FOUNDATION DESIGN FINDINGS AND RECOMMENDATIONS REPORT

McMurdo Station Modernization, Antarctica

Submitted to:
United States Antarctic Program
Lockheed Martin - Antarctic Support Contract

Submitted by:

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1.0 INTRODUCTION

Lockheed Martin Antarctic Support Contract (ASC) group engaged Merrick & Company to visit McMurdo Station and prepare a foundation study report for the proposed McMurdo Station Modernization project. The intent of this project was to perform building observations, review existing building foundation drawings, provide input to the geotechnical firm providing the geotechnical report, review the upcoming geotechnical report, and provide foundation recommendations for future building construction. McMurdo Station is located on the southern tip of Ross Island, Antarctica.

This report is limited to the elements listed in the Scope of Work and does not include the design of foundation systems. Only visual observations of the existing structural foundation systems were made. Detailed inspection or testing of any kind has not been performed as part of this assessment.

1.1. Scope of Work

The Scope of Work includes the following work items:

1) Visit McMurdo Station and review the geotechnical information gathering process, review existing conditions, review existing foundation systems, and confirm preliminary building siting.
2) Coordinate with the geotechnical team at McMurdo and provide general input for the geotechnical report.
3) Review Golder and Associates geotechnical report dated February 2015 for McMurdo Station.
4) Use the geotechnical report to determine the appropriate foundation system for each building site.

2.0 FOUNDATION EVALUATION CRITERIA

2.1 Data Collection

For the purpose of conducting the collection of information and observation of existing building foundation systems, data collection was based on following three sources of information:

1) Existing architectural and structural drawings housed at McMurdo Station. These were provided as prints of online PDFs from the original design drawings.

2) Visual observations made during the site visit and walk-throughs of the buildings while on site.

3) Review of the new geotechnical report from Golder and Associates.

3.0 EXISTING CONDITIONS

3.1 General Foundation

The majority of the existing facilities at the site are pre-engineered metal buildings supported by raised floors with either wood foundations or precast concrete foundations. Existing conditions of the observable foundations varied from good condition to poor condition. It appears that the biggest contributors to foundation degradation appears to be environmental exposure, freeze-thaw cycles, and possible chemical attack from salts in the soils.

3.2 Geotechnical

The existing facilities are sited on a series of flat fill areas that give a terraced look to the topography. The new facilities will be sited on new terraced fill, basalt bedrock, or on existing fill areas.

Based on the boring logs, the soil profile in the geotechnical report show a varying degrees of fill, scoria, basalt fragments bonded by ice, and basalt bedrock. Ice is also present in many of the cores, either as visible ice or as ice bonded material.

Based on the limited data available to Golder and Associates from Scott Base and the wind farm area, it is assumed per the soils report that the active layer of the soils at McMurdo Station extends down to 0.8 meters.

3.3 Structural System

It is anticipated that the new facilities for the station redesign will be steel framed pre-engineered metal building, similar to what exists on site now, but on a larger scale. It is also assumed that the flooring systems for these buildings will utilize precast hollow core plank for modularity, ease of construction, and durability. The weight of the precast hollow core plank flooring also provides additional mass to the building and helps resist wind load overturning forces on the building.

4.0 FINDINGS AND RECOMMENDATIONS

4.1 Foundation Recommendations

Based on Golder and Associates geotechnical report recommendations, there were three foundation types proposed; shallow foundations, pile foundations on bedrock, and insulated ground slabs with artificial cooling.

The use of piles could prove to be difficult due to availability of material, unknown lengths of piles when installed by blow count or resistance, availability of equipment, possible damage to other structures and retaining walls, and noise during installation. Also, piles would not be appropriate for many of the structures due to building loading and the depth of the bedrock. In some locations the bedrock is less than a meter below existing grade, and in others the depth is unknown. The heat sink effect related to steel piles is another concern. This transfer of heat to below surface depths could cause melting of in situ ice if appropriate mitigation measures are not taken.

Insulated slab on grade with artificial cooling is also problematic due to the difficulty of casting concrete on site. The difficulty is compounded by availability of proper materials, temperature, waste material and cleanup. Additionally, the maintenance of the thermal syphons could create issues because of the remoteness to the site, limited access to replacement parts, and skilled labor availability for this type of system. Reference Photos 1 and 2 for a slab on grade and thermal syphon example.

Based on the proposed building configurations, Merrick believes that an elevated slab with an airspace under the structure is a more constructible, easier to maintain option. Reference Photo 3. This option provides access to utilities, and provides a thermal air barrier to help prevent heat transfer to the ground below. However, once the siting of the buildings is complete, Merrick may need to re-evaluate this option and determine if a thermal syphon and slab on grade system needs to be used for a portion of the new facilities. This option would be driven by the amount of cut that might be required for Field Science Support / Trades and Fire Medical / Lounge / Recreation. Therefore, based on the proposed building configurations, it is assumed that shallow foundations make the most sense from a loading and constructability standpoint.

Two materials, timber and precast concrete, are available for a shallow foundation system. Reference Figure 1 and Photo 5. Due to the anticipated footing loads, timber footings are likely to be unable to resist the applied loading due to compression and tension forces at the larger buildings. Precast concrete foundations are much more robust and make the most sense not only from a capacity standpoint, but from a weight standpoint. Due to the anticipated size of the buildings, it is expected that the foundation system will be required to resist substantial uplift loads from overturning forces. Precast concrete footings can be sized such that the weight of the concrete foundation can be used to counter overturning uplift forces. Finally, durability of concrete mixture must be addressed in order to ensure proper performance of the system when subject to the freeze/thaw cycle present at McMurdo Station. This can be addressed through proper mixture design that accounts for aggregate selection, air entrainment, cement selection, fiber reinforcement, and any admixtures needed to resist chemical attack from the soils. Additionally, proper drainage away from the footings is required.

Photo 1 –Slab on Grade Supported Structure with Thermal Syphons

Photo 2 – Installation of Thermal Syphon System

Photo 3 – Existing Precast Spread Footings Supporting Structure

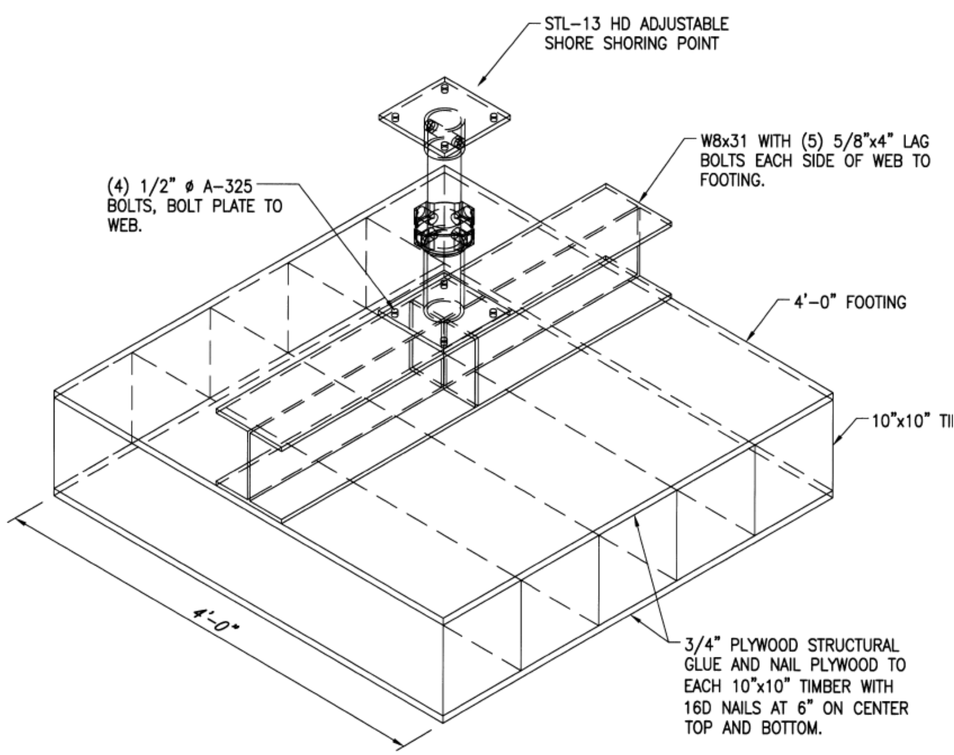

Figure 4 – Timber Footing

Photo 5 – Precast Concrete Footing

5.0 FACILITY SPECIFIC RECOMMENDATIONS

5.1 Waste Handling / Traverse Ops / Helo Ops Facilities

The site selected for the Waste Handling Facility has well bonded fill 3 meters in depth. The Traverse Ops and Helo Ops buildings have basalt bedrock starting around ½ meter to 1 meter. Elevated steel structure with precast floor planks and precast footings bearing directly on bedrock is anticipated for these structures.

5.2 Lodging

Part of this area appears to have once been a landfill area; however, per the soils report, it appears the existing fill is well bonded and extends to at least 3 meters on the east side of the site. On the west side of the building site, the fill extends to 0.8 meters with well bonded scoria and basalt to 3 meters. An elevated steel structure supporting precast floor planks with precast footings is anticipated for this structure.

5.3 Fire Medical / Lounge / Recreation

Site topography in the area supporting this building varies. At the Fire / Medical portion of the building, the fill is well bonded and overlays basalt at 2.8 meters. Towards the center of the building, the fill becomes more varied with poorly bonded material to 0.9 meters, well bonded material from 0.9 to 2.8 meters, and basalt thereafter. The area supporting the Recreation / Lounge section is underlain with ice starting at 0.6 meters to 1.8 meters.

Per the geotechnical report, this ice will need to be removed and new fill compacted in its place. An elevated steel structure supporting precast floor planks with precast footings appears to be most appropriate structural and foundation system.

5.4 Central Services

The topography under this building portion varies here as well. From north to south the building site slopes down. The fill towards the north varies from well bonded material to poorly bonded material. However, the well bonded material appears present in all locations beyond a depth of 0.5 meters. Towards the front of the building and the south west corner, basalt bedrock lies just below grade at around 0.3 meters. As you move to the front of the building towards the south east corner of the building, there is predominantly well bonded fill to 3 meters with no bedrock in the first 3 meters.

An elevated steel structure supporting precast floor plank with precast footings will be used for this building. However, it is anticipated that installation in the bedrock areas will be more difficult. Blasting of bedrock may be required for installation of some of the foundations.

5.5 Field Science Support / Trades

The topography under this portion of the building varies; similar to the area under the Fire Medical building. The site slopes from the back of the building (north end) towards the water (south end). Borings from the north end of building indicate significant ice mixed with fill material and numerous ice lenses to a depth of 5 meters. Bedrock is encountered at a depth of 5 meters. Towards the center of the building, the fill transitions to poorly bonded material to a depth of 1.3 meters. Between 1.3 meters and 1.5 meters, a thin layer of landfill material is present, then beyond 1.5 meters, a layer of ice extends to 3 meters. Well bonded gravel material is present to depths greater than 3 meters. Towards the front of the building and the southwest corner, the fill is well bonded but mixed with ice. No bedrock was encountered at this corner of the facility. At the southeast corner, there is predominantly well bonded fill to a depth of 1.3 meters, and bedrock thereafter.

In three of the four borings located under the facility, hydrocarbon odors were detected per the soils report. According to the report, these odors were detected in the shallow subsurface fill material. To locate the building at the proper elevation, a large volume of fill under this facility may need to be removed, and the contaminated soil with it. If contaminated soil remediation is required, these requirements will need to be per ASC direction. An additional 1.5 meters of ice below the contaminated soil will also need to be removed and new onsite fill compacted in its place.

An elevated steel structure with precast floor plank supported by precast footings is recommended for use at this building. However, depending on the site and ground floor elevation requirements, a slab on grade with thermal syphons may be required for a portion of the facility. The slab on grade could be constructed with solid precast floor plank placed on top of a thermal syphon grid and compacted fill.

5.6 Dive Locker

According to the soils report, the area under this proposed building is comprised of fill and ice bonded scoria with no bedrock encountered to a depth of three meters. Due to the small footprint of the building, an elevated structure with precast footings or possibly timber footings are recommended.

5.7 Data Center

The area located below the proposed data center building addition is comprised of poorly bonded fill material to 0.6 meters, with well bonded material to 1.9 meters, and basalt from 1.9 to 2.6 meters. Since this is an addition to an existing structure, it will be important to match the existing foundation type and not impede the air flow under the existing building. The existing foundation utilizes precast footings, so an elevated structure with precast footings will be used for the addition as well.

5.8 Hazardous Waste

At the proposed Hazardous Waste facility, thick ice was encountered for the full depth of the boring to 3.6 meters. The soils report suggested this area was a snow dump at one time and based on the boring, this appears to be the case. Removal of the ice and replacement with fill material is required if the Hazardous Waste facility must be sited at this location. Conversely, the soils report and Merrick recommend relocating the building to a more suitable location. If the building is not re-sited and if the ice not removed, significant differential settlement could happen over time and cause significant structural distress. Due to the small footprint of the building, an elevated structure with either precast footings or possibly timber footings is recommended.

6.0 CONCLUSION

Based on observed degradation of existing foundations, durability of any concrete mixture must be addressed during the design process. This can be achieved through the proper concrete mix design and the aggregate selection for the precast foundations. Addition of slag, fly ash, proper cement, cement additives, or fibers may also be required for enhanced durability and longevity.

The data collected through site observations of existing facilities, performance of the existing foundation systems, and review of the geotechnical report point to elevated structures with precast foundations as the most cost effective, efficient, and expedient option for the majority of the proposed facilities. This system has a documented record of success in other harsh environments when the proper precautions are taken in the design of the concrete mix.