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Optimization of wind-induced acceleration of super tall buildings by modal shape updating

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Abstract

With the increase of height and flexibility of modern super tall buildings, structural wind-induced vibrations become significant under wind loads. The structural acceleration is commonly requested to be below certain limit in design process to avoid occupant discomfort under wind loads[1]. For slightly excessive wind-induced acceleration responses scenarios, the computational optimization method is usually adopted due to the fact that it's more cost effective than the supplementary damping systems method. The wind induced acceleration of certain super tall building is determined by dynamic properties under given wind loadings. As all known that the wind-induced response of super tall buildings is commonly contributed by the first vibration mode, which is actually related to the building period and modal shape of first vibration mode. A straightforward method to reduce the building acceleration is to change the vibration period. The natural vibration period is not quite effective due to the fact that it is global quantity and expense of changing vibration period is very high. A modal shape updating method is proposed to reduce the building acceleration by locally calibrating the modal shape near the floor where maximum building acceleration occurs. Due to its local impact nature, the expense of changing local curve of modal shape is lower comparing with that of changing vibration period. The power spectra of across-wind loads by curve fitted technique for calculating the acceleration responses was adopted in the wind-induced response analysis[2~3]. A real super tall building project is taken as an example in the last part of this paper to show the effectiveness and applicability of the proposed modal shape updating method. The results show that the modal shape updating method provides a powerful tool for wind-induced dynamic serviceability design of super tall buildings with slightly excessive wind-induced acceleration responses. The following conclusions are obtained: optimization of modal shape normalized with respect to the mass matrix (reducing by 2.7%) bring a 5.3% reduction in the acceleration response when the building period is assumed to be unchanged. Since the acceleration exceeds the code limit by only 4%, the extra optimized 1.3% was for the compensation of the longer building period (from 9.29s to 9.36s). 15% ($54m^3$) additional steel is needed for the acceleration optimization. The expense for the acceleration optimization is acceptable.

References

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