I-349 WAKE-INDUCED OSCILLATION OF TWIN BUNDLED CONDUCTOR

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INTRODUCTION

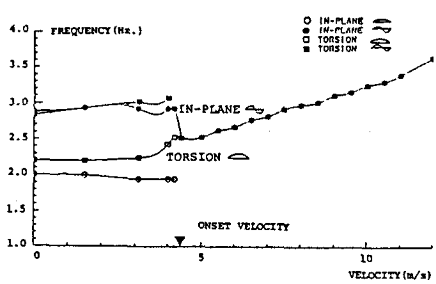
In grouped structures, such as grouped towers or bundled conductors, the leeward body is subjected to the flow disturbed by the windward one. This causes various kinds of aeroelastic instability, in general, called as "Wake-induced oscillation". This paper presents the results of wind tunnel experiment using three dimensional model of twin bundled conductor and attempts to explain the observed phenonena by a numerical study.

EXPERIMENT AND EXPERIMENTAL RESULTS

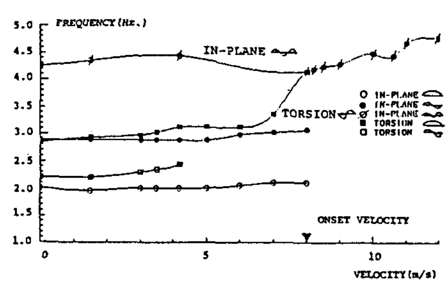
The model of two conductors in a bundle, with span length 15 m, was used in this experiment. Each conductor was made from wire strand inserted in plastic tube whose outside diameter is 0.5 cm. Separation distance between each conducter was 5 cm.

The aeroelastic behaviour of this model with different combinations of model's parameters such as sag ratio(1% and 3%), number of spacers(w/o-3 spacers) and angle of wind attack(-5, 0, 5) is examined at various wind velocities. Some interesting obseration to be noted is as follows.

The self-excited oscillation of twin bundled conductor observed in this experiment was coupled flutter and in all cases the amplitude increased with wind velocity. However, the coupled flutter mode is not the combination of the torsional first mode and the in-plane first mode but it is still the different modal combination as shown in Figs.1.a) and b).



a) 1% SAG, 1 SPACER AT L/2, α = 5°



b) 1% SAG, 2 SPACERS AT L/3, 2L/3, α=5°

FIG. 1 VIBRATION FREQUENCY - WIND VELOCITY RELATIONS

It is indicated in Fig. 1.a) that the in-plane frequency decreased while the torsional first mode frequency increased with wind velocity. As wind velocity approached to the onset wind velocity, the in-plane second mode frequency rapidly decreased and combined with the torsional first mode. Then the bundle started fluttering. Fig. 1.b) also shows different combined flutter mode in the case with 2 spacers. It is the combination of torsional second mode and in-plane third mode.

Furthermore, flutter frequency also increased with wind velocity because aerodynamic forces are functions of wind velocity. This was also observed by Nakamura[1].

COMPARISON WITH NUMERICAL STUDY

A numerical study using the parameters obtained in the experiment was performed. The bundled conductor is modeled as a rigid cross section with constant separation distance between the two. This model is allowed to oscillate freely in vertical, horizontal and torsional directions. Aerodynamic forces in the formulations are taken at the center of the cross section as shown in Fig.2. These forces are summation of forces acting on each conductor and are the functions of wind velocity and of the angle between bundle and oncoming flow. Their coefficients were calculated from empirical formulas introduced by Cooper[2].

The instability zone for different modal combinations of coupled flutter can be determined by the complex eigenvalue analysis of the above model[3]. Some of results are shown in Figs. 3.a)and 3.b).

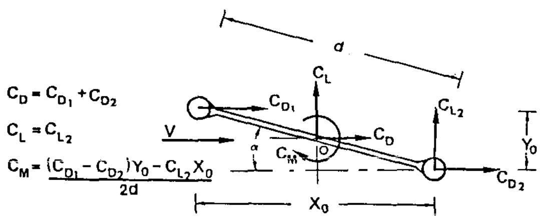
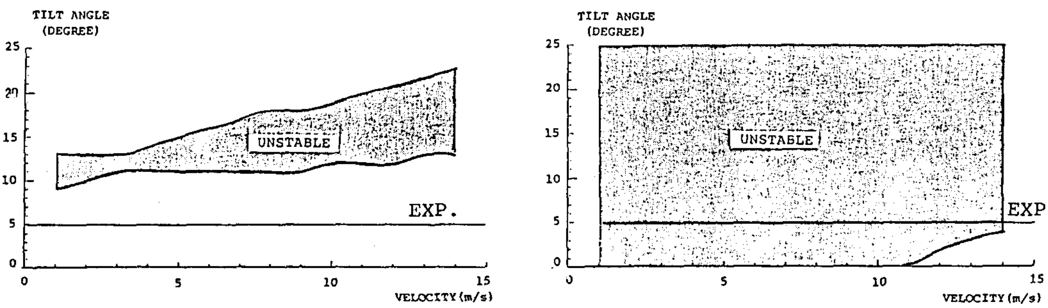


FIG. 2 AERODYNAMIC FORCE COEFFICIENTS ON BUNDLED CONDUCTORS



a) COMBINATION OF IN-PLANE, OUT-OF-PLANE, AND TORSION

b) COMBINATION OF IN-PLANE, OUT-OF-PLANE, AND TORSION

FIG. 3 INSTABILITY OF FULL-SPAN OSCILLATION (1% SAG CASES)

Fig. 3.a) shows the instability region for the combination between the first modes with the lowest frequency in each direction. The instability area is far from the experimental range while the combination of torsional first mode and in-plane second mode is unstable in the experimental range as shown Fig. 3.b). Then the latter combination is unstable and can be observed during experiment while the former one cannot be. This corresponds to the observed phenomena in the experiment.

This analysis can predict the coupled flutter mode when the instability region is not overlapped. Otherwise, it can not predict the flutter mode in the overlapped area between Fig. 3.a) and 3.b).

CONCLUSION REMARKS

The observed combined flutter mode is not necessarily the combination of the modes with the lowest frequeny in each motion. This is supported by the numerical study. Full-span consideration is used for predicting the combined flutter mode. However, it is not valid in the overlapped instability area, suggesting multi-modal approach is required.

REFERRENCES

1. Nakamura, Y., "Galloping of bundled power line conductor", J. of Sound and Vibration, Vol. 73, No. 3, 1980, pp 303-337.

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3. Brzozowski, V.J. and Hawks, R.J., "Waked-induced Full-span Instability of Bundled Conductor Transmission Lines", AIAA Journal, Vol.14, Feb. 1976, pp 179-184.