Robert Wood Johnson University Hospital

Proton Therapy Vault | New Brunswick, NJ

By Michael Herrmann, P.E.

O'Donnell & Naccarato, Inc. was an Outstanding Award winner for the Robert Wood Johnson University Hospital project in the 2012 NCSEA Annual Excellence in Structural Engineering awards program (Category – New Buildings under $10 Million).

Proton Therapy utilizes complex machines that deliver positively charged atomic particles focused precisely on small cancerous growths, without harming the surrounding healthy tissue. Embracing this promising technology, Robert Wood Johnson University Hospital has built a 4,900 square foot Proton Therapy building that houses two Proton Therapy treatment machines.

The three story, below grade concrete structure is located directly adjacent to an existing one-story medical office building, beneath its parking lot. Due to the proximity to the existing building, neighboring properties and a busy thoroughfare, the design and construction teams developed a strategy to accommodate a 40-foot deep excavation with no layback area. The team selected the soil nailing process as a means to effectively retain the earth while working from inside the building footprint. In an effort to provide an efficient exterior "basement wall" design, the team collaborated with the geotechnical engineer to integrate the soil nails into the final design, allowing for the exterior walls to be constructed as a two-way flat plate spanning between the soil nail anchor plates. The result is a cost effective exterior wall system that permits the 40-foot tall, unbraced concrete walls to be only 20 inches thick.

The team's foundation design accounted for a water table located 8 feet below existing grade, resulting in 32 feet of hydrostatic uplift pressure at the base of the building. A series of rock anchors were strategically placed throughout the base of the building to overcome this massive uplift, and the team designed a 26-inch thick, two-way concrete hold down mat to span between the rock anchors.

The connection of the medical equipment to the concrete structure required large steel gantry embedments set into the concrete shielding walls. The steel boxes were fabricated out of 2-inch thick plates and measured approximately 11 x 5 x 4 feet. The equipment layout demanded that these embedment frames be suspended within the concrete formwork approximately 12 feet off of the base slab, and set to a ¼-inch tolerance. To meet these parameters, the team designed a series of complex, braced steel frame supports that utilized leveling nuts in all four corners of the embedment frames to permit the precision setting.

The design team, in conjunction with the concrete subcontractor, carefully selected a concrete mix that balanced the use of fly ash required to reduce the heat of hydration with the need for accelerated set time to prevent form blow-out due to the 40 feet of concrete head. This allowed the monolithically placed 6-foot thick by 40-foot tall shielding walls to proceed in a timely and safe manner.

The team developed a creative construction sequence that would not require shoring and formwork to construct the 8-foot thick concrete lid over the 40-foot tall open vault. A series of steel beams set across the top of the vault support metal deck spanning between their bottom flanges. The lid was cast in three separate pours: the metal deck supported the first pour; the first pour supported the second; and the second pour supported the third. In total, the lid effectively shields the medical equipment while providing support for four feet of backfill and the asphalt parking lot, along with the live loads associated with pedestrians and emergency vehicles.

A vertical shaft/areaway constructed adjacent to each vault permitted installation of the equipment after construction of the building. The team designed a concrete knock-out panel in the side wall of each vault that resists the hydrostatic and soil pressure once the shafts are backfilled, but is still easily removed for installation or replacement of the equipment. The bottom flanges of the lid support beams also doubled as supports for a complex series of rigging and crane beams to allow for the installation of the 60-ton machinery. In addition to allowing for a less expensive and faster construction of the concrete lid, this method also eliminated the need for costly secondary rigging.

The patient treatment areas presented design challenges set by the requirements of the specialized treatments and the operation of the equipment. The design team incorporated a notched cantilevered concrete slab into the floor design. This notch allows the equipment to penetrate the floor slab and easily rotate 180° from directly below to directly above the patient, providing full range treatments. A hung catwalk system permits equipment maintenance within the treatment room without interfering with the motion of the rotating equipment and its counterweight assembly.

Preparations for the 40-foot tall concrete vault pour.

Adding to the complexity of the building design, many of the characteristics of the structure were governed by the requirements of the medical equipment, which was still in the final stages of being invented. Building Information Modeling (BIM) was a tremendous asset to the team, as some of these modifications were transmitted just prior to the pouring of concrete. Quick and thorough coordination by the design team was necessary to maintain the construction schedule.

Ultimately, the team delivered a successful project by combining out of the box thinking, a collaborative approach, and diligent coordination throughout the project. This was facilitated by a decisive and knowledgeable owner that had the foresight and understanding to involve the appropriate contractors in the design phase, and to encourage open communication with all involved parties.▪

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