Establishment of a Widespread Disaster Prevention Office (Open Since 2008)

In 2006, the promotion of elevator earthquake readiness measures became the subject of a national government report/proposal and new legislation. Around the same time, the Tokyo Metropolitan Government designated the Japan Elevator Association (Kanto branch) as a Designated Local Public Corporation under the Disaster Countermeasures Basic Act. This increased level of elevator industry corporate social responsibility led Hitachi to see a need for ongoing and organization-driven work on elevator disaster readiness. Hitachi responded by creating the Widespread Disaster Prevention Office in 2008 to provide a dedicated organization for disaster readiness instead of the project-based approach used previously.

Widespread Disaster Response Training

Every year throughout Japan, Hitachi provides periodic training designed to verify the effectiveness of rapid recovery and response systems for elevators and other building facilities in the event of a widespread disaster (see Fig. 1).
The primary areas covered by the training are:
(1) Establishment of an initial response system responsible for areas such as dispatching staff to business locations and setting up a response center
(2) Identification of damage conditions
(3) Rescue of trapped elevator users and restoration of elevator service
(4) Dispatch of recovery support staff from outside disaster areas

Widespread Disaster Recovery Support System
To respond better to disasters, Hitachi has created a system that uses its in-house information network to centrally manage information such as staff allocation instructions and recovery conditions during the period between disaster occurrence and recovery completion (see Fig. 2)(2).

(1) Identification of damage conditions
Using information such as data sent from elevators to control centers, Hitachi’s widespread disaster recovery support system can identify information for individual buildings such as elevator service statuses or the existence of trapped users. In the first ten minutes after a disaster occurs, the system automatically identifies the statuses of about 5,000 elevators, rapidly pinpointing elevators that have shut down and enabling them to be prioritized for recovery measures from hospitals or public facilities.

(2) Prediction of the scale of damage
Using elevator shutdown data from immediately after an earthquake, the system uses a proprietary analytical method to automatically predict the scale of the damage to each affected area. The prediction information is distributed by email to enable proper allocation of specialist technicians during the initial response phase, and other steps needed to quickly assemble a response team.

System Maintenance of Service Locations and Countermeasures Headquarters
(1) Expansion of means of communication
Hitachi has made efforts to expand the available means of communication by adopting technology such as MCA radio equipment* that is not subject to communications regulations during disasters, phones given priority during disasters, and satellite mobile phones.

(2) Safety checks of all employees
A safety check system sends employees at least three training emails per year and checks the responses.

(3) Disaster response action cards
All employees carry disaster response action cards that provide guidelines for how to act during a disaster, and specify each employee’s role.

(4) Other measures
(a) Expansion of emergency dormitories/company housing in central Tokyo
(b) Relocation to earthquake-resistant buildings, prevention of toppling of office fixtures
(c) Provision of emergency power supply equipment

* Multi-channel access (MCA) radio equipment: Equipment that uses radio communication technology that enables effective use of frequency bands by letting multiple users share multiple radio channels.
(d) Adoption of bicycles with puncture-resistant tires for riding through blocked transport routes
(e) Allocation of a 1,400-member team from headquarters and branch departments and affiliates during emergencies

Control Center Backup System
Hitachi has two control centers (one in eastern Japan and one in western Japan) that perform functions such as remotely monitoring and controlling elevators and other building facilities nationwide, distributing information to business locations, and identifying maintenance situations. In the event of a widespread disaster, the centers have a backup system that enables the functions of the affected center to be rapidly taken over by the other center.

Establishment of Business Continuity System for Disasters in the Tokyo Area
Hitachi has created a support system that can draw on any of its 350 nationwide service networks as required by the disaster conditions. In the event of a disaster in the Tokyo area, recovery support is provided rapidly by unaffected branches (see Fig. 3).

On September 1, 2016 (Disaster Prevention Day in Japan), widespread disaster recovery response training was held simultaneously throughout Hitachi to simulate the conditions of an earthquake that has occurred directly under Tokyo that prevents a response center from being created at the company headquarters (in Tokyo’s Chiyoda ward). The training verified the company’s response when creating an alternative response center at the Kansai Branch (in Osaka’s Kita ward).

Rapid Recovery of Production System during Factory Disaster
The Mito Works (in Ibaraki prefecture) is an elevator production location that was damaged by the Great East Japan Earthquake of March 2011, and was forced to temporarily halt production. The list of items requiring responses was diverse, including damage to critical infrastructure, damage to buildings and production facilities, disruption of transportation routes, and affected suppliers.

To enable rapid resumption of production activities, Hitachi responded by reviewing the procedures for restoring disaster-struck buildings and other initial response areas in the BCP, while systematically working on improving building earthquake resistance and expanding facilities. Hitachi also created a production system designed to restore production activities as quickly as possible and to support the secured site through activities such as creating a system for contacting and assisting suppliers, and studying alternative transportation routes.

TANGIBLE (PRODUCT) WORK

Changes in Earthquake Resistance Standards Due to Past Earthquakes
After the Miyagi-ken-oki Earthquake in 1978, stricter structural earthquake resistance standards were imposed that required building structures to sustain only minor damage from moderate earthquakes with JMA intensity levels of about 5-upper, and to remain standing after major earthquakes with intensity levels from 6-upper to about 7 (see Fig. 4).

Fig. 3—Support System during a Disaster in the Tokyo Area.
Support personnel are recruited from three locations (Omiya, Kashiwa, and Tachikawa) and dispatched to each business office in the Tokyo area.
These standards were soon accompanied by a new design and installation guide for elevators created as standards in 1981. These guidelines covered areas such as:

1. Guide rails and guide rail supports
2. Machine room equipment
3. Measures to prevent main rope disengagement
4. Hoistway devices
5. Earthquake control operation equipment

The 1995 Great Hanshin-Awaji Earthquake resulted in many cases of elevator damage from fallen weight blocks, toppled or broken devices and snagged ropes, so earthquake resistance improvements targeting these issues were added in 1998. In response to the 2005 Northwestern Chiba earthquake, the Council for Infrastructure Development created guidelines in 2009 promoting earthquake readiness measures. The guidelines called for installation of equipment such as devices for earthquake control operation (such as P-wave control operation), and specified methods for rescuing trapped elevator users and reducing user disruption after earthquakes.

In 2013, the Ministry of Land, Infrastructure, Transport and Tourism issued notices for improved earthquake safety that covered the following areas:

1. Structural methods eliminating the risk of escalator falls caused by earthquakes and other tremors
2. Elevator structural design standards for earthquakes and other tremors
3. Structures eliminating the risk of falling counterweights

The 1995 Great Hanshin-Awaji Earthquake resulted in many cases of elevator damage from fallen weight blocks, toppled or broken devices and snagged ropes, so earthquake resistance improvements targeting these issues were added in 1998. In response to the 2005 Northwestern Chiba earthquake, the Council for Infrastructure Development created guidelines in 2009 promoting earthquake readiness measures. The guidelines called for installation of equipment such as devices for earthquake control operation (such as P-wave control operation), and specified methods for rescuing trapped elevator users and reducing user disruption after earthquakes.

The 2011 Tohoku Earthquake of March 11, 2011 (the Great East Japan Earthquake) was the largest earthquake ever recorded in the Japanese archipelago. It had a JMA intensity level of 7 (magnitude 9.0), and resulted in 15,889 deaths and 2,598 missing persons. There were 8,921 damaged elevators (2.43% of the total) and 1,598 damaged escalators (3.9%) over a widespread area, but the damage to equipment conforming to the 2009 guidelines was relatively light (1.13% for elevators and 2.0% for escalators).

Control Operation during Long-period Earthquakes

Long-period seismic ground motion is a slow type of vibration that travels long distances without attenuation, and is undetectable by conventional P-wave (preliminary tremor) and S-wave (principal shock) earthquake detectors when acceleration is low.

Hitachi has developed and implemented an earthquake control operation system for long-period seismic ground motion that plays a key part in elevator systems’ resistance to earthquake damage. The system draws on Hitachi’s expertise in proprietary long-period seismic ground motion response technologies.
enables optimum operation control in response to the amount of oscillation of a long object (elevator rope and traveling cable etc.), using a predictive function driven by long-object oscillation generation, growth, and convergence mechanisms (see Fig. 5 and Fig. 6)\(^5\).

**Control Operation during Power Failures**

Elevator passengers sometimes become trapped in elevator cars when a power failure causes the elevator to become stuck between floors. To prevent passengers from becoming trapped, elevator operation modes that enable the rescue of users trapped by power failures are now mandatory (see Fig. 7)\(^6\).

**Automatic Diagnostics and Recovery System**

In response to an earthquake of intensity level 5-lower, Hitachi’s automatic diagnostic and recovery system

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**Fig. 5—Predicting Long-period Seismic Ground Motion and Long-object Vibration.**

Control operation is performed by using a long-cycle sensor to predict elevator rope behavior in real time.

**Fig. 6—Control Operation during Long-period Seismic Ground Motion.**

If resonance causes the elevator rope to shake, the elevator is stopped at a safe floor to prevent equipment failure caused by snagged ropes when service is resumed.
When power is supplied to elevators by the building's generator

Control operation (return) when power is supplied by the building's generator

Manufacturer-recommended type

When power is not supplied by the building's generator

Automatic landing device

The power needed for a single elevator is supplied by the building’s generator, enabling each elevator in the group to travel one at a time directly back to the exit floor at the rated speed.

The door opens and the passengers exit.

When all of the elevators have returned to the exit floor, manually operated switches enable normal operation to be resumed for selected elevators. (Automatically resumed operation also can be set.)

Automatic operation powered by a battery in each elevator drives all of the elevators to the nearest floor at low speed, simultaneously.

The doors open and the passengers exit.

After the passengers exit, operation is suspended until power is restored.

**Fig. 7—Control Operation during Power Failures.**
The figure shows how automatic landing devices are triggered when no power is supplied by the building’s generator, which prevents users from being trapped in elevators during power failures.

**CONCLUSIONS**

At 9:26 pm on April 14, 2016, an earthquake with a peak intensity level of 7 struck Kumamoto prefecture, shutting down about 15,000 Hitachi and competitor elevators, and damaging over 1,000 of them. Thirty minutes later, Hitachi had set up disaster response centers at the company headquarters and a Kyushu Branch, and had started collecting information and assisting affected areas. The entire company came together as one Hitachi to provide assistance for about a month starting from the early morning of the following day, as a way of improving its disaster relief capabilities. The relief work included dispatching over 400 staff members from unaffected areas. The ability to provide this kind of support was made possible by the earthquake response activities of Hitachi’s elevator and escalator business presented in this article, and was a result of the tireless, round-the-clock, single-minded dedication of each employee to the relief activities.

To enable reliable responses to disasters that can strike unexpectedly and under widely varying

**Fig. 8—Automatic Diagnostic and Recovery System.**
The flowchart shows how Hitachi’s automatic diagnostic and recovery system operates in comparison to a conventional system. The system prevents extended suspension of elevator operation by automatically putting suspended elevators into a diagnostic operation mode to provisionally restore them without waiting for inspection by a maintenance engineer.
Responding to Widespread Disasters in Japan

conditions, Hitachi will continue working on innovating technology (and improving quality) to further improve safety and security, and continue holding periodic training to promote disaster awareness and readiness.

REFERENCES


ABOUT THE AUTHORS

Kiyoshi Yashima
Maintenance Engineering Department, Global Elevator & Escalator Maintenance Division, Hitachi Building Systems Co., Ltd. He is currently engaged in the improvement of technology in the elevator and escalator maintenance business.

Kouzou Mabuchi
Maintenance Administration Department, Global Elevator & Escalator Maintenance Division, Hitachi Building Systems Co., Ltd. He is currently engaged in the improvement of operations in the elevator and escalator maintenance business.