Project Research — **Establishment of Optimal Risk Management**

Strategic Disaster Restoration Support Technology for Electric Power Distribution and Substation Equipment

Background and Objective

In order to effectively support the restoration activities for disaster-damaged electric power distribution and substation equipment, their risk assessment and management technologies against disasters, which shall take into consideration the reliability and accuracy of obtained disaster information during the emergency restoration period, the disaster force (hazards), and the diversity of the region and equipment, are necessary.

The objective of this project is to develop a disaster restoration support system for their equipment against mainly earthquakes and typhoons, which includes earthquake force and typhoon wind-force evaluation systems, equipment damage assessment systems, and emergency restoration process simulators, in order to put it to practical use in an actual target electric power supply area.

Main results

1 Application and Accuracy Improvement of Damage Estimation Systems

The functions of the earthquake damage estimation system (RAMPEr) and the typhoon damage estimation system (RAMPT) have been improved based on the actual operation results of Typhoon No. 12 of 2011 and the 2011 Great East Japan Earthquake.

As for RAMPEr, a new function was developed associated with correcting the seismic ground motion strength distribution evaluated by earthquake point source information (magnitude and hypocenter position, etc.), by using observed seismic intensity information consisting of information obtained from the Japan Meteorological Agency, etc., for the early stages just after earthquake occurrence. As a result, the estimation accuracy of seismic intensity distribution has improved (Fig. 1).

On the other hand, as for RAMPT, it was confirmed that an effective rainfall*, which is proposed as a typhoon damage index, is highly correlated with actual typhoon damage of electric power distribution equipment (Fig. 2). As a future subject, an improved damage estimation model with effective rainfall as one of the input parameters will be proposed to improve the evaluation accuracy level.

A part of the present study was executed as funded research from Tohoku Electric Power Co., Inc., Chugoku Electric Power Co., Inc., and Chubu Electric Power Co., Inc.

2 Verification Analysis of Earthquake Damage with an Earthquake Resistance Evaluation Tool (ELECTREE) for Substation Equipment

The strong ground motion caused by the 2011 Great East Japan Earthquake as sustained by a substation with seismic damaged equipment was estimated by ELECTREE—a developed earthquake resistance evaluation tool for substation equipment. The target substation has no seismic ground motion record. As a result, it was clarified that the seismic damage equipment has a high possibility of meeting the seismic force at its natural frequency more than a designed seismic force regulated by JEAG5003 (Fig. 3).

3 Proposal for the Deterioration Trend Analysis of Electric Power Distribution Equipment

The damage degree of electric power distribution equipment as caused by natural disasters such as earthquakes and typhoons is highly affected by a deterioration condition. Therefore, in order to improve the damage estimation accuracy against natural disasters, methods need to be proposed for analyzing deterioration trends and for estimating the remaining life of equipment. The proposed model focuses on pole transformers and utilizes an equipment management database for the above analysis and estimation. In numerical examples, a database associated with about 1.1 million pole transformers managed by the Chubu Electric Power Co., Inc. was created, and the causation of the age of the replaced pole transformer and surrounding environmental conditions, including weather conditions, was quantified. As a result, a remaining life estimation model for pole transformer is proposed. It is confirmed that the proposed model enables us to estimate the remaining life of a pole transformer based on equipment age and sea salt concentration. A part of the present study was executed as a funded research from Chubu Electric Power Co., Inc.

*Soil moisture remained in the soil.

Project Research - **Establishment of Optimal Risk Management**

Seismic Intensity distribution of the Japan Meteorological Agency (the SIJMA) due to the 2011 Great East Japan Earthquake (Miyagi Pref.)

SIJMA based on the JMA magnitude (M=7.9) obtained just after the earthquake occurrence (Existing system)

SIJMA rectified by observed seismic intensity information (Proposed system)

The evaluation accuracy of the SIJMA is not necessarily high

The evaluation accuracy is improved by the observed seismic intensity information
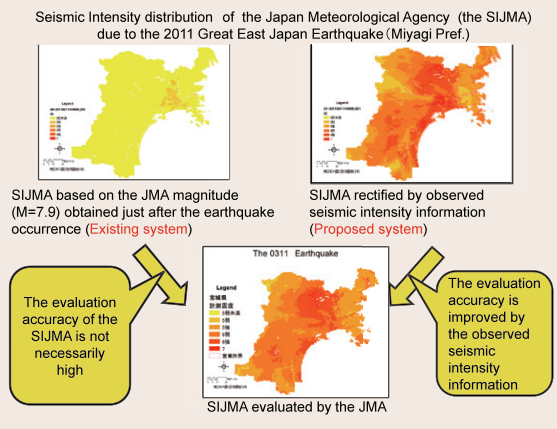
SIJMA evaluated by the JMA

Fig. 1: Improvement of the evaluation accuracy of seismic intensity distribution (SIJMA)

In the 2011 Great East Japan Earthquake, as the JMA magnitude that was announced immediately after the earthquake occurrence was small, RAMPEr underestimated the SIJMA. On the other hand, the improved system enables us to correct such underestimated SIJMA based on observed seismic intensity information.

The effective rainfall, which is correlated with the cumulative rainfall of the ground water, becomes max.

Occurrence of pole damage

Half life 72 hours

The effective rainfall, which is correlated with the rainfall remaining on the ground surface, becomes max.

Power outage occurs : 09/03 07:13UTC
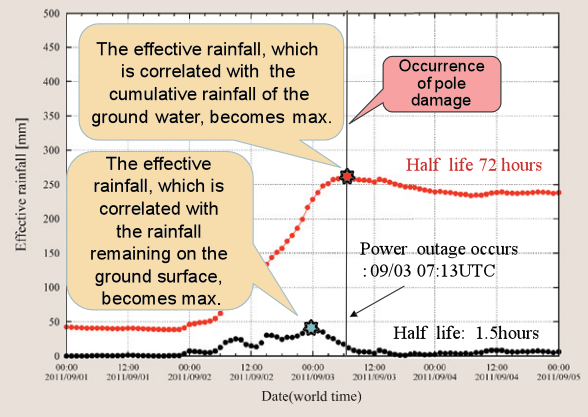
Half life: 1.5hours

Date(world time)

Fig. 2: Estimation of pole damage based on the effective rainfall

The time that the pole damage occurred is consistent with the time that the effective rainfall, for which the half life* is 72 hours, becomes the maximum. This result suggests that the effective rainfall has high correlation with pole damage.

*Half life: The period in which the quantity of remaining rainfall on the ground or underground becomes half of the total cumulative rainfall within a target period (1.5 hours or 72 hours is usually assumed as a target period)

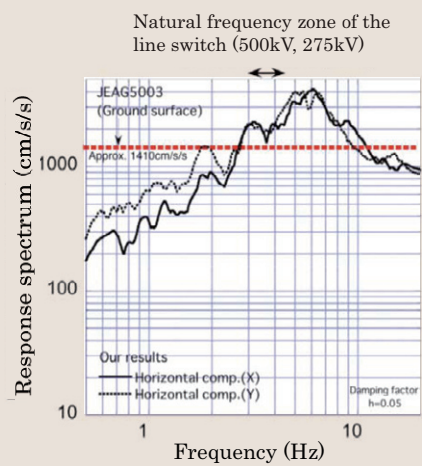Natural frequency zone of the line switch (500kV, 275kV)

Fig. 3: Comparison of the acceleration response spectrum estimated by the developed ELECTREE earthquake resistance evaluation tool and seismic design criterion of JEAG 5003

ELECTREE estimated a strong ground motion on the surface of the target substation with damaged equipment due to the 2011 Great East Japan Earthquake. As a result, it is clarified that the level of the estimated acceleration response spectrum is higher than that of the seismic design force regulated by JEAG5003.
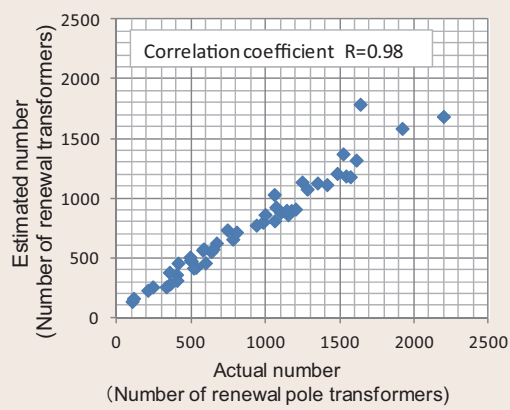

Correlation coefficient R=0.98

Fig. 4: Comparison of the actual number and estimated number of renewal pole transformers

The actual number and the estimated number of renewal pole transformer are compared in Fig. 4. The total number of renewal pole transformers during the period between March 2010 and March 2011 is defined as the actual number. On the other hand, the estimated number is evaluated by the proposed model combined with the age of each pole transformer as of March 2010. The correlation coefficient between the actual and estimated number becomes 0.98. This result suggests that estimation accuracy using the proposed model is high.