Journal of Japan Association for Earthquake Engineering, Vol.4, No.3 (Special Issue), 2004

STRONG MOTION NETWORK OPERATED BY BUILDING RESEARCH INSTITUTE

Toshihide KASHIMA[1]

[1] Member of JAEE, Senior Research Engineer,
International Institute of Seismology and Earthquake Engineering,
Building Research Institute, Tsukuba, Japan,
kashima@kenken.go.jp

ABSTRACT: Building Research Institute (BRI) is operating a nationwide strong motion network. Total 75 stations are disposed in major cities throughout Japan. The observation project aims to contribute to advance in seismic design technology for buildings. Therefore seismic response of buildings is the main target of the observation. A great number of strong motion records have been obtained and utilized to study local site and geological effects, soil-structure interaction and dynamic behavior of buildings. The paper introduces outline of the BRI strong motion network and its recent topics.

Key Words: Strong-motion network, Seismic response of buildings

INTRODUCTION

Building Research Institute (BRI), Tsukuba, Japan, is a national institute that is engaging researches on architecture, urban planning, and building engineering. Strong motion observation for buildings is one of the major activities of BRI. BRI has started the installation of strong motion instruments more than 40 years ago. The aim of the observation is to promote the earthquake resistant design technology by providing seismic records for analyzing their features and seismic responses of buildings. Dynamic soil-structure interaction is also the essential target of the observation.

OUTLINE

For enhancing seismic safety of buildings, it is necessary to understand the characteristics of earthquake ground motions and the behaviors of buildings during earthquakes. Building Research Institute (BRI) is operating strong motion observation in order to investigate actual dynamic behavior of buildings and is conducting research projects concerned.

BRI has installed strong-motion instruments in major cities throughout Japan. 75 observation stations are now in operation as shown in Fig. 1. One third of the stations are located in Tokyo and its outskirts. All stations are equipped with up-to-date digital strong motion instruments and are connected to BRI via public telephone lines in order to maintain these instruments and to collect strong motion records immediately after an earthquake. We purpose to grasp dynamic behaviors of buildings during earthquakes. Therefore acceleration sensors are basically placed on the top and at the basement of a building, and optionally on the nearby ground as shown in Fig. 2.

Fig. 1 Strong motion stations operated by Building Research Institute (BRI)

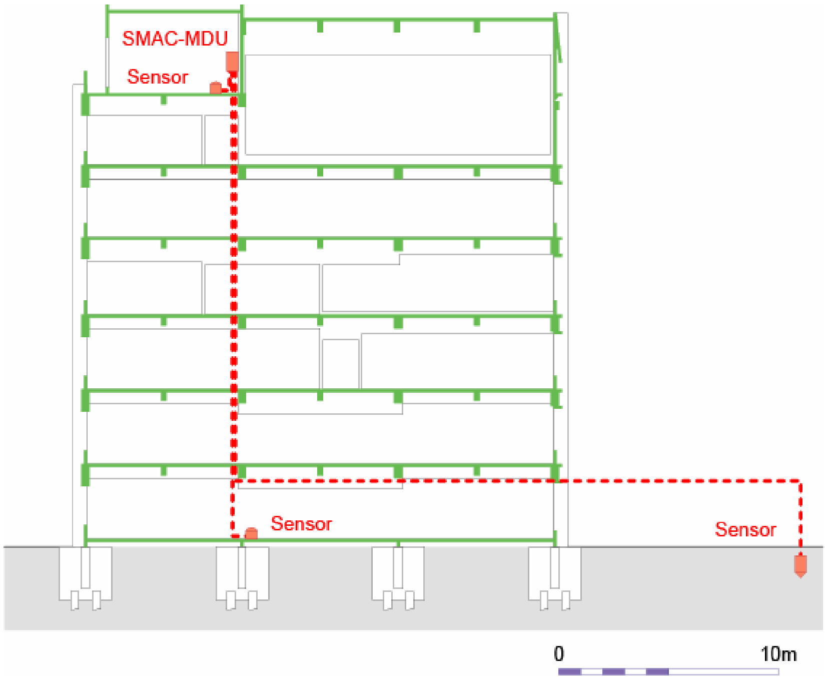

Fig. 2 Typical sensor configuration for buildings

RECENT TOPICS

The BRI strong motion network has obtained a number of noteworthy records such as accelerograms from the 1964 Niigata Earthquake and the 1978 Off Miyagi Pref. Earthquake. The former was the first set of records from a disastrous earthquake in Japan, and latter included a record with a PGA exceeding 1G. In the other example from the 1993 Off-Kushiro earthquake, the peak acceleration of 711 cm/s^2 was observed on the ground surface at the Kushiro JMA Observatory. Moreover, an enormous acceleration record was obtained in the new building of the Hachinohe City Hall for the 1994 Far Off Sanriku Earthquake. The peak acceleration at the 6th floor reached about 1 G. Damage to the new building was slight, but an adjoining old building was severely damaged. The record was valuable to investigate the failure process of the building. Recent examples of instrumentations and strong motion records are introduced hereinafter.

Dense instrumentation at the BRI annex building

In order to investigate input mechanisms of seismic motions to buildings, we need to conduct comprehensive observation of buildings and surrounding ground. The BRI Urban Disaster Mitigation Research Center (annex) building was densely instrumented as shown in Fig.3 in a way that the site effects, SSI effects and the response of this building would be thoroughly discussed.

The recording system has eleven sensors (33 channels) in the annex building, seven sensors (21 channels) in the surrounding ground, and four sensors (12 channels) in the main building. The annex building is a steel reinforced concrete building with eight stories above ground and one below. The observation was started in 1998 with the completion of the building. A great number of records have been accumulated to date and useful fruits have been obtained (Kashima 2004a).

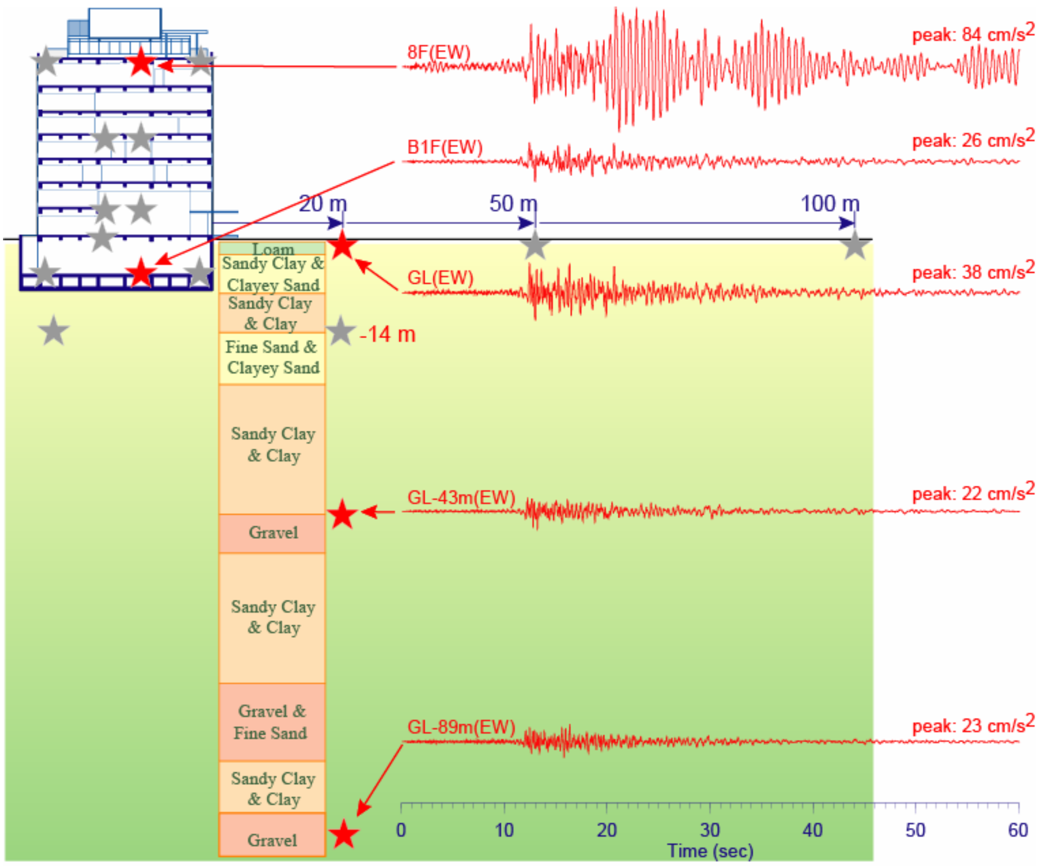

Fig. 3 Sensor configuration and example of acceleration records at the BRI annex building

Strong-motion records from the 2003 Off Tokachi Earthquake

On 26th September, 2003, a disastrous earthquake occurred in the northern Japan. The BRI strong motion network has obtained precious strong motion records at stations in Hokkaido and Tohoku areas. The epicenter of the mainshock and locations of the strong motion stations are shown in Fig. 4. Values in parentheses are Japan Meteorological Agency (JMA) instrumental seismic intensities and peak accelerations at our stations. If no sensor is placed on the ground, the values were calculated form the record at the basement floor.

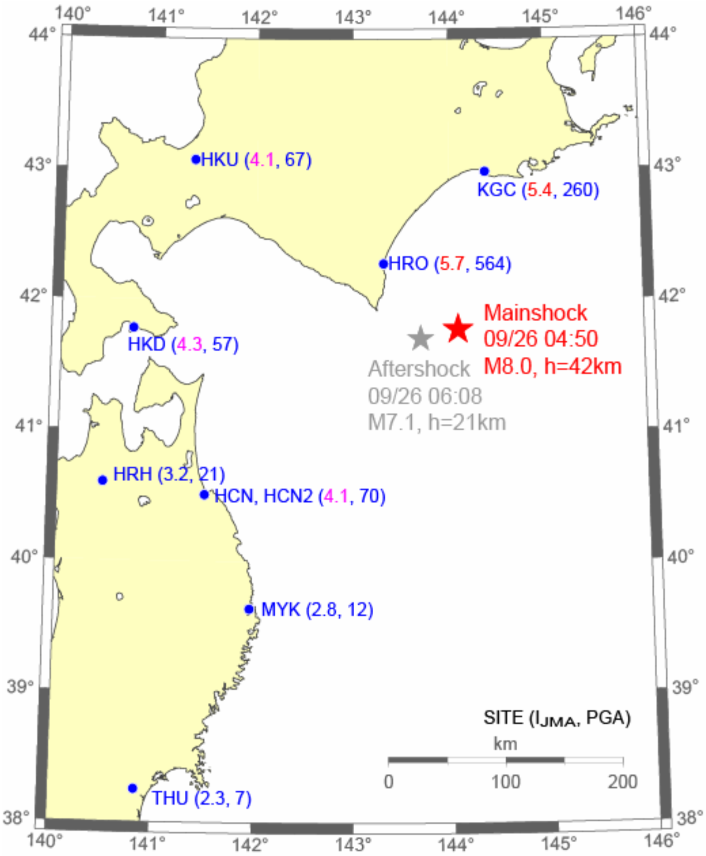

Fig. 4 Epicenter of the mainshock of the 2003 Off Tokachi Earthquake and strong motion stations of BRI. Values in parentheses indicate JMA seismic intensity and peak acceleration on the ground or at the basement floor.

Strong motion records at the Hiroo Town Office

The most intensive strong motion from the 2003 Off Tokachi Earthquake was recorded at the Hiroo Town Office (HRO) that was 84 kilometers away from the epicenter. A strong motion instrument is placed at the first floor of a two-story (partially three-story) reinforced concrete building. The peak acceleration was 564 cm/s^2 in the N140°E direction and the building was somewhat damaged.

The K-NET, which is a large strong motion network operated by National Research Institute for Earth Science and Disaster Prevention (http://www.k-net.bosai.go.jp/), also has a strong motion station on the ground in the same site. The distance between the K-NET instrument and the BRI instrument is about 40 meters. Figure 5 shows accelerations recorded on the ground (GL: K-NET instrument) and at the first floor in the building (1F: BRI instrument). Remarkable differences can be recognized between the both accelerograms. Predominant amplitudes with the frequencies of 4 Hz to 5 Hz can be observed on the K-NET records. Further study of site effects and soil-structure interaction is necessary to interpret such phenomena.

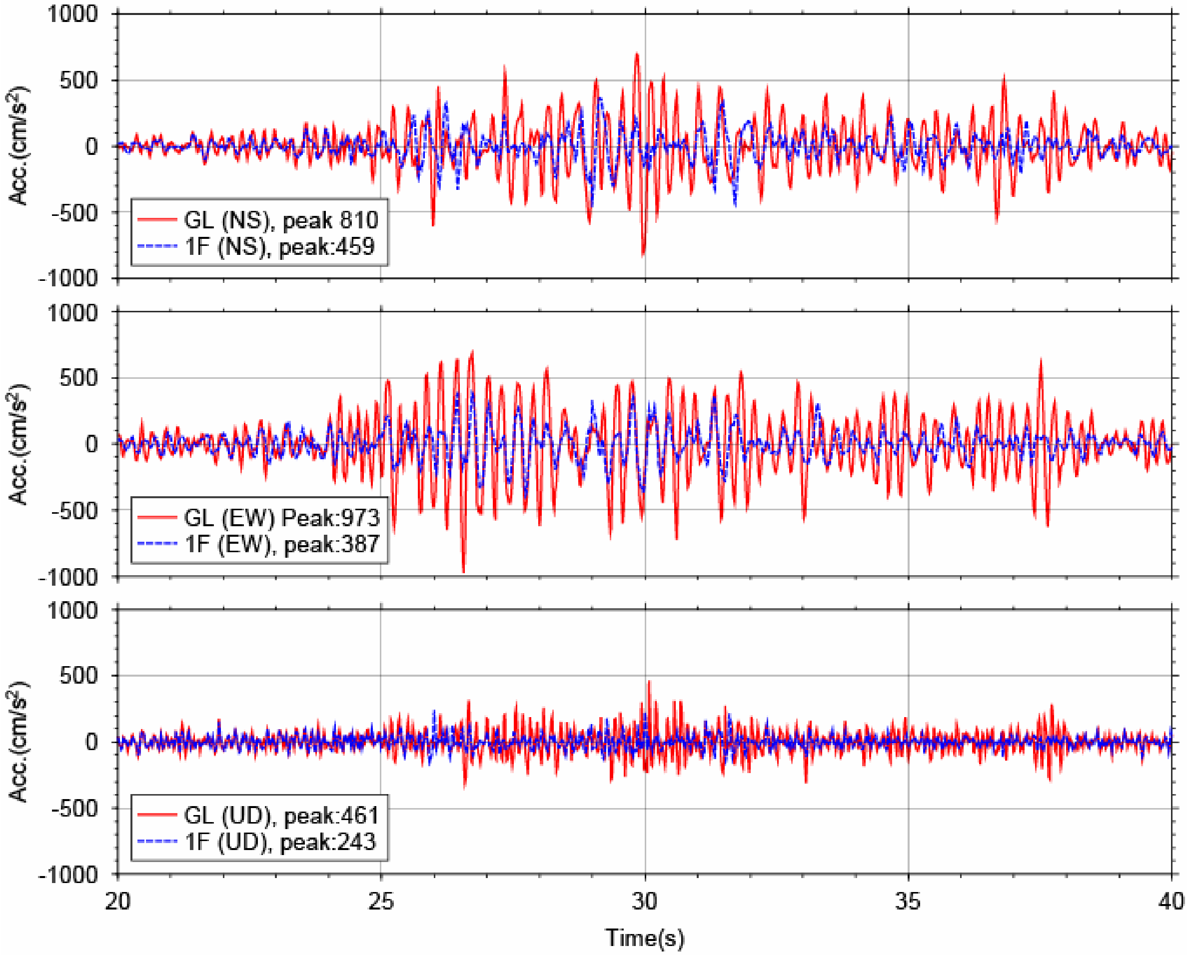

Fig. 5 Acceleration records observed on the ground (K-NET, red solid line) and at the first floor in the building (BRI, blue dashed line) at the Hiroo Town Office.

Strong motion records at the Kushiro Government Office Building

The Kushiro Government Office Building (KGC) is a base-isolated building with nine stories above ground and one below. Six acceleration sensors are configured in the building and in the ground as shown in Fig. 6. The base isolation system consists of 64 laminated rubber bearings, 56 lead dampers and 32 hysteretic steel dampers, and the devices are installed between the first floor and the basement floor.

A graph on the right hand side in Fig. 6 presents the distribution of horizontal peak accelerations along the height. The earthquake motion was magnified twice by the surface soil layers with a thickness of 30 meters in terms of peak accelerations. The peak accelerations were reduced by two thirds as the input to the building. The base isolation system decreased accelerations by half from the basement floor (B1F) to the first floor (01F). Detailed discussion including non-linear behavior of the base isolation devices could be conducted using the strong motion records (Kashima et al. 2004b).

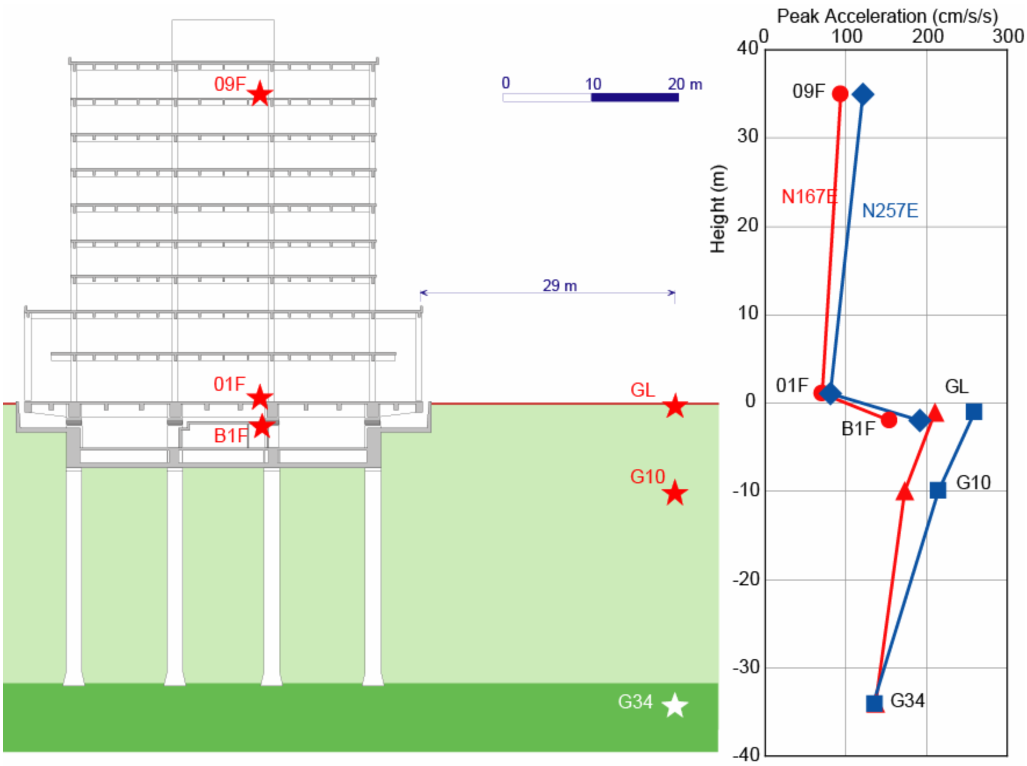

Fig. 6 Sensor configuration and distribution of peak horizontal acceleration during the 2003 Off Tokachi Earthquake at the Kushiro Government Office Building

CONCLUSIONS

The strong motion observation for buildings is one of the major activities of Building Research Institute, Japan. The object of the observation is a contribution to advance in researches on seismic safety of buildings.

A great number of strong motion records have been obtained to date and advanced research works using the records have been conducted. Our strong motion network keeps on providing precious results in the field of earthquake engineering.

REFERENCES

Kashima, T. (2004a). "Dynamic Behavior of an Eight-Storey SRC Building Examined from Strong Motion Records." *13th World Conference on Earthquake Engineering*, Vancouver, Canada

Kashima, T., Ito, A. and Fujita, H. (2004b). "Dynamic Behavior of a 9-Story Base-Isolated Building during the 2003 Off Tokachi Earthquake, Japan", *Proceedings of the Third U.S.-Japan Workshop on Soil-structure Interaction*, California, U.S.A., March 28-30, 2004

(Submitted: March 31, 2004)
(Accepted: June 22, 2004)