

January 31, 2003

Mr. Steve DeWolf, P.E.
Port of Houston Authority
111 East Loop North
Houston, Texas 77029

Re: Assessment of Geotechnical Conditions
Bayport Marine Terminal
Spilmans Island Alternate Development Location
HVJ Project No. 02-220GH-0

Dear Mr. DeWolf:

Submitted herein is our assessment of the geotechnical conditions at the Spilmans Island Disposal Area and the potential impact of those conditions on the proposed container terminal facility. In addition, we detail our experience with design and engineering at the Spilmans Island based on past studies.

Basis of Study

The purpose of this study is to assess the potential impact of soil conditions on construction of a container terminal facility at the Spilmans Island site. This assessment identifies major cost items that would impact construction from a geotechnical perspective based on our extensive experience at the site. Our assessment was based in part on a schematic layout of Spilmans Island Alternate Development Location as shown on Figure E-6 of the Bayport Marine Terminal Draft Environmental Impact Statement as an indication of planned facilities at the site. We used existing boring information as our basis for assessing geotechnical conditions at the site. The information presented in this study should be considered conceptual in nature, and these estimates would be refined during the design process as additional data on the planned facilities and soil conditions are made available.

Related Experience

I personally have over 10 years geotechnical project experience at the Spilmans Island site. This experience was developed through studies performed for the Disposal Area Management Plan (DAMP) for the Port of Houston Authority and for design work related to the Spilmans Island site for the Houston Ship Channel 45-Foot project. The following list highlights some of the significant assignments I have supervised at the Spilmans Island site:

- Disposal Area Management Plan – Spilmans Island, Alexander Island, and Lost Lake (1994). This study entailed a comprehensive review of all available information on site conditions at Spilmans Island to support the development of a management plan for the site. In addition to all available Corps of Engineers borings, eleven additional borings were drilled, sampled, and tested along the levees at the site to further investigate the levees. These borings were drilled to provide soil stratigraphy data in critical areas of the levees and to provide samples for laboratory testing that was not performed by the Corps of Engineers. The overall levee stability was evaluated, and extensive slope stability analyses of previously failed areas of the levees were performed. A professional paper presenting the results of the stability analysis was published in the American Society of Civil Engineers Journal of Geotechnical and GeoEnvironmental Engineering in November, 1998.
- Disposal Area Management Plan – Spilmans Island (1996). Based on the prior study, limited information was available on the soil conditions in the site interior. In this study 19 borings were drilled at various locations within the site interior to assess conditions within the fill material deposited in the site. These borings were performed in order to determine the thickness and characteristics of the soils in the site interior. Typically, the Corps of Engineers drills borings only along the perimeter levee, so these borings greatly increased our knowledge of the soil conditions within the interior of the site. In addition, field instrumentation was installed and monitored to assess the rate of settlement and consolidation conditions in the fill soil. This information was evaluated to provide an assessment of the potential future settlement of the fill soil contained within the site interior.
- Design Analysis Report – Levee Design for Spilmans Island Placement Area (1998). HVJ Associates was retained by the U.S. Army Corps of Engineers to provide an analysis of the Spilmans Island site related to the Houston Ship Channel 45-Foot Project. In this analysis we determined the required levee height for the planned dredging during the project, assessed the site's capacity to contain material accumulated during 50 years of planned maintenance dredging, and evaluated levee stability for both cases. In addition, we prepared design plans showing the levee alignment and design cross sections for the 45-Foot Project construction at Spilmans Island. The data provided by the government included logs and test results from 59 borings drilled in 1978 and 29 borings drilled in 1992. This information was reviewed and combined with the 30 borings we drilled, sampled, and tested in 1994 and 1996.

Also, I personally supervised the geotechnical investigation for the Bayport Terminal Phase 1A Backlands design, and through this I am familiar with geotechnical design issues related to container terminal construction on Port of Houston projects. We have also performed other wharf-related projects for the Port, including one at which ground improvement by deep soil mixing is currently being conducted. I have been involved in container terminal geotechnical investigation at other ports where preloading was used to consolidate dredge disposal material for later use as container terminal backland, particularly at the Port of Los Angeles for their 2020 Project.

Spilmans Island Characteristics

The following section summarizes site condition information presented in the three studies described above. The Spilmans Island Disposal Area is bounded on the north and east side by the Houston Ship Channel, on the south side by Barbours Cut, and to the west by Lower San Jacinto Bay. Features at the site prior to significant placement of dredge disposal material were investigated based on USGS topographic maps from the 1921 survey. The maps show an existing island in the northwest corner of the current disposal area, while most of the disposal area was part of San Jacinto Bay. The southern shore of San Jacinto Bay at that time was located at about the southern side of Barbours Cut. As currently laid out, the Alternative Development Location at Spilmans Island is almost completely located over the area that originally was part of San Jacinto Bay.

Levees with slopes of about 3H:1V have been constructed along the perimeter of Spilmans Island. In 1979, levees were raised to El. +20 feet MLT, and in 1989 they were raised to El. +25 feet MLT. In 1993 attempts were made to raise the levees to El. +32 feet MLT, but a slope failure occurred when raising the levee above about EL. +28 feet MLT along the north side of the Barbours Cut Turning basin. Levee foundation stability problems were also noted at other locations along the levee, and levee raising was limited to about El. +28 feet MLT at that time. The levees have since been raised to El. +32 feet MLT as part of the Houston Ship Channel 45-foot project, based on the designs prepared by HVJ Associates for the U.S. Army Corps of Engineers.

The site interior elevation changes constantly due to settlement of the fill material at the site and deposition of addition material within the site. During the design study HVJ performed for the U.S. Army Corps of Engineers in 1998, we reviewed the 1997 survey data. At that time the site elevation ranged from +18 to +24 feet MLT. The lowest part of the site was along the western edge adjacent to East San Jacinto Bay, and the highest part of the site was along the north side of the cell adjacent to the Houston Ship Channel. (Note: Substantial deposition of material has occurred in the site since the 1997 survey, so the current site elevation is higher than the elevation discussed here.)

Soil Conditions

HVJ Associates has reviewed the soil conditions in the location of the Alternate Development Location at the Spilmans Island site. Since the majority of the site is within the interior of Spilmans Island, the 1996 borings previously described were the most relevant for this assessment. Since these borings were obtained about 7 years ago, some material has been deposited within the site as part of normal maintenance and also as part of the Houston Ship Channel 45-Foot Project. This additional deposition would cause the fill thickness to increase somewhat prior to construction. However, HVJ Associates believes that the conditions observed in our previous borings are representative of the material types and strengths that we would encounter. For this study the type and strength of the material are the most important factors.

Of the 19 borings drilled within the site interior during the 1996 study, four are located within the area designated for the new turning basin and 6 are located within the area designated for the

terminal backlands. Soil conditions are reasonably uniform, with about 20 feet of very soft to soft clay over very loose silty sand and sandy silt. The bottom of the very soft to soft clay layer was encountered at elevations ranging from about El. +3 to El. -8 feet MLT in various borings. Conditions in the southeast corner of the site vary somewhat from these general conditions. In two borings within the backlands, the very soft clay extended to a depth of about 40 feet, with only a few thin sandy layers. In two other borings within the backlands there were sand layers above 20 feet depth, interlayered with very soft to soft clay layers.

Impact on Container Terminal Facilities

From a geotechnical perspective the Spilmans Island Alternative Development Location is a very poor choice for construction of any type of facility, including a container terminal because of the presence of a substantial (at least 20 feet) thickness of very soft to soft clay. This clay is primarily disposal material deposited at the site during dredging for the Houston Ship Channel construction and maintenance. The soil was deposited at the site by hydraulically excavating material from within the Houston Ship Channel, mixing it with large volumes of water and pumping it to the site. Once deposited, the soil sediments settle to the bottom. At this point, the dredged material is in a transitional state from liquid to solid. As additional material is deposited, or as the soil is dried by exposure to sunlight, the soil gets stronger, but the majority of it never reaches a strength remotely approaching that of natural soils commonly encountered in the region. The strength of this soil is generally less than 25 percent of those natural soils. To provide perspective, the soil at the site is so weak that in its native condition it is not even strong enough to support vehicle traffic on a gravel road without special reinforcement within the gravel.

Given adequate funds it is possible to construct almost anything almost anywhere. However, any site comprised of natural ground in the region would probably have significantly better soil conditions than the Spilmans Island Alternative Development Location. Therefore, construction costs for facilities at this site -- and particularly for large areas of pavement for terminal backlands, access roads, and rail corridors -- will be much higher than at other nearby sites comprised of natural ground. Loads imposed by the facilities must either be transferred to stronger soils below the very soft to soft clay layer, or the clay must be treated to increase its strength.

Heavily Loaded Structures. Deep foundations are often needed to support heavy structures and equipment, and most wharf structures are supported by deep foundations. In this case the foundation cost is increased because support structure must be installed in greater numbers, to deeper depths, and/or in larger sizes in order to support the loads. Since deep foundations are already required, there is an incremental cost increase to accommodate weak soil conditions. This cost can be estimated by determining cost related to the additional length of foundation shafts that would be required to support the structures due to the weaker soil condition at Spilmans Island. We know that 20 additional feet of foundation shaft length would be needed due to the presence of the very soft material. We estimate that an additional 20 feet of length would be needed to allow for the effect of weaker soils below the very soft clay. Therefore, we estimate that the wharf shafts would need to be 40 feet longer on average than at the Bayport site. For buildings the foundation system should be estimated to be 75-foot long piles or shafts.

Backlands and Access Corridors. In paved areas the cost increase is much more dramatic because at most sites the natural ground is strong enough to bear the load of pavement, vehicles, and stacked containers. At the Spilmans Island site the soil strength will need to be improved to support the loads. There are many methods to improve soil strength, two of the most likely options being deep-soil mixing and preloading. In deep-soil mixing a machine is inserted into the soil, mixing it with a stabilizing agent such as lime or cement. The stabilizing agent reacts with the soil and after a short time the strength of the mixture is much higher than the strength of the weak soil. In preloading a series of drains are inserted and a large weight (surcharge) piled on the soil. Over time the soil consolidates, resulting in a higher strength. Deep soil mixing is more costly but takes less time. Preloading is cheaper but requires both more time and availability of soil to provide the surcharge load. The costs and assumptions for deep soil mixing and preloading improvements are discussed below.

- HVJ Associates estimates that it would cost about \$450,000 per acre to treat the soil by deep soil mixing to 20 feet and to add 18 inches of imported crushed stone with geotextile reinforcement. This would form a subgrade suitable for installation of the paving system for backlands or access roads, or for a base to construct railroad ballast. We estimate that soil improvement by deep soil mixing could be accomplished in about 4 to 6 months.
- HVJ Associates estimates that it would cost about \$225,000 per acre to treat the soil by preloading. This assumes that a surcharge load about 20 feet high would be needed to achieve adequate shear strength in the soil. We estimate that about 32,000 cubic yards of fill per acre would be needed to construct the surcharge, and we assume that fill for the surcharge would be obtained on-site. Therefore, the area that could be treated at one time would be limited by the volume of fill available to use as surcharge. The preloading process would probably take about 18 to 24 months, and we estimate that it would cause about 7 feet of overall site settlement. This settlement would be partially compensated by placement of an imported sand blanket required for drainage of water from the drains and the addition of 18 inches of imported crushed stone with geotextile reinforcement. However, about 4 to 5 feet of net settlement would occur during preloading.

In both methods, but particularly in the preloading method, the soil is improved but future settlement would still be expected. That settlement would be expected to cause many types of distress in rigid pavements like those typically constructed by the Port of Houston. A flexible pavement system like concrete pavers is often appropriate where settlement is likely to occur. However, even with soil conditions better than expected at Spilmans Island, Port of Houston experience with pavers was sufficiently negative that the pavers were removed due to excessive maintenance requirements. The need to use an alternative to rigid pavements with potential for additional future maintenance and possibly other operational restraints is an additional concern.

Turning Basin. The final main issue is the slope stability for the turning basin excavation. At most sites in the region constructed in natural soil, a 3V:1H slope is stable. At this site, the soil is so weak that it must be supported around the entire turning basin perimeter. This would require a retaining wall system, probably comprised of a sheet pile wall with a deadman system supported by deep foundations. Such a retention system would be needed everywhere that soil is excavated within the existing exterior levees of the disposal site.

HVJ Associates, Inc. appreciates the opportunity to provide our insights into the potential geotechnical problems at the Spilmans Island Alternative Development Location. Please contact me if you have any questions or require additional explanation.

Sincerely,

HVJ ASSOCIATES, INC.



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review

Michael Hasen, P.E.
Executive Vice President

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