

ROAD ADMINISTRATOR'S RESPONSE TO THE 2004 NIIGATA-KEN CHUETSU EARTHQUAKE

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ABSTRACT

At 5:56 p.m. on October 23, 2004, a magnitude 6.8 earthquake occurred with its epicenter in the Chuetsu Region of Niigata Prefecture. It was named the 2004 Niigata-ken Chuetsu Earthquake by the Japan Meteorological Agency. This earthquake first recorded seismic intensity of 7, the highest on the Japanese seismic intensity scale, since the beginning of instrumental measurement of seismic intensity in Japan. With its epicenter in a mountainous region, it caused many slope failures and landslides, cutting off the road network at numerous locations.

Immediately after the earthquake, the headquarters of the Ministry of Land, Infrastructure and Transport (MLIT) proclaimed an emergency status to cope with earthquake damage and established the MLIT Emergency Disaster Countermeasure Headquarters. The Hokuriku Regional Development Bureau (HRDB) of MLIT also proclaimed an emergency status for earthquake disaster and established the HRDB Disaster Countermeasure Headquarters. The MLIT Work Offices in and around Niigata Prefecture proclaimed necessary status ranging from emergency to advisory. With those statuses, MLIT devoted every its resources to restoration so that all MLIT directly administered national highways were reopened to general traffic by the second day after the earthquake except one tunnel, and normal traffic was ensured on all directly administered national highways by the 10th day after the earthquake.

1. INTRODUCTION

Japan is located at the point where the Eurasian Plate, the Pacific Plate and the Philippine Sea Plate meet, and there are approximately 2,000 active faults under its land area, resulting in an extremely high level of seismic activity and volcanic activity. Even during the years since the 1995 Hyogo-ken Nanbu earthquake (magnitude $M=7.3$) that claimed more than 6,400 lives, many disastrous earthquakes have struck Japan, including the 2000 Tottori-ken Seibu Earthquake ($M=7.3$), the 2001 Geiyo Earthquake ($M=6.7$), the 2003 Miyagi-ken Oki Earthquake ($M=7.1$), the 2003 Tokachi Oki Earthquake ($M=8.0$), the 2004 Niigata-ken Chuetsu Earthquake ($M=6.8$) and the 2005 Fukuoka-ken Seiho Oki Earthquake ($M=7.0$).

The 2004 Niigata-ken Chuetsu Earthquake was a magnitude 6.8 earthquake that occurred at 5:56 p.m. on October 23, 2004 with its epicenter in the Chuetsu Region of Niigata Prefecture. This earthquake first recorded seismic intensity of 7, the highest on the Japanese seismic intensity scale, since the beginning of instrumental measurement of seismic intensity in Japan. It was followed by numerous aftershocks including two with

largest seismic intensity of 6 upper on the same day, and two more with largest seismic intensity of 6 lower on October 23 and 27.

The fault rupture zone of the Niigata-ken Chuetsu Earthquake was located where landslides occur extremely frequently, and this earthquake was featured by many slope failures and landslides that it triggered. As a result, in addition to damage to houses, it isolated hamlets by cutting off roads and other lifelines linking them to the outside. And those slope failures and landslide also blocked river courses, causing flood damage.

This report summarizes the response of road administrators to the 2004 Niigata-ken Chuetsu Earthquake, focusing on the response of MLIT [1].

2. OVERVIEW OF EARTHQUAKE DAMAGE

2.1 Casualties and damage to houses

The Niigata-ken Chuetsu Earthquake had, by October 14, 2005, caused 51 fatalities, injured 4,805 people, totally destroyed 3,185 houses, partially destroyed 13,715 houses and partially damaged 104,560 houses (Fire Defense Agency [2]). Of the dead, 16 were killed directly by collapsing buildings, while many others died of shock at the time of the earthquake or later of stress induced by the earthquake. The earthquake occurred a little before 6:00 p.m., presumably a time when people were eating or preparing the evening meal, but a few fires started.

2.2 Disruption of the wide area transportation infrastructure

Figure 1 shows the epicenter of the Niigata-ken Chuetsu Earthquake and major roads serving the region. Immediately after the earthquake, traffic was stopped on the Hokuriku Expressway in both directions between the Kashiwazaki Interchange and the Sanjo-Tsubame Interchange, and on the Kan-etsu Expressway, in the inbound direction between the Nagaoka Junction and the Yuzawa Interchange and in the outbound direction between the Tsukiyono Interchange (Gunma Prefecture) and the Nagaoka Junction. On national highways, traffic was either stopped or forced to travel alternately in only one direction at 55 locations on Routes 8, 17, 116, 117, 252, 291 and others. The derailing of a train on the Joetsu Shinkansen further disrupted transportation between the Tokyo Metropolitan and Niigata Prefecture.

On the Hokuriku Expressway and Kan-etsu Expressway, emergency restoration work was completed, enabling the passage of emergency vehicles at 1:00 p.m. on October 24 only 19 hours after the earthquake. At 10:00 p.m. on October 26 that was 76 hours after the earthquake, traffic restrictions were removed from the entire Hokuriku Expressway and except for one part, from the Kan-etsu Expressway.



Figure 1 Epicenter of the Niigata-ken Chuetsu Earthquake and major roads

On the directly administered national highway Routes 8, 17 and 116, traffic restrictions were gradually relieved during the 20 hours following the earthquake, and by the early morning of October 25, two days later, emergency restoration work was completed at almost all locations, ensuring the passage of both emergency vehicles and disaster region traffic. The completion of emergency restoration at the Wanazu Tunnel on the national highway Route 17, where the interior of the tunnel had been collapsed, enabled the passage of emergency vehicles and disaster region traffic on that route by the tenth day after the earthquake.

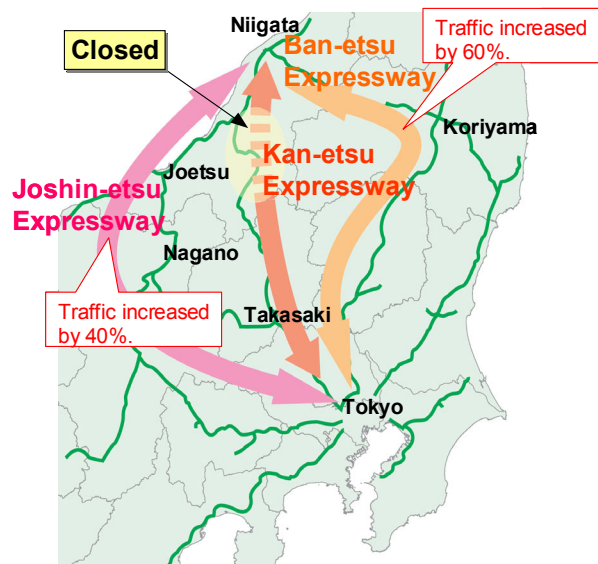


Figure 2 Benefit of nationwide network of expressways after the 2004 Niigata-ken Chuetsu Earthquake

Road traffic linking Niigata with the Tokyo Metropolitan was maintained, because although the Kan-etsu Expressway was closed, an expressway network consisting of the Joshin-etsu Expressway through Nagano and the Ban-etsu Expressway through Fukushima had been constructed in Niigata Prefecture, so these two expressways took over the function of the Kan-etsu Expressway. The average traffic volume of these two expressways from October 25 (Monday) to October 29 (Friday) was compared to before the earthquake, and the comparison shows an about 1.6 times increase for the Ban-etsu Expressway and an about 1.4 times increase for the Joshin-etsu Expressway in traffic volume (Figure 2). The Joetsu Shinkansen resumed service on December 28, but to ensure links between Niigata and Tokyo, emergency flights were provided between Niigata Airport and Haneda Airport until January 4, 2005, carrying a total of 210,000 passengers. Note that there are no regular services between those two airports. In order to compensate for the shutdown of the Shinkansen, many temporary busses traveled on the expressways.

3. SYSTEMS ESTABLISHED BY MINISTRY OF LAND, INFRASTRUCTURE AND TRANSPORT AND JAPAN HIGHWAY PUBLIC CORPORATION

3.1 System established by the headquarters of MLIT

The headquarters of MLIT proclaimed an emergency status for earthquake disaster immediately after the earthquake and established the 2004 Niigata-ken Chuetsu Earthquake MLIT Emergency Disaster Countermeasure Headquarters. MLIT provided officials to coordinate the activities of the local support countermeasure section that the Government had established in the Niigata Prefectural Office.

On November 26, the Emergency Disaster Countermeasure Headquarters was reorganized and the 2004 Niigata-ken Chuetsu Earthquake MLIT Disaster Restoration Support Headquarters (Chief: Vice Minister of MLIT) was established, in response to the Niigata-ken Chuetsu Earthquake Restoration Support Meeting (first meeting) was held by the Government on November 24. The MLIT Disaster Restoration Support Headquarters was responsible for ensuring that the damage restoration performed by MLIT and support for restoration from the disaster were conducted appropriately and smoothly.

3.2 System established by HRDB

3.2.1 *System for disaster countermeasures*

After the earthquake of October 23, HRDB immediately proclaimed a state of emergency for earthquake disaster and established the Niigata-ken Chuetsu Earthquake HRDB Disaster Countermeasure Headquarters to perform emergency restoration work of its facilities and to support local governments. 20 MLIT Work Offices in and around the Chuetsu Region of Niigata Prefecture also declared the following status:

- Emergency status (seismic intensity of 6 lower or higher): 6 offices
- Warning status (seismic intensity of 5 upper and lower): 7 offices
- Advisory status (seismic intensity of 4): 7 offices

In order to efficiently perform emergency restoration work on the national highway Route 291 where MLIT acted on behalf of Niigata Prefecture in response to a request by the prefecture, and emergency restoration work on MLIT directly administered erosion and sediment control work on the Imo River, the Chuetsu Earthquake Restoration Countermeasure Division (Preparation Division) (Division Head: Head of the Wide Area Planning Division of the Planning Department) was formed inside HRDB on November 5.

Under the above-mentioned status, emergency restoration progressed rapidly with MLIT directly administered facilities, for example, two lanes of the Wanazu Tunnel were reopened to traffic on the national highway Route 17 on December 26, and a temporary drainage channel was completed on the Imo River on December 28. So on December 28, HRDB Disaster Countermeasure Headquarters cancelled the state of emergency and replaced it with an advisory status. It was the 67th day since the proclamation of the state of emergency on October 23.

3.2.2 *System established to support restoration*

In order to comprehensively and efficiently support restoration projects and reconstruction, HRDB established the Niigata-ken Chuetsu Earthquake HRDB Restoration Headquarters on December 28. It took over the functions of the Disaster Countermeasure Headquarters to perform rapid restoration and to support recovery. With the Director-General of HRDB as Headquarters Chief, its other members were the Vice Director-General and Directors of every departments, the Director of the Shinano River Work Office, the Director of the Nagaoka Highway Work Office, the Director of the Yuzawa Erosion and Sediment Control Work Office, and the Head of the Chuetsu Earthquake Restoration Countermeasure Division.

3.2.3 *System to support local governments*

In order to support disaster restoration by local governments, the following support headquarters and similar organizations were established inside HRDB to deal with road related issues.

- Niigata-ken Chuetsu Earthquake MLIT Restoration Support Countermeasure Field Liaison Meeting (Chairman: Director of the Planning Department)
The Japan Meteorological Agency, the Japan Coast Guard and other organizations of MLIT concerned held a support liaison meeting on November 2.
- Restoration Support Headquarters for Municipal Roads Damaged by the Niigata-ken Chuetsu Earthquake (Headquarters Chief: Road Survey Officer)

It was formed on October 30 to support emergency surveys of the state of damage to municipal roads.

- Restoration Support Headquarters for Damaged Municipalities (Headquarters Chief: Technical Coordination Administrator)
It was established on November 8 in conjunction with five adjoining Regional Development Bureaus.

3.3 System established by Japan Highway Public Corporation

The former Japan Highway Public Corporation (JHPC) that managed expressways adopted a system similar to that of MLIT. In brief, the headquarters of JHPC proclaimed a state of emergency immediately after the earthquake and established the Emergency Disaster Countermeasure Headquarters. The Hokuriku Branch of JHPC proclaimed a state of emergency and established the Hokuriku Branch Disaster Countermeasure Headquarters. Each of its management offices in the earthquake-affected region proclaimed a state of emergency, inspected expressways and took emergency response measures.

4. DAMAGE TO ROADS

4.1 Overview

Among the MLIT directly administered national highways, Routes 8, 17, and 116 were damaged, and particularly severe damage was inflicted on the Wanazu Tunnel and at Tenno in Kawaguchi Town on the national highway Route 17. There were a total of 41 damaged locations (8 locations, 31 locations, and 2 locations on Routes 8, 17, and 116, respectively), still however, nobody was killed or injured at those locations. These resulted in complete road closures at 17 locations and alternating one-way traffic at 2 locations (Table 1).

On expressways, the Hokuriku Expressway (around the Nagaoka Junction) and the Kan-etsu Expressway (mainly between Nagaoka and Koide) were completely closed to traffic, while 970 locations were damaged on prefecturally administered national highways and major prefectural roads, and those roads were completely closed to traffic at 224 locations. On municipal roads, 1,723 locations were damaged, and traffic was completely closed at 845 locations.

4.2 National highway Route 8

4.2.1 Outline of the route

The national highway Route 8, a wide area trunk highway extending 600km on the Japan Sea side of Japan, originates in Niigata City, passes through Toyama, Ishikawa, Fukui and Shiga Prefectures, and ends in Kyoto. Within Niigata Prefecture, it supplements the Hokuriku Expressway, receiving traffic from the Kanto and Kansai regions, and at the same time it plays an important role as a trunk highway carrying traffic between the major cities of Niigata, Nagaoka, Joetsu and others and in

Table 1 Number of locations completely closed to traffic [1]

| Roads | | Locations completely closed to traffic |
|---|-----------|--|
| Directly managed national highways | Route 8 | 7 (8) |
| | Route 17 | 9 (31) |
| | Route 116 | 1 (2) |
| | Subtotal | 17 (41) |
| Prefecturally managed national highways | | 61 (242) |
| Prefectural roads | | 163 (728) |
| Municipal roads | | 845 (1,723) |
| Total | | 1,068 (2,734) |

* On expressways, traffic was completely stopped on the Hokuriku Expressway (around the Nagaoka Junction) and on the Kan-etsu Expressway (mainly between Nagaoka and Koide).

* () denotes the number of damaged locations.

maintaining links between other towns and cities along its course.

The part of this highway where damage occurred parallels the Hokuriku Expressway, and the traffic volume at its peak location is 46,221 vehicles/day (Shinkumi-cho in Nagaoka City, 1999 road traffic census).

4.2.2 Earthquake damage

This highway was damaged at 8 locations. At Kamishinden in Mitsuke City, the embankment behind an abutment of the Mitsuke Bridge (L=148m) subsided, and caused a level difference (approximately 40cm) on the vehicle lanes (Photo 1). The bridge bearings were also damaged.

In Miyamoto-cho in Nagaoka City, the embankment behind a bridge abutment at the Miyamoto Bridge (L=40.2m) settled, a parapet of the Kan-non Bridge (L=29m) was cracked, and embankments collapsed. Additionally, the road surface subsided in Kashiwazaki City.

These required that traffic be completely closed at a total of 7 locations on the national highway Route 8.

4.3 National highway Route 17

4.3.1 Outline of the route

The national highway Route 17 is a wide area trunk highway that originates in Tokyo then crosses Honshu for 440km to Niigata City. As a main artery linking the Kanto Economic Region with the Japan Sea Economic region, it plays important roles in the development of industrial, economic and cultural activities. Inside Niigata Prefecture, it is linked to the Kan-etsu Expressway to receive traffic from the Kanto Region, and at the same time it is an arterial road that supports transportation between Nagaoka City and municipalities along its route.

The damaged portion of the highway parallels the Kan-etsu Expressway and carries 21,868 vehicles/day (Kizu in Ojiya City, 1999 road traffic census).

4.3.2 Earthquake damage

Damage occurred at 31 locations. At the Wanazu Tunnel (L=300m) in Kawaguchi-cho, the crown of covering concrete (length about 20m, width about 2m, volume about 20m³, and weight about 50t) separated, pushing part of the side wall into the tunnel (Photo 2). Bearings of the Wanazu Bridge (L=300m) were also damaged. At Maejima, the road surface subsided about 40cm. At



Photo 1 Road level difference at the Mitsuke Bridge, national highway Route 8 [1]



Photo 2 Damage inside the Wanazu Tunnel, national highway Route 17

Ushigashima, concrete block retaining walls fell for a length of about 24m, and on the slope behind the walls, surface landslide (width about 30m, length about 50m) occurred, reaching the road (Photo 3). At Tenno, in a section close to the JR Joetsu Line, the road collapsed, enclosing the line (L=56m, H=40m) (Photo 4). An optical fiber communication cable buried under the road was also broken.



Photo 3 Slope collapsed at Ushigashima, national highway Route 17 [1]

At Hiu in Ojiya City, the road surface subsided about 55cm, bearings and main girders of the Ojiya Bridge (L=300m), which spans the Shinano River, were deformed, and the cover concrete of bridge piers were separated, exposing the reinforcing bars (Photo 5). In Tokamachi in Nagaoka City, a level difference (approx. 30cm) appeared on a traffic lane on the Tokamachi Viaduct (L=534.8m).



Photo 4 Collapsed road at Tenno, national highway Route 17 [1]

As a result of these, traffic was completely stopped at 9 locations on the national highway Route 17, and detours including expressways and prefectural roads, the Joetsu Shinkansen, and the JR Joetsu Line were all impassible. Under those circumstances transportation networks between the region and the Tokyo Metropolitan were temporally disrupted.

4.4 National highway Route 116

4.4.1 Outline of the route

The national highway Route 116 is a major trunk highway with total length of 85km connecting Kashiwazaki City and Niigata City. It supplements the Hokuriku Expressway, and plays a major role as trunk road linking towns and cities along its route.



Photo 5 Damaged bridge pier of the Ojiya Bridge, national highway Route 17 [3]

It was damaged in Kariwa Village, a location where it parallels the Hokuriku Expressway and is close to the junction with the national highway Route 8. Its traffic volume is 14,938 vehicles/day (Kariwa in Kariwa Village, 1999 road census).

4.4.2 Earthquake damage

The highway was damaged at two locations in Kariwa Village. In both cases, box culverts for farm roads were damaged. These two locations were treated as one location to completely close the road to traffic.

4.5 National highway Route 291

The national highway Route 291 is a 240km long national highway managed by prefectures that starts in Maebashi City in Gunma Prefecture and ends in Kashiwazaki City in Niigata Prefecture. The Niigata-ken Chuetsu Earthquake caused particularly severe damage on an approximately 10km stretch of the national highway Route 291 from Takezawa in Nagaoka City (formerly Yamakoshi Village) to Oguriyama in Ojiya City, and at some places on the road, damage was so severe that the original shape of the road disappeared (Photo 6). The damaged locations in this road section included the collapse of the road at 15 locations, slope failure at 9 locations, and bridge damage at 3 locations.



Photo 6 Collapsed road at Higashi-Takezawa, national highway Route 291 [1]

4.6 Kan-etsu Expressway

The Kan-etsu Expressway is a major traffic artery that, along with the Joetsu Shinkansen, links Tokyo with Niigata. The Kan-etsu Expressway was damaged between the Koide Interchange, which is close to the earthquake epicenter, and the Nagaoka Junction. The typical forms of damage were subsidence of road surface at bridge approaches and box culverts crossing the expressway, settlement of embankments, accompanying settlement and cracking of road surfaces, and damage of retaining walls. The section where the damage was particularly severe was the section between the Horinouchi Interchange and the Echigokawaguchi Interchange that passes through the earthquake fault region (Photo 7). In this section, large-scale embankment collapses occurred, causing damage that completely destroyed traffic lanes. At bridges, the earthquake caused bearing damage, expansion damage, and damage to the ends of bridge girders. Concrete block retaining walls and reinforced earth retaining walls were also damaged.



Photo 7 Damage to Kan-etsu Expressway (between Horinouchi IC and Echigo-Kawaguchi IC) [1]



Photo 8 Road Consulting Section answering a flood of inquiries (October 24, 2004) [1]

5. IMMEDIATE POST-EARTHQUAKE RESPONSE

Although HRDB declared a state of emergency immediately after the earthquake, power failures prevented on-site CCTV cameras from viewing state of damage, and because companies contracted to perform emergency patrols were also affected by the disaster, it was extremely difficult to gather information. Therefore, HRDB sent the personnel to its

Work Offices and to the sites to gather information. The road consultation section was so overwhelmed by countless inquiries that it extended its hours beyond the normal closing time of 5:00 p.m. to place staff on duty 24 hours/day (Photo 8).

At the Nagaoka Highway Work Office, a disaster countermeasure headquarters was set up to take emergency measures although its bookshelves, lockers, etc. were in disorder, it could not use electricity or water for 2 or 3 days, and gas was not available for more than 2 weeks. Damage to roads was unexpectedly severe, preventing road patrol car traveling, and cell phones were almost completely unusable, so in some districts, the personnel collected and transmitted information on foot. Cooperating with the police, the staff of the Nagaoka Highway Work Office and those from other Work Offices took measures such as closing roads to traffic.

6. EMERGENCY RESTORATION

6.1 Overall Policy

At locations completely closed to traffic, space permitting the passage of at least one emergency vehicle was ensured first, then step-by-step and urgent emergency restoration measures were implemented.

The experts in earthquake engineering and related areas of the National Institute for Land and Infrastructure Management and the Public Works Research Institute were sent to the sites from the second day after the earthquake. To deal with tunnels and bridges where advanced technological judgments concerning emergency repair and restoration had to be made in a short time, technical committees (deliberations partially open to the public) including academic experts among their members were formed in order to ensure fast decisions on restoration methods.

Furthermore, the disaster area is a cold region where they have heavy snow, winter is harsh to restoration works, and road closures to perform the restoration work may obstruct not only the passage of ordinary vehicles but also seriously hampered snow removal work. Therefore, the work was conducted round the clock to reopen all lanes as quickly as possible.

6.2 Transition of Traffic Restrictions

As an example of data indicating the state of progress of restoration works, Table 2 shows the numbers of locations where traffic was completely closed on national highways and prefectural roads. Immediately after the disaster, traffic was completely closed at about 100 locations. By the tenth day, complete traffic closures had been cancelled on all directly administered national highways, but under the impact of aftershocks, the number of

Table 2 Number of locations completely closed to traffic on national highways and prefectural roads

| | Immediately after disaster Oct. 23, 2004 | November 3 | December 27 | July 15, 2005 | October 28, 2005 |
|----------------------------|--|------------|-------------|---------------|---------------------|
| Route 8 | 7 | 0 | 0 | 0 | 0 |
| Route 17 | 9 | 0 | 0 | 0 | 0 |
| Route 116 | 1 | 0 | 0 | 0 | 0 |
| Other national highways | 24 | 21 | 12 | 10 | 10 |
| Prefectural roads | 60 | 89 | 48 | 37 | 35 |
| Total | 101 | 110 | 60 | 47 | 45 |

completely closed locations increased on prefectural roads. The number of completely closed locations was reduced by almost half in about 2 months.

6.3 Bridges

On the directly administered national highways, 12 bridges were damaged, but as a consequence of progress in seismic retrofitting, damage requiring long term restoration such as collapse of bridge did not occur, and directly administered national highways functioned as emergency transportation routes.

6.4 Tunnels

At the Wanazu Tunnel on the national highway Route 17 (L=300m, Wanazu, Kawaguchi Town), the earthquake caused covering concrete to peel from the inside of the tunnel for approximately 120m from the Nagaoka side portal, and this forced the temporary closure of the tunnel to all traffic. The Wanazu Tunnel is a key transportation point used by 17,000 vehicles/day, and because there are no alternative routes usable as detours in the district, it had to be restored as quickly as possible. The emergency measures taken were steel H-shaped timbering work and concrete spraying work, which enabled alternating traffic on a single lane on November 2. And to protect passing vehicles from falling objects, before it was opened to traffic, protectors were installed to prevent damage to vehicles. The Wanazu Tunnel intersects a tunnel on the JR Joetsu Line located directly below it, so the restoration work was done with great care.

6.5 Embankments

Large-scale collapse of embankments occurred at Miyamoto in Nagaoka City on the national highway Route 8 and at Tenno in Kawaguchi Town on Route 17.

At Tenno in Kawaguchi Town on the national highway Route 17, a large-scale slope collapse including part of the road and the JR Joetsu line forced the temporary closure of the road to all traffic. Because it would take a long time to restore the damage, an emergency single lane was immediately constructed on the shoulder of the highway on October 25 (for emergency vehicles and local traffic). With the cooperation of landowners, a detour was constructed on the mountain-side of the highway on October 31 (Photo 9). Efforts to ensure traffic continued and restoration of the main highway was completed on December 29.

Land necessary for the detour was loaned by three landowners during the work period, and compensation was paid for the movement of the combined display space and office of a gravestone maker and one house on the detour route.

6.6 Cuts and Slopes

Large-scale collapse of cuts and slopes occurred on the national highway Route 17 in Horinouchi Town and at Ushigashima in Kawaguchi Town. At Ushigashima, the slope collapsed and the road surface settled in a 200m section including an approximately 90m long cut section. The first step in its restoration was to remove the collapsed soil. Then, in the sheathing section, the soldier piles and lagging method was adopted to prevent soil from flowing into the road lane,



Photo 9 Detour at Tenno, national highway Route 17 [3]

and in the cut section, cracks on the slope were partially cut to ensure safety.

6.7 Kan-etsu Expressway

On the Kanetsu Expressway, as described in 2.2, after the road closure was ended on October 26 except certain sections. Single lane traffic for both directions was released on October 27 so that the emergency vehicles could travel quickly and smoothly. Special measures were taken, such as exempting expressway toll for vehicles transporting emergency support materials. Later, at locations with large level differences, crushed stone was laid, road surfaces were restored with emergency paving, and bridges were restored, then on November 5, one lane was opened in each direction for ordinary vehicles and the closure was cancelled on the entire route. Then all four lanes were opened on November 26.

7. RESTORATION OF NATIONAL HIGHWAY ROUTE 291

On November 2, 2004 that was 10 days after the earthquake, the Governor of Niigata Prefecture required the Minister of Land, Infrastructure and Transport to provide support with the restoration of the national highway Route 291 that was managed by Niigata Prefecture. The Minister of Land, Infrastructure and Transport responded on the same day by designating a 10km part of Route 291 where the damage was most severe as an MLIT proxy exercise of authority road section; one where the Government would perform restoration on behalf of the prefecture, and began emergency restoration work.

Niigata Prefecture is a heavy snowfall region where the maximum snow cover reaches a depth of 5.8m, so the emergency restoration work had to be completed before the snow started falling to prevent the spring thaw from causing any secondary disasters. Therefore, the work was executed day and night, and on December 14 before snow began falling in earnest, the road was able to be used by emergency vehicles and construction vehicles. The restoration plan was enacted by establishing the National Highway Route 291 Damage Restoration Technical Committee, whose members were scholars and other experts, to study restoration policies. At locations where collapsed soil and other damage was particularly severe, restoration was carried out on a separate route.

In order to accelerate the restoration, on March 28, 2005, snow removal began while 2m of snow remained on the ground, then work began in April in earnest. Simultaneous work on bridges and tunnels was executed and new technologies were applied to bridge pier work in order to shorten the work period. To ensure harmonization with natural scenery, execution that added roundness to cutting lines was performed, slopes were vegetated with Japanese pampas grass and other species native to the region, and vehicle guard fences and overturning

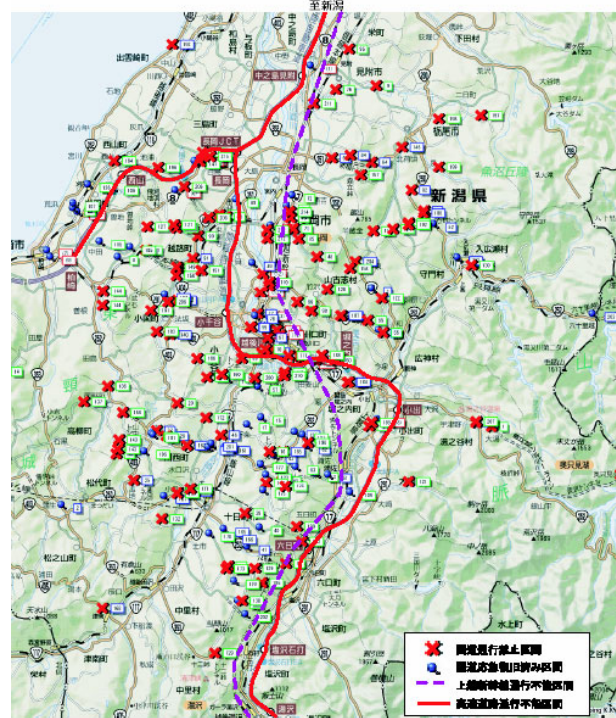


Figure 3 Provision of road closure information on web site [1]

prevention guard fences were constructed using wood obtained by thinning in Niigata Prefecture. On December 22, 2005, work was almost completed on the restoration of the 8km section of the original road, so the traffic closure was cancelled on approximately 5km on the Ojiya side. Later on September 3, 2006, the MLIT proxy exercise of authority road section was opened for about 10km.

8. PROVISION OF INFORMATION ON ROADS

After the earthquake, a flood of inquiries about road damage and restoration were received. In order to satisfy this demand for information, HRDB shared information with Niigata Prefecture, and as shown in Figure 3, information was provided concerning traffic closures on national highways and on prefectural roads on a web site. The Nagaoka Highway Work Office provided information about congestion on roads and on road closures on a cell phone web site (Photo 10). This site was accessed many times by people seeking information about the state of congestion at the Wanazu Tunnel and so forth.



Photo 10 Guide to cell phone road information provision web site [3]

9. CONCLUSION

Japan, as one of the world's most earthquake prone countries, has been struck by many disastrous earthquakes. But in order to ensure the safety of road transportation, a variety of seismic measures have been taken, and guidelines to methods of minimizing the impacts of earthquakes once they have occurred have been prepared. This report has described damage to roads by the 2004 Niigata-ken Chuetsu Earthquake, which caused the worst damage among recent earthquakes. It has also reported actions taken by road administrators to cope with this damage. The authors hope that this report will contribute to greater understanding of initiatives related to measures to protect roads from earthquakes in Japan.

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