

A Basic Study of the Relationship between Earthquakes Kushiro-Oki and Hokkaido-Nansei and the Resulting Damage to Concrete Structures*

Hiroshi SAKURAI,** Koichi AYUTA,** Noboru SAEKI*** Yoshio FUJITA****

Abstrakt

In 1993, two large earthquakes, Kushiro-oki and Hokkaido nansei-oki occyrred, causing death, injuries and damage to industrial and civil facilities. The resulting damage to concrete structures was influenced by the characteristics of each earthquake. If an earthquake of this scale and similar characteristics occurred in a high density metropolitan area, it is feared that damage would be on a huge scale. Several organizations are researching and analyzing the damage of the 1993 earthquakes and studying the effectiveness of earthquake proofing. It should be noted that the design of bridge supports should allow for damage.

This study analyzes the results of site research and of some of the published reports, compares the resulting concrete damage from the two earthquakes, and studies the effectiveness of earthquake proof construction. Since stress concentrated and cracks occurred at the point where longitudinal reinforcing steel was discontinued, a study to prevent this is necessary. Since the maximum acceleration measured by strong motion recorders located near the seismic center was very large, the reliability of measurements should be checked and the values applied to the dynamic analysis of structures in Japan should be re-evaluated.

1. INTRODUCTION

In 1993, two large earthquakes, Kushiro-oki and Hokkaido nansei-oki occurred, causing deaths, injuries and damage to industrial and civil facilities. The resulting damage to concrete structures was influenced by the characteristics of each earthquake. If an earthquake of this scale and similar characteristics occurred in a high density metropolitan area, it is feared that damage would be on a huge scale. Several organizations are researching and analyzing the damage of the 1993 earthquakes and studying the effectiveness of earthquake proofing.

This study analyzes the results of site research and of some of the published reports, compares the resulting concrete damage from the two earthquakes, and studies the effectiveness of earthquake proof construction.

* A part of this report was presented at the Hokkaido branch of JSCE Conference, 1994.

** Department of Civil Engineering, Faculty of Engineering, Kitami Institute of Technology.

*** Department of Civil Engineering, Faculty of Engineering, Hokkaido University.

**** Former guest professor, Kitami Institute of Technology.

2. Outline of Earthquakes and Resulting Damage

2-1 Outline of earthquakes

The earthquakes are outlined in Table 2.1.

Table 2.1 Outline of earthquake

Earthquake	in 1993 Kushiro-oki Earthquake	In 1993 Hokkaido Nansei-oki Earthquake
Time occurred	20 : 06, 15 January 1993	22 : 07, 12 July 1993
Location of seismic center	42.85° N 144.38° E	42.47° N 139.12° E
Focal depth	107 km	34 km
Magnitude (weather office)	7.8	7.8

The following points are some of the significant characteristics of earthquake Kushiro-oki.

- (1) The focal depth was deep compared with that of other magnitude 8 class earthquakes.
- (2) The size of the fault was smaller than other quakes of the same magnitude class, as was the fault breaking continuation time.
- (3) Almost no large aftershocks occurred
- (4) The continuation time of the main shake was short, a little more than ten seconds on a hard quality base.
- (5) The maximum acceleration of measured on strong motion recorders of the Kushiro Weather Observatory was 922 gal in the E-W direction, 817 gal N-S, and 467 gal up-down. The maximum amplitude of displacement was 57 mm in the E-W direction, 111 mm N-S, and 24 mm up-down.

The strong motion recorder of (5) was one type 87 unit, while a SMAC type unit recorded a measurement of 711 gal. Because the influences of the limited short cycle, the setting conditions, the sensitivity characteristics of the strong motion recorders, and the local area ingredient of the base on the value of maximum acceleration, additional investigation was needed.

The following points are some of the significant characteristics of earthquake Hokkaido nansei-oki.

- (1) This large scale earthquake occurred as though to fill a partial void for large earthquakes.
- (2) A large tsunami of magnitude 8.1 occurred in Muroran City.
- (3) The damage from the strong earthquake shake, tsunami landslides, and fire were concentrated on Okushiri island.
- (4) The large accelerations of main earthquake shock were 215.3 gal on E-W direction, 217.3 gal on N-S direction and 100.2 gal on U-D direction at point of the

distance 150 km on ground in Muroran city by ERS-G type recorder.

2.2 Outline of Damage

The outline of damage is shown in Table 2.2. The damage caused by Hokkaido Nansei-oki earthquake was greater than that of the Kushiro-oki earthquake, as the Kushiro-oki earthquake includes tsunami damage.

Earthquake	1993 Kushiro-oki Earthquake	1993 Hokkaido Nansei-oki Earthquake* ¹
Fatality	Dead : 1 Seriously injured : 64 Slightly injured : 657	Dead : 200 Missing : 38 Seriously injured : 39 Slightly injured : 197
Damage to construction	Totally demolished houses : 18* ² Partially demolished houses : 182* ² Damage to roads : 944* ³	Totally demolished houses : 558 Partially demolished houses : 247 Damage to roads : 711 Collapsed cliffs : 14
Amount of damage	About ¥70 billion	About ¥132.3 billion

*¹ : Including damage caused by tsunami

*² : Including buildings

*³ : Excluding national highways

3. A Study of Several Results

3.1 Damage from Kushiro-Oki earthquake

Typical damage to concrete structures is illustrated by the following examples.

1) Concrete bridge pier

In this example, a road bridge pier (compound beam bridge, constructed in Urahoro in 1966) was cracked and the concrete was scaled. Because the base of the front of abutment pier was soft and peaty, the abutment pier and shore protection were pushed into the river bank and the girder moved in the line of its axis. The shoe and mortar of the bridge bearing were damaged. (Photo 1)

2) Bridge abutment and parapet

In this example, a girder of a railroad bridge (steel girder, between Cyokubetsu and Atunai constructed several decades ago using an abutment of wooden piles and laid bricks) smashed into the bridge abutment and moved in the axis of the girder. The abutment suffered a 45 mm width crack and is leaning vertically.

In another example, the abutment of another railroad bridge (T beam of RC, between Ikeda and Shoei) was cracked parallel to the ground at a point 50 cm above the reinforcing steel section decrease point. This was caused by hard shaking in the north/south direction. The shoe stopper was also damaged. (Photo 3)

3) Shoe, mortar of shoe seat, and girder

In this example, a railroad bridge (PCT: T beam of pre stressed concrete bridge

between Hobetsu and Ikeda) was damaged by north/south shaking along the girders' axes. Because of the damage to the shoe, the girders' edges were cracked and scaled, especially in the ninth pier (9P) and the edges of the ninth girder. (Photo 4A)

In another example, the stoppers of shoes of a railway bridge (PC Girder, between Ineshi and Makubetsu) were damaged at the movable shoe of the first pier (1P) and in the slide stopper of the shoe on the fifth pier (5P) (Photo 4B).

In yet another example, a road bridge (PC box girder bridge, constructed in 1991, Urahoro) was damaged by shaking in the direction of the girder. The shoes were damaged and the expansion joint was separated from the bridge parapet. Cracking occurred in the concrete at joint edge and the pavement and footpath behind the bridge abutment subsided (Photo 5).

3.2 Damage from Hokkaido nansei-oki earthquake

1) Damage and collapse of base due to liquefaction

In this example, a snow shed (PC arch structure, Senjyouzaka in Okushiri) collapsed. The base wall of the arch fell outward and the arch collapsed because liquefaction of the paddy field surrounding the structure's base caused the horizontal wall to lose resistance. Prior to this collapse, the structure appeared to reach its limit of stability. The shed experienced hard shaking along its axis (the progress direction) and vertically and the arch parts slid about 30 cm, yet the structure did not fail until liquefaction occurred (Photo 6).

In another example, a lighter's wharf (concrete plate, Aonae in Okushiri) was damaged by the liquefaction and loss of bearing value of its base. The concrete plates were cracked, broken, and faulted due to differential settlement (Photo 7).

2) Abutments

In this example, the outside abutment of a road bridge (concrete girder bridge, Okushiri in Okushiri) was damaged (Photo 8).

3) Damage by tsunami

In the first example, the shore protection of a road bridge (concrete block, Aonae in Okushiri) moved and collapsed due to retreating tsunami carrying back filling material. In this case, vehicle passage was still possible (Photo 9).

Similarly, the parapet and abutment of a road bridge (concrete girder bridge Monai in Okushiri) was damaged by tsunami (Photo 10).

In another example, steel plate covers of a water supply pipe under the river side of a road bridge (concrete girder bridge, Shimamaki) were deformed by tsunami (Photo 11). Tsunami washed over the floor slabs of this bridge, but, for the most part, bridge movement could not be detected.

In the last example, a road retaining wall (concrete retaining wall, Mastumae in Okushiri) collapsed on the seaward side because a retreating tsunami washed over the road and retaining wall. The mat foundations were not able to resist the force of the retreating tsunami (Photo 12).

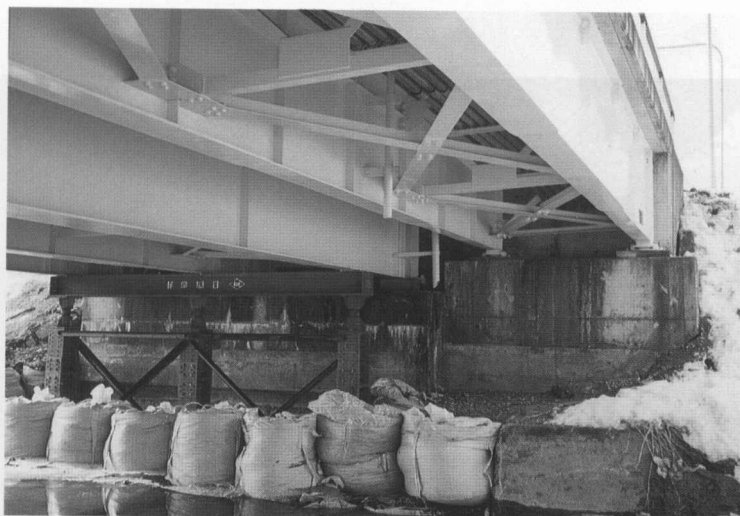


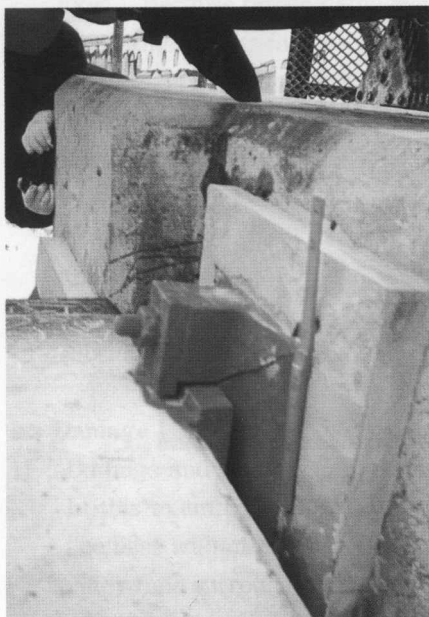
Photo-1 Movement of the abutment pier and shore protection
(compound beam bridge, constructed in 1966)



Photo-2 Crack and inclination of abutment



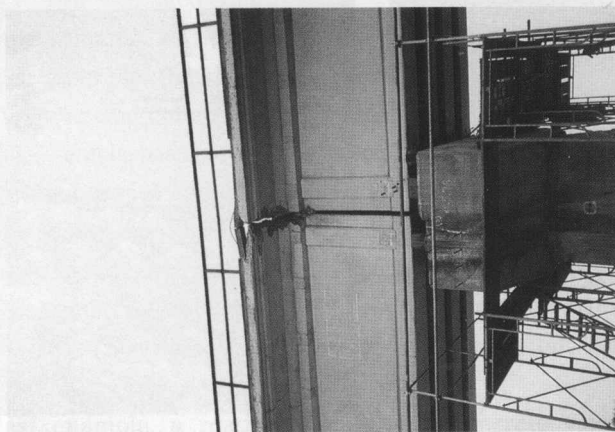
Photo-3 Crack at 50 cm above reinforcing steel
girder, between Chokubetsu steel section
decreases point on and Atsunai abutment
(T-beam of RC, between Ikeda and Shoei).



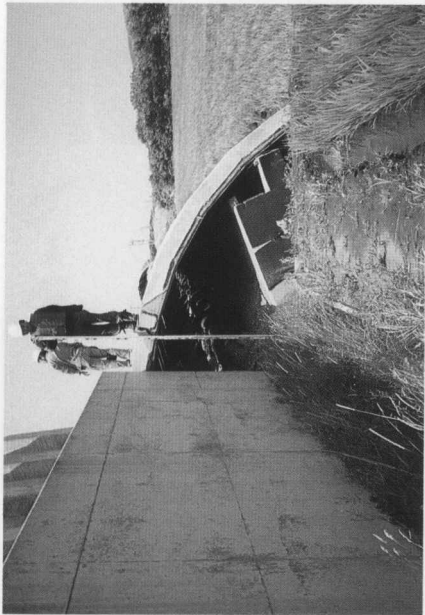
Pohto-4B Broken slide stopper of shoe (PC girder bridge, between Ineshi and Makubetsu)



Pohto-5 Broken shoe (PC box girder bridge, constructed in 1991, Urahoro)



Pohto-4A Broken shoe and concrete girder sedges (PCT : T beam of prestressed concrete bridge, between Hobetsu and Ikeda)



Pohto-6 The collapsed base wall of arch and the collapsed arch (PC arch structure Senjyozaka in Okushiri, just before completion in July 1993)



Pohto-8 Broken concrete of abutment (concrete girder bridge, Okushiri in Okushiri)



Pohto-7 Crack and breaking on lighter s wharf (concrete plate, Aonae in Okushiri)



Photo-9 Moving and collapsing retaining wall due to retreating tsunami (concrete retaining wall, Matsumae in Okushiri)



Photo-10 Damage to parapet and abutment (concrete girder bridge, Monai in Okushiri)

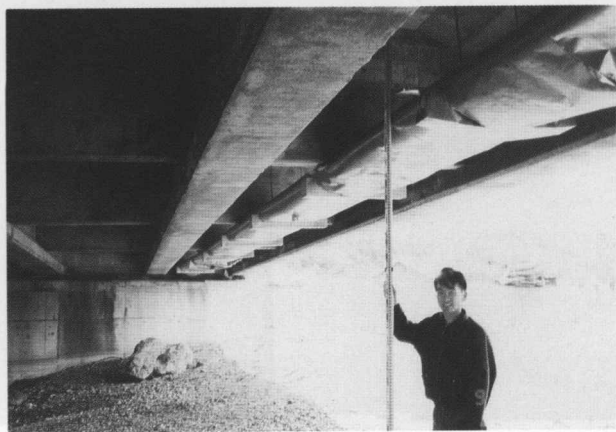


Photo-11 Deformation of steel plate covers of water supply pipe underneath, as caused by tsunami (concrete girder bridge, Shimamaki)

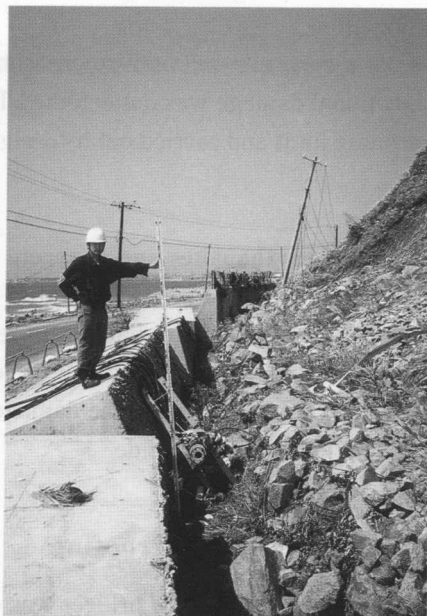


Photo-12 Collapsed road retaining wall
caused by retreating tsunami
(concrete retaining wall, Mat-
sumae in Okushiri)

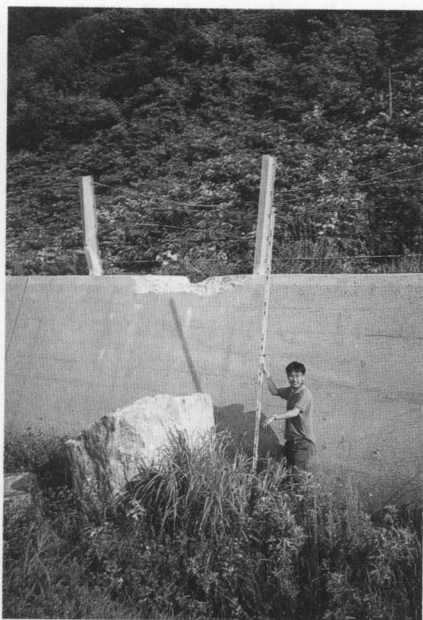


Photo-13 Falling stones caused by earth-
quake and damage to retaining
wall (concrete retaining wall,
Shimamaki)

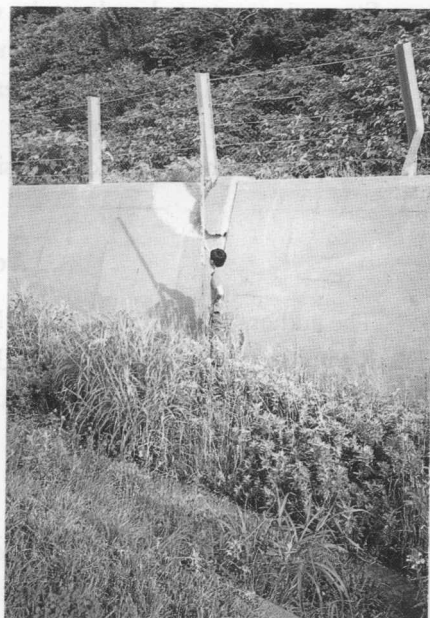


Photo-14 Broken root concrete of falling
stone protection fall (concrete
retaining wall, Shimamaki)

4) Shock damage from falling stone

In this example, the roots of a concrete wall built to prevent falling stones was cracked and damaged, although functional damage was not detected. The wall reached its state of usable limit, but not its ultimate limit and carried out its designed function (Photos 13 and 14) .

3.3 The relation between two large earthquakes and concrete damage

In the Kushiro-oki earthquake damage was concentrated in the support sections of bridges where the foundations were soft, whether shallow or deep and the damage due to displacement in the direction of amplitude was recognizable. Additionally, there was striking damage to relatively heavy T concrete girders. The damage at the point in cases where part of the damage was not on the Pacific Ocean side.

4. Earthquake-Proofing

The damage to support parts and abutments of bridges was conspicuous and these parts need to be reinforced and structured so that, even if they suffer damage, the girder will not collapse. It was fortunate that bridges with broken supports caused by tsunami did not collapse, but bridges in seaside areas should especially allow for this.

Stress concentrated and cracks occurred at the points where longitudinal reinforcing steel was discontinued, showing the necessity of studying ways to prevent this.

The maximum acceleration measured by strong motion recorders located near the seismic center was very large. The reliability of measurements must be checked and the values applied to the dynamic analysis of structures in Japan should be reevaluated.

Acknowledgments

The authors would like to thank Mr. Okada, a technician, Dr. Hirabayashi President of The Kitami Institute of Technology, JR Hokkaido, Mr. Tokusige and Mr. Nawa, graduate students of Hokkaido university, Okushiri Hire Agency, and all others who assisted.

References

- 1) Noboru Saeki: The state of concrete damage by Kushiro-oki earthquake. The lecture paper of Concrete Research Committee of Hokkaido Civil Engineering Society, 17 March 1993 (In Japanese) .
- 2) N. Saeki, T. Mikami, and K. Shimura: Damage to concrete structure of civil facility, Bulletin of the NATURAL DISASTER SCIENCE DATA CENTER HOKKAIDO, Vol. 8, pp. 143-149, July 1993 (In Japanese)
- 3) H. Yoshimura, Y. Kakuta, K. Sato, and T. Hayashikawa: Damage to Bridge, Bulletin of the NATURAL DISASTER SCIENCE DATA CENTER HOKKAIDO, Vol. 8, pp. 150-155, July 1993 (In Japanese)
- 4) Kokusai-Kogyo, Co., Ltd.: Flash Damage by Hokkaido Nanpei-oki earthquake, July 1993 (In Japanese)
- 5) Committee on earthquake-proofing of the JSCE: The research report of Hokkaido Nansei-oki earthquake, 1993 (In Japanese)

- 6) H. Kagami, K. Kuge, B. K. Bhartia and S. Sakai: Reconnaissance Report ON THE 30 SEPTEMBER
1993 EARTHQUAKE IN THE STATE OF MAHARASHTRA, INDIA, March 1994

——パウル・ツェランとインゲボルグ・バッハマン、「伝記」と「註釈」——

芳賀和敏

(平成6年4月30日受理)

Im Mai 1982 in Niendorf an der Ostsee

Kazutoshi HAGA

Abstrakt

Im Mai 1982 in Niendorf trafen sich beide Dichter, Paul Celan und Ingeborg Bachmann wieder. Übergriffige Beziehungen zwischen beiden sind schon bemerkt worden.

——Die erste Ebene: Begegnung zweier Dichter.

Dies wurde zuerst unter dem Aspekt des Einflusses gesehen, den Celans Lyrik auf Bachmann ausgeübt hat.

Die persönliche (unlge) Beziehung zwischen beiden ist auch schon bemerkt worden: Daß zwischen ihnen eine Liebesbeziehung entstand, ist kein Geheimnis.

——Die zweite Ebene des Ereignis.

Durch die Lektüre der Texte beider Dichter und durch kritische Prüfung beider Ebenen wird aus der Vergangenheit das Wesen des Gedichtes hervortreten, das heißt: »Die Sprache spricht«.

I

「もろもろの喪失のただなかで、ただ「言葉」だけが、手に届くもの、身近なもの、失われていないものとして残りました。……すべての出来事にもかかわらず、しかしその言葉にせよ、みずからのあてどなきの中を、おそるべき沈黙の中を、死をもたらす奔舌の手もの闇の中をまなけばなりませんでした。」

(「パウル・ツェラン」、ハンズ自由語訳ブレーメン文字屋受賞展覧会から、版元大沢社)

詩を論ずる言説、いささかなりとも theoretisch な試みは、詩の外側に定位している。強大な現場を有する外部による、解釈学という名の内在解釈にみられたように、自立したテクストという神話は、気ままな奔舌の隠れ蓐と成り下がってしまった観がある。しかし、詩の「外部」というならば、詩人による詩論もまた明らかに詩の外側に立っている。それが theoretisch な言説であれ、詩人や詩作を主題とした成就しなかった《書き残った》詩であれ、テクスト外部の存在者なのである。それらのペラテクストは、テクスト(詩)の圏域に詩の求心力によって縛っているのだが、外部という概念規定は、たとえば豊富な解釈学やその地還元め構造をもつ理論に導く詩論のような、詩にとっでの全き「他者」とは明確に区別されるべきである。

それにしてもツェランの言う「死をもたらす奔舌の手もの闇」(die tausend Finsternisse tod-