

Principal Research Results

Establishment of Performance-Based Maintenance Method – Application to Dam Spillway Gates –

Background

Recent deregulations and the widespread acceptance of performance-based concepts in the civil engineering and construction fields have prompted a general review of the methodologies for inspection frequency, field investigations, repair/renewal criteria, and other aspects of electrical civil engineering facilities. CRIEPI has a background of many years of research on hydropower civil engineering structures and has maintained diagnosis manuals for them. CRIEPI has also developed a database of the steel structures, three-dimensional finite element programs that can assess mechanical characteristics in detail. All of these have been integrated as a diagnosis system that is used in the practical works of electric power companies. At the same time, the needs and technology for maintenance have changed dramatically in recent years, so that including performance-based concepts to actual maintenance jobs, the introduction of condition monitoring, and risk/cost assessment related to maintenance are necessary.

Objectives

For dam spillway gates which are the main civil engineering structures at hydropower plants, performance-based maintenance manual that includes risk/cost assessment and maintenance support system for the data processing of the aforementioned manual are established.

Principal Results

1. Establishment of performance-based maintenance manual

We established a maintenance manual for dam gates that verifies the safety (structural safety, hydrodynamic stability, operational reliability), durability (corrosion resistance, wear resistance, fatigue resistance) and serviceability (ease of operation, water tightness, etc.) under normal conditions (including flooding) and during earthquakes (Fig.1). This manual starts with inspection and investigations, goes on to structural analysis and performance verification, and ends with the rehabilitation strategy determination. The manual has the following features: (1) With respect to inspection and investigations, failure mode and effect analysis has been introduced and the items that line up with performance verification have been extracted; (2) in structural analysis (Fig.2), we have introduced a methodology that uses the three-dimensional finite element method; (3) in performance verification, based on structural reliability analysis, we have made it possible to increase the allowable stress that is the criteria for facility renewal; and (4) in the rehabilitation strategy determination, we have introduced a method that considers risks and life cycle costs.

2. Development of maintenance support system

We have developed a maintenance support system (used over an intranet) for tainter gates and vertical lift gates - including the hoisting equipments, and guide/support structures - to support the basic components of the performance-based maintenance manual, especially the data processing section (Fig.3). This system adds quantitative assessment to a reliability centered maintenance (RCM)* framework that is based on qualitative assessment. Specifically, this system uses investigation results (external appearance, stress, displacement) and a degradation model to assess the remaining life, check operational criteria, determine repair and renewal actions, calculate risk probabilities, calculate life cycle costs, and assess rehabilitation priority levels. By including risk and cost assessment, the system is able to realize facility operation management on the point of view of cost-benefit performance.

This study has been conducted as a joint study by CRIEPI, Hokkaido Electric Power Company, Hokuriku Electric Power Company, and Electric Power Development Company.

Main Researcher: Kosuke Yamamoto, Ph. D.,
Senior Researcher, Structural Engineering Sector, Civil Engineering Research Laboratory

References

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- “Qualitative Risk Assessment Method for Dam Spillway Gates”, CRIEPI Report N05038, 2006 (in Japanese)
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A. Cost reduction and ensuring reliability

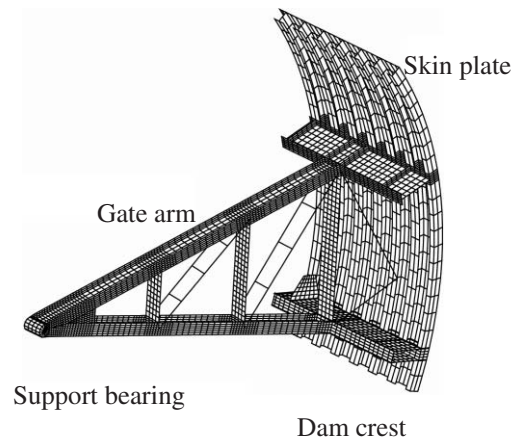
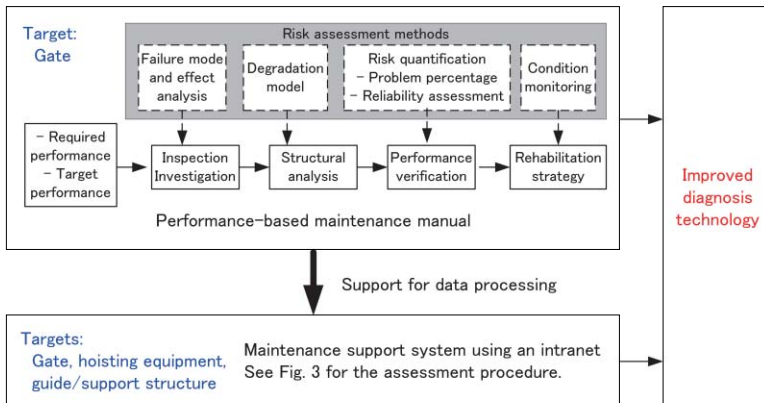
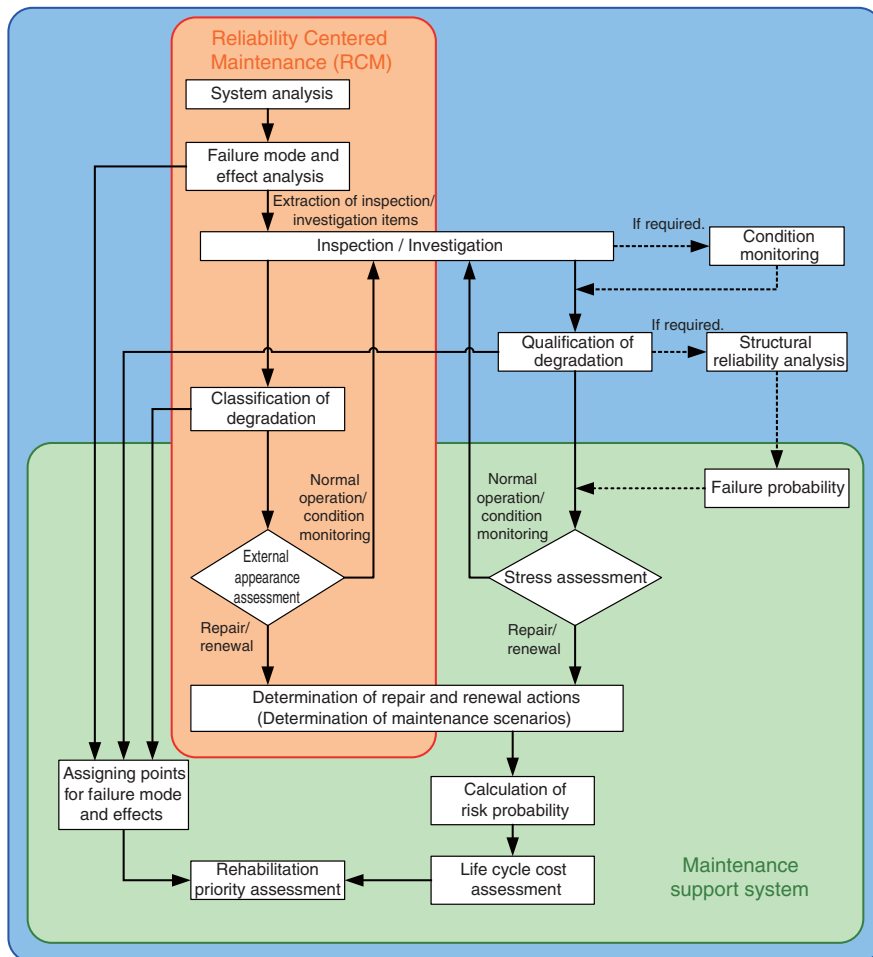


Fig.1 Relation between the Basic Configuration of the Performance-based Maintenance Manual and the Maintenance Support System

Fig.2 Example of Target Facilities (Analytical Model of a Tainter Gate)



Reliability centered maintenance (RCM)* is a generic name for analysis work that is conducted to determine effective maintenance methods through qualitative analysis. Its use has been increasing in recent years in the rationalization of maintenance for energy facilities. Conventional condition monitoring (stress assessment) and risk assessment and costs assessment have been added to this concept to construct a rational maintenance support system.

Fig.3 Assessment Procedure of a Maintenance Support System that Uses Reliability Centered Maintenance (RCM)