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WIND LOAD IDENTIFICATION ON A TOWER STRUCTURE

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ABSTRACT

Force identification, as a specific type of inverse problem, involves reconstructing the force distribution on a structure from measured data. Having an accurate knowledge of the exact loading on a structure or mechanical system is important in any situation where the loading forms a crucial component in the design of the structure, i.e. when the unknown load can be regarded as critical and dictates the design. Measuring these loads is not always possible resulting in the necessity to obtain them by means of such reconstruction. Since the wind load may constitute a critical loading for high towers or mass structures and since it is in general difficult to measure a time-varying distributed load on a structure, the identification of time-varying wind loads on a structure presents itself as an interesting and challenging force identification application. Obtaining these forces requires an indirect computation using measured response data in conjunction with a mathematical model of the structure.

In its broadest sense, force reconstruction can be viewed as being comprised of two main steps, the first of which involves the creation of the mathematical model that relates the observed data to the unknown forces. In the case where a linear elastic behaviour is assumed for the structure, force reconstruction is a linear inverse problem and the relation between the data and the unknown is given by a coefficient matrix. The content and structure of this matrix depends on the specifics of the formulation used and are dictated by, for instance, the domain in which the solution is obtained (frequency/time), the available information used to establish the input-output link (impulse response functions, the output from a strategically chosen forward problem, etc.) as well as the input quantities used (displacements/accelerations).

The second step, referred to as regularization, comprises the manipulation of this, mostly ill-conditioned, coefficient matrix in an attempt to make it better suited for meaningful inversion. These manipulations are a function of the specific type of regularization used which, in turn, is a problem-specific issue.

The wind load application studied has as its main objective the investigation of the feasibility of reconstructing time-dependant wind pressure data from the structural response in a limited number of

observation points. A synthetic example based on a cantilever beam model for a tower structure is studied, the force being a time-dependant wind pressure distribution of which the spatial variation in the vertical direction is considered. The pressure distribution is obtained from a wind velocity field, where a superposition is made of the mean wind velocity, which is typically a log-profile in height, and a stochastic component that varies in time and in the vertical direction. The stochastic component is generated from a given power spectral density function for the time dependence and a given autocorrelation function for the variation with height. The observed data consists of accelerations and displacements in a number of points along the height of the structure. An appropriate mathematical model is created and Tikhonov regularization applied in the inversion process, which serves not only to relieve the inherent ill-conditioning of the problem, but is used to, in the space dimension, incorporate our *a priori* knowledge of the load distribution into the reconstruction process.

REFERENCES

[1] J.F. Doyle. *Modern experimental stress analysis*, 1st. Edition, John Wiley & Sons, 2004.

[2] K.K. Stevens. “Force identification problems: an overview”. *Proceedings of SEM Spring Meeting, Houston*, 838–844, 1987.

[3] P.C. Hansen. *Rank-deficient and discrete ill-posed problems*, 1st. Edition, Society for industrial and applied mathematics, 1998.

[4] S.S. Law, J.Q. Bu and X.Q. Zhu. “Time-varying wind load identification from structural responses”. *Engineering Structures*, Vol. **27**, 1586–1598, 2005.

[5] A.N. Tikhonov. “Solution of incorrectly formulated problems and the regularization method”. *Soviet Math. Dokl.*, Vol. **4**, 1035–1038, 1963.