VIBRATION REDUCTION AND CONTROL FOR TRAFFIC CAMERAS: MECHANICAL DEVICE CONSTRUCTION MANUAL

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CONSTRUCTION MANUAL FOR
MECHANICAL DEVICE
Product 0-5251-P1

Research Project Number 0-5251
Project Title: Vibration Reduction and Control for Traffic Cameras

Performed in cooperation with the
Texas Department of Transportation
and the
Federal Highway Administration

October 31, 2007
Published: January 2008

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TxDOT Camera Project–Construction Manual

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Subcontract:	TxDOT 0-5251
Institution:	Texas Manufacturing Assistance Center (ARRI – UT Arlington)
Title:	Vibration Reduction and Control for Traffic Cameras
Period Covered:	October 2007

CONSTRUCTION MANUAL
FOR MECHANICAL ISOLATOR DEVICE

Introduction

The following describes how to specify and physically produce a prototypical mechanical isolation device for pole vibration abatement, following the design approach presented in this research.

The fundamental components of the vibration isolation device are (a) a set of bearings that allow for relative horizontal motion between the camera and the top of the pole, and (b) tuned amounts of spring force and camera ballast to achieve a target natural frequency of the mass sprung atop the pole. Each of these is discussed in turn.

Bearing Mechanisms

The bearing mechanisms must provide linear translation in two orthogonal horizontal axes, while restraining rotational motion. The latter requirement precludes, for example, the use of a roller bearing bed, unless provisions are otherwise made to constrain rotation. Among the several mechanical configurations that can do this (including pendular and parallel-bar linkage structures), standard linear bearings are the easiest to acquire and implement.

For the best isolation performance, it is important to have low damping ratios (0.1-0.2), implying low friction coefficients. This is readily accomplished through the use of high-quality ball bearing slides, such as those employing cross-roller or recirculating ball configurations.

The bearings must be arranged in a serial (stacked), independent X-Y configuration. Among the several possible choices, the use of a dual slide bridge platform for each axis is recommended, as this provides a cavity for the camera tether to pass. Most bearing manufacturers will customize an X-Y configuration, as described, from their standard slide selection. In this research, model R3206P-XY from the company Deltron was used; there are, however, many other manufacturers that will source similar designs (Velmex, Aerotech, Parker, Newport, etc.).

The following parameters complete the bearing specification:

- Slide travel: 6-10 inches
- Load capacity: 100 lb per axis

The slide stack must be attached to a plate which can be bolted on top of the pole. Typically, this plate will replace the existing one at the pole, or it may simply be mounted on top of the latter with an appropriate bolt pattern. The following pictures illustrate this for the prototype used in this research.

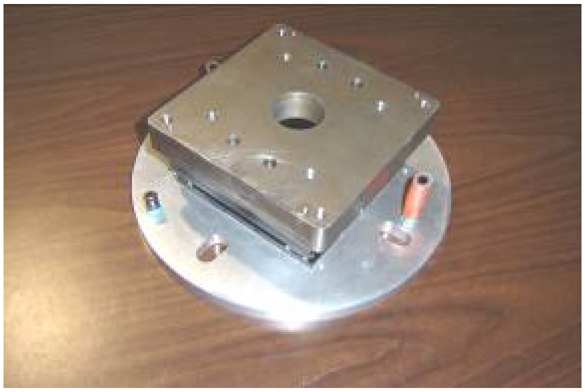
This pole interface plate serves an additional, important function—which is to house features to prevent slide over travel. These may be implemented as hard rubber pegs or rubber-coated posts, providing a positive stop for the slide at each end; one such stop is shown in orange in the next picture. In optimized implementations, the stopping mechanisms may incorporate springs or dampers to absorb impact energy resulting from heavy wind gusts; this will mitigate the "whiplash" effect encountered with certain camera configurations.

Sprung Mass Ballast

The top of the bearing stack is capped with a metal part that couples the slides to the camera; however, its primary purpose is to introduce a tuned amount of inertia to said camera. It is this inertia, in combination with a restoring spring force that provides a specific natural frequency to the sprung mass, and thus its isolation characteristics. The selection of mass and spring rates for a particular isolator performance is explained in detail in Chapter 4 of the final project report. It is important to recognize that the weight of the camera itself must be added to that of the ballast mass in order to arrive at an overall sprung mass value. Typical ballast values will range from a minimum of 10-20 lb up to a maximum practical ceiling of 80-100 lb. Heavy ballast masses may be built up incrementally, 50 lb being the largest increment suitable for manual handling.

The ballast is typically machined out of mild steel, but denser materials may be used where it is expedient to lower the ballast profile.

The top of the ballast is fitted with a center hole through which the camera cable can pass, in addition to a bolt pattern for threaded studs to which the camera is mounted. The picture below illustrates this point in the assembly.

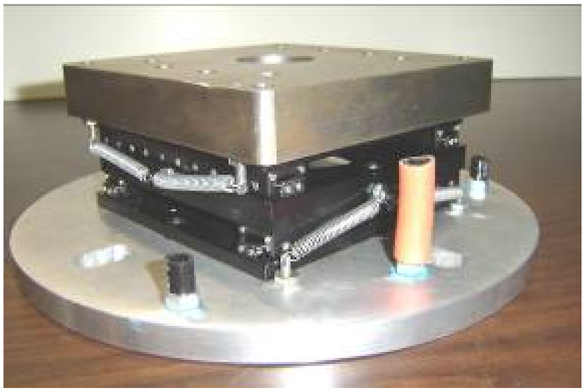


Spring Attachments

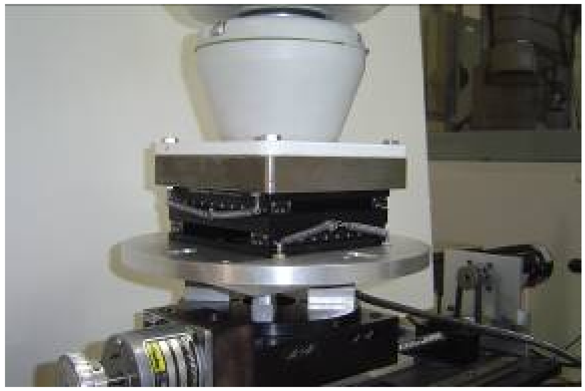
The remaining item for a functional prototype isolator is a set of springs connecting the bottom slide to the pole interface plate, and the top slide to the camera interface plate or ballast plate. As previously stated, the overall spring value is determined based on desired isolator performance and practical ballast mass. Typical overall spring values on a per-axis basis range from 1 to 3 lb/in. Lighter springs will not properly counter aerodynamic wind forces and will have difficulty centering the mass due to friction, while stiffer springs will require correspondingly higher ballast masses to achieve low sprung natural frequencies.

In order to accommodate the typical ±3-5-inch slide travel present in each axis, the recommended arrangement is to use two extension springs of suitable length so that they remain in tension at all times without exceeding their rated maximum length. Springs of the chosen rate and length characteristics may be obtained from several sources; in this research we used stock components provided by the Century Spring Corporation. The same industrial source provides threaded eyelet-style anchors that provide convenient attachment points for the hooked spring ends.

Springs are attached one pair at a time per axis, centered on a common point in the slide and anchored at opposite ends to the pole interface plate or ballast plate; this is shown in the figure below. It is important to recognize that two extension springs arranged in such a manner act as in a parallel configuration, requiring to halve each individual spring value for the sought-after effective axis spring rate.



The isolator is now ready to have the camera installed; a picture of the final assembly is shown below.



Deployment Considerations

The steps described above can be followed to produce a prototypical isolator device, which may be fine tuned in mass, spring, overall displacement, and end-of-travel configuration for the needs of a specific installation. A design suitable for permanent installation would have to address additional matters, such as a safety tether for the ballast mass in case of critical bearing failure, and an adequate specification and environmental protection for the linear bearings. Alternatively, from an implementation perspective, other bearing configurations that would be less susceptible to wear and weather-related damage could be used in place of linear ball bearings.

Given environmentally adequate packaging and properly sized and manufactured components, this type of vibration isolator can be an effective means for reducing high-frequency vibration levels transmitted to the camera from its supporting pole.