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Discussion

Cable Kink Analysis: Cable Loop Stability Under Tension[1]

F. Rosenthal[2]. Yabuta, Yoshizawa, and Kojima's paper on cable kink analysis [1] presents an interesting analysis of the stability of looped cables. However, this paper does not do full justice to the fundamental rod or cable property affecting kinking which was first discovered by A. G. Greenhill in 1883 [2]. For cables under combined tension and torsion, the instability leading to kinking occurs exactly and at times violently, when Greenhill's condition is met, e.g., when the tension is sufficiently small compared to the twisting moment so that

$$\frac{TL^2}{EI} = \frac{1}{4}\left(\frac{ML}{EI}\right)^2 - \pi^2$$

where T, L, EI, and M are the tension, length, bending stiffness, and twisting moment on the cable.

The kinked configuration depicted in the authors' Fig. 1(*b*) depends for its stability on the fact that the cable crosses over itself at one point, thus providing two equal and opposite out-of plane forces, one at each end of the loop's circular segment. As the twisting moment is lowered, such a loop can and will begin to "unkink" precisely at that instant when the mutual contact forces become zero. But from the point of view of strain energy within the loop, these contact forces are reflected in a combination of twisting and out-of plane bending (neglecting shear) strains. Therefore, an energy analysis of "unkinking" must take into account the strain energy resulting from out of plane bending in the loop segment of the cable, as well as that due to twisting. I believe the authors' analysis does not contain this effect.

A more detailed discussion of the kinking problem and its relationship is Greenhills' work may be found in references [3] and [4].

References

1 Yabuta, T., Yoshiziwa, N., and Kojima, N., "Cable Kink Analysis: Cable Loop Stability Under Tension," ASME Journal of Applied Mechanics, Vol. 49, 1982, pp. 584–588.

2 Greenhill, A. G., Proc. Inst. of Mechanical Engineers, London, 1883.

3 Rosenthal, F., "The Application of Greenhill's Formula to Cable Hockling," ASME Journal of Applied Mechanics, Vol. 43, 1976, pp. 681–683.

4 Rosenthal, F., "Greenhill's Formula and the Mechanics of Cable Hockling," Naval Research Laboratory NRL Report 7940, Nov. 7, 1975.

[1] By T. Yabuta, N. Yoshiziwa, and N. Kojima and published in the September, 1982 issue of the ASME Journal of Applied Mechanics, Vol. 49, pp. 584–588.

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Authors' Closure

The authors would like to thank F. Rosenthal for his interest in our paper [1].

We think that cable kink phenomenon is divided into two instability processes in cable kink occurrence. The first instability is cable loop formation due to torsional stress. The second instability is the reopening of the cable loops after cable loop formation due to subsequent tension increase. Our paper dealt with the second problem and clarified the conditions in which cable loops reopen. Rosenthal pointed out that our analysis does not do full justice to Greenhill's condition, which defines the fundamental conditions of cable kinks. However, Greenhill's condition is concerned with cable loop formation, which is only the first problem of our cable kink definition. Therefore, we believe our analysis is not concerned with Greenhill's condition because our analysis deals with only the second problem. Ross studied the first problem of cable loop deformation with the potential energy method [2]. He found that Greenhill's condition defines the upper bound of cable loop formation when compared to experimental results.

Rosenthal also pointed out that our analysis does not contain the effect of "out of plane bending." However, we believe that our analysis contains this effect. That is, our analysis uses a helix assumption for cable deformation which contains "out of plane deformation," as shown in Fig. 2 in reference [1]. Therefore, bending strain energy is obtained from the curvature of the helix, and also considers "out of plane bending."

Moreover, Rosenthal commented on our problem from an "out of plane force" viewpoint. Zajac showed interesting results of a similar problem from a force equilibrium viewpoint [3].

Although we did not compare theoretical results with experimental results in the original paper, since then we have made the comparison, the results of which are discussed in reference [4]. Reference [4] also shows cable kink deformation modes from a cable slack viewpoint, which is a main factor during cable laying.

References

1 Yabuta, T., Yoshizawa, N., and Kojima, N., "Cable Kink Analysis; Cable Loop Stability Under Tension," ASME Journal of Applied Mechanics, Vol. 49, 1982, pp. 584–588.

2 Ross, A. L., "Cable Kinking Analysis and Prevention," ASME *Journal of Engineering for Industry*, Vol. 99, 1977, pp. 112–115.

3 Zajac, E. E., "Stability of Two Planar Loop Elastica," ASME Journal of Applied Mechanics, Vol. 29, 1962, pp. 136–142.

4 Yabuta, T., "Submarine Cable Kink Analysis," *Bulletin of the JSME*, to appear in September 1984 issue.