Building Materials

Used at

Tacoma, Washington.

By George Wesley Bullard, B.S., 1882.

Thesis

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A DESCRIPTION OF THE BUILDING MATERIALS EMPLOYED AT TACOMA, WASH.

BY GEORGE WESLEY BULLARD, B. S., CLASS OF 1882.

The materials and methods employed in the construction of buildings in the city of Tacoma, Washington, do not in general differ in any marked degree from those used in other cities of the United States. But the observer notices this difference, that nearly all residences and many factories, warehouses and business buildings are constructed chiefly of wood. This is due to the abundance and cheapness of the excellent building lumber found here, and to the fact that wooden buildings, especially for residences, prove to be the most healthful, economical and pleasant, in the climate in which our city is located. Taking up the building materials in general use in Tacoma, they will be described, so far as practicable, in the order in which they are used in the construction of buildings.

FOUNDATIONS- PILES.

For structures erected on the harbor fronts, tide lands and water ways, piles are most generally used. These are usually cut from fir trees of suitable size and length as required by the weight to be carried and the depth of the soil in which they are to be driven. The teredo is a very destructive wood worm, being commonly termed the "Plague of the North Pacific Coast," and destroys piles very quickly. Piles driven outside the water line for permanent harbor improvements require to be covered or coated with some substance that will exclude the teredo from the wood. The method most commonly employed for this purpose is to wrap the part of the pile exposed to the water with jute cloth, saturating this with a coating of hot asphalt on
which dry sand is sprinkled before it cools. A sheathing of tin or copper is sometimes used. By this means the durability of the piles is increased. Otherwise, were the piles left exposed to the water, the teredos would within two to five years reduce them to a texture similar to that of a honey-comb.

For heavy structures, the piles are sometimes driven in groups of three or more, then enclosed by a sheet metal cylinder into which concrete is solidly tamped about the piles. This not only protects the piles, but greatly adds to their strength and forms a strong pier.

**CONCRETE AND FOOTINGS.**

The soil of Tacoma above the sea level is such that a natural bed of the most substantial character for foundations can usually be secured. A very compact and gravelly stratum underlies the surface of the ground throughout the greater part of the city. This layer is like a cement concrete, and in many places it can be excavated only by blasting. It is sufficiently thick and hard to carry safely the heaviest buildings. No difficulty from the settling of structures of masonry with a uniform bearing on it has ever been encountered by the writer.

Footings are suitably proportioned to the weight they are to sustain, are made of concrete or masonry for heavy buildings, and are solidly bedded on the natural bed of concrete or hard-pan formation. During the rapid growth of Tacoma, many frame buildings, especially residences, were erected on foundations of wooden timbers, usually cedar sills or blocks bedded on the ground. It can be safely stated that more than four-fifths of the dwelling houses in Tacoma were built on foundations of this character, some being quite expen-
sive structures costing $5,000 or more. This was an unwise practice, as shown by the necessity of underpinning many houses in later years.

CEMENT.

This material is not made in the State. The well known English Portland cement is used in this locality. It makes a good ballast for English vessels sailing to this port, and the market is kept well supplied at prices that do not encourage a local development of its manufacture.

SAND.

Banks and mines of excellent sand are found in Tacoma and its vicinity in great abundance. The deposits are usually clean and sharp, and of a light grey color, and are so varied that any quality may be obtained, from a fine even grain to a coarse gravel. But the architect is obliged to guard against the use of sand mixed with loam or quicksand. The latter is often found in the deposits and prevents the making of a hard and tenacious mortar.

LIME.

An excellent quality of lime is used in Tacoma. The kind most used is the product of the "Tacoma and Roche Harbor Lime Company," and is known as the "Roche Harbor" lime. It is made from a limestone or marble found on the shores of Roche Harbor, a small inlet in San Juan Island, in the northwest part of Washington, near Vancouver Island, British Columbia. The ledge from which this lime is made is a solid mass of marble extending across the neck of a peninsula formed by Roche Harbor and Wescot Bay, a distance of half a mile. It is 850 feet thick and has an average height above the water of 250 feet, containing enough stone to make a monumental shaft for every man, woman and child in the United States.
The Roche Harbor limestone or marble is of unusually good quality, ensuring a product almost absolutely pure and free from deleterious ingredients. Its analysis is as follows:

- Silica: 0.44%
- Iron and aluminum: 1.13%
- Phosphorus: 0.11%
- Carbonate of lime: 98.32%

An analysis of the calcined lime is as follows:

- Pure lime: 97.33%
- Magnesia: 0.96%
- Carbonic acid: 0.01%
- Other impurities: 1.20%

The above analyses were secured from the most reliable assayists and represent the general average of the Roche Harbor product. The Roche Harbor Company is now making 1500 barrels of lime per day, which, in the present dull times, indicates a popular demand for the product over a wide territory. In addition to the lime and marble, the company has also in the vicinity vast quantities of the best materials for the manufacture of the highest grades of Portland cement, and it expects soon to commence the manufacture of cement. The Pacific coast consumes about 1500 barrels of Portland cement per day, which makes a promising field for an enterprise of this kind.

There is another lime known as the "San Juan" lime, produced on the same island as the Roche Harbor lime by a San Francisco company. The limestone is said to belong to the same formation, and the lime appears to be of the same quality as the Roche Harbor lime, though the latter is, as previously stated, most used in Tacoma.

BUILDING STONE.

During the recent years of financial depression there has been so little demand for building stone, that slight new developments have been made of this unlimited resource in Washington. The fact
that almost every variety of the best quality of this building ma­
terial exists in Washington, awaits verification by future developments. However, several good quarries have been opened, and any desired quantity of excellent building stone can be had at Tacoma and other cities of the State at very reasonable prices.

GRANITE.

All of this material used in Tacoma is produced by boulders found in large quantities in and about the city. These boulders vary in size from a few pounds to many tons in weight. They are chiefly used for foundation walls for frame residences and for retaining walls for terraced lawns. The stone usually varies in color from light to dark grey, and is like other specimens of this material.

Some of the boulders are very hard and can only be broken by drilling and wedging or blasting. After breaking, they can usually be shaped with the hammer for rubble work, and when carefully laid with pitched faces and neatly pointed joints, this stone makes a very substantial foundation wall of good appearance. It costs less per cubic foot than brick work and is far more pleasing and durable. There are some well developed quarries of excellent granite near Spokane, but the writer is not aware that any of their product has been used in Tacoma. The use of granite as a building material in Tacoma has been limited to light work, so that a test of its strength has not been considered necessary.

SANDSTONES.

There are several sandstone quarries in Western Washington, that have furnished some building stone for Tacoma. During the financial depression, the demand for building stone has been so limited that
some quarries have suspended operations. A number of tests have been made to ascertain the strength of the stones produced by the principal quarries west of the Cascade range. The tests were made upon one inch cubes carefully cut and rubbed to a uniform size. The machine used is owned by the Northern Pacific Railroad Company, and only has a capacity of 5,000 pounds pressure, therefore the crushing strength could not be determined when it exceeded that amount. The stones were tested in numerical order, and the most impartial tests possible were made. Results of tests were as follows:

Nos. 1 and 2. Dog Fish Point Sandstone Quarry. A hard, light grey stone, with medium fine grain and even color. Showed no signs of cracking at 5,000 pounds per square inch.

Nos. 3 and 4. New Castle Island Stone. A light, grey sandstone of an even color and fine grain. No. 3 cracked at 4,800 pounds pressure, No. 4 cracked at 4,750 pounds pressure.

Nos. 5 and 6. Bellingham Bay Quarry. A hard, fine grained, even colored blue sandstone, quite generally specified and used in Tacoma buildings. Showed no signs of cracking under 5,000 pounds pressure.

Nos. 7 and 8. Eureka Sandstone Quarry. Located on Sucia Island, North Puget Sound. A fine, hard and even colored blue grey stone, excellent for carving. No. 7 did not crack at 5,000 pounds pressure. No. 8 cracked at 4,985 pounds pressure per square inch. This stone was used in building the lower part of the U. S. Government dry dock at Port Orchard, Puget Sound. From a lack of proper quarry facilities, the dock was finished with sandstone from the Tenino quarries hereafter described. The above mentioned stones are all found near
or on the shores of Puget Sound.

Nos. 9 and 10. Wilkeson Stone. A hard, light, grey sandstone. Hard to work and unreliable for cutting and finishing. It is checked and streaked with fine seams and little pockets that contain iron, which colors the stone. The quarry is badly cracked and broken, and dimension stones are secured with great difficulty. It is located in the foothills 30 miles southeast from Tacoma. This stone was used in constructing the Pierce county court house (with trimmings of Tenino stone), and in other structures in Tacoma. It appears well in walls, especially in pitched rough faced work. No. 9 did not crack at 5,000 pounds pressure. No 10 cracked at 4,975 pounds pressure per square inch.

Nos. 11 and 12. Tenino Blue Sandstone. No. 11 cracked at 3,025 pounds and crushed at 3,855 pounds pressure. No. 12 cracked at 2990 pounds and crushed at 3,475 pounds pressure.

Nos. 13 and 14. Tenino Buff Sandstone. No. 13 cracked at 3,010 pounds and crushed at 3,525 pounds pressure. No. 14 cracked at 3,275 pounds and crushed at 3,875 pounds pressure per square inch.

The Tenino quarries are located at Tenino, a small station on the Portland Branch of the Northern Pacific Railroad, some 40 miles south of Tacoma. The formation crops out of the hillsides and lies in a solid and even mass. The buff colored stone lies in the upper part of the formation, and the blue stone below it, the two colors being divided by quite a distinct line, so that but little of the stone is mixed or mottled. The Tenino quarry is well equipped with channeling machines, derricks and other apparatus, and orders for blocks of any size are easily and promptly filled. The company kept for several years samples of the two colors of stone on exhibition in Tacoma,
each stone being 28 feet long and about two feet square. The Tenino stone is a medium fine, even grained, soft sandstone, that hardens somewhat with age and exposure. It is easily dressed and carved, though it is not desirable for cut face work on account of the ar­rises being easily marred. It is excellent for rock faced work, win­
dow sills and for trimmings. Owing to its quality and to the fact that the Tenino company can easily and promptly furnish dimension stone, channeled or sawed, it is the only stone besides granite now used in Tacoma, the other stone quarries not being in operation. The Northern Pacific Railroad Company uses the Tenino stone almost exclu­
sively in constructing its abutments, culverts, bridge piers and other heavy construction west of the Cascade mountains. In the mild cli­mate of this locality the weather does not appear to affect it in any way. The writer has used this stone in all his best work with satisfaction; and as previously stated, it was used by the Govern­ment in finishing the largest dry dock on Puget Sound. In July, 1893, the Tenino Quarry Company had a test made of this stone at the Wa­
tertown Arsenal, Massachusetts, under Maj. J.W.Reilly, U.S.A., which proved it to possess an ultimate strength of 6,879 pounds per square inch. The U. S. Test shows a greater strength than those already quoted which were made with the machine of the Northern Pacific Rail­road, because a five inch cube was used instead of a one inch cube. An analysis of the Tenino stone shows its composition to be as fol­lows:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Silica</td>
<td>74.00</td>
</tr>
<tr>
<td>Oxide iron</td>
<td>6.65</td>
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<tr>
<td>Oxide aluminum</td>
<td>13.51</td>
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<tr>
<td>Oxide calcium</td>
<td>3.61</td>
</tr>
<tr>
<td>Oxide magnesium</td>
<td>1.65</td>
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</tbody>
</table>
SLATE.

There is but one slate roof in Tacoma. This is on the Lowell school building, designed and specified by the writer for one of the public schools of the city. The slate used on this building came from a quarry at New Westminster, British Columbia. The slate is of an even black color, and appears to be equal in quality to the slate produced in the Eastern States. The roof is now six years old and looks as well as when put on. A slate quarry is now being opened in the eastern part of the State near Spokane, that produces a good quality of slate. This material is of a dark silvery gray color. The slate used for blackboards used in the school buildings of Tacoma is obtained from Pennsylvania.

ONYX.

A quarry of very fine onyx is being developed in the State near Spokane. The writer has samples of this tone, but owing to the limited amount of building now being done, there is very little demand for material of this kind in Tacoma at present. By careful inquiry, the writer has learned that the onyx is obtained from an immense ledge lying at an inclination of about 60°, on the lower side of it being a black marble deposit 300 feet wide. The onyx is handsomely mottled, and is streaked and figured in various shades of colors, the richest being a beautiful semi-transparent green, mingled with milky white. In many places the graining and delicate coloring often suggests picture effects of sky and landscape to the eye. Mixed with the green onyx are deposits of alabaster of many shades, running from pure white to delicately mottled white and lavender. Above the onyx ledge, with about 8 feet of mineral quartz between carrying cop-
per, gold and silver, there is a stratum of slate rock from which good roofing slate is obtained. This is the slate quarry already mentioned. The writer is very favorably impressed with the beauty and quality of the onyx, and believes it to be an excellent article. The first car load of material from the quarries is now in Chicago, where it is being cut and polished by Mr. F. H. Samis, at his works on 52d street.

Many other kinds of stone have come under the notice of the writer, that appear excellent, but the present limited demand does not encourage their practical development and use.

BRICK, TERRA COTTA, ETC.

A very good quality of common brick is made near Tacoma, at the brick yard of Mr. F. H. Goss. These bricks are much used by the Northern Pacific Railroad, more than 8,000,000 having been used for lining the Stampede Tunnel alone. The Engineering Department made a series of 12 tests of the strength of these bricks. The average result of the 12 tests is as follows: Cracked under a pressure of 3,175 pounds to the square inch. Crushed under a pressure of 4,525 pounds to the square inch. Tests were made on one inch cubes. The bricks are of a red color, with a surface and texture equal to average common building brick of good quality. The bricks have been very satisfactory to the railroad officials, but Tacoma Architects have had occasion to find much fault with them, on account of their poor quality. This is doubtless due to the fact that the larger part of the choicest bricks were used by the railroad company, and the culled stock was often sold to contractors, with whom the architects have had to contend to secure satisfactory material. The products of
other Tacoma brick yards are not of good quality, and architects have more difficulty in getting suitable brick work than any other kind of work. The rainy seasons and damp climate require the very best brick to make a wall that will withstand the effect of the weather. The Seattle Brick and Tile Company make a brick that is hard, but rough and brittle. These bricks have been used somewhat in Tacoma, but are not to be highly commended. The engineering department of the N. P. R. R. also made a series of tests of these brick. Three tests each of No. 1 and No. 2 brick were made with average results as follows: No. 1 cracked at 1575 pounds to the square inch, and crushed at 3530 pounds per square inch. No. 2 cracked at 1320 pounds to the square inch, and crushed at 2520 pounds pressure to the square inch. The tests were made on inch cubes.

PRESSED BRICK.

Many of the pressed brick buildings of Tacoma are faced with pressed brick from St. Louis, Chicago, and San Francisco; but in recent years these have been supplanted by an excellent quality of pressed brick made by the Denny Clay Company of Seattle, whose works are about 28 miles from Tacoma. The Denny Clay Company manufactures about 20 different colors and shades of brick, but do not use a particle of coloring matter, though the colors vary from white and cream to dark reds and browns. The colors are firm though delicate and permanent, and they are highly satisfactory to the architects of this locality. A series of tests of the Denny Clay Company's brick was made in June, 1894, under J.W. Reilly, Major Ordnance Department U.S. A., the material being contributed from the exhibit at the Columbian Exposition at Chicago. The tests resulted as follows: No. 6534 Facing
brick 2.45 in. thick, 8.96 in. long and 4.48 in. wide. Cracked under pressure of 250,000 pounds, and crushed under 505,800 pounds. Ultimate strength 12,573 pounds per square inch. The brick weighed 13 3/4 oz. and absorbed 6 1/4 oz. of water. Test No. 6535. Facing brick. Cracked under 309,000 pounds, and crushed under 519,700 pounds. Ultimate strength 13,137 pounds per square inch.

FIRE BRICK, ETC.

The Denny Clay Company also make a fire brick of superior quality, pressed, plain or shapes. They also make a good quality of paving brick.

TERRA COTTA, ETC.

An excellent quality of architectural terra cotta, both ornamental and structural, is manufactured by the Denny Clay Company. Sewer pipe, fire proofing, tiles, drain tiles, and all kinds of clay products commonly used in building construction are made by this company. It is gratifying to architects to know that so complete a variety of clay materials, possessing such superior qualities, can be produced so near at hand. The Denny Clay wares are made from pure vein clays found in the foot hills in the coal fields east of Tacoma. This clay is evidently a most excellent article, and the deposits are exceptionally suited for a manufacture of this kind. By mixing the clays in suitable proportions, almost every desirable shade of color is secured, and any quality of the finished product is obtained. With the return of more prosperous times, this company's product will represent one of the foremost industries of the Pacific coast.

ENCAUSTIC TILES.
These are not yet produced in Washington, but an unlimited quantity of fine clays for the purpose is found near this city. Specimen tiles made from local clays have been shown to the writer, which lead him to believe that within a few years high grade encaustic tiles will be manufactured in or near Tacoma. An assay of the clay here referred to is as follows:

- **Silica** - 63.00%
- **Aluminum** - 19.00%
- **Sesquioxide of iron** - 4.20%
- **Lime** - 2.12%
- **Magnesia** - 1.53%
- **Loss by ignition** - 10.15%

**GLASS.**

This article is obtained from the eastern markets. The first sample of glass made in Washington was made in Tacoma, from a glass quartz mined near the north line of the State. The rock is of a fine grade and it will not be long until a Tacoma architect can specify glass made within the State. An attempt has been made to start a glass factory in Tacoma, but for some reason the enterprise did not succeed.

**LUMBER.**

This building material is the leading product of Western Washington. The forests are so abundant and the trees are so large, that timbers of unusual dimensions are easily obtained. The same standard sizes of construction lumber are used in Tacoma as in Chicago or the middle western markets. The sizes range from 1"x4" pieces up to 24"x24" timbers and some are even larger. The writer has seen timbers 100 feet long and 24"x24" sawed and surfaced on four sides at the Tacoma Lumber Company's mill. It is exceedingly gratifying to the
architect when designing roof trusses or other heavy construction, that it is not necessary to detail splice joints in timbers less than 100 feet in length, for at a small additional cost, timbers of special size and length are easily obtained at the lumber mills. The finest of finishing lumber is also produced and is kept in stock by the lumber mills for all parts of the finishing of buildings. Lumber is graded by number instead of by letter. No. 1 finish is absolutely clear and choice lumber. No. 2 is usually clear, but is slightly defective in grain or otherwise, and No. 3 is the lowest quality, a grade listed only in sidings and in a few less important lines of finish. Thick finishing, flooring, wainscoting, ceiling, etc., are usually found only in first and second grades. Stock and box boards are graded by letter, the grades ranging from A down to D. The term "quarter sawed" is not used by the Washington lumbermen, the term "vertical grain" (v.g.), being used instead. No. 1 flooring is all clear and v.g., and much of the No. 2 is also v.g. No. 1 thick finishing, steppings, casing, etc., are usually v.g. Other finishes, as siding, ceiling, wainscoting, boxing, etc., may be v.g. or "slash" (bastard) grained. Much of the lumber both for finishing and construction is sized, i.e. surfaced on two sides, before leaving the mills. This is chiefly done on account of the distant market to which most of the product is shipped. More lumber can be put in a car or ship when sized than when rough, and the weight is also less. The weight makes quite an item in overland shipments to eastern markets, and to save freight charges, all finish lumber is dressed and kiln dried before being loaded on the cars for shipment to the east.
FIR.

This wood is sometimes classified as "Douglas Fir," though we have not been able to learn why it is so called, and is the principal wood for lumber in the State. The trees are large and stately, being often six or more feet in diameter, and from 200 to 300 feet in height. Fir wood possesses great strength, and being comparatively light, it makes one of the best of woods for structural purposes. It is also an excellent finishing wood. The grain is not so highly colored nor so irregular as southern pine, yet richer and more distinct than white pine. As a finish, it is almost as durable as oak. The color changes by exposure to a rich color similar to, though not as dark as that of yellow pine. This color is pleasing to the eye, and though the grain is coarse in places, it is so varied that with care in selecting the wood, very rich and pleasing effects may be secured in finished work. It is very necessary that the wood be thoroughly seasoned when used for finish. If put in place while green or damp, the joints will open by shrinkage, and the pitch contained in the wood will come to the surface and ooze through the varnish or paint with which it is covered. The most effective way of seasoning Washington fir finish is to thoroughly steam it first, then to drive out all moisture in a dry kiln. The steam softens and extracts most of the pitch, and the dry kiln dries and hardens that which remains. The dry kiln, if sufficiently hot, will alone do this quite effectively without the steam. Most of the fir finish used in Tacoma is put through the dry kiln only. The fir finish used in Engineering Hall, U. of I., was not steamed, but the architect saw that it was all for four to five days in a very hot dry kiln before it left Tacoma. For
construction purposes fir lumber has no superior. It is especially excellent for ship building, car building and for constructing bridges, trestles, roofs, heavy floors, etc. As a framing timber it is easily worked and fitted in place, and it resists strains with a very little deflection. Vertical grain fir flooring is very satisfactory when properly finished. As soon as the floor is laid it should be filled with one coat of linseed oil, for if left unfinished the surface soon becomes dingy from dust. The writer believes in finishing all floors in this way, for sanitary reasons, even if a floor is to be carpeted. Common kerosene gives a good finish to a fir floor, especially in kitchens and bathrooms. This has been the experience of the writer in his own residence. The kitchen and second story floors were all finished with two coats of linseed oil. One coat would have been better, for the oil became a little gummy. The floors are frequently mopped with kerosene and they are as firm and fresh now as when first laid, but are slightly darker in color. The first floors are finished with prepared wax, and are quite as pleasing and satisfactory as if they were of oak or other hard wood. Fir grain is very regular and straight and sometimes slivers easily. Care must therefore be taken in working light finish, such as stops, casings, siding, etc., to avoid splitting the wood. About every kind of lumber except shingles is made from fir, from a common lath to a ship mast, and from a carpet strip to a stairway. Several tests of Washington fir have been made for ascertaining its strength, but none have sufficient authority, it seems, to have its strength tabulated with other woods in our Engineer's and Architect's Pocket Books, or.
In January, 1896, a series of tests were made at the South Tacoma car shops of the Northern Pacific Railroad by the general car foreman and other officials as a comparison of Washington fir and eastern white oak. The tests were made with pieces dressed 2 inches square, with 18 inches between bearings, and a lift by a hydraulic jack was applied at the center. In the first tests, green or unseasoned wood was used. Ten pieces of each kind of wood were tested with the following results: - The breaking loads for the fir sticks varied from 2325 pounds to 3200 pounds, the average breaking load being 2845 pounds. The breaking load for the oak sticks varied from 1800 pounds to 3250 pounds, the average breaking load for the ten sticks being 2735 pounds, giving an average excess of 110 pounds in favor of the fir. Using the formula of strength

\[ C = \frac{w}{b^2d^3} \]

we find the fir test gives 533 as the average coefficient of strength. No notes were taken of deflections. In the second test, dry seasoned wood was used with the following results: The breaking load for the fir sticks varied from 3200 pounds to 5000 pounds, the average breaking load being 3900 pounds. The average deflection was 6/16 of an inch. The breaking load for the oak sticks varied from 2300 pounds to 4250 pounds, the average breaking load being 3215 pounds. The average deflection was 4/16 of an inch. The average excess in favor of fir was 685 pounds. This gives an average coefficient of strength of 731 for the seasoned dry fir. In the third test six pieces of fir were selected which had been under cover for one year. The average breaking load was 4233 pounds. The average deflection was 15/32 of an inch. This gives 793 as the average value of C.
The conditions were the same in each test. The best quality of fir and oak was selected for each stick. No attention whatever was given to the bearing in regard to the grain of the wood. In March, 1890, the Chicago, Milwaukee & St. Paul Railway Co. under the direction of John T. Crocker, General Purchasing Agent, sent a testing machine to Tacoma and made a number of tests of the strength of fir timbers at the mill of the St. Paul & Tacoma Lumber Company. One stick 6"x14" with a span of 11 feet broke under a load of 39,111 pounds. This gives \( C = 366 \). Another stick three years old 8"x16" with a span of 16 feet broke under a load of 39,672 pounds. This gives \( C = 310 \). Twelve or more timbers were tested in this way with similar results. The greatest deflection for any of the sticks was \( 3\frac{1}{2} \) inches. The least deflection was \( 1\frac{1}{2} \) inches. The writer has authentic reports of tests made by the Oregon & California Railroad Co. and by the Southern Pacific Railroad Co. Also of tests made at the Watertown U. S. Arsenal. Without going into details, we will state that the results of the tests show that the fir has a tensile strength of 15,900 pounds per square inch; shearing strength, parallel to fibres, 690 pounds per square inch; crushing, parallel to fibres, 3,648 pounds per square inch; crushing perpendicular to fibres 1,200 pounds per square inch. These are not maximum results, but are fair averages of some of the tests made. In the Watertown Arsenal tests for transverse strain, one test by application of the formula gives \( C = 727 \), and another makes \( C = 869 \). Fir trees make the best of piles for foundations, also flag-staffs and ship masts and spars.

CEDAR.

The next most useful wood used in Tacoma is Washington cedar. The chief product from this wood is shingles. These shingles are now
so well known in the middle western markets that a description of
them is unnecessary in this paper. They are much used in Tacoma, not
only for roofing, but for finishing the outside walls of residences
in both plain and ornamental work. The shingles are graded in size
and quality as follows: Sixteen inch, 6 butts to 2 inches thick; two
grades, the first quality being known as Extra Star A Star (*A*),
random widths, vertical grain, with 85 to 95% strictly clear; 2d
quality is known as Standard A, random widths. Five inch dimension,
both plain and fancy, are strictly clear.

Sixteen inch, 5 butts to 2 inches thick; 1st grade is known as
Clears; 2d grade is known as Choice A. Five inch dimension, strictly
clear.

Eighteen inch, 5 butts to 2 inches thick; 1st quality is known
as Eureka; 2d quality is known as Skagit A. Dimension 5 inch,strictly
clear.

Eighteen inch, 5 butts to 2½ inches thick; 1st quality is known
as Perfection; 2d quality is known as Puget A. Dimension, 5 inch,
plain or fancy, strictly clear.

The shingles are very durable and make a good roof that lasts
many years, even in the wet climate of Puget Sound. In all good work
Tacoma architects specify roofs to have one or more coats of creosote
stain, or other paints. In the best work they are dipped in
stains or oil before putting on the roof. This not only preserves the
shingles, but prevents moss from growing on the roofs during the rainy
winter season. On many of the roofs, especially on the shady side,
rolls of moss some two or three inches thick grow along each course
of shingles during the rainy season. In the dry summer this moss dries up into dingy, shrunken lines, only to revive with the return of winter. They make a roof appear very unsightly. The Washington cedar is much used for sash, doors and other inside finish. When "live" cedar is used, the wood is light colored and very pleasing. The grain is regular, though wavy and varied in places, giving an effect that is quite rich. The "dead" cedar produced by dead trees is dark, and sometimes has a gloomy effect. The wood is soft and easily injured, and for this reason is not suitable for public buildings, nor for rooms that are liable to receive rough usage. It is excellent for external finish, such as casings, siding, mouldings, cornices, columns, etc., where it will be covered with paint. We consider cedar siding superior to white pine. Cedar wood is easily worked and it is therefore much used in houses of moderate cost. The cost of the lumber, however, is somewhat more than that of fir. The supply of cedar is not abundant, and at the present rate of consumption, it will soon become a scarce article. Cedar is not a structural wood and it is not used for frames of buildings. For this reason, no special tests have been made of its strength.

SPRUCE.

This is a very fine wood and it is much like white pine. Tests of its strength show that it has approximately the same strength as white pine, though possessing greater resistance to bending. It is very light in color, and has a smooth and firm grain, and is quite odorless. It is excellent for making flour bins, linen drawers, and other work. It makes a nice finish for bed rooms where a light and dainty finish is desired. Spruce lumber is much used for lining ships
before loading wheat or flour. Also for fruit boxes, packing cases, etc. The wood is easily worked and is quite abundant. It makes excellent stock boards, good siding, mouldings and other outside finish. It is a good framing timber for light residences, though it is but little used for this purpose at present.

HEMLOCK.

This is our most beautiful finishing wood and resembles maple when polished. The grain is very pretty, is quite light in color, and varies with rich irregularities that are very handsome. The waves and curly knots make it exceptionally fine for doors, wainscoting, paneled ceilings and other nice inside work. It is very suitable for bed rooms, reception rooms, and wherever a rich, pleasing and cheerful finish is desired. This wood has not been much used by Tacoma architects, but will be a popular finishing wood at the return of more prosperous times. Washington hemlock is also called Alaska cedar. It is a firm wood and is easily worked. It is not used at all for framing timber, and the writer knows of no tests of its strength that have been made.

There are many other woods in Washington, but they are seldom used for building. The oak and ash abound here, but they are very small trees, and there is but little demand for those woods.

IRON AND HARDWARE.

The Tacoma Rolling Mills furnish nearly all the rolled iron now used in building construction, while the local foundries can produce the heaviest castings required. Steel beams are shipped into the State when required. Builders' hardware is not yet made in Washington.
PLUMBING SUPPLIES, ETC.

Plumbing supplies and fixtures, heating apparatus, paints, oils, etc., which are used in Tacoma, are produced in other States. The architect uses his own judgment and taste in specifying these materials.

This completes a description of the most important building materials used in Tacoma.

COMPARATIVE COST OF BUILDINGS CONSTRUCTED WITH BRICK AND WOOD.

Most of the stores and office buildings, and the best hotels in Tacoma are constructed with brick. The frame buildings for business uses were erected during the early growth of the city, and are nearly all cheaply constructed.

A frame store building 25x100 feet in size and one story high, substantially built on low foundation walls of brick or stone, finished complete, ready for shelving and fixtures, will cost about $1200. This would pay for a plain building suitable for a suburban store. To construct such a building with common brick in a manner to comply with Tacoma building laws, with 20% added for better quality of materials and finish, the cost would be increased about $1100, or approximately 90% more than the cost of the wood building.

A frame store building 25x100 feet having a second story containing offices, can be constructed and finished for about $2450. To build the same with common brick, the cost will be increased about $1925, or approximately 78% more than the wood building. These estimates include the painting of the exterior of the buildings. It is to be observed that the ground plans of the buildings above estimated cause a great difference in the cost of the brick and frame structures.
By increasing the width or size of the buildings the percentage of cost of the brick building over that of wood will be greatly lessened. Buildings of this kind in Tacoma are seldom more than two stories high.

There are a number of wood hotels and apartment houses in Tacoma that are three and four stories high. The comparative cost of constructing buildings of this kind with brick or with wood necessarily varies according to the character of the design and the arrangement of the floor plans. From a number of estimates made of the cost of buildings of this kind, it is approximately safe to add 40% to the cost of a wood building to determine cost to construct the same with brick. This percentage will apply to wood buildings that cost from $15,000.00 to $20,000.00.

In public school buildings containing from eight to twelve school rooms, about 50% should be added to the cost of a wood building to ascertain its cost when constructed with common brick, and about 90% should be added to determine the cost of the brick building constructed with pressed brick facings.

There are no stone or brick dwelling houses in Tacoma. From estimates made on a number of residences constructed from plans prepared by the writer, it is found that from twenty-two to twenty-eight per cent would be added to their cost were they constructed with common bricks, the walls being 9" thick. To face the walls with pressed brick, the cost would be increased from fifty-four to sixty per cent.

The cost of stone buildings varies according to the design and the quality of the work. An ordinary dwelling house with its walls
made of good hammer shaped granite rubble masonry would cost from thirty to forty per cent more than a wood residence. By using Tenino sandstone with pitched faces, laid in the walls with neatly pointed mortar joints in broken ranges, the cost would be increased from forty to fifty per cent. In buildings enriched with carved and ornamental work, the cost would be increased according to the richness of the designs. It is understood that the stone walls are estimated to be of greater thickness than the brick walls.

The Pierce county court house is the only stone building in Tacoma.

**COST OF BUILDING MATERIALS AT BUILDING SITE.**

Dimension stone from the Tenino quarries, sawed in slabs one foot thick and upwards costs delivered in car-load quantities 50¢ per cubic foot. Heavy rubble stone from the same quarry, 20¢ per cubic foot. Cost of laying the rubble stone in basement walls, 8¢ per cubic foot. Granite boulder rubble work in wall, 13¢ per cubic foot.

<table>
<thead>
<tr>
<th>Material</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland cement, per barrel</td>
<td>$3.50</td>
</tr>
<tr>
<td>Lime</td>
<td>1.35</td>
</tr>
<tr>
<td>Sand, cubic yard</td>
<td>1.00</td>
</tr>
<tr>
<td>Common brick, per M</td>
<td>$8.00 - 9.00</td>
</tr>
<tr>
<td>Pressed brick, white, per M</td>
<td>$40.00</td>
</tr>
<tr>
<td>&quot; any color, per M</td>
<td>35.00</td>
</tr>
<tr>
<td>New Westminster roofing slate, per square</td>
<td>8.00</td>
</tr>
</tbody>
</table>

The price of lumber at Tacoma remains quite uniform. During the past year the prices on this material have been advanced, owing to the increasing demand and improvement in business. The prices per thousand feet paid for fir lumber delivered at the building site at
the present time are as follows:

Framing lumber, size 2"x4" to 4"x12", lengths 34 feet

and under, rough, .......................... $7.50
Do. S. 1 S. & E. ............................. 8.50

For larger sizes of framing timbers the prices are higher, according to sizes.

Common sheathing, fencing, etc., S. 1 S. ........... $8.50
Lath, 3/8"x1\(\frac{1}{2}\), 4 feet, .............................. 1.75

Thick finishing S. 1 or 2 S. 8, 10 and 12 inches wide:
No. 1 Clear stepping, 1\(\frac{1}{4}\)" to 2", V.G., S. 2 S. ...... 22.50
No. 2 stepping, 1\(\frac{1}{4}\)" to 2", S. 2 S. ...................... 14.50
No. 1 Clear, 1\(\frac{1}{2}\) to 2" .................................. 19.50
" " " 14" to 18" wide, .................................. 22.50
No. 2 " " ................................................. 13.50
" " 14" to 18" wide, .................................. 15.50

Inch finishing, S. 1 or 2 S.:
No. 1 Clear, 4" to 12" wide ............................. 19.00
No. 2 " " ................................................. 13.50

Flooring, dressed and matched:
No. 1 flooring, 1"x4" or 6" .............................. 20.00
No. 2 " " ................................................. 13.50
No. 1 " 1\(\frac{1}{4}\)"x4" or 6" ................................. 22.50
No. 2 " " ................................................. 14.00

V. or Channel Rustic and Drop Siding:
No. 1 6" or 8" wide, ................................ 17.50
No. 2 " " ................................................. 13.00
Bevel Siding 1/2" tied in bundles:

No. 1 Clear, 6" wide, $12.00
No. 2 " " 10.00

4" siding $1.00 per m less than 6".

Ship Lap, D. and M.;

Common boards, 8, 10 and 12 inches wide, $10.00

The above prices are for lengths of 12 to 16 feet. Special lengths 50¢ per m extra.

Ceiling, V, beaded or plain:

No. 1 ceiling 13-16x4 or 6 in. 19.00
No. 2 " " 13.50
No. 1 " 5/8x4 or 6 in. 17.00
No. 2 " " 13.00
No. 1 " 3/8x4 or 6 in. 15.00
No. 2 " " 12.00

WAINSCOTING.

No. 1 4" and 6" wide 12.00
No. 2 " " 10.00

CEDAR LUMBER.

The prices of cedar lumber is becoming higher each year owing to the scarcity of the cedar forests, which are being rapidly exhausted. The prices of this material are as follows:

Cedar finishing S. 1 or 2 S.

No. 1, 1 to 2"x6" to 12" 35.00
No. 1, 1 to 2"x14" to 18" 40.00
No. 1, 1 to 2"x20" to 24" 45.00
<table>
<thead>
<tr>
<th>Description</th>
<th>Dimensions</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. 2, 1 to 2&quot;x6&quot; to 12&quot;</td>
<td></td>
<td>$25.00</td>
</tr>
<tr>
<td>No. 2, 1 to 2&quot;x14&quot; to 18&quot;</td>
<td></td>
<td>30.00</td>
</tr>
<tr>
<td>No. 2, 1 to 2&quot;x20&quot; to 24&quot;</td>
<td></td>
<td>35.00</td>
</tr>
<tr>
<td>No. 1 Bevel siding, ½&quot;x6&quot;, 12 to 16 feet</td>
<td></td>
<td>17.00</td>
</tr>
<tr>
<td></td>
<td>6 to 10</td>
<td>14.00</td>
</tr>
<tr>
<td>No. 2</td>
<td>12 to 16</td>
<td>15.00</td>
</tr>
<tr>
<td></td>
<td>6 to 10</td>
<td>12.00</td>
</tr>
<tr>
<td>No. 1 casings, 4&quot; and 6&quot;</td>
<td></td>
<td>40.00</td>
</tr>
<tr>
<td>No. 2</td>
<td></td>
<td>25.00</td>
</tr>
<tr>
<td>No. 1 base boards, 8&quot; to 12&quot;</td>
<td></td>
<td>40.00</td>
</tr>
</tbody>
</table>

**CEDAR SHINGLES.**

<table>
<thead>
<tr>
<th>Description</th>
<th>Dimensions</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extra <em>A</em> 16&quot; 6 butts to 2&quot;</td>
<td></td>
<td>1.75</td>
</tr>
<tr>
<td>Standard A 16&quot; 6 butts to 2&quot;</td>
<td></td>
<td>1.50</td>
</tr>
<tr>
<td>Dimension 16&quot; 5&quot; wide, plain</td>
<td></td>
<td>2.25</td>
</tr>
<tr>
<td>Dimension 16&quot; 5&quot; wide, ornamental</td>
<td></td>
<td>-2.75</td>
</tr>
</tbody>
</table>

The 18" shingles are not used on ordinary buildings.

Spruce lumber is not generally used. The prices of this lumber are about fifteen per cent higher than those of fir lumber already given. Hemlock is used only when specially specified. The price of this wood is about the same as No. 1 cedar finish.

Fir piles driven in place on the Tacoma harbor line cost from 12 to 15 cents per lineal foot, according to their length and size.