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SERIES L: CONSTRUCTION, INSTALLATION AND PROTECTION OF CABLES AND OTHER ELEMENTS OF OUTSIDE PLANT

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## Disaster management for outside plant facilities

Recommendation ITU-T L.92

ITU-T

International Telecommunication Union

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## Disaster management for outside plant facilities


### Summary

Recommendation ITU-T L.92 gives an overview of the technical considerations for protecting outside plant facilities from natural disasters. Disaster management for outside plant facilities such as cables, poles and manholes are introduced, and countermeasures for natural disasters such as earthquakes, strong winds and floods are described. In the appendices, Korean and Japanese experiences of disaster management are respectively introduced. Also, answers to a related questionnaire are also included to provide basic information about natural disasters around the world. The objective of this Recommendation is to share observations, knowledge, experiences and practices internationally, so that local engineering practices can be adopted to improve the disaster resistance performance of outside plant facilities.



### History

| Edition | Recommendation | Approval | Study Group |
|---|---|---|---|
| 1.0 | ITU-T L.92 | 2012-10-29 | 15 |



### Keywords

Disaster management, earthquake, flood, landslide, natural disaster, outside plant facilities, tsunami.

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## Table of Contents

## Introduction

Recently, natural disasters such as earthquakes and floods have occurred more frequently. Outside plant facilities such as manholes and poles are occasionally damaged by these disasters, and as a result, telecommunication services stop. In order to minimize the damage and/or to safely protect outside plant facilities, appropriate disaster management is needed. This Recommendation provides typical examples of disaster management including technical considerations.

# Recommendation ITU-T L.92

## Disaster management for outside plant facilities

## 1 Scope

This Recommendation:

– describes typical natural disasters and events such as earthquakes, tsunamis, floods, strong winds, etc.;

– describes typical disaster management for outside plant facilities;

– deals with outside plant facilities such as cables and associated hardware (cable tunnels, underground conduits, manholes, poles, towers, cabinets, etc.);

– provides technical considerations for protecting outside plant facilities from natural disasters.

Telecommunication buildings including indoor facilities are out of the scope of this Recommendation. The protection of cables and plants against lightning is dealt with by [ITU-T K.47].

## 2 References

The following ITU-T Recommendations and other references contain provisions which, through reference in this text, constitute provisions of this Recommendation. At the time of publication, the editions indicated were valid. All Recommendations and other references are subject to revision; users of this Recommendation are therefore encouraged to investigate the possibility of applying the most recent edition of the Recommendations and other references listed below. A list of the currently valid ITU-T Recommendations is regularly published. The reference to a document within this Recommendation does not give it, as a stand-alone document, the status of a Recommendation.

[ITU-T K.47] Recommendation ITU-T K.47 (2012), *Protection of telecommunication lines against direct lightning flashes*.

[ITU-T L.81] Recommendation ITU-T L.81 (2009), *Monitoring systems for outside plant facilities*.

[ITU-T Y.1271] Recommendation ITU-T Y.1271 (2004), *Framework(s) on network requirements and capabilities to support emergency telecommunications over evolving circuit-switched and packet-switched networks*.

## 3 Definitions

### 3.1 Terms defined elsewhere

This Recommendation uses the following terms defined elsewhere:

**3.1.1 response spectrum** [b-IEC 60068-2-57]: Plot of the maximum response to a defined input motion of a family of single-degree-of freedom bodies as a function of their natural frequencies and at a specified damping ratio.

**3.1.2 soil liquefaction** [b-ASCE]: Soil liquefaction is a phenomenon whereby a soil loses strength and stiffness during an earthquake, causing it to behave like a liquid. Surface-supported structures have settled several feet below grade, and buried tanks have floated to the surface.

### 3.2 Terms defined in this Recommendation

This Recommendation defines the following term:

**3.2.1 earthquake-resistance performance**: The capacity to withstand a certain level of shaking without excessive damage.

## 4 Abbreviations and acronyms

This Recommendation uses the following abbreviations and acronyms:

IPOCM Incident Preparedness and Operational Continuity Management

NATM New Austrian Tunnelling Method

TBM Tunnel Boring Machine

## 5 Conventions

None.

## 6 Natural disasters

### 6.1 Typical natural disasters

Typical natural disasters which may potentially affect outside plant facilities are listed in Table 1.

**Table 1 – Typical natural disasters**

| Natural disasters | Typical effects |
|---|---|
| Earthquakes | Destruction of all outside plant facilities;<br>duct bursts and disconnection of cables. |
| Tsunami | Damage to all outside plant facilities;<br>damage to central office power supplies in coastal areas. |
| Flash floods/floods | Immersion of cable tunnels;<br>potential cable damage;<br>liquid penetration into cables. |
| Forest fires | Burned down telecommunication poles;<br>disconnection of aerial cables. |
| Hurricanes/tornadoes/typhoons/wind storms | Falling telecommunication poles or towers;<br>physical damage to aerial structures;<br>disconnection of aerial cables. |
| Landslides | Destruction of underground ducts;<br>failure of retaining structures. |
| Severe cold, snow, ice or heat | Destruction of telecommunication equipment. |

### 6.2 Disaster management

Disaster management activities can be grouped into four phases as follows:

– Mitigation (prevention): activities that actually eliminate or reduce the probability of a disaster.

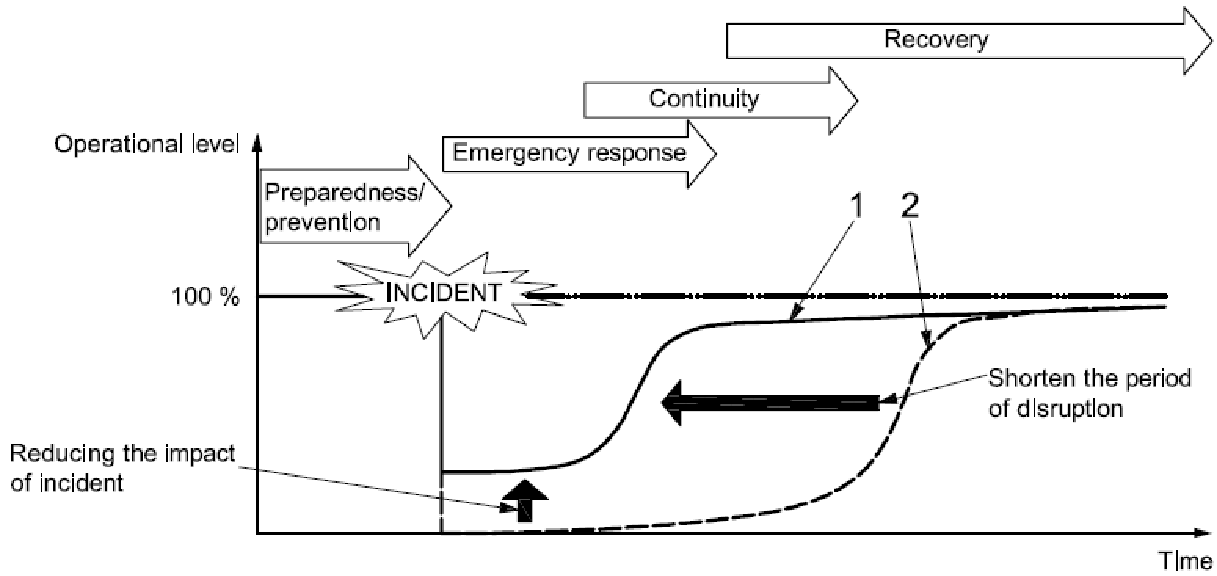
– Preparedness: activities prior to disasters that are used to support the prevention of, mitigation of, response to, and recovery from disasters. In this phase, plans are developed to save lives and minimize disaster damage (for example, installing early warning systems).

– Response: activities following a disaster. These activities are designed to stabilize the situation and to reduce the probability of secondary damage.

– Recovery: activities necessary to return all systems to normal or better (for example, rebuilding destroyed property, or the repair of other essential infrastructure).

### 6.3 IPOCM

Incident preparedness and operational continuity management (IPOCM) provides a basis for understanding, developing and implementing incident preparedness and operational continuity within an organization. This is a tool to allow public or private organizations to consider the factors and steps necessary to prepare for an unintentionally, intentionally, or naturally caused incident (disruption, emergency, crisis or disaster) so that it can manage and survive the incident and take the appropriate actions to help ensure the organization's continued viability. Figure 6-1 explains the concept of incident preparedness and IPOCM.




**Key**

1 after introduction implementation of IPOCM

2 before introduction implementation of IPOCM

*Figure from ISO/PAS 22399:2007 reproduced with the permission of ISO. Copyright remains with ISO.*

**Figure 6-1 – Concept of incident preparedness and IPOCM**

## 7 Technical considerations

### 7.1 Introduction

The objective of this Recommendation is to provide technical considerations when deploying outside plant facilities. These will include design criteria and standard methods that have been already described in other Recommendations or ITU-T handbooks or manuals.

### 7.2 Earthquakes

#### 7.2.1 General

Outside plant facilities may be damaged during earthquakes. Telecommunication services may be lost because of damage to a central office, underground conduits and overhead cables. Therefore, seismic design standards for outside plant facilities are needed to improve their earthquake performance. In addition, it is necessary to perform an initial evaluation of the earthquake hazard and outside plant facilities' vulnerability.

#### 7.2.2 Cables

Telecommunication cables are an important part of the infrastructure and they have to meet a set of requirements. These requirements are intended to protect the cables from the hostile outside plant environment, which includes earthquakes. It is recommended that cables should have good seismic performance. It is desirable that cables have enough length at manholes so as not to be cut due to ground settlement by earthquakes.

#### 7.2.3 Poles

Poles have several failure modes: falling, sinking and breaking. Poles fall to the ground when the bearing capacity of foundation is weak. In liquefied soils, poles sink into the soil. Poles can also be broken at the weakest point. The failure of the pole is attributed to ground motions or to being pulled over when an adjacent pole fails. Appropriate countermeasures should be applied according to these failure modes.

#### 7.2.4 Towers

Towers are lattice steel structures which are used to support telecommunication cables. The design criteria for towers include both seismic and wind loads, but wind loads usually control the design. Earthquake resistance design for towers can be substituted by wind resistance design, if the wind load is proved to be greater than the earthquake load. On building supported towers, however, the dynamic amplification introduced by the building should be evaluated. Though wind loads usually control tower design, earthquake performance evaluation is explicitly considered.

#### 7.2.5 Manholes, hand-holes and conduits

Manholes, hand-holes and conduits are critical components of outside plant facilities. Manholes, hand-holes and conduits are usually damaged during earthquakes. When a conduit is damaged, water can penetrate the closure and small flaws in cables will eventually allow water to enter and degrade cable performance.

Manholes are damaged when soil liquefaction occurs. The soil around the manhole liquefies and loses its shear strength, and as a result, the manhole can sink or float, breaking conduits connected to the manhole.

#### 7.2.6 Cable tunnels

There are two types of cable tunnels: open cut box cable tunnel and shield/NATM/TBM cable tunnel. Typically, cable tunnels have a higher reliability due to their higher rigidity compared with buried conduits. A shield tunnel has a higher reliability due to its deep construction compared with an open cut cable tunnel, because it is not affected by liquefaction and subsidence.

### 7.3 Tsunami

A tsunami consists of a series of sea waves and is usually caused by a massive submarine earthquake. Central offices and outside plant facilities in coastal areas may suffer serious damage. It takes a long time to repair damaged telecommunication services at central offices due to the wide variety of specialized equipment typically installed there. There is a need to design alternate trunk cable routes that can be used to sustain telecommunication services when a large portion of the trunk network is degraded. In addition, it is important to prevent water damage in manholes, hand-holes and cable tunnels and to prevent water damage to the power supplies of buildings and to have backup power supplies available for use during power supply failures.

### 7.4 Floods

Outside plant facilities are also damaged by floods. Water can enter manholes, hand-holes and cable tunnels, which can cause telecommunication equipment to break down. Therefore, manholes and hand-holes are required to be water tight. Cables entering or exiting a manhole or hand-hole have to be sealed. Cables in a manhole should be tied to shelves away from the manhole floor to avoid damage by water when water leaks into a manhole. In the cable tunnels, waterproof doors and water pumps should be provided.

### 7.5 Strong winds

Outside plant facilities may be affected by strong winds, and there is always a risk of loss of telecommunication services. Telecommunication poles should be braced and guyed to withstand maximum expected wind velocities and optical cables should be installed to resist damage due to wind-driven vibration. Towers in strong wind-prone areas shall be designed adequately to survive the high wind speed.

## 8 Disaster management for outside plant facilities

To make outside plant facilities more reliable and stable against disasters, it is recommended that disaster management should be provided. Typical examples of disaster management are listed in Table 2.

**Table 2 – Typical examples of disaster management programmes for outside plant facilities**

| **Disasters** | **Possible preventive measures** (Note 1) | **Phase** (Note 2) |
|---|---|---|
| Earthquake | Observe earthquake-resistance design standards and building codes;<br>restrict installation in active earthquake faults;<br>increase strength of materials which are used in outside plant facilities. | M |
| | Rubber joints for cable tunnels, liquefaction countermeasures on manhole, extendable joints for ducts and seismic simulations;<br>installation of vibration controlling or mitigating systems. | P |
| | Installation of structural health monitoring systems. | R |

**Table 2 – Typical examples of disaster management programmes for outside plant facilities**

| **Disasters** | **Possible preventive measures** (Note 1) | **Phase** (Note 2) |
|---|---|---|
| Tsunami | Locating central offices and cable routes on higher ground;<br>strengthening trunk line backup systems by subdividing physical network loops;<br>laying cables with ducts under the riverbed rather than installing cables along bridges near the mouths of rivers;<br>ensuring an electrical power supply, for example, by establishing duplication using a multiple electrical distribution route and an emergency electrical generation system. | M |
| Flood | Restrict installation in potential flood zones;<br>install concrete structures at the site in which ground settlement may be expected due to heavy rains;<br>install retaining structures or guardrails between outside plant facilities and steep slopes. | M |
| | Installation of waterproof doors and water pumps;<br>sealing the ends of the plastic tubes (at the manholes/pits of our underground infrastructure) with foam filler;<br>installing drainage pumps in cable tunnels and installing flood walls in cable tunnels. | P |
| | Submersion detection modules and cable tunnel management systems;<br>installation of early warning systems. | R |
| Strong winds | Observe design criteria for protection against strong winds. | M |
| | Installation of supports (i.e., struts, guy line or stay wires);<br>bracing poles alternatively with steel wires when the expected wind speed exceeds 40 m/s;<br>using bracing between poles in windy locations.<br>using vibration dampers to protect cables. | P |
| Landslide | Restrict installation in potential landslide zones;<br>keeping away from landslide-prone areas;<br>increasing the slope's stability. | M |
| | Periodic inspection;<br>installation of monitoring systems, and monitoring by measurement. | P |
| | Installation of early warning systems. | R |
| Forest fires | Using fire breaks (isolating clean land strips – mostly in rural areas). | M |
| | Protecting outside plant facilities with non-flammable or fire-retarding materials;<br>Using non-flammable materials in cable structures. | P |
| | Installation of early warning systems. | R |

**Table 2 – Typical examples of disaster management programmes for outside plant facilities**

| **Disasters** | **Possible preventive measures** (Note 1) | **Phase** (Note 2) |
|---|---|---|
| Severe cold, snow, ice or heat | Outside plant facilities that are installed at sites where there is extreme heat or cold should be provisioned with adequate countermeasures in order to operate with stability.<br>Outside plant facilities that are installed at the site or environment where its temperature difference is excessive should be provisioned with adequate countermeasures in order to operate with stability. | M |
| | A manhole cover for snow-covered areas and installing tubes for antifreeze in ducts. | P |
| NOTE 1 – This list of preventive measures is not exhaustive.<br>NOTE 2 – M: mitigation, P: preparedness, R: response | | |

# Appendix I

## Korean experience

(This appendix does not form an integral part of this Recommendation.)

Korean standards relating to stability and reliability for telecommunication facilities.

### I.1 Strong winds

It is recommended that appropriate countermeasures should be provided for outside plant facilities that are exposed to strong wind pressure.

Wind pressure loads are defined to design outside plant facilities. Table I.1 shows some examples of maximum wind pressure loads allowed to act on a vertical profile area.

**Table I.1 – Wind pressure loads**

| Facilities | Wind pressure loads per vertical profile area ($kg/m^2$) |
|---|---|
| Wooden poles, concrete poles | 80 |
| Steel poles | 80 |
| Towers | 170 |
| Cables | 100 |

### I.2 Earthquakes

As severe earthquakes of great intensity have not occurred in Korea, it has not been necessary for outside plant facilities to be earthquake resistant. Recently however, small earthquakes have occurred; this has led to new legislation that suggests most the telecommunication facilities should be designed as earthquake-resistant. In addition, old structures are now being strengthened after evaluating their earthquake resistance capacity.

Outside plant facilities that are constructed on the ground should have earthquake-resistance performance by applying a ground response spectrum. A ground response spectrum uses design parameters of building structure criteria. Outside plant facilities that are constructed on the building should have earthquake-resistance performance for a floor response spectrum. Towers should comply with the extra-first class of earthquake-resistance design. Outside plant facilities should comply with the first class of earthquake-resistance design. Wind loads are applied to tower design when wind loads are larger than earthquake loads. It is recommended that earthquake-resistance performance should be evaluated.

### I.2.1 Scope

| | | Facilities | Remarks |
|---|---|---|---|
| Towers | Building roof | Towers for backbone network;<br>wireless base transceiver station. | If wind loads are larger than earthquake loads, earthquake-resistance design is not considered. |
| | Ground | Towers for backbone network;<br>wireless base transceiver station. | If wind loads are larger than earthquake loads, earthquake-resistance design is not considered. |
| Network infrastructures | Cable tunnel | Open cut box cable tunnel;<br>shield/NATM/TBM cable tunnel. | Soil liquefaction is not considered. |
| | Conduit and manhole | PVC conduit;<br>concrete manhole. | Soil liquefaction is not considered. |
| | Telecommunication pole | Concrete pole;<br>steel pole. | Soil liquefaction is not considered. |

### I.2.2 Earthquake-resistance class

| | | Facilities | Remarks |
|---|---|---|---|
| Towers | Building roof | Towers for backbone network;<br>wireless base transceiver station. | To be designed using a roof response spectrum or floor response spectrum;<br>to be designed by extra-first class criteria.<br>If wind loads are larger than earthquake loads, earthquake-resistance design is not considered. |
| | Ground | Towers for backbone network;<br>wireless base transceiver station. | To be designed by extra-first class criteria. |
| Network infrastructures | Cable tunnel | Open cut box cable tunnel;<br>shield/NATM/TBM cable tunnel. | To be designed by first class criteria. |
| | Conduit and manhole | PVC conduit;<br>concrete manhole. | To be designed by first class criteria. |
| | Telecommunication pole | Concrete pole;<br>steel pole. | To be designed by first class criteria. |

### I.2.3 Earthquake-resistance design methodologies

#### I.2.3.1 Application of response spectrum

- Towers which are built on the roof of a building should be designed using a floor response spectrum that is specified in the criteria.
- Outside plant facilities should be designed using a ground response spectrum that is specified in the criteria.

#### I.2.3.2 Verification/design/analysis

- Outside plant facilities that are to be operated without service interruption during an earthquake should be verified by their earthquake-resistance capacity.
- Outside plant facilities that are built without failure or collapse during earthquake should be analysed and designed using:
  - The equivalent static analysis method
  - The response spectrum analysis method
  - The time history analysis method.

## I.3 Floods

Outside plant facilities in flood-prone areas shall be designed adequately to withstand flood damage. Appropriate countermeasures such as flood management systems should be provided at the sites that have experienced floods in the previous two years. Ground improvements are applied to the sites where ground settlements will be expected during heavy rain. Slopes adjacent to outside plant facilities should have stability even in the case of heavy rain.

# Appendix II

## Japanese experiences – earthquake countermeasures for underground facilities

(This appendix does not form an integral part of this Recommendation.)

### II.1 Introduction

We are becoming more aware of the power of earthquakes and the serious damage caused by them. Accordingly, we have given a high priority to the development of technologies for constructing earthquake-proof networks to ensure the reliability of future broadband services. Earthquake countermeasures for underground facilities have been developed and improved based on analyses of damage caused by actual earthquakes in the past.

### II.2 Earthquake countermeasures

#### II.2.1 Cable tunnels

Cable tunnels are designed to withstand a large scale earthquake based on a sufficient strength design, and so cables inside tunnels are not damaged. However, water leakage and flooding occur at connections. So, the following countermeasures have been developed.

1) Flexible joint for an open-cut tunnel

   This is used to prevent damage caused by relative displacements at the attachment point of the open-cut tunnel between a building and a vertical shaft (see Figure II.1 (5)).

2) Flexible joint for connection between a shield tunnel and a vertical shaft

   This is used to maintain connections between the shield tunnel and the vertical shaft (see Figure II.1 (4)).

#### II.2.2 Ducts

Since ducts are damaged by ground deformation caused by an earthquake, the following countermeasures using ducts with flexibilities to relative displacements is effective.

1) Sliding joint for general ducts

   The joint structure is changed from a screw type to a sliding type to improve the flexibility of the range of a motion (see Figure II.1 (2)).

2) Sliding joint for manhole ducts (duct sleeve)

   This is a sleeve for a duct connecting to a manhole, which also acts as a sliding joint (see Figure II.1 (1)).

3) Sliding joint with a stopper

   This is used near a bridge section and in a liquescent ground. The stopper embedded in the joint limits the excess movement of ducts (see Figure II.1 (3)).

4) Flexible building access duct

   This is used for connecting a hand-hole and a customer's building and absorbing large relative displacements (see Figure II.1 (6)).

### II.2.3 Bridge for telecommunication

As a countermeasure to earthquakes, bridges have a quake absorbing structure. When an earthquake occurs, a bridge will oscillate in all directions (360°) owing to the structure. This behaviour of the bridge prevents the failure of the bridge. However, on the other hand, such a flexible structure of the bridge requires the flexible range of motion to conventional ducts put on the bridge. Therefore, it is insufficient to take into account oscillation in only the forward direction as the countermeasure of ducts put on the bridge. Considerations should be focused on more flexible connection technologies for ducts.

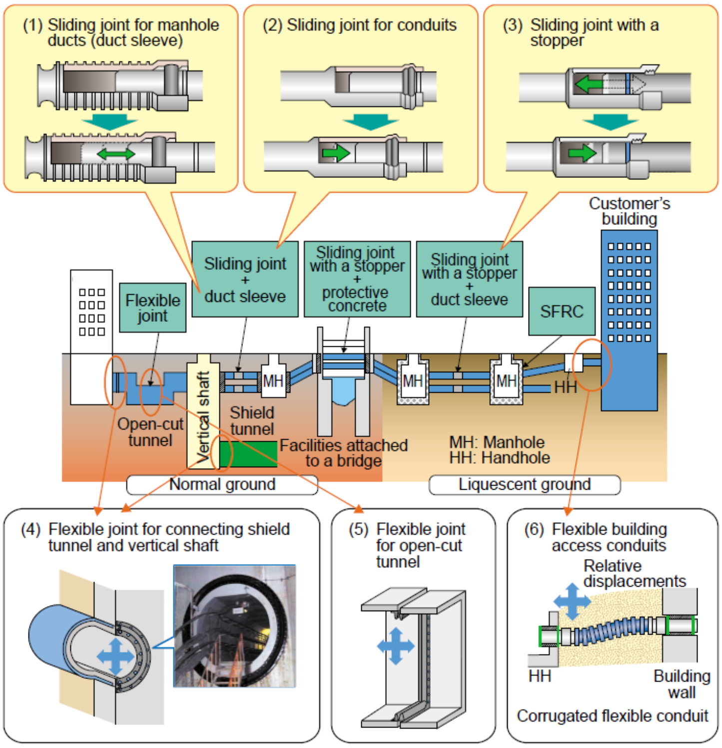



**Figure II.1 – Japanese experience of earthquake countermeasures for underground facilities**

## II.3 Example of evaluating the seismic performance of outside plant facilities

It is necessary to evaluate outside plant facilities in terms of the possibility of them suffering damage and to execute the appropriate countermeasures according to a priority assessment with a limited budget.

Figure II.2 shows an example of an algorithm for evaluating the seismic performance of underground facilities. It can evaluate their earthquake resistance based on 1) information about the facilities (available from various in-house shared databases), the ground (detailed geological data about Japan) and earthquakes (magnitude, epicentre, depth, etc.) and 2) the probability of damage estimated from historical damage data.

By performing simulations, we can predict the seismic intensity and potential liquefaction areas, and utilize this information to make an effective plan for updating facilities taking account of the importance of communication lines. The results help us in making plans for surveying damage and undertaking effective restoration work after an earthquake (see Figure II.3).

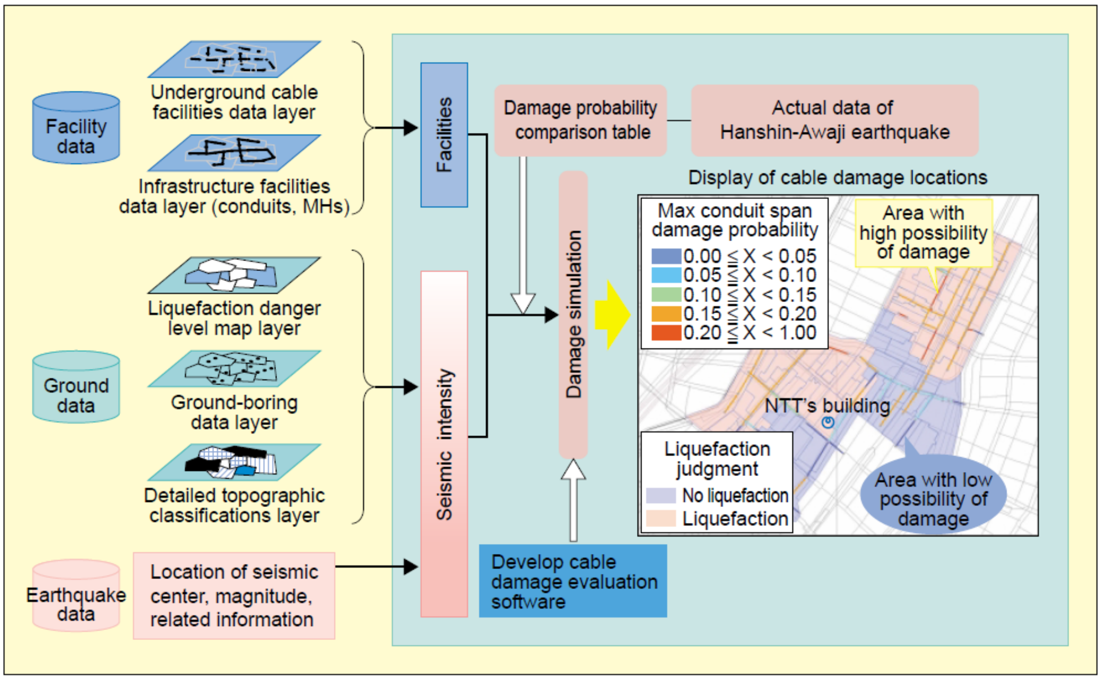



**Figure II.2 – Algorithm for evaluating seismic performance of underground facilities [b-Uehara]**

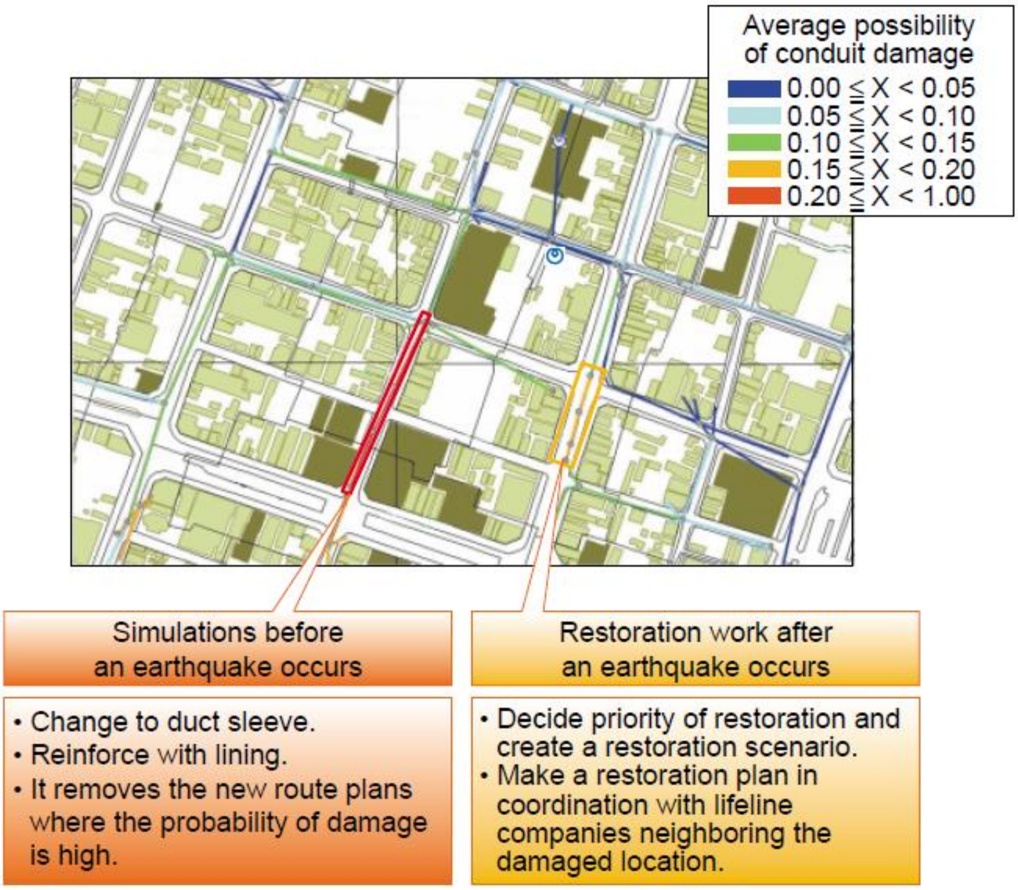



**Figure II.3 – Example interpretation of simulation results**

# Appendix III

## Answers to the questionnaire on "Technical considerations on protecting outside plant facilities from natural disasters"

(This appendix does not form an integral part of this Recommendation.)

This appendix presents answers to the questionnaire on "Technical considerations on protecting outside plant facilities from natural disasters" sent to ITU-T members to collect information regarding the observations, knowledge, experiences and practices of each country. Sixteen countries (Argentina, Costa Rica, Cyprus, Estonia, Indonesia, Iran, Japan, Korea, Mongolia, Mozambique, Poland, Spain, Switzerland, Tanzania, Turkey and Ukraine) replied to the questionnaire.

As illustrated in Figures III.1 and III.2 respectively, 81 per cent of countries that responded have experienced disasters and 87 per cent of countries have experienced communication service interruption due to the failure of outside plant facilities.

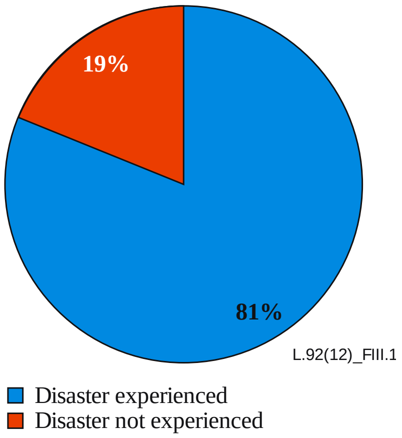



**Figure IIII.1 – Percentage of disaster experienced**

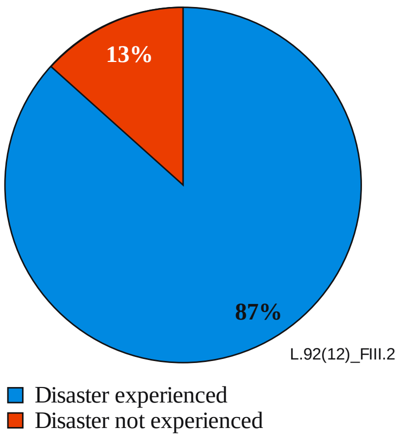



**Figure III.2 – Percentage of service-interruption by natural disasters**

It is found that the most frequently occurring natural disasters are flash floods and strong winds as illustrated in Figure III.3. Among these natural disasters, flash floods, earthquake and strong winds are ranked as the most destructive (see Figure III.4).

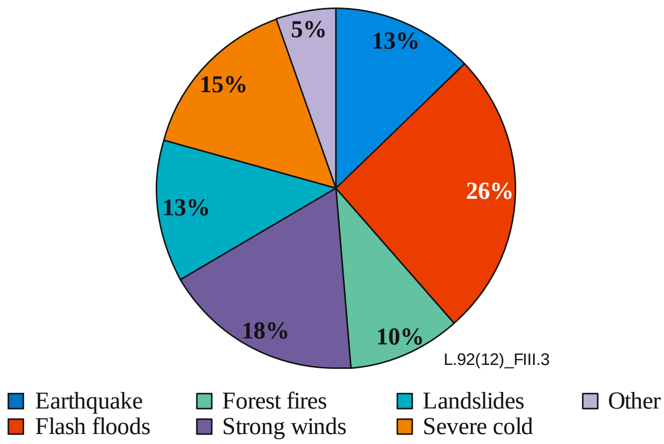



**Figure III.3 – Most frequently occurring natural disasters**

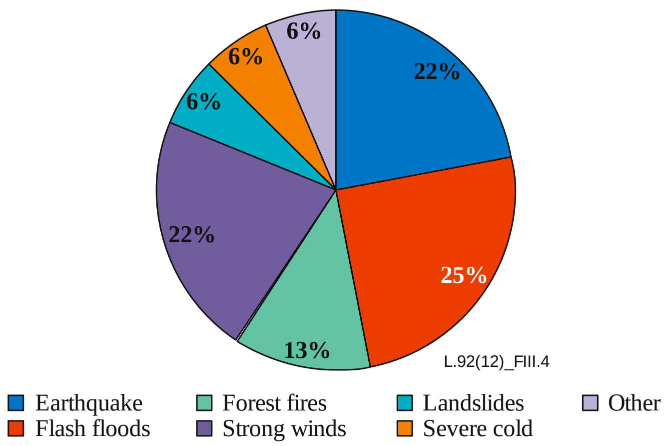



**Figure III.4 – Most destructive natural disasters**

Even though 81 per cent of countries have suffered from natural disasters, it is found that most of them do not have relevant technical standards or guidelines (see Figure III.5). For these reasons, it is required to prepare technical considerations on protecting outside plant facilities from natural disasters.

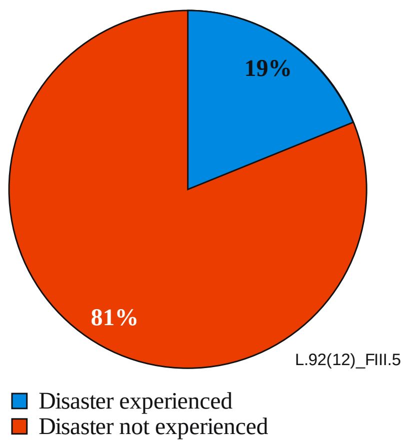



**Figure III.5 – Percentage of countries which have technical standards or guidelines**

Countermeasures for natural disasters are summarized in Table III.1.

**Table III.1 – Countermeasures for natural disasters**

| Natural disasters | Countermeasures |
|---|---|
| Earthquake | Rubber joints for cable tunnels, liquefaction countermeasures on manholes, extendable joints for ducts and seismic simulations;<br>increasing the strength of materials which are used in outside plant facilities. |
| Flash floods | Water pumps, sealed pipe ends;<br>draining water out (from pits) whenever necessary using water pumps;<br>sealing the ends of the plastic tubes (at the manholes/pits of our underground infrastructure) with foam filler;<br>submersion detection modules and cable tunnel management systems;<br>installing drainage pumps in cable tunnels and installing flood walls in cable tunnels;<br>installing concrete structures at the site in which ground settlement may be expected due to heavy rain;<br>installing retaining structures or guardrails between outside plant facilities and steep slopes;<br>cables and cable joints within manholes and cable tunnels are normally constructed to be waterproof;<br>placing waterproof materials in cable tunnel ends inside manholes;<br>water-proof cable channels, tight joints of pipes for cable channels, water-tight manholes, and installing water pump in the cable tunnels. |
| Forest fires | Using fire breaks (isolating clean land strips – mostly in the rural area) all over the island;<br>protecting outside plant facilities with non-flammable or fire-retarding materials;<br>using non-flammable materials in cable structures. |
| Hurricanes/tornadoes/typhoons/ wind storms (strong wind) | Using stay wires, protect our poles by using stay wires;<br>bracing poles alternatively with steel wires when the expected wind speed exceeds 40 m/s;<br>using bracing between poles in windy locations. |
| Landslides | Increasing the slope's stability; keeping away from landslide-prone areas. |
| Severe cold, snow, ice or heat | A manhole cover for snow-covered areas and installing tubes for antifreeze in ducts.<br>Outside plant facilities that are installed at sites where there is extreme heat or cold should be provisioned with adequate countermeasures in order to operate with stability.<br>Outside plant facilities that are installed at the site or environment where its temperature difference is excessive should be provisioned with adequate countermeasures in order to operate with stability. |

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