ROAD GEOHAZARD RISK MANAGEMENT

JAPAN CASE STUDY

ACKNOWLEDGMENTS

Production of the report was led by Akiko Toya, program officer, Global Facility for Disaster Reduction and Recovery (GFDRR), with valuable guidance from Yuka Makino, senior natural resource management specialist of the Social, Urban, Rural, and Resilience Global Practice (GSURR), and Kazushige Endo, director of the United Nations Centre for Regional Development (UNCRD).

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The team extends thanks to internal peer reviewers, namely Shomik Raj Mehndiratta, practice manager for South Asia, T&I GP; Fiona Collin, lead transport specialist, T&I GP; Ashok Kumar, senior highway engineer, T&I GP; and Masatsugu Takamatsu, disaster risk management (DRM) specialist, GSURR. The team is also grateful for support from Luis Tineo, lead operations officer, and Julie Dana, practice manager, of GFDRR.

Special acknowledgments go to the following World Bank staff (and consultants): James Newman, DRM specialist, GFDRR, and DRM specialists Keiko Sakoda and Naho Shibuya of GSURR. In addition, we thank Satoshi Ogita, senior transport specialist, T&I GP; Grégoire Gauthier, senior transport specialist, T&I GP; Frederico Pedroso, DRM specialist, GSURR; Javier Escudero Marroquin, consultant, T&I GP; Deepak Malik, consultant, GSURR; Liljana Sekerinska, senior transport specialist, T&I GP; Senad Sacic, program assistant, T&I GP; Svetlana Vukanovic, senior transport specialist, T&I GP; Darko Milutin, DRM specialist, GSURR; consultants Biljana Abolmasov and Marinos Skempas, T&I GP, and consultants Yoganath Adhikari and Mohammad Dehghani, GSURR.

The report greatly benefited from professional editorial work by Mary A. Anderson and professional graphic design by Carlos Plaza Design Studio.


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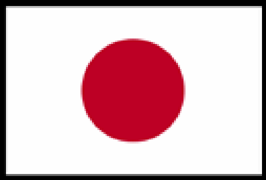
CASE STUDY OF JAPAN



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ABBREVIATIONS

DRM	disaster risk management
JMA	Japan Meteorological Agency
MLIT	Ministry of Land, Infrastructure, Transport and Tourism
TEC-FORCE	Technical Emergency Control Force (MLIT)
PWRI	Public Works Research Institute
VICS	Vehicle Information and Communication System

1 INTRODUCTION

A case study has been developed that captures Japan's experience in road geohazard risk management and offers a way forward for low- and middle-income countries. This case study report includes a discussion of

- Significant issues Japan overcame, such as the initially narrow scope of road management authorities and expansion of the mandate and planning for geohazard risk management in the road sector across various national and subnational governments;
- Turning points in geohazard risk management, such as serious road geohazard incidents;
- Development of critical institutional frameworks, such as passing key legislation and creating funding mechanisms;
- Steps the governments took to identify hazardous locations, conduct risk evaluations, and implement needed structural and nonstructural measures such as an early warning system; and
- Postdisaster response and recovery and preparedness for such reactive measures, including a contingency system.

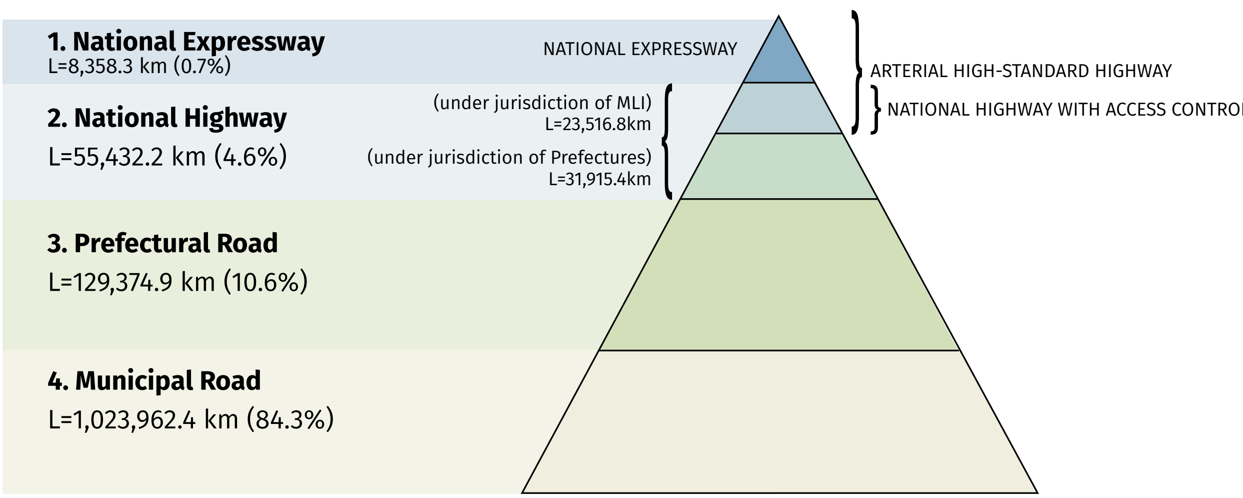
For background information on the overall topic of road geohazard risk management, readers are referred to the main handbook.

1.1 Road System in Japan, by Type

The Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) has set its main geohazard targets for disaster prevention as earthquakes, heavy rainfall, and heavy snow (and cold). The program for road disaster prevention in Japan is thereby subdivided into programs addressing (a) earthquakes and tsunamis; (b) heavy rainfall; and (c) heavy snow and cold temperature (including prevention of surface freezing) (MLIT 2015a).

The MLIT is in charge of the statistical data on road geohazard damage events and road closures due to geohazards, including those affecting expressways, national highways, and rural roads covering a total of 1.2 million kilometers as of 2013 (Figure 1.1).

Figure 1.1 Roads in Japan, by Type and Length, as Defined by the Road Act, as of 2013



Total Length = 1,217,127 km**

**includes very narrow roads. Total length of roads with enough width to pass a car coming the other way. (i.e. 5.5m wide) is only about 340,000km.

As of 2013 April 1

Source: MLIT 2015a.

Note: Figure includes roads classified under Article 3 of the Road Act of Japan (1952), which defines a road as a thoroughfare open to public use and classifies such roads as National Expressways, National Highways, Prefectural Roads, and Municipal Roads.

1.2 Background of Road Geohazard Risk Management

This section was summarized from the "White Paper on Disaster Management in Japan" (Cabinet Office 2015b); the "Disaster Management in Japan" pamphlet (Cabinet Office 2015a); the Government of Japan's MLIT website; and the website of the Japan Meteorological Agency (JMA).

1.2.1 General Situation of Natural Disasters in Japan

Japan is one of the most geohazard-prone countries in the world. Typhoons and heavy rainfall, especially during the rainy season every year, often cause geohazard events. Japan is also an earthquake- and tsunami-prone country where many volcanic eruptions also have occurred.

Japan is located in the circum-Pacific mobile belt, where seismic and volcanic activities occur constantly. Although the country covers only 0.25 percent of the earth's land area, it experiences a high number of earthquakes and active volcanoes: It had 302 earthquakes with a magnitude of 6.0 or more in 2004–13, accounting for almost 19 percent of all the earth's registered earthquakes of that magnitude (Cabinet Office 2015a). Meanwhile, it also has 110 active volcanoes, accounting for 7 percent of all active volcanoes on earth as of 2014 (Cabinet Office 2015a). Moreover, because of geographical, topographical, and meteorological conditions, the country is subject to frequent natural disasters such as typhoons, torrential rains, and heavy snowfalls, as well as earthquakes and tsunami.

Every year, natural disasters in Japan such as typhoons and earthquakes cause great loss of human life and property and extensive infrastructure damage. Until the second half of the 1950s, the thousands of annual casualties had been recorded. Since then, disaster damage has declined as the society increased its capabilities to respond to disasters and mitigate vulnerabilities to disasters by developing disaster risk management systems, promoting national land conservation, improving weather forecasting technologies, and upgrading disaster information communications systems.

In spite of such efforts, in 1995, more than 6,400 people died in the Great Hanshin-Awaji Earthquake (Cabinet Office 2015b). Also, in 2011, more than 18,000 people died or went missing in the Great East Japan Earthquake (Cabinet Office 2015b). A high probability of large-scale earthquakes persists, including impending possibilities of a Nankai Trough earthquake and a Tokyo Inland earthquake. As such, natural disasters remain a menacing threat to the country's safety and security.

1.2.2 Earthquake Disasters in Japan

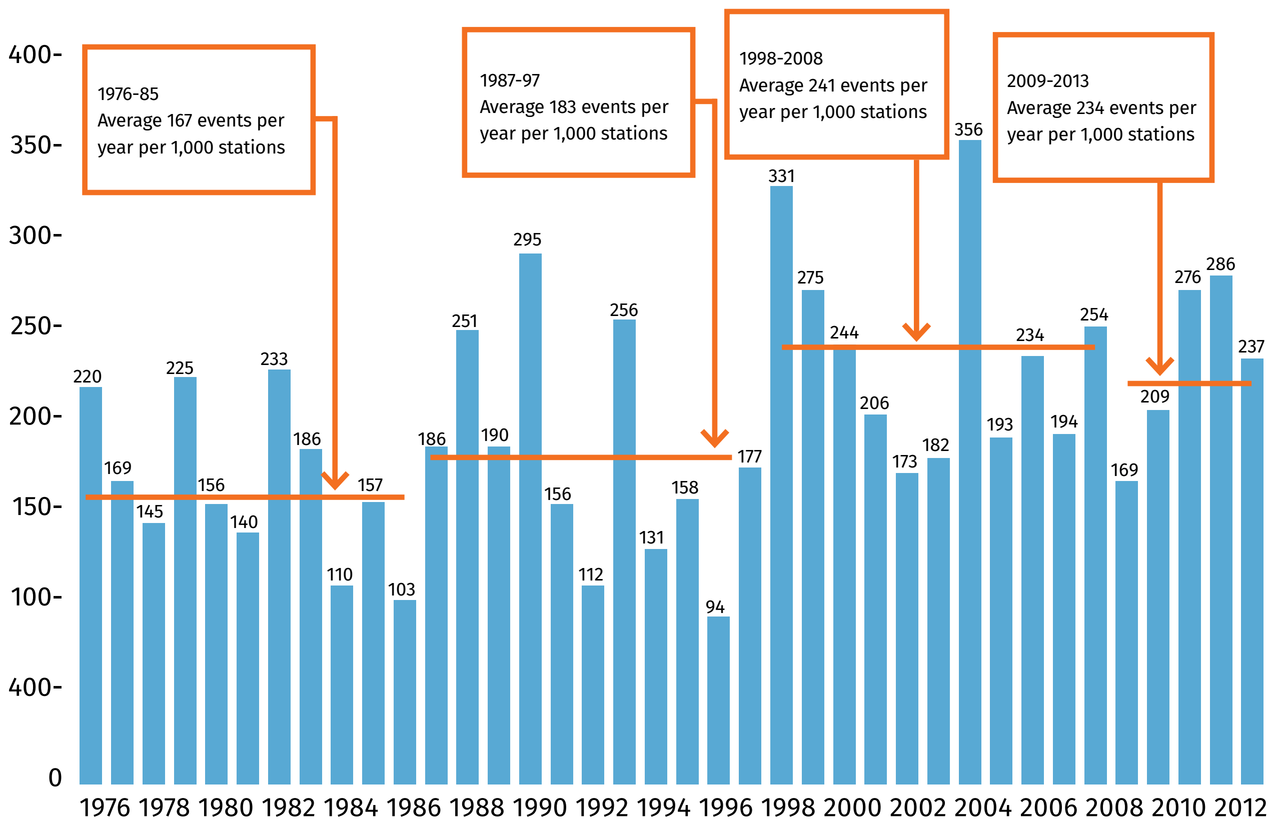
Japan is one of the most seismically active areas on earth, located where 4 of more than 10 tectonic plates covering the globe are crushed against each other, making it an archipelago susceptible to earthquake disasters. Nearly 20 percent of the world's earthquakes (of magnitude 6.0 or greater) have occurred in or around Japan (Cabinet Office 2015a). Japan has suffered great damages from the massive inter-plate earthquakes produced by plate subduction (such as the Great East Japan Earthquake and Tsunami of 2011) as well as from the inland crustal earthquakes caused by plate movements (such as the Great Hanshin-Awaji Earthquake of 1995).

1.2.3 Storm and Flood Disasters in Japan

Japan is prone to a variety of water- and wind-related disasters including flooding, landslides, tidal waves, and storm hazards because of meteorological conditions (such as typhoons) and geographical conditions such as precipitous terrains and steep rivers and settlement conditions in which many of the cities are built on river plains. Approximately one-half of the population (or 60 million people) are concentrated in possible inundation areas, which account for about 10 percent of the national land (Cabinet Office 2015a). Many years of soil conservation and flood control projects have greatly reduced the area inundated by floods, but the value of general assets damaged in flooded areas has increased in recent years.

A long-term trend of increasing downpours throughout the country has been observed. Based on data from the Japan Meteorological Association, rainfall stations recorded an upward trend in the average annual number of hourly rainfall events exceeding 50 millimeters per hour (Cabinet Office 2015a). This increased from 0.17 (events per year per station) during the 1976–86 period to 0.18 during the 1987–97 period, 0.24 during the 1998–2008 period, and 0.23 during the 2009–13 period (Figure 1.2).

Figure 1.2 Annual Torrential Rainfall Events per 1,000 Rainfall Stations in Japan, 1976–2013



Source: Cabinet Office 2015a.
Note: “Torrential rainfall” refers to rainfall of more than 50 millimeters per hour.

1.2.4 Volcano Disasters in Japan

Japan is a highly volcanic country. Poised on the circum-Pacific volcanic belt, or “Ring of Fire,” the Japanese islands are home to 110 active volcanoes, which account for 7 percent of the earth’s total (Cabinet Office 2015a). In the past, eruptions and other volcanic activities have caused heavy damage. Three recent examples—the eruptions of Mt. Usu and Miyakejima Island in 2000 and Mt. Kirishima (Shinmoedake) in 2011—caused thousands of residents to flee their homes.

1.2.5 Snow Disasters in Japan

Japan is a bow-shaped archipelago with steep mountain ranges. When cold winds blow from Siberia in the winter, the warm current up to the coast from the south brings heavy snowfall to the Sea of Japan side of the country. Thus, the northeastern part of Japan has frequent winter snows. Recently, snow had occurred not only in the northeastern part but also in other areas of Japan where it had seldom snowed before. Heavy snow in such areas often creates huge upheaval.

In the winter of 2006, the death toll reached 152. In the winter of 2012–13, many automobile drivers were killed in the snowstorm: some died in their cars from carbon monoxide poisoning because snow had clogged their cars' exhaust pipes, while others left their vehicles and froze to death (Cabinet Office 2015a).

From November 2013 to March 2014, the Kantō and Koshinetsu areas experienced record-breaking snow, damaging a vast area including areas that previously had never been snow-prone. Many stranded vehicles on the streets blocked traffic, forcing railway operations to stop. As many as 6,000 families in 130 settlements were isolated and stranded (Cabinet Office 2015a).

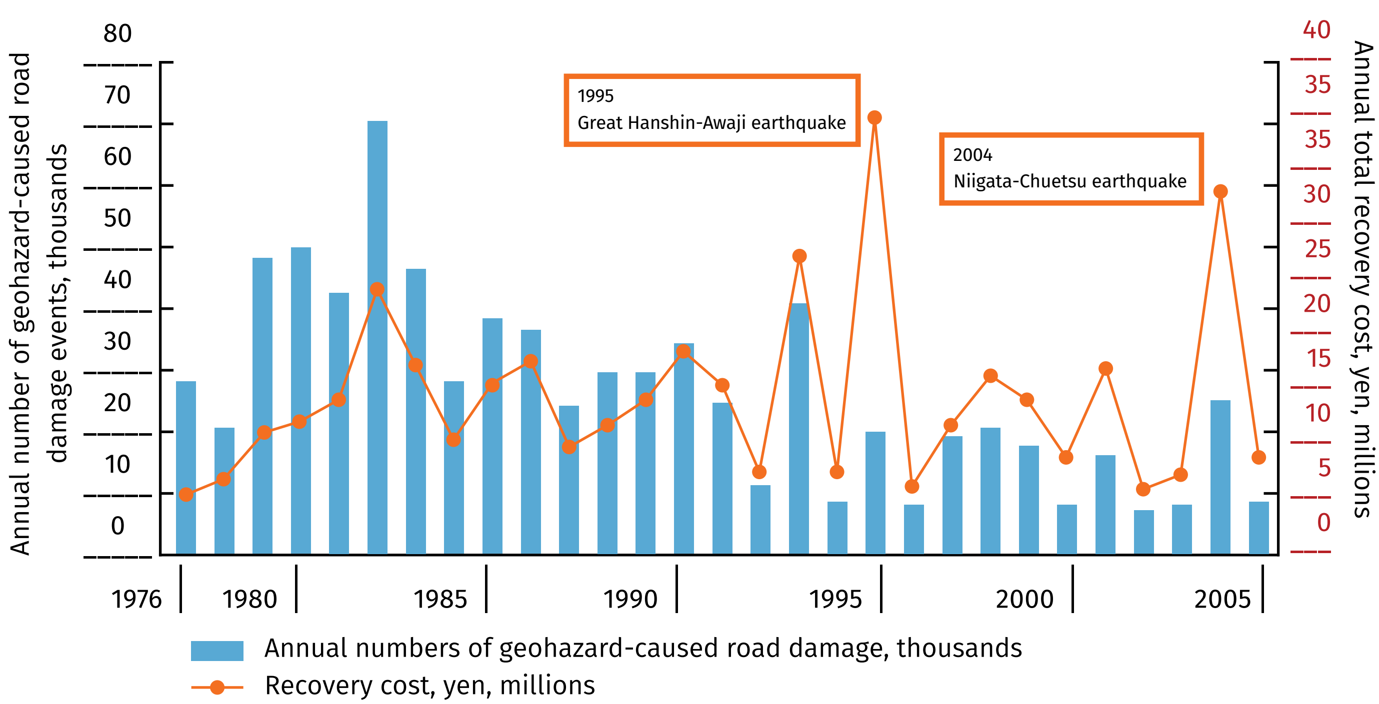
1.3 Current Condition of Road Geohazard Risk Management Issues

1.3.1 Road Geohazards in Japan

Over the long term, annual geohazard-caused road damage events have decreased in number (Figure 1.3). In 11 of the 17 years from 1977 through 1993 (65 percent of those years), more than 30,000 geohazard-caused road damage events were recorded. For the 13 years from 1994 through 2006, the annual number of such events remained fewer than 30,000. This downward trend seemed to be the effect of road geohazard risk reduction investments in proactive structural measures.

Whether the annual recovery cost also decreased is not clear because of the effect of price escalation through the years. The considerable recovery cost in 1995 and 2004 was due to catastrophic earthquake events in those years, which resulted in relatively higher average damage magnitudes and recovery costs for the road damage locations. Figure 1.3 shows the annual number of geohazard-caused road damage events and the recovery costs from 1977 to 2005.

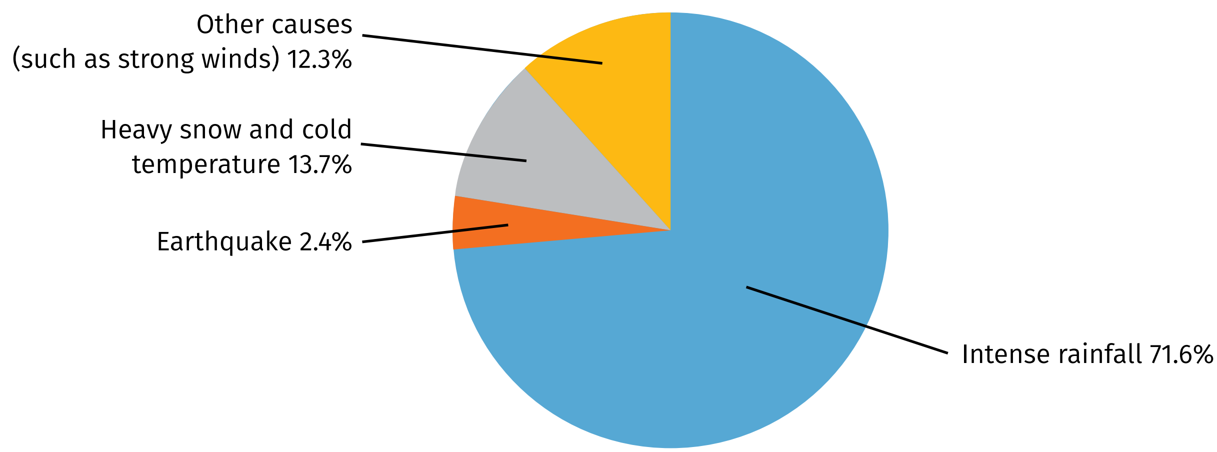
Figure 1.3 Annual Geohazard-Caused Road Damage Events and Recovery Cost in Japan, 1977–2005



Source: Road Bureau data, MLIT, http://www.mlit.go.jp/road/road_e/index_e.html.

Geohazards in Japan caused an average of 7,400 road closures per year during fiscal years 1995–2004. More specifically, the causes, by type of geohazard, are indicated in Figure 1.4, with precipitation-based events (intense rainfall and heavy snow) making up the vast majority of causes.

Figure 1.4 Causes of Road Closures due to Geohazards in Japan, by Type, 1995–2004



Source: Road Bureau data, MLIT, http://www.mlit.go.jp/road/bosai/dourokuukan/.

1.4 Opportunities for Enhancing Road Geohazard Risk Management

1.4.1 Lessons Learned from Historical Road Geohazard Events

Based on the lessons learned from dealing with frequent road geohazard events, the Japanese government has made systematic improvements to road geohazard risk management procedures. Table 1.1 summarizes the history of major road geohazard incidents and the government's actions to address them, including the formulation of laws and preparation of technical manuals. As shown, the legal system and countermeasure techniques have been improved and implemented after the lessons learned from historical road geohazard events.

Table 1.1 Events Related to Road Geohazard Risk Management in Japan, 1952–2014

Event	Geohazard details and government action
1952: Road Act revised (Act No. 180 of 1952)	The Road Act prescribes the authority and responsibility for road traffic by the road management authority to secure road traffic safety.
1954: "Road Earthwork: General Guidelines" published by the Japan Road Association	The guidelines include the countermeasures for road geohazards, describing surveys, plans, designs, construction, and maintenance. The latest edition of the guidelines was published in 2009 (Japan Road Association 2009b).
1959: Typhoon Vera (Isewan-Taifu in Japanese) severely floods and damages the Pacific coastal area of Ise Bay in Central Japan, killing 5,238 people.	The typhoon caused extensive flooding along with matching high tide. The government prepares the Disaster Countermeasures Basic Act to accelerate geohazard risk management.
1961: Disaster Comprehensive Countermeasures Basic Act (Act No. 223 of 1961) enacted	The Act prescribes the roles and responsibilities for each disaster phase (prevention, emergency response, rehabilitation, and reconstruction).

Event	Geohazard details and government action
1968: August 18 Hida River bus-fall incident on National Road No. 41 in Gifu Prefecture in Central Japan, killing 104 people	The road mountainside slope (100 meters high, 30 meters wide) collapsed, directly hitting and pushing three buses into the valley side. Two buses fell into the river during extremely intense, long rainfall. Most of the collapsed slope was outside the right-of-way (area of land managed by the road management authorities). At that time, six buses were isolated and stranded in the road location, blocked on both the front and rear of the road mountainside slope collapse. The Road Bureau of the former Ministry of Construction ordered the national road management authorities to conduct the road geohazard risk inspection (identification, inventory, and prioritization of hazard-prone road locations) and to establish a new risk avoidance system of precautionary road closure (to save lives) during situations highly susceptible to geohazard events affecting road locations.
1968: Japan's first nationwide road geohazard risk inspection conducted in September	After the Hida River bus-fall tragedy, the Road Bureau ordered the national road management authorities to conduct a nationwide road geohazard risk inspection and to prepare an inventory of hazard-prone road locations to be measured.
1969: Precautionary road closure operation established	Precautionary traffic closure is the traffic regulation intended to save road user lives. The director of the Road Bureau designated the road subsections for precautionary traffic closure nationwide. This type of nonstructural measure was established after the lessons learned from the Hida River bus-fall tragedy.
1970: Liability of the road management authority on road disasters determined by Supreme Court, August 20	The decision held that the road management authorities have the responsibility to determine hazard-prone road locations, to eliminate the danger, and to install proactive nonstructural measures such as precautionary road closure to save road user lives. The trial was held for road users because of the road slope collapse on National Road No. 56 in Shikoku Region in 1963. The Hida River bus-fall accident occurred during this dispute and may have affected the Supreme Court decision.
1970: Japan's second nationwide road geohazard risk inspection conducted in October	After the Supreme Court decision, the Road Bureau ordered the management authorities with responsibility for national, prefecture, and municipal roads to conduct road geohazard risk inspections and to update or prepare the inventory of hazard-prone road locations to be provided with proactive measures.
1989: Echizen Coast road rock shed collapse on National Road No. 305 near Tamagawa, Fukui Prefecture, killing 15 people	The rock shed collapsed because of rock collapse on the shed. This rock collapse was newly defined as a type of geohazard and was added to the "Draft Road Geohazard Risk Inspection Guidebook," which included the inspection sheet formats for rockfall, collapse, rock mass collapse, slides, snow avalanche, road embankments, drifting snow, rock sheds, and tunnels (Ministry of Construction 1990).
1990–95: Unzen Fugendake Volcano activities (62 debris flows and 9,472 pyroclastic flows), which hit Shimabara Peninsula (Nagasaki Prefecture, Kyushu Region), leaving 44 people dead or missing and isolating Shimabara City several times by road and railway closures	In 1993, the Ministry of Construction publicly offered the technology for the first remote-controlled, or unmanned, construction machinery for the hazard-prone location to meet the following requirements: • Braking boulders of 2–3 meters • Operation at 100 degrees centigrade, 100 percent humidity • Remote-control operation at 100-meter distance In 2004, the Ministry of Construction also adopted the first remote-controlled, or unmanned, construction machinery for earthworks operations (such as dump trucks, backhoes, and bulldozers) to remove debris from sand pockets or to fill earth dams for debris flow protection.

Event	Geohazard details and government action
1995: Great Hanshin-Awaji Earthquake (magnitude 6.9), with severe damage to Hyogo Prefecture in the southern region along the seashore, killing 6,402 people	The government recommends the strengthening of bridges and embankments against earthquakes. The preparation of the geohazard risk management plan by hazard type begins in addition to the designation of emergency roads. The designated emergency roads are arterial highways and connecting roads between disaster prevention facilities (evacuation points and facilities, storage facilities for emergency aid, rescue facilities, and information and communication facilities). The designated emergency roads are to be used exclusively for emergencies declared by the government. The designated emergency roads have high priority in investments for structural measures for road disaster prevention.
1996: Rock mass collapse at entry of Toyohama Tunnel, Hokkaido, in the northern region, killing 20 people	The rock mass collapse destroyed the entry of the tunnel and vehicles. Despite a sign of the impending collapse of the rock mass just before the incident, this was not relayed to the road management authority and road users. Regional partnerships for road disaster risk management were proposed based on the lessons from this tragedy. The “Road Geohazard Risk Inspection Guidebook” was updated after the accident (ROMAN-TEC 1996)[a].To share the concept and strengthen the quality of inspection, short training courses (four days on the whole, with one day at the site) for public and private engineers engaged in inspections were conducted. The “Road Geohazard Risk Inspection Guidebook” was revised for heavy rain, heavy snow, and earthquakes. Road geohazard risk inspections were conducted on national highways and subnational roads from 1996–97.
1997: Rock mass collapse at entry of the Second Shiraito Tunnel, Hokkaido, in the northeast region, no fatalities	Evaluations of rock mass collapse and advanced studies had commenced for road geohazard risk inspection techniques such as rock slope mass monitoring and numerical analysis of rock mass collapse mechanisms.
2001: Ministry of Land, Infrastructure, Transport and Tourism (MLIT) established by merging the Ministry of Construction, Ministry of Transportation, Hokkaido Regional Development Bureau, and National Land Agency	The Road Bureau in the former Ministry of Construction and the Japan Meteorological Agency (JMA) in the former Ministry of Transportation were transferred into the new MLIT. The Disaster Prevention Bureau of the old National Land Agency was transferred to the Disaster Management Cabinet Office in the Cabinet Office.
2005–06: Heavy snow, killing 152 persons and causing 115 avalanches to hit roads (most seriously, causing a five-day road closure on National Highway No. 405 at the border of Nagano-Niigata Prefectures, isolating 193 households, 501 residents)	The proactive structural measures and nonstructural measures for preparedness—including standby contracts with private construction companies for emergency snow removal—were enhanced. To avoid traffic suspension losses due to road closures on National Highway No. 17 (at the border of Niigata and Gunma Prefectures), the Road Bureau implemented a temporary toll-free opening of a section of National Expressway toll road. The National Expressway is a high-standard road structure and maintenance system that provides safe road driving conditions for non-high-speed driving even under severe weather.

Event	Geohazard details and government action
2006: "Road Geohazard Risk Inspection Guidebook" updated (ROMAN-TEC 2006), edited by a technical committee comprising public and private technical authorities 2009: New edition of "Road Geohazard Risk Inspection Guidebook" published (ROMAN-TEC 2009)[b] (as of 2016, the latest version) 2010: 2009 edition reprinted and published in 2010 (JGCA 2010)	Based on the road slope geohazard event records from 1996, some of the disasters occurred at road locations that had not been identified as hazard-prone locations in previous inspections conducted in 1996–97 after the 1996 publication of the "Road Geohazard Risk Inspection Guidebook" (ROMAN-TEC 1996). Thus, the criteria for identifying hazard-prone road locations were revised in the Guidebook, considering past disaster lessons (ROMAN-TEC 2006). The key aspect of the revision was to confirm the slopes up to the hilltop for possible geohazard by checking water flow possibility on mountainside water-collecting topography and the drainage capacity of developed land (for residents, business establishments, and agricultural land), which may cause water flow into the roadside slope. The 2009 edition included techniques on geohazard analysis using accurate maps formulated by laser (light amplification by stimulated emission of radiation) profiling (ROMAN-TEC 2009; JGCA 2010).
2008: Iwate-Miyagi Earthquake, Northeast Japan A slide-type geohazard blocked a river and formed a natural dam.	The Sediment Disaster Prevention Act was revised in 2011. It was intended to share information (such as susceptible geohazard situations and recommendable evacuation routes under the situation including accessibility of roads) on the emergency evacuation of residents for severe sediment disasters.[c] A natural dam formed by a geohazard is composed of loose soil materials and has a high possibility of an outbreak due to hydrofracturing or overflow of the dam.
2011: Great East Japan Earthquake, east-north region of Japan, killing 15,894 people with 2,563 people still missing; most fatalities killed by tsunami (other causes such as fall- or collapse-type geohazard making up less than 5 percent)	The Disaster Countermeasures Basic Act (1961) was amended in 2012 in response to lessons from disasters, mostly in the east-north region of Japan, such as the need to reopen roads for emergency response. Of note is the efficient reopening or eliminating of obstructions on damaged and closed roads to activate emergency transportation or evacuation roads. The national and regional road bureaus administer the operation through private construction companies. The priority targets were the arterial roads of the inland-coastal or east-west direction access to the seriously damaged coastal road in the north-south direction, starting from the undamaged arterial highway running through the inland (north-south direction). The operation was named "Comb's Teeth Strategy" because of the parallel shape of the inland-coastal connection roads. The cases confirmed that roads served as evacuation sites for local residents and were effective in preventing floods from spreading. In 2011, some of the expressway companies and subnational governments entered into an agreement to use the slope surface of expressway embankments in coastal areas as tsunami emergency evacuation sites. After the earthquake, MLIT started to promote the use of rivers as emergency transport routes—the dry riverbed for vehicles and the waterway for ships.
2013: Disaster Countermeasures Basic Act amended	The following aspects were added: • Intensification of the ability for emergency response on a large scale and forwide-area disasters • Preparation of smooth, secure evacuation routes • Improvement of shelters for victims • Strengthening of disaster risk reduction (proactive measures)
2014: Slope failure due to heavy rain, hitting residential area in Hiroshima, killing 74 people	The Sediment Disaster [= geohazard] Prevention Act was revised in 2014. Modifications made it compulsory to publish all potential hazards for citizens in a particular area.

Event	Geohazard details and government action
2013–14: Highest recorded snowfalls in the Kantō and Kōshin'etsu areas, stranding many vehicles on the street, blocking traffic, halting railway operations, and isolating as many as 6,000 households	Review and revisions are being made on issues such as (a) how the alert, warning, and weather advisories can be provided; (b) measures to clear stranded vehicles blocking traffic; and (c) timing of precautionary road closures, especially for the national expressways, which are relatively safer to use than other roads during heavy snow.
2016: Kumamoto Earthquake, killing 50 persons directly at the event; closing road subsections of National Expressway 23 (between adjacent intersections) and 54 locations on National Highway; and collapsing Aso-Ohashi bridge (205.96 meters long) on National Highway No. 25 because of abutment slope collapse of 500,000 cubic meters	The road closures due to bridge collapse or damage, and fallen utility poles (power and telephone) tied up emergency transportation and postdisaster response and recovery. The importance of the proactive seismic strengthening of roads for emergency transportation has once again been recognized. The many closed-circuit TV cameras for road traffic situation monitoring were useful to capture damage assessments for road infrastructure. But some of the camera and communication devices were damaged by the earthquake and had not functioned; thus, redundant or multiple camera installation systems are desirable.

Sources: Cabinet Office 2015a, 2015b; JGCA 2010; MLIT 2011, 2014a; ROMAN-TEC 1996, 2006, 2009; and information from websites of the Cabinet Office (http://www.cao.go.jp/index-e.html) and Ministry of Land, Infrastructure, Transport and Tourism (http://www.mlit.go.jp/en/index.html).

1.4.2 Lessons Learned from Hida River Bus-Fall Incident and Improvement of Road Geohazard Risk Management Procedures

A significant turning point in road geohazard risk management in Japan was the 1968 "Hida River Bus-Fall Incident," in which debris from a slope collapse hit two buses, pushing them from a mountainside into a river and killing 104 people. The debris flow occurred outside of the road management area (the road right-of-way) and was triggered by extremely heavy rains. The precipitation at that time had exceeded 100 millimeters per hour. The incident revealed the road geohazard risk management issues discussed below.

ISSUE 1: No Proactive Measures Existed for Roads outside the Road Management Authority's Area of Responsibility

ISSUE AND LESSONS LEARNED: The broad geohazard (slope collapse) occurred outside of the road management authority's area (right-of-way). Until this accident occurred, the road management authority in Japan had targeted only road structures (such as roads, bridges, and tunnels) and road earthwork structures (such as engineered slopes and embankments) and did not handle geohazard risks outside its area. Geohazards generated from long distances sometimes damaged the road. These were especially true in the case of steep mountainside rock or soil falls or collapses due to flow-type

[a] The Road Management Technology Center (ROMAN-TEC) was a foundation under the MLIT that conducted research and development and provided technical training on technology for the preservation of roads and road structures and for the operation of the road management system. ROMAN-TEC was established in 1990 and abolished in 2011.

[b] The 2009 edition was reprinted with same content by Japan Geotechnical Consultants Association (JGCA 2010) because the Road Management Technology Center (ROMAN-TEC) delegated the publication to JGCA when ROMAN-TEC was abolished in 2011. JGCA is a foundation under the MLIT's Road Bureau that provides technical training material for geotechnical inspection and investigation as well as training sessions and e-learning materials on road geohazard risk inspection.

[c] Sediment disaster has almost the same meaning as damage due to geohazards. Geohazards include floods, but sediment disasters do not in the exact sense. The relationship between flow-type geohazards of earth or debris flow (including sediment disaster) and flooding are categorized by the water contents, and a clear distinction cannot be made. Furthermore, a flow-type geohazard changes its water contents during an event—for example, starting from floodwaters and changing to earth or debris flow.

geohazards with high water content in the landscape ecosystem upstream of the hazard-prone road location. The hazard-prone location had no proactive structural measures.

Improvement of road geohazard risk management procedures. A month after the August 1968 tragedy, the Road Bureau of the Ministry of Construction ordered the national road management authorities to conduct the first nationwide road disaster prevention inspection simultaneously. Nationwide inspections have now been ordered 10 times (in 1968, 1970, 1971, 1973, 1976, 1980, 1986, 1990, 1996–97, and 2006). The purpose of the inspection was to formulate or update the inventory of hazard-prone road locations likely to suffer road damage from geohazards and to determine the locations where proactive measures could be installed. The evaluation procedure has been updated so as not to miss any hazard-prone road locations, including those that may be damaged by geohazards occurring far from the road. The proactive structural measures were installed in selected priority hazard-prone locations.

ISSUE 2: No Nonstructural Measures Existed for Emergency Information, Including Early Warning or Precautionary Road Closures

ISSUE AND LESSONS LEARNED: The Hida River bus-fall tragedy had occurred under extremely intense, lengthy rainfall, and the location was in a geohazard-prone road subsection. The bus drivers or conductors were not familiar with the geohazard danger to the road situation. The volunteer disaster emergency response team of the community along the road recommended that the bus drivers or conductors not proceed to the hazard-prone road subsection during the highly hazard-susceptible situation, but they had no authority and could not persuade the bus drivers or conductors to follow their advice. On the other hand, the railroad station master near the road location was familiar with the fragile local geology and the potential geohazard from historical heavy rainfall events, and he decided correctly to stop the train at the station to await recovery from the abnormal rainfall and highly susceptible geohazard situation, even though some passengers strongly complained. As a result, the train passengers' lives were saved.

Improvement of road geohazard risk management procedures. In 1969, the Road Bureau ordered the national and subnational road management authorities to identify geohazard-prone road subsections to be subject to precautionary road closure operations. The purpose of the precautionary road closure is to save road users' lives from a geohazard-induced disaster. A "precautionary road closure" is the decision ordering a road closure.

The precautionary road closure system enables each road management authority to apply the road closing criteria to the geohazard-prone road subsection. The Road Bureau director designates the precautionary road closure subsections with their road closure criteria identified, such as cumulative rainfall amount from the start of the rainfall. Geohazards are often triggered by heavy rainfall. Therefore, the rainfall index is normally used as a criterion for a precautionary road closure in Japan. The rainfall index is used to measure the continuous rainfall amount from the start of the rainfall. The road closure criteria using the rainfall index are determined by the value of the historical rainfall index of road geohazard events. The other criteria are dense fog, strong winds, high coastal waves covering the road, and other hazardous conditions.

The operation for precautionary road closure is undertaken not only for designated road subsections but also for any situations that are highly susceptible to geohazard. Road-hazard-prone situations or road closure situations are announced through the electronic road information boards along the roadsides (or above the roadways using the above road structures), in parking areas, through the mass media, and through the internet.

2 INSTITUTIONAL CAPACITY AND COORDINATION

2.1 Institutional Framework

2.1.1 Laws, Regulations, and Technical Standards

Japan has established laws that specify the guarantee of funds related to disaster relief, disaster management plans, and the fundamental matters related to systems during a state of emergency.

Technical standards and manuals have been prepared for (a) disaster risk management; (b) road disaster risk management; (c) risk evaluation for road geohazards; (d) benefit estimation of proactive measures for road geohazards; and (e) business continuity planning for road geohazards. However, regarding (c) risk evaluation for road geohazards, no practical manual on risk estimation of potential economic loss has been developed. Regarding (d) benefit estimation of proactive measures, no practical manual has been developed.

FUNDAMENTAL LAWS ON DISASTER RISK MANAGEMENT

Act on National Treasury Share of Expenses for Recovery Projects for Public Civil Engineering Facilities Damaged Due to Disasters (1951). Before this act was enacted, the cost for recovery was allocated through the budget of the prefectural government of affected areas in Japan. However, the budget allocation often exceeded the annual revenue of prefectural governments. Subsequently, the Japanese national government decided to subsidize a portion of the budget through this act. The amount of the subsidy is determined by the ratio of (a) the amount of the subsidy from the national government to the estimated recovery cost, to (b) the prefectural government's annual revenue (Table 2.1).

Table 2.1 Conditions for Subsidizing Prefectural Governments' Disaster Recovery Costs

Ratio of estimated recovery cost to prefectural government's annual revenue	Amount of subsidy from national government
Cost is less than half the prefectural government's annual revenue	Two-thirds of recovery cost
Cost is half to two times the prefectural government's annual revenue	Three-fourths of recovery cost
Cost is more than two times the prefectural government's annual revenue	All of the recovery cost

Source: Act on National Treasury Share of Expenses for Recovery Projects for Public Civil Engineering Facilities Damaged Due to Disasters (1951).

Disaster Countermeasures Basic Act (1961, the latest amendment as of 2016). The Disaster Countermeasures Basic Act comprises the following provisions:

- ***Definition of responsibility of each administrative body.*** The national government, prefectural administrations, and subnational public entities shall formulate disaster risk management (DRM) plans and implement the plans together with the cooperation of other organizations and shall have responsibility for the protection of human lives and properties through DRM.
- ***Formulation of comprehensive DRM.*** The national government, prefectures, and municipalities shall create a disaster management council to formulate disaster risk strategies and to administer preparedness for disaster. When a disaster is predicted or has occurred, the prefectures and municipalities shall mobilize the emergency response teams. When a serious disaster is

predicted or has occurred, the prefectures and municipalities establish emergency headquarters for disaster emergency measures and damage assessment. In the case of large-scale disaster emergencies covering many prefectures, the national government establishes a national emergency headquarters for major or urgent disaster management and carries out measures and coordinates with DRM organizations at different levels.

- ***Preparation of DRM plan for each administrative body.*** The national DRM council shall prepare a comprehensive national DRM plan based on the disaster risk plans of prefectural governments and municipalities.
- ***Development of DRM.*** The roles and responsibilities of each governmental body are determined for each DRM stage: disaster risk reduction, emergency, recovery, and restoration.
- ***Dispatch for national emergencies.*** If an extremely severe national disaster occurs, the prime minister can declare a state of emergency. The cabinet can prepare the special budget and formulate acts for the security and safety of the state.

Act on Special Financial Support to Deal with Extremely Severe Disasters (1962). The act defines the rules of special financial assistance for subnational public entities and victims in the occurrence of extremely severe disasters.

LAWS ON GEOHAZARD RISK MANAGEMENT

The laws on geohazard risk management are prepared for several geohazard types, software and hardware measures, and several sectors in addition to the road sector such as the river, agriculture, and forestry sectors (Table 2.2). Japan has been enforcing geohazard-related laws based on lessons learned from previous disasters.

Table 2.2 Geohazard Disaster-Related Laws in Japan

Basic DRM law	Purposes
Disaster Countermeasures Basic Act (1961, latest amendment as of 2016)	To maintain a systematic DRM administration system. The main contents are as follows: Clarification on DRM • DRM system • DRM plan • Disaster risk prevention • Disaster emergency measures • Financial measures • Disaster state of emergency
River Act (1964, latest amendment as of 2015)	Mainly to define the regulating authority responsible for river management to reduce damage due to flood
Erosion Control Act (1897, latest amendment as of 2013)	Mainly to prevent production and runoff of sediments from mountain streams and adjoining slopes affecting flood control Provides authorization for road construction near the boundary of a sediment-control designated area
Landslide Prevention Act (1958, latest amendment as of 2014)	To prevent or reduce landslides and the collapse of slag heaps.[a] To stipulate the authorization for road construction in the determined landslide prevention areas

Act on Prevention of Steep Slope Collapse Disaster (1969, latest amendment as of 2005)	To protect human lives and properties of citizens from the collapse of steep slope (more than 30 degrees inclination), it intends to • Restrict any activities; • Execute countermeasures; and • Develop alert and evacuation systems. Establishes guidelines for the authorization of road construction on the steep slope collapse prevention areas
Forest Act (1951, latest amendment as of 2016)	To implement preservation and conservation of the forests and increase forest production capacity Describes prevention measures for geohazard disasters such as the defense of the sediment runoff, soil collapse, and appointment of forest preservation to prevent geohazard Inside the forest preservation areas, certain activities are restricted or canceled if such activity causes the loss of some aspects of the forest function
Sediment Disaster Prevention Act (2000, latest amendment as of 2016)	To establish regulations for living in disaster-prone or dangerous zones and provide for the obligatory publication of all risks to inhabitants in particular areas starting in 2000

Note: DRM = disaster risk management.

a. Slag heaps are rock or soil disposal mounds from mining excavations. At the time the law was established, the Japan coal mine industry was active, and slag heap collapse had become a big problem. As of 2016, all the slag heaps have been measured, and no problem has occurred.

LAWS ON ROAD GEOHAZARD RISK MANAGEMENT

The Road Act (1952, the latest amendment as of 2016) is the basis for road geohazard risk management. Among its provisions,

- ***Article 42*** mandates that the road management authority maintains and repairs roads to keep them in good condition, also specifying the applicable technical standards (including for road inspection and maintenance); and
- ***Article 46*** gives the road management authority responsibility for traffic regulation during the following situations:
  - o The road is dangerous to use because of geohazards on the road.
  - o The road cannot be used because of construction or rehabilitation activities.

TECHNICAL STANDARDS AND MANUALS

Disaster risk management. The Cabinet Office is the agency responsible for DRM in Japan. Most government officials lack sufficient DRM knowledge because they lack experience in actual DRM activities. The Cabinet Office has developed the standard DRM guidelines for public officials. It is also currently developing the Guidelines on the Standardization of Disaster Management to standardize, make more practical, and share the procedures and practices of the disaster recovery system and business operations, based on the latest know-how and lessons acquired from actual DRM practice.

Road geohazard risk management. In Japan, in most cases, cost-benefit analysis has not been conducted for road geohazard risk reduction investment. The Public Works Research Institute (PWRI) developed the "Draft Manual on Risk Analysis and Risk Management Support for Road Slope Disasters" as a reference for conducting project economic feasibility analysis for risk reduction investments (PWRI 2006). The draft manual proposed the following procedures:

- Evaluation of road geohazard occurrence probability using multivariate statistical analysis of historical geohazards and the checklist or category of hazard-prone road locations
- Economic loss estimation of several magnitudes of road closure events due to geohazards
- Risk estimation of potential annual loss
- Risk management planning using the results of the risk estimation.

Risk evaluation for road geohazards. The MLIT's Road Bureau formulated a "Draft Road Geohazard Risk Inspection Guidebook" in 1990 (Ministry of Construction 1990), which was subsequently revised in 1996, 2006, and 2009 (ROMAN-TEC 1996, 2006, 2009) and in 2010 (JGCA 2010). The guide is used to identify hazard-prone road locations, categorized by three levels of road damage likelihood:

- ***High likelihood*** of disaster occurrence for hazard-prone road locations, requiring the application of structural measures
- ***Moderate likelihood*** of disaster occurrence for hazard-prone road locations, to be managed by routine visual inspections
- ***Low likelihood*** of disaster occurrence for hazard-prone road location, requiring no further action.

Benefit estimation of proactive measures for road geohazards. The 2006 PWRI manual (mentioned above in this section) also introduced the method to estimate the economic benefits of proactive measures based on the expected reduction in average annual economic loss. In addition, the MLIT Road Bureau and City Bureau are working jointly to develop manuals for cost-benefit analysis, road disaster function improvement, and measurements related to disaster prevention improvements for the road network and major cities.

Structural measures for road geohazards. The technical committees managed by the MLIT and the PWRI formulated manuals on structural measures for road geohazards and bridges or road crossing culverts, which were published by the Japan Road Association (2000, 2006, 2009a, 2009b). In addition, the Japan Institute of Construction Engineering compiled the *Exposition of Government Ordinance for Structural Standard for River Administration Facilities* to apply to road riverbanks and bridges (Japan River Association 2000). The Government Ordinance for Structural Standard for River Administration Facilities was enforced in 1976 and has been amended six times: in 1991, 1992, 1997, 2000, 2011, and the latest in 2013. Table 2.3 lists the guidelines and manuals that have been published on structural measures for road geohazards, which explain the planning, investigation, and design procedures.

Table 2.3 Manuals on Structural Measures for Road Geohazards in Japan

Title	Year of latest edition, publisher
Rockfall Countermeasure Handbook	2000: Japan Road Association
Exposition of Government Ordinance for Structural Standard for River Administration Facilities	2000: Japan River Association
Road Earthquake Disaster Countermeasure Manual (Proactive Measures)	2006: Japan Road Association
21 Year Edition Road Earthwork Guidelines	2009: Japan Road Association
Road Earthwork: Guidelines on Slope Cut and Slope Stabilization Works	2009: Japan Road Association

"Road Earthwork: General Guidelines" was introduced in 1954 as Japan's first guidelines relating to road geohazard structural measures techniques (Japan Road Association 1954). The latest edition, published in 2009, reflects the revision of the guidelines (Japan Road Association 2009b). Related manuals on road earthwork that describe in detail the contents of the guidelines were also prepared (some of which are shown in Table 2.3). The guidelines and manuals cover geohazard risk management techniques for roadside slopes.

Road operation and maintenance for road geohazard risk management (nonstructural measures). Each road management authority (West, Central, and West Nippon Expressway companies; MLIT Regional Development Bureaus; and prefectures, major cities, and municipalities) has its own manuals on road operation and maintenance for road geohazard risk management (nonstructural measures). They usually include a typical reference book of

- Visual inspection procedures for road slopes, retaining walls, and road drainage;
- Actions under normal and abnormal weather conditions;
- Postdisaster response (emergency inspection, emergency traffic regulation, and public notice); and
- Emergency recovery from road geohazard damage (for example, debris removal from the road surface).

Business continuity planning for road geohazards. In 2005, the Japanese government, through a special committee of the Central Disaster Management Council, drew up a set of "Business Continuity Guidelines: Strategies and Responses for Surviving Critical Incidents," which have since been revised twice (Cabinet Office 2013). Business continuity planning involves management strategies to continue business functions even after a significant disaster event. The national government's own business continuity plan includes securing road functions. According to the Cabinet Office, only 13 percent of subnational governments (prefectures, major cities, and municipalities) have formulated their own business continuity plans as of August 2015.

2.1.2 National and Subnational Government Plans and Strategies

The National Disaster Management Plan was updated in 2015, including the country's general and long-term DRM plan. The MLIT also prepared the Disaster Management Operations Plan, within which the road disaster management plan includes inspection and countermeasure planning, a monitoring and information sharing system, and rapid implementation of recovery measures. In addition, the MLIT formulated the "4th Infrastructure Improvement Priority Plan (2015–2020)" in 2015 (MLIT 2015b). The road sector plan describes the target rate of 50 percent for the implementation of structural measures for priority hazard-prone road slopes by 2020, after having already achieved 49 percent as of 2014. The road geohazard risk management programs and projects are formulated by each road management authority based on periodic or on-demand inspections as well as the Road Bureau's road geohazard management program. The project is mainly classified as a countermeasure construction project, a monitoring project (including early warning system), or both.

Basic DRM Plan

Based on the Disaster Countermeasures Basic Act (1961, the latest amendment as of 2016), the Central Disaster Management Council of the Cabinet Office updated the Basic Disaster Management Plan in 2015, including a general and long-term national DRM plan (Figure 2.1).

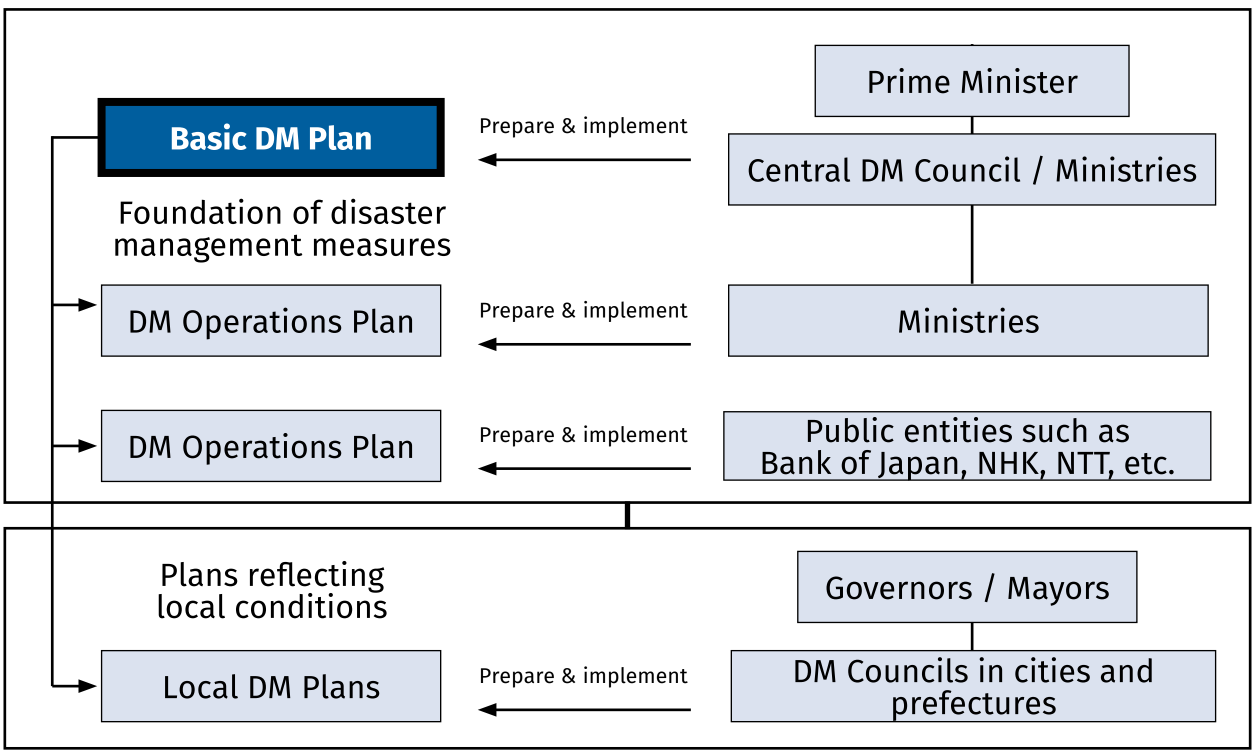
The MLIT also prepared and implemented the Disaster Management Operations Plan in 2012 as well as the seventh (and latest) amendment as of March 2015, which covers disaster risk reduction, emergency, and recovery and restoration from both natural disasters (earthquakes, tsunamis, water hazards, volcanoes, and snow hazards) and man-made disasters (maritime, aviation, railroad, road, nuclear, hazardous materials, large-scale fires, and forest fires). The plan also describes the following activities in the road disaster management field:

- Road inspection and countermeasure planning for disaster risk reduction
- Formulation of monitoring and information sharing system for emergencies
- Dispatch of staff and experts to regional offices and rapid implementation of measures for recovery from disasters.

Figure 2.1 Structure of Disaster Planning System in Japan

COMPREHENSIVE COUNTERMEASURES BASIC ACT OF 1961

Article 34: Prepare Basic Disaster Management Plan (by Central DM Council)
Article 36: Prepare Disaster Management Operations Plans (by Ministries)
Article 39: Prepare Disaster Management Operations Plans (by public entities)
Article 40: Prepare Local Disaster Management Plans (by prefectures)
Article 42: Prepare Local Disaster Management Plans (by municipalities)



Source: "Disaster Management Plan," website of Cabinet Office, Government of Japan (accessed August 16, 2016), http://www.bousai.go.jp/taisaku/keikaku/english/disaster_management_plan.html.

Note: DM = disaster management. NHK = Nippon Hoso Kyokai (Japan Broadcasting Corp.). NTT = Nippon Telegram and Telephone Corp. (Japan Telegram and Telephone Corp.).

The 4th Infrastructure Improvement Priority Plan (2015–2020)

The MLIT formulated the "4th Infrastructure Improvement Priority Plan (2015–2020)" in 2015 to improve the efficiency and effectiveness of social capital in Japan. The plan addresses four challenges (MLIT 2015b):

(a) Strategic operation and maintenance of social capital

(b) Disaster risk reduction based on vulnerability and characteristics of geohazards

(c) Formulation of sustainable regional society against decline and aging of population

(d) Strengthening of the national economy by increasing private investments.

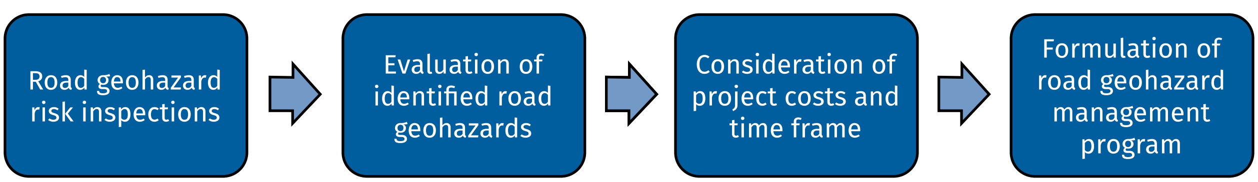
For challenge (b)—that is, disaster risk reduction corresponding to vulnerability and characteristics of geohazards (floods and slope disasters)—the criteria have been formulated to apply proactive measures for geohazards such as river improvements, flood control facilities, stormwater drainage, and debris-flow check dams. The software component highlights public awareness through dissemination of the study results in hazard-prone areas, the development of warning and evacuation systems, and the preservation of disaster prevention facilities.

For the road sector, the plan describes the implementation of geohazard measures to preserve the important transportation networks, to support socioeconomic and emergency lifesaving activities during large-scale disasters, and to promote measures on major hazardous locations such as road slopes and embankments. The target rate for the implementation of proactive measures on important road slopes and embankments is 54 percent by 2020 (having achieved 49 percent as of 2014).

Road Geohazard Risk Management Programs and Projects

The road geohazard risk management programs are formulated by each administrative body, such as the MLIT, subnational governments and authorities, expressway management corporations, and toll road management public corporations. The programs are formulated based on the results of periodic subnational and nationwide inspections of hazard-prone road locations (10 inspections since 1968), as shown in Figure 2.2.

Figure 2.2 Preparation of Road Geohazard Risk Management Programs in Japan



The MLIT's Road Bureau can request thematic subnational and nationwide inspections (such as tunnel portal slope inspections in 1996 and the inspections of large roadside rock-mass slopes in 1997) from the abovementioned road management authorities.

The purpose of the nationwide inspections is to identify the hazardous road locations where proactive measures can be applied, including preparation of the concepts and rough cost estimates of the required measures needed. The Road Bureau consolidates the inspection results and formulates the nationwide road geohazard risk management program using the list of hazard-prone road locations selected for proactive measures and the corresponding draft budget allocations.

Road geohazard risk management projects. Each road management authority formulates its road geohazard risk management projects based on the Road Bureau's road geohazard risk management program. The projects are prioritized for roads where geohazard events had occurred or are predicted to occur, and are identified mainly through the road geohazard risk inspections.

The project is mainly classified as a countermeasure construction project, a monitoring project (including early warning system), or both. Some of the project costs are subsidized by the MLIT, the rate being determined by the type of road (Table 2.4).

Table 2.4 Conditions for Subsidies for Road Geohazard Risk Management Projects

Road type	Manager	Cost burden ratio between national and subnational government	
		Maintenance	Repair
National expressway	Expressway company	Loan or toll revenue	Loan or toll revenue
National highway	MLIT	National: 100 percent	National: 100 percent
	Prefecture or major city	Prefecture or major city: 100 percent	National: 50 percent Prefecture or city: 50 percent
Prefectural road	Prefecture or major city	Prefecture or major city: 100 percent	National: 50 percent Prefecture or city: 50 percent
Municipal road	Municipality	Municipality: 100 percent	National: 50 percent Municipality: 50 percent

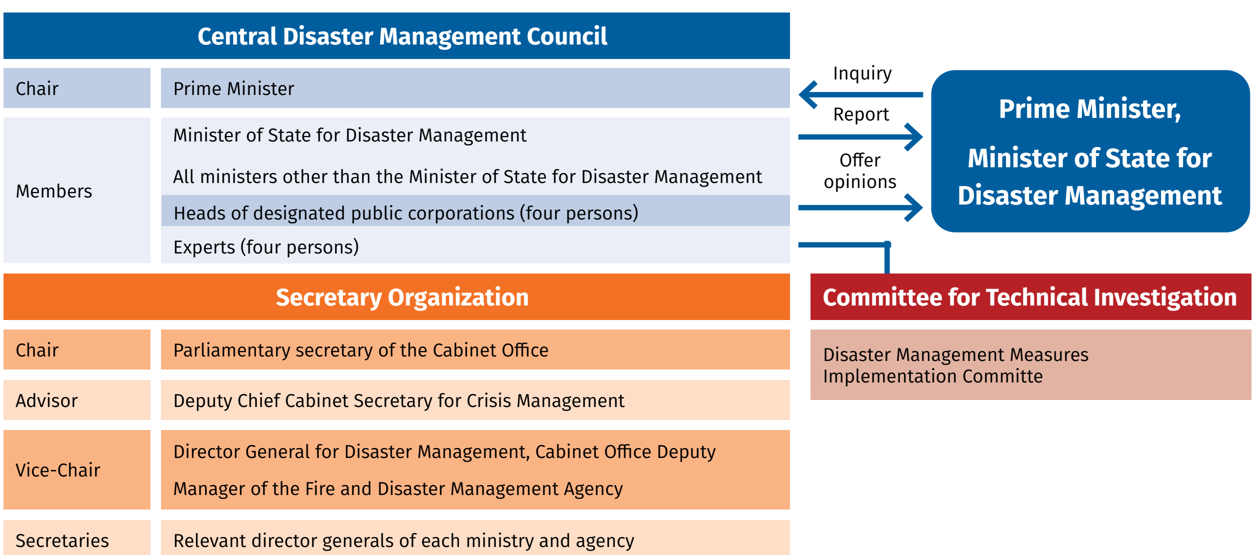
Source: MLIT website (accessed August 16, 2016), http://www.mlit.go.jp/en/index.html.
Note: MLIT = Ministry of Land, Infrastructure, Transport and Tourism.

2.1.3 Mechanisms for Implementation

Cabinet Office

As mentioned earlier, the Cabinet Office is the nerve center of the Japanese government for DRM, including road geohazards. It organizes the Central Disaster Management Council, which is the lead agency responsible for formulating national DRM policies (Figure 2.3). All ministers are members of the Central Disaster Management Council.

Figure 2.3 Organization of Central Disaster Management Council



Source: Cabinet Office website, (accessed September 20, 2016), http://www.cao.go.jp/en/pmf/pmf_5.pdf.

In case of “major” or “extreme” disasters—depending on the disaster’s magnitudes of impact—the Cabinet Office establishes either a Major Disaster Management Headquarters (headed by the minister of state for disaster management) or an Extreme Disaster Management Headquarters (headed by the prime minister) upon consultation with relevant cabinet members, according to the Disaster Countermeasure Basic Act (1961, latest amendment as of 2016) (Table 2.5).

Table 2.5 Cabinet Office Roles in Major Disaster or Extreme Disaster Management Headquarters

Disaster management type	Information collection and emergency operation coordination	Major Disaster Management Headquarters	Extreme Disaster Management Headquarters
Consultation by related cabinet members	n.a.	Applicable	Applicable
Declaration of disaster emergency and headquarters set up by Extraordinary Cabinet Meeting decision	n.a.	n.a.	Applicable
Chief of headquarters	n.a.	Minister of State for Disaster Management	Prime Minister
Location of headquarters	n.a.	Cabinet Office	Prime Minister’s Office
Secretariat	n.a.	Cabinet Office	Prime Minister’s Office and Cabinet Office
Interministerial meeting	Applicable	n.a.	n.a.
Management activities	• Coordination of emergency operations by each ministry • Dispatch of government investigation team • Administration of on-site disaster headquarters and so on		

Source: Based on Cabinet Office 2015a.
Note: n.a. = not applicable.

As of August 2016, during the 55 years since the Disaster Countermeasure Basic Act has been enforced, 24 disaster events (an average of 0.4 per year) have been managed by the Major Disaster or Extreme Disaster Management Headquarters. Major Disaster Management Headquarters were established for 23 major disasters (eight earthquakes, seven storms, six volcano eruptions, one snowstorm, and one crude oil spill). The only case of an Extreme Disaster Management Headquarters was the one established for the Great East Japan Earthquake and Tsunami of 2011.

MLIT and Other Road Management Institutions and Authorities

Ministry of Land, Infrastructure, Transport and Tourism (MLIT). The MLIT is the lead agency for DRM specifically related to land and infrastructure, including proactive and recovery and emergency activities. All MLIT bureaus are concerned with disaster management, particularly the Road Bureau (in charge of road DRM), the City Bureau (in charge of urban DRM), and the Water and Disaster Management Bureau (responsible for geohazard risk management). On January 27, 2014, MLIT also established the Water Disaster Prevention and Mitigation Headquarters for urgent and comprehensive measures to manage severe hydrological hazard events such as typhoons. It is chaired by the MLIT minister (MLIT 2014b).

Whenever a Major Disaster Management Headquarters or an Extreme Disaster Management Headquarters is established in the Cabinet Office or the Prime Minister's Office, respectively, the MLIT establishes its own Major Disaster Management Headquarters or Extreme Disaster Management Headquarters for recovery (Photo 2.1).

Photo 2.1 Meeting at MLIT Extreme Disaster Management Headquarters

Personnel convene for the 32nd meeting at the MLIT Extreme Disaster Management Headquarters for the Great East Japan Earthquake. The Disaster Management Center—in this case, at MLIT's Central Office in Tokyo—equipped real-time monitoring of the disaster site situations.

Source: ©Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

TEC-FORCE. To respond to the occurrence or likelihood of large-scale natural disasters, the MLIT established the Technical Emergency Control Force (TEC-FORCE) in April 2008.

TEC-FORCE members are deployed to smoothly and rapidly implement technical support of subnational governments in affected areas to carry out various emergency disaster measures such as rapidly assessing the extent of the disaster, preventing damages, and assisting affected areas in rapid recovery (MLIT 2014b). Their main activities during emergencies are damage inspection; dissemination of digital images of damaged areas; and emergency recovery work on drainage, earthworks, temporary bridge construction, and so on. As of 2015, TEC-FORCE members comprised 7,296 personnel (mainly staff of the Regional Development Bureaus). Box 2.1 describes the machinery and equipment that TEC-FORCE uses for emergency activities.

Box 2.1 Emergency Machinery and Equipment Used by MLIT TEC-FORCE

When a large-scale disaster occurs, the MLIT's TEC-FORCE calls up machinery and equipment from all over the country to the disaster areas (Table B2.1.1), some of which is shown in Photos B2.1.1, B2.1.2, and B2.1.3.

Photo B2.1.1 Disaster Headquarters Car

Members of a TEC-FORCE team meet at a Disaster Headquarters to report on local activities, procure materials and equipment, and coordinate emergency activities.

Source: ©Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Table B2.1.1 Machinery and Equipment for Geohazard Recovery

Machinery or equipment type	Number *(as of April 1, 2015)*
Pump truck	347
Mobile lighting vehicle	262
Headquarters car or standby support vehicle	113
Remote-controlled backhoe	16
Satellite communication vehicle	49
Small satellite image transmission equipment (Ku-SAT)	166
Helicopter for disaster risk management	8
Sandbag manufacturing equipment	22
Emergency assembly bridge	30
Sprinkler truck	Undisclosed
Bridge inspection vehicle	Undisclosed
Side ditch cleaning vehicle	Undisclosed
Road sweeper	Undisclosed

Photo B2.1.2 Satellite Communication Vehicle

Even if communication lines are disrupted because of a disaster, disaster communication vehicles ensure the continuation of telephone communication, video distribution, and other transmissions in the field using communications satellites. This vehicle was stationed in in Hakuba-mura, Nagano Prefecture, after the North Nagano Prefecture Earthquake in November 2014.

Source: ©Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Photo B2.1.3 Small Satellite Image Transmission Equipment (Ku-SAT)

Ku-SAT enables outdoor phone or fax communication as well as video transmission (over a 64 kbps line), as used in Otaki-mura, Nagano Prefecture, after the Ontake-san volcano eruption in September 2014.

Source: ©Water and Disaster Management Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Road Bureau. The national authority for road geohazard risk management is the MLIT's Road Bureau, which is the government's lead agency for institutional coordination between the national and subnational governments. It is in charge of all road management organizations covering the national expressways, national highways, prefectural roads, and municipal roads (table 2.6). It is also in charge of road geohazard risk management policies and provision of technical and financial support.

As such, the Road Bureau issues orders to the road management authorities, national expressway companies, MLIT Regional Development Bureaus, subnational governments, and other entities—including orders to conduct road geohazard risk inspections to comprehend the requirements for proactive structural measures. After the results of the inspection are collected, the Road Bureau prepares the implementation plan and time frame for the geohazard risk reduction program as well as the budgetary allocations for the national and subnational road management authorities.

Water and Disaster Management Bureau. In addition, the MLIT's Water and Disaster Management Bureau is responsible for river and landscape ecosystem management and thus supports road geohazard risk management (Table 2.6). Because road geohazard risk management includes flow-type geohazard risk management (earth or debris flow, flooding, and road or bridge foundation erosion), coordination is required on river and landscape ecosystem management.

Table 2.6 Organizational Structure for Road Geohazard Risk Management Institutions

Cabinet office	Road management authority: Road manager	Road management authority: Road management office	Road length (L), by type (total: 1,214,917 kilometers)[a]
Ministry of Land, Infrastructure, Transport and Tourism (MLIT) *Road Bureau:* supervises national and subnational road management authorities *Water and Disaster Management Bureau:* supports road geohazard risk management *Japan Meteorological Agency:* disseminates meteorological information and issues warnings or advisories for geohazard events and risky conditions	Minister of Land, Infrastructure, Transport and Tourism	Six expressway companies: East Nippon, Central Nippon, West Nippon, Metropolitan, Hanshin, and Honshu-Shikoku Bridge	National expressways L = 8,358 kilometers (0.7 percent)
		10 MLIT Regional Development Bureaus	National highways (MLIT jurisdiction) L = 23,517 kilometers (1.9 percent)
	Governor of prefecture or mayor of major city	47 prefectures, 20 major cities	National highways (jurisdiction of prefectures and major cities) L = 31,915 kilometers (2.6 percent)
		47 prefectures, 20 major cities	Prefecture roads L = 129,375 kilometers (10.6 percent)
	Mayor of municipality	1,741 municipalities	Municipal roads L =1,023,962 kilometers (84.3 percent)

Sources: Websites of the Cabinet Office (http://www.cao.go.jp/index-e.html) and MLIT (http://www.mlit.go.jp/en/index.html).
a. Road lengths as of April 1, 2013.

Road Types and Lengths as of April 1, 2013

As Table 2.6 indicates, "roads" are classified into four types: national expressways, national highways, prefecture roads, and municipal roads. The road management authorities comprise (a) 6 expressway companies; (b) 10 MLIT Regional Development Bureaus; (c) 47 prefectures and 20 major cities; and (d) 1,741 municipalities. The national and subnational organizations also have branch offices, which include the road management sections.

As of 2013, the various road management authorities managed a total of about 1.217 million kilometers of roads, as follows:

- ***Six expressway companies*** manage about 8,000 kilometers of national expressway; they also have branch offices including the road management sections. The expressway companies are East Nippon, Central Nippon, West Nippon, Metropolitan, Hanshin, and Honsyu-Shikoku Bridge. The MLIT's Road Bureau formulates the management policies on national expressways and controls the expressway companies.
- ***Ten MLIT Regional Development Bureaus*** have the Road Bureau's satellite function in the regions and manage about 24,000 kilometers of the national highway. They have 89 subnational offices and 272 branch offices (Figure 2.4). The branch offices manage road maintenance and activities for geohazard events including highly hazard-susceptible situations such as storms.
- ***Prefectures and major cities*** (47 prefectures and 20 major cities and their subnational offices) have jurisdiction over about 32,000 kilometers of national highway and 130,000 kilometers of prefectural or major city roads. In some cases, the subnational offices have branch offices in remote areas or geohazard-prone areas. These subnational offices manage road maintenance and have task teams responsible for activities in response to abnormal conditions and geohazard events (including preparedness). The governors of the prefectures and mayors of the major cities are representatively responsible for road administration including road geohazard risk management.
- ***Municipalities*** (totaling 1,742) manage about 1.02 million kilometers of prefectural roads, averaging about 590 kilometers per municipality. The road management sections of the municipal government offices manage road maintenance and activities for geohazard events including highly hazard-susceptible situations such as storms. The mayors of municipalities are representatively responsible for road administration including road geohazard risk management.

Figure 2.4 Responsibilities of Road Geohazard Risk Management Authorities for National Highways under MLIT Jurisdiction

MLIT Road Bureau
- National road management planning, including for roads under subnational government management
- Budget planning and allocation
- Administration of postdisaster activities and recovery for roads after widespread geohazard events

Regional Development Bureaus (10)
- Include regional branches of the Road Bureau that exercise the Road Bureau's function in the regions

Subnational Offices (89)
- Average road jurisdiction extends to around 260 kilometers
- Road management and budget planning
- Road information management
- Risk evaluation and management planning for road geohazards
- Design, cost estimation, and construction management for structural measures for road geohazards
- Operation of nonstructural measures for road geohazards
- Establishment of headquarters for disaster control administration during abnormal conditions and road geohazard events (including preparedness)

Branch Offices (272)
- Average road jurisdiction extends to tens of kilometers
- Management and deployment of patrol and maintenance staff
- Establishment of the task teams with jurisdiction over road geohazard risk management for abnormal conditions and geohazard events (including preparedness)

Sources: MLIT 2015a and MLIT website (http://www.mlit.go.jp/en/index.html). Note: The numbers of bureaus and offices are as of 2012.

Meteorological and Hydrological Organizations

Japan Meteorological Agency (JMA). The JMA disseminates meteorological information and warnings or advisories on geohazard events, including dangerous conditions. It also issues notifications to the public on abnormal weather or likely geohazards, including real-time landslide risk maps.

National and subnational road management authorities take precautions based on the JMA warnings. The agency analyzed the relationship between historical geohazard events and rainfall and developed a rainfall index: the soil water index. The index shows numerically simulated shallow groundwater contents for rainfall-induced landslides. The 5-kilometer grid data—indicating precipitation data for two hours of forecasting and the five risk-level warnings for slope- or stream-type geohazards—are provided in detail. These data are useful for specifying the local risk levels and appropriate evacuation decisions.

JMA researchers also advise the road management authorities on the warning criteria for the rainfall index regarding precautionary road closure measures. When the risk of geohazard events increases because of heavy rainfall, a geohazard alert is jointly issued by the prefectures and the JMA in each municipality. Road management authorities can refer to the geohazard alerts to make decisions on preparedness for emergency activities, including evacuation orders announced by municipalities or calls for the voluntary evacuation of residents. Road users can also use this alert information to make appropriate driving decisions.

Japan Weather Association (JWA). Established in 1950 as Japan's first private weather forecasting company, the JWA provides rainfall forecasts for the operation of specific precautionary road closure sections. The JWA has brought timely weather information to all areas of Japan and provides rainfall forecasts to enable road management authorities to calculate rainfall volumes for the management of designated precautionary road closure sections. Because precautionary road closure is a trade-off between saving human lives and preventing losses from traffic suspension, proper precautionary operation (road closure based on accurately forecast danger circumstances) is essential. Therefore, the JWA's provision of forecast rainfall data is significant.

Technical Road Institutions

The government technical institutions supporting road management in engineering and/or administrative fields—all under the MLIT—are the key organizations developing manuals, research, and development of efficient new technologies for road geohazard risk management:

- ***The National Institute for Land and Infrastructure Management (NILIM)*** conducts technology and policy research in a variety of areas, including road geohazard risk management.
- ***The Public Works Research Institute (PWRI)*** provides research and development services related to civil engineering, including geohazard-resilient road infrastructures.

Expressway companies, universities, and private construction companies or construction consultants also have their own technical institutions.

In addition, MLIT started an online (Internet and intranet) New Technology Information System (NETIS) in 1998 to promote new technology development by private and public institutions to solve public-works issues, including road geohazard risk management (particularly issues that are costly, dangerous, time-consuming, or have a negative impact on the environment).

Road Users and Other Stakeholders

The direct participation of road users is important in informing the road management authorities about any abnormality detected on a road location, such as rockfall, collapse, cracks, road deformation, or inundations. The information they provide is beneficial and valuable in preventing road damages because it enables the road management authorities to take road maintenance emergency measures before road damage develops. Even when road damage has already developed, early abnormality information can also shorten road traffic recovery times because of the early action of road maintenance staff.

Road users, residents, and the private sector can participate in road geohazard risk management by dialing the free emergency information number (#9910) to reach the corresponding road management authorities—the same number used throughout Japan (Photo 2.2). Signboards including this information are placed particularly in roadside parking pits in geohazard-prone road subsections (Photo 2.3).

Photo 2.2 Signboard at Roadside Parking Pit Shows How to Report Emergency Road Conditions to Road Management Authorities

The signboard on a roadside parking space in Odate City enables the public to call and report emergency road abnormalities (report number #9910) to the road management authority, or to make requests, complaints, or suggestions to the road management authorities using the road consultation number (0185-58-5446).

Source: ©World Bank. Permission required for reuse.

Photo 2.3 Roadside Parking Pit in a Geohazard-Prone Road Subsection

Roadside parking pits in geohazard-prone road subsections (such as this one in Odate City) provide emergency safety parking as well as signboards that display phone numbers enabling road users to report road abnormalities to the road management authorities.

Source: ©World Bank. Permission required for reuse.

In addition, the volunteer support program for roads is the main channel for civic participation in road maintenance and cleaning activities—especially road drainage cleaning, which helps reduce road geohazard risk. Road drainage cleaning is particularly effective in reducing the risk of road inundations and road embankment collapse due to the overflow of water from roadside drainage. Volunteers also assist with road beautification and cleaning (weeding, planting, growing flowers, and snow removal) as well as the provision of information.

After civic groups apply for the volunteer support program, the road management authorities evaluate the applications, prepare the contracts, and provide required tools and garbage bags to support the volunteer activities. As of March 2013, a total of 2,393 people were involved in the volunteer support program, of whom 105 (4 percent of the total) undertake snow clearance.

Funding Mechanisms

The funding processes for new road and existing road projects are detailed below for four types of cost: road geohazard risk evaluation; road geohazard risk management planning; proactive measures; and postdisaster activities and recovery.

Funding for road geohazard risk evaluation. The funding sources for road geohazard risk evaluation differ for new roads and existing roads. For new road projects, geohazard risk evaluation is often included in the engineering survey budget of the MLIT or the subnational governments at the preconceptual, conceptual, or design stage. For existing roads, the budget is generally included in the operation and maintenance cost of existing roads by each road management authority. In special cases, nationwide road geohazard risk inspections of existing roads (identification and risk evaluation surveys of hazard-prone road locations) are ordered by the MLIT's Road Bureau. The MLIT allocates the additional national subsidy to all road management authorities.

Funding for road geohazard risk management planning. The annual MLIT or subnational government budget allocations include funding for road geohazard risk management planning for new road and road rehabilitation projects. For existing roads, funding is included in the road management authorities' annual expenses for road operation and maintenance.

Funding for proactive measures. Based on the results of the nationwide road geohazard risk inspections—including the results from the subnational governments (subnational road management authorities) and expressway companies—the MLIT's Road Bureau formulates a nationwide, medium-term budget plan for proactive measures for national and rural roads. The budget is allocated by the national government to the national road management authorities and the subnational governments (subnational road management authorities).

Funding for postdisaster activities and recovery. For road disaster events (damages due to geohazards), the costs of postdisaster activities (emergency inspection, emergency traffic regulation, and public notification) are included in the ordinary road operations and maintenance costs. The recovery (recovery or recovery with improvement) for geohazard-damaged public facilities (including roads) are undertaken under the direct control of the national or the subnational governments by using each road management authority's budget and the national contingency fund. The subsidy from the contingency fund is provided by the Ministry of Finance's Treasury Division. The amount of the subsidy from the contingency fund is determined by taking into account both the estimated annual cost of the recovery and the subnational government's annual revenue.

The process is as follows (Table 2.7): The contingency fund requirements are prepared by the road management authorities, evaluated by the MLIT's Road Bureau using the estimated cost for postdisaster activities and recovery, and allocated to the road management office. Finally, after the activities or measures are completed, the MLIT recalculates the actual costs of the activities or measures through site inspections, and the road management authorities return the remaining amount to MLIT as necessary.

Table 2.7 Process of Contingency Fund Allocation for Disasters in Japan

Stage	MLIT	Management authorities
Contingency fund preparation	• Review the cost required for recovery • Allocate the contingency funds needed	Estimate costs of recovery
Implementation	None	Implement recovery
Completion	• Recalculate actual amount of recovery costs through inspection • Request refund of remaining contingency-fund allocation from the management authorities as necessary	Inform MLIT of completion of recovery Refund remaining amount received from the contingency fund to MLIT

Source: Based on MLIT data.
Note: MLIT = Ministry of Land, Infrastructure, Transport and Tourism.

2.2 Institutional Capacity Review

This capacity review for Japan was conducted based on Handbook appendix A, "Terms of Reference 1 (ToR1): Institutional Capacity Review and Target Setting." A sample of the assessment tables is contained in annex C1 (at the end of this case study) to illustrate the form of responses. Of note is that even for a country such as Japan—where there is a long history of geohazard management—for many of the factors under assessment, Japan is only at the starting point of developing appropriate capability and capacity.

The results of the review were shared with concerned people in the public sector, private sector, and academia, including the MLIT, the Japan International Cooperation Agency (JICA), the Japan Landslide Society, the International Sabo Network, and the Sabo & Landslide Technical Center. The review was also discussed with, and comments collected from, participants in the 12th Disaster Risk Management Seminar—"Road to Resilience: Managing Geohazards for Less Risky Roads in Developing Countries"—organized by the World Bank's Tokyo Office and Tokyo Disaster Risk Management Hub (Tokyo DRM Hub) and held in Tokyo on July 21, 2016.

3 SYSTEMS PLANNING

3.1 Risk Evaluation

The national road management authority of the Ministry of Land, Infrastructure, Travel and Tourism (MLIT) in addition to subnational road management authorities are responsible for evaluating related risks related to their respective road systems. The road bureaus are the lead agencies for (a) developing technical manuals or guidelines for risk evaluation, and (b) setting rules and time frames for conducting on-demand or periodic risk evaluation inspections on existing roads. The risk evaluation inspections are normally conducted by the staff, experts, or engineers contracted by the national or subnational road management authorities.

3.1.1 Geohazard Risk Evaluation for New Roads

Detailed hazard mapping is a common practice in Japan for new road planning. Detailed hazard maps are used for selecting a safer route or to avoid causing man-made geohazards to the surrounding areas such as cutting or banking.

Detailed hazard mapping is conducted by experts in geology and hydrology of engineering consulting firms contracted by the road management authorities. Mapping of geohazards should indicate falling, collapsing, or sliding slope areas and historically damaged areas of flow-type geohazards (earth or debris flow, flooding, river erosion). The consultants prepare the detailed hazard maps by interpretation of maps, aerial photographs, or satellite images together with field reconnaissance and interviews regarding historical geohazard events.

In Japan, slide-type geohazard distribution maps that cover all of Japan (which are good examples of detailed hazard maps) are prepared by the National Research Institute for Earth Science and Disaster Prevention (NIED) as reference material for infrastructure or regional development projects.

Engineering consultants contracted by road management authorities usually conduct the outline investigations for new road planning. They prepare detailed hazard maps through simple evaluation of the potential hazard levels such as slope instability. Each geohazard is assigned to one of either two (high and low) or three (high, medium, and low) potential hazard levels. The hazard levels are determined by using available geographical information such as maps, aerial photographs, and satellite images.

It is a general practice that the engineering consultants contracted by the road management authorities prepare the alternative road alignments including the risk evaluation results. The risk evaluation results include detailed hazard maps showing the new road alignment, an inventory table of hazard-prone locations with simple hazard level evaluation, and a risk summary of alternative road alignments (number of hazard-prone locations, their potential hazard levels, and geohazard characteristics).

The alternative new road alignment is planned to avoid hazard-prone locations as much as possible. This geohazard avoidance saves construction costs, including the costs of structural measures for geohazard and subsequent maintenance costs.

It is a general practice that the engineering evaluation includes a social and environmental assessment process. To this end, the National Institute for Land and Infrastructure Management (NILIM) developed a technical procedure for the evaluation of ground deformation and geohazards (NILIM 2013).

3.1.2 Geohazard Risk Evaluation for Existing Roads

Identification of Hazardous Locations

In Japan, hazardous locations are identified according to the following three method levels: basic, intermediate, and advanced.

Basic method: Identification of hazard-prone road locations by road maintenance staff using maintenance experience, on-site visual inspections, and information from road users. The basic methods are conducted during routine maintenance activities by the road maintenance staff. In 1962, the Road Bureau disseminated an "Order for Road Maintenance and Management" to national and subnational road management authorities. This order instructed the road management authorities to conduct routine patrols of roads with annual average traffic volume exceeding 300 vehicles per day. It further stipulated that the patrols be conducted during typhoons or heavy rains. The purposes of the patrols were to preserve the roads, ensure smooth traffic, and properly maintain the roads—enabling the authorities to immediately address defective road locations with the appropriate measures as soon as possible. As still practiced according to the 1962 order, the patrols were undertaken once a day throughout the week.

Information provided by road users is also used: users can call the road management authority by dialing #9910.

Intermediate method: Identification survey of hazard-prone road locations by engineering geology experts. The Road Bureau of the MLIT ordered all road management authorities to conduct a total of 10 nationwide road geohazard risk inspections from 1968 to 2006. These inspections were to identify hazard-prone road locations through visual inspection by engineering geology and civil engineering experts in private engineering firms contracted by road management authorities. The identification categories of hazard-prone road locations were stipulated by the Road Bureau for each order given for the nationwide road geohazard risk inspection.

The 1st nationwide road geohazard risk inspection was ordered in September 1969, triggered by the August 18 Hida River bus-fall accident—a road geohazard incident that killed 104 people when two buses fell into a flooded river because extreme storms had caused a slope collapse.

The 2nd nationwide road geohazard risk inspection was ordered in October 1970 after the Supreme Court judgment on August 20 that the road management authority was liable for a 1963 road mountainside collapse incident on National Highway No. 56 in Shikoku Region. The court pointed out the liability of the road management authority to identify and eliminate the geohazard dangers along roads and to order precautionary road closure because of the high possibility of geohazard occurrence.

The 3rd nationwide road geohazard risk inspection was ordered in 1971 after a rock mass fall on National Highway No. 150 in Shizuoka Prefecture in Central Japan.

The 4th–8th nationwide road geohazard inspections were ordered in 1973, 1976, 1980, 1986, and 1990. The identification procedures for hazard-prone road locations were improved every time. The first "Draft Road Geohazard Risk Inspection Guidebook" was prepared by the Road Bureau for the 8th nationwide geohazard inspection in 1990 (Ministry of Construction 1990).

The 9th nationwide road geohazard risk inspection, conducted over two years in 1996–97, was called a "comprehensive nationwide road geohazard risk inspection," for which a full-fledged "Road Geohazard Risk Inspection Guidebook" was prepared by a technical committee of public, academic, and private experts appointed by the Road Bureau (ROMAN-TEC 1996). The 1996 inspection guidebook refined the criteria for identifying hazard-prone road locations in consideration of the many unidentified road locations that had been seriously damaged in past geohazards despite the prior eight geohazard risk inspections. It specified nine types of geohazards: rockfall or collapse, rock mass collapse, slide, snow avalanche, debris flow, embankment collapse, retaining wall collapse, scouring of bridge foundation, and drifting snow.

For example, a location would be identified for a "rockfall or collapse" type of geohazard if any one of these conditions corresponds to the road mountainside slope:

- Slope height is more than 15 meters or with a natural slope of 45 degrees.
- There are loose rocks susceptible to falling from rock cliffs or boulders on the slope.
- There is collapsible soil or rock property, and cracks or a geological discontinuity plane (bedding, joint, shearing or fractured plane, fault, or other) structure is collapsible.
- Existing structural measures are damaged or old.

Engineers in both public and private sectors received training on the use of the guidebook. The 9th nationwide road geohazard risk inspection identified 356,000 hazard-prone road locations.

The 10th nationwide road geohazard risk Inspection was ordered in 2006 (10 years after the 9th inspection) because the 9th road geohazard risk inspection had not identified all of the hazard-prone locations and had not accurately evaluated the hazard level (likelihood of road disaster occurrence). The 10th inspection focused on the identification of hazard-prone road locations missed during the 9th inspection as well as the missed geohazard sources (such as rockfall, slope collapse, and debris flow) and locations (mostly outside the right-of-way under the jurisdiction of road management authorities). The latest edition of the "Road Geohazard Risk Inspection Guidebook" (for heavy rain and snow) was prepared by a committee of public, academic, and private expert members delegated by the Road Bureau (JGCA 2010).

In the case of very serious road geohazard incidents, the Road Bureau ordered that the inspections identify similar types of hazard-prone locations nationwide and evaluate the necessity of countermeasures. Thus, two specific thematic geohazard risk inspections were ordered:

- A tunnel entrance slope inspection was conducted in 1996 after the rock mass collapse at the entrance of the Toyohama Tunnel, Hokkaido, in the northern region, which killed 20 people.
- A large rock slope inspection (inspection of roadside rock slope of more than 30 meters in height) was conducted in 1997 after the rock mass collapse at the portal of the Second Shiraito Tunnel, Hokkaido, in the northern region.

Advanced method: detailed hazard mapping of geohazard-prone road subsections and landscape ecosystem areas. Detailed hazard mapping was mostly prepared for geohazard-prone road subsections on national highways using private engineering consulting firms.

The road geohazard risk inspection guidebooks (ROMAN-TEC 2006, 2009; JGCA 2010) stipulated a geohazard identification procedure consisting of desk-checking and field visual inspection. Desk-checking is the review of geohazard information on historical disaster events and designated geohazard areas and interpretation of maps and aerial photographs. Geographical interpretation identifies microtopography and evaluates assumed geohazard movement types, magnitudes, and effects on roads.

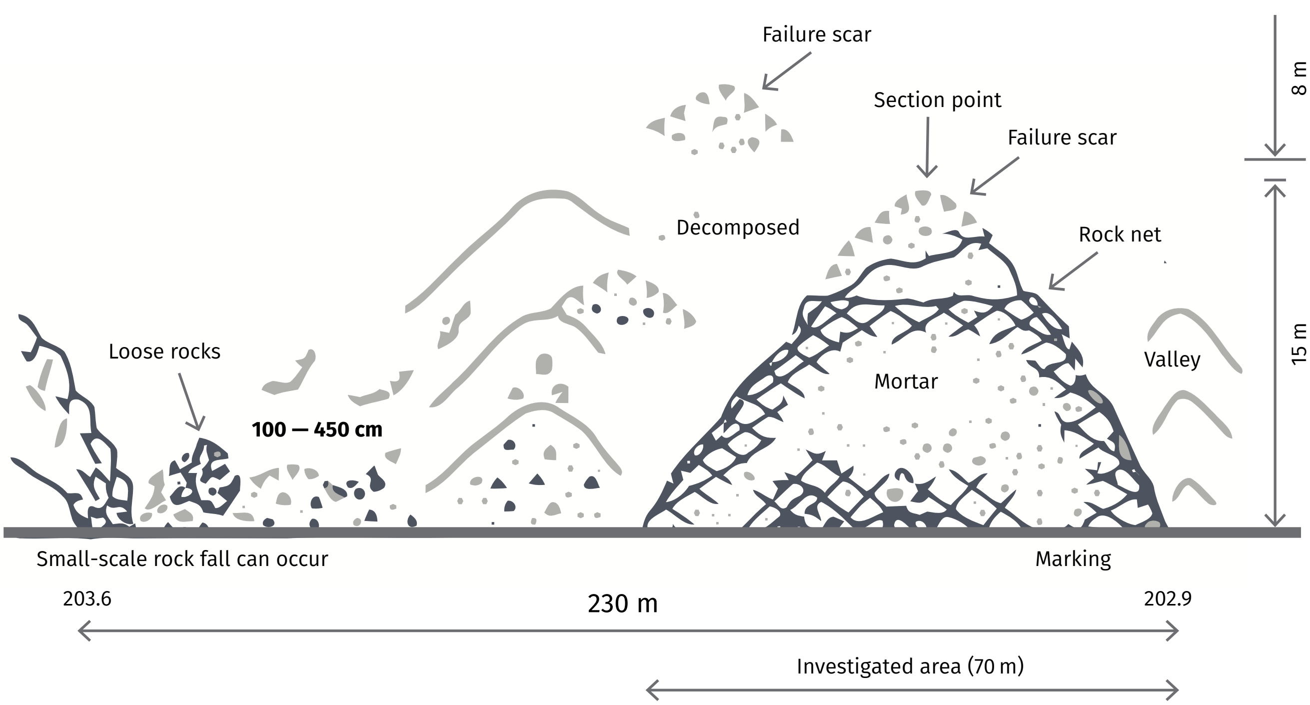
The inspection area of the road geohazard risk inspection in 1996–97 was mostly in the right-of-way or the management area of the road management authority. The road geohazard risk inspection guidebook (ROMAN-TEC 2006) stipulated that the slope facing the road should be interpreted from the mountain ridge (or hilltop) to the valley bottom and, if a geohazard-contributing factor is identified, it should be confirmed by visual field inspection. Nowadays, accurate maps using laser profiling and geographical information systems (GIS) are used to conduct detailed hazard mapping.

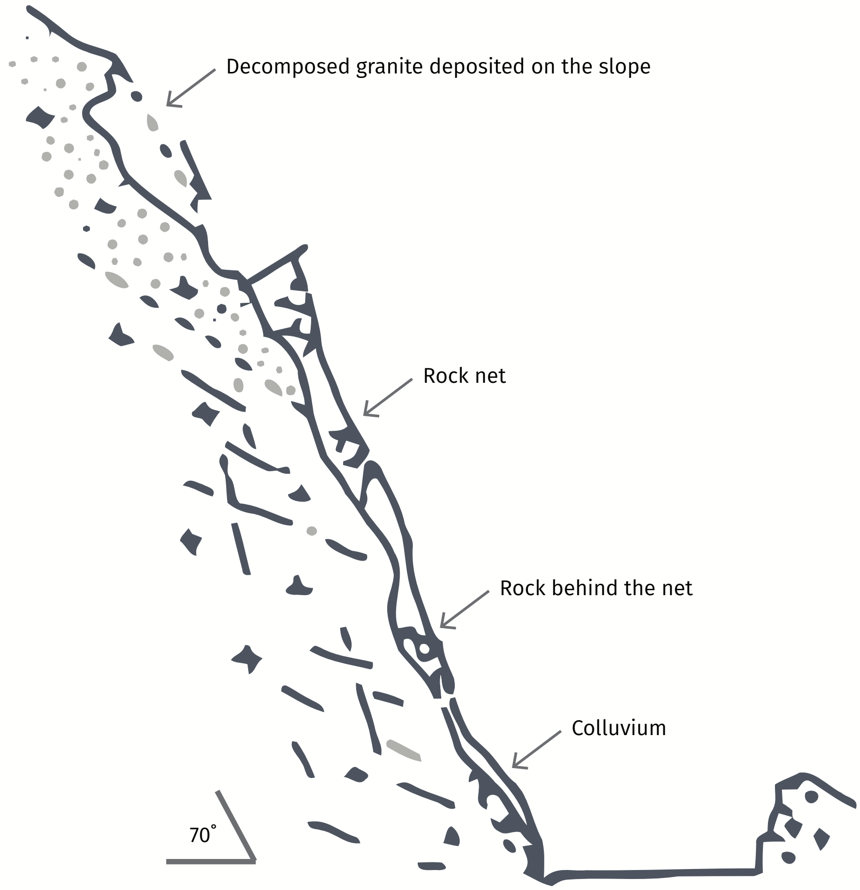
Risk Evaluation of Endangered Road Locations

In Japan, the risk evaluation of hazardous locations is also undertaken according to three method levels: basic, intermediate, and advanced, as described below.

Basic method: simple risk evaluation of a hazard-prone road location using multiple criteria. The Road Bureau recognized that past inspections had been conducted without a clear inspection procedure, and the result of the inspections had not accurately evaluated the hazard-prone road locations. The 1996 "Road Geohazard Risk Inspection Guidebook" contained the vulnerability (or stability) inspection check sheet (ROMAN-TEC 1996). This check sheet evaluates the likelihood of road geohazard damage events using a rating score from 0 to 100 (a score of 0 indicating stability and a higher score indicating more vulnerability). The vulnerability inspection check sheets are prepared for nine types of geohazards: rockfall or collapse, rock mass collapse, slide, snow avalanche, debris flow, embankment collapse, retaining wall collapse, scouring of bridge foundation, and drifting snow. The inspection format includes sketches of the plan and cross-section and photographs (Figure 3.1).

Figure 3.1 Sample Sketches in Road Geohazard Risk Inspection for Rockfall or Collapse





Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

If a location has risks for several types of geohazard, all of the geohazard types will be checked. An example of the rating system for rockfall or collapse is as follows (Figure 3.3):

- ***A: Contributing factors of road geohazard damage occurrence.*** The score is the sum of evaluation points assigned to the selected category for 13 check items. For example, in the check item for “the road slope talus cone,” 3 points are given for “applicable to talus cone,” while a score of 0 (zero) is given to “not applicable to talus cone.” The maximum score for all the check items is 100 points (Figure 3.2).
- ***B: Effectiveness of existing structural measures.*** The evaluation score for “A: Contributing factors of road geohazard damage occurrence” is modified by the score for “B: Effectiveness of existing structural measures” as follows (Figure 3.2):
    - — For prevention of a rockfall or collapse or for sufficient protection in case a rockfall or collapse occurs: multiply zero by the score for “A: Contributing factors of road geohazard damage occurrence.”
    - — For prevention of a rockfall or collapse but for less than 100 percent of sufficient protection: subtract 20 points from the score for “A: Contributing factors of road geohazard damage occurrence.”

— For only partial prevention of a rockfall or collapse, or for only partial protection: subtract 10 points from the score for "A: Contributing factors of road geohazard damage occurrence."

— If a countermeasure is not installed, or if an existing countermeasure is expected to have almost no function: add or subtract 0 points from "A: Contributing factors of road geohazard damage."

- ***C: Historical road damage events due to geohazards and their damage levels.*** The assigned individual points (not added to the combined scores of A and B) are as follows (Figure 3.2):

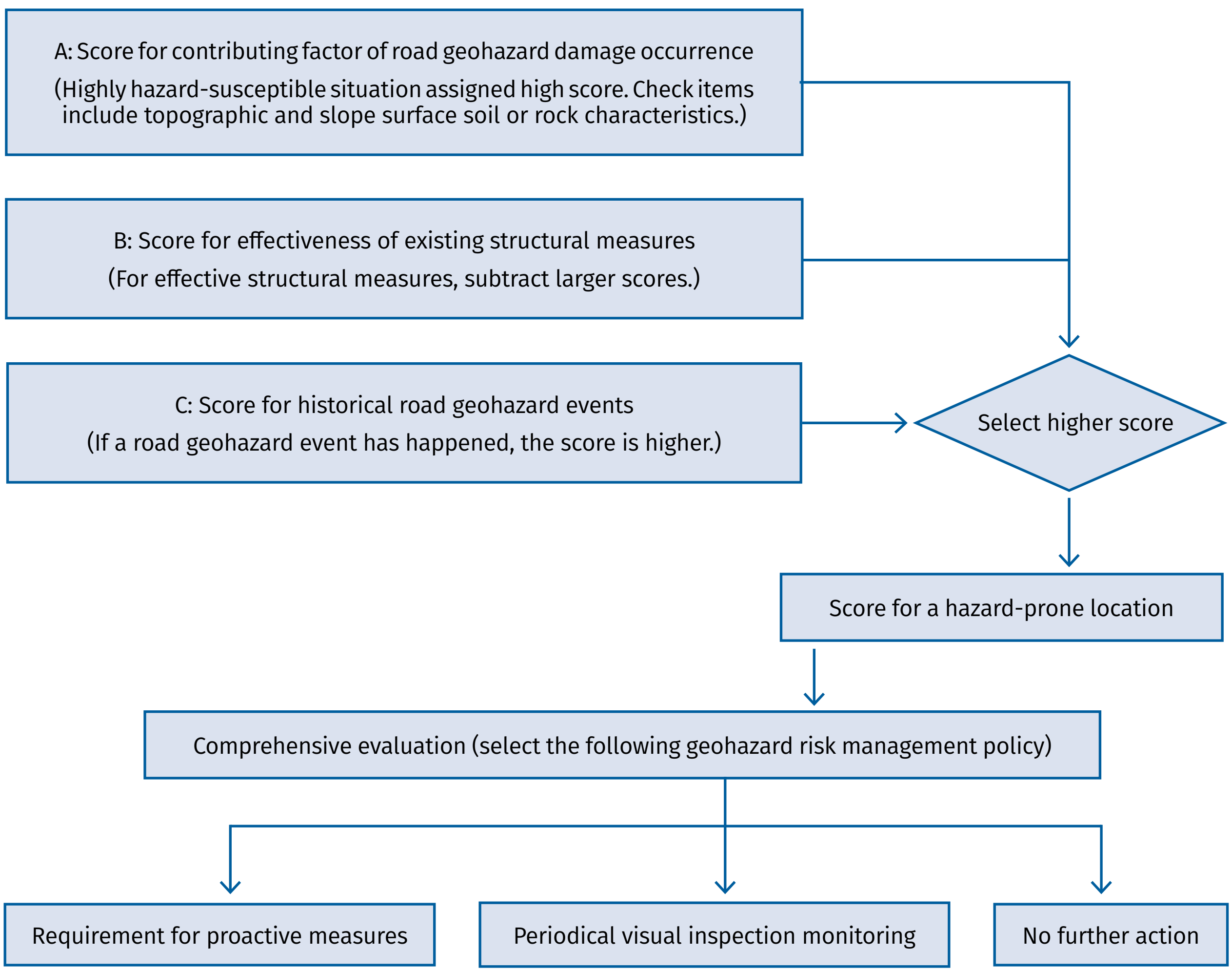
— If there were historical disturbances of traffic, 100 points are given.

— If there was no historical disturbance of traffic, but some rockfall or collapse occurred, 70 points are given.

— If some rockfall or collapse occurred but did not reach the road carriageway, 40 points are given.

The final rating is the higher of either (a) "A: Contributing factors for road geohazard damage occurrence" plus "B: Effectiveness of existing structural measures"; or (b) "C: Historical road damage events due to geohazard and their damaged level."

Figure 3.2 Evaluation Structure Using Vulnerability Evaluation Check Sheet for a Hazard-Prone Road Location



Source: Ando et al. 2015.

Figure 3.3 Score for Contributing Factors of Road Geohazard Damage Occurrence for Rockfall Collapse

A: Score for contributing factors of road geohazard damage occurrence

Factor		Cause	Excavation Slope: Evaluation	Score Allotment	Evaluation Score	Natural Slope: Evaluation	Score Allotment	Evaluation Score
Topography	Topography with collapsing factors	G1: Telus slope	If G1	3		More than one conditon from G2	③	
		G2: Slope of old failure Clear knick line				If G2	2	
			If not G1	⓪		If not G2	0	
		G3: Foot of plateau, Toe erosion, Overhanging, Catchment slope, Debris flow deposits	More than one condition from G2, 3	③		More than one condition from G1, 3	③	
			If G2 or G3	2		If G1 or 3	2	
			If not G2, G3	0	3	If not G1, 3	0	6
		G4: Convex slope	If G4	○	(6)	If G4	○	(6)
Soil, Geology, Structure	Collapsing soil	The soil is week against erosion. The soil lowers its strength in a wet condition.	Conspicuous	8		Conspicuous	②	
			Less conspicuous	④	4	Less conspicuous	1	2
			None	0	(8)	None	0	(2)
	Collapsing rocks	Density of cracks and soft layers is high. The rock is weak against erosion and weathers fast	Conspicuous	⑫		Conspicuous	⑧	
			Less conspicuous	6	12	Less conspicuous	4	8
			None	0	(12)	None	0	(8)
	Collapsing structures	Dip slope structure (Bedding plane)	Conspicuous	⑧		Conspicuous	②	
			None	0		None	0	
		Soil covering impervious bedrock The rocks are hard at the upper part and weak at the foot part	Conspicuous	6		Conspicuous	4	
			Less conspicuous	④	12	Less conspicuous	③	5
			None	0	(14)	None	0	(6)
Conditions of surface		Conditions of soil, loose rocks and boulders	Unstable	⑫		Unstable	24	
			Slightly unstable	6		Slightly unstable	⑫	
			Stable	0	12	Stable	0	12
		Loose rocks, boulders are unstable～slightly unstable	Condition met		(12)	Condition met		(24)
		Conditions of spring water	Unstable	8		Unstable	4	
			Slightly unstable	4	0	Slightly unstable	2	0
			Stable	⓪	(8)	Stable	⓪	(4)
		Conditions of surface	Unstable	5		Unstable	16	
			Slightly unstable	3	1	Slightly unstable	⑩	10
			Stable	①	(5)	Stable	0	(16)
Form		Gradient (i), Height (H)	Soil: H>30 m	18		Height: H≧50 m	⑩	
			Soil: H≦30, i > Standard	15		Height: 30≦H<50 m	8	
			Soil: i ≦Standard, 15≦H<30	10		Height: 15≦H<30 m	6	10
			Soil: i ≦Standard, 15<H	5		Height: H<15	4	(10)
			Rock: H≧50 m	18		Gradient: i ≧70°	10	
			Rock: 30≦H<50 m	16		Gradient: 45≦ i <70°	⑩	10
			Rock: 15≦H<30 m	⑫	12	Gradient: i <45°	5	(10)
			Rock: H<15	10	(18)			
Disturbance		Present disturbance (Slumps, small rock falls, gully erosion, scouring, piping hole, depression, bulge, fallen trees, cracks, crevices and others)	More than one clear evidence	⑫		More than one clear evidences	⑩	
			Obscure evidence	8	12	Obscure evidence	5	10
			No evidence	0	(12)	No evidence	0	(10)
		Disturbances of the adjacent slopes (rock falls, collapses, cracks, bulge and others)	More than one clear evidences	⑤		More than one clear evidences	④	
			Obscure evidence	3	5	Obscure evidence	2	4
			No evidence	0	(5)	No evidence	0	(4)
Total Score			Excavation Slope : 73 (A1)			Natural Slope : 77 (A2)		

B: Score for effectivness of existing structural measures

(Bi) = (Ai) + α or × 0

Effect of the existing countermeasure works	Score (α)	Evaluation: Excavation	Evaluation: natural
Well-effective against the possible rock falls and slope failures.	×0		
Effective against the possible rock falls and slope failures but not perfect.	−20		
Not perfectly protected from the possible rock falls and slope failures.	−10	○	
No countermeasure work is constructed.	±0		○

Total	(B1:Excavation slope)	(B2:Natural slope)
	63	77

C: Score for historical road geohazard

[Disaster Record] (C)

Frequency and degree of disaster	Score	Evaluation
The disaster has caused a traffic disturbance after the recent implementation of the countermeasure work.	100	
No traffic disturbance has occurred, but there is a record of comparatively serious rock falls and slope failures that reached to the road.	70	
There are records of rock falls and slope failures on a small scale that did not reach to the road.	50	○
	(C) 40	

(D) = MAX (B, C)

Total score of main cause	(B)=MAX(B1, B2) 77
Total score of disaster record	(C) 44
Bigger score in (B) and (C)	(D)=MAX(B, C) 77

Source: Based on data from the Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

Intermediate method: risk level rating of a hazard-prone road location. In Japan, a "risk level rating" is not conducted; only the "hazard level rating" (likelihood level of road geohazard damage event occurrence) is conducted, as described in the preceding description ("Basic method: simple risk evaluation of a hazard-prone road location using multiple criteria"). A "risk level rating" procedure has not been established.

Advanced method: risk estimate calculated as potential annual economic loss. The Japanese practice of the advanced method of risk evaluation (risk estimate calculated as the potential annual economic loss) is further summarized in subsection 3.1.3.

Evaluation Results of the 9th and 10th Nationwide Road Geohazard Risk Inspections

The 9th nationwide road geohazard risk inspection was a comprehensive nationwide road geohazard risk inspection. As of 2017, progress management of structural measures was being conducted based on this nationwide geohazard inspection. The 10th nationwide road geohazard risk Inspection, ordered in 2006, was just a review of the 9th inspection.

The 9th nationwide road geohazard risk inspection (in 1996–97) was carried out by engineers of contracted private consulting firms with experience in geohazard evaluation and geohazard structural measure engineering. The inspections were conducted by selecting the appropriate season when geohazard factors can be well observed (for example, in the rainy season to detect spring water or in the winter when vegetation is sparse). The multiple-criteria evaluation was conducted by inspectors in three categories of the risk management policy: “requirement for structural measures,” “periodical visual inspection monitoring,” and “no requirement for structural measures” (Table 3.1).

Table 3.1 Multiple-Criteria Evaluation Results of Nationwide Road Geohazard Risk Inspection in Japan, 1996–97

Risk management policy category	Number of hazard-prone road locations nationwide
Requirement for structural measures	83,000
Periodical visual inspection monitoring	118,000
No requirement for structural measures	155,000
Total	356,000

Source: Ando et al. 2015.

Photos 3.1 and 3.2 depict views of road geohazard risk situations found during the 9th nationwide road geohazard risk inspection. The inspections were conducted by an engineering geologist or geotechnical engineer. The Road Management Technology Center (ROMAN-TEC) held training sessions both in the training venue and on-site in 1996 and 2009 for the consultant engineers who had applied to participate. After the ROMAN-TEC dissolved in 2011, the Japan Geotechnical Consultants Association (JGCA) took over annual training sessions for such engineers. The JGCA also provides e-learning materials for road geohazard risk inspection, which are prepared under the supervision of the MLIT’s Road Bureau and the Public Works Research Institute (PWRI).

Photo 3.1 Road Geohazard Risk Inspection from Distant View

Distant-view observation is needed for proper understanding of the entire slope.

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from Road Bureau, MLIT; further permission required for reuse.

Photo 3.2 Road Geohazard Risk Inspection with Proximity Observation

A proximity observation confirms a boulder’s characteristics.

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from Road Bureau, MLIT; further permission required for reuse.

Because the evaluation rating results of the vulnerability check sheets have some vague descriptions, there was variability in the evaluation results even among well-experienced inspectors.

Periodical visual inspection monitoring aims to (a) record slight abnormalities and their progress, and (b) detect serious geohazard damage events at an early stage. The inspection is performed periodically (once a month) and after extreme rainfall events by the road maintenance staff with the aid of simple methods (taking photos and measuring crack openings using rulers). The inspection format includes sketches for plane and cross-section and photographs. If the progress of abnormality is apparent in the deformation of the geohazard area, the hazard-prone road location will be subjected to engineering inspection for structural measures.

The 10th nationwide road geohazard risk inspections, in 2006, were the latest nationwide road geohazards inspections as of 2016. The Road Bureau ordered reinspection of the geohazard-prone road subsections (limited section, not nationwide) in 2009 and in 2010 using the 2009 edition of the "Road Geohazard Risk Inspection Guidebook" (ROMAN-TEC 2009) or its reprint (JGCA 2010).

3.1.3 Calculation of Risk Estimation as a Potential Annual Economic Loss

The PWRI developed a "Draft Manual on Risk Analysis and Risk Management Support of Road Slope Disasters" in 2006 (PWRI 2006). This draft manual provides the calculation procedure to estimate the potential annual economic loss. (Potential annual loss can be estimated using integral computation of sets of probability and economic loss due to road geohazard damage for a road location.) Some road locations or road subsections are evaluated for the potential annual economic loss. The study is resource-intensive, so it has no practical use yet.

Some of the Japan International Cooperation Agency (JICA) projects or surveys simplified this procedure and used it in the Philippines in 2006–07 (JICA 2007); in Nepal in 2007–08 (JICA 2009); in Santa Catarina State, Brazil, in 2010–11 (JICA 2011); in El Salvador in 2012–15 (JICA 2015a, 2015b); and in Honduras and Nicaragua in 2015 (JICA 2015a).

3.2 Risk Management Planning

3.2.1 Geohazard Risk Management Planning for New Roads

In Japan, the following is undertaken to manage geohazard risks during planning for new roads:

- Survey(s) to identify the geohazard locations or areas
- Avoidance (to the extent possible) of road routes into potentially hazard-prone locations to reduce construction costs for geohazard countermeasures and to reduce potential economic losses during the service period caused by road damage or closure due to geohazard(s)
- Planning of proactive structural measures for hazard-prone locations on selected new alignments—including consideration of minor alignment shifting and using bridge structures and tunnels as alternative solutions for securing road users' lives and reducing economic losses due to road closing and recovery.

Types of New-Road Planning for Geohazard Risk Reduction

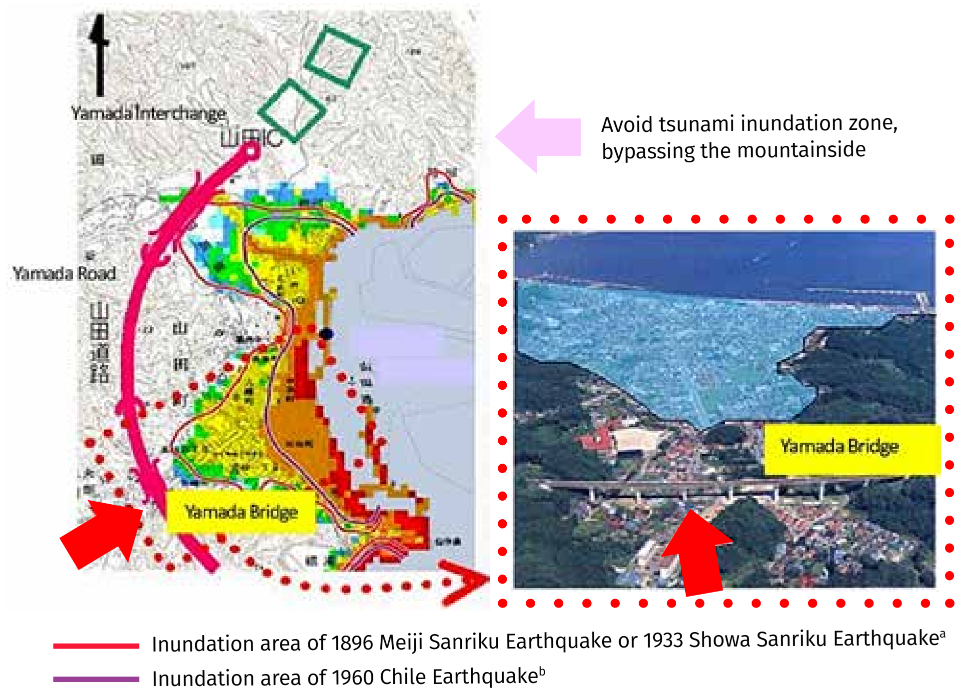
Tunnels and bridges can shorten the road distance, which generates benefits in terms of travel time-saving. At the same time, tunnels and bridges can avoid hazard-prone locations and make roads robust against geohazards. Such roads can be emergency transportation and evacuation routes during wide-area disasters such as earthquakes, tsunamis, storms, and so on (Figure 3.4).

The geohazard risk management policy takes into account the road priority type—with lower-priority roads having a lower design safety factor and also permitting temporary road traffic suspensions. This is especially relevant for flooding conditions because it permits the use of low-cost structures such as river ford crossings.

Historically, roads were built with a low initial investment and road geohazards managed mostly through recovery measures. Now, road geohazard management focuses on proactive measures. Currently, there are road plans, which restrained road function or investment, such as 1.5-lane roads out of 2 lanes, for partial operation. In this case, proactive measures for road geohazard are essential.

If the new road planned is an expressway or a national highway under MLIT jurisdiction that has major geohazard issues such as flooding, two MLIT bureaus—the Road Bureau and the Water and Disaster Management Bureau—coordinate their geohazard risk management efforts.

Figure 3.4 Use of a Bridge to Avoid Potential Geohazards on a High-Standard Highway



Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).
Note: "High-standard highway" refers to a national expressway or highway planned as part of a strategic high-speed surface-traffic network.
a. The 1896 Meiji Sanriku Earthquake and 1933 Showa Sanriku Earthquake hit approximately the same location on the Sanriku coast of the Tōhoku region of Honshu, Japan, and were of almost identical magnitude (8.5 and 8.4, respectively).
b. The 1960 Chile Earthquake (or Valdivia Earthquake), the most powerful earthquake ever recorded (9.4–9.6 in magnitude), had its epicenter in southern Chile but sent a tsunami affecting Hawaii, Japan, the Philippines, eastern New Zealand, southeast Australia, and the Aleutian Islands.

The following are Japanese examples of new-road planning practices that take into account regional geohazard risk reduction:

- Retarding facilities (temporary water storage facilities to cut peak water flow runoff) are installed if the new road construction would increase the runoff to the downstream areas.
- Redundancy planning within the subnational road network ensures that robust roads are available to secure an alternative detour option for emergency situations such as earthquakes and tsunamis.
- Residential accessibility to road networks is planned so that no residential areas would be isolated during a serious disaster event.
- Emergency road designations are made of some roads that are connected to emergency protection centers (Photo 3.3).
- Adoption of embankment structures serve a river dike or tide barrier function on new roads; these can function as flood control structures along the roads.

Photo 3.3 Example of Emergency Road Designation

The road information board (on Sotobori Avenue in Kagurazaka-shita, Shinjuku Ward, Tokyo) informs the public that, in the event of a major earthquake, it is an emergency road that will be open only to emergency vehicles. It is announced by the Government of Metropolitan Tokyo and Metropolitan Tokyo Police Department.

Source: ©World Bank. Permission required for reuse.

Roadside Stations (Michi-no-Eki)

Roadside stations, or rest areas (Michi-no-Eki in Japanese), have been built since 1993 on national highways to provide users with three amenities: “a place for resting” including parking and restrooms for road users, “a place to provide information” for both road users and locals, and “a place to facilitate communications” between communities and visitors (MLIT 2015a).

Roadside stations are also important as a facility for road disaster risk management (DRM). The MLIT is promoting the enhancement of the roadside stations for DRM functions. The municipalities manage their roadside stations as disaster evacuation centers in their DRM plans. Roadside stations have the following DRM functions (MLIT 2015a):

- Disaster evacuation or support centers for early warning and postdisaster situations. Some roadside stations have in-house power generators in preparation for disasters, and they have played important roles in life-saving activities and distribution of relief goods and food.
- Information delivery centers for damage information, including road closures.

About 1,093 roadside stations have been constructed in all parts of Japan as of May 2016. Information provision at the rest areas is being enhanced to improve and increase services provided for road users. Roadside stations are also expected to revitalize local economies by serving as a spot for tourists visiting nearby natural, historical, and cultural sites (Figure 3.5 and Photo 3.4).

Figure 3.5 General Layout of Roadside Station (Michi-no-Eki) in Japan

Source: MLIT 2005. ©Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission from MLIT; further permission required for reuse.

Photo 3.4 Road and Regional Climate Information Board at a Roadside Station

This electronic bulletin board keeps visitors updated on weather and road conditions at a roadside station in Kuragi, Saga Prefecture, Kyushu Region.

Source: ©World Bank. Permission required for reuse.

3.2.2 Geohazard Risk Management Planning for Existing Roads

Precautionary Road Closure of Hazard-Prone Subsections

Critical geohazard-prone road subsections are identified through operation and maintenance activities. After the Hida River bus-fall incident in August 1968, the MLIT designated geohazard-prone road subsections as "Precautionary Road Closure Subsections" and defined the road closure criteria based on rainfall indexes. The designated road subsections and road closing criteria are updated based on the results of routine periodic inspections.

The use of the rainfall index for a precautionary road closure in Japan has been implemented using the cumulative rainfall amount from the start of the rainfall (generally called the continuous rainfall amount). However, for evaluating highly susceptible rainfall-induced geohazards, the rainfall index has some weak points. A new rainfall index that accurately predicts geohazard events using rainfall intensity has been studied. Since July 2015, on national highways under MLIT jurisdiction, some road subsections were designated for the trial use of new precautionary road-closing criteria based on hourly rainfall amounts (rainfall intensity). This is to save road users from suffering in case of a road geohazard event caused by intense rainfall. In the adaptation of hourly rainfall volume (rainfall intensity), conventional criteria using the cumulative rainfall amount are also utilized.

Geohazard Risk Management for Each Hazard-Prone Location

The road geohazard risk management authorities conduct the initial decision making by reviewing the recommendations of the engineering consulting firms on the results of the road geohazard risk inspections. The risk management policy for each hazard-prone location is based on the following three criteria, by risk level: "requirement for structural measures" (for high risk), "periodical visual inspection monitoring" (for medium risk), and "no requirement for structural measures" (for low risk).

Planning of Combination of Nonstructural Measures, Structural Measures, and Preparedness for Postdisaster Actions and Recovery

The road management authorities are in charge of the planning activities. Proactive measures are planned by combining structural and nonstructural measures against the likelihood of geohazard events and the concept of life-cycle cost including the maintenance and repair of the countermeasures.

As a tool of the nonstructural measures for road geohazards, various monitoring devices for hazard activity detection are used, and precautionary road closure measures are put in place to protect road users. These proactive measures are planned in consultation with relevant government organizations such as DRM authorities, river management, police, and subnational government. As mentioned earlier (in chapter 2), the MLIT's online New Technology Information System (NETIS) promotes the use of new technology by private and public institutes to solve public works issues. The new technology would reduce both the costs and the potential environmental problems of these measures.

Each national and subnational government (in coordination with the government's road management authorities) takes local DRM plans into consideration as part of geohazard risk management on existing roads. Sometimes, the coordination extends to other government and road management authorities at the national, prefecture, major city, and municipality levels.

If the existing risk management plan for an expressway or national highway addresses major geohazard issues including flood management (thus under MLIT jurisdiction), two MLIT units—the Road Bureau and the Water and Disaster Management Bureau—must coordinate their efforts. For example, flow-type geohazard risk management (earth or debris flow, flooding, or roadside river erosion) aims not only to preserve the road but also to protect human lives and properties in the surrounding landscape ecosystems.

3.2.3 Cost-Benefit Analysis of Investment for Road Geohazard Risk Reduction

The estimation of benefits and cost-benefit analysis for road geohazard risk reduction is not conducted in most cases in Japan because it involves costly investigations and studies. Instead, the focus is on identifying the lowest life-cycle-cost option, on the presumption that the need for the road to be open was justified when the road was first constructed and that benefits would generally be similar between options.

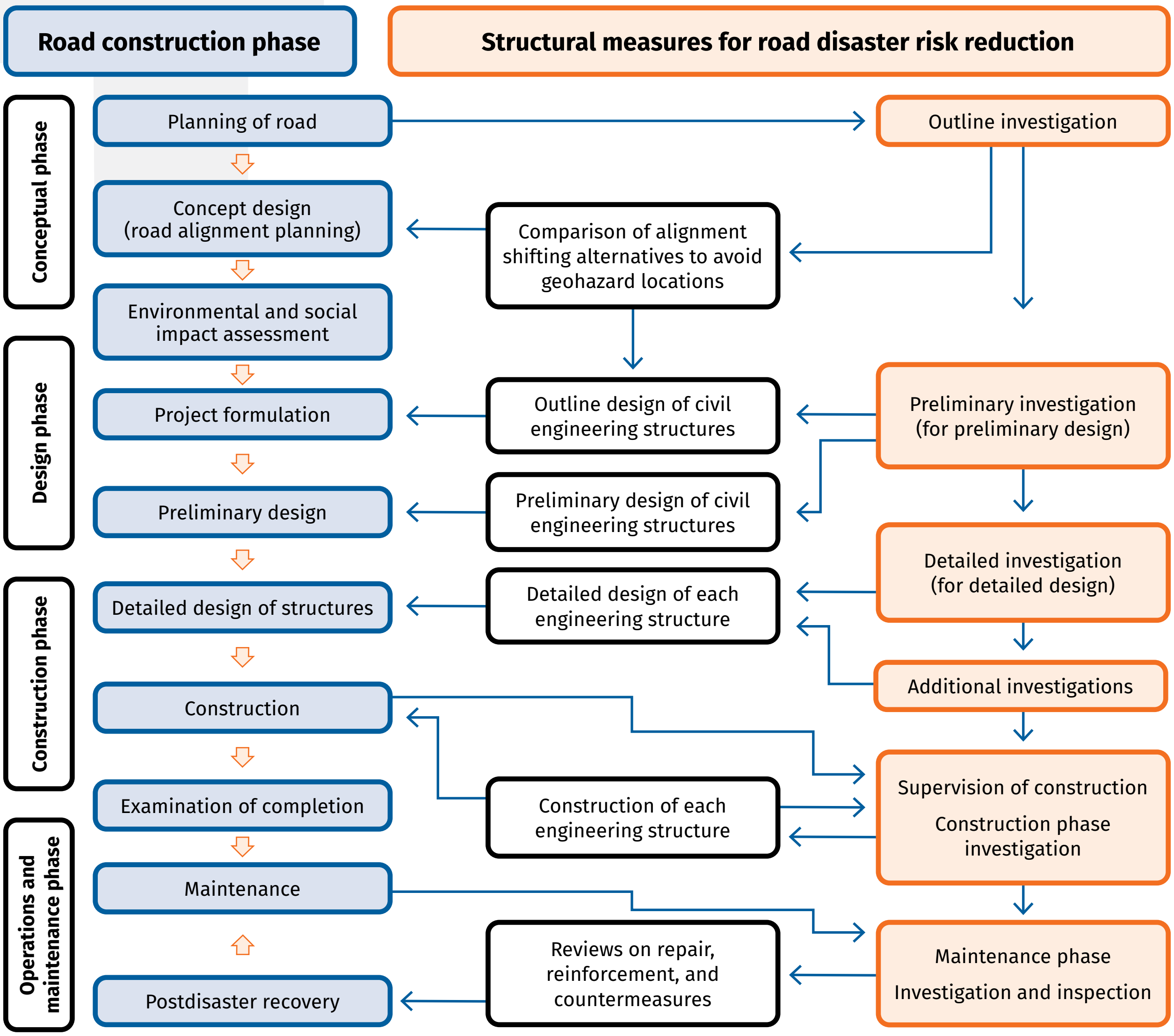
4 ENGINEERING AND DESIGN

4.1 Process of Implementing Structural Measures

In Japan, the term "construction of countermeasure" is used to define structural measures. In the case of small works conducted without design (such as removal of soil deposits, repair of cracks on retaining walls, and so on), the countermeasures are called "maintenance works." The maintenance works are undertaken by the road maintenance staff of the road management authorities.

Structural measures are usually implemented based on the priority of the hazardous locations where countermeasures are required (Figure 4.1). Structural measures for geohazard risk reduction can also be implemented as postdisaster reactive (recovery) measures. An environmental and social impact assessment (ESIA) is conducted during the concept design phase of the new road construction or during the planning of proactive structural measures for existing roads.

Figure 4.1 General Flow of Road Construction and Structural Measures



Source: Japan Road Association 2009b. ©Japan Road Association. Reproduced, with permission, from the Japan Road Association; further permission required for reuse.

4.2 Types of Structural Measures and Design Considerations

A number of measures are implemented to protect road users from road geohazards: roadside slope stabilization or protection works, construction of roads that bypass geohazard-prone areas, and structural measures in road crossings or along rivers or streams (Photos 4.1 through 4.6). Other types of structural measures are described in "Landslides in Japan," which provides engineering knowledge on structural measures in Japan in English (JLS 2012).

The road management authority usually determines the type of structural measures after consultation between the road management authority and the engineering consultant. If there is a significant impact on the surrounding social environment, a technical review committee (including authorized specialists, universities, and technical and/or administrative institutes) is organized to support the decision-making process.

Photo 4.1 Slope Stabilization Measures for Mountainside Road Slope

Slope stabilization measures here use a retaining wall, a slope framework (grid beam) with anchoring, shotcrete, and vegetation (bioengineering).

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Photo 4.2 Slope Stabilization Measures for Road Mountainside Rock Collapse

Unstable rock mass is stabilized here using steel wire rope with anchoring to prevent collapse.

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Photo 4.3 Shelter for Road Mountainside Fall or Collapse

Shelters against rock, debris, and snow are often built over roadways adjacent to steep slopes. There is no substantial difference between shelters that protect against rock or soil fall and those built for snow avalanches. They usually serve both rock or soil fall and snow avalanches in a snowy region. The material of the shelter is three types: reinforced concrete, prestressed concrete, and steel.

Source: MLIT 2015a. ©Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Photo 4.4 Barrier (Catch Fence with Wall Foundation)

Concrete retaining walls are often used as the foundation of fences to prevent falling rocks. Energy absorption capacity of 45–650 kilojoules (kJ) was the norm; however, recently, a rockfall prevention fence capable of high energy absorption up to 1,000 kJ has been developed, and in the MLIT's New Technology Information System (NETIS).

Source: MLIT 2015a. ©Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Photo 4.5 Wire Netting (Rockfall Net)

Wire netting (rockfall net) is subdivided into covering type and pocket type (shown in the photo, left). The covering type tightens loose rock mass and stops these from falling through the tensile force of the wire net. The pocket type is a barrier to protect roads against rockfalls from reaching the road, while the flexible net does not break and buffers the falling rock energy and retains the rockfalls on the mountainside of the road.

Source: MLIT 2015a. ©Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Photo 4.6 Debris Flow Protection Check Dam (Permeable Type)

a. Before debris flow event on September 11, 2015

b. Just after the debris flow event on September 11, 2015

This example shows a check dam in Nikko City, Tochigi Prefecture, before and after the September 2015 Kanto-Tōhoku Storm.

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

5 OPERATIONS AND MAINTENANCE

5.1 Maintenance of Structural Measures

The engineering staff (contracted by the road management authority) is in charge of maintaining structural measures as part of road maintenance in most cases. Private contractors usually provide the heavy equipment required for maintenance such as removal of debris deposits in dam reservoirs or the repair of damaged slope reinforcement works.

Substantial infrastructures have been built during the rapid growth period of Japan's economy in the 1960s and 1970s, but they are nearing the end of their useful life within the 2010–2030 period. The Ministry of Land, Infrastructure, Transport, and Tourism (MLIT) made the "Action Plans for Life Extension of Infrastructure" in May 2014, which includes the following activities to be conducted by the MLIT and subnational governments (MLIT 2014a):

- Inspection, diagnosis, maintenance, and renewal
- Preparation of engineering standards
- Preparation of information database
- Preparation of maintenance plan for structural measures at each facility
- Research and development of new technology
- Budget allocation
- Formulation of maintenance procedure and organization
- Formulation of laws and regulations.

5.2 Early Anomaly Detection and Emergency Information Collection

Visual inspections of the road (just watching for abnormalities from patrol cars) are conducted by road management authorities as part of their routine patrols. A daily patrol is conducted by road patrol cars for national expressways, national highways, prefecture roads, and arterial municipality roads.

The Road Bureau of the MLIT ordered nationwide road geohazard risk inspections and on-demand specific thematic risk inspections (as described earlier in section 3.1.2, "Geohazard Risk Evaluation for Existing Roads"). These visual inspections are conducted on foot by the engineer of the contracted consulting firms. For highly vulnerable geohazard sites, the geohazard monitoring is conducted with the aid of devices such as closed-circuit television (CCTV) and detection devices for land movement or debris flow.

An efficient communication system for road networks was developed in Japan in 2005. Any person can report a road disaster or road abnormality to the corresponding road management authority by calling the road emergency information number #9910. This system has also been a tool for emergency information collection. After notification from road users or other personnel, patrol cars and vehicles equipped with satellite communication systems rush to the site and collect information.

Recently, besides the conventional field surveys, more efficient methods are being used to identify traffic congestion due to road closings, such as the use of probe cars equipped with Global Positioning Systems (GPS), the use of Vehicle Information and Communication System (VICS) data, and other intelligent transportation system (ITS) technologies in cooperation with police departments.

5.3 Road Condition Emergency Information System Including Early Warning or Precautionary Road Closure

On arterial roads, electrical road information boards are installed by road management authorities along the road and at driver amenity areas. The driver amenity areas, sometimes called roadside stations (or Michi-no-Eki), were developed by the national government to provide road users with amenities such as parking, restrooms, road and local information displays, and community centers for residents (Photos 5.1 through 5.6). These provide information on the occurrence of road geohazard damage events; road closures due to geohazards (with recommended detour routes); early warning for geohazard occurrence; or driving conditions during dangerous situations (such as heavy rain, strong winds, and dense fog). Such emergency information is also provided via mass media (radio and television), the internet, and VICS.

Photo 5.1 Road Information Board above a Carriageway

This electronic information board—placed above a carriageway using a bridge structure—announces traffic regulations or conditions. During normal conditions, the electric information board delivers messages that remind vehicle drivers to drive carefully.

Source: © World Bank. Permission required for reuse.

Photo 5.2 Road Information Board in a Parking and Rest Area

This electronic information board announces the traffic regulation for one-way alternating traffic on a road subsection.

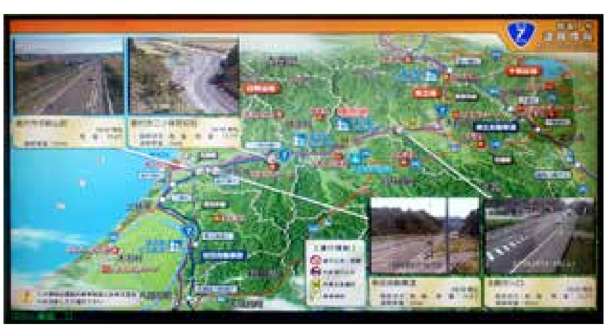
Source: © World Bank. Permission required for reuse.

Photo 5.3 Roadside Information Center

This building, which provides road information, is managed by a Regional Development Bureau of the MLIT at the Takanosu Roadside Station on National Highway No. 7, Akita Prefecture, Tōhoku Region.

Source: © World Bank. Permission required for reuse.

Photo 5.4 Video Display of Road Information, Driving Conditions, and Traffic, Including Geohazard Information



This real-time video display provides updated road, driving, traffic, and geohazard information to visitors at the Takanosu Roadside Station on National Highway No. 7 in Tōhoku Region.

Source: © World Bank. Permission required for reuse.

Photo 5.5 Detail of Road and Weather Information from a CCTV Camera

The information board displays closed-circuit television (CCTV) monitoring images of hazard-prone road locations with weather conditions such as temperature and cumulative rainfall amount from the start of the rainfall.

Source: © World Bank. Permission required for reuse.

Photo 5.6 Detail of Legend in Video Display to Indicate Traffic Regulation and Road Closures

The legend at the bottom of the screen helps viewers to identify road traffic situations: whole-width closures, partial-width closures, closures for large vehicles only, or road subsections with alternating one-way traffic.

Source: © World Bank. Permission required for reuse.

The precautionary road closure is an established system, and the MLIT's Road Bureau has designated the hazard-prone road sections based on criteria such as a threshold rainfall amount. These traffic regulation criteria—for historically known or apparent dangerous situations for geohazard disasters such as slope or progressing road deformation—are used to ensure the safety of road users from disasters by

- Prohibiting vehicle traffic on dangerous subsections identified beforehand when an abnormal weather condition, mostly rainfall, exceeds the regulation criteria;
- Enabling the road management authority to protect road users from running or stopping their vehicles in dangerous road subsections; and
- Avoiding the risk of subjecting road users to a possible disaster—despite the consequences of traffic closures in terms of road users' loss of time waiting for traffic to reopen, increases in vehicle operating costs, loss of time from possible longer detours, and opportunity losses due to the cancellation of trips.

Road management authorities suspend the road closure when geohazard-induced situations are normalized and danger no longer detected through emergency visual observation patrols. The weather association provides the forecast data for rainfall intensity to calculate the rainfall index and to apply the criteria for precautionary road closures.

The road management authorities have equipment, machinery, staff, and operating rules to respond to emergencies caused by abnormal weather conditions, other highly geohazard-susceptible conditions, and reported disasters or other abnormalities along the roads. The road management authorities can also have yearly contracts with private companies to provide additional staff and machinery.

5.4 Local and Institutional Partnerships for Geohazard Risk Management

As described in chapter 1 (Table 1.1), a massive rock-mass failure killed 15 road users on a national highway in 1989. The lesson learned after this tragedy was that lives could have been saved if road users or residents had previously reported the abnormalities (small intermittent rockfall) to the road management authority and had precautionary road closures been implemented.

In 2012, the Local Disaster Prevention Research Committee for Rock Collapse—formed in 1997 under the MLIT's purview and comprising five academic researchers in DRM and disaster information management—proposed the concept of "local disaster prevention partnerships" to create strong local alliances against disasters among residents and road users, subnational DRM agencies, and road management authorities.

These local partnerships contribute to disaster risk reduction activities such as road patrols and proactive structural measures against geohazards. Specifically, residents and road users allied under the proposed partnerships can ideally undertake the following:

- Help to obtain geohazard information such as disaster history and abnormalities
- Strengthen the region's overall disaster prevention capabilities.

After the MLIT put the partnership concept into practice, a nationwide road emergency number (#9910) was established, and some roadside emergency phones and parking spaces were provided in the hazardous road subsections of the arterial roads.

5.5 Control of Road Disasters Caused by Human Activities

Human activities that trigger road geohazard events are regulated by several laws (Table 5.1).

Table 5.1 Countermeasures to Mitigate Road Geohazards Caused by Human Activities

Human activity	Road geohazard-inducing mechanism	Countermeasures
Garbage disposal in roads	Garbage in roadside drainage makes the drainage less effective and could activate road geohazards.	Garbage disposal on public infrastructure such as roads is prohibited under the Waste Management and Public Cleaning Act of 1970 (last amended in 2015). Police control the illegal garbage disposal. Signboards to stop the activities are placed by the road management authority in cases of frequent garbage disposal.
Sand extraction from rivers or streams that cross or run along roads	The sand extraction may increase roadside river erosion or erosion of the foundations of road-crossing rivers and streams.	The sand extraction activities require approval under the Gravel Gathering Act of 1968 (last amended in 2015).
Deforestation of landscape ecosystems along roads	Deforestation may increase the peak flow rates of rivers or streams along roads, thus increasing the erosion of roads along rivers and also increasing flow-type geohazard risks (such as flood or earth or debris flow).	The minister of the Ministry of Agriculture, Forestry and Fisheries (MAFF) or the governors of prefectures designate the conservation forest and restrict deforestation under the Forest Act of 1951 (last amended in 2016).

Human activity	Road geohazard-inducing mechanism	Countermeasures
Watering or earthwork near roads	Watering such as irrigation, banking of the potential sliding slope head, or cutting the slope foot may cause geohazards.	The Landslide Prevention Act of 1958 (last amended in 2014) restricts landslide-inducing activities such as watering or earthworks in designated landslide prevention areas, which are areas of high probability for inducing landslides, as designated by the MLIT, MAFF, and the Forestry Agency (under MAFF). Project approval for new watering systems or earthworks in landslide prevention areas is the responsibility of the governor of the prefecture where the project is located. New watering systems or earthworks plans require an environmental impact assessment (EIA) under the Environmental Impact Assessment Law of 1997 (last amended in 2014). (For more information, see a translated version at http://www.env.go.jp/policy/assess/2-2law/1.html, or see Ministry of the Environment [2012].)

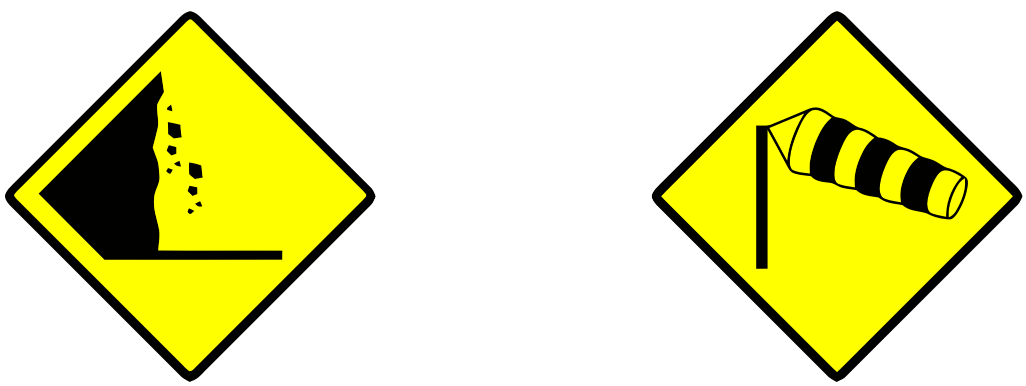
5.6 Traffic Signs

In Japan, road signage delivers messages such as traffic regulation, warning, and dangers. As for road geohazard risk management, danger warning signs for rockfall and crosswinds are used (Figure 65.1).

Figure 5.1 Danger Warning Signs for Geohazards

a. Sign code 209-2: Rockfall caution

b. Sign code 214: Crosswind caution



Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

At designated geohazard-prone road subsections, the road management authorities provide information boards notifying road users that the road subsections are designated for precautionary road closures, displaying road closure criteria. When roads are closed during highly dangerous situations or because of geohazard, the road management authority places the temporary danger warning on the information board, and the affected road is closed using barricades or crossing bars (Photos 5.7 and 5.8). Reactive road closure (road closure as a reactive measure) may be implemented for any roads as needed. The road information board announces the permanent or temporary dangerous road condition and/or the road closure situation.

Photo 5.7 Road Information Board for Precautionary Road Closure

The information board displays closed-circuit television (CCTV) monitoring images of hazard-prone road locations with weather conditions such as temperature and cumulative rainfall amount from the start of the rainfall.

A roadside information board on traffic regulation in between Kouchiumi District, in Miyazaki-shi City, and Kazeda District in Nichinan City reads as follows:

> Traffic is closed for this subsection in case of (1) Continuous rainfall amount from the start of the rainfall is 170mm or more; or (2) Highly rockfall-dangerous situation. Thank you for your cooperation.
>
> Ministry of Land, Infrastructure, Transport and Tourism, Director of the Miyazaki River and National Highway Administration Office

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Photo 5.8 Roadside Electrical Information Board with Alarm Light

A sample notice on this roadside electrical information board, if the alarm light were on, would note in red light, "Caution! Flooded due to rain. Water depth 30 cm."

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5.7 Awareness Raising and Training for Road Stakeholder Engagement

Raising road disaster awareness involves educational activities to improve and disseminate knowledge on road disaster prevention to residents and road users. Since 1992, Road Disaster Prevention Week has been held during the period of August 25–31 and preceding Disaster Prevention Day (September 1). (August is Road Preservation Month.) During Road Disaster Prevention Week, road management authorities provide exhibitions, lectures, and workshops on road DRM to residents and road users (Photos 5.9 and 5.10).

Photo 5.9 Disaster Prevention Exhibit by Road Management Authority

Local residents and road users visit a public exhibit displayed during Road Disaster Prevention Week, August 23–28, 2015, in a local shopping mall of Tokushima Prefecture in Shikoku Region.

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Photo 5.10 Poster for Road Disaster Prevention Week

A poster advertising Road Disaster Prevention Week (August 25–31, 2001) promotes exhibitions, lectures, workshops, and other activities to educate road users about road DRM. The poster states, in part, “It is not just other people’s concern, but road disaster threatens our very lives.”

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

In addition, with cooperation from the media, experienced scholars, and others involved in education, the MLIT’s Kantō Regional Development Bureau has released a textbook—“Prepare for a Major Earthquake (Consider Life's Path)”—for elementary school students. It covers “road disaster prevention and mitigation” and “the importance of self-help, cooperation, and rescue and assistance during a rapid evacuation and relief in case of a disaster.” To make the textbook easy to use in an educational setting, the “Disaster Prevention Training Start Guide” was also published. The textbook was distributed to public elementary schools in five prefectures (Tokyo, Ibaraki, Saitama, Chiba, and Kanagawa) at the beginning of September 2016 so that they can use it in the educational field. The textbook and “Disaster Prevention Training Start Guide” are expected to have many applications.

6 CONTINGENCY PROGRAMMING

Within Japan, the three main focus points of contingency programming in relation to postdisaster response and recovery are

- Emergency inspection and postdisaster needs assessment;
- Emergency traffic regulations and public notice arrangements pertaining to the closure of roads; and
- Emergency recovery activities.

These are each expanded upon further in the sections below.

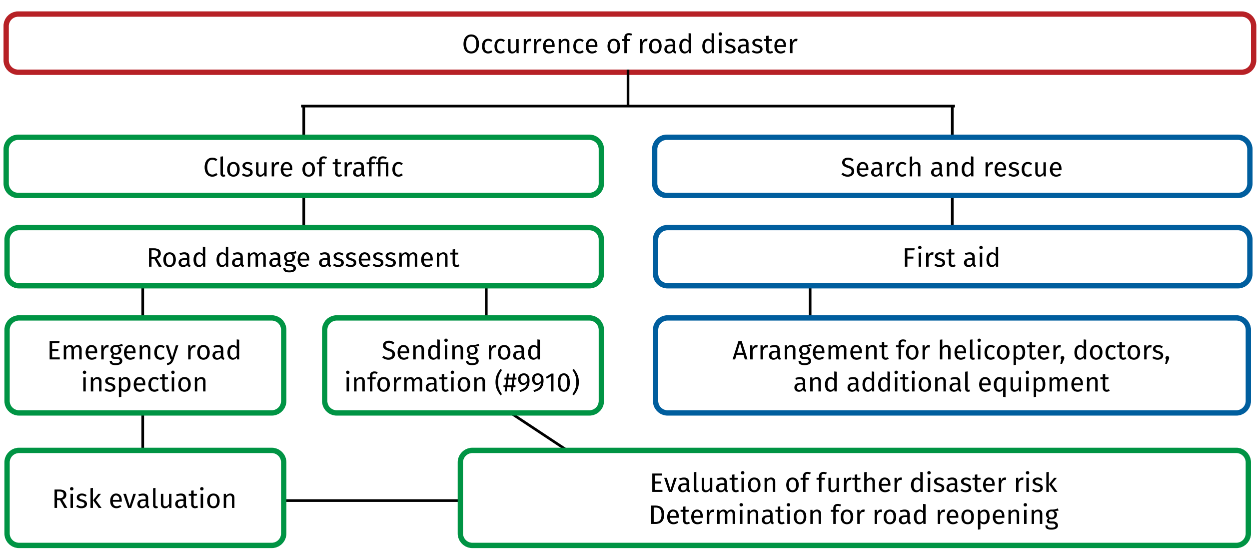
6.1 Emergency Inspection and Postdisaster Needs Assessment

Postdisaster damage information is collected by the same staff responsible for routine road maintenance. If road users are injured or killed or if vehicles are damaged, the police also conduct inspections. Along with the required emergency inspections, any necessary urgent measures are taken to protect road users and road structures from secondary damage.

The procedures for emergency inspections and postdisaster needs assessment are shown in Figure 6.1. Postdisaster needs assessments are carried out by personnel including rescue teams dispatched by the major cities or municipalities in response to the emergency calls by victims, road users, or residents. A rescue team evaluates the first aid needs of injured road users and carries out the proper emergency treatment. The rescue team or road operation staff may request additional rescue teams, ambulance cars, rescue helicopters, or medical helicopters equipped with medical instruments.

The road management authority assesses the condition and availability of the road network by collecting local road damage information. The free road emergency number (#9910) is used to obtain information from users concerning the routes. Information exchange with other road organizations such as the police is also conducted. Assessment results on the road network availability are used to coordinate the required operation for reopening the roads (elimination of road obstacles).

Figure 6.1 Procedure for Emergency Inspection and Postdisaster Needs Assessment



Note: Boxes outlined in green designate tasks conducted by road management authorities. Boxes outlined in blue designate tasks conducted by police or subnational government rescue teams.

6.2 Emergency Traffic Regulation and Public Notice

When road traffic is unpassable or highly dangerous based on the results of the emergency inspection, the road management authority sets a temporary barricade and closes the roads in consultation with the traffic police until the road obstructions and highly susceptible hazard source(s) are eliminated.

In addition, emergency information is published for road users and residents through information boards on the highways. The information system can be linked to various media such as television, radio, car navigation sets, and the internet. The Vehicle Information and Communication System (VICS), the world's first real-time road traffic information system, began in April 1996. The information is transmitted to onboard equipment such as car navigation systems.

6.3 Emergency Recovery

Emergency recovery for minor works such as road debris removal is managed by the road maintenance offices of the road management authorities, including the branch offices of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT).

As part of emergency preparedness for disasters, some road management authorities make agreements with private construction companies to undertake emergency activities concerning severe geohazards. These private companies remove road obstructions and restore hazardous situations upon request from the road management authorities. The MLIT also developed a "Doctors for Road Disaster" system to dispatch experts and professionals in academic societies and engineering associations when road disasters occur, to provide technical recommendations to the road management authorities.

In addition, the MLIT's Technical Emergency Control Force (TEC-FORCE) mobilize special emergency recovery staffs as well as special equipment in the MLIT Regional Development Bureaus, including pump trucks, mobile lighting vehicles, headquarters cars or standby support vehicles, remote-controlled backhoes, disaster management helicopters, sandbag manufacturing equipment, emergency assembly bridges, sprinkler trucks, side ditch cleaning vehicles, and road sweepers.

In the case of large-scale geohazard events, the TEC-FORCE and teams with equipment are dispatched, depending on requirements, not only to roads under MLIT jurisdiction but also to roads under the jurisdiction of subnational governments for emergency recovery work needed in the wake of disasters. Private construction companies also conduct emergency recovery work by order of the MLIT or subnational governments, in collaboration with TEC-FORCE. For emergency cases, the MLIT can make standby contracts with private construction companies for emergency recovery works.

Photo 6.1 shows an emergency recovery operation using an emergency assembly bridge and mobile lighting vehicle in 2004.

Photo 6.1 Example of Emergency Recovery Operations

August 2, 2004: Immediate aftermath of road geohazard event — August 4, 2004: Installation of emergency assembly bridge — August 5, 2004: Traffic secured on one-way alternating road

General vehicle traffic was restored about three days after geohazard damage occurred on National Highway No. 32, Otoyo Town, Kōchi Prefecture, Shikoku Region.

Source: ©Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (MLIT). Reproduced, with permission, from MLIT; further permission required for reuse.

Box 6.1 discusses emergency recovery after the magnitude 9.0 Great East Japan (or Tōhoku) Earthquake and Tsunami in 2011. This emergency recovery strategy was implemented efficiently for several reasons:

- The MLIT staffs (assigned to the branch offices or for road management) had prepared emergency action plans for the maintenance of roads.
- TEC-FORCE employees at the MLIT's Regional Development Bureau routinely had carried out training with equipment arranged for emergency recovery.
- MLIT had made standby contracts for emergency recovery operations with private construction companies.

To facilitate and expedite payment to the companies involved in the emergency recovery and restoration works, an increased advance payment rate and the reduction of the confirmation documents of finished work quality and quantities were taken into consideration under the exceptional circumstances.

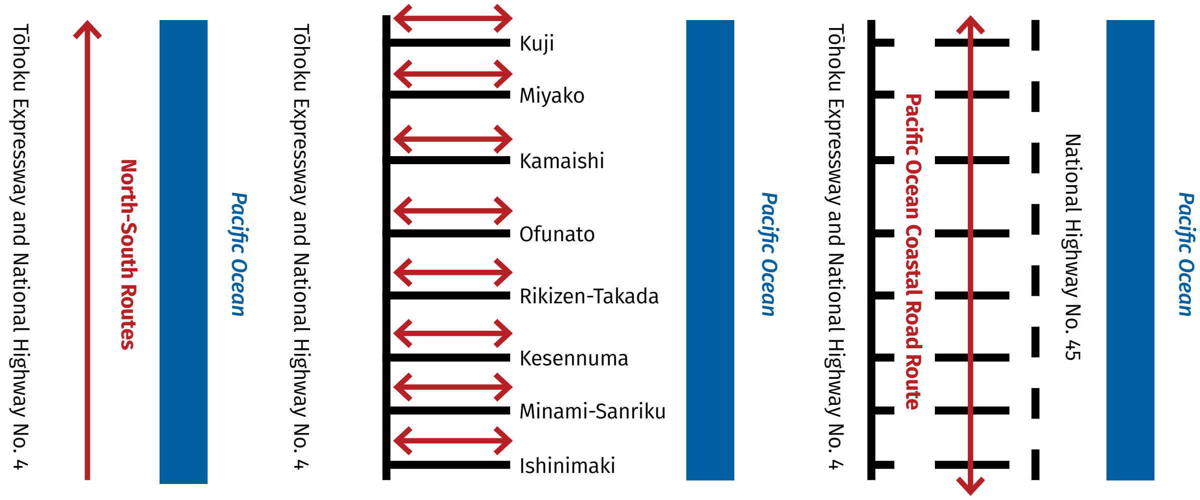
Box 6.1 Efficient Operation to Reopen Roads (Eliminate Road Obstructions) after Massive Earthquake and Tsunami of 2011

The magnitude 9.0 Great East Japan (or Tōhoku) Earthquake caused a series of tsunamis and damaged the main roads along the Pacific coast. However, the high-standard roads transecting northeast Japan inland with the longitudinal highways of North–South Routes (Tōhoku Expressway and National Highway No.4) were not damaged so much.

A key for efficient recovery was the reopening of the main eight East–West Routes in parallel, connecting inland longitudinal highways to seriously damaged coastal roads.

The road reopening operation was later called "Operation Toothcomb" because the shape of the transportation network of East–West Routes in parallel resembled a comb's teeth (figure B6.1.1).

Figure B6.1.1 Steps to Eliminate Road Obstructions after Great East Japan Earthquake, 2011



Step 1: Secured Tōhoku Expressway and National Highway No. 4, "North–South Routes."

Step 2: Opened East-West routes toward the damaged areas along the Pacific Ocean until March 15, 2011.

Step 3: Reopened 97 percent of National Highway No. 45 until March 18, 2011.

Source: @Ministry of Land, Infrastructure and Transport and Tourism (MLIT).

7 CONCLUSIONS AND KEY FINDINGS

Based on this case study, the following are the key findings and conclusions across each phase of the geohazard risk management process.

1. Institutional capacity and coordination. Japan has established laws that specify the guarantee of funds related to disaster relief, disaster management plans, and the fundamental matters related to systems during a state of emergency.

Technical standards and manuals have been prepared for (a) disaster risk management; (b) road disaster risk management; (c) risk evaluation for road geohazards; (d) benefit estimation of proactive measures for road geohazards; and (e) business continuity planning for road geohazards. However, regarding (c) risk evaluation for road geohazards, no practical manual on risk estimation of potential economic loss has been developed. Regarding (d) benefit estimation of proactive measures, no practical manual has been developed.

The capacity review for Japan concluded that even for a country such as Japan—where there is a long history of geohazard management—for many of the factors under assessment, Japan is only at the starting point of developing appropriate capability and capacity. For those just commencing implementation of geohazard risk management practices, a long-term commitment is required.

2. Systems planning. Japan makes extensive use of geohazard mapping as part of the planning and management of risks on both proposed and existing roads. Using a mix of basic, intermediate, and advanced methodologies allows the Japanese to make efficient use of their resources—focusing the advanced methodologies where they are most needed to address complex situations.

The estimation of benefits and cost-benefit analysis for road geohazard risk reduction is not conducted in most cases in Japan because it involves costly investigations and studies. Instead, the focus is on identifying the lowest life-cycle-cost option, on the presumption that the need for the road to be open was justified when the road was first constructed and that benefits would generally be similar between options.

3. Engineering and design. Structural measures are usually implemented based on the priority of the hazardous locations where countermeasures are required. Structural measures for geohazard risk reduction can also be implemented as postdisaster reactive (recovery) measures. An environmental and social impact assessment (ESIA) is conducted during the concept design phase of the new road construction or during the planning of proactive structural measures for existing roads.

To protect road users from road geohazards, a number of measures are implemented, including roadside slope stabilization or protection works, construction of roads that bypass geohazard-prone areas, and structural measures in road crossings or along rivers or streams. There are other types of structural measures, such as those described in “Landslides in Japan” (JLS 2012), which provides engineering knowledge on structural measures in Japan in English.

The road management authority usually determines the type of structural measures after consultation between the road management authority and the engineering consultant. If there is a significant impact on the surrounding social environment, a technical review committee (including authorized specialists, universities, and technical and/or administrative institutes) is organized to support the decision-making process.

4. Operations and maintenance. The O&M tasks within Japan consist of

- Routine maintenance of the structural measures;
- Early anomaly detection and emergency information;
- Road condition emergency information systems;
- Establishment of partnerships with other road authorities and institutions;
- Management of human impact on the causation of geohazards;
- Appropriate traffic signs for managing geohazards; and
- Awareness raising and training for road stakeholders.

5. Contingency programming. Within Japan, the three main focus points of contingency programming in relation to postdisaster response and recovery are

- Emergency inspection and postdisaster needs assessment;
- Emergency traffic regulations and public notice arrangements pertaining to the closure of roads; and
- Emergency recovery activities.

The overarching finding of the Japanese approach to road geohazard risk management is that of taking a systematic approach—covering all aspects of geohazard risk management from governance and laws; through to the design, construction, and maintenance of countermeasures; and on to the engagement with a wide range of stakeholders before, during, and after a geohazard event occurs.

ANNEX C1 CHECKLISTS FOR INSTITUTIONAL CAPACITY REVIEW

Tables C1.1, C1.2, and C1.3 contain a sample of the road geohazard risk management checklists as completed for Japan. They are provided to illustrate the nature of completing the checklists and the variation in resulting score between categories.

Table C1.1 Checklist A: Institutional Framework for Road Geohazard Management (Sample of Checklist Only)

Question	Item number	Check items	Status (options 0–4)	Score	Effectiveness or appropriateness 0: No 1: Low 2: Moderate 3: High
Have laws and/or regulations been formulated?	I-1	Laws of disaster risk management	0. Not yet started 1. Formulating 2. Formulated 3. Enforcing partially 4. Enforcing fully	4	2
	I-2	Laws of general geohazard risk manage-ment	0. Not yet started 1. Formulating 2. Formulated 3. Enforcing partially 4. Enforcing fully	4	2
	I-3	Laws of road geohazard risk management	0. Not yet started 1. Formulating 2. Formulated 3. Enforcing partially 4. Enforcing fully	4	2
Have technical standards, guidelines, or manuals been prepared?	I-4	Disaster risk management	0. Not yet started 1. Preparing 2. Prepared 3. Utilizing partially 4. Utilizing fully	1	0
	I-5	Road geohazard risk management	0. Not yet started 1. Preparing 2. Prepared 3. Utilizing partially 4. Utilizing fully	4	2
	I-6	Risk evaluation for road geohazard	0. Not yet started 1. Preparing 2. Prepared 3. Utilizing partially 4. Utilizing fully	4	2
	I-7	Benefit estimation of proactive measures for road geohazard	0. Not yet started 1. Preparing 2. Prepared 3. Utilizing partially 4. Utilizing fully	1	0

	Description of current status Summarize current status, effectiveness, problems, and so on. Add remarks and/or comments if necessary.	Reference materials or name of respondent, position, and agency Author (year): Title of reference or Name, position, agency
	The Disaster Countermeasures Basic Act (1961) defines the (a) responsibility of each administrative body; (b) creation of disaster management councils; and (c) strategies by the national/local government. The rules on the contingency are defined by related laws.	Japan (1951): Act on National Treasury Share of Expenses for Recovery Projects for Public Civil Engineering Facilities Damaged Due to Disasters Japan (1961): Disaster Countermeasures Basic Act Japan (1962): Act on Special Financial Support to Deal with Extremely Severe Disasters
	The laws on general geohazard risk management were prepared for several types of geohazard, for structural and nonstructural measures. Japan has been enforcing geohazard-related laws based on lessons learned from previous geohazard events.	Japan (1961): Disaster Countermeasures Basic Act Japan (1964): River Act Japan (1897): Erosion Control Act Japan (1958): Landslide Prevention Act Japan (1969): Act on Prevention of Steep Slope Collapse Japan (1951): Forest Act Japan (2000): Sediment Disaster Prevention Act
	The Road Act (1952) is the basis for road geohazard risk management. Article 42 mandates that the road management authority maintains and repairs roads to keep these in good condition. Article 46 gives the road management authority responsibility over traffic regulation and control when the road is dangerous to use due to geohazards.	Japan (1952): Road Act
	The Cabinet Office is currently developing the Guidelines on the Standardization of Disaster Management.	Cabinet Office: web page in Japanese
	The Public Works Research Institute (PWRI) developed the “Draft Manual on Risk Analysis and Risk Management Support for Road Slope Disasters” in 2006, which includes risk estimates of potential economic annual losses.	Public Works Research Institute (PWRI 2006): “Draft Manual on Risk Analysis and Risk Management Support for Road Slope Disasters”
	The Road Bureau formulated the “Draft Road Geohazard Risk Inspection Guidebook” (Ministry of Construction 1990), which was subsequently revised. For the latest version, see JGCA (2010).	Japan Geotechnical Consultants Association (JGCA 2010): “Road Geohazard Risk Inspection Guidebook”
	The Public Works Research institute (PWRI), which developed the “Draft Manual on Risk Analysis and Risk Management Support for Road Slope Disasters” in 2006, introduced the methodology to estimate the economic benefits of proactive measures based on the expected reduction in average annual economic loss.	Public Works Research Institute (PWRI 2006): “Draft Manual on Risk Analysis and Risk Management Support for Road Slope Disasters”

Table C1.2 Checklist B: Geohazard Risk Management Activities for New Roads (Sample of Checklist Only)

Check items	Status (options 0–4)	Score	Effectiveness or appropriateness 0: No 1: Low 2: Moderate 3: High
Detailed hazard mapping of new road planning for landscape ecosystem areas	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducted fully	4	3
Simple evaluation of hazard levels at each hazard-prone location	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducted fully	4	3
Risk evaluation for new alternative road alignment plan	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducted fully	4	3
Evaluation of potential damage to local social environment	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducted fully	4	2
Geohazard management planning for new roads	0. Never done 1. Planning 2. Planned 3. Considering partially 4. Considering fully	4	2

Description of current status Summarize current status, effectiveness, problems, and so on. Add remarks and/or comments if necessary.	Reference materials or name of respondent. position, and agency Author (year): Title of reference or Name, position, agency
Detailed hazard mapping is a common practice in Japan for new road planning. Detailed hazard maps are used for selecting a safer route or to avoid causing man-made geohazards to the surrounding areas such as cutting or banking. Detailed hazard mapping is conducted by experts in geology and hydrology of engineering consulting firms contracted by the road management authorities. Mapped geohazards are falling, collapsing, or sliding slope areas and historically damaged areas of flow-type geohazards (earth or debris flow, flooding, river erosion). The consultants prepare the detailed hazard maps by interpretation of maps, aerial photographs, or satellite images together with field reconnaissance and interviews regarding historical geohazard events.	Ministry of Land, Infrastructure, Transport and Tourism (MLIT) National Research Institute for Earth Science and Disaster Prevention (NIED): http://www.bosai.go.jp/e/
Engineering consultants contracted by road management authorities usually conduct the outline investigations for new road planning. They prepare detailed hazard maps through simple evaluation of the potential hazard levels such as slope instability. Each geohazard is assigned to one of either two (high and low) or three (high, medium, and low) potential hazard levels. The hazard levels are determined by using available geographical information such as maps, aerial photographs, and satellite images.	MLIT
It is a general practice that the engineering consultants contracted by the road management authorities prepare the alternative road alignments including the risk evaluation results. The risk evaluation results include detailed hazard maps showing the new road alignment, an inventory table of hazard-prone locations with simple hazard level evaluation, and a risk summary of alternative road alignments (number of hazard-prone locations, their potential hazard levels, and geohazard characteristics). The alternative new road alignment is planned to avoid hazard-prone locations as much as possible. This geohazard avoidance saves construction costs, including the costs of structural measures for geohazard and subsequent maintenance costs. Figure 3.3 of the main Handbook shows the sample of a detailed hazard map showing the alternative new road alignments.	MLIT
It is a general practice that the engineering evaluation (as contracted by the road management authorities) include a social and environmental assessment process. To this end, the National Institute for Land and Infrastructure Management (NILIM) developed a technical procedure for the evaluation of ground deformation and geohazards (NILIM 2013).	MLIT National Institute for Land and Infrastructure Management (NILIM 2013): "Environmental Impact Assessment Technique for Road Project (Edition of FY 2012)."
The following is undertaken to manage geohazard risks during planning for new roads: • Survey(s) to identify the geohazard locations or areas, including flow-type geohazard sources in landscape ecosystem areas through which a new road is planned • Avoidance (to the extent possible) of road routes into potential hazard-prone locations to reduce construction costs for geohazard countermeasures and to reduce potential economic losses during the service period caused by road damage or closure due to geohazard(s) • Planning of proactive structural measures for hazard-prone locations on selected new alignments—including consideration of minor alignment shifting and using bridge structure and tunnels as alternative solutions for securing road users' lives and reducing economic losses due to road closing and recovery. Tunnels and bridges can shorten the road distance, which generates benefits in terms of travel time-saving. At the same time, tunnels and bridges can avoid hazard-prone locations and make roads robust against geohazards. The roads can be emergency transportation and evacuation routes at the time of wide-area disasters such as earthquakes, tsunamis, storms, and so on.	MLIT

Table C1.3 Checklist C: Geohazard Risk Management Activities for Existing Roads (Sample of Checklist Only)

Question	Item number	Check items	Status (options 0–4)	Score	Effectiveness or appropriateness 0: No 1: Low 2: Moderate 3: High
Has risk evaluation for existing roads been conducted?	ER-1 Basic method	Identification of road hazard-prone location Basic method: On-site visual inspections and information from road users	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducting fully	4	3
	ER-1 Intermediate method	Identification of geohazard-prone road locations Intermediate method: Identification survey	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducting fully	4	2
	ER-1 Advanced method	Identification of geohazard-prone road locations Advanced method: Detailed hazard mapping	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducting fully	3	2

	Description of current status Summarize current status, effectiveness, problems, and so on. Add remarks and/or comments if necessary.	Reference materials or name of respondent, position, and agency Author (year): Title of reference or Name, position, agency
	The basic methods are conducted during routine maintenance activities by the road maintenance staff. In 1962, the Road Bureau disseminated an "Order for Road Maintenance and Management" to national and subnational road management authorities. This order instructed the road management authorities to conduct routine patrols of roads with annual average traffic volume exceeding 300 vehicles per day. It further stipulated that the patrols be conducted during typhoons or heavy rains. The purposes of the patrols were to preserve the road, ensure smooth traffic, and properly maintain the roads—enabling the authorities to immediately address defective road locations with the appropriate measures as soon as possible. As practiced according to the 1962 order, the patrols are undertaken once a day throughout the week. Information provided by road users is also used: users can call the road management authority by dialing #9910.	Ministry of Land, Infrastructure, Transport and Tourism (MLIT)
	The Road Bureau of the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) ordered all road management authorities to conduct a total of 10 nationwide road geohazard risk inspections from 1968 to 2006. These inspections were to identify hazard-prone road locations through visual inspection by engineering geology and civil engineering experts in private engineering firms contracted by road management authorities. The identification categories of hazard-prone road locations were stipulated by the Road Bureau for each order given for the nationwide road geohazard risk inspection.	MLIT Japan Geotechnical Consultants Association (JGCA 2010): "Road Geohazard Risk Inspection Manual" Ando et al. (2015): "Risk Inspection Procedure for Road Slope Geohazard Prevention"
	Detailed hazard mapping was mostly prepared for geohazard-prone road subsections on national highways using private engineering consulting firms. The "Road Geohazard Risk Inspection Guidebook" (JGCA 2010) stipulated a geohazard identification procedure consisting of desk-checking and field visual inspection. Desk-checking is the review of geohazard information on historical disaster events and designated geohazard areas and interpretation of maps and aerial photographs. Geographical interpretation identifies microtopography and evaluates assumed geohazard movement types, magnitudes, and effects on roads. The "Road Geohazard Risk Inspection Guidebook" (JGCA 2010) stipulated that the slope facing the road should be interpreted from the mountain ridge (or hilltop) to the valley bottom and, if a geohazard-contributing factor is identified, it should be confirmed by visual field inspection. Nowadays, accurate maps using laser profiling and geographical information systems (GIS) are used to conduct detailed hazard mapping.	National Highway and Risk Management Division, Road Bureau, MLIT Japan Geotechnical Consultants Association (JGCA 2010): "Road Geohazard Risk Inspection Guidebook"

Question	Item number	Check items	Status (options 0–4)	Score	Effectiveness or appropriateness 0: No 1: Low 2: Moderate 3: High
Has risk evaluation for existing roads been conducted?	ER-2 Basic method	Risk evaluation of a geohazard-prone road locations Basic method: Simple risk evaluation using multiple criteria	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducting fully	4	2
	ER-2 Intermediate method	Risk evaluation of a geohazard-prone road location Intermediate method: Risk level rating	0. Never done 1. Planning 2. Planned 3. Conducting partially 4. Conducting fully	1	0

	Description of current status Summarize current status, effectiveness, problems, and so on. Add remarks and/or comments if necessary.	Reference materials or name of respondent, position, and agency Author (year): Title of reference or Name, position, agency
	Risk evaluation includes evaluation of likelihood and damage impact (or consequence) of a road location. The Japanese practice first evaluates the likelihood of occurrence of a road geohazard event, after which the damaging impact or consequence is evaluated by priority road section, including identification of the designated emergency roads and existence of detour roads. The risk evaluation procedure is as follows: 1) Evaluate the likelihood of a geohazard occurrence for a road location using three categories: (a) requirement for proactive measures; (b) periodical visual inspection monitoring; and (c) no further action. 2) The road location of the “required for proactive measures” is categorized by the road section priority (arterial or not arterial, designation as emergency road, and/or existence of detour road).	National Highway and Risk Management Division, Road Bureau, MLIT Japan Geotechnical Consultants Association (JGCA 2010): “Road Geohazard Risk Inspection Guidebook”
	In Japan, a “risk level rating” is not conducted; just the “hazard level rating” (likelihood level of road geohazard damage event occurrence) is conducted, as described in subsection 3.1.2 (“Basic method: Simple Risk Evaluation of a Hazard-Prone Road Location Using Multiple Criteria”). A “risk level rating” procedure has not been established.	MLIT

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GFDRR is a global partnership that helps developing countries better understand and reduce their vulnerabilities to natural hazards and adapt to climate change. Working with over 400 sub-national, national, regional, and international partners, GFDRR provides grant financing, technical assistance, training, and knowledge sharing activities to mainstream disaster and climate risk management in policies and strategies. Managed by the World Bank, GFDRR is supported by 37 countries and 11 international organizations.

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Layout/graphic design by Carlos Plaza Design Studio.

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