Advanced
Engineering
Consultants
180 Montgomery Street, Suite 850 San Francisco, CA 94104
Telephone: (415) 291-9600 Fax: (415) 291-9696

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Dr. Denis McGee
Westinghouse Idaho Nuclear Co., Inc.
Box 4000
Idaho Falls, ID 83403

Subject: Report on Preliminary Review of Impact on Tank Farm due to Characterization Activities

Dear Dr. McGee:

AEC has completed a brief preliminary review of the subject problem. We understand that WINCO intends to drive 5 in. tubular piles into the soil down to rock. These piles are closed off at the bottom to accommodate instrumentation needed for the characterization process. Concern has been raised about the potential of damage to the existing vaults from the pile driving process.

The most vulnerable vaults in the Tank Farm are judged to be those housing tanks WM-182 to 184 and WM-185 and 186, referred to as the piller and panel vaults. The objective of this review is to evaluate the potential of a failure of the piller and panel vaults as a consequence of driving these piles within a 7 ft distance of the vaults.

Vault Description

The vault configuration for tanks WM-182 to 184 is octagonal in plan and is composed primarily of precast concrete construction. The concrete mat foundation bears on bedrock. A total of 16 columns are distributed around the vault perimeter. Six inch thick precast wall panels are clipped to the columns. Precast perimeter beams interconnect the column tops. Roof beams span in the N/S direction and bear either on the columns or the perimeter beams. Concrete roof panels span between ledges of the roof beams. Stability was maintained during construction by a steel wide-flanged ring beam bolted to the inside of the columns. About ten feet of soil overburden lies above the roof.

The vault configuration for tanks WM-185 and 186 is very similar to the one enclosing tanks WM-182 to 184. The primary differences are greater amounts of steel reinforcement were typically provided, and the tops of the columns were tied together by a combination of precast/cast-in-place ring beam.

Preliminary Evaluation of the Vaults

AEC has performed preliminary calculations to scope out the potential for a catastrophic collapse of the piller and panel vaults. These calculations have required many assumptions to be made. AEC has also depended on previous preliminary calculations that were prepared to evaluate these vaults for gravity and seismic loads. Based on this previous evaluation of the vaults, AEC has assumed that the most vulnerable elements of the vaults during the pile driving process are the precast wall panels. Consequently, only these panels have been evaluated herein.

The problem can be postulated as having a static part which deals with the displaced soil volume as the pile is driven into the soil, and a dynamic part which deals with the stress waves transmitted into the soil due to the impact of the hammer on the pile.

1. Static Effects: The static part of the problem derives from volumetric changes in the soil (pile driving displaces a volume of soil equal to the penetrating volume of the pile). To accommodate this volumetric change, the soil must consolidate, and/or push out. There is very little potential for consolidation in the compacted fill around the vaults. Therefore, AEC has assumed that the displaced soil will be accommodated by pushing the vault panels. This is a somewhat conservative assumption, but is reasonable for the lower elevations of the vault. At these elevations, the soil is restrained by the rock below, and the weight of soil above. The most flexible direction to displace soil is toward the vaults. Assuming the pile will be driven along the centerline of a wall panel (the most flexible wall location), wall displacements to accommodate soil displacement were calculated, and converted to moments in the panel. Maximum moment in the bottom wall panels from the displaced soil (static problem) is estimated to be 1.0 K-ft/ft.

2. Dynamic Effects: The dynamic part of the problem is very complex. A limited literature review reveals that there are no rigorous solutions to this problem. There is some empirical data on the effects of pile driving on near-by structures available in the literature. This data is compiled from pile driving projects, and is generally for distances of more than 20 ft. We don't believe this data to be a reliable source for this problem.

The only reliable data are those from testing in the field. This can be by testing an adjacent structure where failure does not pose a problem, by constructing an equivalent structure for test purposes or conducting a test in equivalent soil conditions as at the tank farm, with the objective of measuring soil pressures at depth from the pile driving process.

The dynamic problem can be postulated as that of dissipating the energy of the hammer striking the pile. Energy is dissipated in rebound of the hammer, in penetration of the pile into the soil, in stress waves in the pile and in body waves in the soil. The problem is even more complicated by the fact that the waves generated in the soil may reflect and refract from traveling through different layers of soil and rock, which will affect the wave front reaching the vaults. As mentioned above, AEC is not aware of rigorous analytical approaches that can be used to solve the dynamic pile driving problem.

AEC has estimated the behavior of the pile under hammer drop using available solutions of a pile on an elastic homogeneous medium. This solution assumes that the pile does not penetrate the soil medium, and the soil is assumed to undergo only elastic displacements. Furthermore, the surrounding soil is assumed to have zero friction with the pile. We have assumed the hammer to weigh 300 lbs, drop 6 ft in a short duration and to have zero rebound after it strikes the pile. The pile is assumed to be made of steel, to rest on soil or rock, and to be 40 ft long. The soil and rock are assumed to have zero material damping.

The solution used in this case postulates that the impact load on the pile will produce compression waves in the pile. Some of the stress wave will reflect back up the pile. The rest of the wave will be refracted into the soil, or rock, below the tip of the pile. The refracted wave in the soil is assumed to propagate outward in the soil, or rock, as a compressional (body) wave producing displacement in the vault wall panels. These displacements were then translated into moments in the wall panels.

Maximum moments in a wall panel from the compressional wave (dynamic problem) are estimated to be 0.9 K-ft/ft.

Conclusions and Recommendations

Maximum moments due to volumetric changes in the soil are estimated to increase moments in the wall panels by 1 k-ft/ft. This is a 5% increase in estimated moments from the at-rest soil pressures. Stresses from volumetric changes represent the static component of the pile driving problem, which is also the total added stress if the piles are pushed into the soil at a slow rate (i.e. no dynamic component due to impact on the pile). It is our opinion that a 5% increase in the existing wall panel moments will not cause a failure of the vaults. Estimates of added stresses due to volumetric change are reliable for use in this case.

Total maximum moments in the vault panels from pile driving (static and dynamic effects) have been estimated to be 1.9 k-ft/ft. This is a 10% increase in estimated moments from the at rest soil pressures. It is our opinion that a 10% increase in the existing wall panel moments will not cause a failure of the vaults. AEC has attempted to make conservative assumptions in its calculations, but the fact remains that a rigorous analytical solution of this problem is not available at this time. Consequently, there is considerable uncertainty in these results, and the increased moments could be larger than those calculated herein. AEC recommends that these results be utilized with due caution.

AEC recommendations, based on this brief preliminary evaluation of the problem, are:

1. The best solution to eliminate concerns about the existing vaults is to drill the piles in the soil. This will eliminate both the volumetric (static effects) as well as the dynamic soil pressure effects on the vault walls.

2. Another alternative is to push a pile into the soil at a slow rate, at a distance of 7 ft or more from the existing vaults, to eliminate dynamic pressures on the wall panels. Reduction of the pile diameter will also help reduce pressures from volumetric changes in the soil. AEC recognizes that this alternative may not be practicable.

3. Should pile driving by impact loads (load drop on top of pile) be chosen, AEC recommends that a testing program be initiated to better define dynamic loads on the vaults. This test should be conducted by a certified testing firm (AEC does not offer such services), and can be conducted away from the tank farm at an INEL location with similar soil profile as that at the tank farm. Such a test should be designed to measure in-soil dynamic pressures from pile driving. Such pressures, or other measured parameters which can be used to calculate dynamic soil pressures, can then be used in evaluations of the vaults.

Please call me if you have any questions.

Very truly yours,

Ahmad F. Kalim

for Lincoln E. Malik
President

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