Reliability-based design of long-span bridges – Wind load combination

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Summary

This research introduces the process of determining the reliability-based wind load factor. Limit state is focused on strength limit of pylon along with in-plane moment. Reliability analysis is performed based on the probability model of wind load which is composed of analysis factor, pressure coefficient, exposure coefficient, gust factor and wind speed and the probability model of moment resistance of pylon. Target reliability indices are determined based on the moment resistance of real bridges and the minimum required resistance obtained from design code. The wind load factor satisfying the limit state is proposed.

Keywords: Long-span Bridges, Reliability Analysis, Wind Load Factor, Probability Model of Wind Load, Limit State Design

1. Introduction

This paper introduces the wind load factor as a part of the reliability-based design guidelines. The limit state for the wind load combination is defined as the axial-bending strength of the pylon and the target reliability is proposed considering previous design experiences. The wind load model considers the probabilistic characteristics of the analysis factor, pressure coefficient, exposure coefficient, gust factor, and wind velocity. Through reliability analysis with probabilistic models of wind parameters and member strength, wind load factors are proposed.

2. Probabilistic models of loads and resistance

Probabilistic models are referred from existing literature. Dead, wind load and resistance is based on reference of Nowak(1999), Yoon(2010), Ellingwood et al.(1980). The probabilistic model of wind speed which is one of variables in wind load is determined by regional wind speed data.

3. Reliability analysis

For determining target reliability index, two kinds of reliability index are checked. One is the reliability index of as-is bridges. The resistance of pylon sections and member forces generated by dead and wind load are used for analysing the safety level of real constructed bridges. The other is the reliability index guaranteed by the design code. The Ultimate Stress Design(USD) and Load-Resistance Factor Design(LRFD) in Korean Bridge Design Code(KRTA. 2010, MLTM. 2012) are utilized for the analysis.

4. Wind load factor

Probabilistic models of wind load and resistance, the definition of limit state and the target reliability are determined for calibrating the wind load factor. Since the in-plane moment of the

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pylon due to dead load is usually small compared to win load effect. Limit state is defined by variables of resistance and wind load effect. When the wind load governs, the section goes into tension controlled region. Thus strength reduction factor can be assumed to be 0.85. The results of calibration are shown in Table 1 and 2. The wind load factor is calculated for the bias and COV of the annual maximum wind speed. Table 1 illustrates for the case of the target reliability index of 2.5 which Table 2 for 3.0.

Table 1 : Wind load factor($\beta_T = 2.5$)

Bias / COV	0.97	0.98	0.99
10%	1.440	1.470	1.500
11%	1.458	1.488	1.519
12%	1.478	1.508	1.539
13%	1.498	1.530	1.561
14%	1.520	1.552	1.584
15%	1.543	1.575	1.607
16%	1.567	1.599	1.632
17%	1.591	1.624	1.657
18%	1.616	1.650	1.684
19%	1.642	1.676	1.711
20%	1.669	1.703	1.738

Table 2 : Wind load factor($\beta_T = 3.0$)

Bias / COV	0.97	0.98	0.99
10%	1.700	1.735	1.770
11%	1.725	1.761	1.797
12%	1.752	1.788	1.825
13%	1.780	1.817	1.854
14%	1.810	1.847	1.885
15%	1.841	1.879	1.917
16%	1.873	1.912	1.951
17%	1.906	1.946	1.986
18%	1.940	1.981	2.021
19%	1.976	2.017	2.058
20%	2.012	2.054	2.096

5. Conclusion

According to the reliability analysis, the reliability indices guaranteed by the design code are distributed in 2.0-2.4. The reliability analysis of the actual bridge deduces the reliability index of 3.0. The wind load factor proposed in the study is 1.4~1.7 for the target reliability index of 2.5 and 1.7~2.1 for 3.0

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7. References

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