LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

link to excel sheet

LIGO Laboratory / LIGO Scientific Collaboration

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Controls Prototype: - Library of Clamps for the Cantilever Blades in the Mode Cleaner Suspension.

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LIGO Science Collaboration

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Introduction

Cantilever blades designed for use in the Advanced LIGO suspensions are based on those used in the triple pendulum suspensions that have been installed in GEO 600. The original design for the cantilever blade was supplied by the VIRGO group. For several reasons, which is covered in a companion report T030107 and T030104, the amount by which a particular blade deflects from the horizontal can only be predicted to within approximately 5%. The repeatability within a batch of cantilever blades can also vary by as much as 5%.

Currently for a single stage in a suspension where two cantilever blades are required six spares are ordered. For a stage that requires four blades twelve spares are ordered. The deflection of each blade is measured suspended under the 'desired load' [1]. Thus allowing us to arrange them into sets that are matched with respect to the deflection.

Testing a Cantilever Blade

Consider a cantilever blade under the 'desired load', as shown in figure (1). The deflection from the horizontal can be measured using a Height Gauge mounted on a flat surface, as shown in picture (1).

For example let us say that under this desired load the tip of the cantilever blade furthest away from the clamped end is 2mm below the horizontal then if this had not been taken into account the entire suspension would be either too high or too low by 2mm.

Various concepts can be incorporated in order to correct for this effect. For example, in VIRGO, corrections include extra mass is added or removed from the next stage in the suspension chain, mass added to the tips of the blade and changing the length of blade that is clamped. In GEO 600, which uses much smaller blades than those used in VIRGO, blades are re-shaped to correct for this mis-match in the deflection prior to installation.

Several ideas were considered to update this deflection in situ. It was decided that due to restrictions on mass, moments of inertia and noise considerations that a simple approach could be very effective. The idea was to create a "library of clamps" for each clamping stage and to load each blade individually prior to assembly and installation in order to select a particular set of clamps.

The idea is to vary the angle of the clamp with respect to the Y-direction, as shown in figure (iii).

[1] If there are n blades in a particular stage of a suspension then the 'desired load' is 1/n of the total suspended mass from that stage.

Other ideas have been incorporated into the design in order to adjust the overall position of the test mass optic with respect to the optical table. For example, in the Mode Cleaner Controls Prototype Suspension for LASTI small "fishing rods", similar to those used in LIGO I, can be used if the optic is closer than the desired position to the optical table.

Each cantilever blade is clamped between 2 stainless steel clamps, as shown in figures (i) to (iii). The upper half of the clamp has its central section removed. This helps to ensure that the blade is clamped in only 2 locations and adjacent to the outside of the clamp.

In order to test the concept of using a set of "library of clamps" 2 sets of clamps were created, one set each for upper and lower cantilever blades designed for the mode cleaner controls prototype. The upper blade set has a range from -3.5^{O} to $+3.5^{O}$ in 0.5^{O} increments and the lower blade set has a range from -2.5^{O} to $+2.5^{O}$ in 0.5^{O} increments.

Each set of clamps was tested on several different types of blades, as can be see listed below: -

In each case the deflection was measured with respect to that measured with the 0.0^{O} of flat clamps, shown in figure (ii). The "desired load", mass, m, was fixed throughout the experiment. A height Gauge was used to measure the deflection. The clamped cantilever blade was bolted to a large plate that in turn was bolted to an optical table. Each measurement was checked several times.

Please reference the attached excel file for data collected with the library of clamps. It is possible to estimate what clamp to use once you have deflected a blade with the desired load with a 0.0 degree of flat set of clamps. If an angled set is required it is recommended to again deflect the blade with the desired load in order to confirm this estimate.

Experiment on Lower Blades

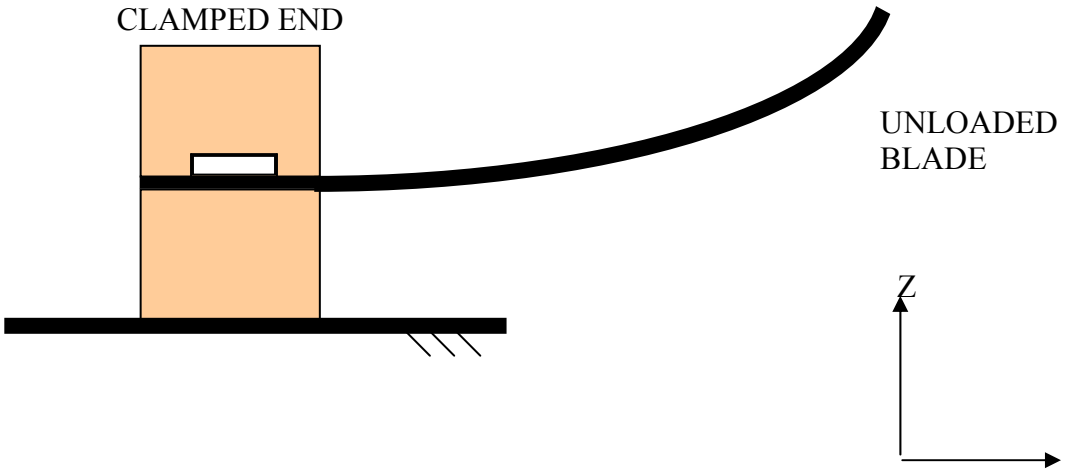
Appendix

Put info and tests on other blades into an appendix! This will ease confusion and make it easier to write up.

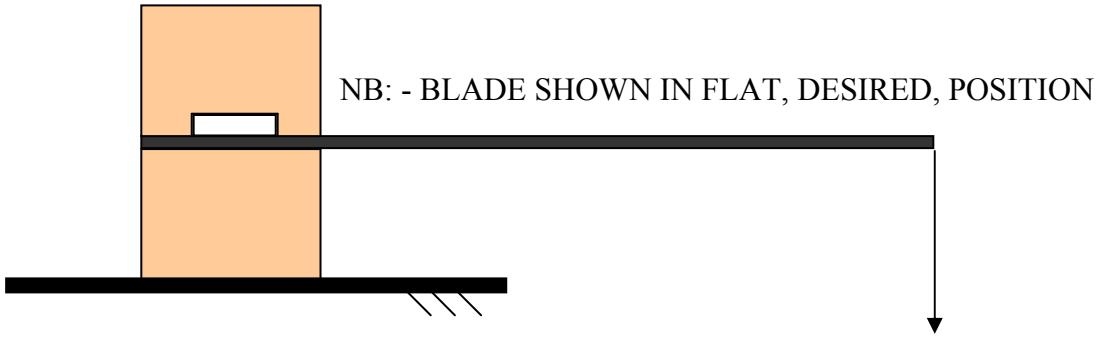
Check thesis and MVP papers for wording

Photo of set up from Lab

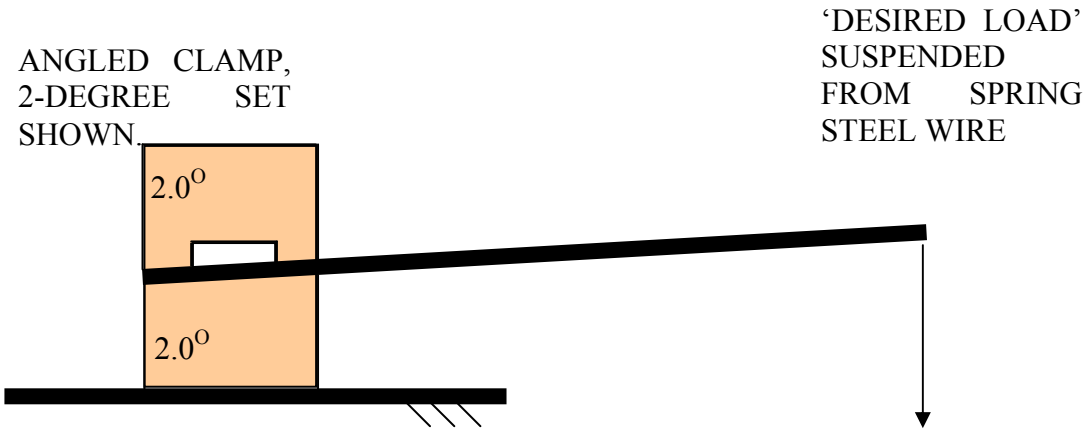
Conclusions



FIGURE(i): Unloaded Cantileve Blade Clamped at One End.

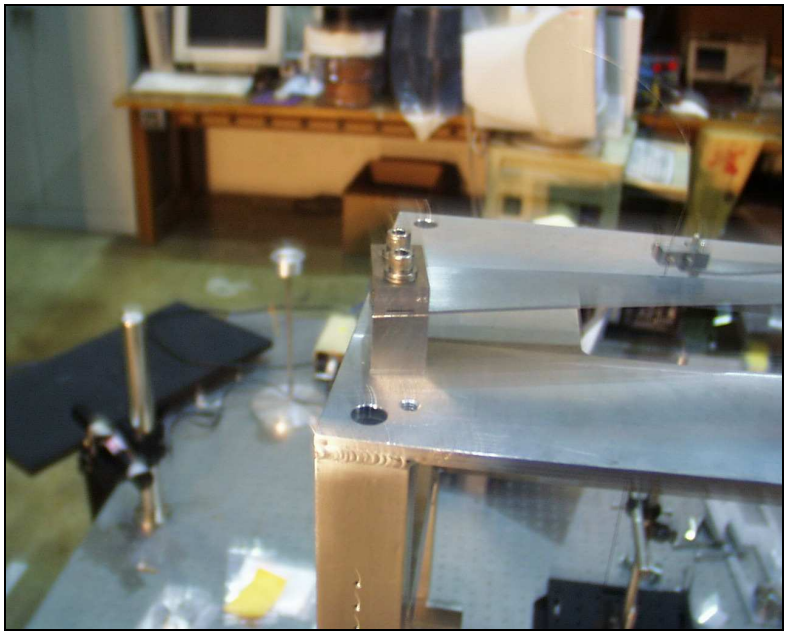


FIGURE(Ii): Loaded Cantileve Blade Clamped at One End with 'desired load' suspended from Spring Steel Wire. The blade is shown in the flat, desired, position. In reality it could be +/- several mm from this position with a 0 ^{O} or flat clamp with perpendicular sides.



FIGURE(iii): Loaded Cantileve Blade again with the same 'desired load' as in figure (ii). The clamps used here are the 2.0° set of clamps.

PICTURE (1): - Library of Clamps



PICTURE (2): - Upper Cantilever Blade Clamp set, showing a 2.5 degree set of clamps.

PICTURE (3): - Height Gauge and Cantilever Blade under Load.