国土交通省
Ministry of Land, Infrastructure, Transport and Tourism

国総研ニューズレター

NILIM News Letter

NILIM

No.37
Summer 2011

Contents

■ Estimating distribution of the earthquake motion of the Great East Japan Earthquake
■ Initiatives for Rapid Restoration of Sewage System Facilities
- Proclamation by the Sewage System Earthquake/ Tsunami Countermeasure Technology Study Committee -
■ Characteristics of highway bridge damage due to the Great East Japan Earthquake
■ Earthquake and tsunami-induced damage to buildings and the later review of related technical standards
■ Damage to port facilities
■ Damage to Sendai Airport Facilities

Special Edition: The 2011 off the Pacific coast of Tohoku Earthquake (Great East Japan Earthquake)

Estimating distribution of the earthquake motion of the Great East Japan Earthquake

Research Center for Disaster Risk Management,
Earthquake Disaster Prevention Division

Distributions of the earthquake motion during the Great East Japan Earthquake are estimated in order to clarify the relationship between damage to facilities and the earthquake motion which struck these facilities.

The Great East Japan Earthquake had moment magnitude (Mw) of 9.0, which is the highest ever observed in Japan and triggered powerful earthquake motion throughout East Japan, including seismic intensity of 7 in Kurihara City in Miyagi Prefecture, high 6 in Miyagi, Fukushima, Ibaraki, and Tochigi Prefectures, and low 6 in Iwate, Gunma, Saitama, and Chiba, Prefectures, accompanied by extensive damage to infrastructure facilities.

In order to clarify the failure mechanisms of these damaged facilities and establish the relationship between facility damage and the earthquake motion to estimate facility damage, it is necessary to clarify the earthquake motion at the locations of the facilities. Therefore, the widespread and detailed distribution of earthquake motion during the Great East Japan Earthquake, including that in regions without earthquake observation stations, were estimated.

Japan Meteorological Agency (JMA) has released the Estimated Seismic Intensity Distribution Map, which estimates JMA seismic intensity for 1km meshes based on seismic intensity data observed in various regions by seismographs operated by JMA and local governments. It has, however, been pointed out that it is difficult to fully estimate damage to various kinds of infrastructure facilities with respective vibration properties based only on the distribution of JMA seismic intensity.

Hence, in addition to JMA seismic intensity, spectrum intensity (SI), which is considered to be highly correlated with earthquake damage to infrastructure facilities, and peak ground acceleration are chosen as indices for estimation of earthquake motion distributions.

These indices were calculated based on the accelerogram recorded at each earthquake observation station, and a planar interpolation was performed using the amplification of ground motion of subsurface ground for each 250m mesh. The results of the calculation are shown on the Estimated Earthquake Motion Distribution Map.

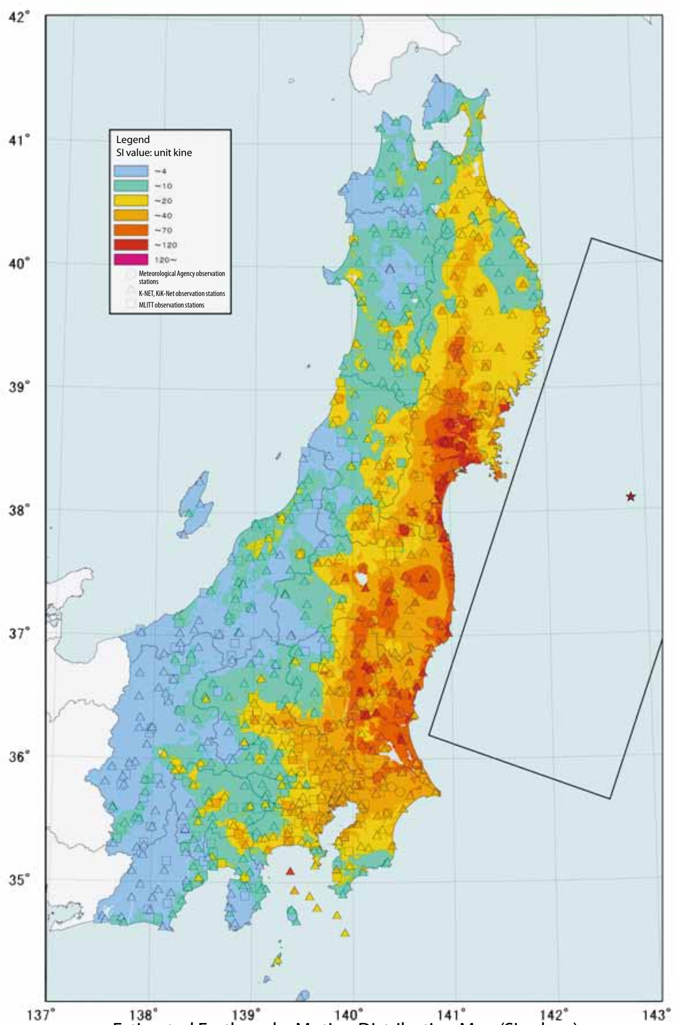
The observed records from K-NET and KiK-net operated by National Research Institute of Earth Science and Disaster Prevention and from JMA seismic intensity observation stations were used for the estimation along with those from Ministry of Land, Infrastructure, Transport and Tourism (MLIT) seismograph network.

The Earthquake Disaster Prevention Division is conducting research on methods of evaluating similarity between two earthquakes by comparing the estimated earthquake motion distributions, and has been establishing a system for the estimation of earthquake motion distribution just after an earthquake has occurred by using observation records of MLIT and related organizations, and for quick and automatic selection of a past earthquake that is considered similar to the one that just occurred.

When a large earthquake occurs, reports of past recent earthquakes which caused disasters similar to that of this earthquake are provided to concerned organizations as information that supports prompt crisis management.

The earthquake motion distribution map and values estimated will soon be available on the NILIM website along with accelerogram records observed by the MLIT seismograph network.

Website of MLIT Seismograph Network
http://www.nilim.go.jp/japanese/database/nwdb/index.htm



Estimated Earthquake Motion Distribution Map (SI values)

Initiatives for Rapid Restoration of Sewage System Facilities
- Proclamation by the Sewage System Earthquake/ Tsunami Countermeasure Technology Study Committee -

Water Quality Control Department, Wastewater System Division

On April 12, the Sewerage and Wastewater Management Department, Water and Disaster Management Bureau of the Ministry of Land, Infrastructure, Transport and Tourism, cooperatively with the Japan Sewage Works Association, established a committee of academic experts, the Sewage System Earthquake/Tsunami Countermeasure Technology Study Committee (Chairman: Professor Hamada Masanori of Waseda University), to carry out appropriate emergency restoration of sewage system facilities damaged by the Great East Japan Earthquake, and complete final restoration to prevent the recurrence of such a disaster.

Approximately five months have passed since the unprecedented massive earthquake, the Great East Japan Earthquake of March 11. Although after-shocks are occurring with decreasing frequency, many sewage treatment plants have not recovered their former functions (16 sewage plants as of July 25), and their operators are searching for restoration methods.

The first unique characteristic of this earthquake was the unforeseen tsunami it generated, and the way that the external force (wave force) of the tsunami, the inundation it caused, and the floating debris it carried inflicted catastrophic damage on sewage treatment facilities along the coastline. Along with damage to civil engineering structures, damage to electrical machinery and electric power equipment was astonishing, and it is necessary to not only aim for total recovery of their functions, but to improve their functions to prepare for future tsunami protection measures; a task predicted to take many years.

The earthquake's second characteristic is that in the Kanto region far from the epicenter, it triggered large-scale liquefaction, mainly on reclaimed land, causing severe damage to pipelines. This includes manholes and pipes forced up above ground level and liquefied soil filling pipelines, obstructing the flow of sewage. Not only sewage systems, but surrounding buildings, roads, water supply pipes and other buried structures were seriously damaged by the liquefaction phenomenon, so it is necessary to quickly establish restoration policies for the entire region and efficiently carry out the restoration work.

The committee announced the Proclamation on the Technological Urgency of Sewage Treatment System Restoration on April 15, and a second proclamation, the Proposal for the Staged Emergency Restoration, on June 14. On July 19, the committee held its third meeting, where it conducted a lively discussion of how to effectively conduct the final restoration. The NILIM is, as the administrative organ of the committee, analyzing the damage and carrying out a technical study of restoration measures, etc. Based on these proclamations, initiatives to complete the final restoration in the disaster region are being accelerated, and are counted on to restore the lives of the people of the region in the shortest possible time.

Reference URL: http://www.mlit.go.jp/crd/crd_sewerage_tk_000170-1.html

View of Damage at the Minami Gamo Wastewater Treatment Center (Sendai City)

Second Meeting of the Committee

Characteristics of highway bridge damage due to the Great East Japan Earthquake

Road Department, Bridge and Structures Division

We have surveyed road bridges damaged by the Great East Japan Earthquake. The following are its principal characteristics.

Immediately after the Great East Japan Earthquake on March 11, the NILIM conducted surveys of damaged road bridges in cooperation with the Public Works Research Institute.

NILIM surveyed more than 150 road bridges by the end of May 2011 in the prefectures of Chiba, Ibaraki, Fukushima, Miyagi, and Iwate.

Damage to road bridges caused by this earthquake is broadly categorized as three types: damage by earthquake motion, damage by tsunami, and damage by liquefaction.

Road bridges designed based on old standards (Specifications for Highway Bridges) before 1980, and not seismically retrofitted, suffered relatively severe damage. The following are the main forms of damage shown in the surveys.

- Damage to the cutoff section of longitudinal reinforcing bars in RC bridge piers
- Damage to the bodies of RC substructures with small quantities of longitudinal reinforcing bars

Damage caused by the tsunami which struck the Pacific coast of the Tohoku and Kanto regions includes the washing away of bridges erected in the region.

On road bridges at locations of nearby river levees severely damaged by ground liquefaction, cracking near attachments of bearings in bridge abutments and level differences at bridge abutment attachments caused by nearby ground subsidence were confirmed by the survey. But, no damage threatening bridge safety was found on the structural bodies of the bridges. In addition, the survey focused on bridges where nearby levees were severely damaged, but at this time, no sign of severe deformation of any bridge has been confirmed. Reports and details regarding the surveys will be regularly published at the Great East Japan Earthquake page especially prepared on the NILIM web site (http://www.nilim.go.jp/lab/bbg/saigai/h23tohoku/index.html).

Bridge with Part of its Spans of its Superstructure Washed Away
(Photo provided by the Tohoku Regional Development Bureau)

Earthquake and tsunami-induced damage to buildings and the later review of related technical standards

Building Department, Research Center for Land and Construction Management

The NILIM provides support for field surveys and the reviews of technological standards in cooperation with the Building Research Institute in order to reflect knowledge obtained from the state of damage to buildings in future countermeasures against earthquake and tsunami.

The NILIM conducted field surveys of damage to buildings in the disaster regions immediately after the earthquake in cooperation with the Building Research Institute.

Buildings etc. damaged by earthquake motions included wooden structures, steel structures, reinforced concrete structures, residential land and foundations, and non-structural elements. The results of surveys have revealed that characteristics of the damage caused by the earthquake motion include relatively widespread damage to non-structural elements of steel gymnasiums (fallen ceilings, etc.), damage to wooden buildings caused by ground deformation in developed housing areas, and large-scale ground liquefaction, etc. Almost all reinforced concrete buildings in which structural damage was observed were designed under the old seismic design standards, and the types of damage states were clearly identical to those observed after past destructive earthquakes.

With respect to damage to buildings caused by the tsunami, field surveys were conducted in the primary tsunami disaster regions. The details of damage states such as overturned or washed-away structural elements and broken openings were collected as well as inundation depth and fundamental specifications of structural elements necessary to calculate horizontal load-carrying capacity. The results of the above surveys are summarized as "the Database of Buildings Surveyed" and are reflected in the verification of design methods under the current guideline on the structural design of buildings for vertical evacuation from tsunamis.

Under the 2011 Project to Promote the Review of Building Standards and based on the results of field surveys, the reviews of technical standards related to buildings in tsunami-prone areas and countermeasures against the fall of suspended ceilings in buildings with large-scale atriums have begun in addition to the review of safety verification methods against seismic effect of long-period earthquake motions. The NILIM is supporting and cooperating actively in these reviews and working to prepare technical standards which will contribute to the mitigation of future damage.

Quick report on the above field surveys can be viewed at the following URL.

http://www.nilim.go.jp/lab/bcg/siryou/tnn/tnn0636.htm

Examples of Building Damage Caused by Earthquake Motion (Left) and Tsunami (Right)

Damage to port facilities

Port and Harbor Department , Port Facilities Division

The Great East Japan Earthquake of 2011 severely damaged port facilities. This damage can be broadly categorized as damage to breakwaters caused by tsunami and damage to quaywalls caused by earthquake ground motion.

Damage to breakwaters caused by tsunami was conspicuous in ports where the tsunami waves were high, which included ports ranging from Aomori Prefecture to Fukushima Prefecture. At Hachinohe Port, Kamaishi Port, and Ofunato Port and others, breakwater caissons slid, overturned, or sunk. Large scouring caused by the current was also seen.

Quaywall damage was extensive in ports in Fukushima Prefecture and Ibaraki Prefecture. In ports in and north of Miyagi Prefecture, quaywall damage was not severe because the amplitude of the earthquake motion was not strong as a consequence of the fact that the sedimentation in these ports was shallower than that in the ports in Fukushima Prefecture and Ibaraki Prefecture.

In Soma Port and Ibaraki Port, earthquake motion caused severe damage to quaywalls. Quaywalls collapsed at multiple locations, particularly in Soma Port shown in the photograph. It is hypothesized that first, the earthquake ground motion caused the quaywalls to bulge out towards the sea and the aprons behind them to subside, then the tsunami acted on the quay walls in this condition and the backwash caused a large water level difference, collapsing the quaywalls. Damage caused by the combined action of earthquake motion and tsunami of this kind is extremely rare. Another characteristic is that as a result of variations of ground conditions, even in a single port or harbor, the degree of damage varied greatly. In Onahama Port for example, the ability to explain the gap between the severe damage at No. 3 Pier and the absence of any damage at the Otsurugi Pier as a difference in the dominant frequencies of the ground was confirmed by observing microtremors.

Collapsed Quaywall (Soma Port)

Damage to Sendai Airport Facilities

Airport Facilities Division, Airport Department

This report presents an overview of the state of damage and emergency restoration performed immediately after the earthquake at Sendai Airport.

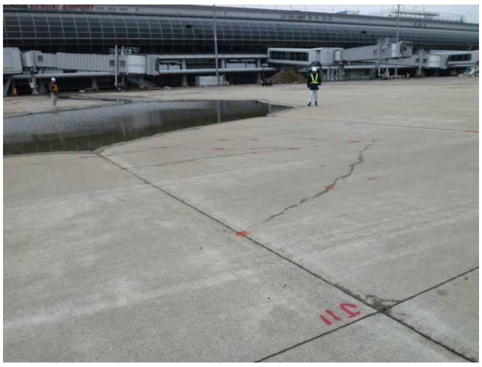
The Great East Japan Earthquake severely damaged basic airport facilities (runways, taxiways, aprons). The damage can be broadly categorized according to its cause as damage by earthquake motion, damage by liquefaction, and damage by tsunami.

Damage caused by earthquake motion was a total of 22 cracks on runways and taxiways. The cracks were lateral and spanned the full width of the asphalt surfaces. The cracks penetrated the asphalt mixture layer, but from the results of FWD testing, which is a non-destructive test used to diagnose the structure of paving, it was decided that they did not obstruct its use for the time being, so emergency restoration work was performed by injecting sealant.

Damage caused by the liquefaction phenomenon occurred on taxiways and on aprons. Damage to the taxiways was a result of liquefaction and subsidence which occurred because the backfill soil around underground structures was sandy material. On these taxiways, material was removed in the depth direction from the surface layer to the base course, then the entire surface was replaced including smoothing and roller compacting of the subgrade. Underground structures intersected a runway or taxiway at four locations, but three of these were undamaged, because liquefaction measures had already been executed.

Subsidence occurred in part of the international service area of the aprons, causing deviation of gradient and cracking of concrete slabs (photo). In this part, liquefaction countermeasure works followed by restoration of the paving is necessary, so for the time being, the facilities are closed and work to restore the entire surface is now in progress.

Damage caused by tsunami was mainly deposition of gravel and soil, but these have been removed and the affected areas have been cleaned and restored to use.



Cracks and puddles on an apron

Schedule of Principal Events (August to December 2011)

Scheduled Dates	Event Name
Aug. 29 to 30	The 43rd Joint Meeting of the Panel on Wind and Seismic Effect of the United States Japan Cooperative Program in Natural Resources (UJNR)
Nov. 8	The 9th Environmental Research Symposium
Nov. 19	Open House (Public Works Day)
Dec. 1	2011 Conference of the National Institute for Land and Infrastructure Management

RESEARCH REPORT of National Institute for Land and Infrastructure Management (May-July,2011)

No.	Title of Paper	Names of Divisions
42	The Architecture of Landscape Simulation System Ver.2.09, provided by MLIT	Research Coordinator for Housing Information System
44	Nationwide study on the sessile assemblage inhabiting coastal structures, Japan	Marine Environment Division
45	Dimensions of Mega Container Ship and Berth Dimensions/Container Terminal Area Compatible	Port Planning Division

TECHNICAL NOTE of National Institute for Land and Infrastructure Management(May-July,2011)

No.	Title of Paper	Names of Divisions
620	Cooperative Research on Performance Verification for Highway PRC Bridge	Bridge and Structures Division
622	Survey on Evacuation from the Chilean-Earthquake Tsunami in 2010	Coast Division
627	Dependence on horizontal diffusivity of estimated inflow of drifting litter in Tokyo bay	Coastal Zone Systems Division
628	An Investigation Analysis on the Overseas Supersized Container Terminals	Port and Harbor Department
629	Study on Port Management Policy in the United Kingdom	Port Planning Division
630	Estimating the Economic Effects of Port Investment with Interregional Input-Output Table at the Prefecture Level	Port Systems Division
631	An Examination on International Maritime Container Cargo Flow Focused on Eastern Asia by Sacrifice Model	Port Systems Division
632	A Characteristic Analysis on the Passengers Flows Departing from Local Airports at kyusyu and Setouchi Districts	Airport Terminal Division
633	Sensitivity Analysis of Design Values used for Empirical-Mechanistic Design Method of Airport Pavement	Airport Facilities Division
634	Report of the Evaluation Sub Committee of NILIM in FY 2010 Evaluation Committee of NILIM	Research Administration and Evaluation Division, Planning and Coodination Division
635	Investigation of actual conditions concerning evacuation of vulnerable people at flood damage	Flood Disaster Prevention Division
636	Quick Report of the Field Survey and Research on "The 2011 off the Pacific coast of Tohoku Earthquake" (the Great East Japan Earthquake)	Building Department, Housing Department, Urban Planning Department
638	Investigation of actual conditions concerning system of flood fighting	Flood Disaster Prevention Division

- Documents issued by the NILIM can be viewed at our web site. (http://www.nilim.go.jp/lab/bcg/siryou/index.htm)
- NILIM research activities and achievements are now available on the web site (http://www.nilim.go.jp/lab/bcg/siryou/2011report/index.htm), as Annual Report 2011.

National Institute for Land and Infrastructure Management
Ministry of Land, Infrastructure, Transport and Tourism
Asahi 1, Tsukuba, Ibaraki, 305-0804, Japan
(Tachihara) Tachihara 1, Tsukuba, Ibaraki, 305-0802, Japan
(Yokosuka) Nagase 3-1-1, Yokosuka, Kanagawa, 239-0826, Japan
TEL:+81-29-864-2754 FAX:+81-29-864-4322
http://www.nilim.go.jp/english/eindex.htm

No.37
Summer 2011

Edited and Published by
National Institute for Land and Infrastructure Management