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Steilacoom Gravel

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Introduction

The Steilacoom gravel, found along and near the shore of Puget Sound southwest of Tacoma, Washington, is of glaciofluvial origin. It is outstanding for its high quality, large volume of present and past production, and for the large amount of reserves available for future production. Operations in this area furnished 47 percent of all the gravel and sand produced in the State of Washington during the year 1946. The excellent qualities of the product for concrete work have long been recognized, and its performance record is used by the Washington State Highway Department in its specifications as the standard by which all other gravels are measured. The gravel is well suited to a variety of uses, the largest volume being used in concrete as a structural aggregate. The term Steilacoom gravel should be understood to mean Steilacoom gravel and sand, since the material as it occurs in the area actually is a well-graded mixture of stream-worn boulders, cobbles, pebbles, and sand, so uniformly distributed that sized products can be produced only by screening. The Steilacoom gravel is made up of a heterogeneous mixture of igneous and metamorphic rocks transported by ice of the latest continental glacial advance in Pleistocene time. It was deposited as glacial outwash, and appears to have been reworked by a large amount of melt water, which washed it clean of silt and clay.

Area covered by Steilacoom gravel

The Steilacoom gravel was named by Bailey Willis in 1898, [1] in his report, Drift phenomena of Puget Sound,[1] and the type locality, designated by him the Steilacoom Plains, was stated to extend for many miles southward and southwestward from Tacoma. He mapped [2] a large area there, and also an area of about 30 square miles situated about 15 miles northeast of Tacoma. Later, Bretz, [3] in his report, Glaciation of the Puget Sound region,[3] described in considerable detail the glacial outwash gravels of the Steilacoom Plains, and associated deltaic gravels in what he termed the Steilacoom and Sequalichew Deltas, which are at the western edge of the plains on the present shore of Puget Sound. Only the gravel and sand of the area covered by the Steilacoom Plains and Steilacoom and Sequalichew Deltas will be considered in this paper.

The Steilacoom Plains occupy an area of about 60 square miles and are bounded on the northeast by a 75-foot terrace which extends about 9 miles southeastward from the head of Flett Creek, at the south edge of the city of Tacoma, to the head of Clover Creek, 4 miles east of Spanaway Lake. The southern boundary extends from the head of Clover Creek due westward to Puget Sound, a distance of 15 miles. The plains are abruptly terminated on the west by gravel bluffs which drop approximately 200 feet to the shore of Puget Sound. The northern boundary is marked by the slightly higher dissected terrain on which Tacoma was built.

The Steilacoom Delta lies at the northwestern corner of the plains, and the Sequalichew Delta at the southwestern corner.

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The town of Steilacoom, for which the gravel was named, is about midway between the two deltas. The deltas are not recognizable as present-day physiographic features, but gravel-pit excavations have exposed well-developed topset

and foreset beds typical of deltaic deposits. The top surfaces of the deltas are continuous with the Steilacoom Plain which broadens out from them and rises gradually to the east with a grade of 10 to 15 feet to the mile. Sea cliffs show the Sequalichew Delta to be about 2 miles wide, and Sequalichew Valley, which is deeply incised into the delta, shows the deltaic gravels to thin towards the east to a thickness of about 50 feet one mile back from the coast. The Steilacoom Delta is also exposed in sea cliffs for a width of 2 miles, and is exposed inland for an equal distance in the incised valley of Chambers Creek. The delta gravels on the coast show for the full height of the bluffs, and a water well drilled at the ~~Pioneer Company's~~ Pioneer Sand & Gravel Company's plant showed that apparently the same sand and gravel continues to a depth of 202 feet, where a stratum of blue clay 201 feet thick was encountered.

no 9 In the Pioneer pit and that of the adjacent Glacier Sand & Gravel Company in the same delta, individual foreset beds rise towards the east at 20-degree slope without interruption from the pit floor, which is 11 feet above sea level, to flat-lying topset beds 10 to 15 feet thick.

The depth of the gravel underlying the Steilacoom Plains is imperfectly known, but a water well at the town of Dupont, near the southwestern corner of the plain, penetrated 40 feet of clean gravel and sand. Commercial gravel pits near the center of the plain have extracted gravel to a depth of about 30 feet, and the pits are all bottomed in good sand and gravel. Due to the occurrence of numerous springs, most of the operations in the plain area have considerable water in their pits.

Geologic history

The Steilacoom gravel was deposited during Pleistocene time, as outwash

from the continental ice of the Vashon glacial age. This, the latest of two glacial ages, was named and described by Willis in his discussion of the Pleistocene glacial drift phenomena of the Puget Sound region. 1/ According to Bretz, 3/ the Vashon corresponds to the Wisconsin glacial age of the middle western and eastern United States. In the Puget Sound region the Vashon deposits are underlain by stratified sand, gravel, clay and lignitic material which Willis considered to have been deposited during the Puyallup interglacial age. The Admiralty, or older glacial age, according to Willis is represented largely by blue laminated clay. Since in the gravel pits of the Steilacoom Plain and the Steilacoom and Sequalichew Deltas there have been encountered only what is considered to be Steilacoom gravel of Vashon age, only the history of Vashon time as it applies to this area will be considered here, and it is essentially that presented by Bretz 3/ in his report on glaciation of the Puget Sound region.

The Vashon ice at its maximum extended at least as far south as that of the Admiralty ~~epoch~~ age, as evidenced by terminal moraines as far as 25 miles south of Tacoma. Vashon terminal moraines are rather small, but the amount of outwash gravel and sand is astonishingly large, the Steilacoom gravel being only a small part of the whole. As the ice sheet slowly retreated northward across the site of the present Steilacoom Plains, glaciofluvial gravels and sands were deposited to a sufficient thickness to completely mask the pre-existing topography. By the time the glacier front had retreated to the site of Tacoma it exposed topographic depressions, in which were formed narrow marginal lakes which received the glacial debris and melt water from the glacier. Two outlets from these lakes exist as present-day channels, Clover Creek channel at the eastern end of the Steilacoom Plain, and the South Tacoma channel now occupied in its southern part by Flett Creek. Water flowing southward and westward through these channels

discharged onto the Steilacoom Plains and rewashed and reworked the outwash already there, and carried part of the sand and gravel along to be deposited in the Steilacoom and Sequalichew Deltas. These deltas were built into a Pleistocene glacial lake, named by Bretz Lake Russell, which occupied at that time the southern end of the present site of Puget Sound. The position of the topset beds indicates the surface of the lake was about 200 feet above present sea level, and, if the log of the Pioneer water well is correctly interpreted, the bottom of the lake was at least 200 feet below present sea level.

After the base levelling effect of Lake Russell was removed the present-day streams, Chambers and Sequalichew Creeks, eroded their narrow valleys through the Pleistocene delta gravels. Chambers Creek Valley is drowned for a mile back from its mouth, indicating that the new base level to which the valley was eroded was lower than that of today. In other words, sea level is relatively higher now than at the time the lower valley was eroded.

Gravel characteristics

The characteristics of the Steilacoom gravels responsible for its over-all superiority are: great strength, freedom from stain or coatings, low abrasion loss, low moisture absorption, rough texture, and freedom from deleterious foreign matter.

no 11 Other reasons for this deposit being used as a standard are: that there are large, practically unlimited reserves, it is advantageously located as to markets, and it is directly adjacent not only to railroad but also to cheap water transportation on Puget Sound.

The pit-run gravel in the plain is somewhat coarser than that in the deltas, and a few boulders as large as 4 or 5 feet in diameter are encountered.

Sand is mixed with the gravel, the ratio of sand to gravel being larger in the deltas than in the plain. In the Steilacoom Delta the two large pits of the Pioneer Sand & Gravel Co. and the Glacier Sand & Gravel Co. show remarkably clean, well-graded gravel and sand, with very few cobbles larger than six inches in diameter. With practically no exception, the material from bluff top to sea level is fresh, unstained, unconsolidated Vashon sand and gravel. A screen analysis made in 1945 of a representative sample of pit-run material from the Pioneer pit showed 63 percent passing a 3/8-inch square opening screen, and only 0.46 percent passing a 100-mesh screen. Although the relative proportions of gravel to sand vary from one bed to the next and from place to place in the deltas and plain, at no operation is either sand or gravel the sole product.

A pebble count showed the gravel to be composed of basalt, quartzite, rhyolite, andesite, granite, and quartz proportioned in the order named.

Production

At the present time there are five properties operating in this area, and in the year 1946 (the last year for which the production figures are available) shipments amounting to 2,153,828 short tons or 1,387,322 cubic yards, of sand and gravel were made. These were divided as follows:

Gravel		Sand	
Structural	72 percent	Structural	69 percent
Paving	17 percent	Paving	22 percent
Railroad ballast	10 percent	Engine	8 percent
Other	1 percent	Blasting	1 percent

The following tests are taken from Bulletin 22 of the Washington Geological Survey. 4/

Abrasion tests show these gravels to have a remarkably low percentage of wear, being only 2.4 percent as compared with an average of 5.2 percent for the other gravels of the state.

Briquet tensile tests of the fine aggregate, made to determine their quality for concrete use, showed an average higher than 100 percent in strength ratio, as compared with standard Ottawa sand, for both the 7- and 28-day briquets.

The following tests were made by the Washington State Highway Department laboratory. 5/

Modulus of rupture (beam strength)

Pierce Island (Columbia River)	~~6.71~~	R = 671
Willamette River	~~7.48~~	R = 748
Steilacoom	~~8.93~~	R = 893

Compressive strength, 14-day cylinders 6" x 12", same mix and slump

Willamette River	4,500 pounds
Steilacoom	6,200 pounds

Absorption test

Willamette River sand	3.52 percent
" " gravel	1.62 percent
Hutchison (Kittitas) sand	2.22 percent
" " gravel	2.02 percent
Cowlitz River sand	1.61 percent
" " gravel	1.00 percent
Steilacoom sand	.80 percent
" gravel	.75 percent

Pioneer Sand & Gravel Co. plant

The largest producer in the area is the Pioneer Sand & Gravel Co., who have been operating for over 30 years and are just completing an entirely new plant. This plant, which is constructed ~~entirely~~ of concrete, has a capacity of a million yards per year.

One 5-yard electric shovel and a 1½-yard power shovel are used for loading at the pit face. The sand and gravel is conveyed by belts to the storage pile where the plus 2½" is screened out and goes to a large gyratory crusher making a crushed rock. The 2½" minus goes by belt conveyor to the main plant where it is washed and sized. The sand is sized in a series of sluices, and the gravel, over vibratory screens making an exceptionally uniform product. The finished product is stored over a concrete tunnel which has gates in the roof through which the different products are delivered onto a belt conveyor which carries ~~it~~ them either to scows at the dock or to railroad cars for shipment.

In the past, washing of the product was performed with sea water, but at present only fresh water is used.

no 9 A spring delivering 2,700 gallons per minute and a deep-well pump of 3,000 gallons per minute capacity provide an ample supply of water for all requirements.

Seven sizes of gravel are made, ranging from 2½" down to pea or 3/16". Four sizes of sand are regularly produced, coarse, construction or mortar, building, and superfine.

no 9 The arrangement of the storage facilities permits any specified mix requirements to be met.

Reserves

The reserves of Steilacoom sand and gravel available for future exploitation are practically unlimited. Figuring from indications as shown by current operations, it is reasonable to assume a figure in excess of 2½ billion yards, which at present rate of production would last some 1,500 years.

References

1. Willis, Bailey, Drift phenomena of Puget Sound: Geol. Soc. America Bull., vol. 9, pp. 111-162, 1898.
2. Willis, Bailey, and Smith, G. O., U. S. Geol. Survey Geol. Atlas, Tacoma folio (no. 54), 10 pp., 1899.
3. Bretz, J Harlan, Glaciation of the Puget Sound region: Washington Geol. Survey Bull. 8, 244 pp., 1913.
4. Leighton, M. M., Road building sands and gravels of Washington: Washington Geol. Survey Bull. 22, 307 pp., 1919.
5. Lang, Frank, personal communication.