Japan's Winter Road Traffic Policies and New Snow- and Ice-Control Measures

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Japan is an East Asian country that measures 380,000 km^2. Despite its small size, it has a population of 120 million and is the world's second-mightiest economic power, accounting for 18% of global GNP.

I will introduce the history, culture, geography, and climate of this nation's snowy regions, regions that play a significant role in Japan. I will also outline the development of winter road management policies that have supported life in these regions, as well as new technologies for their future development.

I will start by comparing Japan's snowy regions to other countries in terms of history, culture, geography, climate and living activities.

The mountainous backbone of Japan's main island hinders east-west travel and forces travelers to traverse steep mountain passes. The large proportion of mountains to plains has contributed to population concentration in the latter. This has made Japan prone to disaster. The left map shows Japan and Germany, on the same scale. Brown indicates elevations exceeding 500 meters. We see that Japan has a smaller proportion of plains, which are areas usable for a wide range of human activities, than does Germany.

Japan's mountainous topography hinders the interregional exchanges that are necessary today. The right figure shows the roads connecting major cities. Between Tokyo and Niigata, one of the leading cities in the snowy region, mountains rise 2,000 to 3,000 meters. To cross the mountains, it is necessary to traverse highlands 800 meters in elevation, even now that the 11-kilometer-long Kan-Etsu Tunnel is there to facilitate the journey. Compare this with the trip between Berlin and Hamburg. Although these German cities are as far apart as Tokyo and Niigata, the flatness between them makes for a much easier trip.

Snowfall is seen throughout Japan, from Hokkaido to Kyushu, except in Okinawa. The amount varies by district. The blue indicates snowy regions, which account for 60% of Japan's land area. The regions need special snow- and ice-control measures. The 28 million people who live here account for about 20% of the nation’s population.

The north-south spine of mountains on the main island blocks moist air from the Japan Sea and causes heavy snowfall in the regions on the Japan Sea side. It results in a less changeable, less snowy winter climate on the Pacific side. Every day in winter, Tokyo enjoys clear skies, in contrast with cloudy Niigata. Such weather facilitates economic activities in Metro Tokyo.

Because of their unique mechanism of snowfall, Japan's snowy regions are the snowiest in the world, despite their location at relatively low latitudes. Many major cities with populations from a few hundred thousand to more than a million are found in these regions. Sapporo is one such city. It numbers more than 1.8 million residents and sees more than five meters of snowfall a year. It is rare to see so many people living in such a snowy region anywhere in the world. In this figure, the horizontal axis indicates annual snowfall, and the vertical axis indicates latitude. The circle shows population scale. Unlike in Europe and North America, in Japan you find snowy cities at latitudes as low as 35° North to 45° North. No major city beyond Japan sees more than 500 centimeters of snowfall.

Next, I would like to outline the economy of Japan's snowy regions.

From the top, the bars show the GNP of Japan's snowy regions, of the four Scandinavian countries, and of Canada. Despite the tremendous snowfall, the GNP of Japan's snowy regions equals that of the four Scandinavian countries combined, or that of Canada. You might wonder how 28 million people can live in these snowy regions and achieve such productiveness. It is because there are fewer typhoon disasters and because snowmelt yields abundant water resources.

Let's take a look at the history, culture and climate of the snowy regions.

The regions feature four distinct seasons. The seas, mountains, and townscapes look different in each season.

The photo in the upper right shows *gasshozukuri* construction, an old method of snow-resistant building. These *gasshozukuri* houses have been designated a World Heritage Site.

Gangi are traditional arcades devised in extremely snowy regions. Various foods preserved by cold wind have been developed. The hardships of snow may have fostered people's diligence and perseverance, creating a culture that is unique to the snowy regions.

People enjoy various winter festivals, including traditional local festivals. Sapporo Snow Festival which will start next week is shown in the photo at right.

Snow has served both as a natural blessing and as a cause for suffering, such as from snowfall disasters.

I will introduce how we have struggled to overcome the challenges posed by snow.

Heavy snowfall disasters have struck Japan. Houses have collapsed, roads have been closed and many local communities have been stranded. As the photo shows, heavy snowfall frequently forces homeowners to expose themselves to the dangers of shoveling snow from their roofs or it forces them to exit through a second-story window.

The heavy snowfalls of 1963 and of 1981 resulted in particularly serious damage: 231 people were killed in 1963, and 103 were killed in 1981. Many local communities were isolated for weeks.

Snow disasters occurred last year, due to the heaviest snowfall in 15 years. The more than five meters that fell seriously hindered traffic. A special budget was allocated for heavy-snowfall countermeasures to lighten the local governments' financial burden by covering snow-control expenditures that exceeded annual budgets.

In recent heavy snowfalls, the disaster damage has been mitigated by various snow- and ice-control measures and by innovative snow-removal and snow-melting technologies.

I will describe how snowfall influences the economy and life in snowy regions.

Every winter, a number of roads are closed. In snowy regions, these closures total 5,700 kilometers of road extension, or 7% of the 80,000 kilometers of roads higher in grade than prefectural road. Some roads are closed almost for a half year. The x marks in the figure show roads closed during winter. Among the eight roads connecting Akita Prefecture and Iwate Prefecture, for example, fewer than half -- one national highway and two sub-national highways -- are available in winter because other roads are closed. Even on the artery roads that are open in winter, traffic restrictions and road closures are not rare, due to blowing snow, heavy snowfalls and snowslides. In 1999, there were more than 60,000 hours of road closure or traffic suspension. These seriously affect road traffic and consequently harm the local economy, life, and emergency operations.

About 60% of weather-related closures or traffic suspensions on expressways are due to blowing snow or heavy snowfall in winter. The blue bar in the graph indicates the proportion of hours of road closure due to blowing snow and heavy snowfall.

In winter, there is a notable increase in travel time due to the narrowing of road width by snow piled at the roadside, the emergence of slippery road surfaces and the closure of roads. Even if we look at increases in travel time only for roads of higher grade than prefectural road, we see economic losses of 500 billion yen. Winter travel time between Sakata and Shinjo in Tohoku, for example, increases by 135%.

Here, I will introduce the history of winter road management.

The Ministry of Land, Infrastructure and Transport has made various efforts to secure winter road traffic, particularly through its pursuit of countermeasures to heavy snowfall. This figure shows a hypothetical concept to explain development of Japan's snow and ice control. The concept regards that snow and ice control has improved to meet needs arose from social changes such as economic development, achievement of affluent life, and new lifestyle. At the first stage, the focus was to protect people from local isolation and avalanches. At the second stage, where economic development was under way, traffic policies were promoted to support interregional economic exchange. At the third stage, where environment and energy issues emerged, technological solutions to these problems were sought. At the fourth stage, where infrastructure development has been largely completed, various strategies are required to meet social needs. These needs include improvement of pedestrian mobility in winter and telecommunication-based information provision that promotes infrastructure utilization and addresses demographic aging.

I will describe individual measures to improve winter road traffic.

The first stage required fundamental measures to protect people's lives and assets from disasters. Securing arterial road networks as lifelines is a must in winter. In Japan, the national and local governments cooperate to realize the best snow-removal operation around the clock. Snow removal, which used to depend on manual labor, is now conducted by advanced machinery and its efficiency has improved to an amazing degree. The photographs show snow removal on a national highway to maintain effective road width and snow removal on an expressway by snow removal machinery operating in unison.

As you see in the photo, sidewalks are narrowed in winter and sometimes they become impassable. This forces pedestrians to walk in the dangerous carriageway, where they are at great risk of being hit by a car.

Sidewalk snow removal by machinery also is promoted. The length of sidewalk on which snow is removed has increased 35-fold in just 25 years.

To protect roads from snowslides, avalanche control fences and snow sheds have been installed.

The second stage included measures to enrich and bring stability to life in snowy regions.

Snowfall seriously impedes interregional exchanges and cooperation in winter. Extension of the road network is one solution to such barriers caused by snowfall. I will introduce an example in which traffic accessibility improvement has facilitated regional exchange between the prefectures of Nagano and Gifu. These two are separated by a long range of mountains, and the national highway between them had been closed in winter, which had forced drivers to make a detour. A tunnel constructed through the mountain shortened the travel time from 186 minutes to 115 minutes and facilitated interregional exchanges.

A report shows that improved traffic has enabled residents living in a region far from the sea to purchase fresh fish, and it has decreased their salt intake from preserved fish. As a result, the number of brain strokes has decreased in the region. Thus, securing winter road networks is vital not only for the economy but also for people's physical wellbeing.

This graph shows a case in which the interregional economy was stimulated by the development of an expressway that satisfied latent traffic demand. The increase in traffic volume between the two prefectures is attributed to the new expressway.

Farmers in Niigata Prefecture cannot grow tomatoes in winter because of snowfall. In 1965, only 3.6 tons of tomato was marketed in the prefecture and this vegetable was expensive. Construction of an expressway enabled distribution of tomatoes grown outside Niigata, so that as of 1995 there were 128 tons of tomatoes being sold, or 35 times the amount in 1961. This means that Niigata residents can enjoy a more diverse diet.

Even as efforts are made to control snow, it also is used as a local asset.

Improvements in efficiency of winter road traffic have facilitated tourist visits to snowy regions from throughout Japan and overseas, including East Asia. Unique sightseeing opportunities and events that focus on snow and ice have come to be held in various places. The basic idea is to treat snow and ice as tourist resources. The Sapporo Snow Festival, which will be held from February 5, is a leading snow-related event. Information vital for winter driving, such as forecast of snowfall at mountain passes, is provided to road users through the Internet or other telecommunication media.

Such information provision will be required if events are to be hosted successfully.

Winter sports also are popular. Japan has hosted two Winter Olympic Games, one in Sapporo in 1972 and another in Nagano in 1998. At the Nagano Olympic Games, access to event venues sites was available only through roads. Provision of information on traffic congestion, snowfall, and road surface condition by comprehensive use of ITS greatly contributed the Olympic Games' success.

In the 1970s, environmental pollution emerged as a major issue. In winter road management policies, air pollution caused by the dust abraded by studded tires gained attention. Studded tires allow cars to start and stop smoothly. However, when they are used on bare pavement, they abrade the surface and generate dust that becomes air pollution. The pollution became a public issue. The photo above shows downtown Sapporo before studded tires were banned. The dust was harmful to human health, and snow all over town turned a sooty black. The government finally banned these tires in 1990. The photo below shows downtown Sapporo after the ban, a ban that restored clean air.

Although the air pollution by dust was eliminated by the ban on studded tires, it led to the emergence of extremely slippery road surfaces in snowy regions.

These road surfaces brought with them their own winter road management issues, such as those of traffic accidents including rear-end collisions and minor collisions, and pedestrian falling accidents. This graph shows the number of pedestrian who fell and required emergency transport to hospitals in Sapporo City. The number was 200 to 300 as of the 1980's, but after the ban on studded tires, it rapidly increased to 500 to 600 in the 1990's. It also prompted an increase in the amount of anti-freezing agents spread to prevent skidding accidents.

Relative to the volumes spread in Europe and North America, the amount of anti-freezing agents used here is quite low. On roads like expressways that require a high level of service, the amount of anti-freezing agents spread is increasing. The graph shows anti-freezing-agent use on national highways in Hokkaido. It has increased conspicuously since 1991.

Road management in the future requires the cooperation and participation of local residents. The graph compares the rate of elderly in snowy regions shown by the upper bar with that in other regions below. Snowy regions are experiencing depopulation due to the migration of working-age population to large cities, and this has been exacerbating the problem of demographic aging in smaller towns. The percentage of elderly over 65 has increased to nearly 20% in snowy regions. Thus, how to support elderly drivers and pedestrians is becoming an important issue. This photo shows a snow-flowing gutter, a facility into which residents dump snow where it is carried away and melted by the flow of water.

Snow-flowing gutters are installed to help residents to treat the snow. This system works effectively to secure local residents' mobility and a safe pedestrian environment.

To ensure sidewalk space, administrative efforts such as the installation of snow-treatment facilities including snow-flowing gutters, the leasing out of sidewalk snow removal machinery and other partnership

activities between the private and public sectors will be promoted.

I have introduced the history of Japan's winter road management policies. Here we move on to prospective winter road management policies, including the introduction of advanced technologies indispensable for winter road management.

To date, we have tried to overcome snow-oriented challenges and to use snow as a resource by developing infrastructure, by installing and maintaining snow-control facilities and vital highway networks, by securing budgets for these works, and by developing and introducing necessary technologies. However, improvements in living standards and increases in the elderly population have called for mobility improvement in which road development is significant. Demands for road services are increasing such that what were once wishes have become firm requests. Improved service has been regarded as indispensable and it is on this basis that major social systems have come to be organized. Further road service improvement will be sought.

Requests are classified broadly into three kinds.

1. Improved road services (e.g., better road surface management, improved snow removal and more comfortable pedestrian environments). These will lead to increases in road service costs.
2. Environmental preservation and reduction of energy consumption
3. Improvement of winter traffic safety

In light of financial constraints, energy issues and the need for environmental protection, however, there are limits to road service improvement by conventional measures such as increase in the number of snow removal machines and increase in the amount and spreading frequency of anti-freezing agents.

To satisfy ever more demanding requests, the development and introduction of advanced technologies such as information technology are significant. The solutions below are considered for each of the three requests noted above.

1. Reduced costs and labor, and limits to road service improvement such that the road services are sufficient to ensure economic activities and daily living.
2. Participation in global efforts to solve environmental problems, including those resulting from fossil fuel consumption.
3. Intensified efforts to further improve winter traffic safety.

Here I will introduce prospective snow- and ice-control measures that rely on new technologies such as "Intelligent Transport Systems," or ITS.

The first solution is improving winter road service while reducing the costs, including the social costs. Telecommunications technology and other advanced technologies can realize efficient and timely road surface management and snow-removal operation. The provision of real-time road information will improve travel efficiency.

Various types of road sensors that gather information on snow depth, road surface freezing, and images at mountain passes are indispensable for developed winter road maintenance works including snow removal. The provision of such information to road users supports safe and convenient driving. More precise real-time weather forecasts of snowfall or road-surface freezing on the basis of information detected by road sensors enable the most suitable deployment of snow removal machinery, so that more efficient snow removal and greater cost reduction will be realized.

Conventionally, when snow piled at the roadside was removed, it was loaded into a truck that ran alongside

the rotary snow remover, thereby occupying two lanes of traffic. A single-lane rear-loading rotary plow was recently developed. It mitigates traffic congestion caused by snow removal, because the removed snow is loaded on a truck that follows the snow remover in the same lane. To operate a rotary snow-remover, two people are required, a driver and another person for blower operation and roadside supervision. ITS will automate the machinery operation to realize efficient personnel assignment and cost reduction. You can see this technology on one of the Technical Visits.

In addition to the electronic information display in the upper left photo, ITS technology, the Internet, and portable phones are used for rapid, efficient road information provision to improve driving convenience and traffic safety.

This figure shows snow-melting facilities and anti-freezing pavement installed at subway entrances and other places where the sidewalk or road surface is prone to rapid deterioration.

The second solution is environmentally friendly measures. Conventional snow- and ice-control measures including the use of snow-melting facilities and the spreading of anti-freezing agents call for solutions to mitigate their adverse effects on the environment. Measures are sought to reduce the consumption of fossil fuels and to minimize the environmentally harmful effects of sodium chloride.

Using wasted or under-exploited natural energy to power snow-melting facilities will reduce costs and afford environmentally friendly road maintenance. For example, there is a tunnel where wind power supplies the electricity for road heating and lighting. The surplus electricity is sold to an electric power company. The waste heat of hot spring baths, and the heat of river and lake water are used at other places.

Increase in use of sodium chloride as an anti-freezing agent after the ban on studded tires is a concern, because by 90% of it consists sodium chlorides, which badly affects roadside environment. The development of a new anti-freezing agent that does not contain chlorides but that has greater effect at smaller spreading volumes is being studied.

As the third solution, we will develop measures to ensure safer and more reliable road traffic. Technology to measure the distance to the leading vehicle is useful under conditions of poor visibility due to blowing snow, and an obstacle detector that warns of obstacles ahead will improve traffic safety and reliability.

The technological conditions to use VICS, a vehicle-mounted device that provides real-time and graphic information on road closures, traffic congestion, snowfalls, and disasters are developed and the number of VICS users is rapidly increasing.

Ensuring winter pedestrian safety also is an important issue. ITS technologies will be utilized to improve pedestrian safety by providing comprehensive information including the location of the pedestrian, snow-removal status on his walkway, road-surface conditions, and gaps on the walkway.

I would like to summarize my presentation.

Japan has struggled to overcome and to coexist with snow in the world's the snowiest environment. Winter road maintenance has greatly helped to support and improve life in snowy regions. In other words, winter road maintenance has freed residents of snowy regions from the restrictions of snow. It also has brought others to realize the benefits of snowy regions, which has stimulated interregional exchange. This in turn has promoted efficient use of Japan's small area.

For issues that have arisen or are expected to arise, the development and use of ITS and technologies that involve telecommunications, energy, and environment promise improved road service. Through congresses and other PIARC endeavors, we would like to advance international cooperation by exchanging information that we have developed and experiences that we have accumulated.

We will seek the further development of infrastructure for safe and comfortable living in snowy regions, regions that can be regarded as a national asset.

Thank you for your attention.