Outline of
"Earthquake Damage and Measure to Concrete Poles for Shinkansen"

「新幹線用コンクリート製電柱の地震被害とその対策」の概要

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1. Introduction

The 2011 off the Pacific coast of Tohoku Earthquake caused serious damage on the contact line facilities of JR East. Particularly, many of the concrete poles on the viaduct of Tohoku Shinkansen were broken and/or slanted, and recovery of those poles was a critical path to resume the operation.

Therefore, a seismic retrofitting method was developed to prevent fatal damage such as concrete pole breakage and greatly tilt, and can be restored in a short time.

Damage of concrete poles is shown in **Fig.1** and **Fig.2**.

Fig.1 Damage of poles on the viaduct

Broken pole **Slanted pole**

Fig.2 Damage of poles

2. Scope of the Paper

(1) Damage of The 2011 off the Pacific Coast of Tohoku Earthquake

The damage of concrete poles in the main shock that occurred on March 11, 2011 occurred in a wide area extending over 500km in the northern part of Omiya to Morioka. Furthermore, in the aftershock on 7th April, it was damaged from around Koriyama to the northern part of Morioka.

Number of damaged poles is shown in **Table-1**.

Table-1 Numbers of Damaged pole

Type of Damage	Numbers of Damaged pole	
	Main Shock	Aftershock
Broken	120	68
Slanted	416	200

(2) History of Seismic Design of Railway Pole

Although pole was designed for wind load and tension of electric wire, after Miyagi Prefecture Offshore Earthquake that occurred in February and June 1978, seismic design was adopted also for the design of pole, and in 1982 Seismic Design Guideline for the pole was formulated. In this Guideline, a design method was adopted that changes the response acceleration of poles according to the natural period of viaducts.

After that, the 1995 Southern Hyogo Prefecture Earthquake that caused catastrophic damage to the Sanyo Shinkansen and other infrastructure equipment occurred, and in 1999, Design Standard for Railway Structures and Commentary (Seismic Design) was published. Since the seismic design of the poles on the viaduct is closely related to the seismic design of the viaduct, the Seismic Design Guideline for pole was also revised at the same time.

In addition, Design Standard for Railway Structures and Commentary (Seismic Design) was revised in September 2012 to incorporate research results after the 2011 off the Pacific coast of Tohoku Earthquake. Following the revision of Design Standard for Railway Structures and Commentary (Seismic Design), Seismic Design Guideline for the pole was also revised in March 2013. As a result of this revision, the response acceleration of the pole, which is taken into consideration in the design, has further increased, because the response acceleration of the pole is influenced by the locking caused by the rotation of the viaduct.

(3) Seismic Retrofitting Method

Restrictions of development are followings.

① Measures to directly reinforce the existing pole. (In order to rebuild a pole, it is necessary to build another foundation structure.)

② Reinforcement without increasing strength of the pole (Increasing the strength of the pole also requires reinforcement of the foundation structure.)

③ Work in a small work space. (The space between the pole and the handrail is very small.)

④ Construction work during a short time slot at nighttime avoided the operation time of Shinkansen.

Seismic retrofitting method to overcome these restrictions was developed and confirmed its performance by the full scale shaking table test. This measure is to remodel the PC structure to the RC structure by cutting PC wires in the pole and by attaching steel tube with rebar to the pole. It is possible to simultaneously cut and attach without temporary constructions. As a result, the pole has excellent deformation performance. Even if earthquakes that are supposed by the latest design occur, the pole will not collapse and will be kept within tolerance even if it deforms. The construction procedure is shown in **Fig.3**, State after full scale shaking table test is shown in **Fig.4**, and Reinforced pole is shown in **Fig.5**.

1. Filling the mortar inside the pole

2. Setting the steel pipe with reinforcing bar, and filling the mortar

3. Cutting PC pole by wire saw

4. Attaching plasticity hinge part, and filling the mortar

Fig.3 Construction Procedure

Fig.4 Full scale shaking table test

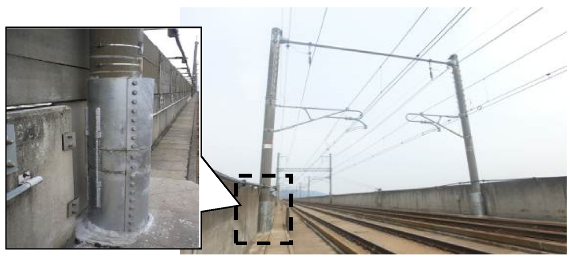

Fig.5 Reinforce pole on the viaduct

3. Conclusion

The developed method is planned to be constructed with about 2,300 poles by FY 2021.

This reinforcement makes it possible to rationally improve the safety of Shinkansen, and it is possible to effectively utilize existing poles. This project won Award of Japan Concrete Institute 2016.