CORROSION DETERIORATION CHARACTERISTIC OF STEEL BRIDGES

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1. INTRODUCTION: For steel bridge, corrosion of steel can be observed in several years after construction. The aim of this study is to evaluate the amount of corrosion based on steel exposure test, paint life and corrosion ratio. The final aim is to find the effect of corrosion to the strength of bridge.

2. CORROSION OF BRIDGE STRUCTURE: In general, paint is used for protecting corrosion. Paint life is estimated based on investigated data conducted by Japan National Railway.[1] Regression equations of paint layer deterioration in the form of Rating Number (RN) as a function of time are estimated. Results are shown in Table 1. Paint life is assumed to finish when RN is lower than 2. Figure 1 shows an example of estimated paint life based on this assumption.

TABLE 1 REGRESSION EQUATIONS OF PAINT

ENVIRONMENTS	POSITION IN BRIDGE	REGRESSION EQUATION	STANDARD DEVIATION
RURAL	WEB	Y=4.0-0.264X	σ=0.0742X
	LOWER FLANGE	Y=4.0-0.377X	σ=0.1192X
MOUNTAINOUS	WEB	Y=4.0-0.235X	σ=0.0813X
	LOWER FLANGE	Y=4.0-0.317X	σ=0.0988X
INDUSTRIAL	WEB	Y=4.0-0.382X	σ=0.1697X
	LOWER FLANGE	Y=4.0-0.571X	σ=0.1728X
MARINE	WEB	Y=4.0-0.282X	σ=0.0760X
	LOWER FLANGE	Y=4.0-0.464X	σ=0.1581X

For corrosion of steel material, regression equations for predicting corrosion for exposure period of 1,2,3,4 and 5 years are obtained. They are

$$Y_1 = 551.7+53.2X_1-15.4X_2-0.111X_3+33.9X_4+4.46X_5 \quad (1)$$
$$Y_2 = 878.3+75.1X_1-26.9X_2+0.021X_3+47.8X_4+5.99X_5 \quad (2)$$
$$Y_3 = 2001+101.3X_1-49.1X_2+0.120X_3+57.3X_4+6.83X_5 \quad (3)$$
$$Y_4 = 5289+118.3X_1-96.1X_2+0.333X_3+39.4X_4+7.29X_5 \quad (4)$$
$$Y_5 = 5793+131.5X_1-111.4X_2+0.503X_3+55.9X_4+7.57X_5 \quad (5)$$

where Y_1, Y_2, Y_3, Y_4 and Y_5 are expecting corrosion depths(10^{-4}mm) for exposure period of 1,2,3,4 and 5 years, X_1:temperature(°C), X_2:humidity(%), X_3: precipitation(mm/year), X_4:SO_2(10^{-3}ppm), X_5:sea-salt particle(10^{-4}g/cm^{2}year)

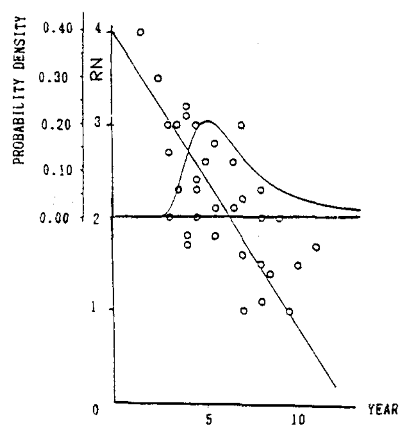

FIGURE 1 PROBABILITY DENSITY FUNCTION OF PAINT LIFE LOWER FLANGE, MOUNTAINOUS ENVIRONMENT

Horikawa et al[2] have introduced the predicting equation for long-term corrosion which is

$$Y = A X^B \exp(C/X) \quad (6)$$

where Y:expecting long-term corrosion, X:exposure time, A,B and C : constants. Based on the data in Table 2, Y_1, Y_2, Y_3, Y_4 and Y_5 are obtained. Applying the results into Eq.6, parameters A,B and C are estimated as 0.088, 0.627 and 0.157 respectively.

TABLE 2 DATA OF ENVIRONMENTAL FACTORS

X1	X2	X3	X4	X5
16.2	67	1400	22.6	8.1

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Corrosion depths of steel materials of bridge structure are estimated based on the following assumptions: 1) Corrosion will not occur until finishing of paint life. 2) After finishing of paint life, behavior of corrosion of middle part at lower flange of external girder is the same as in exposure test. 3) For other parts, corrosion ratio (Figure 2) is applied into predicting equation (Eq.6) for adjusting the state of exposure of steel. Figure 3 shows comparison of corrosion between estimated values and measured values of plot types of bridge.

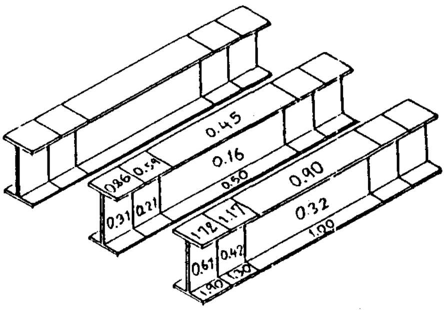

FIGURE 2 CORROSION RATIO. RURAL ENVIRONMENT

3.EFFECT OF CORROSION TO THE STRENGTH OF BRIDGE

Stress ratio is introduced as a performance index to evaluate the strength of bridge due to corrosion. This ratio is the comparison of bending stress values between original materials and corroded materials. Figure 4 shows the girder section used in estimation. Results of estimation are shown in *Figure 5*.

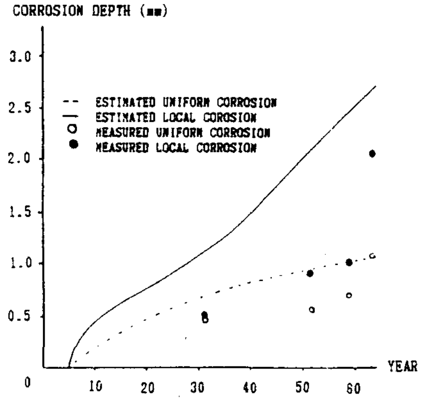

FIGURE 3 COMPARISON OF CORROSION BETWEEN ESTIMATED VALUES AND MEASURED VALUES (RURAL, LOWER FLANGE)

4. CONCLUSION: In this study, predicting eqs. for corrosion as well as regression eqs. of paint layer deterioration were obtained. Paint life is assumed to finish when RN is 2. Corrosion ratio was estimated based on data of 5 bridges. Local corrosion is assumed to develop when average corrosion is 0.7mm. Based on these results, corrosions of steel bridge were estimated. Results accord well with measured values.

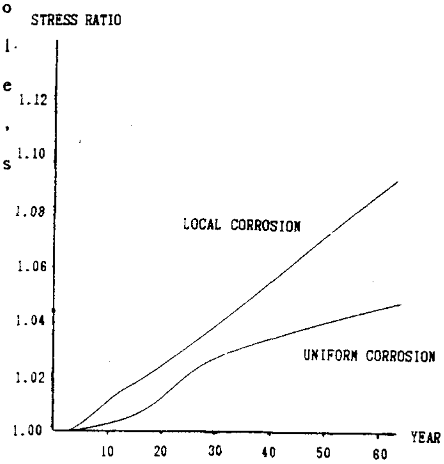

FIGURE 5 ESTIMATED STRESS RATIO AS A FUNCTION OF TIME (RURAL ENVIRONMENT)

5. REFERENCES:

1)Sato,Y.and Hashimoto,T.:Investigation on the corrosion of steel bridges and the method of maintenance painting; Railway Technical Research, Report No.392, Feb.,1947

2)Horikawa et al: Kakushu kinzoku zairyo oyobi boseihimaku no taiki fushoku ni kan suru kenkyu(No.5); Corrosion Eng.,Vol.16,1967,153-158

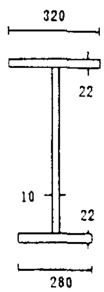

FIGURE 4 REPRESENTATIVE CROSS-SECTION OF GIRDER FOR ESTIMATING STRESS RATIO