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11/19/96
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Revision B 7/18/97

BSC Support Assembly
Analytical Design

November 19, 1996
Revised July 18, 1997

Abstract

This technical note updates the analysis of the design for the BSC support structure. Results are presented for natural frequencies only. Revision A of this document dealt with the issues of gravitational loading, earthquakes, and buckling of the support structure under the load of the stack.

PREPARED BY: ____________________
Bernie Weinstein

PROJECT MANAGER: ____________________
Tim Thompson

HYTEC Inc.
110 Eastgate Dr., Ste. 100
Los Alamos, NM 87544
(505) 661-3000 / Fax (505) 662-5179

LIGO PROJECT

Table of Contents

1. Introduction

The main impetus for this revision was the elimination of the Stacis 2000 from the support system and the redesign of the Z actuator stage. The height of the piers was increased to maintain the support beams at the proper height.

The support assembly, shown in the finite element model of Figure 1, consists of a support platform, 2 support beams, and 2 cross beams resting on actuators atop four steel piers. The support platform provides support for the BSC seismic isolation stack. The support beams penetrate the BSC chamber through 4 welded diaphragm bellows and hold the support table. Cross beams on the outside of the chamber connect the ends of the support beams and interface with the coarse and fine actuators (not shown).

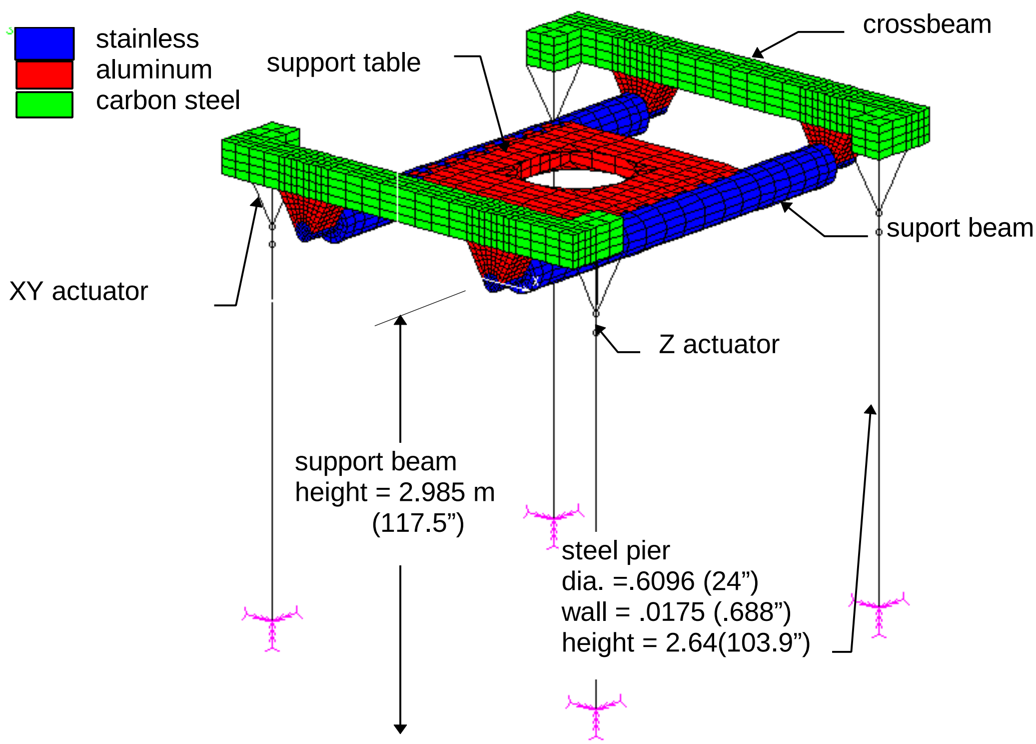

Figure 1. BSC support system

2. Description

The support table is a welded aluminum sandwich structure with a 19.1 mm (.75") thick upper face, a 12.7 mm (.5") lower face, and a grid of 6.4 mm (.25") rib plates for the core. Aluminum is used to minimize weight at the center of the support beam span. (Analysis shows that the weight of the support platform is a major factor in determining the lowest resonant frequency.)

The support beams are made of stainless steel tubing 305 mm (12”) in outside diameter with a wall thickness of 12.7 mm (.5”). Solid stainless steel plugs with a diameter of 140 mm (5.5”), are welded to the tube at each end. The plugs incorporate a knife edge and tapped holes to seal and mount the custom flange that is welded to one end of the bellows. These plugs rest in cast aluminum V-blocks bolted to the cross beams. The analysis simulates this connection with solid elements.

The cross beams are built up from standard square steel tubing, 254 x 12.7 mm (10” x .5”).

A shorter array of 4 beam elements is used to spread the reaction across the face of the cross beams. In the actual device, the load would be spread even more as the cross beam rests on the solid face of the air bearing. A finite element representation was added to account for the Z actuator compliance. We established the compliance by constructing a separate finite element analysis for the Z-stage. Beam element properties were chosen to match the characteristics developed by the analysis of the Z-stage, and those properties are inserted into this model just above the pier.

3. Performance

3.1 Resonant Frequencies

Figures 2 through 9 show the first 12 resonances of the support assembly. The first mode of 23 Hz is a dramatic improvement over the 15 Hz reported in revision A of this technical note.

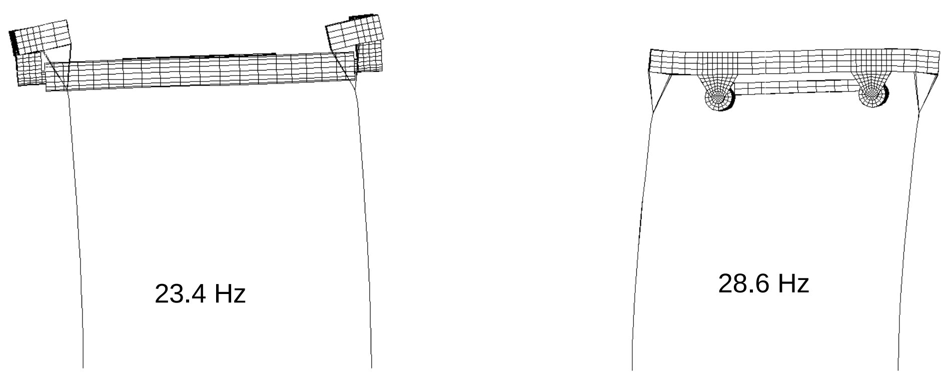

Figure 2. Mode shapes 1 and 2 of the BSC support system

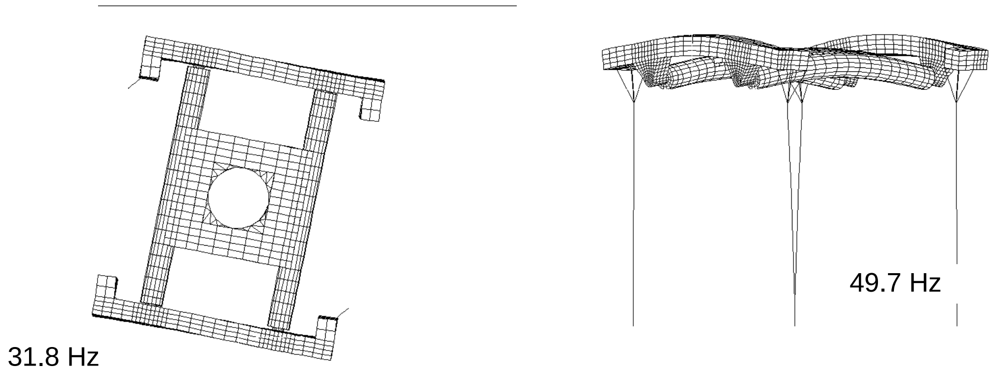

Figure 3. Mode shapes 3 and 4 of the BSC support system

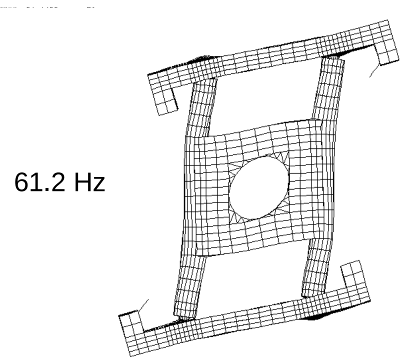

Figure 4. Mode shape 5 of the BSC support system

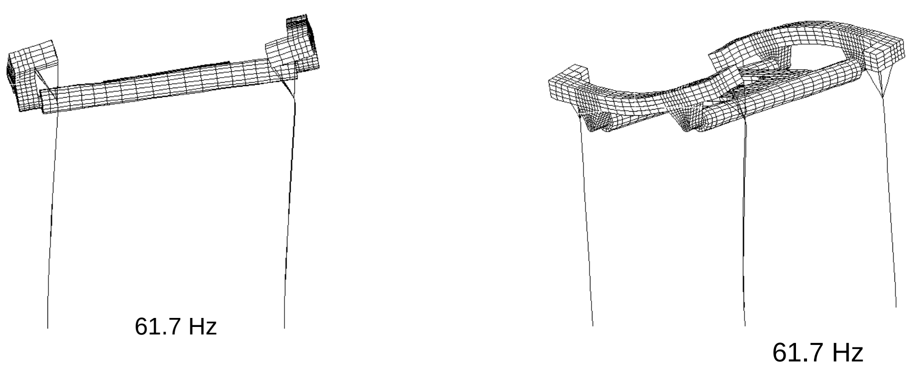

Figure 5. Mode shape 6 of the BSC support system

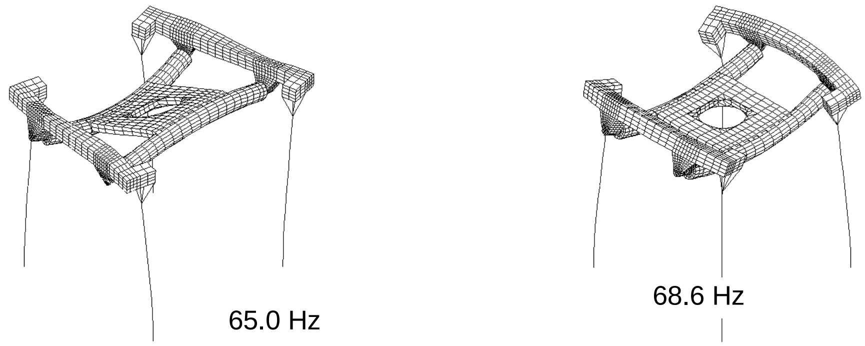

Figure 6. Mode shapes 7 and 8 of the BSC support system

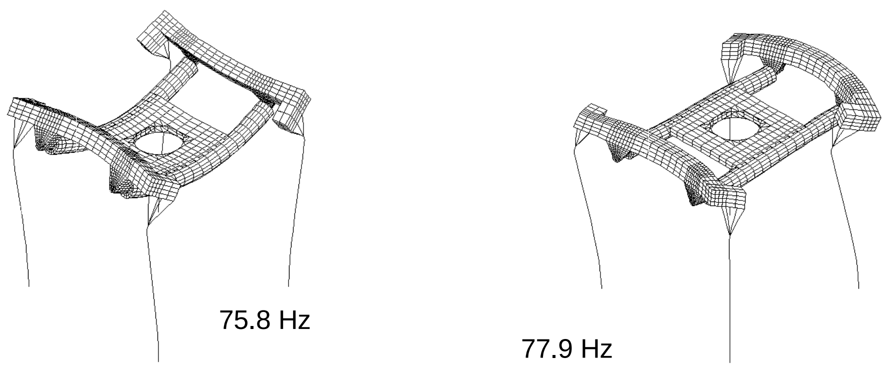

Figure 7. Mode shapes 9 and 10 of the BSC support system

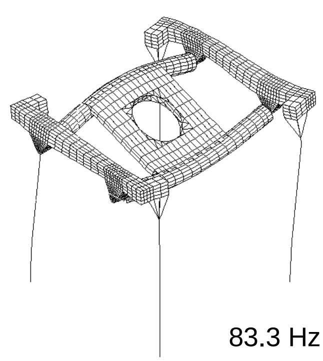

Figure 8. Mode shape 11 of the BSC support system

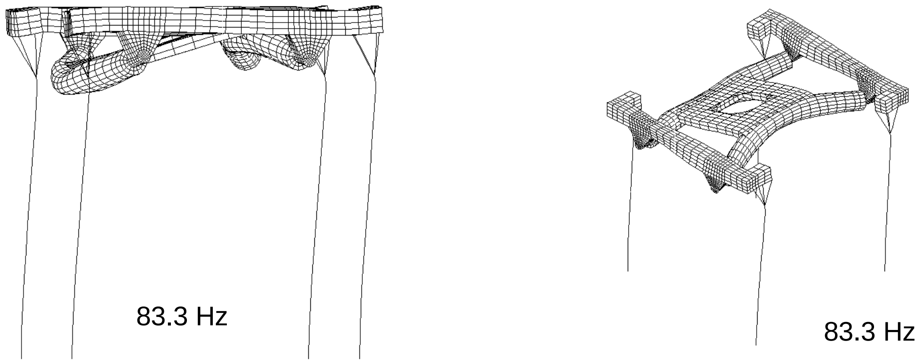

Figure 9. Mode shape 12 of the BSC support system

4. Conclusion

The redesign of the Z actuator stage and the elimination of the Stacis 2000 have combined to raise the first natural frequency from 15 to 23 Hz. Since the increased natural frequency implies a stiffening of the structure, it may be concluded that the system design change can only maintain or slightly increase the already satisfactory structural safety margins observed in revision A of this technical note.

The previous safety factors were:

for static operational loading	>17
for pseudo earthquake loading	15
for buckling	220

In conclusion, it appears that the support system for the BSC will adequately meet the SEI requirements as configured.

Note 1, Linda Turner, 09/03/99 11:30:59 AM
LIGO-T960214-B-D