

At the base of it all

The Navy's new Freedom Souq and its foundation

On the outside it is an architectural marvel. The inside is designed down to the smallest detail. It is two stories tall, encompasses 188,488 square feet, and is more than two football fields long from end-to-end.

Below this structure is the unglamorous and rarely touted – the soil and foundation that keep this mammoth building afloat.

Freedom Souq, as it is known on the Naval Support Activity Bahrain, is not alone. Any facility built here, or anywhere, has to first lay the foundation on which to build, which is oftentimes long forgotten after a building has been constructed. But, it is a critical step nonetheless.

The foundation is taken for granted, unless of course a problem occurs, said Dr. John Piggott, a geotechnical/civil engineer with the Engineering and Construction Technical Directorate.

For Piggott and others who design foundations, being forgotten is like a success story. Usually, he said, the only time foundations get talked about is when something has gone wrong with the structure that can be traced back to a flaw in the foundation design.

Before the foundation is placed, many things are considered. For example, the height and weight of the building has to be considered, as does the equipment and people that would eventually occupy the space, said Piggott.

It was also important to know what is underneath because the land under Freedom Souq was not land; rather it was part of the gulf. Dredge material was taken from the seabed, enlarging the island and allowing much needed space for the Navy.

Fortunately, because other facilities have been built on this naval compound in Bahrain, much about the soil composition is already known. During these investigative missions, holes are drilled with an auger, which pulls up a sampling of the soil underneath, Piggott said.

The material pulled from the holes is tested in order to classify it, said Piggott. Moisture content and other geological properties of the material helps the engineers decide on the strength properties of the earth below.

Test pits are used to get bulk samples of material to test.

"It is an inexpensive and easy way to get a look at what's under ground," he said.

Once what is underneath is known, the geotechnical engineers pursue the foundation options and offer their recommendations to structural engineers.

The weight, height and other forces exerted from the perceived building to the ground it will sit upon helps the engineers decide on a recommendation; either footers or piles for the foundation. Footers are a part of a foundation where the bearing is directly on the earth, while piles are long, slender columns that are driven into the ground to carry a vertical load.

Subsurface explorations for Freedom Souq indicated that groundwater was about three-feet below the ground surface. Because of the high water table, weak bearing soils, and the need to limit differential settlement, it was recommended that the facility be supported by a deep foundation system. These piles would be 600-millimeter (almost two-feet) wide cast-in-place concrete while the decision to use 800-millimeter (more than two-and-a-half-feet) wide piles in some places were also used, said Piggott.

Once the foundation system is designed, the structural engineers offer their expertise – in this case, to place the piles to bear the load (mass or weight) of the building.

And there are many different types of different loads that bear on the structure that must be accounted for, said Kent Owen, a structural engineer with the Engineering and Construction Technical Directorate.

The dead load is the building and all of its components and the live load accounts for the people who use the facility. Other forces that are accounted for in the structures load bearing capacity are wind and seismic conditions, he said.

Force protection requirements also mandates that structures of facilities must be designed to handle what is called a blast load, which is incorporated into designs due to the threat of terrorism.

"One of the aspects of designing the building to meet force protection considerations was to keep exterior openings ... to a minimum," said Crawford Horne, the senior architect involved with Freedom Souq.

Omaha District is the Corps of Engineers' center of expertise and recommended the blast load, said Owen. "Then we incorporate that load into our design."

Recommendations differ for each facility depending on the function, capacity or location within the base.

Freedom Souq was built with a greater blast load than many other facilities, Owen said. "A lot of times we have to increase wall thickness or even the wall material," he said. This can simply mean exchanging cinder block construction for reinforced concrete slabs and increasing the column size, slab thickness and weight of each section.

This not only adds the proper level of protection to the building, but weight as well. Therefore, the foundation is designed to hold any additional weight.

And to make sure the foundation will hold, the geotechnical engineers test the foundation to see how much weight each pile can bear.

"In this case, each pile can take 150,000 pounds," said Owen.

Once this was calculated, Owen worked with Horne to lay out the floor plan for column placement.

The approach of the structural engineer may seem backward to some, and it is. Instead of thinking from the bottom up, it is their job to think from the top down, said Owen.

"I start at the roof slabs and design down because the structural engineer needs to know all the weights bearing down on the foundation," he said. "I can't get at the foundation if I don't know how everything else works on top of it."

Because of the limited amount of available land, all the mechanical units were put onto the roof. The bearing capacity of the roof slabs and the other interconnected elements had to withstand the weight because each unit weighs roughly 35,000 pounds.

Work on Bahrain has become slightly easier for these engineers as more buildings are constructed and the terrain becomes familiar.

Because of the size, it took about a year to complete the design of the structure, said Horne.

The building has a cast-in-place concrete structural frame with a cast-in-place exterior walls and roof slabs, he said.

The two-story building, likened to a typical American shopping mall, includes a gymnasium, fitness center, racquetball courts, two movie theaters, retail shopping outlets, a multi-purpose assembly hall with stage, Internet café, food court, credit union, travel agency, post office, coin-operated laundry, Navy exchange, commissary, and administrative offices, Horne said.