Effective Road Construction in Sparsely Populated and Cold, Snowy Regions – An Example in Soya, Hokkaido, the Northernmost Part of Japan

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Abstract: Against the backdrop of severe fiscal conditions of the Japanese government, more effective and efficient implementation of public projects is required. In terms of physical distribution efficiency and medical support, the roles and demands of road construction in rural areas without expressway networks are even more important than those in urban areas. However, prompt construction of roads in rural areas is not expected because of the low priorities based on traffic volumes. Under these conditions, effective and efficient road construction in view of local characteristics and traffic conditions has begun in the Soya region of Hokkaido, the northernmost part of Japan, ensuring the required functions of safety, high speed and the like. The purpose of this report is to introduce pioneering work in the region, where the challenges include a sparse population, snow and low temperatures.

Key Words: sparsely populated area, cold, snowy region, road construction, cost-effectiveness

1. INTRODUCTION

As public finance is being rationalized in Japan, all projects conducted by each ministry are being re-examined. Stricter evaluation of and transparency in procedures of public projects are also being promoted.

Road construction such as building expressways forms the main part of public projects and attracts increased attention. The construction has to be carried out more effectively and efficiently within the limited budget. Expressway construction in Japan is being promoted based on a 14,000 km-expressway network plan (established in 1987) with the catchphrase of “One hour to an expressway interchange from anywhere in Japan.” Approximately 70% of the planned national expressways have been completed and are currently in service (Figure 1).

On the other hand, the 1,825 km-long expressway network planned to be constructed in Hokkaido – which lies in northernmost Japan and accounts for 20% of the nation’s land area – is only 50% complete. In the northern part of Hokkaido (between Asahikawa and Wakkanai), only 30% of the planned expressways have been completed.
The main industries of the Soya region are agriculture, fishery and tourism. Small-scale municipalities are scattered over a large area, and all face problems such as improvement in efficiency of physical distribution and lack of medical facilities for their declining and aging populations. The construction of expressways is cited as one of the solutions to these issues. However, the priority is not considered to be so high because of the low volume of traffic. And also, since it is a cold, snowy region, the costs of measures for dealing with snow are high. Therefore, in terms of project evaluation, the conditions for expressway construction in the Soya region are unfavorable. In order to proceed with the steady construction of roads in this region, distinctive innovations in road structures based on local characteristics and traffic conditions are required.

2. CHARACTERISTICS OF THE SOYA REGION

2.1 Geographical characteristics

2.1.1 Topographical features
Japan is a crescent-shaped archipelago stretching 3,000 km from north to south and is made up of four main islands (Honshu, Kyusyu, Shikoku and Hokkaido). The Soya region is located in the northernmost part of Hokkaido, which lies in the northernmost part of Japan (Figure 2).
The Soya region is a large area of land measuring 150 km in an east-west direction and 100 km north-south, and includes two islands. Its population is only 74,000 (as of 2009) and has declined since peaking in 1960. The region has a population density of only 17 people per square kilometer, while the figure for the whole of Japan is 343. The region consists of ten municipalities. More than half of the population (approx. 40,000) is concentrated in the northern port city of Wakkanai. With the capital city of Hokkaido, Sapporo located approximately 340 km away and the logistics gateway to the Pacific Ocean, Tomakomai approximately 400 km away, Wakkanai is far from the main market and logistics hub. This positional relation is linked to the issue of how people receive social services. For example, since there are no advanced medical facilities in the region, people are forced to go as far as Nayoro (170 km) or Asahikawa (240 km). The national roads that connect these cities are sometimes called “lifeline roads” (Figure 3, Table 1).

### 2.1.2 Climate
Because of the effects of seasonal winds and currents in the Sea of Japan and the Sea of Okhotsk, the Soya region is colder in summer and has more snow in winter compared to other cities in the world at the same latitude (Torino, Harbin, Minneapolis, etc.) The region has a high level of precipitation. The annual number of days with precipitation is 280. The total accumulative snowfall per year

<table>
<thead>
<tr>
<th>Transport Method</th>
<th>Cities</th>
<th>Time</th>
<th>Number of services per day</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Car</td>
<td>Wakkanai-Sapporo</td>
<td>approx. 6 hours</td>
<td>Route 40 + expressway</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Wakkanai-Asahikawa</td>
<td>approx. 4 hours</td>
<td>Route 40 + expressway</td>
<td></td>
</tr>
<tr>
<td>Intercity Bus</td>
<td>Wakkanai-Sapporo</td>
<td>approx. 6 hours</td>
<td>6 round trips</td>
<td>Route 40 + Route 232 + expressway</td>
</tr>
<tr>
<td>Train</td>
<td>Wakkanai-Sapporo</td>
<td>approx. 5 hours</td>
<td>3 round trips</td>
<td>Limited express</td>
</tr>
<tr>
<td></td>
<td>Wakkanai-Asahikawa</td>
<td>approx. 3.5 hours</td>
<td>3 round trips</td>
<td>Limited express</td>
</tr>
<tr>
<td></td>
<td>Wakkanai-Asahikawa</td>
<td>approx. 6 hours</td>
<td>2 round trips</td>
<td>Local train</td>
</tr>
<tr>
<td>Airplane</td>
<td>Wakkanai-Shinchitose</td>
<td>approx. 1 hour</td>
<td>2 round trips</td>
<td>Throughout the year</td>
</tr>
<tr>
<td></td>
<td>Wakkanai-Tokyo</td>
<td>approx. 2 hours</td>
<td>2 round trips</td>
<td>Throughout the year (1 round trip from Oct. to May)</td>
</tr>
<tr>
<td></td>
<td>Wakkanai-Osaka</td>
<td>approx. 2.5 hours</td>
<td>1 round trip</td>
<td>From June to September</td>
</tr>
</tbody>
</table>

Table 1: Transport methods between Wakkanai and other cities

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Figure 4: Temperatures and amounts of snowfall around the world
is more than five meters. Blizzard and high-wave warnings are often issued (Figure 4).

2.2 Industrial characteristics

2.2.1 Local development
Hokkaido has been developed as part of a national policy to utilize the underground and food resources in the development of the national economy. Comprehensive development plans have been carried out over seven terms after the establishment of the Hokkaido Development Act (1950). Roads, rivers, harbors and the agriculture infrastructure have been developed as a part of government-run projects. As a result, the population of Hokkaido expanded from 60,000 to 5.5 million in 140 years. The gross production in Hokkaido has reached 20 trillion yen. Hokkaido’s grown is such that the scale of its regional economy and society are often compared with those of European countries such as Finland and Denmark.

The Soya region, on the other hand, has been regarded as an important strategic place with regards northern security, due to its close proximity to Sakhalin, Russia. In terms of its transportation infrastructure, regular ferry services between Wakkanai and Sakhalin began in the 1920s after the end of the Japanese-Russo War, and railways lines were opened linking Wakkanai with Sapporo and Asahikawa. The social infrastructures, including roads and harbors, have been developed since 1950 according to the above-mentioned Hokkaido Comprehensive Development Plan (Figure 5).

2.2.2 Main industries
The main industries in the Soya region are the marine product industries, agriculture and tourism.

a. Marine product industries – One of the most prolific scallop-producing regions in Japan
The length of the coastline, which faces the Sea of Japan and the Sea of Okhotsk, is approximately 350 km. There are 39 fishing harbors and eight ports. Among them, facilities have been improved at four fishing harbors and six ports as part of projects run directly by the government. After the end of the Second World War, Wakkanai Port-based deep-sea fishing developed dramatically, but with the exclusive economic waters that the former Soviet Union formed, the fishery production dropped to less than one-third. However, the amount subsequently stabilized thanks to coastal fishing for seaweed, scallops and the like. In particular, the production value of scallops is one of the best in Japan and accounts for 40% of the nation’s share. These scallops are also exported.

b. Agriculture – Large-scale dairy farming
Due to the severe climate and the large amount of peat land unfit for sustainable agricultural development, only potatoes and other vegetables were grown in some parts of the region.
before land improvement work was carried out. However, since the development of dairy-farming land began as part of a national project in 1956, the Soya region has continued to grow into one of the largest areas of pasture land in Japan, accounting for 8% of the Japan’s total. The cultivated acreage for each farm is approximately 40 times larger than the national average.

c. Tourism – Attracting visitors with local resources including the natural environment
With abundant natural resources such as a national park and wetlands registered under the Ramsar Convention, the tourist industry that takes advantage of such local resources is expected to become one of the main industries of the Soya region. However, due to the effects of the prolonged recession, the number of visitors has dropped from a peak of 3.1 million (2002) to 2.1 million (2009). Under the circumstances, efforts such as developing experience-based sightseeing programs and publishing information on local tourist spots are being made by local private organizations and others to make the region more attractive to tourists (Photo 1).

2.2.3 Relationships between Wakkanai and Sakhalin of Russia – Various kinds of exchanges at citizen level
The shortest route across La Pérouse (Soya) Strait to Sakhalin, Russia is 43 km. With scheduled ferry services to Korsakov several times a week in summer, the Soya region is a gateway to trading with Sakhalin. A large-scale oil and gas development project (the so-called Sakhalin Project) on the continental shelf, which lies northeast of Sakhalin, began in the 1990s. A construction company in Wakkanai possesses know-how with regard to construction in cold environments and has formed a business link with a company in Sakhalin to establish a joint venture corporation, which receives orders for construction connected with the Sakhalin project as well as the infrastructure, including roads. In the future, business collaboration is expected to expand in infrastructural investment and energy development in Sakhalin.

2.2.4 Renewable energy – Active utilization of wind and solar power
With an abundance of renewable energy resources on the expansive land, such as wind, solar and biomass (livestock waste), the Soya region is described as having the most advanced renewable energy system in Japan. In Wakkanai, approximately 80% of the total electrical power consumed in the city is from renewable energy. Further efforts to promote renewable energy and to attract experiment facilities are being made through collaboration between the public and private sectors.
a. Wind-powered generation
There are 112 wind turbines in the region, generating over 100,000 kW of electricity (2009), which accounts for 10% of the national production and 40% of the production in Hokkaido (Photo 2).

b. Solar-powered generation
Japan boasts the world’s second largest share of electricity (30%) produced from solar energy. Small-scale generators installed in houses and public facilities contribute greatly to this. In Wakkanai, a 5-megawat (capable of producing enough electricity for 1,700 standard households) solar energy generation module – one of the largest in the world – was built, and a verification experiments are being conducted with the aim of putting the large-scale generation system into practice (Photo 3).

2.3 Characteristics of transportation

The transportation infrastructure in the Soya region consists of roads, railways, airports and ports. Physical distribution and the transportation of people largely depend on road traffic due to the closing of unprofitable railway lines and the fact that freight shipments are not handled.

The road network in the region consists of 260 km of national roads, 800 km of prefectural roads and 3,100 km of municipal roads. Fifty-five percent of the traffic is concentrated on national roads, which accounts only for 7% of the total length of the road system. The average trip length on national roads in the region is 1.3 times longer than the average on national expressways, showing that the role of the national roads is as important as that of the expressways in terms of transportation functions (Figures 6 and 7).

2.4 The direction of road construction

2.4.1 Construction of expressways in the Soya region

It was determined that an expressway would be constructed from Hokkaido’s southern tip (Hakodate) to the northern tip at...
Wakkanai via Sapporo, in the relative laws of 1957, as part of the nation’s skeletal expressway network. However, 50 years after the plan was made, the construction has still not begun. One of the main reasons is that it has been taking too much time to extend the expressways from the central city, Sapporo, to the cities at the far end of the network. With the limited public finance, the government is focusing on only selected construction plans. It will not become any easier to promote the construction of expressways in rural areas in the future, since priority is determined based on traffic volume and cost-effectiveness. Therefore, it is necessary to deal with the various problems faced by the national roads, while at the same time developing them effectively and efficiently as an alternative to part of the functions that were expected of the expressways.

2.4.2 The current situation and issues regarding traffic on national roads

a. Ensuring punctuality in winter
Traffic speed in winter is much slower than in summer (approx. 30% slower on Route 40), due to bad road surfaces with snow and ice, and to poor visibility with drifting snow (Photo 4 and Figure 8).

![Photo 4 Poor visibility with drifting snow](image)

![Figure 8 Relationship between visibility and traffic speed (Route 40)](image)

b. Ensuring reliability in winter
In the period of snowfall from the end of November to the beginning of April, drifting snow and the resulting snowdrifts often occur due to strong winds from the Sea of Japan. Therefore, the national roads are occasionally blocked for dozens of hours. In such cases,

![Figure 9 Average snowfall and number of days with snow (2005-2007)](image)

![Figure 10 Average wind speeds in Wakkanai (2005-2007)](image)

small villages become isolated and drivers are forced to make long detours since there are no
other roads. It severely affects local socioeconomic activities (Figure 9, 10 and 11).

Improvement of safety
The accident rate on national roads in the region is relatively low (21 accidents per 100 million vehicles kilometers), but the number of deaths accounted for by those accidents is extremely high (the fatality rate is 4.90 per 100 accidents in the Soya region and 0.95 in Japan as a whole). This indicates that an accident causes serious damage, once it happens. More than 40% of fatal accidents are caused by head-on collisions and collisions with objects (Figure 12).

c. Ensuring fluidity and high-speed performance
Due to the fact that there are no expressways in the region, the national roads are used by different vehicles with a variety of purposes, from long-distance haulage to farmers and leisure drivers from the cities. In particular, there are many low-speed agricultural vehicles on the roads, since the region is one of Japan’s largest dairy farming areas. This adversely affects traffic speed and safety (Photo 5).

2.4.3 Functions and points to keep in mind regarding the construction of roads
The functions of roads in the region are 1) ensuring safety and reliability throughout the seasons under severe climatic conditions in winter and long distances between cities, 2) ensuring high-speed performance and comfort for long-distance drivers, 3) the coexistence of two functions as a major highway and a community road, and 4) protecting and improving roadside landscapes as important tourism resources for drivers. In order to build roads that fulfill those functions in a region with low...
population and traffic volume, it is crucial to come up with new ideas and innovations to design and construct roads at low cost.

3. CONSTRUCTION OF HIGHWAYS ACCORDING TO LOCAL CHARACTERISTICS

The major national road (Route 40) in the region is planned to be upgraded effectively and efficiently with originality and ingenuity according to local characteristics and traffic conditions, in order to improve the current functions as a national road and to add some of the functions of an expressway. Such ideas and standards of design are called “Hokkaido Standards.”

3.1 Road construction according to the characteristics of the Soya region

3.1.1 Need for snow measures
In the Soya region, poor visibility due to snowstorms causes not only low traffic speed, but also blocked roads and car accidents. Therefore, appropriate measures against snowstorms are required in order to ensure the reliability and safety of traffic on national roads.

3.1.2 Thoughts regarding the types of measures
There are two stages (planning/construction and maintenance management) and six types of methods for measures against snowstorms. The six types of methods are a) avoidance of snowstorm hazard areas, b) improvement of cut and fill road structures, c) construction of structures such as snow shelters, d) construction of auxiliary facilities such as snow fences and snow-break forests, e) maintenance management by snow removal work, and f) information management including conveying information on road conditions to drivers (Table 2).

In the Soya region, large-scale civil engineering projects and measures with structures are avoided due to the limited budget and the protection of natural environments and landscapes. The work is based on improving the existent national roads. Therefore, snow fences and snow-break forests in d) have been replaced with snow pillars. Visual guidance during snowstorms using LEDs (light-emitting diodes) has been experimentally installed on road shoulders.

<table>
<thead>
<tr>
<th>Types of Measure</th>
<th>Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Route Planning</td>
<td>Route selection and avoidance of snowstorm hazard areas</td>
</tr>
<tr>
<td>b) Structure of road</td>
<td>Improvement in structure of road by cut and fill method</td>
</tr>
<tr>
<td>c) Roadside structures</td>
<td>Tunnels and snow shelters</td>
</tr>
<tr>
<td>d) Auxiliary facilities</td>
<td>Snow fences, snow-break forests, visual guidance, etc.</td>
</tr>
<tr>
<td>e) Maintenance management</td>
<td>Snow removal work and traffic control during snowstorms</td>
</tr>
<tr>
<td>f) Information management</td>
<td>Information monitoring, service, etc.</td>
</tr>
</tbody>
</table>

Table 2 Types of measures against snowstorms

3.1.3 Countermeasure work based on snow-break forests
This method creates barriers using steel fences or forest zones in order to reduce the speed of blowing snow and prevent it from reaching roads. It is common to choose either steel fences
or forest zones as barriers, but a combination of both is used in the region. This is because 1) steel fences are easy to build and have immediate impact, 2) snow-break forests have good effects on natural environments, including absorption of oxygen, and do not disturb surrounding landscapes, but it takes time for the trees to grow. Therefore, both of these methods are used to complement each other with their strong points.

3.1.4 Design of snow-break forests
a. Setting up forest zones
Snowstorms occur differently depending on wind direction, wind speed and land features. Therefore, solutions to poor visibility were examined in simulations to determine the shapes of the snow-break forests.

According to a document released by the Civil Engineering Research Institute for Cold Region, drivers’ behavior is affected by visibility range and that a) it is almost impossible to drive with a visibility range of less than 50 m, b) with a visibility of between 50 and 100 m, driving in groups increases and the driver’s behavior becomes unstable, and c) with a visibility range of more than 100 m, drivers can drive stably according to road surface conditions, etc.

The simulation was conducted with 10 m-, 20 m- and 30 m-wide forest zones and without a forest zone (Figure 13).

As a result, the 20 m-wide forest zone was chosen because it could maintain the ideal visibility range of more than 100 m (Figure 14 and 15).

b. Selection of tree types and locations
For the snow prevention measures to function effectively, a combination of basic woodland (mainly evergreen fir trees) and advance woodland, which protects the initial growth of the basic
woodland, is necessary. As for the selection of the types of trees, local species must be considered. Glehn’s Spruce (*Picea glehnii*) was selected for the basic woodland and a variety of willow was selected for the advance woodland. Locations were decided according to weather conditions, occurrence frequency of snowstorms, land features and roadside vegetation.

3.1.5 Visual guidance during snowstorms
One of the measures against snow is LEDs on road shoulders. The LEDs irradiate on road shoulders and the light reflects on snowflakes, forming a sort of “pillar of light” to guide the drivers (Photo 6).

3.2 Improvement of high-speed performance, comfort and safety – “2+1” lanes that enable drivers to overtake

3.2.1 Need for a “2+1” lane for overtaking
As discussed in the previous chapter, the major highway in the Soya region is the national road (Route 40). The existence of low-speed vehicles can reduce the speed of following vehicles and can cause stressful situations for drivers. As a result, drivers try to overtake recklessly, which can cause serious accidents.

For a road with two lanes in each direction, overtaking is not a problem. However, the traffic volume in the region is low and the road has only one lane in each direction. In order to solve the problem, additional lanes were built alternately on both sides (Figure 16). Low-speed vehicles can move to an inside lane like with a slow lane on a hillclimb. This is called a “2+1” lane.

3.2.2 Length and spacing of “2+1” lanes
The standard length of a “2+1” lane is set between 1.5 and 2.0 km in line with the examples of existing slow lanes. This is because if the length is less than 1.0 km, it is difficult to overtake with slower speed in winter. On the other hand, if the length is more than 2.0 km, it creates a false sense among drivers that the road has two lanes in each direction.

To avoid stressful situations for divers, it is ideal to set a slow lane once every three minutes, and the total length of yield lanes should be more than 30% of the total length of a road.
Local drivers and road managers in the region cooperated in examinations to determine the location of “2+1” lanes on relatively straight parts of the road with clear visibility. As a result, four yield lanes were established, and the total length of them became approximately 6 km, which accounts for 34% of the total length of the road (19 km) in the region (Figure 17).

According to a study on the usage of completed “2+1” lanes, it was confirmed that the amount of following cars was reduced by 6% (increasing free flow by 9%) and the safe traffic speed increased by 9%.

3.3 A system to prevent head-on collisions – center dividers

The main causes of head-on collisions on two-lane roads are slipping on icy surfaces, mishandling in poor visibility, dangerous overtaking, and straying into the opposite lane while catnapping. One method of preventing such head-on collisions is the establishment of median strips, and in Soya these strips are established in three types of sections according to road conditions, topography, land usage, landscape, etc. (Figure 18) The three sections are 1) guardrail structures: used in undulating and curved sections divided by existing guardrails, 2) division using wide, green belts: used in gently undulating and relatively straight sections where roadside land is used and the scenery must be protected, and 3) raised curbstones: used in sections approaching urban areas where the same kind of dividers (raised curbstones) are used.

3.4 A system to allow drivers to change directions safely – Right-turn lane with wide, green belts (Soya Turn)
As discussed in the previous chapter, median strips should be set continuously in order to ensure safe and smooth traffic, and intersections with roadside entrances and exits should be consolidated wherever possible. When doing so, it is important to create a system whereby drivers can change directions (turn right) safely. A waiting space for U-turns was established at a wide, green belt-type median strip as a safe intersection (to enter the opposite lane) without traffic lights (known as a “Soya turn”). It is a structure designed from a similar example in Michigan, USA. Drivers first turn left and drive in the opposite direction of where they are heading until they reach an opening in the median strip, where they can make a U-turn. Drivers may feel as if they are detouring a little, but it reduces the risk of rear-end collisions by allowing the drivers to concentrate on turning while the following cars can maintain their speed (Figure 19).

3.5 Decision-making process regarding structure of roads

3.5.1 Cooperation between different sectors and road administrators – Collaborative Infrastructure Management

The above-mentioned ideas (design specifications) for road structures in the region were formed at workshops involving road administrators (Hokkaido Regional Development Bureau; Ministry of Land, Infrastructure, Transport and Tourism), scholars, local municipalities, citizens and others interested in road construction. The participants worked on finding the best solutions and forming a consensus (so-called Collaborative Infrastructure Management) (Figure 20).

3.5.2 How the Collaborative Infrastructure Management works

The workshops were carried out in three steps. First, the roles and functions required for Route 40 were listed and then the construction and managements of national roads were examined. Finally, the following steps were examined:

Step 1: Local characteristics
- Roles of a road
- Problems and necessary functions of a road
  - Safety, reliability, fluidity, punctuality, comfort, high-speed, scenery

Step 2: Examination of construction and management
- Measures to deal with snowstorms, traffic accidents, overtaking, etc.

Step 3: Specific measures
- Snow-break forests, median strips, 2+1 lanes, etc.

Figure 21 Road functions and measures necessary in the Soya region
specific measures, both in construction and management, were discussed. Some of the measures that came up in the workshops are currently being used (Figure 21).

4. EFFORTS REGARDING ROAD CONSTRUCTION AND USAGE IN THE SOYA REGION

4.1 Environmentally friendly system using renewable energy

Verification experiments have begun in the use of solar energy for lightning and road heating on national roads in Hokkaido. As an advanced area for renewable energy, many ways of using such energy for road facilities are being discussed in the region. Against the backdrop of the promotion of the development and commercialization of electric and plug-in hybrid cars in Japan, the installation of recharging facilities at rest areas is being discussed to promote the use of such vehicles, since the distances between cities are long in the region.

4.2 Creation of sightseeing spaces by maintaining roadside landscapes – Scenic Byways

Roadside scenery is an important tourism resource in the region. Drivers can enjoy splendid views of nature and the pastureland. In order to make beautiful road scenery, attractive sightseeing spaces, etc. (so-called “Soya Scenic Byways”), many efforts are being made and PR campaigns taking place, including the planting of flowers and trees on byways and at airports, the building of roadside parking lots with nice views (viewpoint parking).

It is a part of “Scenic Byway in Hokkaido,” and Soya region is actively involved with the activities (Photo 7).

4.3 Involvement of private organizations in road administration

As discussed previously, the collaboration between public and private sectors in road construction and management is becoming more widespread. One of these private organizations is the Future Lifestyle and Soya Road (Network) Examination Association, commonly known as the “Soya Road Association.” The association takes part in the Collaborative Infrastructure Management and inspections of road construction in the region. The association organizes study groups on themes related with expressway networks and local industries and life. Its members are also involved in PR activities to promote the use and construction of expressways. Such citizen-level activities can boost public interest in social infrastructures. Their contribution to the sustainable development of the region is greatly expected (Photo 8).
5. CONCLUSION

In a sparsely populated, cold, snowy region without an expressway network, it is extremely important to add necessary functions to existing roads (the current national roads). In Hokkaido there are many other regions in the same situation as Soya. Therefore, systems that incorporate “Hokkaido Standard” designs such as snow-break forests, 2+1 lanes, etc., and ideas resulting from Collaborative Infrastructure Management (collaboration of people from different sectors) are planned to be introduced to road construction projects in other regions with similar circumstances (three remote cities including Nemuro in the eastern part of Hokkaido). In the future, the use and effects of the installed systems in service will be verified and circumstances regarding traffic accidents and safety on the road will be examined. With the results of verification, the methods introduced in this report are expected to be proven as effective in sparsely populated, cold, snowy regions.

REFERENCES
