MODELLING AND SIMULATION ASPECTS OF PERFORMANCE-BASED WIND ENGINEERING OF TALL BUILDINGS

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ABSTRACT

The paper is concerned with developing an adequate Performance-Based Wind Engineering (PBWE) framework for tall building design. The focus is to introduce advanced modelling and simulation techniques to improve key analysis stages, namely by using Computational Fluid Dynamics (CFD) and Computational Structural Mechanics (CSM). The clearly defined five-stage PBWE framework is realised and implemented using both existing and newly developed simulation components. The performance of the probabilistic framework is explored by comparative PBWE analyses to assess the wind-induced behaviour of a regular 180-metre tall building with a rectangular cross section.

The performance of CFD was primarily dependent on the turbulence model. The Reynolds-Averaged Navier-Stokes (RANS) model was able to adequately compute the mean pressure coefficients acting on the tall building, including the peak suction towards the upwind edge. However, its inability to sustain the atmospheric turbulence resulted in a significant under-estimation of the top floor accelerations. Hence, it was concluded that the RANS model is not suitable for competent PBWE studies. As expected, the results showed that the Large Eddy Simulation (LES) model offered the closest alternative to wind tunnel testing. However, full LES was too computationally expensive to be used for the PBWE framework, and hence a hybrid RANS-LES simulation strategy was formulated as a compromise. This was considered to offer an appropriate representation of the wind-induced pressure field without prohibitive complexities emanating from a full LES model.

The transient response of the regular tall building was compared for both the RANS and the LES computed wind loads. This identified that the atmospheric turbulence had a much greater affect on the response of the tall building than the structure-induced turbulence.

The PBWE framework is thought to offer great potential to complement and/or augment traditional deterministic methods. However, a considerable research effort is required to facilitate the eventual transition from academia to practical implementation.