Inspection/diagnosis and Repair/ renovation Technologies for Conduits

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Abstract

This article introduces maintenance and management technologies for communication cable conduits, focusing on technologies for repairing and renovating corroded metal pipes accommodating optical communication cables.

1. Introduction

The total length of NTT's communication conduits is approximately 630,000 km. Of this total, the main line conduits that connect between manholes account for about 590,000 km. The breakdown by conduit type is shown in **Fig. 1**. A recent inspection of about 20,000 km of conduits found that up to 25% of conduits were in poor condition, making the installation of cables difficult. Metal conduits had a higher defect rate than vinyl conduits. In metal conduits, defects are mostly caused by rust, as shown in **Fig. 2**. Rust buildup inside the conduit was the number-one cause preventing cables from being laid. The photographs in **Fig. 3** of the inner surfaces of metal conduits taken with a pipe camera compare conducts in good condition with corroded ones.

The proportion of defective metal conduits tends to increase over the years. An increase in the defect rate may decrease NTT's ability to respond quickly to service requests or may increase maintenance and management costs. Therefore, we are developing cost-effective and timely inspection and diagnosis technologies as well as repair and renovation technologies for appropriately maintaining and managing existing conduits to allow them to continue to be used for a long time to come.

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2. Inspection and diagnosis technologies for conduits

A pipe camera and its related equipment are shown in **Fig. 4**. It is utilized for an inspection before cables are installed into a conduit or an inspection for pre-

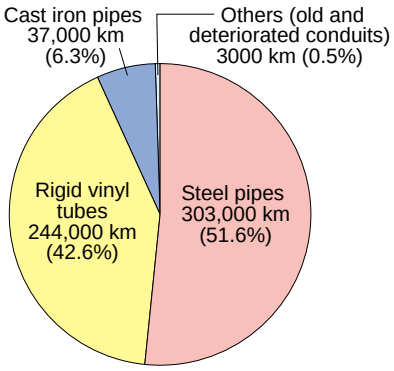


Fig. 1. Types of main line conduit.

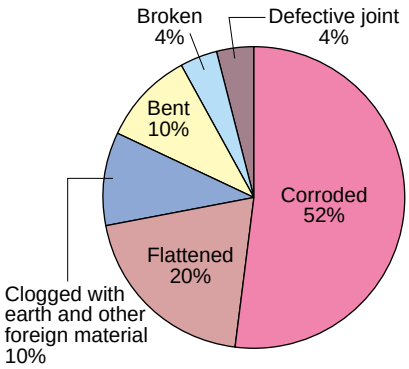
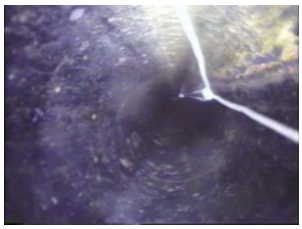
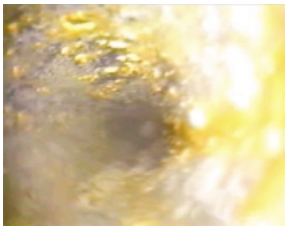


Fig. 2. Causes of defects in metal conduits.



Conduit in good condition



Corroded conduit

Fig. 3. Pipe camera images of the insides of metal conduits.

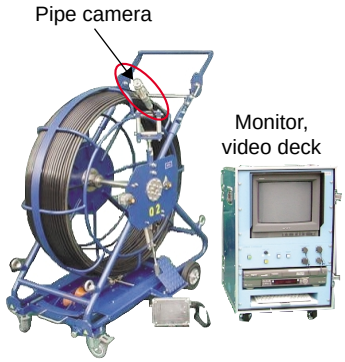


Fig. 4. Pipe camera equipment.

ventive maintenance. A pipe camera designed with a head small enough to be used during the installation of multiple cables has been developed and introduced for practical use.

3. Underground conduit repair technology

3.1 For empty conduits

Some defective conduits that do not contain any cables cannot have cables installed because of rust or earth intrusion or because they are old and weak because they were constructed a long time ago and have insufficient resistance to earthquakes. (Old and weak conduits correspond to concrete conduits or trough conduits constructed from the late 19th century to the first half of the 20th century.) Technologies for repairing empty conduits in various conditions without the need to dig a trench are shown in **Fig. 5**. Of those, we describe the TM (thick membrane) lining and thin film lining technologies in this section.

(1) TM lining

In TM lining, a resin film about 3 mm thick is formed on the inner surface by inserting a resin lining material into an existing old and degraded conduit (**Fig. 6**). Since this method can inexpensively renovate conduits that were previously unusable because of insufficient strength, it is used to provide space for installing optical fiber cables. The technology is based on municipal technology used for repairing sewage pipes. A resin hose is inserted by high-pressure air or water or a flattened shape-memory resin hose is pushed into the conduit. Then, the inserted hose is hardened by heat from hot water or steam.

(2) Thin film lining

A thin film lining can repair and extend the working life of corroded metallic conduits other than excessively old ones. After rust has been removed, a resin material is sprayed on or a hose is used to line the inner surface, forming a thin paint film or a resin film less than 1 mm thick.

3.2 For cable conduits

We are adapting repair and renovation technology used for empty corroded tubes to develop repair technology for corroded metal conduits in which cables have already been installed.

(1) Washing

We are researching a method of removing rust on the inner surface of cable conduits by using a water

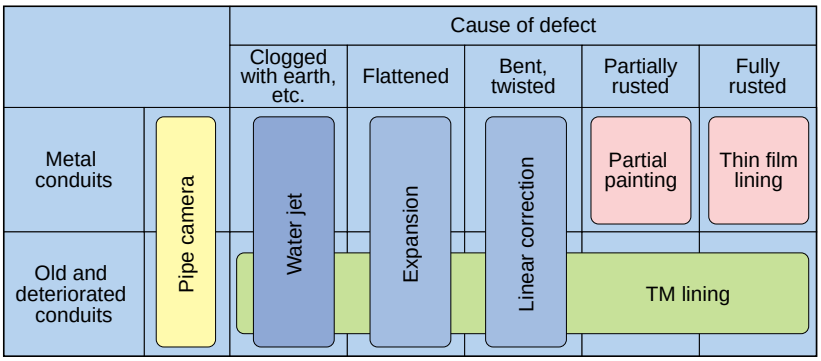


Fig. 5. Trenchless repair technologies for empty conduits.

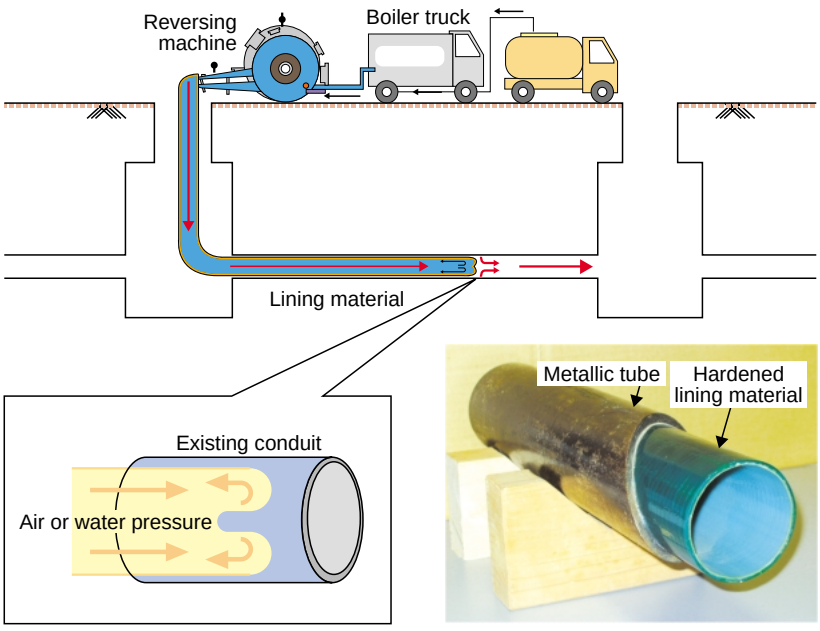


Fig. 6. Concept of TM lining technology.

jet (**Fig. 7**). While the cable with the attached washing device head is held, a water jet is emitted from nozzles attached to the head. Removed rust or other foreign material is carried by the water flow to a manhole. We are now investigating the optimum nozzle specifications and the influence of water jets on existing cables.

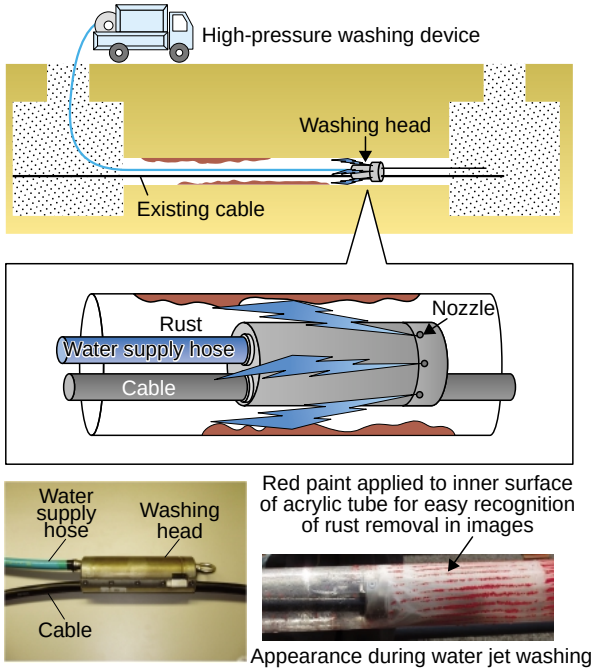


Fig. 7. Concept of cable conduit washing technology.

(2) Lining

We are investigating lining technologies to prevent rust and create a space for installing cables after the inner surface has been washed (**Fig. 8**). A lining layer

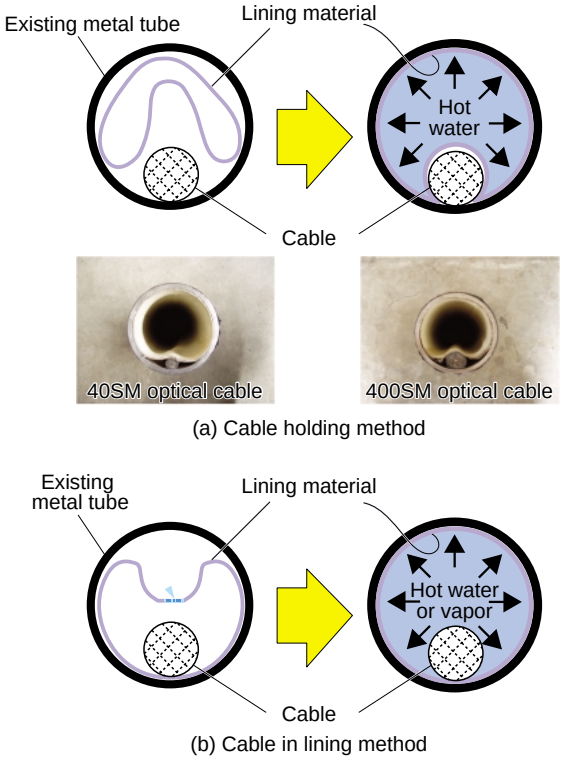


Fig. 8. Concept of cable conduit lining technology.

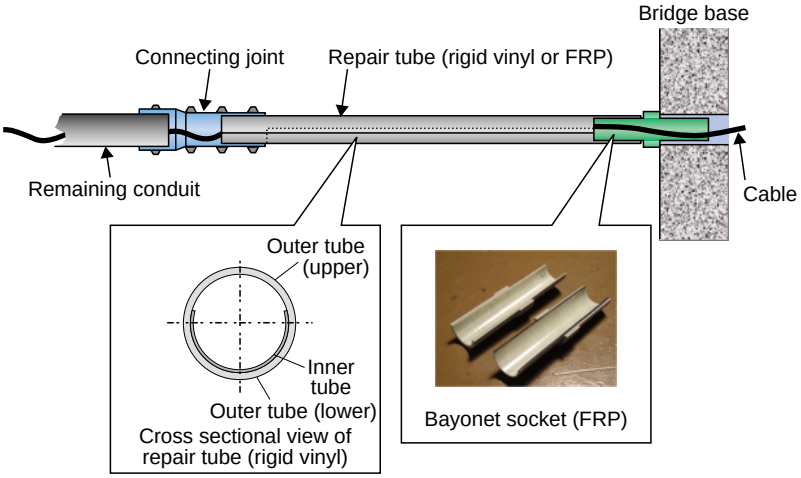


Fig. 9. Concept of bridge base conduit repair technology.

that creates a clear space for installing cables is formed using the same technology as existing tube renovation technology (Fig. 8(a)). Alternatively, space for installing multiple cables can be created by the following method. Lining material is pushed into the conduit accommodating the existing cable and is closed with a fastener or other device. It is then expanded to form a space and hardened with hot water or steam (Fig. 8(b)). This method lets us fully utilize the space remaining inside the tube. In the future, we will further investigate methods of closing the lining material.

4. Repair technology for conduits attached to bridges

Metal conduits attached to bridges suffer from severe environmental conditions such as repeated dry and wet cycles, adhesion of anti-freezing material used in winter, or accumulation of salt in seaside areas, which can all lead to rusting or corrosion. Recently, the degradation of metallic conduits located at the bases of bridges due to corrosion has become a serious concern. The trend of defective conduits by age based on past inspection data is the same as seen with metal conduits deteriorating with time. An overview of deteriorated metal conduit repair technology that we are now developing, focusing on conduits located at bridge bases, is shown in **Fig. 9**. A tube with a socket is inserted into the bridge base and repair tubes connected to this socket connect existing tubes to each other. For a cable-accommodating conduit, split-type repair tubes are used. We are studying rigid vinyl and fiber reinforced plastic (FRP) as materials for the repair tube.

5. Future plans

We will further develop conduit management and repair technologies that take into consideration life-cycle cost reduction, including cable conduit repair technologies that are more economical and functional, and nondestructive inspection technologies for measuring tube thickness reduction due to corrosion from inside the tube.

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