federation, with a large area and complicated administrative division, the Ministry, which is responsible for road management, includes divisions, one of which usually serves only federal roads, the other - the rest of the network. In the subjects of the Russian Federation with a small size and relatively simple administrative division, there is one unit that manages all subordinate road operational organizations.

Production units of road service on public roads are management of road maintenance and construction (MRMC). Recently, more and more often maintenance of roads is carried out by road-building contractors. (VSN 24-88, 1998)

Road organizations which serve the federal roads, are typically built on a linear principle, sometimes there are used the territorial principle.
Road service is created on all public roads, and it is responsible for the timely and proper execution of works for the maintenance and repair of roads, organization and ensuring the traffic safety on them.

Road service provides continuous supervision of the technical condition of roads and structures, evaluates this condition, develops and implements long-term and annual plans of raising the technical level and the operational condition of roads and structures. Road service also identifies hazardous traffic areas, develops and implements measures to improve traffic safety, keeps records and accident analysis, takes the necessary measures to prevent accidents, interruptions and traffic restrictions, seasonal deformations, promptly informs road users about traffic conditions on the roads.
The extent of areas serviced by the road service depends on the type of road, the climatic characteristics and coating types. (A. Vasilyev, 2005)

In order to ensure the effectiveness of the Road Service, dispatch centers of automated production management (CPM) exist in contractor organizations and their structural subdivisions, which obey the center of operations management (COM) of road authority.

Schematic diagram of the organization of a unified management system of federal highway maintenance is reflected in Figure 5.2.

Funds for the maintenance of public roads are included in the budget of the Russian Federation. The Ministry of Transport of the Russian Federation transmits them to Federal Road Agency (Rosavtodor). Rosavtodor distributes funds to the
federal state establishments in Federal districts, which are responsible for road maintenance.

5.2 Finland

In 2001 the Finnish National Road Administration was divided into the Finnish Road Administration (Finnra), which orders services from producers, and the Finnish Road Enterprise, which takes care of construction and maintenance among other contractors. In the beginning of 2008 Finnish Road Enterprise became known as Destia. (Snow and Ice Databook, 2010, p. 84)

The Finnish Road Administration (Finnra) was a state agency responsible for the management of the countrywide public road network. Streets in cities and municipalities are the responsibility of the municipalities. The private road network is the responsibility of the landowners living along the private roads. (Snow and Ice Databook, 2010, p. 83)

Finnra ordered winter maintenance along with summer maintenance as area maintenance contracts from contractors.

Now the Finnish Transport Agency is in charge of the maintenance and management services for roads and ensures the trafficability and safety of all routes throughout the year. Together with the regional Centers for Economic Development, Transport and the Environment, the Finnish Transport Agency is in charge of maintenance and development of the state-owned road network. In total, the Finnish Transport Agency is responsible for approximately 78 000 kilometers of highway.

The Parliament decides on the funding of the infrastructure management. The Ministry of Transport and Communications allocates the funds for roads to the Finnish Transport Agency. Infrastructure management, including road maintenance, is funded from the state budget. (Finnish Transport Agency)
The Finnish Transport Agency operates through 15 regional Centres for Economic Development, Transport and the Environment and they have replaced the Finnish Road Administration as a road manager and a client of the road maintenance. The contractors for each region are chosen on the grounds of a price and quality competition. (Centre for Economic Development, Transport and the Environment of Finland)

The road network is divided into 81 contract districts. They are presented in Figure 5.4. Area-wide maintenance contracts awarded by Centres for Economic Development, Transport and the Environment consist of regionally limited projects in which the maintenance contractor is responsible for the year-round maintenance of the roads belonging to the area. Maintenance work is performed in accordance with the quality criteria set by the Centres for Economic Development, Transport and the Environment. The length of road network in these areas varies from 500 kilometers to 2 000 kilometers and lasts 5-7 years.
Figure 5.4 Contractors and their road maintenance areas for the period of 1.10.2013-1.10.2014. (Finnish Transport Agency)

Streets are maintained by the local municipality. Winter maintenance of roads and streets is managed by a local authority. (Finnish Transport Agency)

In order to ensure the timeliness of maintenance, various kinds of information on the current and impending weather conditions are necessary. To this end, the Finnish Transport Agency has at its disposal road weather stations and weather camera systems. The weather information is available to the regional contractors. The road weather station network of the Finnish Road Administration consists of over 350 road weather stations. The stations gather information on factors affecting the weather and driving conditions. The contractor plans and decides on the procedures that are to be carried out in relation to the road network and, by moni-
toring weather conditions and the conditions of the roads, ensures that the neces-
sary measures are carried out at such a time that allows for the fulfillment of the
quality requirements. (Snow and Ice Databook, 2010, p. 85)

6 THE IMPLEMENTATION OF ROAD MAINTENANCE IN RUSSIA

Road maintenance includes a set of engineering activities for the systematic care
of highways, road constructions and the adjacent territory in order to maintain
them properly throughout the year and corrections of minor deformations and
damage of all components. Implementation of road maintenance in high quality
and full volume slows the deterioration of transport and operational performance of
the road.

Assessing the level of road maintenance is an obligatory road management func-
tion, carried out in order to:

- Determine the degree of achievement the planned level of road mainte-
nance on the basis of which the level of funding is accepted.
- Obtain objective information on the actual level of road maintenance ser-
ved by various performers.

(ODM 218.0.000-2003, 2003)

There are three adopted normative levels of road maintenance in Russia - allowa-
ble, medium, high, and one is not normative level - not allowable, that does not
comply with the requirements for the maintenance of roads. On the same road,
different levels may be set for different parts. The normative levels of road mainte-
nance is assigned by the owners (federal agencies) for each site, based on the
level of funding, traffic intensity, weather conditions, and the level of road safety.

Requirements provided by the road service depending on the intended level of
maintenance are presented in Figure 6.1.
Requirements to the level of maintenance of the road depend on the level of consumer properties. They are grouped into the following groups.

Grouping of roads for the purpose of assessing the level of maintenance is presented in Table 6.1 (ODM 218.0.000-2003, 2003).

- A1 - Roads relating to highways;
- A2 - Roads 1 category;
- A3 - Roads 2 categories;
- Б - Roads 3 categories;
- В - Roads 4 and 5 categories with a coating of bituminous mixtures;
- Г1 - Roads 4 and 5 categories with a coating of crushed stone, gravel;
- Г2 - Unpaved roads.
Table 6.1 Grouping of roads for the purpose of assessing the level of maintenance (ODM 218.0.000-2003, 2003)

<table>
<thead>
<tr>
<th>Group of roads</th>
<th>The actual traffic in the transport units, the auto (24\text{h})</th>
<th>The number of lanes</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>from 40 000 to 20 000</td>
<td>8</td>
<td>highways</td>
</tr>
<tr>
<td></td>
<td>to 7 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A2</td>
<td>from 40 000 to 20 000</td>
<td>8</td>
<td>Roads coated with concrete, asphalt and bituminous mixtures</td>
</tr>
<tr>
<td></td>
<td>to 7 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>A3</td>
<td>from 3 000 to 1 000</td>
<td>2</td>
<td>Roads coated with treated and untreated astringent gravel materials.</td>
</tr>
<tr>
<td></td>
<td>to 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Б</td>
<td>from 1 000 to 100</td>
<td>2</td>
<td>Unpaved roads</td>
</tr>
<tr>
<td></td>
<td>to 100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Г1</td>
<td>from 100 to 1 000</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>to 1 000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Г2</td>
<td>from 100 to 1 000</td>
<td>1-2</td>
<td></td>
</tr>
</tbody>
</table>

6.1 Maintenance of the roads in spring, summer and autumn

6.1.1 Requirements for the indicators characterizing road in spring, summer and autumn

Table 6.2 Requirements for the main indicators characterizing road maintenance in spring, summer, autumn and the terms of liquidation of defects. (ODM 218.0.000-2003, 2003)

<table>
<thead>
<tr>
<th>Parameter, the defect of the road</th>
<th>Group of roads</th>
<th>levels of road maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Group of roads</td>
<td>Allowable</td>
</tr>
<tr>
<td>1. The roadbed</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elevation of shoulders and the dividing line over the roadway in the absence of border stones. Understatement of shoulders and the dividing line to the edge of the roadway more than 4 cm. Term of liquidation of the defects is no more than 7 days</td>
<td>A1</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td>A2, A3</td>
<td>5.0 (5)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>7.0 (7)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>15.0 (10)</td>
</tr>
<tr>
<td></td>
<td>Г1</td>
<td>20.0 (15)</td>
</tr>
<tr>
<td></td>
<td>Г2</td>
<td>-</td>
</tr>
<tr>
<td>Individual damages, no more than m2 per 1000 m2 of total area of unfortified shoulders., (In brackets: the depth of damage, no more than cm) Term of liquidation of the defects is no more than 7 days</td>
<td>A1</td>
<td>0.3 (1,0)</td>
</tr>
<tr>
<td></td>
<td>A2, A3</td>
<td>0.3 (1,5)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>1.5 (3,5)</td>
</tr>
<tr>
<td></td>
<td>B</td>
<td>2.5 (7,0)</td>
</tr>
<tr>
<td></td>
<td>Г1, Г2</td>
<td>-</td>
</tr>
</tbody>
</table>
Grass on shoulders and dividing line, height more than 15 cm.
Grass on slopes more than 25 cm in height.

<table>
<thead>
<tr>
<th>Rubbish and foreign objects on the roadsides, slopes of roadbed not affecting the traffic safety, occurring more frequently than, m. Term of liquidation of the defects is no more than 1 day.</th>
<th>For all groups of roads</th>
<th>not allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A1</td>
<td>100</td>
<td>300</td>
</tr>
<tr>
<td>A2, A3, B, B, Г1, Г2</td>
<td>200</td>
<td>300</td>
</tr>
</tbody>
</table>

### 2. Roadway

<table>
<thead>
<tr>
<th>Individual damages, no more than m² per 1000 m² of total area of roadway. The limit dimensions of the damage: length - 15 cm, width - 60 cm depth - 5 cm.. Term of liquidation of the defects is no more than: 5 days for A1, A2, A3; 7 - for B; 10 - for B; 14 – for Г1; 20 - for Г2. (In brackets: the requirements for the spring period, the duration of which is established by the Customer depending on local climatic conditions.)</th>
<th>A1</th>
<th>0,3 (1,0)</th>
<th>not allowed (0,5)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2, A3</td>
<td>0,3 (1,5)</td>
<td>not allowed (1,0)</td>
<td>not allowed</td>
</tr>
<tr>
<td>Б</td>
<td>1,5 (3,5)</td>
<td>1,0 (2,0)</td>
<td></td>
</tr>
<tr>
<td>В</td>
<td>2,5 (7,0)</td>
<td>1,5 (3,5)</td>
<td></td>
</tr>
<tr>
<td>Г1</td>
<td>7,0 (15,0)</td>
<td>5,0 (10,0)</td>
<td>2,5 (5,0)</td>
</tr>
<tr>
<td>Г2</td>
<td>15 (30,0)</td>
<td>10,0 (20,0)</td>
<td>5,0 (10,0)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Untreated areas of extruding the bitumen no more than m² per 1000 m² of carriageway. Term of liquidation of the defects is no more than 4 days</th>
<th>A1</th>
<th>not allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A2</td>
<td>7,0</td>
<td>5</td>
</tr>
<tr>
<td>A3</td>
<td>10,0</td>
<td>7,0</td>
</tr>
<tr>
<td>Б</td>
<td>15,0</td>
<td>10,0</td>
</tr>
<tr>
<td>В</td>
<td>20,0</td>
<td>15</td>
</tr>
<tr>
<td>Г1, Г2</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Profile Infraction, comb, no more than m² per 1000 m² of roadway,</th>
<th>A1, A2</th>
<th>-</th>
</tr>
</thead>
<tbody>
<tr>
<td>A3, Б В</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Г1</td>
<td>100</td>
<td>70</td>
</tr>
<tr>
<td>Г2</td>
<td>150</td>
<td>100</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Disclosed rough cracks on asphalt concrete and cement concrete pavement, opening width of 3 mm and a the total length no more than, m</th>
<th>A 1, A 2</th>
<th>400</th>
<th>200</th>
<th>not allowed</th>
</tr>
</thead>
<tbody>
<tr>
<td>A 3, Б, В</td>
<td>300</td>
<td>150</td>
<td>not allowed</td>
<td></td>
</tr>
<tr>
<td>Г1, Г2</td>
<td>-</td>
<td>-</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### 6.1.2 Maintenance of the road’s subgrade

Maintenance work to the subgrade is undertaken to retain its geometric shape, providing the required strength and stability of the subgrade, shoulders and slopes, the constant maintenance of the drainage and culvert systems. Particular attention should be paid to areas with poor soil and hydrological conditions, places of occurrence and development of frost boiling, road sections in the marshes and in the areas of irrigation.

The main objectives of the subgrade maintenance by periods of the year are:

- In the spring - to exclude overwetting subgrade’s soil by groundwater;
• In the summer - to perform the work to clean and restore the defects of drainage equipment, shoulders and slopes;

• In the autumn - to warn overwetting the subgrade by atmospheric precipitation, ensure a minimum soil moisture

In order to prevent, eliminate and mitigate the effects of rain and melting water on the subgrade, the systematic works are performed to ensure the smooth flow of water in drainage facilities with regular cleaning of drainage ditches, with cutting bushes, mowing grass, removing stones and other objects, continuously monitoring the passage of rain and melt water, eliminating the delays and liquidating the washouts of the subgrade.

Preparation of the drainage system for the winter period includes closing the holes, tubes and small bridges by wooden shields to prevent clogging by snow and subsequent icing as well as clearing ditches and channels of small streams near the engineering structures. Wells are cleaned of silt.

Maintenance of shoulders and slopes includes the complete removal of snow and ice from them at the end of the winter, grass mowing, removal of bushes and foreign objects, systematic planning, the alignment holes, ruts and other recesses. (Tsupikoff S., Gritsenko D., 2005)

6.1.3 Maintenance of road pavements

The main tasks of the maintenance of road pavements are the systematic care and improvement of transport and operational qualities of the coating and keeping it clean and tidy.

Maintenance works of the roadway in the spring, summer and autumn mainly consist of the prevention and liquidation minor injuries caused by the action of vehicles and environmental factors. The nature of the activities under the maintenance of the roadway largely depends on the type of coating. On the dirt road with no pavement, the maintenance of the roadway, in essence, consists of the subgrade maintenance activities. (Tsupikoff S., Gritsenko D., 2005)
6.1.4 Maintenance of roads with improved surface

In spring, before the start of intensive melting, snow and ice are removed from the roadway and shoulders. The works for cleaning the coating from dust and dirt, and washing them with a watering machine are carried out. (Road Encyclopedia)

On roads with pavement with insufficient strength and a large number of weakened regions (overwetting subgrade abyss) road service restricts the movement of heavy vehicles, reduces the speed of transport or completely closes the passage, by translating it into a specially prepared detours. With the onset of warm and stable weather, Road service removes small damages in the form of potholes, cracks, individual waves, hillocks, and roughnesses of the road edges.

The most difficult work of keeping the road pavements with asphalt coverings, includes repairing cracks, holes and liquidation of ruts with the depth till 30 mm. (Tsupikoff S., Gritsenko D., 2005)

Any defects with dimensions of length, width and depth more than 15 x 60 x 5 cm on the road surface are not allowed, and the number of more small damages and defects in the spring-summer-autumn periods are allowed less than the values given in Table 6.2.

6.1.5 Maintenance of roads with the transitional surfaces

The works for maintenance consist of dissipation of small stones on the cover, the removal of large stones, dedusting the surface by water. Other de-dusting materials such as calcium chloride or organic astringent are used in road repair. In spring and autumn transient coating has to be cleaned of dirt, as well as drain water if it is delayed on the carriageway. Motor graders align gravel coating by profiling or pressing of metal irons. (Tsupikoff S., Gritsenko D., 2005)

6.1.6 Maintenance of unpaved roads

Intense and frequent profiling is carried out to eliminate the formed holes, ruts and other irregularities. Also, for increasing the quality of the roads surface, ironing is used - prevention activities which are carried out before the formation of large-scale roughness, when the soil contains the optimum moisture. During the period
of heavy rains or rasputitsa, it is advisable to close unpaved roads. (Tsupikoff S., Gritsenko D., 2005)

### 6.1.7 Maintenance of buildings and structures of road service

The scope of works under the maintenance of road barriers includes periodic inspection of barriers and signal columns, replacement and minor repair of defective parts, pulling up of fasteners, removal of dust and dirt, washing, and if necessary, painting the barriers.

Maintenance of road signs consists of systematically clearing shields and pillars from dust and dirt, paint surface of pillars, straightening or replacing shields and pillars, pulling up the bolts, replacing of light sources in the illuminated signs.

Auto Pavilions are kept clean, washed and repainted, road service also corrects small damages and replaces damaged parts.

Road buildings and ancillary structures should be inspected regularly (advisably twice a year - in spring and autumn) to determine their conditions and measures required to correct deficiencies. (Tsupikoff S., Gritsenko D., 2005)

### 6.2 Winter maintenance

The winter season refers to the time when the average daily air temperature falls below 0 °C in autumn and until the reverse transition.

Winter maintenance of roads is a set of activities, including:

- Protection of the roads from snow drifts;
- Cleaning of the roads from snow;
- De-icing;
- Protection of the roads from avalanches;
- Protection of the ice dams;

These works are aimed at ensuring smooth and safe movement of vehicles.
Winter season is the most difficult for the maintenance of roads and organization of traffic. The duration of this period varies from 20 days in the southern regions up to 260 days in the northern regions of Russia.

The most characteristic feature of the winter season is the formation of snow and ice deposits on the road surface. As a result, there is a sharp changing of the conditions of vehicle interaction with the road.

The whole system of measures for winter maintenance of roads should be constructed in such a way as to ensure the best conditions for the movement of vehicles, and to make the winter maintenance easier and cheaper. To meet these objectives under the winter maintenance, the following measures are carried out:

- Preventive measures aiming at preventing or to weakening the formation of snow and ice deposits on the road; such measures include preventive treatment of coatings by chemical deicing materials;
- Protective measures which block access to the road of snow and prevent the ice formation. These include the usage of protection against snowdrift transfer (including works of the snow protection landscaping), avalanches and ice;
- Measures to remove snow and ice deposits on the road and reduce their impact to the car traffic (treatment of snow and icy road surface by materials, which increase the coefficient of tire grip).

(Vasilyev A., 2005, p 42)

6.2.1 Snow and ice removal

Snow on the carriageway can be caused by various reasons, described in Figure 6.2.
As a rule, clearing of the roads from the falling, or wind-blowing snow should be done on the full width of the roadbed, and the liquidation of winter slipperiness - on the width of the carriageway and paved shoulders.

The main indicators of the level of winter maintenance are: width of clean road surface from snow and ice - $B_1$; thickness of the layer of compacted or loose snow on the roadway accumulated since the start of snowfall or blizzard before the snow removing hp; thickness of the layer of snow on the roadsides $h_0$; These indicators are presented in Figure 6.3

According to the level of winter maintenance, the roads are divided into groups:

- **A** — roads with cleaning of the entire width of the surface;
- **Б** — roads with cleaning of the entire width of the roadway;
- **В** — roads with cleaning of middle of the roadway;

![Figure 6.2](image1)

**Figure 6.2** The main causes of the snow deposits on the roads.

![Figure 6.3](image2)

**Figure 6.3** The main indicators of the level of winter maintenance (Vasilyev A., 2005, p 42)
— roads with compacted snow on the roadway.

For each road the deadlines for clearing snow and ice must be set, defined on the basis of technical and economic calculations, taking into account the administrative importance of the road and maintenance level, intensity and composition of traffic, weather and climatic characteristics of the area of the road and equipment and materials for winter road maintenance. These deadlines must be agreed with the local authorities. The maximum permissible values of these terms are given in Table 6.3. (VSN 24-88, 1998)

Table 6.3 Terms of liquidation winter slipperiness and permissible thickness of snow on the roadway (ODM 218.0.000-2003, 2003)

<table>
<thead>
<tr>
<th>Parameter, the defect of the road maintenance</th>
<th>Group of roads</th>
<th>Levels of road maintenance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friable (melted) snow on the shoulders, after the snow removing a thickness not exceed, cm. Cleaning width of shoulders for groups A1, A2 is 100 % for the rest — 50 %</td>
<td>A1, A2 A3, Б</td>
<td>Allowable Medium High</td>
</tr>
<tr>
<td>Term of snow removing from shoulders after the end of cleaning of the carriageway, no more, h</td>
<td>Г1, Г2</td>
<td>1,0 (2,0)</td>
</tr>
<tr>
<td></td>
<td>Б</td>
<td>3,0 (6,0)</td>
</tr>
<tr>
<td>Friable (melted) snow on the sidewalks after the snow removing a thickness not exceed, cm</td>
<td>A1, A2, A3</td>
<td>Allowable Medium High</td>
</tr>
<tr>
<td></td>
<td>Б</td>
<td>5</td>
</tr>
<tr>
<td></td>
<td>В</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>Г1</td>
<td>12</td>
</tr>
<tr>
<td></td>
<td>Г2</td>
<td>-</td>
</tr>
<tr>
<td>Snow banks at the roadside barriers, term of liquidation is no more than 5 days</td>
<td>For all groups of roads</td>
<td>not allowed</td>
</tr>
<tr>
<td>Friable (melted) snow on the sidewalks after the snow removing a thickness not exceed, cm</td>
<td>A1, A2</td>
<td>A3, Б , В</td>
</tr>
<tr>
<td></td>
<td>5(3)</td>
<td>5(5)</td>
</tr>
</tbody>
</table>

The minimum length of the shoulders in which there should be no snow banks: near railway level crossings / before crossing in one level / near public transportation stopping points / near pedestrian crossing, m.

<table>
<thead>
<tr>
<th>Group of roads</th>
<th>A1, A2</th>
<th>A3</th>
<th>Б</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friable (melted) snow on the shoulders, after the snow removing a thickness not exceed, cm</td>
<td>500/250/20/5</td>
<td>500/200/20/5</td>
<td>500/150/20/5</td>
</tr>
</tbody>
</table>
As a rule, clearing the road from the snow is carried out on the full width of the roadbed, and the liquidation of winter slipperiness - on the width of the carriageway and shoulders. The layer of the small thickness of compacted snow is allowed to leave on a road surface of the transitional and dirt roads. Snow on the roadway and shoulders should be regularly profiling to prevent irregularities.

6.2.2 Anti-skid treatment

Measures to prevent the winter slipperiness are aimed at preventing the formation of ice and snow deposits on the road and to eliminate them, if they have formed on the road. In this regard, winter road maintenance service performs the following actions:

- Preventive treatment of coatings by chemicals, if there is the likelihood of snow and ice deposits in order to prevent the formation of slippery snow-ice layer or weaken its grip with pavement;
- Melt the ice or snow-ice layer by using solid and liquid chemical materials, if it is already formed;
- Sprinkle materials on the icy coating, which increase the friction coefficient (friction material). (VSN 24-88, 1998)

In winter maintenance of roads chemical, friction, and combination of the methods are used to deal with winter slipperiness. These ways are shown in Figure 6.4.

The chemical method is used in different regions at the roads of I and II categories. Friction method is used on the roads (sections) III - V categories, as well as on the roads, which are located in regions with long and stable low temperatures (below -20 ...- 25 °C). The combination of the methods is used if there is a need to eliminate snow and ice deposits and increase the coefficient of friction on them.

Figure 6.4 Methods of prevention and liquidation of winter slipperiness.

The main method for preventing winter slipperiness and controlling it is the usage of chemical materials. Frictional method to deal with winter slipperiness is to be used only in those cases, in which the usage of chemical methods, for some reasons, is impossible. (VSN 24-88, 1998)

De-icing materials are distributed uniformly over the surface of the coating in accordance with the required standards of consumption. In addition to the chemical
de-icing materials, for dealing with winter slipperiness is recommended to use natural brines and salt solutions. Salt solutions are recommended to prepare of NaCl and CaCl₂.

The optimal values of normative distribution of solids (g/m²) and liquid (l/m²) chemical deicing materials, as well as natural brines and solutions are presented in Table 6.4.

Sand-salt mixture, as icemelter material, is used in the friction method. It is prepared on the bases belong to road maintenance organizations by mixing the friction material with a crystalline salt in a percentage from 90:10 to 80:20 (by weight, respectively). The norms of distribution of the mixture prescribed are based on the quantitative mixing ratio so, that the amount of salt in the mixture corresponds to the specified value in Table 6.4 for solid chlorides. (VSN 24-88, 1998)

Table 6.4 Optimum distribution norms of deicing materials (VSN 24-88, 1998)

<table>
<thead>
<tr>
<th>№</th>
<th>The name of chloride</th>
<th>Content of the basic substance, %</th>
<th>Compacted snow and loose snow (at 1 mm of precipitation)</th>
<th>Glaz ice</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Air temperature, °C</td>
<td>- 5</td>
</tr>
<tr>
<td>1</td>
<td>Sodium chloride in the form of: a) common salt; b) salts from the sylvinitite c) a mixture of salts of a) and b) with calcium chloride as a percentage of 88:12;</td>
<td>90</td>
<td>20</td>
<td>35</td>
</tr>
<tr>
<td></td>
<td>Calcium chloride in the form of: a) calcium chloride; b) phosphated calcium chloride</td>
<td>80</td>
<td>25</td>
<td>40</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>35</td>
<td>65</td>
</tr>
<tr>
<td>2</td>
<td>Brine of sodium chloride</td>
<td>76</td>
<td>25</td>
<td>45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>67</td>
<td>30</td>
<td>55</td>
</tr>
<tr>
<td>3</td>
<td>Brine of calcium chloride</td>
<td>25</td>
<td>0.05</td>
<td>0.10</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>0.07</td>
<td>0.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>15</td>
<td>0.10</td>
<td>0.14</td>
</tr>
<tr>
<td>4</td>
<td>Brine of calcium chloride</td>
<td>35</td>
<td>0.03</td>
<td>0.06</td>
</tr>
<tr>
<td></td>
<td></td>
<td>30</td>
<td>0.04</td>
<td>0.08</td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>0.06</td>
<td>0.12</td>
</tr>
</tbody>
</table>
7 THE IMPLEMENTATION OF ROAD MAINTENANCE IN FINLAND

The main aim of road maintenance in Finland is to keep roads usable every day and ensure that traffic can flow safely. Only diligent road maintenance will ensure the road network's safety and trafficability. ELY Centres are responsible for maintaining a total of 78,000 km of roads plus adjoining structures, bus stops and road lighting. Road maintenance includes both the upkeep and management of paved roads, gravel roads, bridges, the road environment and adjacent equipment and structures. Road maintenance has been outsourced to companies operating on the open markets. (Centre for Economic Development, Transport and the Environment of Finland)

The road network is divided into 80 contract districts. Local contractors are in charge of road maintenance in compliance with the service level specified by the Finnish Transport Agency. Based on their properties, the roads are divided into maintenance classes, and the response times for snow ploughing, for example, vary accordingly.

7.1 Maintenance of the roads in Finland in spring, summer and autumn

Summer maintenance includes pavement maintenance, repairs of gravel roads and bridges and care of the traffic environment. (Centre for Economic Development, Transport and the Environment)

7.1.1 Paved roads

Paving maintenance includes patching, surfacing or replacing the paving entirely. Deficiencies in the structures may also require structural modernisation of the roads.

The principal reason for the replacement of paving on heavily trafficked roads is rutting. Correspondingly, the main reason for replacing paving on roads in the secondary network is excessive disrepair, unevenness and loss of load-bearing capacity. (Finnish Transport Agency)
7.1.2 Maintenance of the traffic environment

The maintenance of traffic environments plays an important role in ensuring the safety of traffic routes and road environments and the fluency of traffic. In addition, clean traffic routes and a carefully finished landscape image make road use more pleasant. From the point of view of roadkeeping, the professional maintenance of structures and equipment also preserves the capital value of traffic routes.

Green areas are maintained according to area-specific quality levels and the needs for action required by valuable areas. Green area maintenance includes mowing, defoliation and planting of flowers in parks. (Destia website)

Typical traffic environment maintenance tasks:

- Maintenance of green areas and sports areas
- Cleaning of roads/streets/areas
- Repair of surfacings and minor frost damage
- Maintenance of traffic signs and signposts
- Maintenance of drying systems and securing of their operation
- Maintenance of fixtures, structures and equipment (e.g. kerbs, railings, lighting, traffic lights)
- Waste management
  (Destia website)

Maintenance of the traffic environment is a major factor in promoting traffic safety and wellbeing.

7.1.3 Maintenance of gravel roads

Most of the roads in Finland are gravel roads, the maintenance of which is one of the most important roadkeeping tasks. It is important to the economy and private users that the service level of gravel roads is maintained. (Destia website)

When compared to paved roads, gravel roads are more vulnerable to heavy traffic loads. In addition, heavy rain, dry summers and ground frost can cause further damage to gravel roads. Despite of continuous repairs, weight restrictions are nevertheless necessary on roads subject to frost heaving.
The maintenance of gravel roads has an impact on the condition of surfacing and, thus, on the road user’s driving comfort. Maintenance operations include, for example, reshaping, patching, gravelling and dust binding. The roads are also modified, and surface heaving and minor frost damage repaired, stone blocks are removed. (Finnish Transport Agency)

7.1.4 Maintenance of bridges

Bridge maintenance ensures structural safety and a longer service life. A great many bridges will soon require major renovation.

There are approximately 14,200 bridges on the highways, approximately five percent of which are in relative disrepair. Weight restrictions have been applied to 180 bridges in poor condition. According to the Finnish Transport Agency's estimate, approximately 7,000 bridges will require major renovation prior to 2020. The number of bridges in disrepair is slowly increasing despite the Finnish Transport Agency's investment in major repairs. (Finnish Transport Agency)

Maintenance service package includes:

- Cleaning and maintenance
- Annual inspections
- Assessment of maintenance needs

(Destia website)

7.2 Winter maintenance

In winter, the main road maintenance tasks are snow ploughing, gritting and keeping road surfaces even.

The road network is divided into five main maintenance classes (Ia, I, Ib, II, III). In addition, class Ib has a corresponding maintenance class T1b for built-up areas. Pedestrian and bicycle paths are divided into two maintenance classes (K1, K2). Each class has a different level of service and quality standards. The level of service is mainly defined according to traffic volume, road functional class and regional climate, but local conditions, nature and composition of traffic, speed limit
and qualitative integration with the level of service of municipality’s road network are also taken into consideration.

Most of the main road network belongs to categories Is, I and Ib. (Snow and Ice Databook 2010, p. 83)

![Figure 7.1 Rough division of the road network into winter maintenance classes in Finland. (Winter Maintenance Policy, Finnish Road Administration, 2008)](image)

Determining the level of service of winter maintenance is the responsibility of Finnrna. Road users’ opinions regarding the maintenance of the previous winter are sought out by a customer satisfaction survey every spring. (Snow and Ice Databook 2010, p.84)

When deciding the maintenance class of the road, in addition to the class criteria, the following criteria are also taken into consideration: local conditions, the nature and composition of traffic, and the connection (in terms of quality) to the level of service in the municipality’s road network. The road’s speed limits are set so that they match the level of winter maintenance.

The criteria for a higher service class are:

- A large volume of heavy traffic
• The road has a much higher than normal amount of export shipments, transit traffic, shipments of hazardous substances, special deliveries, regular bus traffic or school taxi traffic.
• The road’s geometry on the main road network is such that safe travel requires enhanced winter maintenance.

Correspondingly, the criteria for a lower service class are, following traffic calculations, a reduced or clearly diminishing need for travel. The maintenance classes must also be logical with respect to the manner of implementing the maintenance, because maintenance measures are carried out mainly as connected maintenance links. The maintenance class can be lowered from the standard level for reasons connected to the efficient and economical implementation of the maintenance. (Winter Maintenance Policy, Finnish Road Administration, 2008)

7.2.1 The level of service in different maintenance classes

Maintenance class Is (4 % of roads, 42 % of road traffic)

The road is clear except during changeable weather situations. In central and northern Finland, and during cold periods in the southern part of the country, there may be some long, thin patches of compacted snow on the road that do not particularly impair driving. During long periods of sub-zero temperatures, when the use of salt is not possible, the surface of the road may be partly icy. Slippery conditions are primarily prevented through proactive measures. Busy roads, with an ADT of over 15,000, are always clear except during exceptional conditions (Section 4.4) and long periods of sub-zero temperatures.

On these roads, antiskid treatment is always carried out through proactive measures. Due to the high volume of traffic, on busy roads salt can be used outside the normal temperature limits (-6°C in the Is class).

Maintenance class I (5 % of roads, 17 % of road traffic)

The road is clear most of the time or it may have long, thin patches of compacted snow in between carriageways and roadways. The road may be slightly slippery during situations in which the weather is changing. The intention is to prevent
problem situations because of slipperiness through proactive antiskid treatment.

Maintenance class Ib (13 % of roads, 22 % of road traffic)

The road is maintained at a high quality, but mainly without salt. Depending on the volume of traffic and weather, the surface of the road is partly clear, partly covered with patches of compacted snow, or the road may be entirely covered with compacted snow. With the exception of problem situations, the road has good winter road conditions; antiskid measures are not carried out to the same level, but the road is sufficiently safe if road users take the prevailing conditions into consideration. Patches of compacted snow, or a layer of compacted snow, are levelled out to be as smooth as possible. Slippery conditions are prevented by using salt mainly during slippery conditions in the autumn and spring, or in similar “warm conditions”, as well as in certain problem situations. During midwinter, sanding in points and lines is used when necessary.

Maintenance class T1b (urban area)

The roads are covered with a layer of compacted snow during mid-winter. The quality is similar to the quality on Ib roads, but the road may have thicker patches of compacted snow, which do not cause problems for traffic due to the low speed limits.

Maintenance class II (25 % of roads, 14 % of road traffic)

The road is mostly covered by a layer of compacted snow or, depending on the volume of traffic, the compacted snow may occur partly in patches. In normal conditions, the road is sufficiently treated for antiskid and smooth for a moderate level of traffic. Intersection areas, hills and curves are sanded so that driving is safe under normal conditions. The road is sanded completely during problem situations. During difficult weather conditions, such as when the weather suddenly becomes milder, during freezing rain, or immediately after snowfall, road users must be especially careful.

Maintenance class III (the rest of the roads)
The roads are covered by a layer of compacted snow most of the time, and there may be ruts in some places. During periods of sub-zero temperatures, the driving conditions are mostly satisfactory, but may vary in some places. When the weather changes, and especially during freezing rain on layers of compacted snow, the road conditions may be problematic for several hours, during which great care must be exercised when driving.

Bicycle and pedestrian lanes

K1

Road maintenance is carried out in the mornings before school trips and commuter traffic and serves the needs of leisure time travel during the evenings and weekends. The level of maintenance allows bicycling, and the use of prams, wheelchairs and walkers.

K2

There is usually also a certain amount of school trip and commuter traffic on the roads. Following the maintenance measures, the level of quality is almost the same as on K1 roads, but the maintenance measures are carried out later than on K1 lanes. (Winter Maintenance Policy, Finnish Road Administration, 2008)

Each class has a different level of service and quality standards. The level of service is mainly defined according to traffic volume, road functional class and regional climate, but local conditions, nature and composition of traffic, speed limit and qualitative integration with the level of service of municipality’s road network are also taken into consideration. (Snow and Ice Databook 2010, p. 83)
7.2.2 Snow ploughing

In terms of wintertime maintenance of roads, the first process is to plough the snow, followed by de-icing. The busiest roads take priority in terms of ploughing. The target is that on heavily trafficked roads and pedestrian and bicycle lanes the snow should not exceed a couple of centimetres in depth. After snow stops falling, it will be removed from the main roads within a couple of hours and from pedestrian and bicycle lanes within four hours, at the latest. Roads with a lower traffic volume are permitted to have ten centimetres of snow. (Finnish Transport Agency)

Table 7.1 Quality requirements of snow removal (Snow and Ice Databook, 2010)

<table>
<thead>
<tr>
<th>Winter maintenance class</th>
<th>Is</th>
<th>I</th>
<th>Ib and T1b</th>
<th>II</th>
<th>III</th>
<th>K1</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Max. snow depth during snowfall</td>
<td>4 cm</td>
<td>4 cm</td>
<td>4 cm 8 cm, night</td>
<td>8 cm</td>
<td>10 cm</td>
<td>3 cm</td>
<td>4 cm</td>
</tr>
<tr>
<td>Time to clear after the end of snowfall</td>
<td>2,5 Hours (slush 2 hours)</td>
<td>3 Hours (slush 2,5 hours)</td>
<td>3 Hours</td>
<td>4 Hours</td>
<td>6 Hours</td>
<td>3 hours</td>
<td>4 hours</td>
</tr>
<tr>
<td>If snowing stops after 22 at night</td>
<td>Ploughed clean within cycle time</td>
<td>Ploughed clean before 06</td>
<td>Ploughed clean before 07</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 7.2 Quality requirements of the smoothing of the road surface (Winter Maintenance Policy, Finnish Road Administration, 2008)

<table>
<thead>
<tr>
<th>Winter maintenance class</th>
<th>Is</th>
<th>I</th>
<th>Ib and T1b</th>
<th>II</th>
<th>III</th>
<th>K1</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Evenness requirement</td>
<td>-</td>
<td>1 cm</td>
<td>1,5 cm (T1b 3 cm)</td>
<td>2 cm</td>
<td>2 cm</td>
<td>2 cm</td>
<td>2 cm hindering ruts</td>
</tr>
</tbody>
</table>

7.2.3 De-icing

Weather services allow anticipation of road surface freezing. On heavily trafficked roads, de-icing is based on salting; other roads are gritted. Rock salt, i.e. sodium chloride NaCl, is used for roads contained in the the clean state; less - in the form of a solution of calcium chloride CaCl2. On other roads methods of sand distribution and levelling of packed snow are used.
De-icing measures on heavily trafficked main roads and associated pedestrian and bicycle lanes must be implemented within a couple of hours. The corresponding target for heavily trafficked roads of a lower class is four hours, while gritting may take a while longer on roads with infrequent traffic. (Finnish Transport Agency)

Salt can be distributed dry hydrated or in solution.

- Salt solutions (concentrated) are distributed on an equal layer and diluted with existing moisture on the road. If there is too much moisture on the surface of the road, the road can freeze.
- Dry granular salt is distributed on the road surface unevenly and some of the grains immediately fly into a ditch. In order to start acting, the salt should absorb moisture. Because of the large losses, dry salt distribution is prohibited.
- The wet salt has the necessary initial moisture, so contact with the ice and melting the ice increases. Moistening increases the weight of the grains connecting small fractions and reduces losses in the distribution on the road. When humidifying, a brine in amount of 25-30 % by weight of the salt is added into a dry salt. (Winter maintenance of roads, Technique FINNMAP Infra Oy., 2005)

Figure 7.2 shows the melting of ice, using different types of salts, and Table 7.3 presents the recommended consumption of salt.

Distribution of sand, along with loosening, are the primary methods of fighting against slipperiness on roads with compacted snow and pedestrian-bike paths.

With a linear distribution, the consumption of sand is 0.7 - 1 ton per kilometer of road. In spot distribution, the consumption is about 200 - 400 g/m². On bare ice, the most suitable material is gravel. (Winter maintenance of roads, Technique FINNMAP Infra Oy., 2005)
Table 7.3 Recommended salt consumption when using different methods. (Winter maintenance of roads, Technique FINNMAP Infra Oy., 2005, p.45)

<table>
<thead>
<tr>
<th>The road surface condition</th>
<th>saline solution g / m²</th>
<th>wetted salt g / m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road surface temperature</td>
<td>0° -2 -4 -6 -8</td>
<td>0° -2 -4 -6 -8</td>
</tr>
<tr>
<td>little bit wet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>spotty dark coating</td>
<td>10 10 10 10 10</td>
<td>5 5 5 5 5</td>
</tr>
<tr>
<td>moist</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Clearly dark coating</td>
<td>10 20 20 20 -</td>
<td>5 10 10 10 10</td>
</tr>
<tr>
<td>wet</td>
<td>20 30 40 - -</td>
<td>10 15 15 15 20</td>
</tr>
</tbody>
</table>

Figure 7.2 Effect of saline solution and granular salt to the road surface immediately and after 15 minutes. (Winter maintenance of roads, Technique FINNMAP Infra Oy., 2005, p.43)
Table 7.4 Quality requirements for antiskid treatment (Winter Maintenance Policy, Finnish Road Administration, 2008, p.26)

<table>
<thead>
<tr>
<th>Winter maintenance class</th>
<th>Ia</th>
<th>I</th>
<th>Ib and T1b</th>
<th>II</th>
<th>III</th>
<th>K1</th>
<th>K2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friction requirement</td>
<td>0,30</td>
<td>0,28</td>
<td>0,25</td>
<td>Roughened surface, problem locations are spot sanded</td>
<td>Roughened surface, problem locations are spot sanded</td>
<td>Traffic necessary</td>
<td>Traffic necessary</td>
</tr>
<tr>
<td>Must be considered</td>
<td>Road surface below -6°C 0,25</td>
<td>Road surface Below -4°C 0,25</td>
<td>Spot sanding 0,25, Line treatment 0,22</td>
<td></td>
<td>After 10 o’clock pm, before 6 o’clock am</td>
<td>After 10 o’clock pm, before 7 o’clock am</td>
<td></td>
</tr>
<tr>
<td>Time to carry out measure when falls below</td>
<td>2 hours, on busy roads 0 h</td>
<td>2 hours</td>
<td>Salt 3 hours Sand 4 hours</td>
<td>Line sanding of icy compacted snow 6 hours</td>
<td>Line sanding of icy compacted snow 8 hours</td>
<td>2 hours</td>
<td>3 hours</td>
</tr>
</tbody>
</table>

If special traffic needs so require, timing or quality on specific sections on road may be modified locally without changing the maintenance class. The target of tailor-made maintenance is to improve the service provided for road users based on the special needs of the customers. (Snow and Ice Databook 2010, p.84)

8 MAINTENANCE EQUIPMENT

Both in Russia and in Finland mechanization equipment which is used for the maintenance of coatings, is divided into two groups:

- Water-washing, sweeping, vacuum cleaning machines, equipment for pavement marking are used for summer maintenance; Examples of such machines are shown in Figures 8.1-8.3.
Figure 8.1 Water-washing machine

Figure 8.2 Cleaning sweeping machine
- For Winter maintenance, mainly uses snow blowers, snow loaders, machines for thermal, wind, mechanical and chemical action to ice. Examples of such machines are shown in Figures 8.4-8.6
Machines for maintenance are usually self-propelled, they are mounted on the base of vehicles or wheeled tractors.

Depending on the duration of usage throughout the year, there is a distinguish between seasonal (e.g. snow plows, snow loaders) and universal machines which are applicable throughout the year (sweeping). The kit of universal machine includes additional towing equipment.
9 CONCLUSIONS

The aim of this study was to investigate the approaches of the two countries, Russia and Finland, in the issue of road maintenance, to identify similarities and differences in the requirements for conditions of the roads, to get acquainted with the natural features of the two countries, traffic intensity, road networks, classification of roads and the organizational structure of maintenance services in these countries.

The project includes materials that reflect the climatic characteristics of the two countries in general level, as well as in the neighboring areas of the two countries - the North-West Federal District of Russia and Southern Finland. Also, the materials containing a brief description of maintenance equipment and information, about the deicing materials and norms of their distribution are given in the work.

This work has been developed on the basis of relevant information by using the competent sources.

The present thesis has investigated that, in general, the requirements and the organizational structure of maintenance services between the two countries have insignificant differences that do not affect the final result. In spite of this, according to information provided by the World Bank, for the regional and federal highways in Russia, the cost for maintenance and repair is about 8 038 euros per 1 km of the road, but only about 60 % of the roads complies with regulations (according to data for 2010 for the Russian Federation). The cost of road maintenance in 2008, in the case of Finland, constituted 7 274 euros for all types of roads. Another advantage of Finland is the availability of weather camera service, which broadcasts online the road condition information for the road users.

In recent years, Russia has actively adopted the experience of the Nordic countries in the issue of winter maintenance. This has a positive effect on the road conditions and road safety.

The generalized indicators, similarities and differences of the two countries are shown in Table 9.1
Table 9.1 The similarities and differences between the two countries in the field of road maintenance.

<table>
<thead>
<tr>
<th></th>
<th>Russian Federation</th>
<th>Finland</th>
</tr>
</thead>
<tbody>
<tr>
<td>Road network</td>
<td>1,283,000 km</td>
<td>78,093 km</td>
</tr>
<tr>
<td>Density of the road network</td>
<td>6.4 km/100 km²</td>
<td>23.1 km/100 km²</td>
</tr>
<tr>
<td>Vehicles per kilometer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Presence of the toll roads</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Average cost of road maintenance</td>
<td>8,038 euros/km</td>
<td>7,274 euros/km</td>
</tr>
<tr>
<td>Funding for public roads maintenance</td>
<td>By government</td>
<td></td>
</tr>
<tr>
<td>Conclusion of a maintenance contract only on the basis of the tender</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Terms of liquidation winter slipperiness</td>
<td>Approximately the same, on the roads of the highest category – about 2.5-3 hours</td>
<td></td>
</tr>
<tr>
<td>Use of sand as a friction material</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>Use of calcium chloride as well as sodium chloride</td>
<td>Yes</td>
<td>Very seldom (10% of the total volume of reagents)</td>
</tr>
<tr>
<td>Use of winter tires (studded tires) in winter time</td>
<td>Now-recommended, from 1.01.2015 - obligatory</td>
<td>Obligatory</td>
</tr>
<tr>
<td>Maintenance equipment</td>
<td>The same</td>
<td></td>
</tr>
<tr>
<td>Sand consumption</td>
<td>200 - 700 g/m²</td>
<td>200 - 400 g/m²</td>
</tr>
<tr>
<td>Salt consumption (in solution); air temp. -2°C</td>
<td>35 g/m²</td>
<td>20 g/m²</td>
</tr>
</tbody>
</table>

The main future prospects of both countries are the reduction of the cost of road maintenance, improving the quality of works and ensuring of high safety level on the roads for the minimum time.
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