Increasing the Level of Infrastructure Facilities Management

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Abstract

The migration from metallic-cable-based communication to optical communication will require sufficient underground space to accommodate optical fiber cables without impediments in terms of quality and quantity. Therefore, we must provide ways to effectively maintain the existing infrastructure facilities, which are aging and degrading, as well as identify shifts in demand for optical communication. This article describes our approach to infrastructure facility management aimed at systematizing such measures.

1. Introduction

We are developing strategic management techniques for infrastructure facilities to effectively operate, manage, and maintain facilities that are becoming old and degraded in a situation where optical broadband services exist alongside existing telephone system services. Although the amount of infrastructure facilities has remained at about the same level in recent years, there are concerns that infrastructure facilities may become strained, especially in urban areas where the demand for traffic is high, because telephone services using metallic cables and broadband services using optical cables will coexist for the time being (**Fig. 1**). In addition, there are concerns over long-term deterioration because more than 20 years has passed since the time of installation for 50% of cable tunnel facilities and for 80% of cable conduit facilities.

On the other hand, in the field of social infrastructure, such as roads and bridges, rational methodology for constructing, maintaining, and operating the infrastructure facilities is being developed using the concept of asset management developed for managing real estate assets. For NTT's infrastructure facilities, we are investigating facility management techniques that incorporate such concepts to solve quality and quantity problems (**Fig. 2**). In this article, we describe the technologies involved in infrastructure

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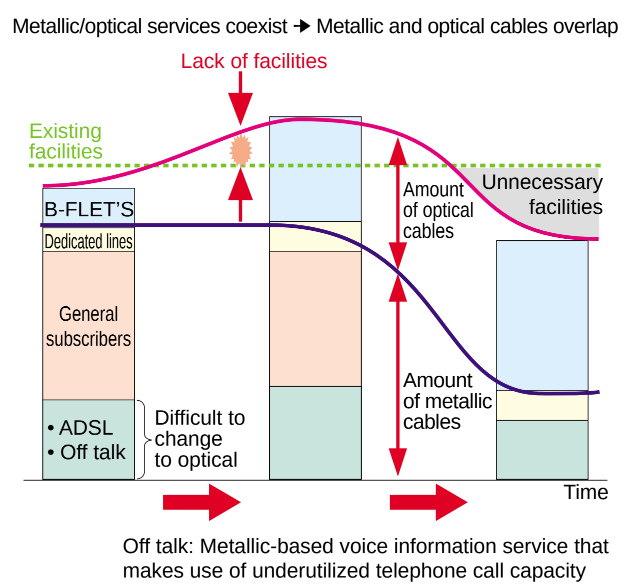


Fig. 1. Quantitative concerns about infrastructure facilities.

facilities management.

2. Technologies for optimizing the composition of infrastructure facilities

Optimizing the composition of infrastructure facilities means evaluating quantitative excesses and deficiencies taking into account shifts in supply and demand for infrastructure facilities, optimizing measures to solve problems mainly of insufficiency, and developing planning techniques. We created a procedure for diagnosing the status of supply and demand of infrastructure facilities in order to meet NTT's goal of providing optical access to 30 million of customers by 2010 (**Fig. 3**). The fundamental idea is as follows. First, we identify the availability of infrastructure facilities in terms of the number of optical fibers that can be accommodated, taking into consideration issues such as multiple cable installation and degradation of infrastructure facilities. Then, we estimate the amount of work needed to improve infrastructure facilities and the amount of corresponding infrastructure improvement work by comparing the availability with the expected future demand for optical fibers. That takes into account the usage ratio of optical fibers, ratio of optical cable subscribers to total users, and future access methods. Results to date show that the amount of investment required for infrastructure facilities is greatly influenced by two factors:

- Ratio of PDS (passive double star) systems to all optical access systems and
- Need for reserved space (additional space reserved for the installation of at least one optical cable between manholes)

In the future, we will work to establish optimum infrastructure facilities management techniques with an eye on cable routing design methods to effectively utilize the existing facilities and the latest transmission technology in access systems.

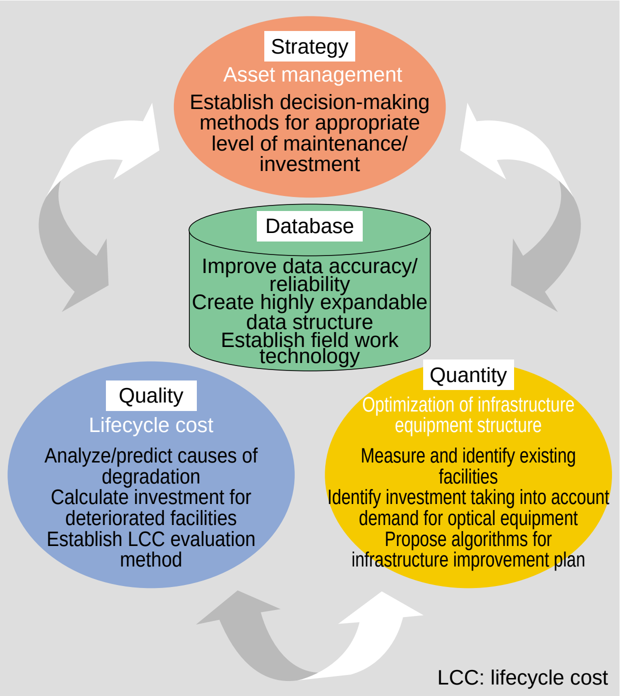


Fig. 2. Structure of infrastructure facilities management.

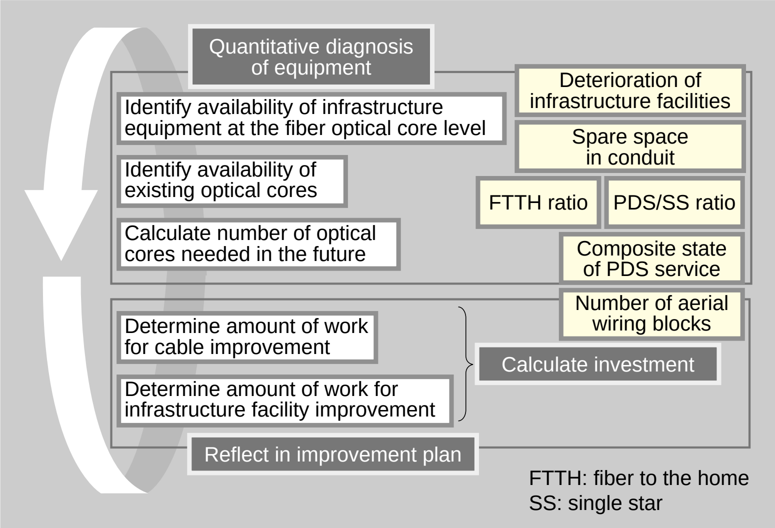
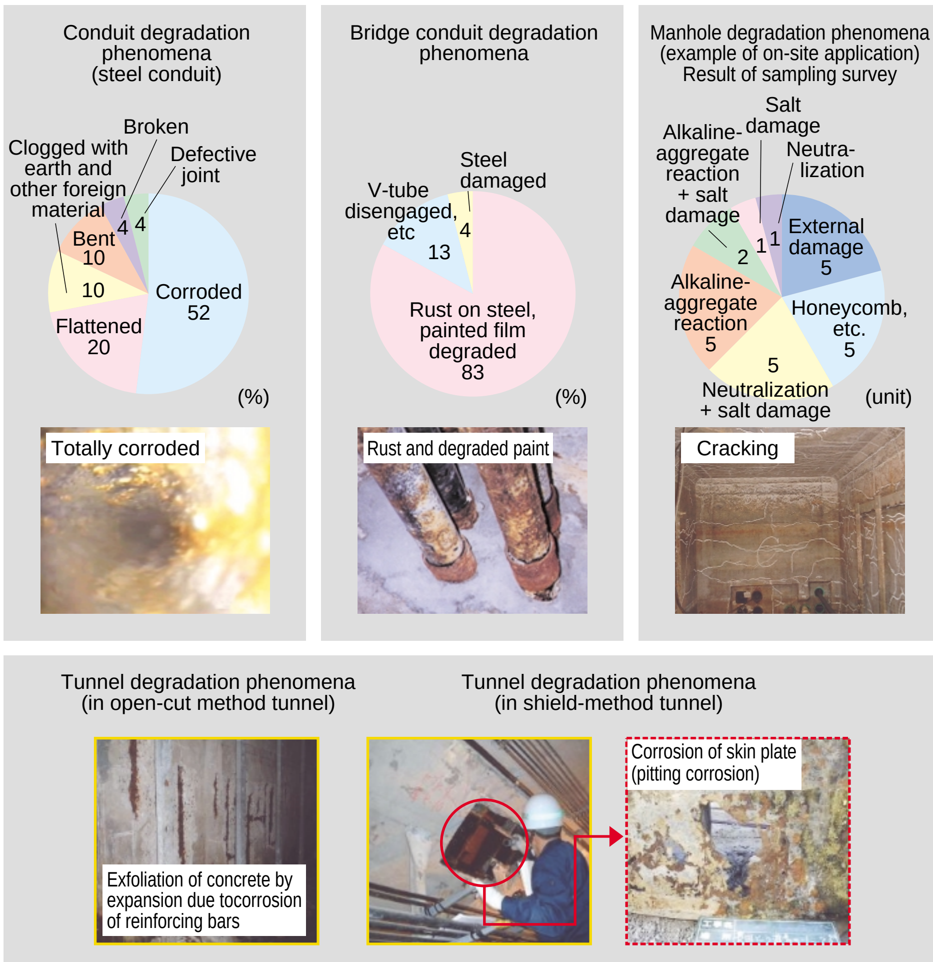


Fig. 3. Quantitative simulation of infrastructure facilities for the switch to optical communications.



Honeycomb: Cracked surface generated at the botom of a structure member by the precipitation of coarse aggregates in the concrete

Fig. 4. Examples of degradation in infrastructure facilities.

3. Lifecycle cost evaluation techniques

There are concerns about the deterioration and degradation of infrastructure facilities. Typical examples of such deterioration are shown in **Fig. 4**. They show the following visible characteristics:

- Cable conduits: Corrosion of metal tubes
- Bridge conduits: Corrosion of steel tubes and tube attachment fixtures
- Manholes: Salt damage to concrete*1 and reduction of durability caused by corrosion of reinforcing bars by long-term neutralization with age*2
- Open-cut method cable tunnel: Deterioration of reinforced concrete caused by corrosion of reinforcing bars and water leakage from junctions
- Shield method cable tunnel: Corrosion of steel segments and water leakage from junctions

Since there is concern that management costs will increase in the future as the result of these types of deterioration, we need to optimize the methods of managing and maintaining the facilities and minimize the cost of such management and maintenance. Therefore, we are aiming to establish management and maintenance techniques based on lifecycle cost evaluation techniques. These techniques let us estimate the lifecycle cost once we have identified the state of deterioration of facilities, and they enable us to determine the most economical timing in terms of total cost that allows cost equalization.

The concept of this lifecycle cost assessment method is shown in **Fig. 5**. To establish it, we must estimate the deterioration status of various kinds of facilities. We are currently analyzing the degradation

*1 The strength of structural bodies is reduced by cracks or by reductions in cross-sectional area of reinforcing steel as the result of accelerated corrosion caused by chloride ions in concrete.

*2 Reinforcing steel is easily corroded if the environment ceases to be alkaline as a result of carbonation caused by CO_2 penetrating concrete from the air.

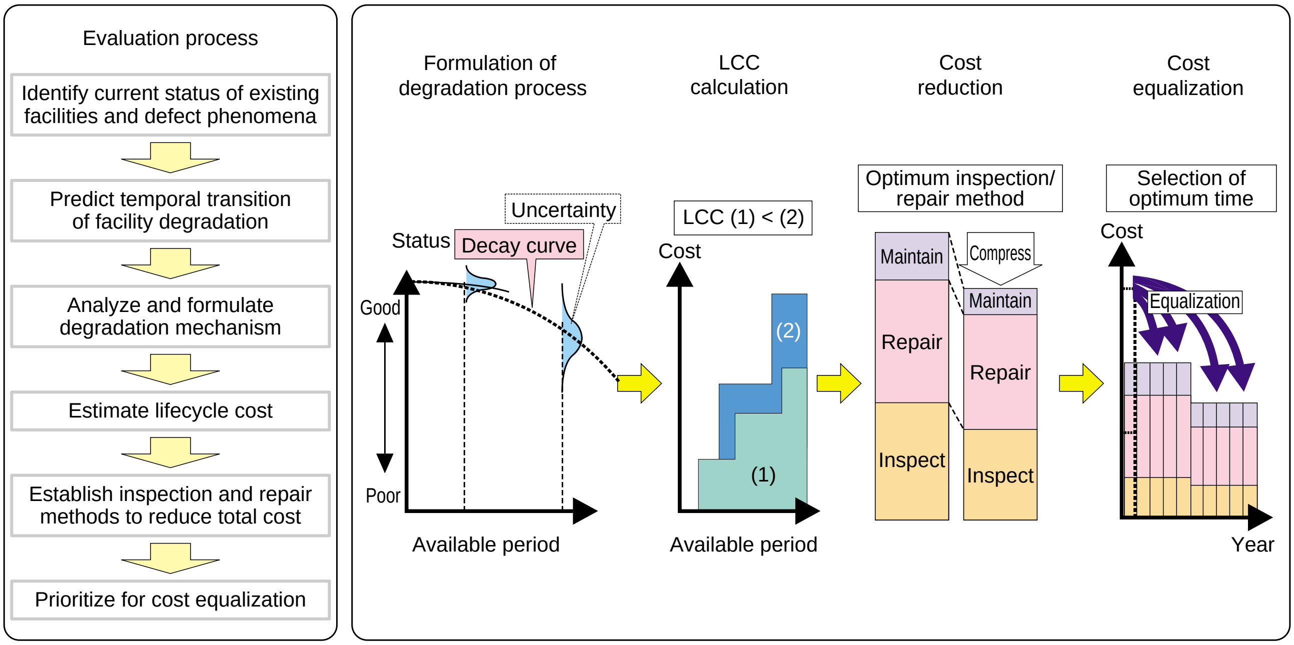


Fig. 5. Concept of lifecycle cost (LCC) evaluation method.

mechanisms of various facilities as a prerequisite to that estimation. From the results of analyzing the causes of degradation of metal tubes for cable conduit, for example, we have found that the generation of rust is greatest in places within 10 m of manholes. For the manholes themselves, we are analyzing the degradation mechanisms of concrete by performing on-site sampling and by studying the results of previous research. And for cable tunnels constructed using the open-cut method, we are investigating the relationship between the degree of exposure and the degree of corrosion of reinforcing steel. An example of this analysis is shown in **Figs. 6** and **7**.

In the future, we will formulate the deterioration process based on these analysis results and reflect it in the minimization of maintenance and management costs by establishing a method of calculating the lifecycle cost.

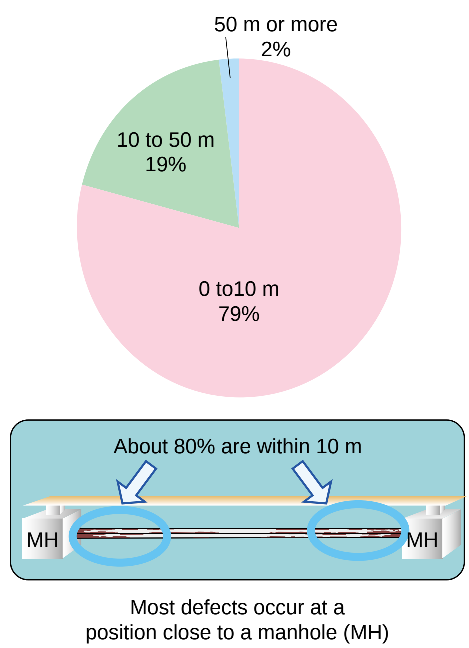


Fig. 6. Degradation analysis of metal conduit.

4. Infrastructure facilities database technology

Sufficient data about the current status of facilities is indispensable to reflect efforts on facilities management effectively in maintenance and management work. Therefore, we are developing database technology that takes into account future infrastructure facilities management work. It involves the following elements.

- Time-space database that uses chronological information that expresses the location, form, and shape of facilities
- Application of XML (extensible markup language) to enable the consolidation of various information including graphics, photographs, and video
- Application of GIS (geographical information systems) in expressing time-space data
- Coordination with other systems having an international standard interface

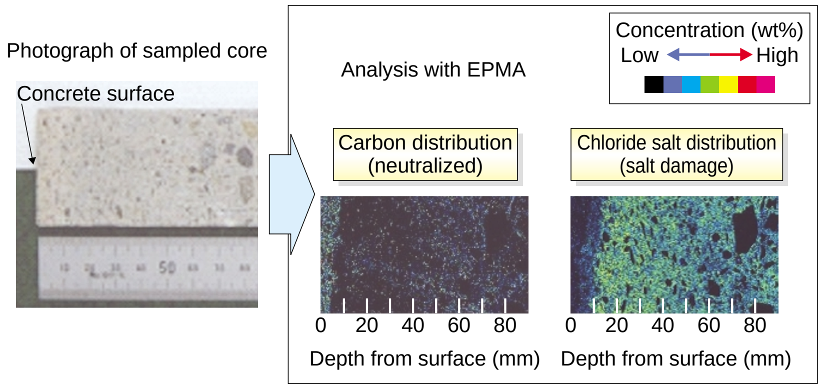
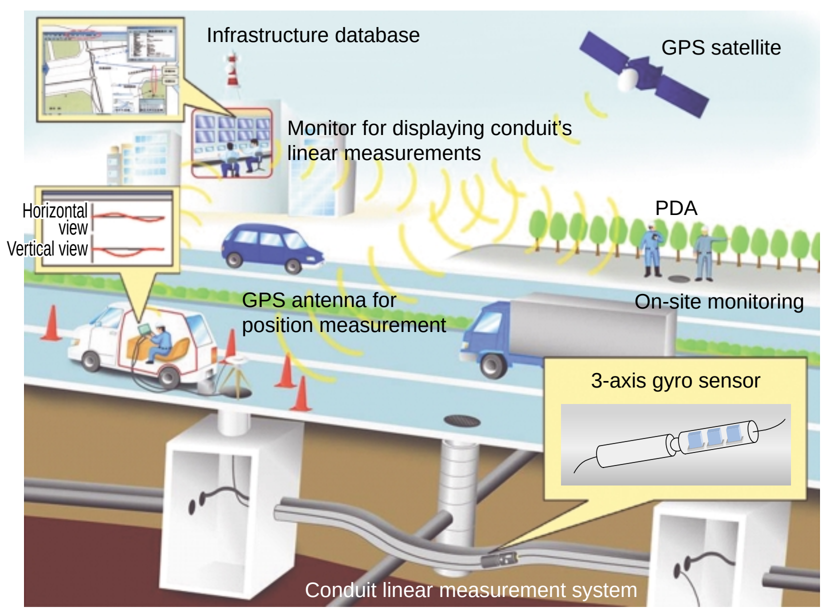


Fig. 7. Analysis on concrete sampled from manholes, including beach sand. (EPMA: electron probe microanalysis)



PDA: personal digital assistant

Fig. 8. Outline of conduit position measurement system.

- Field work technology
- RFID (radio frequency identification) technology as a user interface
- Digital watermarking and voice recognition technologies as supplemental technologies to single input
- Infrastructure position measurement utilizing GPS (global positioning system)

Here, we will explain the conduit position measurement technology as one example among those mentioned above. It precisely measures the position of a conduit using gyroscopic and GPS techniques and generates drawing data (making a database) on a global coordinate system (**Fig. 8**). In this system, it is possible to obtain linear data about the position of a conduit in an absolute coordinate system by taking measurements in latitude, longitude, and altitude absolute coordinates between two existing manholes using GPS and by measuring linear data about the conduit between two manholes using gyroscopic technology. From these measurements, it is possible to obtain accurate linear data about a conduit between two manholes that is not affected by factors such as road construction. The concept of a future infrastructure database utilizing these technologies is shown in **Fig. 9**.

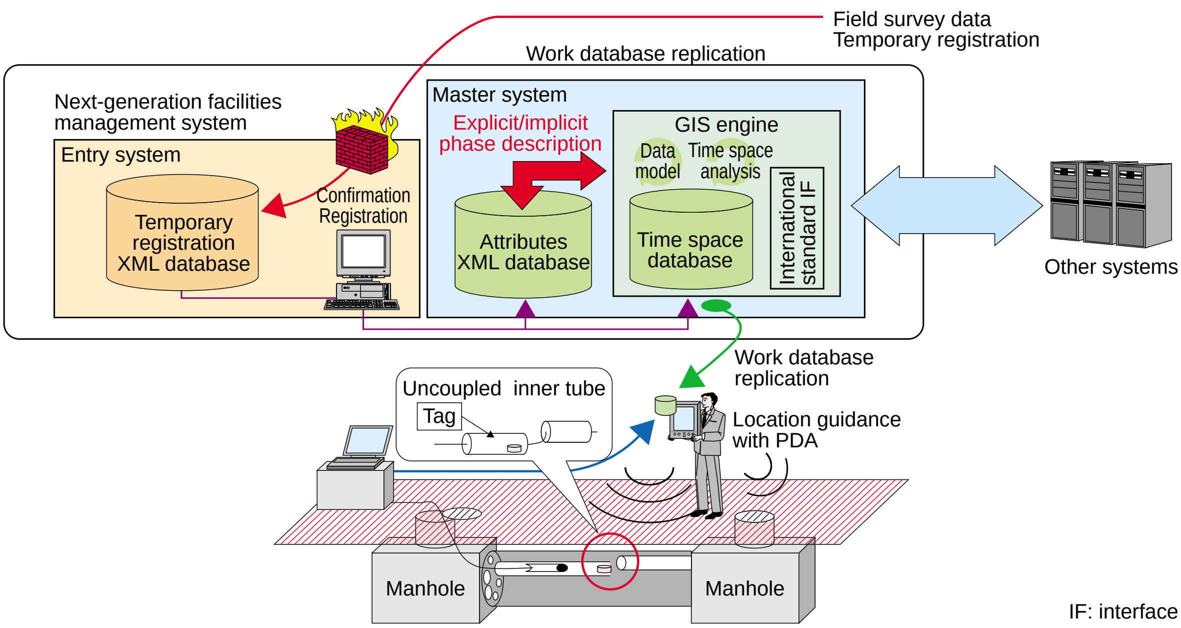


Fig. 9. Concept of future database technology.

5. Future development

We will integrate the infrastructure facilities management technology incorporating the concept of asset management to derive a systematic process and method that can reduce maintenance and management costs of infrastructure. Through these activities, we plan to develop and provide various timely and effective measures to extend the lifecycle of infrastructure facilities that continue to degrade but that we still need to use for a long time as infrastructure inventory to achieve our target of 30 million of optical service subscribers.

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