BEN C. GERWICK, INC., Consulting Engineers

Ocean & Arctic Construction
Marine Terminals
Deep Foundations
Prestressed Concrete
Bridges

601 Montgomery Street
San Francisco, CA 94111

Phone: (415) 398-8972

Fax: (415) 433-8189
Telex: RCA 278713 GRWIK UR

December 30, 1993
Ref.: 9224.00

BY FAX: (206) 671-1697

Anvil Corporation
Bellingham, WA
Attn.: Mr. John Macpherson

Re. : ARCO D.C. Project
Pile Driveability

Dear John:

At your request, we have reviewed the revised draft of Interim Report No. 2 by Lyman C. Reese & Associates which you faxed to me today.

In the discussion of the Breasting Dolphins, they described the analyses of an 8 ft. diameter pile with a lateral load of 500 kips. The penetration required is 80 ft.

In the subsequent paragraphs, they imply that the penetration of a 10 ft. diameter pile under a lateral load of 500 kips is also 80 ft. I'm a little surprised that the required penetration is not less for the 10 ft. diameter pile when the lateral load is reduced from 1000 kips to 500 kips.

I discussed this with Shin-Tower Wang and he said that the penetration could probably be reduced somewhat after more detailed analyses.

For installing the 10 ft. diameter piles by driving and jetting, we note that a Vulcan 560 hammer appears to be adequate. Although this is still a big hammer, this now appears to be a reasonable approach.

We note the concern expressed by LCR & A about the "locking-over" of a pile due to large deflections at the mudline. We'll work closely with LCR & A during the final design phase to mitigate this potential problem.

Very truly yours,

Dick

C. R. Firth
Vice President

cc: Shin Tower Wang, LCR & A Fax (512) 467-1384
Paul Richardson Fax (714) 832-9603

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PAUL RICHARDSON & ASSOCIATES
CONSULTANTS FOR FOUNDATIONS AND SHAFT DRILLING

December 30, 1993
Job # 9224

Mr. C. R. Firth
Ben C. Gerwick, Inc.
601 Montgomery St.
San Francisco, CA 94111

Subject: Lymon C. Reese & Associates Reports- Jetty Approach Piles And Large Diameter Caissons For Mooring And Breasting Dolphins- ARCO D. C. Project, Bellingham, WA.

Dear Dick,

I reviewed both the Interim Report No.2 and the Revised Interim Report No.2. looking particularly at the driving resistance of the piles and the recommended pile driving hammer sizes. As you are aware I was on site during the drilling of B-13 and B-7 bore holes. The Shannon Wilson bore hole logs compared very closely with what I observed during the drilling and core sampling. Most of the other bore hole logs with some exceptions appear to have about the same soil characteristics. The soil varies from loose to very dense all along the dock extension. During the core sampling there was some lost circulation at around ML-29' causing B-13 to be abandoned before reaching the original programmed depth. In most of the subsequent bore holes the section was cased off.

Based on the bore hole logs and my personal observations during the core drilling I thought it would be feasible to install large diameter steel caissons for the mooring and breasting dolphins. The installation of the caissons could be done with current technology using appropriately sized pile driving hammers and soil plug relief methods as required to reduce the internal pile wall to soil friction. Of the several methods of relieving the internal soil plug to pile friction that are available it appears that the most popular and certainly the simplest is a system of internal jets to fluidize the soil plug with water while driving the caisson with the pile driving hammer. Since the berthing and mooring dolphins will have tension (uplift) loads less than 200 kips and the soil is generally granular or dense sand the caisson should regain some if not most of its friction capacity as the soil redensified when the jetting is stopped.

There are some things that would bear consideration as far as the mooring and berthing dolphins are concerned.

1. As stated in your letter to Anvil the head pressure inside the caisson/pile should be maintained as nearly as possible to the external head pressure while jetting and driving.

2. Upending and holding vertical a 170' long 10'OD caisson while starting the driving will probably require some type

13521 LAURINDA WAY, SANTA ANA, CA 92705
TELEPHONE (714) 832-0855 TELEFAX (714) 832-9603

PAUL RICHARDSON & ASSOCIATES

of guide system. If the caisson starts penetrating off vertical it may be difficult to straighten it.

3. If there is enough movement of the berthing dolphins at the seabed to cause a "locked in" offset over time it would seem that both the pile and the fender system need to be designed in such a manner as to minimize the movement to some acceptable magnitude. One such method that you mentioned on the telephone would be to design a caisson that is tapered from bottom to top. Another method might be to use higher tensile strength thinner wall plate for the caisson above the seabed.

4. The Reese report seems to want to limit the blow count of the pile driving hammer during driving. In the case of both the 8'OD pile the final blow count is estimated to be 38 BPF and for the 10'OD pile the final blow count is estimated to be 49 BPF. In offshore pile driving it is not uncommon to see blow counts over 100BPF for fairly long lengths. Also it seems that in some cases a smaller pile driving hammer with a faster stroke performs better than a larger pile driving hammer with a slower stroke.

Dick, I get the feeling from the reports that maybe Lymon and Shin-Tower have not completed all of their analyses and are being somewhat conservative with their recommendations until they complete the studies.

It is still my opinion that the 10'OD caissons can be installed using a built in jetting system or combination jet air-lift system. It is also my opinion that the piles could probably be driven with a Hydroblok pile driving hammer similar to the HBM-3000A or HBM-4000 without jetting. The cost of getting such a pile driving hammer to the site and driving the caissons would be relatively costly probably around $1.5 to $2 million.

Sincerely,

Paul Richardson

Paul Richardson