LIGO Laboratory / LIGO Scientific Collaboration

LIGO- E080176-00-D *LIGO* 15 February 2008

- HAM ISI Installation Fixture for LLO - Fixture Assembly and Tests under load done at Southern Enterprises

Fabrice MATICHARD for the SEI team

Distribution of this document:
Advanced LIGO Project

This is an internal working note
of the LIGO Laboratory

California Institute of Technology
LIGO Project – MS 18-34
1200 E. California Blvd.
Pasadena, CA 91125
Phone (626) 395-2129
Fax (626) 304-9834
E-mail: info@ligo.caltech.edu

Massachusetts Institute of Technology
LIGO Project – NW22-295
185 Albany St
Cambridge, MA 02139
Phone (617) 253-4824
Fax (617) 253-7014
E-mail: info@ligo.mit.edu

LIGO Hanford Observatory
P.O. Box 1970
Mail Stop S9-02
Richland WA 99352
Phone 509-372-8106
Fax 509-372-8137

LIGO Livingston Observatory
P.O. Box 940
Livingston, LA 70754
Phone 225-686-3100
Fax 225-686-7189

1 PURPOSE

- This document reports the work made at Southern Enterprises on Friday 8th of February 2008, on the Installation Fixture for the HAM ISI.

- The structure has been fully assembled. The second section of this document gives details about this assembly.

- The third section of this document describes the tests under load realized in order to validate the bridge for utilization.

- The fourth section is a comparison of experimental results and FEA results.

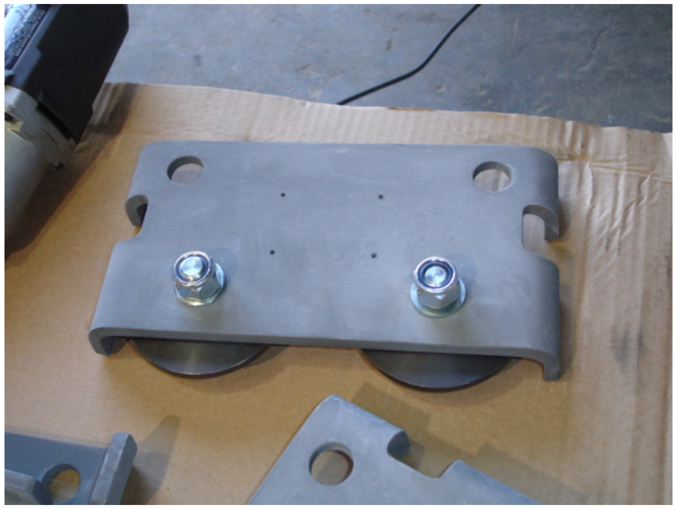
2 BRIDGE ASSEMBLY

- The Bridge parts at the Southern facilities

- Installation of all the wheels and leveling pads

- Assembly of the external stands

- The trolley assembly:



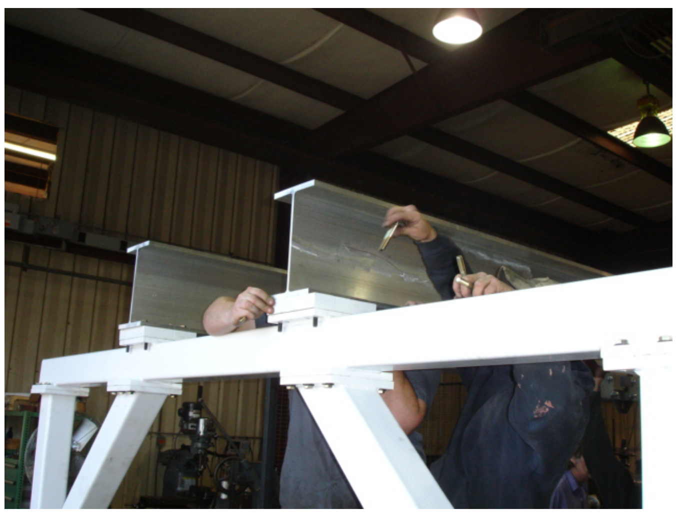
- Installation of the trolleys on the beams:

- Installation of the beams on the two external stands:

- The beam standing on the external stands:

- Clamping of the beam on the external stand:

- Same procedure for the second beam:



- Installation of the middle stand:

- Middle Stand installed:

- Leveling of the stand:

- Leveling pads at their nominal height:

3 TESTS UNDER LOAD

- Test preparation:

- Test#1

- Test#1 :

During this test#1 we applied the load on one beam (the right beam on this picture) via two trolleys:

During the HAM ISI installation process, the nominal load on each beam will be:

$$M_{nom/beam} = \frac{M_{isi}}{2} = \frac{5600}{2} = 2800 \text{ pds}$$

And the nominal load on each trolley will be:

$$M_{nom/trolley} = \frac{M_{isi}}{4} = \frac{5600}{4} = 1400 \text{ pds}$$

During this test#1 at Southern Enterprises, the load used was:

$$M_{test\#1} = 4800 \text{ pds}$$

The corresponding deflexion of the beam was:

$$\delta_{test\#1} = 0.147''$$

The Test Load over Nominal Load ratios is

$$\lambda_{Beam} = \frac{M_{test\#1/beam}}{M_{nom/beam}} = \frac{4800}{2800} = 1.7$$

$$\lambda_{Trolley} = \frac{M_{test\#1/trolley}}{M_{nom/trolley}} = \frac{2400}{1400} = 1.7$$

This loads on the beam and each trolleys were 1.7 times higher than the nominal load they will carry during the HAM ISI installation.

- Test#2

During this test#2 we applied the load on the other beam (the left beam on this picture) via the trolleys. This test has been done in order to check if the results obtained are the same on both sides.

The results are summarized in the following table:

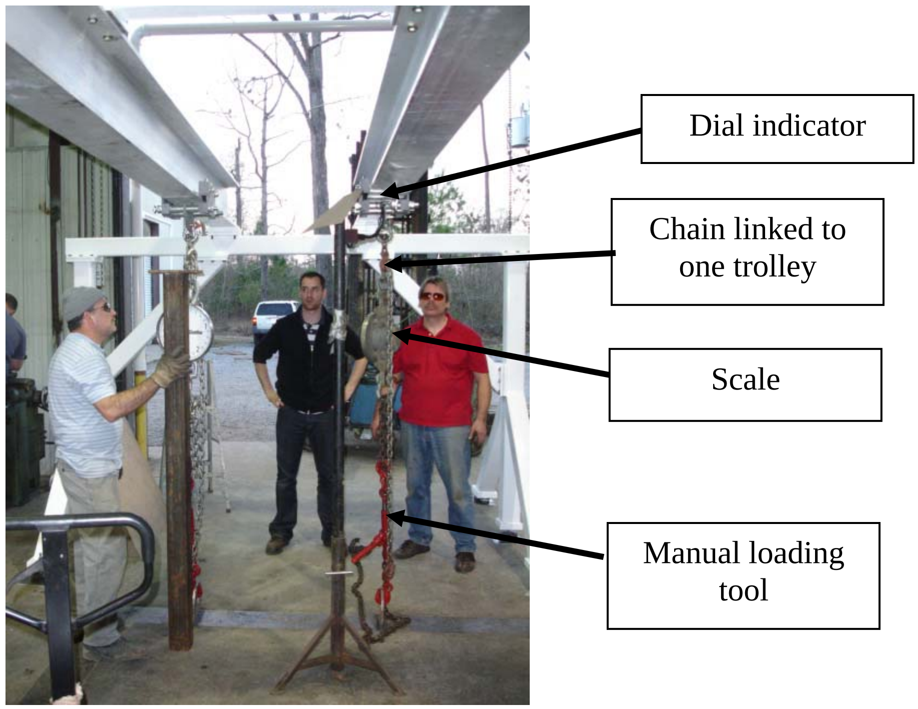
Test	Load	Deflexion	Compliance	Test load /Nom load
#1 (Left beam)	4800 pds	0.147	0.031 Mils/pds	1.71
#2 (Right beam)	3700 pds	0.121	0.033 Mils/pds	1.32
#2 (Right beam)	5000 pds	0.155	0.031 Mils/pds	1.78

The right beam and each trolleys were loaded with a test load 1.78 times higher than the nominal load they will carry during the HAM ISI installation.

The compliance results show a good consistency.

- Test#3

During this test#3 the two beams are loaded. We used one trolley per beam. One dial indicator, one scale and one loading tool are used on each side:



Test	Load	Deflexion	Compliance	Test load /Nom load
#3 (Left beam)	3700 pds	0.153	0.041 Mils/pds	1.32
#3 (Right beam)	3800 pds	0.160	0.042 Mils/pds	1.35

In this test, the left beam and the right beam are loaded at the same time. This is why the compliance is higher than for test #2.

The Test Load over Nominal Load ratios are:

$$\lambda_{Bridge} = \frac{M_{test\#3}}{M_{nom}} = \frac{3700+3800}{5600} = 1.34$$

$$\lambda_{Trolley} = \frac{M_{test\#3/trolley}}{M_{nom/trolley}} = \frac{3800}{1400} = 2.7$$

This means that the bridge has been tested with 1.34 times the nominal load, and each trolley has been tested with 2.7 times the nominal load.

- Test#4

Rolling test: a load of 2000pds has been hung to one trolley.

The Test Load over Nominal Load ratios is:

$$\lambda_{Trolley} = \frac{M_{test\#3/trolley}}{M_{nom/trolley}} = \frac{2000}{1400} = 1.42$$

Two persons pushed the mass. It moved pretty easily while the mass per trolley where 1.42 times higher than the nominal load for the ISI installation.

4 Comparison of Experiment end FEA results

- Stand and beam experimental compliances

The test#2 and #3 permit to extract the compliance of each beam and the compliance of the stands:

C_{beam} is the compliance of one beam
C_{stand} is the compliance of one stand (average value between external and middle stand)

Test#2: $$(C_{beam} + \frac{C_{stand}}{2})\, 3700 = 0.121''$$

Test#3: $$(C_{beam})3700 + (\frac{C_{stand}}{2})\,(3700 + 3800) = 0.153''$$

Wich can be written:

$$3700\, C_{beam} + 1850\, C_{stand} = 0.121$$
$$3700\, C_{beam} + 3750\, C_{stand} = 0.153$$

This gives:

$$C_{beam} = 0.024 \text{ mils/pds}$$
$$C_{stand} = 0.017 \text{ mils/pds}$$

- Stand and beam compliances from FEA

The FEA model based on simply supported assumptions – E800053-A-D, page12, Case2- provides the following compliance results:

$$C_{Beam} = \frac{2.4}{2800} = 0.86e-3 \text{mm/pds} = 0.034 \text{ Mils/pds}$$

This model is closer to the experiment than the two other models based on clamped assumptions. This means that the beam slightly rotate on the support points.

Comparison of results:

$$C_{beam\ Expe} = 0.024 \text{ mils/pds}$$
$$C_{Beam\ FEA} = 0.034 \text{ Mils/pds}$$

This FEA model over evaluates the compliance of the stands. We can assume that the stress values obtained from this FEA are also over evaluated.

- The bridge compliance can be compared with the results obtained with the FEA:

The FEA model based on Brick Meshing, clamped basis – E800053-A-D, page5 provides the following compliance results for the external stand:

$$C_{Stand} = \frac{1.0}{5600} = 0.18e-3mm/pds = 0.007\ mils/pds$$

The FEA model based on Brick Meshing, clamped basis– E800053-A-D, page8, provides the following compliance results for the middle stand:

$$C_{Stand} = \frac{3.2}{5600} = 0.57e-3mm/pds = 0.022\ mils/pds$$

These models (3D Brick elements) and their assumptions (Stands modeled clamped on the ground) are closer to the experiment than the two other models. This is because the 1-D beam meshing does not permit to take into account with accuracy the influence of the plates in the top corners of the stands. The pined assumptions seem to over evaluate the rotations at the basis of the stands.

The average value is:

$$C_{Stand\ FEA} = \frac{0.07 + 0.022}{2} = 0.015\ mils/pds$$

Comparison of results:

$$C_{Stand\ Expe} = 0.017\ mils/pds$$

$$C_{Stand\ FEA} = 0.015\ mils/pds$$

The FEA model provides compliance results close to those obtained in experiment. We can assume that the stress values obtained from these FEA are also pretty close to reality.

CONCLUSION:

- All the components have been tested with a load at least 1.34 times higher than the nominal load.

- Comparison of results between experiment and FEA show that the FEA values are either accurate enough or over evaluated. This allows assuming that the conclusions regarding the safety ratios (LIGO E800053-A-D) obtained from these models are valid.