

# Tower Power

By Correspondent Tonia Jurbin

**B**C Hydro's tallest transmission towers recently underwent a major seismic upgrade as a safety measure to help ensure the structures will survive the major earthquake some are predicting will eventually hit Canada's west coast.

The two, 120 m suspension tow-

ers, together with two, 30 m anchor towers, make up one of several Fraser River crossings spanning from Delta to the west tip of Annacis Island to Richmond... a crossing that is critical to the BC Hydro grid. So critical, in fact, that experts say that should it ever be destroyed, it would take months to rebuild because the towers consist of thousands of pieces that have to be fabricated and assembled.

That aside, one of the first steps in the recent seismic upgrading called for each tower to have four, 0.4 m closed-ended, concrete-filled steel pipe piles driven by Vancouver Pile Driving to a depth



Photos (counter clockwise) show tower site before, during, and nearing the end of tower "donut" construction.







of 30 m at each leg. The concern being that the existing timber piles would deform, move or fail during an earthquake as the loose and saturated sands liquefy.

In addition to the pile driving portion of the work, the Annacis Island site, which had been eroding at a rate of about 3-5 m/year, was reclaimed and erosion protection and ground improvement densification berms were installed. Extensive ground improvement also strengthened the soil around the tower and has improved the sites resistance to liquefaction using a vibro-replacement method both in the river using the bottom feed method, and on the land using a combination of top and bottom feed.

For the water-based portion of the work, 302 stone columns were installed to about -18 metres elevation in water ranging from about 4 to 6 m deep. The biggest concern during this stage of the construction was obtaining clean stone. Even a small amount of fines will cause the bottom feed vibro equipment to plug continually. At least one scow load of stone was rejected.

A total of 256, 16 m columns were installed on land, resulting in a densification berm that surrounds the 25



**A view from the top shows the amount of water at the site.**

m-square tower base. About 4700 m<sup>3</sup> of stone were used to build the 7450 linear m of stone columns.

The contract dictated a performance specification and, as such, the final layout and spacing of the gravel columns was determined by the ground improvement sub-contractor, Hayward Baker of Seattle. Based on their equipment, method and experience, they installed the columns at 3 m centres on a square grid. A square grid is easier to lay-out than a triangular grid and it also leaves the option to come back over the grid and install additional columns if the densification specification is not met.

During the vibro-replacement work, the engineering design and installation procedure was continually adjusted to optimize the product for the conditions that were encountered.

After the water-based ground improvement work south of the tower was completed, the area was







Heavy equipment was barged to the site to help move large volumes of riprap being used to protect the towers.

was trying to cycle and co-ordinate the scows and securing enough riprap" says Sue Laforest, the project manager for Vancouver Pile Driving. "We had to use two suppliers because we had only secured

covered with a substantial riprap protection berm. Once the permanent berm was complete around the south side of the site, a temporary berm was built around the north side of the site to create a riprap 'donut'... the inside of which was built up with temporary and permanent fill to create a workpad.

The berm was lined with a filter fabric to contain fines that would have otherwise been released into the Fraser River during the reclamation of the southern tip of the island, stone column installation, pile driving and other related construction activities.

BC Hydro routinely protects tower sites that are subject to erosion with shoreline protection berms or riprap donuts. Typically, scour depth and water velocity is established and riprap volumes and stone sizes are determined based on those parameters. The initial volume for the permanent berm was about 7000 m<sup>3</sup>, and about 1500 m<sup>3</sup> for the temporary berm.

The biggest challenge facing the contractor and the design engineers

during the construction of the berm was that the estimated volume of riprap almost tripled as a result of the original mudline being lowered by 4 to 6 m in elevation during the ground improvement process in addition to the meter or so lost to natural processes during contract preparation and tendering. The berm height was also increased by one meter because of the large wakes caused by the river traffic during the high tide which could have repeatedly flooded the site.

The volume for that change alone was in the order of 650 m<sup>3</sup>.

Because the environmental approval process for this project was extremely arduous, both the size and volume of rock called for by the designers was considerably larger that may have been used for a more accessible shoreline.

The median stone size (the D50) for this berm was 0.7 m (50% of the rock by weight is larger than 0.7 m). As the volumes increased, finding the material and getting it to the site became a problem.

"I guess the biggest challenge

enough of the large rock for the original design. This size of riprap is not an off-the-shelf product. When the volumes required more than doubled, we had to scramble to find more rock and our suppliers had to scramble to find scows to move it. During that phase of construction, the crews were only working a three-day week... we just couldn't bring the rock in fast enough."

About 12 000 m<sup>3</sup> of riprap were placed over about 4000 m<sup>3</sup> of 8 in. minus mattress material. The mattress material was used to restore the original mudline elevations so that the toe of the riprap slopes would not extend and interfere with future pile driving. About 2500 m<sup>3</sup> of permanent fill was used to reclaim Purfleet Point, and about 3700 m<sup>3</sup> of temporary fill was used to build a work pad above the high tide elevation.

In-water stone columns and most of the riprap berm was done off of Vancouver Pile Driving's Derrick No. 6, the largest floating derrick in western Canada. For this job, it was equipped with a 200 ton crane, a 37 m boom and two, 6 m clamshells. ♦

