neer (vide Mr. C. W. Darley on leave), J. P. Mackenzie, M.I.C.E., Resident Engineer, September, 1881—June, 1186; E. W. Young, Resident Engineer, June, 1886 to April, 1889, when caisson was in order; Sir John Fowler, P.P.I.C.E., Consulting Engineer in England.

Contract No. 1.—Preliminary work down to coping level commenced February, 1883, and completed at end of year.

50,000 cu. yards of rock excavated.
17,000 cu. yards of soft soil excavated.
2,700 square yards scabbling.
Cost, less than £10,500.

Contract No. 2.—Coffer dam at entrance, and all necessary works except engine and boiler houses (work commenced early in 1884), and the preparation of the subaqueous foundations for sea wall. (These foundations were carried out by day-labour under Engineer-in-charge.)

Engine and Boiler Houses (Supplementary Contract).—The sinking of pump-wells for engines, and the erection of boiler and engine houses, excluding roofing, let as a supplementary estimate to Mr. E. L. Samuel; the buildings, including roofing, complete July, 1888.

Pumping Machinery.—Messrs. James Watt & Co. (erected by their agent, Mr. E. L. Samuel).

Caisson.—Messrs. Easton & Anderson (erected for them by their agent, Mr. E. L. Samuel.)

	Cost.
Graving Dock	£207,317
Pumping Machinery	15,478
Engine & Boiler Houses	6,441
Valves and Moorings, Cables, &c.	3,343
Caisson	17,140
Plant	7,517
Water Supply, roadway	2,639
Salaries	7,950
Total	£267,825

A few specimens of prices from the contractors' schedule (lowest tender of 15) :—

Ordinary Labourer, 10/- per diem.
Artisan and Mechanic, 16/- per diem.

Portland Cement, £6/5/- per ton.
Sandstone Ashlar (stone found on site), 3/6 cu. ft.
Granite Ashlar, 11/6 cu. ft.
Ironbark Piles, 4/3 lineal ft.
Oregon timber, 5/- cu. ft.
Wrought Iron, 35/- cwt.
Cast Iron, £15 per ton.

The cost of the work was approx. double the cost of similar work in England at that time, partly owing to the high cost of labour.

It will be noted that there is but little difference between the then rates for both materials and labour and those ruling immediately before the war commenced in 1914.

WORKS IN BRITISH COLUMBIA.

Introduction.

The standards of measurement in this country are practically the same as adopted in New South Wales, the most noteworthy exceptions being:—

(1) Brickwork, measured per cubic yard (in lieu of per rod).

(2) Timber, "per 1000 foot-board measure," M.F.B.M. (i.e., 10 times the amount of the N.S.W. standard of "100 feet reduced to 1in. thickness).

Whilst I was with the City Engineer of New Westminster, J. W. B. Blackman, M. Can., C.E., &c., &c., 1912-13, we had works, in hand or proposed, aggregating some $2,000,000.00, much of which was contract work, and the following prices are useful for comparison of costs of similar work here.

1.—PRICES OF MATERIALS.

Note.—There are two standard tons, viz., (1) Long ton (i.e., English ton = 2240lbs.; (2) Short ton (i.e., Canadian ton = 2000lbs.

The English equivalent of the money values is based on a rate of exchange of 4/2 to 1 dollar.

	$	English equivalent. s.	d.
Ordinary bricks, per thousand	14.50	60	5
Cement, 62/65 cents (2/7, 2/8½) per sack, barrel of 4 sacks (1 sack = 1 cu. ft.)	2.50	10	5
Gravel in bunkers .. yard cube	1.50	6	3
Road Metal in bunkers .. ,,	1.70	7	1
Sand in bunkers .. ,,	1.25	5	2½
Lumber, fir, from 1in. x 6in. to 3in. x 12in.	17.00 to 17.50	70 to 72	10 to 11
	M FBM.		
(Note the practice of giving smaller dimensions first. In N.S.W. larger dimensions are given first.)			
1in. x 4in. fir V-jointed ceiling, M FBM	40.00	166	8
Shingles (250 to bundle, av. width 4in.), 1000	2.00	8	4
W.I. in gully covers, 5 cents per lb	—	0	2½
R.S.Js., not fixed, 4 cents per lb.	—	0	2
Steel reinforcement, 6 cents per lb.	—	0	3
6in. C.I. pipe, F.O.B. New Westminster, long ton	43.6[illegible]	181	11½
Wood piping (for 200ft. head of water), per 100 lin. ft.—2in., 11.50 dol. (47/11); 3in., 12 dol. (50/-); 4in., 17 dol. (70/10); 6in., 25.50 dol. (106/5); 8in., 33.50 dol. (139/7); 10in., 42 dol. (175/-).			

2.—PRICES OF LABOUR.

(For City Contracts 8-hour day minimum.)

	$	English equivalent. s.	d.
Carpenter	4.00	16	8
Cement Worker	5.00	20	10
Electrician	4.00	16	8
Elevator Constructor	4.00	16	8

		English Equivalent.
Engineer (Mechanical)	4.50	18 9
Marble Cutter	5.00	20 10
Marble Cutters	5.00	20 10
Glass Workers	4.50	18 9
Lathers	5.50	22 11
Plasterers	6.00	25 0
Painters	4.00	16 8
Plumbers and Steam Fitters	5.00	20 10
Tile Layers	6.00	25 0
Sheet Metal Workers	4.50	18 9
Shingler	6.00	25 0
Structural Iron Workers	4.50	18 9
Stone Cutters	4.50	18 9
Granite Cutters	5.00	20 10
Bricklayers	6.00	25 0
Machinists	3.50	14 7
Labourers—		
Plasterers' and Bricklayers'	3.50	14 7
General	3.00	12 6
Teamster (team of 2 horses & teamster)	7.00	29 2

It will be noted that the prices are generally higher than those ranging here.

The highest-paid artisans were the plasterers, tilelayers, bricklayers and shinglers, at $6.00 a day (i.e., 25/-), but this high wage is, to an extent, counterbalanced by the fact of the limited quantity of work in these specific trades. For example, the majority of the residences are timber-framed, and, consequently, bricklaying is sometimes very scarce. Again, with reference to shinglers, although shingling is very much used for roof covering, and also for external walls, yet it is quickly fixed, and so this work is but intermittent.

3.—PRICES FOR PAVING.

Five distinct species of road paving were being laid simultaneously on various roads, and so the comparison of these prices is of particular interest. They were as follows:—

Yard sup.	$	English equivalent. s.	d.
(a) Bithulithic, including bituminous base	2.25	9	4½
(b) Hassam	2.25	9	4½
(c) Wood block, including concrete base	3.75	15	7½
(d) Vitrified Bricks, including concrete base	4.00	16	8
(e) Granite setts, including concrete base	4.75	19	9½

(And for further comparison it should be noted that macadamised roads were costing 50 cents per yard super = 2/1.)

The following particulars should be noted:—

(a) Bithulithic—a patent bituminous paving.—Some very fine roads were made of this paving, which readily lends itself to any necessary repairs.

(b) Hassam.—This paving was, practically speaking, of patent compressed concrete, 6in. thick, laid "in situ," and steam rolled.

(c) Woodblocks, Fir.—Size, 4in. x 4in. x 5in. to 9in. long.

(d) Brick Paving was for hill-climbing purposes, and an analysis of the cost of this is herewith given.

The actual measurements were taken over 100 yards lineal of roads, and the price, per yard super., worked out as follows:—

Yard super.	$	s.	d.
Vitrified hill-climbing bricks from Seattle (price delivered on site), per 1000	47.00	195	10
50 bricks to yard (including 1 closer and 2 culls)	2.35	9	9½
Labour laying, per yard	.10	0	5
Grouting (complete, including labour, cement and sand)	.06	0	3
	2.51	10	5½
Add profit, 10 per cent.	.25	1	0½
	2.76	11	6
Add 6in. concrete, 6-1 base, cost, including profit	1.25	5	2½
Total cost, per yard super.	4.01	16	8½

(Contractor's price was $4 (16/8) per yard.)

4.—APPROXIMATE AVERAGE COSTS OF WORKS, WITH ANALYSES IN SOME INSTANCES OF ACTUAL COSTS.

(a) Excavation for Sewers, excluding backfill—

(Value—30 cents per yard cube)

Feet	$	s.	d.
0-5 deep, per yard cub.	1.00	4	2
5-10 ,, ,, ...	1.50	6	3
10-15 ,, ,, ...	2.00	8	4
15.20 ,, ,, ...	2.50	10	5

(b) Cement Concrete—Analysis.

(6-1) per cubic yard.

(Specification required that the aggregate should consist of gravel or crushed rock and sand mixed in such proportions that the sand would completely fill the interstices between the stones.)

(6-1) Concrete in Sewer Manholes, &c., including forms—

	$	s.	d.
1 yard cube of aggregate (27 cu. ft.) ..	2.30	9	7
4½ sacks of cement (4½ cu. ft.) at 60 cents (2/6)	2.70	11	3
Labour, mixing, wheeling and placing—4 men at 2 hours each, or 1 man at 1 day	3.00	12	6
Forms, average, say	1.00	4	2
	9.00	37	6
Add 10 per cent. profit	.90	3	9
	9.90	41	3

Say, per yard cu., $10.00 = 41/8.

Concrete in Monolithic Sewers, per cu. yard $17.25 71 10½

(c) Sewers—

Supply and lay, per foot run.

Vitrified Drain			Glazed Cement			Reinforced Concrete		
4 inch	·30c	1/3	6 inch	·35c	1/5½	20 inch	$2·50	10/5
6 ,,	·40c	1/8	8 ,,	·40c	1/8	24 ,,	2·60	10/10
8 ,,	·50c	2/1	10 ,,	·50c	2/1	27 ,,	2·70	11/3
10 ,,	·60c	2/6	12 ,,	·70c	2/11	33 ,,	3·80	15/10
12 ,,	·70c	2/11	14 ,,	1·00c	4/2	36 ,,	4·00	16/8
14 ,,	1·20c	5/-	16 ,,	1·30c	5/5	39 ,,	4·70	19/7
16 ,,	1·60c	6/8	18 ,,	1·60c	6/8	48 ,,	6·60	27/6
18 ,,	2·00c	8/4	20 ,,	2·20c	9/2	54 ,,	7·50	31/3
20 ,,	2·40c	10/-				60 ,,	9·50	39/7
						00 ,,	10·80	45/-

(d) Tile (or Agricultural) Drain.—Analysis.

3 inch drain	per foot run.	
Pi,e	·04½c. ..	2¼d.
Laying	·02c. ..	1d.
Digging	·02½c. ..	1¼d.
Carting	·01c. ..	½d.
Gravel	·07½c. ..	3¾d.
Total	·17½c. ..	8¾d.

(e) Suspended Sidewalks—

These were sidewalks, or footpaths constructed on the main streets, in front of business premises, over basement areas, hence the term 'suspended in contradistinction to ' ordinary.'

SUSPENDED SIDEWALK.

Analysis of 280ft. Super.

Material.	Unit Price.		Cost.	
	$		$	
280ft. super "Shiplap" (i.e., boarding for Shuttering), delivered on site, or forms per 1000 FBM	15.00	(62/6)	4.20	(17/6)
300 run. 2in. x 4in. lumber, do., do.	11.00	(45/10)	2.20	(9/2)
5-1 approx. Concrete—				
34 bags of cement ..	.75	(3/1½)	25.50	(106/3)
6 yds. cu. of aggregate of gravel and sand	2.25	(9/4½)	13.50	(56/3)
280ft. super. reinforcement wire	.05	(-/2½)	14.00	(58/4)
Labour.				
2 Carpenters, 2 days each, per day	4.25	(17/8½)	17.00	(70/10)
Labour on concrete—				
4 labourers, 2 days ..	3.00	(12/6)	24.00	(100/–)
1 finisher, 2 days ..	5.00	(20/10)	10.00	(41/8)
Setting forms—				
1 formsetter, ¾ day ..	4.00	(16/8)	3.00	(12/6)
Striking forms—				
2 labourers, ½ day ..	3.00	(12/6)	3.00	(12/6)
			116.40	(485/–)
Add 10 per cent profit			11.64	(48/6)
			128.04	(533/6)

= 46 cents .(1/11) per ft. super.

(f) MACADAM ROADS.

Analysis.

	$	s.	d.
1 cu. yd. of rock = 6 super. yds. of roadway	1.70	7	1
Hauling by steam waggon	.65	2	8½
Spreading and rolling	.30	1	3
Topping	.30	1	3
Cost per 6 cu. yards	2.95	12	3½
„ 1 „	.50	2	1

50c = 2.1d.

(g) OILING ROADS.

This proved a very efficacious and cheap method of reducing the dust nuisance to a minimum. The roads were first swept of the top covering of dust, and the oil was then sprayed on from cart sprinklers.

The actual cost on 2.15 miles of road (from 12ft. to 16ft. wide) = 19,115 yards super., was—

	cents.	pence.
Oil, per yard	1.08	.54
Labour, per yard	.23	.115
	1.31	.655

Total, say 1 1-3 cents per yard = 2-3 of a penny.

(h) SHINGLING.

Analyses.

	$	s.	d.
Sawn cedar shingling, fixed to 4½in. "weather" or gauge), 800 to square, net at $2.50 (10/5) per 1000, square	2.00	8	4
Waste, nails and labour	2.00	8	4
Total cost per square	4.00	16	8

VANCOUVER SEWERS.

Approximate estimated average prices, ignoring disproportionate prices:—

	$	s.	d.
Excavate, solid rock in open cut, cu. yd.	3.28	13	8
Excavate, other material, cu. yd.	1.75	7	3½
Concrete—3 classes, cu. yd.	12.44	51	10
	11.27	46	11½
	10.36	43	2

Common brickwork masonry in cement, cu. yd.	18.50	77	1
Cast iron, per lb.	.054		2 7
Wrot iron, per lb.	.074		3·7
24in. dia. wood stave pipe, per ft.	1.42	5	11
Fir lumber, M FBM	19.64	81	10

These various prices I have quoted are sufficient to form as good judgment of comparison with similar work locally.

I will now proceed with the final section of my paper.

(c) WORKS IN BRITISH EAST AFRICA AND ZANZIBAR.

Introduction.

With reference to this part of the world the standards of measurements usually adopted differ, generally speaking, considerably from the methods adopted in this country. The practice in vogue is practically identical with the Indian custom, the "cubic foot" being generally used as a standard unit for concrete, stone, &c., &c., in lieu of the "cubic yard" adopted here, although this latter standard is being used more and more throughout Zanzibar. Amongst other standards may be specially noted that for the roof, which is measured "per square," inclusive of tiling (or other covering), battens, rafters, principals, eaves, gutters, downspouting, &c., and, in the case of a contractor tendering, his price per square is inclusive of all the above-mentioned items, which, of course, is quite different to the method in practice here, where the respective items are measured separately, viz., tiles per square, timber per 100 feet superficial reduced, gutters and downpipes per foot lineal.

Through the courtesy of A. R. Galbraith, Esq., M.I.C.E. (I), the late Director of Public Works, Zanzibar, I am able to give examples of costs of work from 1909 to 1914 at Zanzibar as follows. The English equivalents of the money values are based on the following rates:—Rupee equals 1s. 4d.; anna, 1d.; cent, 1/100 rupee; pice, 1½ cents:—

1.—PRICES OF LABOUR.

(8-hour day, P.W.D. rates.)

Unskilled—Swahili .. .. .. 8 anna = 8d.
Indian .. .. .. 8/12 „ = 8d. to 1/-
Also Swahili women, carrying and breaking stones, 36 cents = 5¾d. approx.

(It should be noted that one woman will break into 3in. stone 7 or 8 cu. feet per day.)

Skilled—
(a) Masons—Swahili .. 10/14 anna = 10d to 1/2
Indian .. 12 an. to 1 rupee = 1/- to 1/4
(b) Carpenters—Swahili .. .. 10/14 anna = 10d to 1/2
Indian .. .. 1½/2¼ rupee = 2/- to 3/-

The above rates seem extremely low, but it is necessary to recognise that a man can live on 2 annas (2d.) a day, his food consisting of rice, yams, &c.

In passing, it may be mentioned that even in Zanzibar they have their labour troubles as well as in New South Wales, as the Swahili, who is native-born, is of an ingrained indolent nature and, after working one day, will often absent himself from work for the following two days or so until his last pice is exhausted, when he reluctantly returns in order to earn the wherewithal for another prolonged rest.

2.—ACTUAL COSTS.

Work executed by day-labour at Chun Chun.

	rupee	s.	d.	
Excavation in hard rock, per cubic yard	8.37	11	2	app.
Excavation in soft rock, per cubic yard	4.94	6	7	
Excavation in soft soil (sand), cubic yard	3.01	4	2	app.
Excavation in soft soil (sand), cubic yard	3.01	4	2	
Concrete foundation walls of tank (1-2-3-mixture), per cubic yard	38.00	50	8	
Crushed stone, including quarrying, carting, stone-breakers, labour and materials, cubic ft.	25c.	0	4	
Stone, broken by hand, including quarrying and carting, cu. ft.	46c.	0	7	1-3 ap.
Ironwork for pile shoes, per lb.	23c.	0	3	2-3 ap.
Ironwork for manhole covers, per lb. ..	64c.	0	10¼	app.

3.—P.W.D. CONTRACT PRICES.

	rupee	s.	d.	
Quarrying stone, per 100 cubic feet ..	2/3	2	8–4	0
Carting stone, per 100 cu. ft. (per mile)	3	4	0	
Dealwood scantling and planks for scaffolding, per 100 sup. ft. (1in. thick)	11.70	15	7	app.
Cement, per barrel	9.75	13	0	
Cement concrete (1-2-4), per 100 cu. ft.	45/50	60	0–66/8	
Rubble coursed masonry of Bet-el-ras stone, and cement mortar, 100 cu. ft.	65/75	86	8-100/-	

4.—ESTIMATED COST FOR CONCRETE FOR HARBOUR WALL.

	rupee	s.	d.
Bet-el-Ras stone, per cubic yard	5.00	6	8
Breaking ditto to 1½in.	2.70	3	7 1-5
Sand (cost 2.50 per ton from M'Toni Creek)	1.25	1	8
Cement, per barrel	10.00	13	4
Mixing and depositing	4.00	5	4
Total per cubic yard	22.95	30	7 1-5

Say, 23 Rs. (30/8).

5.—CONTRACT PRICES OF MATERIALS.

(English equivalent of prices.)

(Note "frasila" is a weight unit of 35 lbs.)

	English equivalent		
	s.	d.	
Flat iron bars	3	1	per frasila
Teak beams	4	10	per cubic foot
Ditto, hand-sawn scantlings	5	4½	,,
Lime, in bags	1	8	per bag
Iron chains (½in. to 1in.)	6	0	per frasila
Mild steel	4	8	,,
Corrugated iron	4	2	,,
Coal, Welsh	57	4	per ton
,, Indian	36	4	,,

The foregoing prices are interesting for comparative purposes, and as such are quoted.

In conclusion, I have to gratefully acknowledge my thanks to the following gentlemen (in addition to those mentioned in the paper) for having supplied me with valuable data for inclusion in this paper:—

1. M. Cooper Day, Esq., Quantity Surveyor, Sydney.
2. G. H. Halligan, Esq. (by courtesy of J. Davis, Esq., M.I.C.E., Director-General of Public Works, N.S.W.).
3. Messrs. Morrow & Deputron, Architects, Sydney.
4. G. J. Oakeshott, Esq., Works Director for N.S.W. Commonwealth Dept. of Works and Railways.
5. H. D. Walsh, Esq., M.I.C.E. (Engineer in Chief, Sydney Harbour Trust).

Finally, I would reiterate that, in many instances, the various points have only just been touched upon, but it is hoped that what has been quoted will afford basis for an interesting discussion.

DISCUSSION.

MR. McEWIN: I have much pleasure in proposing a vote of thanks to Mr. Mitchell for the paper he has brought before us this evening, and I would like to congratulate him on the diligence he has displayed in getting up this information and the trouble he has taken in presenting the facts to us so clearly. He has shown us the methods used for estimating throughout the world, and the difficulties which arise in trying to arrive at a fair estimate when calculating costs. Engineers know how difficult this is, and in the building trade it is even more difficult. On a bill of quantities prepared by a Sydney quantity surveyor, in which prices ranged from £6,500 to £18,000, the man who quoted the smaller price got the job and made money out of it. In another case, where prices quoted were from £14,000 up to £40,000, the man who got the work lost £3,000 on it.