Project Summary

Texas Department of Transportation

0-5251: Vibration Reduction and Control for Traffic Cameras

Background

Long tapered poles are commonly used to support closed circuit television (CCTV) cameras for security and traffic monitoring. Images received from CCTV are normally distorted depending on the wind-induced vibration characteristics of the forcing function. This study builds on the findings of TxDOT project 0-4470, Development of Standard CCTV Camera Structures, in which stiffness characteristics and functionality of the CCTV camera poles, with different material characteristics, were evaluated. To reduce image distortion, three approaches were integrated to optimize the process: (1) identification of the range of frequencies experienced by the TxDOT CCTV camera poles; (2) development of a mechanical damping device to isolate the pole's vibration from that of the camera; and (3) development of an electrical image processing device for image corrections.

What the Researchers Did

Identification of a long tapered hollow steel pole's natural frequency is the most important parameter in the design and calibration of the mechanical damping device. Three dimensional finite element models (FEMs) were developed for dynamic analyses to determine the natural frequency equations for the poles most commonly used by TXDOT in terms of their geometric variables. For each pole analyzed, the FEM was verified by the results obtained from project 0-4470 and the field tests conducted in this study. A sensitivity study was performed to study the effect of the different geometric parameters on the overall natural frequency of the pole. Using the results from the parametric study, empirical formulas between the geometric parameters and the first, second, and third mode natural frequencies for the long tapered hollow steel poles were obtained. In order to further verify the FEM analysis, data was collected from the accelerometers installed on the poles and analyzed. A natural frequency envelope was obtained by varying the pole's geometric variables provided by TxDOT for vibration isolator design.

A bi-axial mechanical vibration isolator was developed which specifically aimed at horizontal high-frequency motion abatement in pole-mounted camera applications and similarly conditioned supports. The device works on the principle of force and displacement transmissibility reduction by the use of a lightly damped spring interface with a tuned natural frequency. The isolator was inserted between the top of the structure (pole) and the seat of the camera, and works by rejecting undesirable high-frequency modal vibrations experienced by the main support, which has the effect of diminishing high-acceleration ground input.

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Project Completed: 8-31-07

By design, the isolator trades its high-frequency performance for a low-frequency heave, which does not induce blur but causes a limited horizon shift. The developed mechanical device is designed to significantly reduce the high pole vibration frequencies experienced by the camera.

In addition, the digital algorithm for image stabilization was developed, which is effective for low frequencies. For this reason, the proposed mechanical solution was prescribed as an ancillary technique to image processing in installations where high-frequency or displacement conditions prevail at the camera support.

What They Found

- The laboratory test and field results showed that the digital image processing algorithm is effective for low vibration frequencies (1.2 Hz and less).
- The field and laboratory studies showed that the developed mechanical device is highly effective in stabilizing image distortion, and in most cases eliminating it. It was shown that at high pole frequencies (4.8 Hz and higher), images are corrected by up to 90.6%.
- Videos obtained for the images before and after stabilization by the developed mechanical device indicate that the distorted images are significantly corrected, and the distortions are completely eliminated when viewed by human eyes.

What This Means

The mechanical device can be deployed on the CCTV camera poles to eliminate camera vibration for enhanced traffic monitoring.

Image without the mechanical device

Image with the mechanical device

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