REPORT OF THE URAKAWA-OKI EARTHQUAKE OF MARCH 21, 1982

BY

TOMOMITSU YASUE
TOSHI O IWASAKI
YASUSHI SASAKI
HIDEYA ASANUMA
TAKEO NAKAJIMA

PUBLIC WORKS RESEARCH INSTITUTE *
MINISTRY OF CONSTRUCTION

Fourteenth Joint Meeting
U.S. - Japan Panel on Wind and Seismic Effects, UJNR
Washington, D.C., U.S.A.
May 17 - 20, 1982

* Dr Toshio Iwasaki, Head
Earthquake Engineering Division
Public Works Research Institute
Ministry of Construction
Tsukuba Science City
Ibaraki - Pref.
305 Japan
ABSTRACT

On the Sunday morning of March 21, 1982, a severe earthquake of a magnitude of 7.3 on the Richter Scale hit Urakawa-oki or off Urakawa, the southern part of Hokkaido Island in Japan. This report briefly describes an outline of the earthquake and damages to civil engineering structures due to the Urakawa-oki Earthquake of March 21, 1982.

OUTLINE OF EARTHQUAKE

From the report of the Japan Meteorological Agency (JMA)\(^1\), the outline of the Earthquake is summarized as follows:

1) Date and Time: 11:32 am, Sunday, March 21, 1982
2) Magnitude (Richter Scale): 7.3
3) Epicenter: 20 km off Urakawa, 150 km south-east from Sapporo
   \(42.1^\circ N, 142.6^\circ E\)
4) Depth: 10 km
5) JMA Intensities: 6 - Urakawa
   4 - Tomakomai, Sapporo, Otaru, Iwanizawa, Hiroo,
   Kuchan, Obihiro
   3 - Kushiro, Asahikawa, Muroran, Hakodate, Aomori,
   Morikawa

Fig. 1 indicates the epicenter and JMA intensities at various locations reported by JMA. Fig. 2 is a detailed map showing epicenters of aftershocks, as well as the main shock epicenter, obtained from a densely instrumented network of Science Department of Hokkaido University.\(^2\) From Fig. 2 it is seen that the epicenter is located off Mitsuishi about 15 km west from Urakawa, and the depth is about 30 km.

Strong-motion accelerographs recorded accelerations at several locations. Table 1 tabulates typical values of peak accelerations on grounds and structures. The locations and peak accelerations are also shown in Figs. 3 and 4. Unfortunately no record was available near the epicenter. The largest acceleration (about 300 gals) was triggered at Hiroo, about 60 km east from the epicenter. At Horoman Bridge located about 40 km east from the epicenter, the peak value was only about 80 gals (uncorrected value obtained from SMAC-82 type accelerograph). Peak accelerations at Sapporo city were also about 70 gals.
Fig. 1  Epicenter and J.M.A. Intensities,
Ura kawa—oki Earthquake of March 21, 1982
Fig. 2 Epicenters of Fore Shock, Main Shock and Numerous Aftershocks (After Science Department, Hokkaido Univ.)

Photo 1 Damage to Slope along National Highway Route 235, at Irifune Area, Shizunai Town. An electric post was overturned.
Fig. 3 Strong Motion Stations Recorded and Peak Horizontal Accelerations on Ground

Fig. 4 Epicentral Distance Versus Peak Horizontal Ground Acceleration (Δ is measured from the center of octagon of Fig 2)
<table>
<thead>
<tr>
<th>Station</th>
<th>Location Direction</th>
<th>Ground Accel (gal)</th>
<th>Structural Accel (gal)</th>
<th>Instrument</th>
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<td>Horoman Br.</td>
<td>40</td>
<td>53</td>
<td>76</td>
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<td>Hiroo Br.</td>
<td>62</td>
<td>247</td>
<td>207</td>
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<td>Tokachi Port</td>
<td>62</td>
<td>151</td>
<td>263</td>
<td>78</td>
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<td>Hiroo JMA,BRI</td>
<td>62</td>
<td>206</td>
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<tr>
<td>Tomakomai Port</td>
<td>86</td>
<td>63</td>
<td>64</td>
<td>21</td>
</tr>
<tr>
<td>Nishikioka Br.</td>
<td>95</td>
<td>77</td>
<td>58</td>
<td>25</td>
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<td>Shimamatsu-zawa Br.</td>
<td>105</td>
<td>115</td>
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<tr>
<td>Chiyoda Br.</td>
<td>112</td>
<td>48</td>
<td>53</td>
<td>10</td>
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<tr>
<td>Sapporo I.C. Br.</td>
<td>130</td>
<td>(274)</td>
<td>(318)</td>
<td>(51)</td>
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<tr>
<td>Sapporo Hokkaido U.</td>
<td>130</td>
<td>72.5</td>
<td>66</td>
<td>30</td>
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<tr>
<td>Muroran Port</td>
<td>130</td>
<td>138</td>
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<td>Ishikari Estuary Br.</td>
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<td>Otaru Port</td>
<td>168</td>
<td>15</td>
<td>18</td>
<td>4</td>
</tr>
<tr>
<td>Otanoshike Br.</td>
<td>170</td>
<td>18</td>
<td>14</td>
<td>3</td>
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</table>

Notes:
1) A denotes an epicentral distance equal to the distance between an observation station and the epicenter, the center of the octagon of the main shock shown in Fig. 2.
2) Records are taken by Hokkaido Development Bureau, Port and Harbour Research Institute, and Building Research Institute.
3) Accuracy of Sapporo I.C. Br. Instruments is under checking.
DAMAGE STATISTICS

Table 2 indicates general statistics of damages to persons and various facilities. It is seen from this that no one was killed, 21 were seriously injured, and 146 were slightly wounded. Most injuries were caused by overturning of furnitures and scalds due to the overturning of kettles with boiling water. As for public facilities, damages to highways, bridges, ports, and water supply systems were comparatively severe.

DAMAGES TO HIGHWAYS

The National Highway Route 235 connecting between Tomakomai and Erimo sustained rather heavy damages. Landslides of mountain sides of the highway took place at five locations between Shizunai and Higashi (East) - Shizunai, Shizunai town, shown in Photos. 1-3. Retaining walls of sea sides of the highway overturned and failed at Koshiumi Area, Mitsuishi town, as shown in Photo. 4. Settlements of highway embankments were observed at a number of locations. Photo 5 shows an example of the embankment settlements. All of those damages were quickly repaired by temporary repair works, and all portions (except Shizunai Bridge described in the next section) were open to the public traffic in 3 days after the outbreak of the Earthquake. It will take a few months, however, to completely finish those repair works.

HIGHWAY BRIDGES

Shizunai Bridge, spanned Shizunai River in Shizunai town, was severely damaged. It is seen from Fig. 2 that the bridge is located in the north end of the focal area. The general drawings of the bridge are illustrated in Fig. 5. This bridge has 9-span steel plate girders, two abutments and 8 piers. Foundations of the most piers (P1 to P7) are open caissons with a diameter of 6 m and the depth of 16 m. The foundation of P8 is a footing foundation. Soils are rather soft near the surface in the right-bank and the central part, as shown in Fig. 5. Each pier has a circular reinforced concrete column with diameter of 2.2 m. The superstructure has 9 spans (3 of 3-spans continuous steel plate girders). Three pier columns of P2, P3, and P6 sustained heavy cracks. Especially P3 column was seriously cracked, as shown by Photos. 6 to 8. Photos. 9 and 10 show the damages to P2 and P6, respective-
<table>
<thead>
<tr>
<th>Damages to</th>
<th>Damage Quantity</th>
<th>Damage Cost (Million Yen)</th>
<th>Remarks</th>
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<td>Inhabitants</td>
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<td>Fatality</td>
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<tr>
<td>Serious Injury</td>
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<td></td>
</tr>
<tr>
<td>Slight Injury</td>
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<td>Collapse</td>
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<td>95</td>
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<td>Half Collapse</td>
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<td>123</td>
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<td>Partial Failure</td>
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<td>Non-residential Houses</td>
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<tr>
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<tr>
<td>Half Collapse</td>
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<td>Sanitary Facilities</td>
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<td>Commercial, Industrial Facilities</td>
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<td>9</td>
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<td>156</td>
<td>850</td>
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<tr>
<td>Electricity</td>
<td>142</td>
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<td>Others</td>
<td>37</td>
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<td>Grand Total</td>
<td>3,102</td>
<td>7,762</td>
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Fig. 5
General View, Cross Section, and Soil Profiles of Shizunai Bridge
Photo 2
Damage to Slope along National Highway Route 235 at Iriume Area Shizunai Town. A wagon was buried under soils.

Photo 3
Light Damage to Slope along National Highway Route 235 at Iriume Area Shizunai Town. Retaining walls protected from a large failure.

Photo 4
Overturning of Coastal Retaining Walls along National Highway Route 235 at Koshiumi Area Mitsuishi Town.
Photo 5
Settlement of Embankment National Highway Route 235 Near Ura Bridge Shizunai Town.

Photo 6
View of Shizunai Bridge from Right Bank to Left Bank (Downstream) Pier 4 in foreground.

Photo 7
Damage to Pier 3 Shizunai Bridge from Pier 2.
Photo 8
Closer View of
Failed Section
Pier 3
Shizunai Bridge.
Seen from Downstream.
Note cut off bars.

Photo 9
Damage to Pier 2
Shizunai Bridge
Seen from Upstream of
Pier 1 side.

Photo 10
Damage to Pier 6
Shizunai Bridge
Seen from Pier 7.
ly. Three other pier columns of P4, P5 and P7 sustained light cracks, as shown in Photos. 11, 12, and 13, respectively.

Temporary repair works to P2, P3 and P6 were finished by the middle of April, and this bridge reopened to light traffic (lighter than 5 tons) on April 15.

The Ministry of Construction and Hokkaido Development Agency are now investigating causes of the damages to the bridge columns and procedures of permanent repair works.

Several bridges sustained minor damages, such as small crackings of reinforced concrete pier columns and reinforced concrete girders. Settlements of back fills of abutments were observed at many bridge sites, as usually seen in the past strong earthquakes.

RIVERS, COASTS, DAMS AND SLOPES

Dyke protections made of concrete blocks were damaged. A water gate located shortly down form the right-abutment of Shizunai Bridge had differential settlements of about 30 cm at its back fills. The water gate and piers did not sustain any damages.

Dykes suffered from cracking (5 cm wide, 50 cm deep or more, and 5 m long) at the downstream from the right-abutment of Shizunai Bridge.

Coastal retaining walls slid, inclined and even overturned at Koshiumi area of Mitsuishi town, as shown in Photo. 4.

Although one dam (Miicappu Dam) recorded peak acceleration of 136 gals at the crown, no dam damages were observed.

A few steep slopes slid in Shizunai and Urakawa towns. In Urakawa town, one steep slope which was reinforced by slope protection facilities did not sustain any damages.

WATER SUPPLY SYSTEMS

Water supply systems sustained rather severe damages, stops of water supply were reported at 14,086 houses of 11 towns. In Urakawa town, 165 locations had damages to pipelines. It took about ten days to repair and re-open the system at the town. Damages to water supply systems affected most seriously people's daily lives. Water pipeline systems in Urakawa town have one value at every 200 m length. This facilitated discovery of damaged portions and repair works.
Photo 11
Damage to Pier 4
Shizuna Bridge

Photo 12
Damage to Pier 5
Shizuna Bridge
Diagonal Cracking on Downstream side.

Photo 13
Damage to Pier 7
Shizuna Bridge
Light Horizontal cracking.
OTHER FACILITIES

Telephone lines stopped at 590 lines, electricity also shut down at 10,400 houses. These stops were repaired very quickly, and in 24 hours at most.

Japanese national railways also sustained heavy damages to railway bridges, slopes, and embankments at 156 spots totally. The railways reopens early April up to Urakawa, and on April 14 up to Samani, the east terminal. No fires broke off.

LESSONS FROM THE URAKAWA-OKI EARTHQUAKE

1) Earthquake resistant design methods of reinforced concrete pier columns should be examined, in view of the damages to pier columns of Shizunai Bridge. Also quick repair methods should be prepared in advance.

2) As settlements of back fills approaching to bridges and water gates were frequently observed, back fills should be strengthened.

3) As natural soil slopes are vulnerable to earthquake shaking, important portions of slopes should be strengthened.

4) It took a long time to assess the extent of damages to underground water pipelines. Technology to judge damage extent of pipelines should be developed.

5) Although bridge substructures sustained heavier damages, bridge superstructures did not have any serious damages, as seen in the past earthquakes.

6) Water supply pipeline systems which have many values are very efficient in finding damaged portions and in repairing.

7) Assessments of degree of damages to various civil engineering structures were rather difficult. Simple procedures of damage assessment should be prepared for practical purposes.

8) Fires can be avoided during and after an earthquake, if people behave very cautiously. Daily practices are inevitable to appropriately respond to a large earthquake shaking.

References


2) Hokkaido University (Science Department), "Report of the Urakawa-oki Earthquake", March 31, 1982