I-387 WindCAD - A PC based Finite Element System for Analysis of Cable Structures under Wind Excitation

Kyoto University, Research Student, St. Stoyanov
Member, M. Matsumoto
Member, N. Shiraishi

Introduction

A number of FE systems for structural analysis, such as SAP, ADINA, MSC/PAL and NASTRAN, has been developed in the last two decades. While these systems can be employed in a wide spectrum of problems, they are quite sophisticated, and the user must have extensive training. The need for a powerful computer often limits their applicability. Recently, some of the FE programs have appeared for use on PC's and Work Stations. Most are sealed-down versions of the mainframe one. As a result they have certain disadvantages, since they were not designed for PC's.

For the class of structures,including cable structures,cable-stayed and suspension bridges, masts, net structures etc., application of a FE system is vitally important. Prediction of their static and dynamic response poses a great challenge to designers. Especially difficult to predict is their behavior, [1], to the wind loads. Clearly, a need for a economical, but powerful, tool for the analysis of these structures to wind excitations exists.

Features of WindCAD

Fig.1 presents a very basic model of a CAD/CAE system and the elements added to permit the analysis of response to wind excitations. In the preprocessor, aerodynamic data such as wind orientation and surface exposure are added to the usual structure properties data. The wind generator serves to create various artificial wind loads. A filer is available to input a measured wind data. The feed-back load control in the computational process adjusts the loading to become adequate to the newly calculated structure orientation. Finally, the computed results are presented by a special purpose developed 2-3D graphic subsystem.

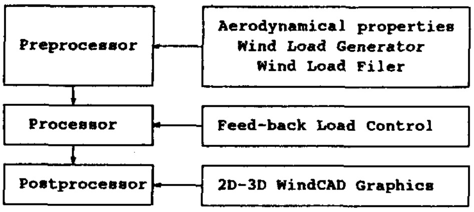

Fig. 1 WindCAD advanced features

Equilibrium equations

For the dynamic response analysis the equilibrium equation is

$$M \ddot{U} + C \dot{U} + K U = P \quad (1)$$

where M, C and K are the mass, damping and stiffness matrices;

$\ddot{U}$, $\dot{U}$, U and P are the acceleration, velocity, displacement and load vectors.

A realistic structural model can be created using a FE library containing space cable, truss and beam line-type elements and space plane and plate membrane elements. Matrix C represents Rayleigh type damping. Structural masses should be lumped. For cables modeling, a geometrical nonlinearity is applied. Solution of Eq. 1 is provided by numerical integration methods, [2], as Willson, Newmark or central differences available in the system.

A two span cable-stayed bridge (Fig. 2) excited by a artificialy generated wind is shown (Fig. 3) as an example of some of the system capabilities.

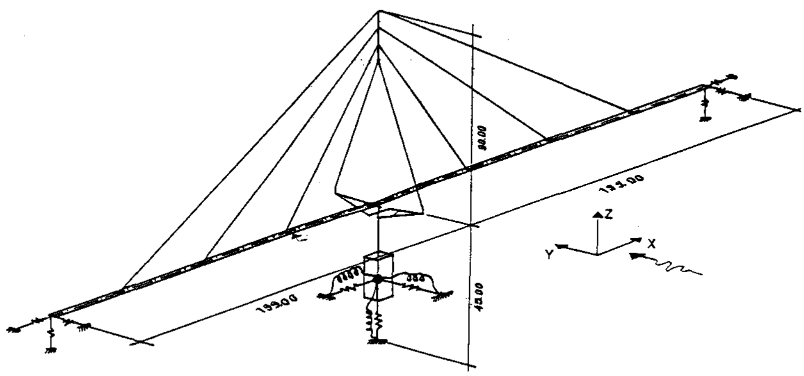

Fig.2 Computational model of Cable-Stayed Bridge.

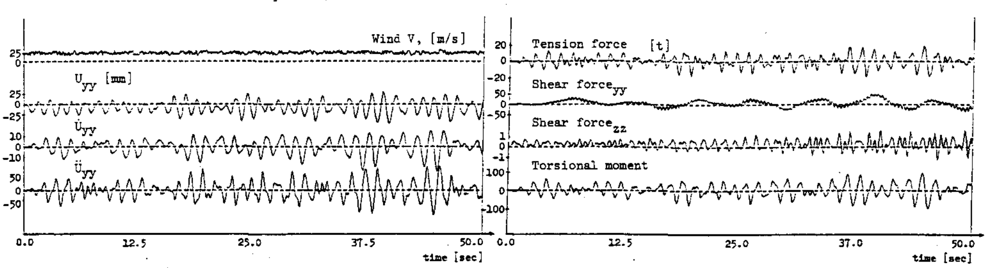

Fig.3 Motions and corresponding internal forces at the centre of the span due to simulated wind record. Time 50 sec.

Conclusions

WindCAD can be used for 2-3D static and dynamic analysis of cable structures. It is advantageous for application to small and medium sized systems. The WindCAD system can be applied to a new studies on wind-structure interactions.

References

1. Shiraishi, N. and Matsumoto, M. On Classification of Vortex-Induced Oscillation and its Application for Bridge Structures J. of Wind Engng and Ind. Aerodynamics, Vol.6, pp. 419-430, 1980

2. Bathe, K. J. and Wilson, E. L. Numerical Methods in Finite Element Analysis, Prentice-Hall, Inc., New Jersey, 1976