the Gift of the Fraser

The intent of this Technical Note is to suggest an alternative approach to the well established method of surcharge preloading, whereby the foundation preparation for structures built in the Fraser River delta area, currently seems to be the only approach considered.

It is also quite possible that the methodology to be outlined below would prove appropriate to many similar deltaic areas throughout the world.

Geomorphology

Figure 1 is intended to show the typical foundation strata in the Delta area of Vancouver where the Fraser River flows into the Pacific. In essence it consists of a deep sand stratum overlain by a silty over-bank deposit, the latter being agriculturally fertile. Both these soils are remnants of the large blocks of rock which start their existence by being undermined from the steep creek walls at the headwaters of the tributary streams. These rocks are gradually broken down by impact with the creek bed and other boulders until by the time they reach the sea they have been ground down to sand and silt size particles. The sand sizes are easily carried along by the meandering stream until water velocities abruptly drop as the stream runs into the broad seafront; there the sands fall out of suspension while the silts continue out to sea.

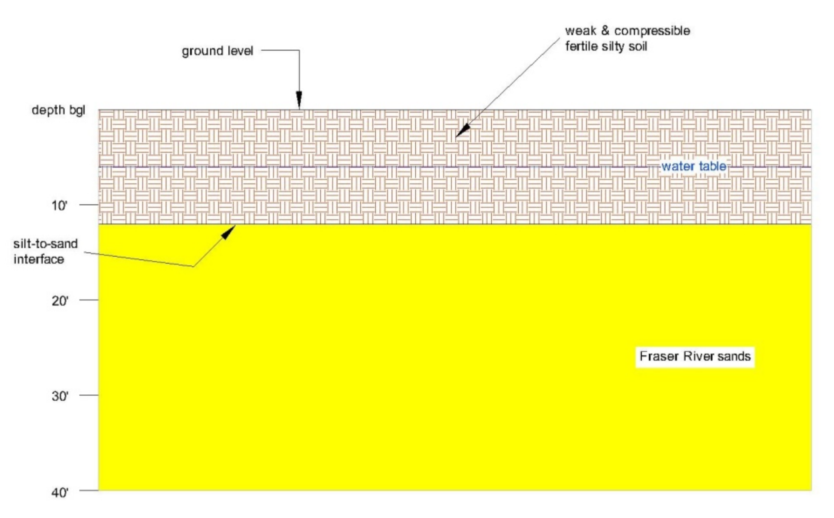

Figure 1 : Idealized Deltaic Stratigraphy

It is only during the annual freshet that the silt sizes may run into the tranquil velocities necessary to permit their sedimentation within the delta lands. At such times the river may be carrying enough water volume to overtop its banks so that the overflow enters the open floodplain spaces, thereby offering a much wider flow channel, and consequently much lower velocities. It is under such hydraulic conditions that the silt sizes can sediment out – on top of the sands – giving us this particular problematical geology depicted in Figure 1.

The water table is found within the silty layer.

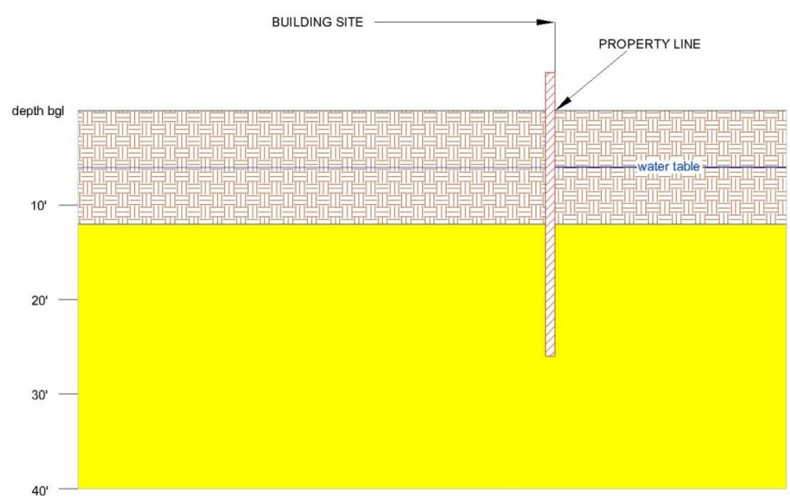

Figure 2 : Construct sheet pile cells

Process

Figure 2 shows the first step in this proposed alternative way of providing competent foundation for commercial buildings and engineering structures in deltaic stratigraphy. It portrays a longitudinal section perpendicular to the property line. The depth scale drawn down the left hand side of the figures is not intended to be any more than a way of suggesting the approximate size of the project: the vertical and horizontal scales are equal.

The general idea is to cordon off the building area within a temporary continuous sheet pile wall so that earthwork can be carried out under controlled conditions. For larger sites it may prove more convenient to subdivide the building zone into separate contiguous cells.

The sheet pile sections are driven into the ground along the property lines to depths appropriate for safe/standard cantilevered design. Since this wall is intended as a temporary cordoning-off of the silty stratum it can be constructed using lightweight steel section. To save drawing space, the inside line of piling is not shown on these sketches.

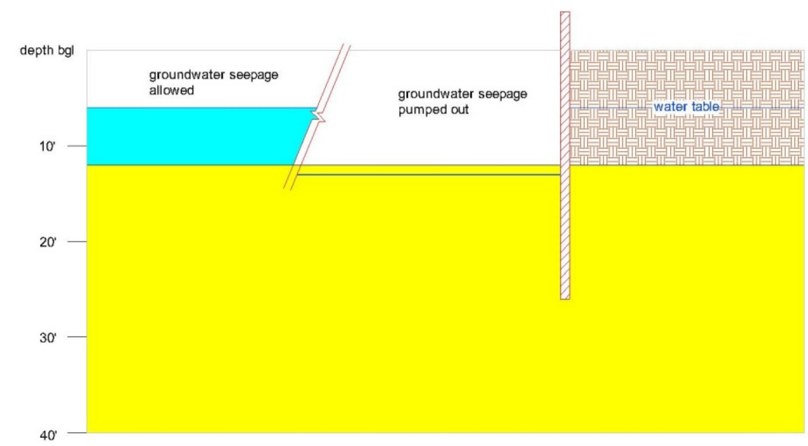

Figure 3 : Excavate weak Silts from inside Cell

Figure 3 shows the next stage of the work: The excavation/removal of the weak and compressible fertile silty soil from within the confines of the particular cell. Here there are two options open to the contractor: Either the groundwater seepage may be allowed to flow into the hole, or it may be pumped out in order to work in the dry. This would be the contractor's choice since whichever route is taken would not affect the end product.

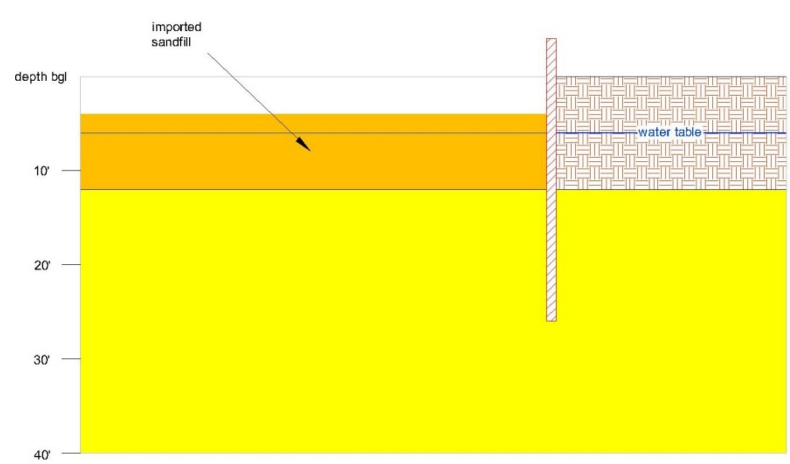

Figure 4 : Backfill with Sand to above water table

The pros and cons of these options will become more obvious after it is seen in Figure 4 that the next stage in the process is to fill the excavated space, up to a foot or two above the water table level, with imported sand. This sandfill can be satisfactorily placed through standing water, if the cell is not pumped dry, therefore that is not a determining issue.

Here it would be well to address two matters which do not arise in the pre-load sandfill alternative :

a. The fertile soil which is simply buried and lost in the pre-load method, is recovered in this approach, and could be transported to nearby parts of the Delta where there is a dearth of agricultural/silt, places where at certain times of the year areas of farmland can be seen flooded. This would be undoubtedly an environment benefit, but for the contractor it entails the risk of muddying the highways en route, that is if the dredged silt is saturated or sloppy, thus implying that excavation in-the-dry would be better.

b. Nearby this same low-lying agricultural land there is an overabundance of sand – thus giving rise to the possibility of creating a balancing of the materials hauling situation. In the case of pre-loading it is an unfortunate matter of deadheading one way during both the mound construction stage, and then again subsequently during the removal of the mound after the silts have finally consolidated. Whereas, in this new mode of ground improvement, it is conceivable to avoid deadheading almost entirely. The contractor, shortly after the startup stage, might arrange his trucks to haul excavated silts away from the site to the farmland on the outbound trip, then load sandfill nearby for delivery to the site on the return leg.

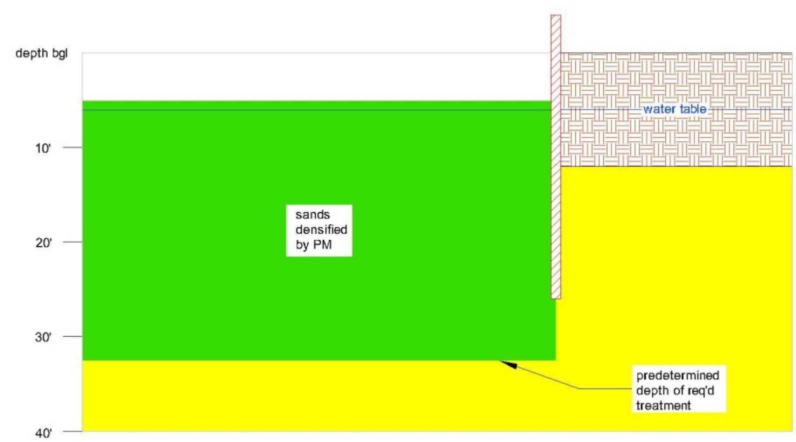

Figure 5 : Actify the Phoenix Machine inside Cell

Figure 5 identifies that portion of the sandfill, together with that depth of the underlying natural Fraser River sands needing to be made into a competent foundation support. This dimension would have been previously assessed by the client's engineer during the design stage – probably by CPT probing.

Finding/having the means of accomplishing the feat of improving the engineering behaviour of saturated ground at a considerable depth below surface working level, is of course, the crucial element in making this proposition of practical interest. Fortunately this task can be accomplished by deploying the proprietary ground improvement equipment developed by Phoenix Engineering Ltd [**PEL**] who refers to this machinery as the Phoenix™ Machine [**PM**]. As has been established in the field, the PM can routinely achieve relative densities greater than 90% in saturated sands - and to depths of at least 15m (50 feet). Since this type of work is well within the competency of experienced civil/marine contractors, PEL has decided to change its former policy of only permitting the use of this hydrodynamic vibrator to pre-approved GI companies; henceforth, such PM units will be made available for sale to contractors wishing to acquire this tool for themselves.

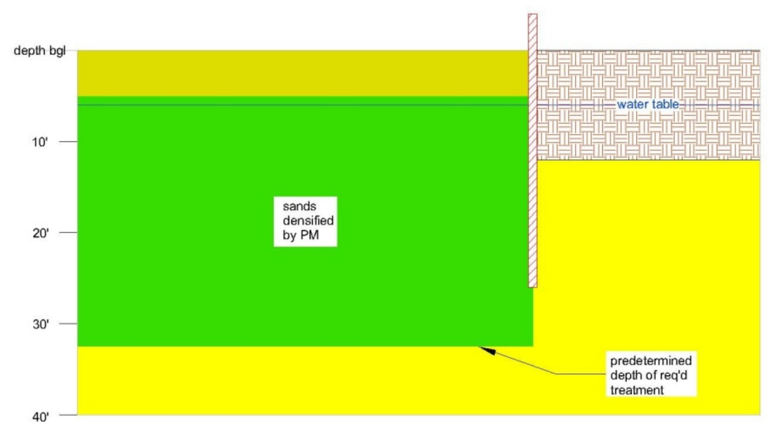

Figure 6 : Bring to grade with compacted granular

Figure 6 shows the second last activity. This is simply a matter of placing and compacting the granular fill material layers suitable for foundation bearing: this work is done in the dry.

Figure 7 shows the finished profile after the temporary sheet piling has been extracted, and at which time the site is immediately ready for building to start. Here is perhaps the crucial difference between these two approaches to going about foundation preparation in deltaic stratigraphy: In contrast to the surcharge pre-load method, there is no need in the new method advocated here for standby while the weak soils consolidation - a period which unfortunately leaves the waterfront property idle for a year or more.

This figure also shows a comparison between the setback behind the property line required for the method advocated here and the current standard approach. To allow for surficial disturbance likely to occur during sheet pile withdrawal a margin of about 1.5m (5 feet) is suggested; whereas for the other, current procedure, a more substantial area needs to be left vacant simply because the side slope geometry of the surcharge sand pile has a long reach.

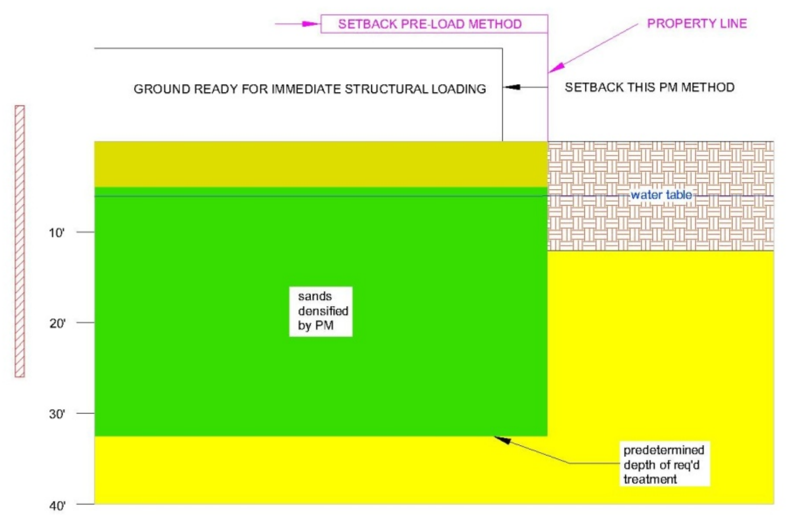

Figure 7 : Recover sheet piling - Start building

Heavy structures

The level of densification which the PM is capable of imparting to saturated sands is very high. The separate grains are jostled so close together that there is virtually no remaining space for them to occupy – essentially, the aggregation has reached the condition where any ground movements are kinematically inadmissible. From the geotechnical point of view, the sand's resistance to deformation becomes at this stage comparable to that of sedimentary bedrock.

Such favorable engineering characteristics becoming readily available simply from the hydrodynamic vibration treatment of mere river-borne sand particles seems at first quite an unrealistic ambition. But as we know hereabouts, individual sand grains which have made their way intact from headwater to Pacific are anything but weak. And here it might well be recalled, that it has been standard practice in preparing the surface ground for heavy point-loading tests, to sprinkle a thin layer of sand on the ground where the thick steel plate will be placed so as to provide a level surface, and thereby prevent excessive stressing of the steel.

The foregoing suggests that the cost of construction the foundations of any heavy structure, such as the proposed second crossing of the Deas Island causeway, might find a cost benefit by applying this technology in its designs.

Text and illustrations by

William E Hodge

Phoenix Engineering Ltd

https://www.phoenix-hodge.com/index.php

wehodge@shaw.ca

July 9th 2020