

Engineering-Contracting

A Weekly Journal for Civil Engineers and Contractors

With which are Incorporated

ENGINEERING WORLD AND CONTRACT NEWS

VOLUME XXIX

NEW YORK
PUBLIC
LIBRARY

January-June, 1908

THE MYRON C. CLARK PUBLISHING CO.

355 Dearborn St., Chicago, Ill.

FW

able to agree then they shall choose a third engineer of like standing, and the vote of the majority shall be final and binding. The referee engineers herein provided for shall have power to affirm, modify, or reject the order of the state Board of Health submitted to them, and their decision, as reported in writing to the governor and attorney general, which shall be rendered within a reasonable time, shall be accepted by the state Board of Health, and shall be enforced by said board in the manner provided for in this act. The fees and expenses of said referee engineers shall be equally divided between the city, village, corporation or owner requesting such reference and the state Board of Health.

Sec. 5. It shall be the duty of every such municipal council, department or officer having jurisdiction to provide for the raising of revenues by tax levies, sale of bonds or otherwise to take all steps necessary to secure the funds for any such purpose or purposes; and when so secured, or the bonds thereof have been authorized by the proper municipal authority, the same shall be considered as in the treasury and appropriated for such particular purpose or purposes, and cannot be used for any other purpose; provided that the bonds herein authorized to be issued for the purposes enumerated in this act shall not exceed 5 per cent of the total value of all property in any city or village, as listed and assessed for taxation, which may be in addition to the total bonded indebtedness allowable under the provisions of Sec. 2,835 of the Revised Statutes, but the question of the issuance of such bonds shall not be required to be submitted to a vote.

Sec. 6. If any council, department or officer of any municipality, or person or private corporation, shall fail or refuse for a period of 30 days after notice given him or them by the state Board of Health of its findings and the approval thereof by the governor and attorney general of the state of Ohio, to do and perform any act or acts required of him or them to be done and performed by this act, such members of council or department, and such officer or officers, or person or private corporation shall be and become personally liable for such default, and upon conviction thereof shall forfeit and pay to the state Board of Health \$500 * * * to be deposited with the state treasurer to the credit of said board; provided, however, that the governor and attorney general, upon good cause shown, may, in their discretion, remit said penalty, or any part thereof.

Sec. 7. An action may be begun for the recovery of any such penalty by the prosecuting attorney of any county in the name of the state of Ohio in the court of common pleas of such county having jurisdiction of any such party or parties; or it may be begun by the attorney general in any such county or in the county of Franklin, as provided for by Secs. 210 and 211 of the Revised Statutes of Ohio.

Railway Section

Note: This section is devoted to methods and costs of constructing railways. It will cover road-bed and track construction, contractor's plant and organization, surveying methods and permanent way structures.

The Itemized Cost of the Great Northern Railway System as Estimated by Its Chief Engineer.

In our issue of April 15 we gave an estimate of the cost of the Northern Pacific Railway similar to the one that will be given here. Both these estimates were presented as testimony before the Interstate Commerce Commission in their hearing of the "Spokane Rate Case." Since the object of the hearing was to ascertain the reasonableness of railway rates on the N. P. and on the G. N. railways, the railways naturally claimed a high physical value for their property. As stated in our April 15 issue, Mr. Halbert P. Gillette, testifying in behalf of the city of Spokane, claimed that the estimates presented by the railways were much too high, frequently being high not only as to unit prices but as to quantities.

Mr. A. H. Hogeland, Chief Engineer of the Great Northern Railway, presented the following as his estimate of the cost of reproducing the railway new at present prices.

The mileage of the Great Northern under operation April 1, 1907, was:

	Miles.
Main track.....	6,523.09
Second, 3d, 4th, 5th and 6th track.....	112.25
Side track.....	1,480.24

Grand total of all tracks..... 8,115.58

Mr. Hogeland's estimate of the cost was presented in the following summarized form:

1. Engineering	\$6,870,187
2. Right of way and station grounds	87,067,532

27,018 acres clearing at.....	\$82.50	\$ 2,228,985
340,000 square rods grubbing at.....	1.65	561,000
165,438,650 cubic yards earth at.....	0.31	51,285,882
33,975,350 cubic yards hardpan at.....	0.45	15,288,908
8,441,860 cubic yards loose rock at.....	0.55	4,643,023
12,771,060 cubic yards solid rock at.....	1.10	14,048,166
1,765,675 cubic yards riprap at.....	2.00	3,531,350
92,500 cubic yards retaining wall at.....	9.00	832,500
194,250 cubic yards slope wall at.....	3.50	679,875
Total grading		\$93,098,889

3. Grading.....	93,098,889
4. Tunnels	7,447,620
5. Bridges, trestles and culverts.....	17,953,028
6. Ties	18,690,731
7. Rails	31,054,392
8. Track fastenings	7,375,495
9. Frogs and switches.....	904,450
10. Ballast	10,509,000
11. Track laying and surfacing.....	6,908,409
12. Fencing right of way.....	760,815
13. Crossings, cattle guards and signs	1,922,160
14. Interlocking or signal ap-	

paratus	386,190
15. Telegraph lines	2,198,283
16. Station buildings and fixtures	3,276,300
17. Shops, roundhouses and turntables	3,667,900
18. Shop machinery and tools.....	1,779,692
19. Water stations.....	1,983,325
20. Fuel stations	575,700
21. Grain elevators	2,708,100
22. Storage warehouses	276,500
23. Docks and wharves.....	1,222,900
24. Gas making plants.....	15,000
25. Miscellaneous structures.....	3,194,850
26. Track and bridge tools.....	142,877
27. Stores and supplies on hand Feb. 28, 1907.....	5,395,463
28. Contingencies	15,291,252
29. Equipment:	
Locomotives.....\$10,756,324	
Passenger cars	4,915,764
Frt. cars and other equip. 25,249,096	40,921,184

Total	\$373,688,224
30. General and legal expenses (1%).....	3,736,882
Total	\$377,425,106
31. Interest during constr. (10%).....	37,742,510

Grand total

Engineering was estimated at 3 per cent of all items requiring engineering supervision, being all items except items 2, 26, 27, 29, 30 and 31.

Right of way and station grounds were estimated by the Right of Way Department.

The grading was estimated as follows:

Mr. Hogeland testified that the quantities of grading were arrived at as follows: "For 82 per cent of the mileage of the system the actual quantities moved in construction were obtained from Engineering Department records. For the balance of the system the quantities could not be obtained in that way, because no records were available, and they were estimated from profiles and by comparison with adjacent portions of the system where the quantities were known. To these quantities were added the quantities moved since construc-

tion, in widening banks, reducing grades, taking out sags, filling bridges and widening and deepening cuts. The result being the actual quantities as nearly as possible to arrive at same, required to make the roadbed as it exists today."

It will be noted that Mr. Hogeland's estimate gives an average of 33,250 cu. yds. of excavation per mile of main track, distributed thus:

Earth	75.0%
Hardpan	15.4%
Loose rock	3.8%
Solid rock	5.8%

Total 100.0%

Mr. Hogeland testified that the part of the G. N. east of Havre (4,553 miles of main line) averaged 27,760 cu. yds. per mile, whereas the line west of Havre (2,082 miles of main line) averaged 45,250.

Mr. Hogeland gave the percentages as follows:

	East of Havre	West of Havre
Earth	88.4%	57.0%
Hardpan	10.2	22.4
Loose rock	1.1	7.4
Solid rock	0.3	13.2

Total 100.0% 100.0%

Mr. Gillette testified that Mr. Hogeland's estimate of yardage per mile was much too high, and cited actual records of the G. N. in the state of Washington where much of the heaviest grading on the G. N. is found. But, as we shall publish in detail Mr. Gillette's quantities and estimates of cost of each of the railway systems in the state of Washington, the reader may make comparisons for himself.

Mr. Hogeland arrived at his unit prices as follows:

Clearing:	Per Acre.
Contract price	\$75.00
Transporting men, tools and supplies	7.50

\$82.50

Grubbing:	Sq. Rod.
Contract price	\$1.50
Transporting men, etc.	0.15

\$1.65

Earth:	Cu. Yd.
Contract price up to 1,000 ft. haul	\$0.23
Overhaul	0.035
Transporting men, etc.	0.045

\$0.31

Hardpan:	Cu. Yd.
Contract price up to 1,000 ft.	\$0.35
Overhaul	0.045
Transporting men, etc.	0.055

\$0.45

Loose rock:	Cu. Yd.
Contract price up to 1,000 ft.	\$0.45

Overhaul	0.045
Transporting men, etc.	0.055
	\$0.55
	Per
Solid rock	Cu. Yd.
Contract price up to 1,000 ft.	\$1.00
Overhaul	0.045
Transporting men, etc.	0.055

	Per
	\$2.00
	Per
Riprap:	Cu. Yd.
Contract price	\$1.50
Overhaul or train service	0.35
Transporting men, etc.	0.15

	Per
	\$0.00
	Per
Retaining wall:	Cu. Yd.
Contract price (concrete or rubble)	\$7.50
Train service	0.80
Transporting men, etc.	0.70

	Per
	\$3.50
	Per
Slope wall:	Cu. Yd.
Contract price	\$2.50
Train service	0.75
Transporting men, etc.	0.25

It is interesting to note in this connection that the actual yardage of excavation on about 700 miles of the G. N. in the state of Washington was 26,000 cu. yds. per mile for the original construction in the early '90's, and that the item of "overhaul" actually averaged less than 1/2 ct. per cu. yd. for every yard of material excavated, as compared with the 4 1/2 cts. estimated by Mr. Hogeland. The free haul limit was 1,000 ft. Much the same criticism also applies to Mr. Hogeland's estimate of the cost of transporting men and supplies to and from the site of the work.

Mr. Hogeland's estimate of tunnels was as follows:

5,232 lin. ft. unlined sgl. track tunnel at \$70	\$ 356,240
17,346 lin. ft. timber lined sgl. track tunnel at \$120	2,081,520
6,139 lin. ft. concrete lined sgl. track tunnel (Boulder) at \$175	1,074,325
13,813 lin. ft. concrete lined sgl. track tunnel (Cascade) at \$195	2,693,535
5,141 lin. ft. concrete lined dbl. track tunnel at Seattle. \$1,848,000, two-thirds to G. N.	1,232,000

Total \$7,447,620
The unit prices were arrived at as follows:

	Per
	Lin. Ft.
Unlined tunnel:	Lin. Ft.
Contract price for standard unlined section	\$55
Extra excavation	8
Transporting men, tools, supplies, etc.	7
	\$70

	Per
	Lin. Ft.
Timber lined tunnel:	Per
Contract price for standard unlined section	\$5
Enlargement for timber lining	30
Timber and iron in place	25
Transporting men, etc.	10
	\$20

	Per
	Lin. Ft.
Concrete lined tunnels:	Per
(Boulder Tunnel.)	Lin. Ft.
Excavation	\$ 90
Temporary timber lining	30
Permanent masonry lining	45
Transporting men, etc.	2

	Per
	Lin. Ft.
	\$175
	Per
(Cascade Tunnel.)	Lin. Ft.
Excavation	\$ 85
Temporary timber lining	25
Permanent concrete lining	50
Transporting men, etc.	25
	\$195

	Per
	Lin. Ft.
Bridges, trestles and culverts:	Per
1 stone arch (Minneapolis), 1,770 lin. ft.	\$ 867,000
260 steel bridges with masonry piers, 63,557 lin. ft.	6,941,545
3,934 timber trestles, 429,851 lin. ft.	5,216,480
189 Howe truss spans, 19,996 lin. ft.	905,478
4,940 permanent culverts	3,021,985
4,021 timber culverts	1,000,740

Total \$17,953,268

Mr. Hogeland did not give the number of pounds of steel, yardage of masonry, etc. He stated, however, that he used the following unit prices, to which he subsequently added 1/2 ct. per ton per mile for transporting the materials, so that these unit prices do not include the cost of transporting the materials:

Steel in bridges:	Per Ton.
Contract price ready to erect. f. o. b. St. Paul	\$65.00
Mill and shop inspection	75
Erection	12.00
Painting	2.25
	\$80.00

This is equivalent to 4 cts. per lb. erected, exclusive of the cost of transportation from St. Paul.

	Per
	Cu. Yd.
Masonry:	Cu. Yd.
First class	\$12
Second class	8
Concrete	6
Excavation, coffer dams, pumping, etc. variable.	
Timber trestles:	
Timber in place, per M.	\$31.50
Piling in place, per ft.	0.35
Wrought iron, per lb.	0.05
Freight to be added.	

	Per Lin. Ft.
Howe truss spans:	
44 ft.....	\$18.50
60 ft.....	27.00
75 ft.....	34.00
87½ ft.....	35.50
100 ft.....	37.50
125 ft.....	42.00
150 ft.....	45.00
Freight to be added.	
Howe truss timber, per M.....	\$25.00
Rods, plates, etc.....	0.03
Bolts.....	0.025
Freight to be added.	

	Per Lin Ft.
Vitrified pipe culverts:	
12-in. pipe.....	\$0.25
18-in. pipe.....	0.50
24-in. pipe.....	1.15
27-in. pipe.....	1.52
Freight to be added.	
Cast iron pipe culverts, \$30 per net ton, plus freight.	
Mr. Hogeland estimated 2,850 ties per mile of main track and 2,750 per mile of side track, at the following cost:	
Delivered on right of way.....	\$0.48
Train service and loading and handling.....	0.09
Burnettizing ¼ of all ties at 16 cts....	0.04
Transporting 500 mi. at ½ ct. ton mile	0.21
Total.....	\$0.82

He estimated 8,880 sets of switch ties as follows per set:

F. o. b. mill, per M.....	\$60
Transporting 500 miles, per M.....	15
	\$75

The rails for the main track averaged 68.1 lbs. per yd. and for the side track 60 lbs. Five rails per mile were added for "repair rails." The cost of rails was estimated to be:

	Per Gross Ton.
F. o. b. St. Paul, including handling....	\$32
Transp. 800 miles at ¼ ct. ton mile....	4
	\$36

Angle bars were estimated at 17,600 lbs. per mile of side track at a cost of:

	Per Net Ton.
F. o. b. St. Paul.....	\$40
Transporting 800 miles.....	4
	\$44

Bolts and nuts were estimated at 1,800 lbs. per mile of main track and 1,500 lbs. per mile of side track, at a cost of:

	Per Net Ton.
F. o. b. St. Paul.....	\$54
Transporting 800 miles.....	4
	\$58

Spikes were estimated at 6,500 lbs. per mile of track, at a cost of:

	Per Net Ton.
F. o. b. St. Paul.....	\$42
Transporting 800 miles.....	4
	\$46

Tie plates were estimated at 29,000 lbs. per mile of track where fully tie plated (or 5 lbs. per tie plate), and it was assumed that 2,451 miles were fully tie plated and 1,950 miles half tie plated, at a cost of:

	Per Net Ton.
F. o. b. St. Paul.....	\$45
Transporting 800 miles.....	4
	\$49

It was assumed that 750 miles of track were provided with rail braces at 2,000 braces per mile, at a cost of 10 cts. per brace.

Summary of track fastenings:

Angle bars.....	\$3,090,736
Bolts and nuts.....	431,288
Spikes.....	1,304,284
Tie plates.....	2,399,187
Rail braces.....	150,000
	\$7,375,495

Mr. Gillette testified that these items were substantially correct except as to the number of tie plates, which was very much overestimated.

Frogs and switches:

Complete turnout, f. o. b. St. Paul (3,750 lbs.).....	\$85.00
Transp. 800 mi. at ¼ ct. ton mile....	7.50
	\$92.50

8,880 turnouts (except ties) at \$92.50.....	\$821,400
302 crossing frogs at \$275.....	83,050
	\$904,450

The "complete turnout" includes switch stand and bolts, lamp, switch points, connecting and tie rods, plates, rail braces, clips, frog and guard rail, but does not include cross ties.

Mr. Hogeland estimated that 3,750 miles of the main track averaged 3,000 cu. yds. of gravel ballast per mile, and that 1,900 miles averaged 2,250 cu. yds. per mile. Of the 1,480 miles of side track, he estimated that 950 miles were ballasted with 1,500 cu. yds. per mile. This made a grand total of 16,950,000 cu. yds. of ballast on the system, the cost of which was estimated as follows:

	Per Cu. Yd.
Loading, unloading, putting under track and dressing track.....	\$0.27
Maintenance and repairs of steam shovels.....	0.05
Train service, hauling, repairs and rental of equipment, transp. of men, tools and supplies.....	0.30
	\$0.62

Mr. Gillette testified that this estimate of unit cost was fully 50 per cent more than

the actual cost as shown by the records of the G. N. and that gravel ballast could be placed for less than 40 cts. per cu. yd. under existing conditions.

Mr. Hogeland estimated the cost of track laying and surfacing as follows:

	Per Mile.
Curving rails, laying and surfacing....	\$350
Labor of tie plating (average).....	45
Train service and rental of equipment and hauling to front.....	390
Transporting men, supplies, etc.....	50
	\$835

Mr. Gillette testified that the item of train service was about three times higher than the actual cost, and that the transportation of men, etc., was even more excessive.

Mr. Hogeland estimated 4,611 miles of right of way fences at the following cost per mile:

	Per Mile.
Standard fence.....	\$150
Train service distributing materials....	10
Transporting men, etc.....	5
	\$165

He estimated the cost of crossings, cattle guards and signs as follows:

6,635.34 miles at \$75 for cattle guards, signs, etc.....	\$ 497,650
58 steel highway bridges (overhead).....	1,344,000
Timber bridges (overhead).....	80,510
	\$1,922,160

Interlocking or signal apparatus:

Interlocking.....	\$327,750
Block signaling.....	58,440
	\$386,190

Telegraph lines:

Labor.....	\$ 650,614.48
Material.....	1,295,207.46
Train service.....	16,638.00
Transp. men, tools, matl., etc..	219,598.22
Quadruplex instruments, batteries, furniture, etc., in 8 main offices.....	16,225.00
	\$2,198,283.16

This is equivalent to the following cost per mile of telegraph line:

	Per Mile.
Labor.....	\$ 98.00
Material.....	200.00
Train service.....	2.50
Transporting men, etc.....	33.00
Quadruplex instruments, etc.....	2.50
	\$336.00

Mr. Gillette testified that this was an excessive estimate, and that, so far as the state of Washington was concerned, the G. N. did not own a large part of the telegraph lines and that, in fact, it was the

common practice for railways to share the ownership of the lines with telegraph companies, as shown by the accounting records of the railways.

Passenger depots:

Seattle (one-half interest).....	\$ 295,000
Spokane	137,500
Grand Forks.....	37,500
Fargo	41,800
Sioux City.....	180,000
Minneapolis union depot.....	342,500
29 other passenger depots of brick or stone.....	419,600
705 frame passenger and freight depots	1,226,700
14 freight depots of brick or stone	422,900
Frame freight houses.....	172,800

Total\$3,276,300

The St. Paul union depot (of which the G. N. owns one-ninth interest) and the Superior depot (of which the G. N. owns one-third interest) are not included above, but are included under "right of way and station grounds." Mr. Hogeland did not give any dimensions of buildings, so that it is impracticable to check his estimates.

Shops, roundhouses and turntables:

Shop, St. Paul.....	\$ 854,400
Shop, St. Cloud.....	75,400
Shop, Superior.....	91,000
Shop, Barnesville.....	17,500
Shop, Sioux City.....	12,500
Shop, Devils Lake.....	60,000
Shop, Havre.....	91,000
Shop, Great Falls.....	42,000
Shop, Spokane.....	124,800
Shop, Everett.....	70,200
Roundhouses, frame, 88 stalls, at \$1,400	123,200
Roundhouses, masonry, 554 stalls, at \$2,100.....	1,163,400
Boiler houses, power houses and small shops	216,000
Turntables, frame, 10, at \$1,800	18,000
Turntables, steel, 57, at \$6,500.....	370,500
Cinder pits.....	140,000
Store houses, oil and sand houses and scrap bins.....	198,000

Total\$3,657,900

Water stations:

420 water stations (at \$4,722)....\$1,983,325

This includes tanks, pump houses, pumps, engines, wells, reservoirs and all appurtenances of water stations. It will be noted that this supplies one station every 16 miles of road.

Fuel stations:

52 standard coaling stations at \$9,500	\$544,500
52 platforms coaling stations, portion with cranes and buckets, \$600	31,200

Total\$575,700

Grain elevators:

Minneapolis	\$ 240,000
Superior, A and X.....	823,100

Superior S (steel).....	1,536,400
Seattle, Smith's Cove.....	108,600
Total	\$2,708,100

Storage warehouses:

Superior, flour shed.....	\$142,800
Five wool houses.....	19,800
Seattle, warehouse, Smith's Cove.....	113,900
Total	\$276,500

Docks and wharves (including dredging):

Superior No. 1.....	\$ 175,000
Superior No. 2.....	80,800
Superior Nos. 5 and 6 and mchy.....	449,500
Seattle, Smith's Cove dock.....	517,600
Total	\$1,222,900

Miscellaneous structures:

General office building, St. Paul.....	\$ 590,000
Division office buildings.....	18,000
Boarding houses.....	87,500
Section houses, bunk houses, hand car houses.....	853,500
Ice houses.....	107,500
Stock yards.....	157,600
Track scales.....	92,250
Snow sheds.....	295,000
Snow fences.....	450,000
Loading platforms.....	71,000
Quarry and crusher plants.....	45,000
Tie treating plant.....	85,000
Commissary buildings.....	15,000
Miscellaneous buildings.....	327,500
Total	\$3,194,850

Mr. Hogeland allowed 10 per cent of items 3, 4, 5, 10, 11, 16, 17, 19, 20, 21, 22, 23 and 25 for "contingencies," to cover the increased cost of the work due to unforeseen causes, such as fires, floods, tornadoes, accidents, etc. Mr. Gillette testified that, while an allowance for "contingencies" is certainly permissible in estimating the cost of projected work, it is not permissible in estimating the cost of completed work, particularly where the actual costs are on record for nearly all the work, as is the case on the G. N.

In estimating the interest charges during construction Mr. Hogeland assumed that the system, including equipment, would be unproductive for a period of two years. He assumed that it would take eight years to reproduce the system, 1,000 miles of track (main and side) being built per year, and that it would be two years after the beginning of the work before the first 1,000 miles would produce sufficient revenue to pay interest on the investment, and so on with the rest. Hence, two years at 5% is 10% of the total cost to be charged for interest.

It will be interesting to compare this estimate with the actual interest charges as taken from the ledgers of the different railway companies operating in the state of Washington. These data will be published in this journal in the near future, along with the other items of actual cost as ascertained by Mr. Gillette for the Railroad Commission of Washington.

For purposes of comparison with the estimated cost of the N. P. (published in our

April 15 issue) we append the estimated cost of the G. N., by items per mile of main and second track, as determined by dividing Mr. Hogeland's items by 6,635.34:

The mileage of the Great Northern under operation April 1, 1907, was: 6,635.34 miles main and second tracks. 1,480.24 miles side tracks.

8,115.58 miles total tracks.

There are 112.25 miles of second track included in the above, and it will be seen that there is 0.22 mile of side track per mile of main and second track.

	Cost of reproduction per mile of main and second track. (6,635.34 miles.)
Engineering	\$ 1,035
Right of way and station grounds.....	13,160
Grading	14,030
Tunnels	1,070
Bridges, trestles and culverts.....	2,705
Ties	2,820
Rails	4,680
Track fastenings.....	1,110
Frogs and switches.....	135
Ballast	1,585
Track laying and surfacing.....	1,055
Fencing right of way.....	115
Crossings, cattle guards and signs.....	290
Interlocking and signal apparatus.....	60
Telegraph lines.....	330
Station buildings and fixtures.....	495
Shops, roundhouses and turntables.....	550
Shop machinery and tools.....	270
Water stations.....	300
Fuel stations.....	90
Grain elevators.....	420
Storage warehouses.....	40
Docks and wharves.....	185
Gas making plants.....	2
Miscellaneous structures.....	480
Track and bridge tools.....	20
Stores and supplies on hand.....	815
Contingencies	2,300
Equipment	6,170
General and legal expense.....	563
Interest	5,690

Grand total.....\$62,570

Deduct right of way and station grounds 13,160 |

Cost, exclusive of right of way and station grounds.....\$49,410

Deduct equipment..... 6,170

Cost, exclusive of lands and equipment \$43,240 |

Plans have been completed for the erection of three new coke plants by the H. C. Frick Co., in the Connellsville region. They will cost \$4,000,000.

The average cost of all sweeping and cleaning of asphalt, asphalt block or brick streets at Rochester, N. Y., in 1906, was \$557.87 per mile, or \$32.175 per thousand square yards. The average width of street is 28 ft.