Summary of work on LIGO structures

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DCC Number	Title	Notes	Date
G050187-00-Z	Advanced LIGO SUS ETM structural design summary – LSC meeting, March 2005, Livingston LA	Design summary for controls prototype, FEA predictions, design constraints and mass budget.	March 2005
T050237-03-D	Preliminary Frequency Analysis of the Quadruple Pendulum Controls Prototype (second) Structure	This document records the status of the frequency analysis performed on quadruple pendulum controls prototype structures as well as summarizing experimental data collected from the "Stanford" structure. Furthermore, it will address possible stiffening designs.	Oct 2005
T050171-01-K	Selection of aluminium alloys for use on advanced LIGO UK parts	This note aims to address the issues of material availability and suitability for use on Advanced LIGO.	Oct 2005
T060058-00-K	Static deflection of advanced LIGO SUS ETM structures	A static deflection of the controls prototype design, the load is applied in a similar way to a point load on the end of a cantilever. Contains a mass summary of the design.	Feb 2006
T060059-01-K	Finite Element Analysis of Advanced LIGO SUS ETM Structures	This work documents the progressive steps made in analysing the controls SUS ETM structure towards meeting the frequency requirement. The focus is on bolted connections and how to model them in FEA.	March 2006
T060087-00-K	Finite Element Analysis of Advanced LIGO SUS ETM Structures using ANSYS Classic beam models	The purpose of this document is to improve the structural performance of the SUS ETM structure by introducing a third structure known as the sleeve design. The existing x-bracing in the lower structure does not increase the fundamental frequency, the reason for this is fully explained in T060059-00-K section 6. The sleeve design seeks to take advantage of the four stiff corners of the upper structure, increase the section/stiffness of the "x" braces and reduce the mass of the lower structure. The document looks at trends for single and double cross bracing with varying wall thickness.	May 2006
T060088-00-K	Finite Element Analysis of Advanced LIGO SUS ETM structures using ANSYS workbench	This document continues on from the analysis work done in document LIGO-T060087-00-K which looks at trends for a new design of the noise prototype structure. In the new design the lower structure has a comparatively stiff outer sleeve with "x" bracing; the internal functional part is a similar light weight version of the previous design. The	May 2006

		development of the design is shown here using Pro-Engineer CAD models and the finite element package, ANSYS workbench.	
T050077-05-K	Separation of chains in Quad suspensions		
T070155-00-K	Preliminary Measured and Predicted Frequency Analysis of the Noise Prototype Structures	This document records the status of the frequency analysis performed on the noise prototype structure. A series of frequency tests were done to gain confidence in the structural design presented in the Advanced LIGO ITM/ETM Noise prototype Preliminary Design Review -3 (PDR). For the PDR it was necessary to demonstrate that the proposed design had an experimentally measured fundamental frequency to within 25% of the predicted finite element result (reference LIGO T060088-00-K). Due to the unavailability of some of the structures the tests began with the sleeve and a simplified face plate design, progressing to the sleeve combined with the upper structure.	June 2006
T070154-00-K	Finite element analysis of the noise prototype structure	An analysis was done on the final design of the noise prototype structure to understand it's modal frequencies. Models were run at various stages of the structures construction to gather data points for comparison with physical tests.	May 2007
T070033-00-K	Finite element analysis of the face plate design for the beam splitter and folding mirror structures	This work looks at the benefit of light weighting the face plate designs for the beam splitter and folding mirror structures. The work gives an appreciation of how a beam splitter structure will behave with and without the addition of stays.	2007
T070160-00-K	Preliminary finite element analysis of beam splitter design	This note takes a simple approach to understanding the contribution made by elements of the beam splitter design, in particular the addition of stays. A representation of the beam splitter structure is made using an ANSYS finite element model made up of beam and shell elements	2007
T070161-00-K	Finite element analysis of the stay design for the beam splitter structure	Looks at various options for stay arrangements	2007
T070162-00-K	Preliminary modal testing of the beam splitter structure	This work covers a preliminary modal test of the beam splitter structure to get an idea of its behaviour before committing to a more detailed study, any lessons learned will be applied to subsequent work. Modal testing was	2007

		done with the structure on four steel blocks	
T070163-00-K	Preliminary finite element analysis of the folding mirror design with beam and solid elements	This note looks at the possible arrangement of members for the folding mirror design.	2007
T070164-00-K	Comparison of uniform versus taper channel section beam models	The work looks at the possibility of using taper section face plates to increase the frequency of the beam splitter and folding mirror structures.	2007
T070117-01-K	Effect of steel base blocks on frequency measurements of BS structure	Frequency measurements differ from FEA predictions, with more massive structures and higher frequencies being the most affected. This note explores the idea that the finite elasticity of the massive steel blocks to which the structure is bolted, may at least partially explain the discrepancy.	May 2007
T070147-00-K	Comparing the modal frequency results of a finite element analysis with physical tests on a suspended noise prototype structure – 1	During physical testing of LIGO structures, modal frequencies have been seen below the first predicted frequency as calculated by finite element analysis (FEA). The purpose of this work is to go some way in proving that these lower frequencies are not attributed to the structure and that they are more likely to do with the clamping method, or that the structure is not, as assumed, clamped to something that is infinitely stiff. In order to get a clear picture of the modal frequencies of the LIGO structures physical tests have been carried out on unconstrained structures. The structures are suspended by a sling in a way that does not limit the motion of the mode shapes, accelerometers are placed in positions that will identify the mode shapes predicted by the finite element analysis. The results from the physical tests are then compared to a finite element analysis of the same unconstrained structure; the first modal frequency measured from the physical tests is compared to the seventh modal frequency of the finite element analysis. In this report the upper and sleeve structure are considered to see whether their behaviour can be predicted by FEA, similar reports exist for the beam splitter structure, T070148 and T070149.	June 2007
T070148-00-K	Comparing the modal frequency results of a finite element analysis with physical tests on a suspended beam splitter structure without shear	A previous report explaining the methodology is T070147, and a subsequent report continuing the work for a beam splitter with shear plates is T070148.	June 2007

	plates – 2		
T070149-00-K	Comparing the modal frequency results of a finite element analysis with physical tests on a suspended beam splitter structure with shear plates – 3	Previous reports explaining the methodology and earlier work are T070147 and T0707148.	June 2007
G070421-00-K	Modal frequencies of LIGO structures	During tests on LIGO structures, frequencies have been seen below the first predicted frequency as calculated by finite element analysis. Is this discrepancy to do with the clamping, or that the structure is not fixed to something that is infinitely stiff? This presentation offers answers to these questions by reporting on a variety of tests and simulations, it includes references to a number of more detailed reports.	June 2007