CALIFORNIA INSTITUTE OF TECHNOLOGY

Laser Interferometer Gravitational Wave Observatory (LIGO) Project

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Refer to: LIGO-E950107-00-E
Date: 23 December 1995

Subject: LIGO Foundation Thickness Decision: Minutes of Integration Meeting on 8 December 1995.

The Integration Meeting of Friday 8 December 1995 was dedicated to a discussion of LIGO Options with regard to LVEA//VEA foundation slab thicknesses. In attendance were Althouse, Asiri, Bork, Coles, Lazzarini, Matherney,Sanders, Savage, Sibley, Stapfer, Vogt, Weiss, Whitcomb, Worden, Zucker

AGENDA:

[I.] Close out of Facilities PDR RFAs
Coles and Asiri asked for a delay of this discussion due to the need to iterate with Parsons on their proposed dispositions of the Requests for Action which were generated at the Facilities PDR. Coles later suggested the agenda item could be handled by distribution of the Parsons memorandum on disposition in the near future.

[II.] Discussion on choice of LVEA/VEA foundation thickness.

Althouse led the discussion of the choice of foundation technical thickness. Althouse proposed that there were actually three separate aspects to deciding upon a thickness:

[1] Thickness requirements needed to meet the LIGO scientific criteria which were communicated to Parsons in the course of the design.

[2] Cost impact of the choice of thickness.

[3] Other (engineering and not scientific) considerations which could affect choice of foundation thickness.

He proposed that at this meeting we concentrate on item [1]. He summarized the LIGO requirements as (refer to LIGO-T950113-03-O by Spero/Savage). With regard to foundation thickness, these may be summarized by the following four points:

[i] Need to keep broadband (1-100Hz) response of the foundation from seismic sources of excitation below 2X the LIGO Standard Spectrum (LSS).

[ii] Need to keep responses of the foundation (1 - 100Hz) due to acoustic sources of excitation below 1X the LSS.

[iii] Need to keep responses of the foundation due to narrowband sources of excitation below 2.4 x 10^{-7} m/sec^2 (in RMS acceleration, RSS, 3-axes). Weiss has proposed that this requirement be kept in RMS displacement rather than RMS acceleration: the spectral dependence of the LSS gives an RMS value for acceleration which weights the frequencies differently from RMS displacement. The different requirements come from different ways of treating the fundamental requirement that narrowband excitations be kept at or below levels of motion caused by violin resonances.

[iv] Desire to provide adequately stiff foundation for alignment stability of operating interferometer.

DISCUSSION SUMMARY:

Lazzarini provided several graphs summarizing the RMP analysis results.

[A] Foundation thickness weakly determines response to ambient seismic excitation; a thickness of 18" or greater is expected to meet performance requirements.

In discussion, this conclusion was accepted.

[B] Responses to narrowband excitations are below LIGO requirement levels and are independent of foundation thickness.

In discussion, this conclusion was also accepted.

[C] Acoustic excitation of the foundation by a sound pressure level derived by LIGO ("LIGO Acoustic Criterion") exhibits exponential dependence on thickness, with a 1/e folding length of 18". The results from RMP indicate that thickness of 30" or greater would meet LIGO ground motion requirements at all frequencies studied: an 18" thickness exceeds the LIGO requirement by a small (<2) factor in a narrow band around 60Hz.

In the ensuing discussion, one point made was that this excedence is not serious because it appears that the LIGO Acoustic Criterion is more severe than the present estimate, by M. Long (RMP consultant), of the LVEA acoustic environment which was performed taking into account the building and HVAC designs. His estimates are at least an order of magnitude lower than those calculated by using the acoustic level requirements originally specified by LIGO. This consideration indicates that a foundation thickness 18" or greater satisfies LIGO requirements.

On the other hand, it was also pointed out that, at the Hanford site where the measured vibration spectrum is below the LSS at some frequencies, the acoustic-induced vibration might dominate and the additional margin provided by a thicker slab would make a noticable difference. The "comfort zone" associated with this consideration seemed to become acceptable at 30" or greater.

[D] In regard to quasistatic deformation of the foundation due to thermal gradients and atmospheric pressure load imbalances, even the thickest slab considered by Parsons gives performance which is worse than interferometer alignment reference needs by a large factor (>100x). Thus, another alignment strategy will need to be developed, irrespective of foundation thickness.

It was suggested that this last conclusion would lead one to deduce that foundation thickness shouldn't be an issue: if neither an 18" nor a 68" slab is acceptable by a large factor, then the factor of 3-5 improvement in going from 18" to 68" should not impress us. Zucker argued that reducing the foundation thickness in favor of as-yet unconceived solutions to maintaining optical alignment of the interferometer would not be a sound decision. His concerns centered on the need to maintain interferometer alignment in the presence of differential thermal and pressure effects which had the potential to produce significant misalignments. His concerns were echoed by Whitcomb. Shoemaker was absent. In the end it was generally felt that the commitment should be made to make the alignment design work independently from the slab.

R. Weiss also reported on discussions he held with two Civil Engineering Professors at MIT (see separate email report sent out by Weiss). They raised concerns whether a 68" slab should be considered monolithic when predicting its dynamic and quasi-static behavior. Their experience has been that practical engineering issues encountered during construction will require expansion joints, and that cracking of the concrete during curing and possibly afterwards due to thermal cycling would compromise its characteristics so that it would be less rigid than a monolithic slab characterized by (published) homogenous bulk properties of concrete.

After a lengthy discussion of the pros and cons of opting for a thinner foundation thickness than 68", Althouse presented the following propositions to the assembled group:

[1] Any slab greater then 18" meets the LIGO Scientific Requirements

[2] Other (engineering & cost) considerations should be used to discriminate among thickness options;

[3] Any need for margin should be decided in favor of a thicker foundation.

After additional discussion about risks and benefits of reduced slab thickness, Whitcomb proposed that the number in Althouse's first proposition be changed to 30". This was agreed upon by those present at the meeting, and the meeting was adjourned.

Savage was asked to review the technical note he and Spero drafted restating the LIGO requirements and to modify it where require to reflect the group's decision. The new memorandum was to be forwarded to RMP through Asiri. (Savage completed this action with T950113-05-O.)

AL:al

cc:

Althouse	Coyne	Matherney
Asiri	Jones	Shoemaker
Coles	Lindquist	Stapfer
Zucker	Whitcomb	Raab
Sanders	Barish	Sibley
Spero	Savage	
Vogt	Weiss	Chronological File
Young	Worden	Document Control Center