

## Equivalent static wind load procedure for skew winds on large bridges

### Risto KIVILUOMA

D.Sc. (Tech.)

WSP

Helsinki, Finland  
[risto.kiviluoma@wsp.com](mailto:risto.kiviluoma@wsp.com)

Risto Kiviluoma, born 1967, received his civil engineering degrees from the Helsinki University of Technology. He has 26 years of experience working on specialist issues in bridge, wind and structural engineering.



### Atte MIKKONEN

M.Sc. (Tech.)

SOFi Consulting Oy

Espoo, Finland  
[atte.mikkonen@sofistik.com](mailto:atte.mikkonen@sofistik.com)

Atte Mikkonen, born 1972, received his civil engineering degree from the Helsinki University of Technology. He has 21 years of experience on bridge design in domestic and international projects.



Contact: [risto.kiviluoma@wsp.com](mailto:risto.kiviluoma@wsp.com)

## 1 Abstract

This paper describes theoretical framework on forming equivalent static wind loads (ESWL) for large bridges. A method is proposed for efficient handling of large number of load cases, when vibration and structural analysis is extended to skew winds, i.e., to the wind directions other than the principal ones. These appear to be increasingly important in many practical cases when complex bridge geometry is used for architectural uniqueness; or when the bridge is situated in city centres or hilly terrain, where local obstacles make the wind turbulence difficult to assess with standard models.

The method uses a set of load cases for principal wind directions to be input and solved with the static Finite Element (FE) model. Combination matrix is deduced for the results to assess skew winds. The method is alike that is frequently used in wind-tunnel studies of tall buildings. ESWL determination is done in co-operation with the wind and the bridge engineer. The needed input for the wind engineer includes numeric vibration mode shape data, global nodal coordinates and mass distributions. ESWL are created in numeric form that could be easily input to the FE-model. The method allows utilisation of various type analysis results and experimental data available for the bridge, including section-model based analysis, full-model wind-tunnel tests and structural monitoring results. It facilitates examination and adjustment of appropriate safety marginal to wind loads that take into account methodologic uncertainties in each.

It is proposed that wind-tunnel laboratories, or other wind engineers with bridge analysis expertise, should more often include ESWL-extraction to their services.

**Keywords:** wind engineering, bridges, wind loads, wind, wind-tunnel testing, wind-induced fatigue

## 2 Introduction

Equivalent static wind loads (ESWL) are static load distributions that are formed to take into account ordinary wind load as well as the wind-induced vibrations of the structure, i.e., to take into account

dynamic addition to peak displacement, rotations, stresses and stress resultants.

The main purpose of ESWL is to provide the bridge engineer a consistent and feasible method to include dynamic additions to the structural analysis and regular load combinations. Here, the bridge