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RISK MANAGEMENT: A NEW APPROACH TO IMPROVING SAFETY

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ABSTRACT

Japan is one of the most earthquake-prone countries in the world and also one of the unusually rainiest countries with a large annual precipitation due to the seasonal stay of a rainy front and frequent landings of typhoons. Topographically and geologically, Japan is very mountainous, with the backbone ranges spreading through the center of the archipelago, and has many major cities developed on soft alluvial plains. With all these conditions combined, natural disasters frequently occur and have serious impacts on road traffic of the country. Although the deaths by traffic accidents are recently decreasing in number, the number of the casualties and that of traffic accidents are both increasing. Under those circumstances, responses to natural disasters and measures to ensure traffic safety are crucial for the road risk management in Japan. This paper reports the current status of Japan's road risk management by presenting the measures against road disasters, such as earthquake countermeasures, heavy rainfall countermeasures and tunnel disaster prevention, and road traffic safety actions.

1. INTRODUCTION

The Japanese archipelago is located at the joints of the Eurasia Plate, the Pacific Plate, and the Philippine Sea Plate. Extremely rich in seismic and volcanic activities, Japan has some 2,000 active faults on its land. Although the land area of Japan and its adjacent waters area cover only 0.1% of the entire surface area of the earth, the seismic energies discharged there are known to occupy about 10% of the entire globe. In addition, since Japan is located at the eastern edge of the Eurasian Continent, the island nation is in the beaten track of the rainy front and typhoons that bring plenty of rainfall. Because of its geography with the Japan Sea between the Continent and Japan, the coastal area facing the Japan Sea has one of the world's heaviest snowfall due to the seasonal winds blown from the Continent in winter. Coupled with those meteorological characteristics, the severe topographical conditions, including about 70% of the national land being mountainous or steep backbone ranges spreading across the archipelago, cause many natural disasters, which forces Japan to take effective measures to ensure road safety against those natural phenomena.

Rapid motorization took place in the post-war years of Japan amid the inadequate road traffic conditions as described by the Watkins Report (1956) saying "There have been no other industrialized countries that have ignored their road network that perfectly." The deaths by traffic accidents shot up by 1970 but were almost halved by 1979 because of various measures taken to tackle the problem. But thereafter the tendency of casualties and traffic accidents had been almost always toward aggravation because of various factors, including the rising number of aged drivers as the society goes aging. Since road traffic is expected to grow in volume and the population of the aged people, who are logically likely victims of traffic accident, is rising, the Japanese are methodically carrying out various measures to solve the problems, such as improvement of the road traffic environment, in an effort to ultimately create a society without traffic accidents.

Under the above circumstances, this paper outlines the current situation of the efforts being made in Japan with respect to measures against road disaster and for traffic safety.

2. ROAD DISASTER PREVENTION ADMINISTRATION IN JAPAN

2.1 Status of road disasters and development of disaster-resistant roads

Natural conditions that face Japanese roads, namely topography, geology and meteorology, are rigorous to road construction and management. As shown in Table 1, the annual number of road disasters goes beyond 10,000 in some years, which is a detrimental impact on the people's life and economic activities. Since roads are essential facilities for daily living and economic activities of the people, it is quite natural for Japan to put high priority on prevention of natural disasters that affect the road network and on enhanced safety of road traffic.

Table 1 - Road disasters and closures

Fiscal year	Road disasters	Road closures*	Road closure time (hour)	Fatalities	Injured
1994	7,105	2,847	448,890	21	18
1995	6,266	4,451	1,212,651	29	31
1996	3,861	4,648	460,373	3	25
1997	6,149	6,620	1,522,689	0	9
1998	12,337	10,376	2,758,256	4	29
1999	10,683	8,022	2,517,798	6	32
2000	6,481	6,923	1,536,819	1	20
2001	6,229	6,056	1,524,299	5	21
2002	4,658	5,830	1,537,343	1	7
2003	5,718	5,877	1,576,919	11	12
2004	19,417	13,146	4,002,843	14	27

* Full road closure.
Source: Road Traffic Management Statistics

In Japan, the year 2004 saw damage from torrential rainfall brought by frequent typhoons and the Niigata-ken Chuetsu Earthquake, and the year 2005 saw serious damage mainly in West Japan by Typhoon No. 14. The 2005-2006 winter experienced unusually heavy snowfall in the Tohoku and Hokuriku areas, blocking road traffic at various places.

These disasters made the road administrators as well as the general public recognize anew the necessity of safe and secure road construction. Associated with recent improvement of the living standard and reformation of social structure, people want more for and from roads. A number of disaster prevention measures are currently being taken to develop safe and reliable road networks and road spaces resistant to earthquakes, tsunami, and heavy rainfall and snowfall. The Ministry of Land, Infrastructure and Transport (MLIT) indicates the rate of cities possessing wide rescue routes in case of a disaster as an index to represent outcome of road disaster administration, and this rate steadily increased from 66% in 2002 to 73% in 2005. The improvement of the index indicates a fact that prompt rescue activity and emergency supply are available from major cities in adjacent areas after a disaster, which contributes to create safe and secure regional society against disasters.

2.2 Earthquake countermeasures

2.2.1 Basic law for earthquake countermeasures and actions against large earthquakes

The Earthquake Disaster Prevention Special Act, which is the fundamental law for earthquake countermeasures, is effective since June 1995 and stipulates the Earthquake Disaster Prevention Emergency Project Five-Year Plan (herein the Five-Year Plan). The Five-Year Plan designates roads necessary to ensure emergency transport (emergency transport roads), evacuation routes, and other roads that contribute to elimination of areas where firefighting activities are difficult, and the necessary measures are being promoted under the Five-Year Plan.

There have been many large earthquakes occurred at the plate boundaries off the Pacific coast, including the Tokai Earthquake, Tonankai Earthquake and Nankai Earthquake, and inland earthquakes with epicenters underneath the Metropolitan area. For instance, the Tokai Earthquake (Figure 1), which is currently predicted to occur, will be a huge earthquake with a magnitude of 8.0, and is estimated to cause approximately 9,200 deaths and 37 trillion yen economic damage. The Central Disaster Prevention Council issues the General Principles for Countermeasures against each of those large earthquakes. Under those General Principles the Earthquake Disaster Prevention Strategies are laid down for each earthquake, which specify the concrete targets (mitigation targets) including the deadline to mitigate human and economic damage by major earthquakes, and clarify important and strategic actions to take. The Earthquake Disaster Prevention Strategies provide mitigation targets that aim at reducing the deaths and economic damage by 50% in 10 years, and promote seismic retrofit of road bridges and development of evacuation routes in the field of road disaster prevention management.

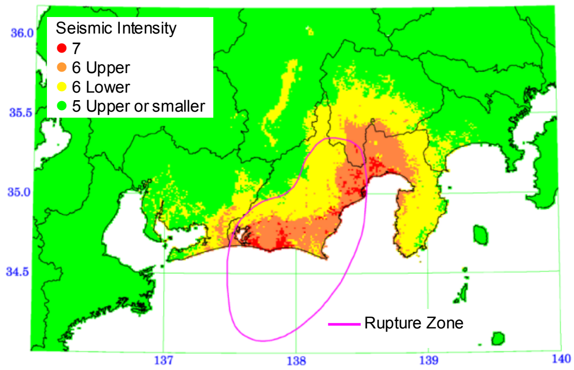

Figure 1 - Assumed fault rupture zone of Tokai Earthquake and distribution of seismic intensities

2.2.2 Seismic inspection of road facilities

Destructive earthquakes including the San Fernando Earthquake that hit Los Angles area in USA in February 1971, increased the Japanese awareness of the importance of earthquake prevention measures for roads, particularly in major cities. In response to such movement, the relevant governmental ministries and agencies joined collaborative work to promote comprehensive measures against earthquake damage. The Ministry of Construction (Presently, MLIT) carried out seismic inspection of facilities under their management, such as roads, dams, embankments, sewerage, parks and governmental buildings, in April 1971.

Roads were then inspected for earthquakes in 1976, 1979, 1986 and 1991 when relevant technical standards were revised following addition of new findings, with the increase in the number of roads to be inspected, or as required by deterioration of facilities over time. From 1996 to 1997, the roads were again inspected for earthquakes as part of the Comprehensive Road Disaster Prevention Inspection.

The seismic inspection of roads from 1996 to 1997 as part of the Comprehensive Road Disaster Prevention Inspection was the sixth seismic inspection for the roads. Roads checked for this inspection included all major municipal, prefectural and national highways.

There were eight road facilities inspected, which include the conventional six, or bridges, pedestrian bridges, embankments, common utility ducts, retaining walls, and rock and snow sheds plus the new two items, or depressed roads and cut-and-cover tunnels, added after the lessons learned from the damage of the Hyogo-ken Nanbu Earthquake in 1995. For each facility or structure, the applied design code, structural condition, ground condition, history of deterioration, etc. were systemically inspected. The results of inspection were put into databases and have been widely applied for evaluating seismic performance of road facilities.

2.2.3 Seismic design and retrofit of road bridges

The first requirements for seismic design of road bridges in Japan was included in the "Details of Road Structures (Draft)," which were issued by the Ministry of Internal Affairs in 1926, following the 1923 Kanto Earthquake. After experiencing significant damage due to strong earthquakes, seismic regulations for road bridges were revised several times, and the first comprehensive seismic design stipulations were issued in 1971 in a separate volume exclusively for seismic design as "Seismic Design Guidelines of Highway Bridges." Thereafter, the seismic design regulations for highway bridges have been repeatedly revised, based on earthquake disaster experience and progress of research. After the 1995 Hyogo-ken Nanbu Earthquake, which caused the worst damage to various structures including highway bridges since the 1923 Kanto Earthquake, the Design Specifications for Highway Bridges were revised in 1996. Reflecting the destructive ground motions generated by the earthquake, the design seismic force assuming strong near field ground motions (peak design lateral force coefficient =2.0) was newly introduced to ensure seismic safety of road bridges.

(a) Bridge pier damaged by the 1995 Hyogo-ken Nanbu Earthquake

(b) No damage with pier retrofit (2004 Niigata-ken Chuetsu Earthquake)

Photo 1 - Effect of bridge pier retrofit (Both bridges were located in the areas recorded seismic intensity 7)

Seismic retrofit of bridges has been pursued as part of the efforts to improve seismic resistance of road facilities. Photo 1 shows the effect of bridge pier retrofit as a typical retrofit method of road bridges. Recently, in view of the occurrence of the Niigata-ken Chuetsu Earthquake in 2004 and a fact that major earthquakes, such as the Tokai, Tonankai and Nankai Earthquakes, and strong inland earthquakes in the Metropolitan area may occur, MLIT laid out the 3-year Bridge Seismic Retrofit Program for Emergency Transport Roads (2005 to 2007) and the 3-year Bridge Seismic Retrofit Program for Road Bridges Over Shinkansen Tracks and Expressways (2005 to 2007), and have promoted seismic retrofit of those bridges. Those programs are intended to expedite seismic retrofit of the bridges in order to prevent serious damage such as collapse of bridges, ensure the function of emergency transport roads, and prevent secondary damage, for the strong ground motions such that generated by the 1995 Hyogo-ken Nanbu Earthquake.

2.2.4 System for disaster response and prompt restoration of roads

As an example of the organizational system established in MLIT in case of a major disaster, one that was set up for the Niigata-ken Chuetsu Earthquake in 2004 is introduced. At around 17:56, October 23, 2004, an earthquake with a magnitude of 6.8 occurred with its epicenter in the Chuetsu area, Niigata prefecture. The Japan Meteorological Agency named the earthquake the Niigata-ken Chuetsu Earthquake in the following day October 24. It was the first earthquake that recorded 7 on the seismic intensity scale, the highest in the Japanese seismic scale, since instrumental measurement of seismic intensity started in Japan.

MLIT immediately declared an emergency status to cope with earthquake damage and set up the MLIT Emergency Disaster Control Headquarters. The Hokuriku Regional Development Bureau of MLIT also immediately declared an emergency status for earthquake damage after the outbreak of the earthquake, set up the Hokuriku Regional Development Bureau Emergency Disaster Control Headquarters and provided emergency restoration of facilities and support to local governments. 20 MLIT Work Offices in and around the Chuetsu area, Niigata prefecture immediately made necessary status declarations, ranging from emergency to warning status. National highways including the Route 17, which is a trunk highway between the Metropolitan area and Niigata, were damaged at 41 locations. MLIT restored the national highways vigorously under the above-mentioned status, and the national highways were reopened to general traffic except one tunnel two days after the earthquake. National highways were made available for the entire lengths by 10th day after the earthquake.

The former Japan Highway Public Corporation managing expressways organized a similar system to MLIT. Consequently, the Kan-etsu Expressway connecting Tokyo and Niigata, which was severed by the earthquake, was reopened to emergency traffic along the entire length at 1 p.m., October 24, about 19 hours after the breakout of the earthquake, by emergency restoration work. On the 13th day, the expressway was made available for general traffic, and about a month after the earthquake, or on November 26, 2004, the expressway was fully restored and reopened to traffic. While this expressway was unavailable, the Ban-etsu Expressway and the Joshin-etsu Expressway, as shown in Figure 2, substituted the trunk road functions. The average traffic volume of these two expressways from October 25 (Monday) to October 29 (Friday) was compared to before the earthquake, which shows an about 1.6 times increase for the Ban-etsu Expressway and an about 1.4 times increase for the Joshin-etsu Expressway in traffic volume.

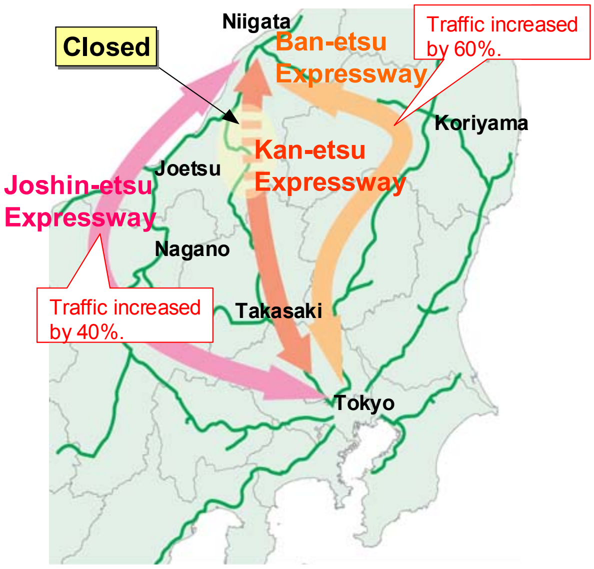

Figure 2 - Benefit of nationwide network of expressways after the 2004 Niigata-ken Chuetsu Earthquake

2.3 Heavy rainfall countermeasures

2.3.1 Inspection of hazardous spots and solutions

Grave accidents such as the Hida River Bus Fall Accident that occurred on the national highway Route 41 in Gifu prefecture in August 1968 (104 were killed) made the people keenly aware of the need of inspection of rockfall spots and development of preventive facilities. In response, formulating various actions and schemes, including preventive traffic control in abnormal weather conditions, development of patrol inspection procedures, and development of information networks, was started.

To begin with, inspection of hazardous spots was first conducted as the nation-wide comprehensive inspection of hazardous spots (Comprehensive Road Disaster Prevention Inspection) in 1968. Based on the results of the inspection, it was decided to make roads more resistant to disasters and to take specific actions for solving the identified problems, which include slope protection works for rockfall hazardous spots, such as by covering slopes with concrete frames; building of fences or nets to block rockfall; and improvement of existing facilities, such as covering of slopes to prevent rockfall or changing alignments, where necessary. As roadside conditions changed with time thereafter, it was found necessary from time to time to further improve measures to eliminate rockfall spots and other hazardous locations, and thus the Comprehensive Road Disaster Prevention Inspection has been continued by once every about five years. Between the inspections, ad-hoc inspection was conducted whenever such inspection was judged necessary due to intermittent occurrences of disasters. The most recent inspection of 1996-1997 checked the facilities more in detail than the previous inspections, and the results were used to improve measures. To be specific, there were 9 check items: rockfall and failure, rock failure, landslide, avalanche, debris flow, embankment, snowdrift, scouring of bridge foundation, and retaining wall. The results were evaluated and categorized into three ranks, and measures were systematically developed and conducted to match the evaluation rank depending on the spot. Disaster prevention charts were also prepared to clearly describe the problems of each spot. This is part of the road inspection procedure, including postinspection management, introduced after the 1996-1997 inspection to ensure application of the inspection results to daily road management services.

2.3.2 Comprehensive slope disaster prevention

As earlier discussed, Japan is about 70% covered by mountains and rich in precipitation due to the stay of a rainy front from June to July and frequent landings of typhoons. There are a large number of slopes along roads that need some protection for preventing disasters. Although actions are steadily being taken, it takes a long time to cover all those dangerous slopes. Therefore, roads that have unprotected slopes are intentionally blocked for traffic when the rainfall exceeds a certain level, and as the rainfall slows down or stops, the problem location is patrolled to check safety of the road and the slope and the road is reopened to traffic only when safety is confirmed. This traffic control procedure, or precautionary road closure, is applied to many such problem locations. The continual rainfall level to close a road is established for each road section, based on the past history of disasters, and so forth.

Figure 3 shows the details of the cumulative road closure time by road slope disasters and precautionary road closures in national highways in the past 10 years (1995 to 2004). Precautionary road closure by precipitation accounts for about 30%, disasters inside the precautionary road closure sections for about 20%, and disasters outside the precautionary road closure sections for about 50%. As indicated by this figure, it is necessary to take effective actions to prevent roads from being damaged or blocked by heavy rainfall in order to reduce road closure by heavy rainfall disasters or precautionary road closures from the viewpoint of maintaining safe road space for road users and ensuring road network continuity.

Figure 4 shows the change of total road closure time by disaster. Various actions are taken to reduce road closure time by disasters by reducing the frequency or magnitude of disasters that cause road closure. To be specific, structural works, such as constructing slope protection frames or building fences to block rockfall directly on the slopes, are implemented at hazardous spots that are judged to need actions based on the results of the disaster prevention inspection. For some locations where the topography is especially steep or the geology is particularly fragile, structural works directly constructed on the slopes cannot fully restore or guarantee safety or can require considerable cost. Then, alternative measures are taken, such as changing the alignment of the road itself or constructing a bypass to detour around dangerous spots.

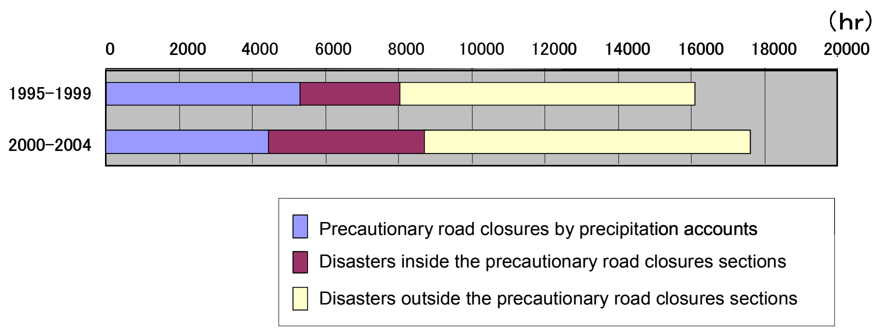

Figure 3 - Precautionary road closures and breakdowns (National highways, 1995-2004)

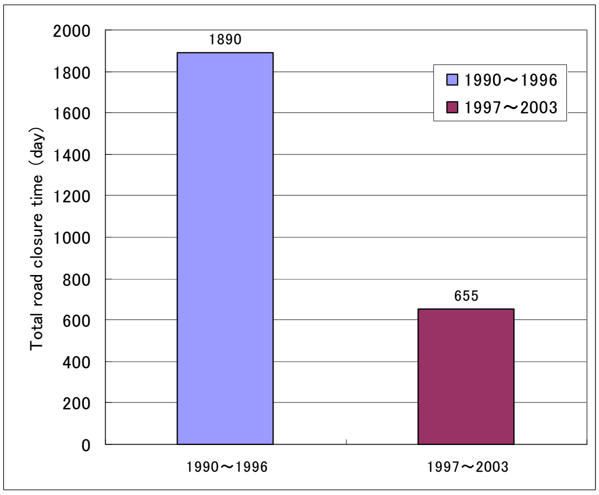

Figure 4 - Change of total road closure time by disaster (National highways)

Various efforts such as lifting of precautionary road closure status or mitigation of the road closure rainfall level are made for the precautionary road closure sections, based on the effects of the disaster prevention measures as explained above. For national highways, the precautionary road closure status was lifted for 19 road sections (down to 182 sections from 201) from 1990 to 2005, the road closure rainfall level was reduced for 25 sections from 1997 to 2005, and the precautionary road closure section length was shortened for 17 sections. Consequently, the number of precautionary road closure sections is gradually decreasing due to the progress of road slope protection works. To further improve the reliability of the road network, it is necessary to promote lifting of the precautionary road closure status and relax the road closure rainfall level in a methodical manner.

In addition to large-scale road inspections conducted once in a few years, such as the Comprehensive Road Disaster Prevention Inspection, or emergency inspections as triggered by the occurrences of large-scale disasters, periodic inspection, about once a year, or daily patrol is conducted with the help of the disaster prevention charts for early detection of problems. Whenever a problem is found, appropriate actions are taken, such as emergency repair. National highways are basically patrolled once a day. At part of road slopes where sight inspection or disaster measures are difficult, sensors are installed, as shown in Photo 2, to constantly monitor changes of the slope as part of the efforts to improve management of disaster-prone hazardous spots. New technologies such as optical fiber sensor are applied to monitoring. Vigorous efforts are being made to establish efficient precautionary road closure and evacuation guide by detecting and coping with a disaster in the early stage and predicting collapse.

Photo 2 - Installation example of sensor for slope failure measurement

2.3.3 Provision of road information and publicity

Information on road traffic closure is provided to road users through the Information Service Center for Disaster Prevention on the MLIT's website, the Japan Road Traffic Information Center, and so on. It is also necessary to have understanding and cooperation of the road users in general, not to mention roadside residents, to ensure safe use of roads. As publicity means, the Road Disaster Prevention Week is established to promote knowledge on road disaster prevention, and emergency drills and exercises are also conducted with the help of relevant organizations.

2.4 Tunnel disaster prevention

Road tunnels in Japan experienced serious fire accidents. These accidents became a good lesson and have contributed to improvement of the disaster prevention technology for road tunnels. The road tunnel disaster prevention technology is largely divided into two: the technology to prevent accidents in tunnels from happening and the technology to prevent the damage caused by accidents in tunnels from spreading. The latter is further divided into the technology related to emergency facilities installed in tunnels to save human life and the fireproof technology to ensure stability of the tunnel structure.

The technology to prevent happening of accidents in tunnels consists of three factors: (1) tunnel design, (2) traffic control, and (3) installation of ventilation system, lighting system and interior panels and their appropriate daily maintenance. For (1) tunnel design, important review points are horizontal and vertical alignment to ensure safe driving in road tunnels or installation of emergency parking bays in tunnels for temporary evacuation in case of a trouble in the tunnel. Elements of (2) traffic control include such ongoing measures as speed restriction, prohibition of overtaking, or traffic control for hazardous material transporting vehicles in tunnels. Ventilation systems are generally installed to prevent deterioration of visibility in tunnels by exhaust gas emitted from vehicles, while lighting systems are installed to ensure safe and comfortable driving in tunnels. Interior panels are intended to improve visibility of vehicles running ahead or comfort of driving.

Emergency facilities in tunnels put top priority on rescue of human life in case of a fire in a tunnel. Specific purposes of those facilities are early detection of an accident or a fire, early provision of information to tunnel users, traffic control, evacuation of tunnel users to safe space, and extinguishing fire in the early stage. They are largely categorized into (1) information and alarm, (2) fire extinguishing, (3) escape and guidance and (4) others. Installation of those facilities or equipment is dictated in Japan by the Road Tunnel Emergency Facility Installation Standard. As shown in Figure 5, the class of disaster prevention is established for each tunnel depending on the length of the tunnel and the traffic volume, and appropriate equipment is to be installed depending on the class of disaster prevention as shown in Table 2. In addition to installation of above-mentioned appropriate equipment or facilities in tunnels, it is also important to carry out non-structural measures, such as periodic holding of evacuation drills, education to tunnel users on how to act appropriately in case of a fire accident, development of operation manuals for the equipment, or coordination with the fire department, police station or relevant organizations in order to effectively and efficiently operate those facilities and pieces of equipment in the face of fires and other accidents. Implementation of those non-structural measures is also an important part of the ongoing effort.

Table 2 - Standard of emergency facilities of road tunnels

Emergency facilities	Tunnel classification	AA	A	B	C	D
Information and alarm equipment	Emergency telephone	O	O	O	O	
	Pushbutton type information equipment	O	O	O	O	
	Fire detector	O	Δ			
	Emergency alarm equipment	O	O	O	O	
Fire extinguishing equipment	Fire extinguisher	O	O	O		
	Fire plug	O	O			
Escape and guidance equipment	Guide board	O	O	O		
	Smoke exhaust equipment or escape passage	O	Δ			
Other equipment	Hydrant	O	Δ			
	Radio communication auxiliary equipment	O	Δ			
	Radio re-broadcasting equipment or loudspeaker equipment	O	Δ			
	Water sprinkler system	O	Δ			
	Observation equipment	O	Δ			

Note: In the table, O indicates that the equipment should be installed as a rule, and Δ indicates that the equipment should be installed as required.

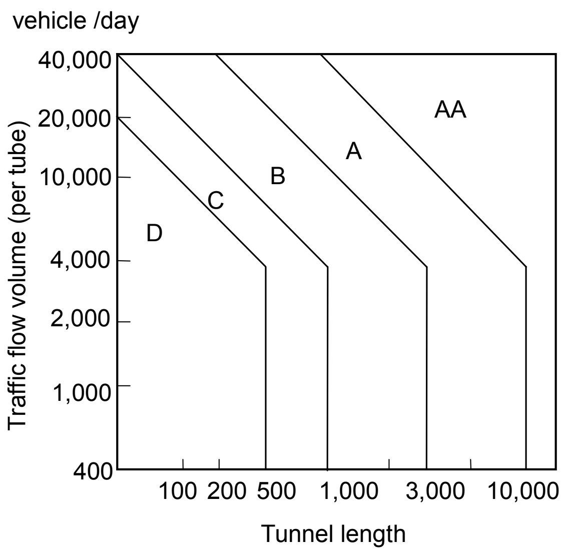

Figure 5 - Tunnel classification

A tunnel must be structurally stable when appropriate actions are taken to cope with a fire in the tunnel. To be specific, it is essential for tunnel users to swiftly evacuate from the tunnel, for firefighters to ensure firefighting activities inside the tunnel, and for nearby residents or environment to prevent the spread of damage by the failure of the tunnel. The majority of road tunnels in Japan are constructed by the mountain tunneling method, with which concrete lining is applied to the internal surfaces of the tunnel. The concrete lining in such tunnels is required to provide the adequate fireproof performance. No special fireproofing has been provided even if the concrete lining is damaged because the tunnel structure is generally designed to be stabilized by the surrounding natural ground. But there are more and more tunnels constructed by the shield tunneling method that eliminates use of concrete lining. In such tunnels, fireproof plates are generally applied to the internal surfaces of the tunnels for fire resistance.

2.5 Transport of hazardous materials

In Japan, the Road Law entitles the road administrators to prohibit or restrict the passage of vehicles carrying hazardous materials in underwater tunnels or long tunnels in order to maintain the stability and safety of the tunnel structure and avoid traffic danger in advance. Such prohibition or restriction is applied to 24 tunnels in Japan.

Conventionally, restriction to transport of hazardous materials is stipulated by the Fire Service Law, High Pressure Gas Safety Law and other laws enacted for each hazardous substance, and such provisions must be followed by those related to standards for transport of or engaged in transport of each such substance.

When Japan's first underwater tunnel, the Kanmon Tunnel, was constructed and opened in 1958, the tunnel managers had to ensure safety of the tunnel because of its special structural characteristics never experienced before. It is also logically imaginable that the impact of a possible accident inside the tunnel, such as explosion, would be so devastating that it could easily damage the tunnel structure and deprive the tunnel users of their lives. Therefore, they decided to apply restrictions to transport of hazardous materials through the tunnel.

In 1975 when the Enasan Tunnel, more than 8 km long, was completed, the restriction of passage of hazardous material transporting vehicles was also applied to long tunnels, or those over 5 km, in addition to underwater tunnels.

One of recent hot topics about traffic restriction of hazardous material transporting vehicles is the passage of vehicles carrying fuel-cell cars using hydrogen for energy source. Fuel-cell cars using hydrogen as fuel are newly developed ecological vehicles amid the rising international interest in reduction of environmental impacts, particularly reduction of CO_2 emissions, and energy security, but trucks carrying such hydrogen cars are categorized as those restricted for passage in tunnels. Fuel-cell cars are basically fully fueled with hydrogen when carried on trucks for transport, which is the very condition controlled by passage restriction. Considering the strong demand for commercialization and diffusion of environmentally friendly fuel-cell cars, however, safety evaluation had to be made to check if such trucks were a real threat to the tunnels. The conclusion of the evaluation was toward relaxing the restriction condition for those carrier trucks providing necessary safety equipment is provided. In 2006, restriction for the Kuko-kita Tunnel on the national highway Route 357 was relaxed. The review is currently being made for relaxing the restriction for other tunnels.

3. EFFORT FOR TRAFFIC SAFETY

3.1 Traffic accidents in Japan - Changes and characteristics

The number of traffic accidents and the related fatalities and casualties in Japan are shown in Figure 6. 16,675 were killed in traffic accidents in 1970, and the fatalities then started to decline after 1971 to 8,466 in 1979, almost half that in 1970. The number again rose to 11,451 in 1992. After 1993, the fatalities showed a gradual decrease again to 6,871 in 2005. The factors contributing to a recent decline in traffic accident fatalities are improvement of road traffic environment, implementation of measures to prevent and eliminate drunken, law-violating and dangerous drivers through toughening the penalties for drunken driving, reduction of fatality ratio through improvement of the number of seat belt wearers, and improvement of structural strength of vehicles against crash.

Despite such efforts, the casualties and the number of traffic accidents are increasing almost constantly since 1978, and although the casualties, or 1,163,504, and the number of traffic accidents, or 933,828, in 2005 are slightly smaller than those in the previous year, they still stay at a high level. The casualties per 10,000 vehicles in Japan are leveling off in these years.

For international comparison, the number of people who were killed or died within 30 days from accidents per 100,000 people is 6.7 in 2004, which is the 5th lowest among 29 countries for which the data are disclosed in the International Road Traffic and Accident Database (IRTAD). It is a relatively good position.

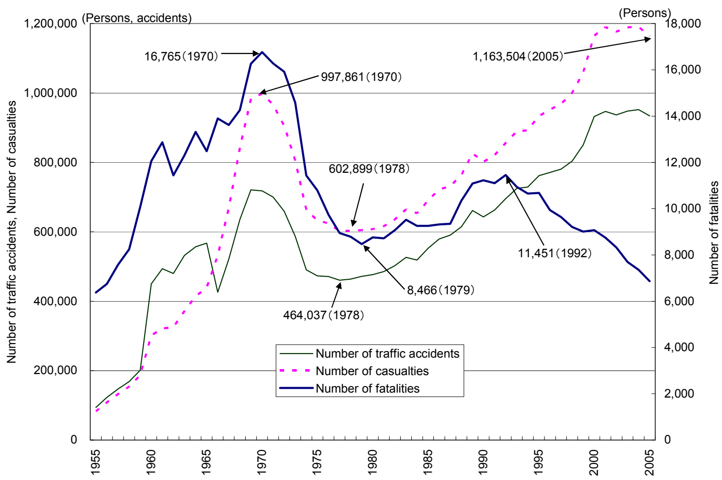

Figure 6 -Changes in road traffic accidents, casualties and fatalities

3.2 Characteristics of the occurrence conditions of recent traffic accidents

Traffic accidents involving fatalities in recent years in Japan happened with the following characteristics:

- The old people aged over 65 occupy about 40% of the total fatalities, indicating a rising number of fatality accidents caused by aged drivers. This means the accidents involving the aged people continuously occupy a high percentage every year.
- The ratio of pedestrians to the total fatalities in Japan is higher than in many countries in Europe and North America.
- The percentage of car accidents on trunk roads is relatively high, as about 60% of

casualties in local areas occurred on trunk roads. The ratio of accidents involving pedestrians or bicycle riders on residential roads is relatively high in urban areas.

3.3 Outline and effects of accident prevention measures

3.3.1 General measures based on the Fundamental Traffic Safety Program

The Traffic Safety Measures Basic Law was established in 1970 to systematically promote comprehensive measures for traffic safety. Based on the law, five-year Fundamental Traffic Safety Programs were prepared starting in 1971 to make the national government, local governments and relevant private organizations join forces in strong promotion of traffic safety measures. The present five-year plan formulated in March 2006 is the 8th and aims at reducing the traffic accident fatalities to below 5,500 and casualties to below 1 million by 2010.

3.3.2 Identification of hazardous spots and analysis of accident factors

Accidents on trunk roads tend to concentrate on certain specific locations. 3,196 locations known as accident-prone spots were identified based on the nationally common standard to analyze what caused the accidents. Based on the results of analysis, urgent measures were taken at those hazardous spots, such as improving the intersection structure and installation of road lights, from 1996 to 2002. Consequently, the deterrent effect appeared at about 40% of those spots. Furthermore, 3,956 hazardous spots where a fatality accident occurs at a probability of more than once a decade were identified and special measures to reduce accidents are being intensively taken to reduce the number of casualty accidents by 30%.

3.3.3 Optimal traffic safety measures by the accident factors

It is crucial to develop highly effective measures and evaluate their effects in order to reduce accidents at hazardous spots. To help smoothly go through the process of action development to evaluation, the procedure for such process was systematically developed and put together as the Traffic Accident Measures and Evaluation Manual. Figure 7 is the outline of the procedure. Using the Manual, the effort is being made to take more effective and efficient measures to prevent traffic accidents, which includes active use of the Road Safety Manual at Hazardous Spots that collects and sorts out the past measures taken, the specific measures taken at hazardous spots in Japan, the evaluation results before and after the accident, and the Database for Traffic Accident Prevention Measures that accumulates the findings obtained from development of measures to evaluation of effects.

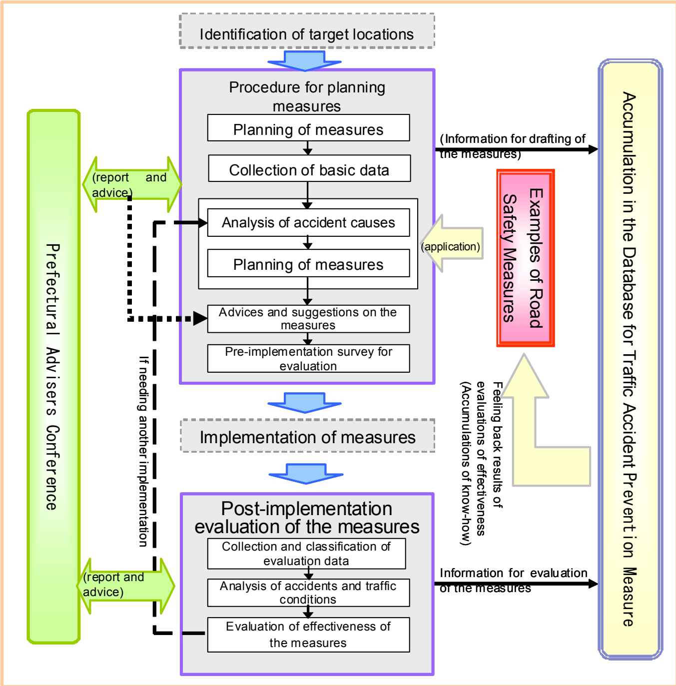

Figure 7 - Flow of planning and evaluation of measures

3.3.4 Effects of traffic safety measures

In order to earn the people's understanding of investment of taxes in the public enterprises including traffic safety measures, it is important to inform them of the effect intelligibly. Therefore, we have been replacing output indices (Length of sidewalks etc.) that simply represent the effectiveness of traffic safety measures with outcome indices in recent years. As the outcome indices, the rate of reduction of accidents causing casualties, etc. are used.

Photo 3 shows intensive measures taken at a hazardous spot. The type of accidents that frequently occurred at this spot include exceedance of the speed limit in the intersection, accidents caused by cars turning left or right due to the inappropriate road alignment, and accidents in the night due to poor visibility. Solutions to those problems were installation of a traffic island, construction of a pedestrian bridge, down-sizing of the intersection by relocating stop lines, paving in colors, clarification of the nearside lane, and installation of additional road lights. Those measures successfully produced favorable results, a remarkable reduction in the number of accidents both in the daytime and night time, as shown in Figure 8.

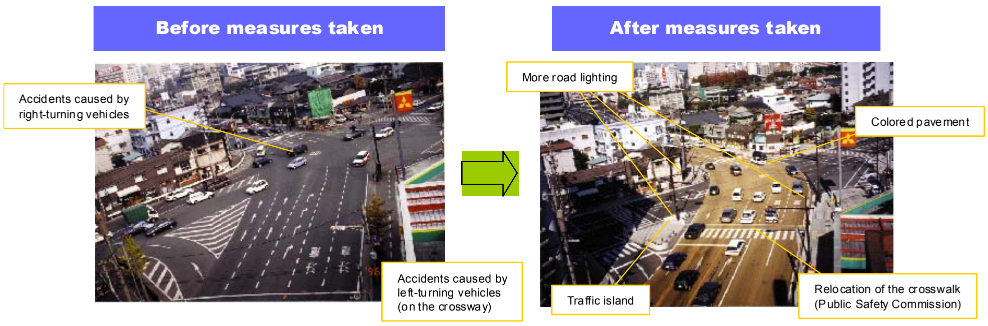

Photo 3 - Example of measures taken at an intersection

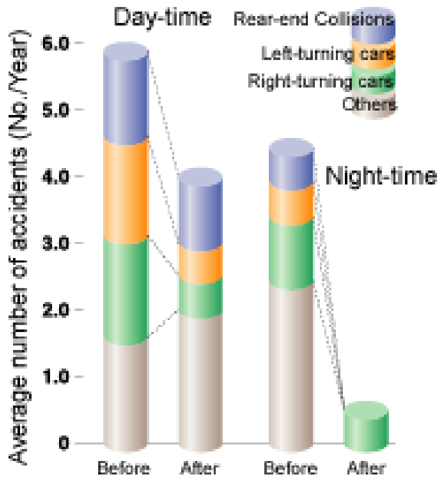

Figure 8-Effects of measures

3.4 Problems and direction of future efforts

3.4.1 Improvement of PDCA cycle efficiency in traffic safety measures

To effectively carry out traffic safety measures, it is desirable not only to develop measures based on accurate analysis of accident factors but also to appropriately evaluate the measures taken to make sure if additional measures are necessary. In this sense, more efforts should be made to improve the PDCA cycle by swiftly understanding the effectiveness of measures taken and smoothly providing feedback to the sites.

3.4.2 Measures for residential roads

Many accidents still occur on residential roads in urban areas, whereas accident-prone roads are major ones in rural areas as earlier mentioned. Measures particularly focusing on safety of residential roads have been taken since 2002 as spot-specific and linear measures, while plane-specific measures have been taken since 2003. For the latter, model measures, such as "safe walking area" or "zonal road development for daily life," are being taken, while trying to build consensus of residents for those programs. So as shown in Figure 9, the effective measures, which combine physical measures such as widening sidewalks or installing humps to reduce traveling speed and non-physical measures such as prohibiting through traffic in specified zones, are tried. It is desired if the successful results may be obtained from traffic safety measures taken for residential roads, particularly those where such model measures were completed. It is also hoped that ideas for more effective measures may be gathered and handed down in the form of handbooks or case examples for future betterment of traffic safety.

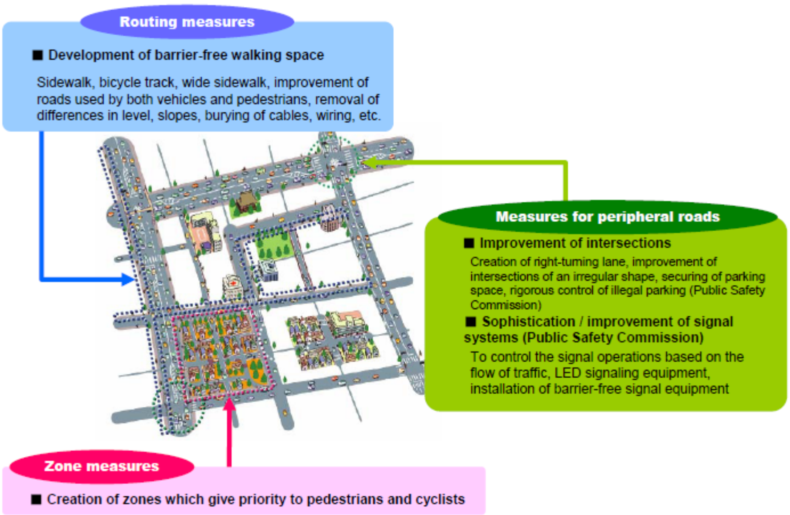

Figure 9 - Image of safe walking area

3.4.3 Utilizing advanced technology such as ITS

Analysis of accidents showed that around 75% of accidents are caused by mistakes of drivers such as delay in recognition, errors in judgment and errors in operation. AHS, a category of ITS that provides drivers with information, warnings, and operational support should be effective for this category of accidents.

Several services have been defined as AHS services, such as "Support for Prevention of Collisions with Forward Obstacles," and "Support for Prevention of Overshooting on Curves." Real field tests have been implemented from 2002 to 2004 at seven sites around Japan.

The first on-board unit based service has been realized in a field test since 2004 at the Sangubashi curve in the Metropolitan Expressway. As shown in Figure 10, the system equipped at the curve detects congestion, standing and slow vehicles beyond the blind curve in real time, and transmits the information from a VICS beacon to on-board car navigation devices of approaching vehicles. Remarkable effects, such as reduction of accidents by 60% and other milder characteristics of driver behaviors, have been observed by the introduction of the system.

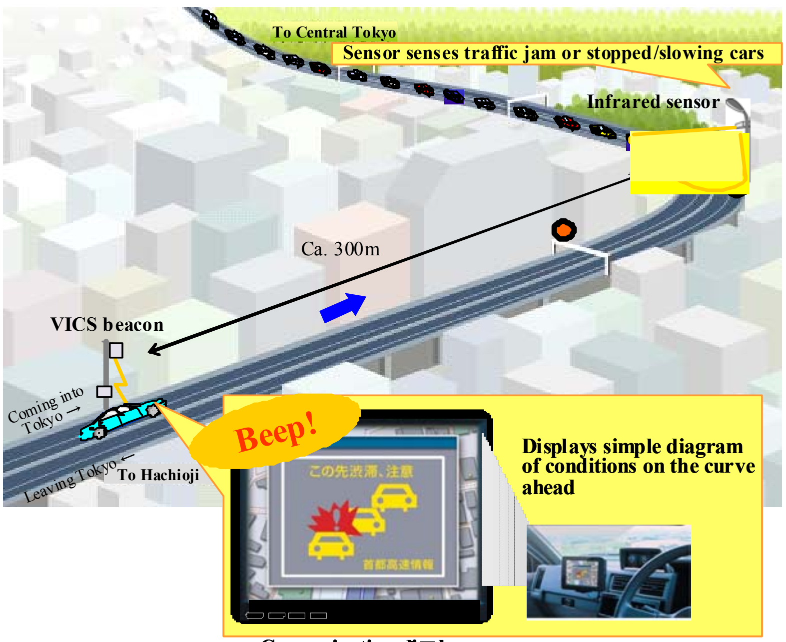

Figure 10 - System at Sangubashi curve

4. CONCLUSION

Japan faces severe natural conditions, such as earthquake and heavy rainfall and snowfall, which disturb safe and smooth traffic. To reduce the damage of those natural disasters and ensure enhanced traffic safety, it is necessary to take various preventive actions in the road improvement and management, and to mitigate the impact of the disasters once the disasters occurred. All those measures have been steadily taken in Japan. Furthermore, it is necessary to develop and take measures against large earthquakes expected to occur and to reinforce measures to tackle torrential rainfall that frequently occurs in recent years. What is also necessary is appropriate modification of the road traffic environment to match the changing structure of society with a decreasing number of the young and an increasing number of the aged. For traffic safety, since it is the supreme objective to create a society with no traffic accidents under the principle of respect of human life and based on the Fundamental Traffic Safety Program, greater efforts need to be made to promote more effective measures, including scientific analysis of data and promotion of the PDCA cycle. It is the wish of the authors that this paper will be able to provide a better glimpse of the efforts in road disaster prevention measures and traffic safety measures in Japan.