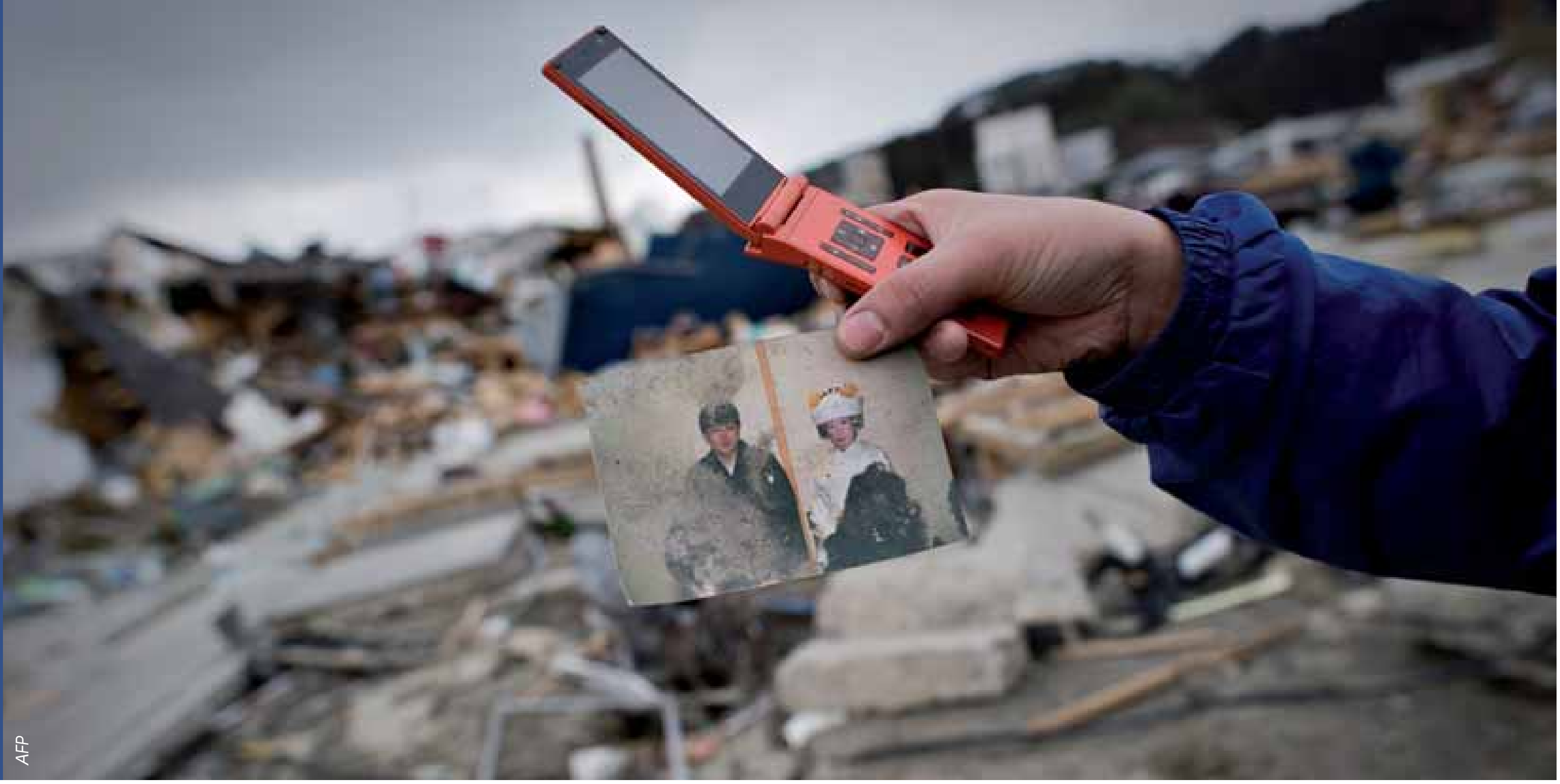
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Japan: what forces did the infrastructure have to face, and how did it stand up to the disaster?

Lessons learned

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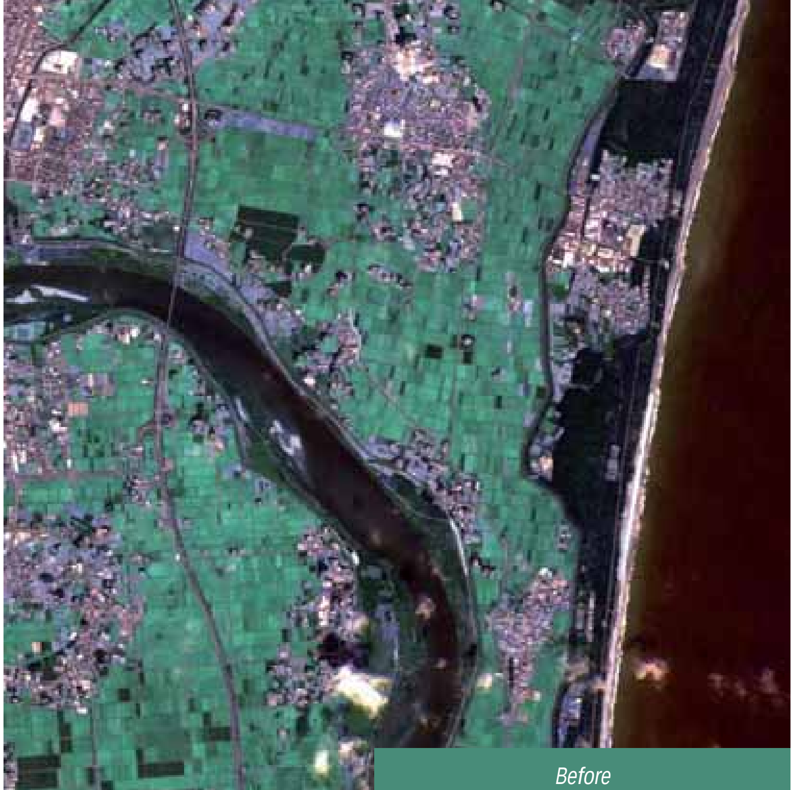
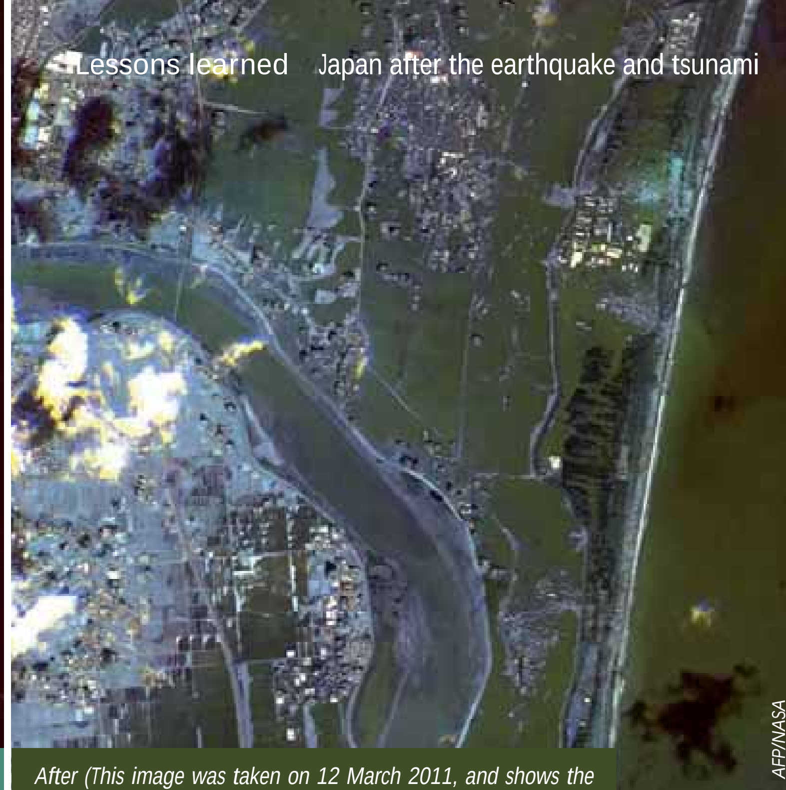
Urban planning aims to provide infrastructure that can withstand disaster or that can easily be restored if it is damaged during a disaster. Emergency communications are vital in providing disaster relief, so access infrastructure for telecommunication networks needs to be especially robust. At NTT Access Network Service Systems Laboratories, we think that it is important to co-operate with national and local government in building access systems for telecommunication networks because the capital investment in disaster-resistant infrastructure is huge.

Earthquake and tsunami

In Japan, infrastructure — and telecommunications infrastructure in particular — has been put to the test by the biggest earthquake ever recorded in the country's history that struck at 14:46 hours on 11 March 2011 off the eastern coast of Japan. The hypocentre was offshore from Sanriku at 38.1° north and 142.9° east, at a depth of about 24 km. The earthquake registered 9.0 on the Richter scale, seismic intensity decreasing with distance from the hypocentre. The seismic intensity was 7 in the northern part of Miyagi, up to 6 in southern and central Miyagi, Fukushima, and below 6 in southern Iwate and southern Gunma. And the earthquake triggered a huge tsunami, which swept



Before
(5 September 2010)



After (This image was taken on 12 March 2011, and shows the effects of the tsunami on Japan's coastline and inland)

AFP/NASA

inland with a maximum height of about 38 metres, far exceeding any previous assumptions.

The direction of the pressure axis of this reverse fault earthquake was from west-northwest towards east-southeast. It was a plate borderline earthquake, generated by the Pacific plate and the boundary of the plate on the land. The maximum amount of land shift was about 25 metres, and the scale of the fault was about 200 kilometres in a north-south direction and about 500 kilometres in an east-west direction. The fault rupture expanded in the vicinity of the point where the destruction began, then progressed north and south, continuing for about three minutes.

Damage to general infrastructure

Cities, roads and communications infrastructure were damaged by the earthquake and tsunami. What forces did the infrastructure have to face, and how did it stand up to the disaster?

The scale of the disaster and its effects on infrastructure can easily be seen from the maps and photographs shown here.

The two images shown above, from the United States National Aeronautics and Space Administration (NASA), were taken before and after the disaster. The image on the right was taken on 12 March 2011, and shows how far the tsunami penetrated inland, having flooded Miyagi and Iwate. Photo 1 shows the damage caused by the ground liquidizing. This occurred in the Itako-shi, Ibaraki, area, and caused both subsidence and surfacing. Itako-shi, Ibaraki, suffered less damage than Miyagi and Iwate, but the effects were significant. Photo 2 shows damage caused by fill subsidence at the back of a bridge abutment, with two views of the broken bridge and a picture of the broken conduit. Photo 3 shows some of the other damage caused by the earthquake and tsunami. A widening of the gap between girders caused a bridge to fall. A dramatic landslip closed a road. Sometimes infrastructure was deformed rather than broken, for example the wavy road near the port or the undulating Hitachinaka Kaihin Railway.

Damage to communications infrastructure

The disaster caused water leaks in the communications cable tunnel. Pumping stopped because of loss of power, but the communications cable was not affected and remained usable. Concrete flaked off in the cable tunnel, but there was little damage. The reason for this is because the cable tunnel was built using technology that is in accordance with standards for earthquake resistance.

It might be asked why there was not more earthquake-resistant infrastructure in Japan. The answer is depressingly simple — because of the high cost of applying these technologies in construction.

Access to communications infrastructure

The reliability of networks can be improved by means of:

- network design technology, including the distribution of data centres and the use of physically redundant transmission routes;
- network monitoring and control technologies;
- building physical networks using improved earthquake-resistant technologies.

As a telecommunications carrier and a public corporation, NTT is obliged to ensure the security of communications in the event of disaster, in accordance with the measures enshrined in law. This includes ensuring the security of access infrastructure, which is, of course, essential for supporting communication services.

Access infrastructure comprises equipment such as conduits, cable tunnels and manholes. In Japan, this infrastructure was all constructed after 1950. Access infrastructure accommodates and protects communication cables, such as metallic and optical fibre cables, and provides access via manholes, as shown in Photo 4.

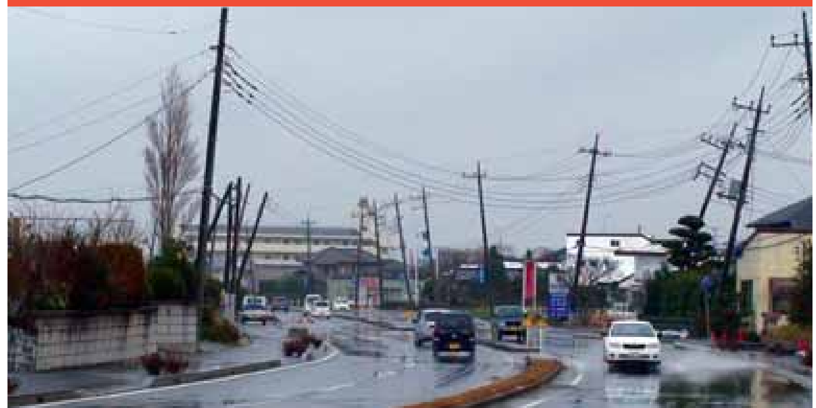
There are about 620 000 kilometres of conduits carrying cables in Japan at present, along with about 650 kilometres of cable tunnels large enough to permit human access (see Photo 4).

Earthquake-resistant technologies

NTT has researched and developed various technologies that minimize the impact of earthquakes on communication services.

Photo 1 — Damage caused by land liquidizing

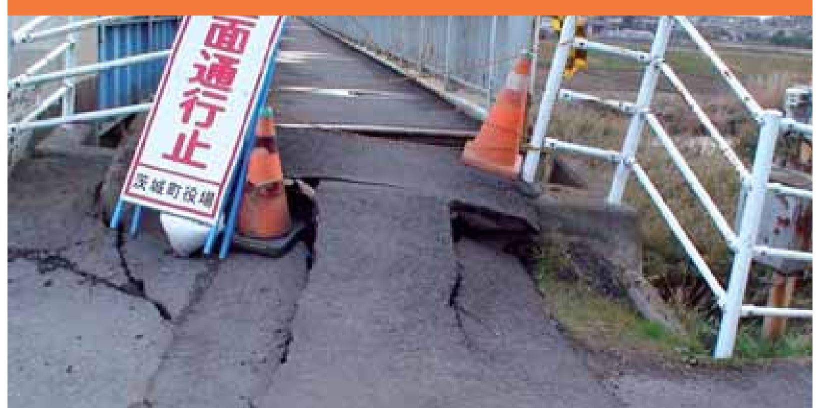
Inclination and subsidence of electrical pole



Surfacing of NTT's manhole

Photo 2 — Damage caused by subsidence

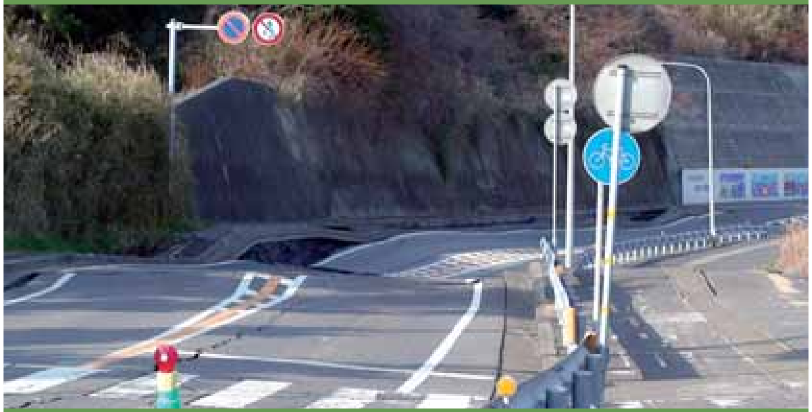
Broken bridge



Broken bridge (side view)

Photo 3 — Damage to road and railway

Deformed road



Deformed railway

Photo 4 — Access infrastructure equipment

Cable tunnel

Manhole

To counteract the tension along the axes of conduits or tunnels, caused by diastrophism resulting from an earthquake, NTT has developed a telescopic joint and duct sleeve, both of which can expand and contract.

To counteract equipment surfacing caused by ground liquidizing, NTT constructs gravel drains around manholes. The effectiveness of this technology was confirmed by a study of the effects of the earthquake that occurred in the southern part of Hyogo in 1995.

As a countermeasure to seismic ground motion at level 2 on the Richter scale, (the maximum within the range of assumptions), NTT has researched and developed various flexible technologies, such as a flexible building access conduit, a flexible excavation cable tunnel and a flexible shield shaft connection, to protect communication cables.

Ageing infrastructure

Much of the equipment now in use in Japan was constructed more than 30 years ago. About 75 per cent of cable tunnels and about 40 per cent of conduits are at least 30 years old. More than 80 per cent of manholes are more than 30 years old.

Everyone understands the importance of basic equipment, but there is almost no new construction because the capital cost is so huge, and investment is now focused on the operation and maintenance of equipment. Faced with the problem of controlling investment costs, national and local government have to make a choice between either spending money on the maintenance and management of existing access equipment or on constructing new earthquake-resistant infrastructure.

Future research and development

Continuing research and development to improve earthquake-resistant construction technologies is clearly important to ensure access to network infrastructure in the event of disaster, so that telecommunications can be maintained. It is equally clear that future research and development needs to focus on lowering the cost of basic equipment.

Priorities will need to be set, taking into account the deterioration of equipment.

NTT is researching and developing "check and repair" technologies that can be used to monitor ageing equipment. Photo 5 shows two examples of non-destructive diagnosis technology, which use two different methods to assess the deterioration of concrete: the supersonic wave method; and the electromagnetic method. The supersonic wave method is a technology for assessing concrete thickness, the depth of cracks, the compressive strength of the material, and corrosion. The electromagnetic method is a technology for assessing the depth of cracks, along with deterioration factors such as salinity.

If infrastructure is found to be deteriorating dangerously, it must be repaired or replaced. Photo 6 shows technology that can be used to repair two different types of cable accommodation tube. Using this technology, it is possible to repair and reinforce conduits that carry cables. This technology offers a way of maintaining operations at low cost.

Learning from disaster

The earthquake and tsunami that struck Japan in March 2011 affected the access infrastructure essential to supporting communication systems. Technologies now exist that are earthquake-resistant but much current equipment is superannuated. A lot will undoubtedly be learned from analysing the damage caused by the March disaster. Meanwhile, NTT will continue to work on the technologies for access construction that it has developed to date to ensure that communications lifelines remain open.

Photos on pages 38–40 are by NTT/Japan.

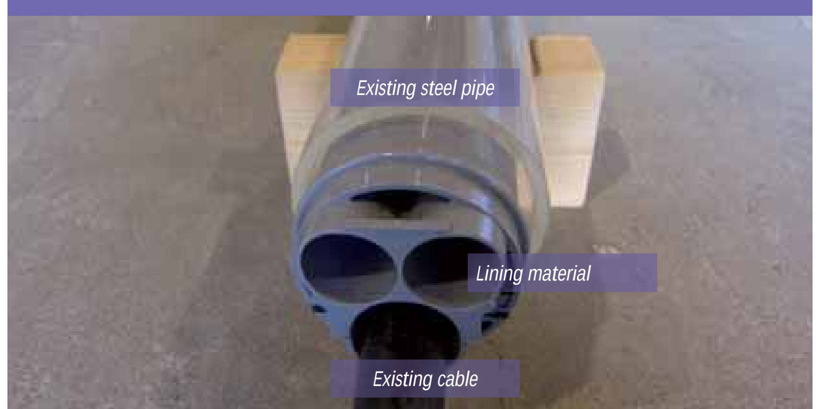
Photo 5 — Non-destructive diagnostic technology to monitor concrete

Comprehensive supersonic wave method

Electromagnetic method

Photo 6 — Repair technology for cable accommodation tube

Segmented lining



Simple lining