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WHEELER & GRAY, INC
CONSULTING ENGINEERS

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To: FRED ASIRI Fax: (818) 304-9834

cc: -LIGO

From: PAUL WEICKERT Phone 213-256-2101

Fax Phone 213-258-3934

Hard copy to follow: ☒ Yes ☐ No

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Subject:

7462 NORTH FIGUEROA STREET ☐ LOS ANGELES ☐ CALIFORNIA 90041 ☐ (213) 256-2101

WHEELER & GRAY, INC
CONSULTING ENGINEERS

April 4, 1996

W&G # 92185

Memo To: Fred Asiri

From: Paul Weickert

Subject: Instrumentation Slab for the Facility
LIGO Project - Hanford, Washington

Talked to Bob Tobin (818) 447-1005 on 3/28/96 in regard to the 30" thick slab for this facility. Discussed several points relative to the design and construction of the slab. It was indicated that with 0.5% to 0.6% reinforcing steel, cracking would be very limited and checking would be sealed as slab cures.

He also referred to the ACI Manual of Concrete Practice. We looked through the manual to which Bob referred and saw the following article. It may be of some help. Reference ACI Manual of Concrete Practice 207.2R-90 - Effect of restraint, volume change, and reinforcement on cracking of mass concrete.

Bob Tobin has been associated with the concrete industry for many years. He has been with trade associations in the industry and is considered very knowledgeable in the use of concrete.

Attached is a copy of a section of the Code dealing with reinforcing of slabs.

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C. Shear and torsion *[See also Section 2625 (c) 3 A for shear walls in Seismic Zones Nos. 3 and 4]* 0.85

D. Bearing on concrete [See also Section 2618 (n)] 0.70

E. Flexure in plain concrete 0.65

3. Development lengths specified in Section 2612 do not require a ϕ factor.

4. In Seismic Zones Nos. 3 and 4, strength-reduction factors shall be as given above except for the following:

The shear strength-reduction factor shall be 0.6 for the design of walls, topping slabs used as diaphragms over precast concrete members and structural framing members, with the exception of joints, if their nominal shear strength is less than the shear corresponding to development of their nominal flexural strength. The shear strength-reduction factor for joints shall be 0.85.

(e) Design Strength for Reinforcement. [9.4] Designs shall not be based on a yield strength of reinforcement f_y in excess of 80,000 psi, except for prestressing tendons.

(f) Control of Deflections. [9.5] 1. General. Reinforced concrete members subject to flexure shall be designed to have adequate stiffness to limit deflections or any deformations that may adversely affect strength or serviceability of a structure at service loads. (See Section 2307 for deflection limits.)

2. One-way construction (nonprestressed). A. Minimum thickness stipulated in Table No. 26-C-1 shall apply for one-way construction not supporting or attached to partitions or other construction likely to be damaged by large deflections, unless computation of deflection indicates a lesser thickness may be used without adverse effects.

B. Where deflections are to be computed, deflections that occur immediately on application of load shall be computed by usual methods or formulas for elastic deflections, considering effects of cracking and reinforcement on member stiffness.

C. Unless stiffness values are obtained by a more comprehensive analysis, immediate deflection shall be computed with the modulus of elasticity E_c for concrete as specified in Section 2608 (f) (normal-weight or lightweight concrete) and with the effective moment of inertia as follows, but not greater than I_g.

$$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr} \qquad (9\text{-}7)$$

WHERE:

$$M_{cr} = \frac{f_r I_g}{y_t} \qquad (9\text{-}8)$$

and for normal-weight concrete

$$f_r = 7.5\sqrt{f'_c} \qquad (9\text{-}9)$$

When lightweight aggregate concrete is used, one of the following modifications shall apply:

(i) When f_{ct} is specified and concrete is proportioned in accordance with Section 2604 (c), f_r shall be modified by substituting $f_{ct}/6.7$ for $\sqrt{f'_c}$, but the value of $f_{ct}/6.7$ shall not exceed $\sqrt{f'_c}$.

(ii) When f_{ct} is not specified, f_r shall be multiplied by 0.75 for "all-lightweight" concrete, and 0.85 for "sand-lightweight" concrete. Linear interpolation may be used when partial sand replacement is used.

D. For continuous members, effective moment of inertia may be taken as the average of values obtained from Formula (9-7) for the critical positive and negative moment sections. For prismatic members, effective moment of inertia may be taken as the value obtained from Formula (9-7) at midspan for simple and continuous spans, and at support for cantilevers.

E. Unless values are obtained by a more comprehensive analysis, additional longtime deflection resulting from creep and shrinkage of flexural members (normal-weight or lightweight concrete) shall be determined by multiplying the immediate deflection caused by the sustained load considered, by the factor

$$\lambda = \frac{T}{1 + 50\rho'} \qquad (9\text{-}10)$$

where ρ' shall be the value at midspan for simple and continuous spans, and at support for cantilevers. Time-dependent factor T for sustained loads may be taken equal to

Five years or more	2.0
12 months	1.4
Six months	1.2
Three months	1.0

F. Deflection computed in accordance with this section shall not exceed limits stipulated in Section 2307.

3. Two-way construction (nonprestressed). A. This section shall govern minimum thickness of slabs or other two-way construction designed in accordance with provisions of Section 2613 and conforming with the requirements of Section 2613(h) 1 B. Thickness of slabs without interior beams spanning between the supports on all sides shall satisfy requirements of either Section 2609(f) 3 B, C or E. Thickness of slabs with beams spanning between supports on all sides shall satisfy requirements of either Section 2609 (f) 3 C or F.

B. Minimum thickness of slabs without interior beams spanning between the supports shall be in accordance with the provisions of Table No. 26-C-2 and shall not be less than the following values:

(i) Slabs without drop panels as defined in Section 2613 (e) 6 A and B ..... 5 inches

(ii) Slabs with drop panels as defined in Section 2613 (e) 6 A and B ..... 4 inches

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