LASER INTERFEROMETER GRAVITATIONAL WAVE OBSERVATORY

LIGO Laboratory / LIGO Scientific Collaboration

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Pier Stiffness and Modes

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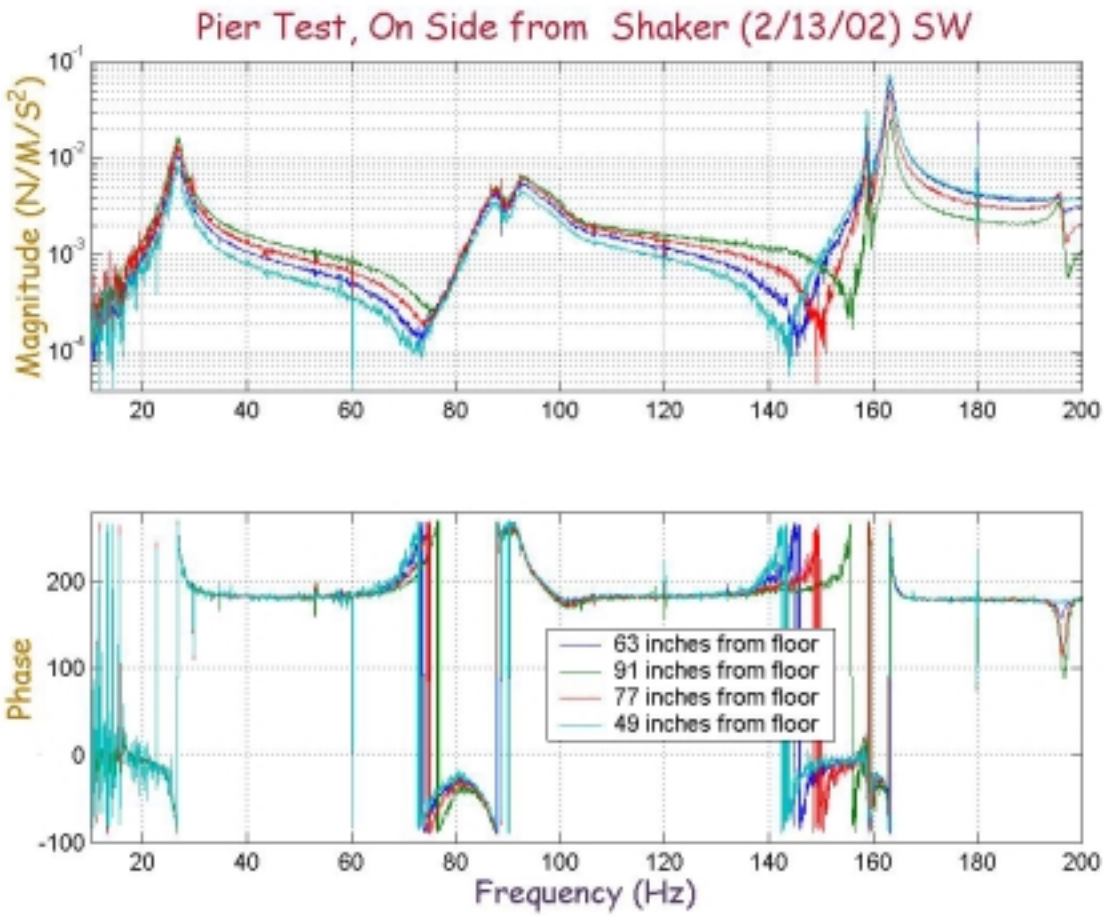
Abstract

The DC compliance and the natural mode frequencies of the seismic isolation support pier were measured in the LASTI facility (see the 15 Feb 2002 LASTI elog entry). This note provides companion finite element results and a possible explanation for the low measured stiffness of the pier.

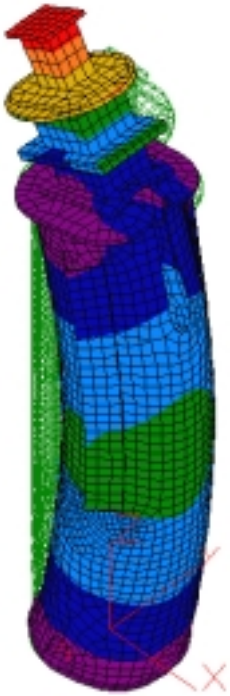
Rev 01: correction to the measured pier stiffness.

1 Modes

The LASTI elog entry of 15 Feb 2002 has several transfer function plots for shaker excitation near the top of the pier with the pier disconnected from the crossbeams but with the spacer weldments in place. The following plot is typical of the transfer function results:



Finite element analysis indicates that the resonances at ~27 Hz and ~165 Hz are likely the first and second beam bending modes. These modes are indicated below in the displaced mode shape plots. The model does not include the structure indicated in the transfer function measurements between these two bending modes. These may be due to interaction with adjacent structures (such as the chamber).

Mode 1: 26.2 Hz	Mode 2: 26.2 Hz	Mode 3: 188 Hz
		

Note: The mode frequencies obtained for the model shown are actually 28.7 Hz, 29.5 Hz and 215 Hz. The frequencies cited in the table are for a model with significantly more elements.

2 Stiffness

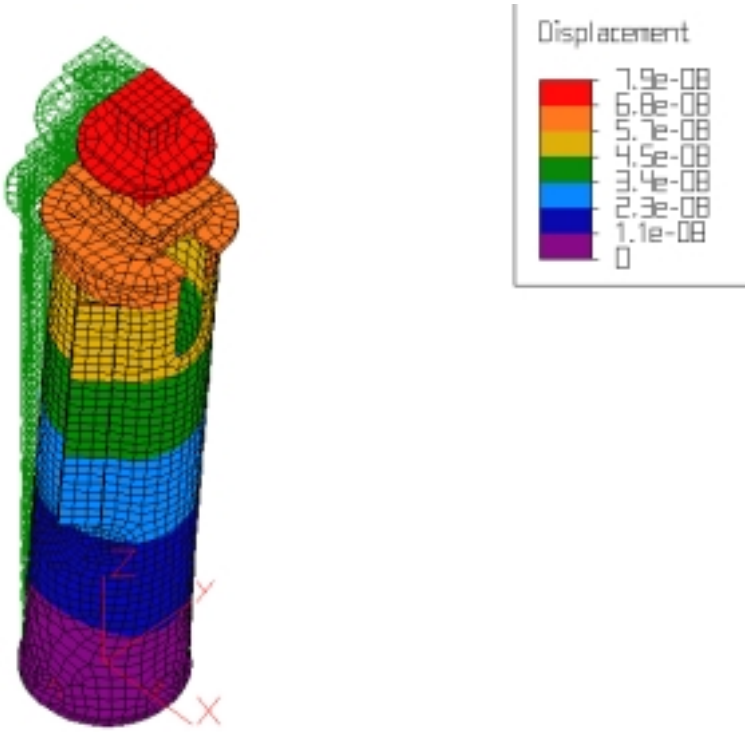
A measurement of the stiffness of the pier to a lateral load near the top of the pier (center of the flat plate welded to the side of the pier at it's top) was also reported in the LASTI elog on 15 Feb 2002. The result of this measurement was a static compliance of **0.089 microns/Newton**. (Note: The original entry in the elog is incorrect and will be amended.)

The corresponding result from the finite element analysis is 6 x 10^{-8} cm displacement for 1000 dynes of applied force, or 0.06 microns/N. This result is (approximately) consistent with the modal analysis:

$$k = m_k (2\pi f)^2$$

where k = stiffness, m_1 = modal mass of the first mode ~ ½ pier mass (a guess)= 550 Kg, f_1 = frequency of the first mode = 26 Hz, so k = 15 x 10^6 N/m or 1/k = 0.07 microns/N.

The discrepancy between the analysis and the measurement is likely due to the compliance of the bolts and possibly the grout and floor at the base of the pier. Consequently the measured value is to be preferred over the analytical valve.


Displacement
7.9e-08
6.8e-08
5.7e-08
4.5e-08
3.4e-08
2.3e-08
1.1e-08
0
Z
Y
X