I-B 31

# Nonlinear Effects of Secondary Cable on its Control Performance

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## 1. Introduction

Recently done investigation[1] showed that the addition of secondary cable connecting two main cables in a catwalk cable system reduces the vibration of main cable to some extent. Due to the geometrically nonlinear characteristics of a cable, the steady-state response of secondary cable is not simple harmonic but complicated periodic motion with sub or super harmonic components. This nonlinearity affects the control performance of secondary cable in the reduction of main cable vibration, but no investigation is carried out in this respect. In the present study a model of a catwalk cable system is used to investigate the nonlinear behavior of secondary cable and its effects on the control performance

## 2. Experimental Model

The catwalk cable model, which is used in this investigation, consists of two identical main cable connected by one sagged secondary cable as shown in the Fig.1. Harmonically forced oscillation in the lateral direction is applied to the catwalk cable system and the steady-state responses of both the main catwalk cable and the secondary cables are measured in the horizontal and vertical directions. Nonlinear behavior of secondary cable has become obvious from the steady state response curve (Fig.2) and the corresponding power spectral density curve (Fig.3) of the secondary cable.

## 3. Analysis and Results

Fig.4 shows the frequency response curve of both the main catwalk cable and the secondary cable. From this figure it is obvious that the addition of secondary cable, connecting two main cables, changed the resonance peak of lateral vibration of main catwalk cable which is similar to the effect of a TMD.

Sub-harmonic component of response with frequency of one-third of the excitation frequency is evidenced in both the main catwalk cable response and the secondary cable response. This phenomena is shown in Fig.5 and Fig.6. Again, at some frequency the sub-harmonic component become more dominant in comparision to the main harmonic in the main catwalk cable and in case of secondary cable the main harmonic is negligible in comparison to the

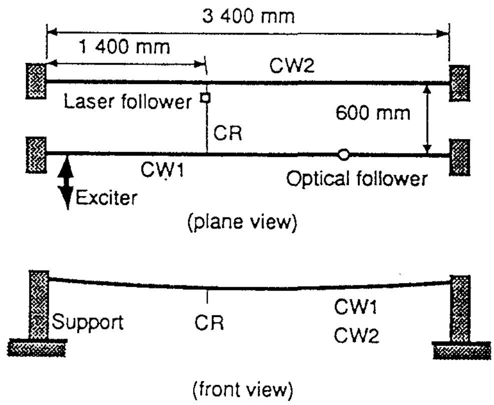



Fig. 1 Experimental setup of catwalk cables with a cross-rope.

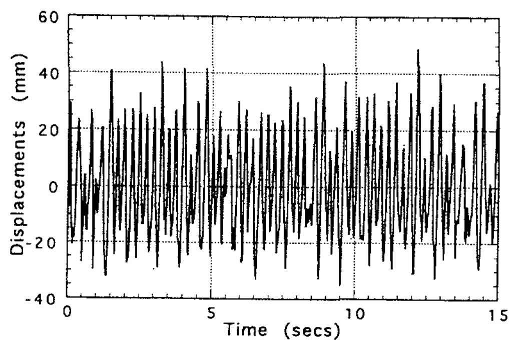



Fig.2 Nonlinear steay-state responses of secondary wire recored at 1/4 point in the experiment at f=7.86 Hz (Ampl.=1.75 mm)

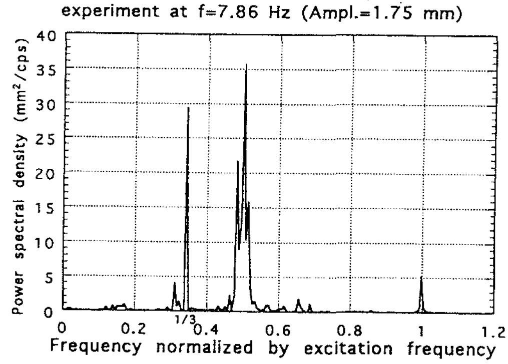
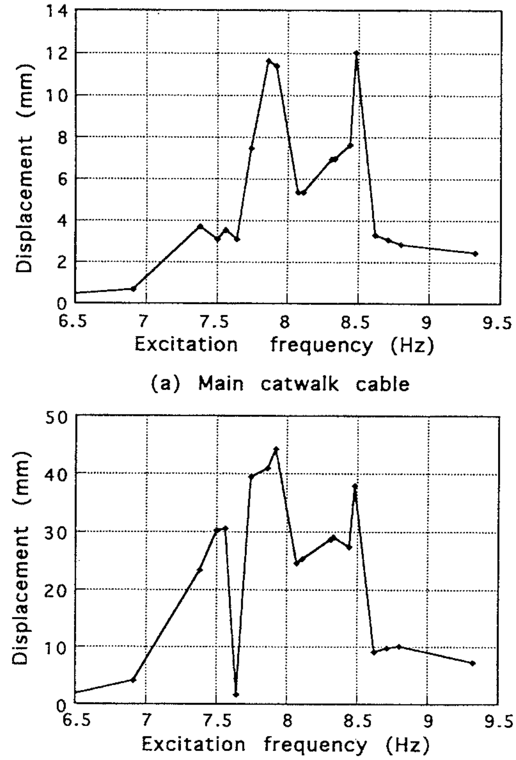



Fig.3 Power spectral density curve for the response of secondary cable at f=7.86 Hz (Ampl.=1.75 mm)

sub-harmonic. Comparing Fig.4, Fig.5 and Fig.6 it can be noted that at the excitation frequency of 7.74, 7.86, 7.92 and 8.48, subharmonic frequency component with frequency of one-third of the frequency of excitation make the response greater. As soon as this frequency component with frequency of one-third of the frequency of excitation disappear, the resonant peak of the main catwalk cable vibration is reduced considerably. In this region, there is sub-harmonic component of response with frequency of one-half the excitation frequency. So it can be said that existence of sub-harmonic component with frequency of one-half of the excitation frequency in the response of secondary cable has some controlling effect in the reduction of resonant vibration of main cable.

## 4. Concluding Remarks

Nonlinear responses of secondary cable have some effect on it's control performance in a catwalk cable system. Actually the controlling effect of the secondary cable is also dependent on the type of nolinearity present in the secondary cable response. Nonlinear response component of frequency of one-half the excitation frequency can reduce the resonant peak but other harmonics evidenced in this investigation may not be beneficial in the reduction of main cable vibration.




(a) Main catwalk cable

(b) Secondary cable

Fig.4 Frequency response curve for the catwalk cable system (Ampl. = 1.75 mm)

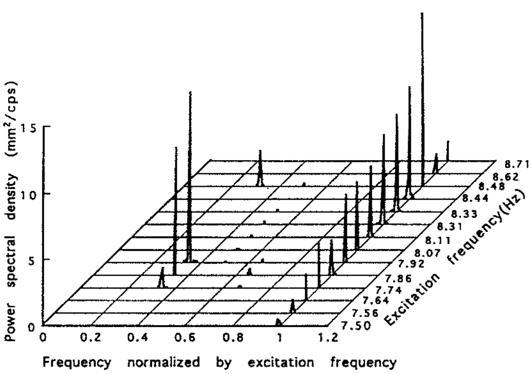



Fig.5 Power spectral density curve for main cable for different excitation frequency.

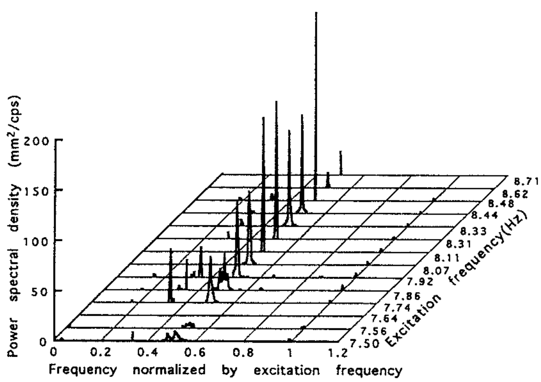



Fig.6 Power spectral density curve for secondary cable for different excitation frequency

## References

[1] Yamaguchi, H., " Control of cable vibrations with secondary cables", Proc. of Int.Symp. Cable Dynamics, Liege,Belgium, pp.445-452, Oct. 1995.