Rationalization of the Inspection for a Spillway Radial Gate based on the Maintenance History Record

Background

Maintenance cost reduction of power facilities is widely needed due to the change in the business environment that surrounds the electric enterprise. Thus, maintenance rationalization to deal with progressive deterioration of old facilities is discussed especially in thermal power and nuclear power maintenance sections. On the other hand, since the deterioration speed for civil engineering facilities is slower than that for other facilities including electric equipment in general, it is difficult to collect damage history data that can quantitatively analyze the deterioration frequency for them. Therefore, Attention is paid to a maintenance rationalization methodology called Reliability Centered Maintenance (RCM) *1 whose theory focuses on qualitative analysis.

Objectives

The purpose of this research is to propose a maintenance rationalization support system based on RCM that mainly targets civil engineering facilities and to demonstrate its applicability using an actual spillway radial gate.

Principal Results

1. Summary of the proposed system

The proposed system consists of two analytical stages; qualitative and quantitative (Figure 1). In qualitative analysis based on RCM, the following three rationalization points of view are discussed and reasonable rationalization alternatives that can be applied are selected: (1) Change in maintenance policy, (2) Rationalization of the inspection work, and (3) Change in repair, renewal and painting criteria. On the other hand, the quantitative analysis using the maintenance history data is performed in order to evaluate the reliability and cost-effectiveness of the maintenance rationalization alternatives. As a result, the facility manager can reasonably select an optimum alternative for the maintenance rationalization which fills a limited budget.

2. Discussion of the applicability of the proposed system (application to an actual spillway radial gate)

The proposed method was applied to an existing spillway radial gate (Figure-2). In the qualitative analysis, it was shown that the postponement of the inspection interval is one of the reasonable rationalization alternatives for the target gate. Based on the quantitative analysis using maintenance history records of repair, renewal and repainting from 1957 to 1997 for the same type of target gate, average availability *2 was estimated. As a result,we demonstrated that average availability (the decreasing rate is within 5%) is less affected by the change of the inspection interval from once/0.5 years to once /two years (Figure-3). It was also shown that when the inspection interval was fixed to once/two years, annual expected total cost (=inspection cost + expected damage cost) becomes minimum (Figure-4).

On the basis of the above results, we suggested that the inspection interval for the all components of the target gate should be changed from once /0.5 years to once/a year.

Future Developments

We will accumulate the maintenance history data while increasing the application examples of the proposed system.

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Reference

Yoshiharu Shumuta, Kosuke Yamamoto, Kiyoshi Saito (2004), Study on a maintenance management system based on Reliability Centered Maintenance (RCM) - Application to a spillway gate-, CRIEPI report, U03032.

*1：Reliability valuing maintenance (Reliability Centered Maintenance, RCM): Generic name of an analytical procedure to choose effective maintenance alternatives systematically based on qualitative analysis. The proposed system enables us to deal with serious maintenance troubles for engineering facilities.

*2：Availability: A probability (ratio) which maintains the healthy condition of structures during a target period.

This research is a part of the result for a cooperative study with Electric Power Development Co., Ltd.

Alternatives of the maintenance method are examined considering the economic rationalization target

(1) Setting of rationalization target
(Example: 5% maintenance cost is reduced more than the current state)

The first analysis (qualitative analysis)

(2) Selection of maintenance method based on RCM
i) Selection of damage mode
ii) Selection of influence factor for each failure mode
iii) Selection of maintenance rationalization alternatives based on the following points of view
・Change in maintenance policy
・Rationalization of the inspection work
・Change in repair, renewal and painting criteria

The second analysis (quantitative analysis)

(3) Availability analysis
(Reliability assessment of rationalization scenario)

(3) Cost effectiveness analysis
(economy evaluation of rationalization scenario)
・Evaluation of expected total cost in each unit time

(4) Confirmation of restriction condition
Is the rationalization target filled ?
Is the selected alternative safe ?

No

Yes

(5) Decision of the best maintenance rationalization alternative

Fig.1 Flow diagram of maintenance rationalization support system

The point: The proposed system consists of two analytical approaches: the quantitative based on RCM and the qualitative based on maintenance historical data.

Based on the qualitative analysis, we understand that it is possible to discuss the reasonable inspection interval as a maintenance alternative.

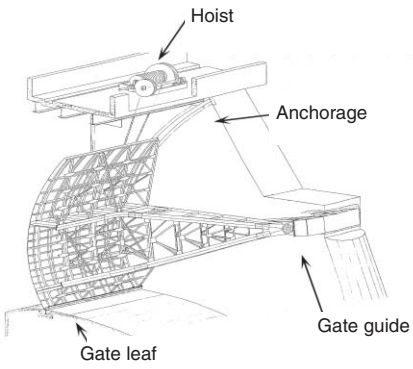


Fig.2 Target spillway radial gate

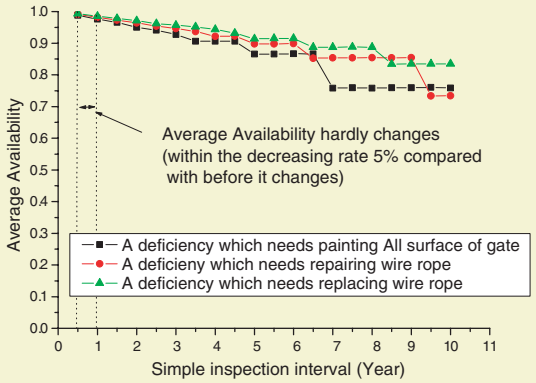
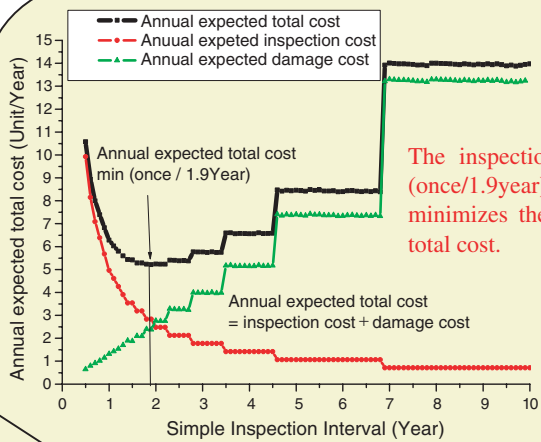


Fig.3 Relationship between the simple inspection interval and the average availabilities

The point: The availability is utilized as a scale of the maintenance reliability level.



The inspection interval (once/1.9year) minimizes the expected total cost.

Fig.4 Relationship between the expected total Cost and simple inspection interval

The point: The proposed system enables us to evaluate the cost-effectiveness for maintenance alternatives.

The inspection interval is changed from once/0.5 years to once /a year.