GOVERNMENT OF JAPAN.
PUBLIC WORKS DEPARTMENT.
Lighthouse Establishment.

Yokohama 24th Oct. 1874

H. E. Okuma Sanji.
Minister of Finance.

Dear Sir

Herewith I beg to hand you copies of my proposed plans for a Harbour in Yokohama Bay and my report and estimate of the same — I shall also send you in a few days a perspective view of the proposed scheme which will give you a better general idea of it — Trusting to hear from you soon concerning it

I am
Your Excellent servant
A Henry Brunton

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formation of a Harbour at Yokohama are 1st To provide a sufficient length of quay wall in water deep enough to take the largest and as many vessels as are likely to visit either this port or Yedo so as to enable all cargo for either place to be loaded or delivered with despatch and regularity — 2nd To afford a protection to vessels so that they

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Yokohama Harbour

The present open roadstead of Yokohama has ever since the introduction of trade to the port been the subject of complaint from shippers and shipowners on account of the want of facilities for the landing and shipping of cargo of the inconvenience and danger of communicating with ships in any but fine weather and on account of the want of protection to ships and the consequent damage done to them in the heavy gales of wind which occur. The roadstead at Shinagawa also, whither a large amount of trade is now carried in native owned steamers is nearly as exposed and further has the disadvantage that vessels cannot approach nearer than within 4 or 5 miles of Yedo — to which place all goods have to be carried in small boats. —

The objects to be attained therefore in the formation of a Harbour at Yokohama are 1st To provide a sufficient length of quay wall in water deep enough to take the largest and as many vessels as are likely to visit either this port or Yedo so as to enable all cargo for either place to be loaded or delivered with despatch and regularity. — 2nd To afford a protection to vessels so that

they

they may not be exposed to the heavy seas which occur at certain seasons and may at all times be easily communicated with. — 3rd " To make the harbour so that it can be directly connected with Leeds by Railway by this means it will offer the necessary accommodation to both ports — and secure the traffic of both. —

To accomplish this it is evident at the outset that a pier must be constructed on the Eastern or Seaward side of the present Bay as it is from the South and East that there is the longest fetch and consequently the heaviest seas. —

To give an increased length of quay wall another pier may be built on the West side of the harbour so enclosing a space which will be perfectly still in all weathers and will offer all the advantages of a wet dock. — These are the Principles on which the present design is made. —

Site of Piers — In deciding upon the best position for the Eastern Pier one object to be attained is to place it so that it will enclose as large a part of the present harbour as possible and in this way make the space available in the new harbour and another object is to get into deep water as soon as possible so as to secure a good length of available quay wall — These two objects militate

militate against one another because if the pier is placed far to the eastwards it would come upon the shallow spit which lies off the mouth of the creek.—
To avoid this the land end of the Eastern Pier is fixed at the Eastern end of the Bund and the pier then runs out towards the present P. & O. Buoy with a flat curve so that it encloses a large tract of water and at the same time gets quickly into deep water.—
The pier is made convex towards the sea and is formed with a radius of 5,000 feet— a convex form has been adopted as the southerly swell which occurs at certain seasons will strike it at right angles or thereabouts and this form is always preferable to a long straight pier in such cases.—
The curve is so flat that no inconvenience need be feared from vessels lying alongside it— as the curve in the form of the longest vessels is sharper than that of the pier and they will therefore always have a bearing against the pier amidships.—
The Western Pier commences at the sharp bend in the Longhit Hatoba so that advantage may be taken as much as possible of the existing

Hatoba

Batoba and goes towards the Eastern pier which it approaches very nearly at right angles.—
These two piers will then enclose a space of 112 acres and afford quay accomodation for six of the largest vessels and for nine of the smaller sized ones frequenting the port.—
There is a space inside the piers of about 45 acres having a depth of water of 15 ft and over at dead low water and with the allowance which is usually given for well sheltered harbours of refuge viz of 2 large ships to an acre this space would accommodate at moorings 90 vessels.—
The depth of water at the point of the Eastern Pier at the lowest spring tides is 28 ft and at high water it may be taken at 35 ft.—
The depth of water at the point of the Western Pier is 24 ft at low water and 31 feet at high water.—
Should circumstances demand it the lengthening of the Eastern Pier could be carried on to any distance and more quay accommodation could in this way be procured and in a greater depth of water.—
Likewise dredging operations would, at little cost or labour, give an increased depth of water if ever were needed.—
The length of the Eastern Pier according to the present design is 5,300 feet

Feet and the Western Pier 2420 Feet.—

Entrance The Entrance to a harbour is always designed on certain well known principles, in reference to the prevailing winds, the direction in which the silt in its neighbourhood is likely to travel and the complete protection of the enclosed space from the turbulence of the sea outside.— In regard to the prevailing winds at Yokohama those which are likely to cause any trouble at the mouth of the proposed harbour are the North East winds which generally blow during the winter months.—and its entrance is therefore pointed to the North West or in such a direction as will enable sailing vessels both to leave or enter the harbour during these winds while by the prolongation of the Eastern Pier it is effectually protected from the waves that such winds cause.— The prevailing winds in summer are from the South and a heavy swell comes into the Bay when they blow strongly but the entrance is also protected from this by the Eastern Pier.— In reference to the movement of the silt this generally travels from seaward and so there may be a slight collection at the back of the Eastern Pier but there is very little probability of any great deposit taking place at the entrance—

on account

on account of the nature of the bottom which is mud.—
The width of the Entrance is fixed at 450 Feet which is considerably more than the generality of Tidal Harbours in Europe.— Sunderland having an entrance of 315 ft. Aberdeen 378 feet. Flushing 426 feet. Ostend 197 feet. Dover 120 ft.—
This great width is given for the purpose of allowing Large vessels to lie along side the Eastern Pier at its extreme end where there is the greatest depth of water.—
From the entrance and all round it there is a clear space of about half a mile of water having a depth of water of 5 or 6 fathoms.— So that vessels entering or leaving the harbour have sufficient space to manoeuvre in before taking the entrance.—
The Northern spit buoy lies direct North from the entrance distant 1/2 of mile.—

Construction of Piers. To make the cost of the scheme as small as is compatible with efficiency those parts of the piers which are nearest the shore and are in shallow water are proposed to be made of wood.— while those parts in deep water alongside of which vessels will lie and which will be exposed to the heaviest seas

seas are to be formed with concrete — A considerable saving is in this way effected - as the cost of a concrete pier is nearly two and a half times that of a wooden pier of the same size — An objection might be taken to the wooden piers on account of the liability of the silt to wash through them and to fill up the Harbour but owing to the nature of the bottom which is mud there can be only a very slight movement of it and this may be at any time stopped if found necessary by a bank of rough stones along the outside of the wooden piers.—

Form of Piers — The first point to be taken into consideration in regard to the forms which the piers should have is the effect which the waves that they will have to stand is likely to have upon them.—

The Royal Commission on Harbours of Refuge which issued their report in 1859 gave it as the result of their investigations that in water deeper than 12 or 15 feet — waves were only oscillatory that is the water which composed them merely rose and fell but did not move horizontally and that therefore such waves do not exert any horizontal force further than that produced by their hydraulic pressure — Although there is still very great want of unanimity

in

in regard to this theory it is pretty generally conceded that the best method of treating these waves is to reflect them or send them back without breaking them and to accomplish this – a vertical wall if it be built of the proper material is best. The method adopted in breakwaters constructed in former years was to break the waves by a long artificial slope and to lead them up this till their strength became expended but this – it is now pretty generally allowed is wrong in principle. – because it has the effect of converting the merely oscillatory wave into a wave of translation. — the water itself then moves at more or less rapidity and its force and power are so increased and so rendered destructive. Following therefore the examples given at the piers at Tynemouth – Aberdeen the Sulina mouth of the Danube and the new breakwater at Dover. —

The outside face of the proposed piers are made practically vertical. —

They are given a slight slope inwards of 1/20 to 1 but this is merely to prevent any chance of overhanging from carelessness or want of skill in workmanship. — The inside face of the piers should also be as nearly as practicable ~~permit~~ plumb so as to prevent any possibility of the projecting portions of the bottoms of vessels grazing on it and it has also been given a batter of 1/20 to 1 for the same

same reasons — when fenders 1 ft deep are placed on it they will afford an effectual protection to it. —

In order to protect the roadway and also to afford as much shelter as possible to the vessels lying inside a parapet wall is proposed to be built at the backs of the concrete piers 10 ft high. — Along this a shelf 3 ft wide and 6 ft above the bed of the roadway is formed. —

The roadway is made with a slope of 1 ft in 100 towards the inside of the harbour so that the spray which comes over the parapet wall may run off. —

The width of the concrete piers is fixed at 50 ft over all — The minimum width decided on by various authorities for constructions intended to resist the waves is from 35 to 45 feet. —

Seven feet of this width of 50 ft will be occupied by the parapet wall and 43 feet will thus be left clear for traffic. — In this space two lines of rails are proposed to be laid and the roadway will all be covered with causeway blocks of stone. — Sufficient width will so be provided for both the railway waggons and for such carts, drays or other conveyances as are required for the traffic. — The thickness of the outside walls of the concrete piers has been fixed at from 13 to 11 feet at bottom diminishing to seven feet at top. —

The inside walls are from 11 to 9 feet

thick

thick at bottom and six feet thick at top. — These sizes are sanctioned by various well known authorities thus the Albert Harbour Greenock which is built of the same material as the proposed piers and in very similar circumstances regarding exposure has walls — 11½ feet thick at the base and 5 ft thick at the top. —
A thickness of 3 feet of loose rubble stones of a size of from 6" to 1 ft in diameter is placed inside the walls and will be built up simultaneously with them — The centre of the pier being filled up with earth or gravel. —
The height of the roadway above high water is proposed to be 8 feet which is also in accordance with various examples of dock walls and is the most suitable height for the class of vessels frequenting Yokohama. —

Material & Manner of Construction

Previous to the erecting the walls of the Concrete Piers a trench will be dredged out for them from 4 ft to 6 ft deep so as to ensure a solid foundation and prevent any undermining from a washing away of the earth below them. The walls will be formed by placing concrete in a liquid state between moulds which are made of the exact size and shape of the walls. — These moulds will be formed by driving piles about 6 ft apart on each

on each side of the wall, between which planks will be slipped down a groove which is formed on the piles for the purpose so forming a trench.— Inside this a lining of canvas is put and is sunk to the bottom with stones for the purpose of preventing the lime in the concrete being washed out by any movement of the water in the trench.—

The concrete after being thoroughly mixed and prepared is put into a box which is fitted with a moveable bottom and is lowered in it into the trench.— When it reaches the bottom a bolt is withdrawn and the concrete drops out. The dive will require to be at the bottom to spread the concrete so that it will fill all interstices and to properly consolidate it.—

When the concrete hardens sufficiently which will probably take place in about 3 or 4 months, the piles and planks forming the trench may be removed and used for another length of the pier.—

This Mode of construction has been largely adopted and with success in various parts of the world.— In some places in the South of Europe efficient sea walls have been erected merely by throwing the concrete into the moulds and allowing it to find its own way to the bottom, thus the Docks at all at Genoa were built by carrying the concrete

concrete as fast as it was mixed in baskets and throwing it into moulds which were formed something in the same way as above described.

But various Engineers think that in doing this there is a danger that during the passage of the concrete to the bottom the lime which is in it may get washed out and leave only the gravel and sand behind. Lowering it by means of skips or boxes is therefore proposed to be adopted in this case as the surest and safest method - & very generally adopted and also a very efficient method of building in concrete is by forming it into blocks allowing these to harden in the open air and then to build them on one another in the water as is done in stonework - but the objections to this in the construction of these piers are first that the blocks to be efficient require to be made in sizes weighing from 5 to 10 Tons and the appliances necessary to move such heavy weights are so difficult to procure in Yokohama that this would greatly add to the cost of the work - and Second that to build these blocks on one another and also to form a fair even and hard foundation for them would necessitate very extensive diving operations which are always slow & tedious and most expensive. —

Many

Many Engineers have borne testimony to the thorough efficiency of walls built by putting the liquid concrete into moulds. Some have passed it through as great a depth of water as 60 feet with success and many great works have been executed on this principle. —

A graving dock at Toulon which is 100 ft. wide. — the walls of which are 16 feet thick and which was built in 40 ft. depth of open water was made by first forming a trough round the proposed dock of the same width as the walls. filling this with liquid concrete and then pumping out the water from the enclosure so formed. — It is without doubt the most inexpensive system and best suited for such works as the proposed piers and especially in Yokohama where both skilled labour and machinery are difficult to procure. —

The concrete is proposed to be formed of

1 part of lime
½ part of volcanic sand
1 part of clean sharp sand
4 parts broken stone

These proportions have been judged by certain experiments which have been made to be the best suited for the material to be procured here. —

Though further investigation may perhaps cause them to be slightly modified. —

They

They approximate pretty nearly with those in use at other works of a like nature thus at Greenock the quantities were —

1 part of lime
½ part of mine dust
1 part of Sand
3 parts gravel

In London what is generally used is. —

1 part Portland Cement to
6 or 8 parts of Thames gravel. —

while at Port Said Breakwater the blocks were formed of 1 part of lime to 15 parts of sea Sand. —

The proportions naturally depend on the qualities of the different substances and it would be advantageous before the works were actually commenced to have an analysis made of them —

The lime proposed to be used will come from extensive quarries near Omaisaki in Tohodomi. —

This lime has a good reputation with the Japanese — It however is not a hydraulic lime or it has not the property of becoming hard under water. — The Hydraulic limes in use in England contain as much as 40 per cent of foreign matter such as clay, silica, magnesia &c — and to form hydraulic lime from the pure lime these substances must be added to them in the necessary proportion Puzzolona, or volcanic Sand is

known

is known to be composed of these or similar substances and it therefore, when mixed with lime makes it hydraulic.
Thus the Puzzolona found in Italy contains 45 per cent of silica 15 per cent of clay 9 per cent of lime 5 per cent of magnesia the remainder being made up of water soda and oxides of iron.
The volcanic sand which is to be had in large quantities in the Province of Iden is presumably of the same nature Its outward appearance is similar to that got in Italy it being of a dark brown & dirty red colour with innumerable cavities like a cinder. The lime stone should, in such large works as the proposed be brought to Yokohama and burned in kilns specially made for the purpose here.
After having been calcined it should be ground up and mixed with the volcanic sand in mortar mills in such quantities as are required for the due prosecution of the work.
All projecting angles as also the top surfaces of the concrete walls will be protected by masonry formed of the hard trap rock which is procured from Iden. Those coping stones on the top of the Parapet wall will be held together by large Kiaki joggles so that the sprays or waves that strike them will not be liable to displace them.

The

The estimated relative cost of building in concrete as proposed and building in stone is as follows.—

Concrete 2.25 yens pr. cubic yard
Stone — about 20 yens pr cubic yards

so making concrete about 1/8th of the price of stone.— The causeway of the roadway which will be formed of hard stone will be laid in a bed of concrete 1 foot thick below which there will be a layer of gravel also 1 foot thick— The stones will be well grouted with lime or cement so as to make the roadway as impervious to water as possible. Double fenders will be placed on the pier at distances of 44 ft apart which will be made of Kiaki and secured to the walls by means of strong iron fixings.—

Mooring posts will also be placed 40 ft apart which will be made of Kiaki and will be 1'6" square— They will be solidly built in with masonry so as to enable them to withstand the greatest strain which is likely to come upon them— Four sets of steps will be placed on each pier— to facilitate landing from boats or for the discharge of cargo from small craft.—

The ends of each pier will be enlarged to 70 feet wide and on each will be built a small lighthouse and watch house.—

A large capstain will also be placed in

in a convenient position which will be of use in rendering assistance to vessels which may leave got into trouble at the entrance. I — In order to protect the concrete walls as far as possible from any chance of disintegration by the washing of the water upon them, and also to make a hard crust which is unlikely to be destroyed by anything striking or rubbing against it a coating of cement plaster 3/4" thick is proposed to be laid over the whole exposed surface above low water. — For the part between low and high water Roman cement will be used as it sets very quickly and is so leashable to be destroyed by the water before it becomes hard but above High water Portland cement will be used because although it sets slowly it becomes much harder than the other. — The wooden Piers are designed after the model of Folkestone piers and the scantlings of the timbers are pretty nearly the same. —
The Piles are 12 inches square and will be driven into the earth by steam pile drivers until they will sustain all the weight which it is possible can come upon them. —
It is proposed to cover each pile from where it enters the earth to near High water mark with sheet copper or Muntz metal weighing 16 oz to the superficial foot — This will protect them

them from the worms known as the "Teredo Navalis" which are very distinctive in these waters. —
There will be six piles in each bay and the bay will be 20 feet apart. —
On tops of those will be placed cross and longitudinal beams on which will be securely spiked — planking 3 inches thick
There will also be diagonal struts and stays between each pile as well as cross wathings further to stiffen the structure —
The whole wood work will receive two coats of the best coal tar and at those places where the surfaces of two pieces of timber touch each other a coating of asphangh tar will be given. — The joints will further be caulked to prevent any moisture getting in to them and so rotting the wood. — The whole framework will be securely bolted together with galvanized iron bolts, and iron straps will also be employed where necessary —
A wooden handrail will be placed at the back of the Eastern pier but this will not be required at the Western pier as vessels may, at times, lie on both sides of it. —
The wood used in these piers is proposed to be Japanese Matz but it is a question which should have full consideration whether Oregon pine should not be imported from America for the purpose. —

Yrs

Its price laid down in Yokohama of the necessary sizes will be about 5b per per cubic foot and this is about the same as the average price of Hatz.- It is a finer wood than Hatz and will probably last a much longer time.— And further such large quantities of seasoned wood as are required could be delivered in Yokohama in less time from America than the same could be procured in Japan on account of the custom of the Japanese not to store wood in large quantities.—

It is most essential that neither green wood or wood that has not been properly seasoned should be put in the Pier.—

Railway— A double lines of rails is proposed to be laid along each Pier to their extreme ends also along the shore between them and as far along as the present custom house sheds.— The Railway must however be eventually connected with the Yokohama and Yedo Railway so as to enable goods landed at the Harbour to be taken directly to Yedo.—

The rails are proposed to be flat bottomed rails weighing 40 lbs to the lin yard laid on longitudinal sleepers which will be fixed on cross sleepers placed 4' 6" apart.—

P.T. The whole

The whole will be secured together by ½" fang bolts.— The sleepers will be laid on a bed of concrete about 1 foot deep.—

Extension of Shore — It is proposed to extend the shore in front of the present Pound for a distance of from 150 to 200 feet.— The stones in the present wall may be used in the new face wall.—
The ground so made will be required during the construction of the Piers for the necessary operations of building also for storing lime stone wood &c and for erecting the temporary buildings & machinery required.— It may afterwards be formed into an esplanade or gardens or may be used as a site for warehouses as may be decided on.—

Mooring Buoys — In under certain circumstances it may be desirable to keep vessels away so that they will not touch the Piers, buoys are proposed to be fixed by means of screw moorings along the inside of both Piers at a distance of about 100 feet from them and 400 feet apart.— To these outside moorings may be attached from each vessel.— Besides these various buoys are proposed in the interior of the harbour for the purpose of swinging or turning vessels

vessels by—

Method of carrying on Works. The first thing to be done is to fill in the proposed space in front of the Bund.— to build the face wall for it and to prepare it for the temporary erections.— Temporary staging required for carrying the pile drivers &c should then be erected and the wooden piers completed.— The concrete piers might then be proceeded with.— but in the meantime the apparatus required in burning the lime stone, grinding the lime, and puzzolona and mixing the concrete should be got ready for work and suitable quantities of all materials should be got upon the ground.—

Estimate The following is an abstract of the cost of the proposed work.—

East wooden Pier	101185.84
East concrete Pier	304914.31
West wooden Pier	90946.50
West concrete Pier	225,636.
Extension of Shore	96.055.
Railway	28.698.90
Mooring Buoys	11.900.
Lighthouses	10.000
Capstains	600
Carbeam Superintendence	46,260
Machinery	41.595—
Temporary Erections	91.211
	1029.003.26
Add for Contingencies 5 %	51.450.16
	$ 1,080,453,42

The Prices taken in the above estimate are the prices which are at present paid for small quantities.— These would in all probability be considerably reduced with proper steps taken for their delivery in large quantities such as would be required for these works.—

Probable Time of Completion— To get the machinery required and also to procure the supplies of material to make an effective commencement to the works would probably occupy about 9 months or 1 year from the time of sanction to the execution of the scheme being given.— The extension of the shore however as well as the erection of the temporary staging might be completed before this.— The wood required for the piles and frame work of the wooden Pairs would also be prepared and fitted during this time— Their creation might probably take about 9 months more— and after their completion the concrete piers should be proceeded with— They would, most likely occupy 18 months in construction so making a total of 3 years for the entire completion of the scheme.—

Probable Revenue.

The advisability of proceeding with an extensive work of this nature depends entirely upon the requirements of the Port and the likelihood of remunerative return which

which it may afford — on judging on this point before a few facts may be of use.— —In 1870 the number of foreign vessels which entered the Port of Yokohama was 721.— They having a Tonnage of 536.662 Tons the average size of each vessel being 744 Tons.— The tonnage has considerably increased during late years at Southampton which is known as a harbour having a large export trade and only a small coasting trade.— —In 1859 the number of vessels which entered the port was 1,014 and their Tonnage was 323,361 Tons, the average size of each vessels being 318 Tons— Though Yokohama receives a smaller numbe of vessels than Southampton they are of more than twice the average size of those visiting Southampton and the aggregate tonnage of the shipping at Yokohama is therefore considerably more.—

The exports and imports at Southampton amount in value to nearly £7.000,000.— Those at Yokohama in the Years above named to $34,851,482.— Yokohama therefore exceeds Southampton by about $3,000,000.— The customs duties received at Southampton amounted to £127.072.— those at Yokohama to 585,318 dollars.— those are therefore very similar and both ports have had a great increase of Customs duties.—

The Duck

The Docks at Southampton have cost nearly ½ a million sterling while the proposed harbour in Yokohama will not cost more than half of this sum. The Dock Dues payable at various ports in England, taking all charges into consideration average about 1/6° per Ton. — Thus in London Docks the charge is from 1/- per ton for coasting vessels up to 2/6° per ton for foreign going ships. —

At Liverpool the rate is 1/3° per ton and at Dundee 1/9° per ton.

Taking the tonnage of Yokohama as in 1859 — at 536,662 Tons, and adding to it 100,000 Tons as that which now goes to Yedo the total estimated tonnage which would be likely to enter the proposed harbour will be 636,662 Tons per annum. —

And should an average rate of 50 Sen or 1/5° per ton be charged on this which is lower than the usual dock rate in England a revenue would be realised amounting to 190,998 dollars or about 18 per cent on the estimated expenditure. —

H. Pemy Brunton

Yokohama Harbour

Quantities and Estimate of the Stone, Wood, Iron, and other Work in the formation of Two Wooden and Two Concrete Piers in Yokohama Harbour

Quantity	Description of Work	Price	Amount Yen	Amount Sen	Total Yen	Total Sen
	Machinery					
1	One dredging Machine working on a platform (Furness & Slaters patent) to raise 25 yds: of stuff per Hour from a depth of 40 feet		10,000			
4	Four diving dresses & Gear	950	3,800			
8	Eight Concrete Mixers, Ridleys patent to work by hand & to mix 40 c yds: per day	500	4,000			
2.	Two Mortar & Crushing Mills dia: of pan 8ft: to produce 18 c yds: per Hour	470	940			
2.	Two 6 horse power protable Engines to drive Motar Mills	1,100	2,200			
2.	Two steam pile driving Machines Height 35 ft Weight of Monkey 1 Ton	1,200	2,400			
1	One hand pile driving Machine of 30 feet height Weight of Monkey 1/2 Ton		260			
2	Two Travelling Cranes (Hand) to lift 3 Tons	700	1,400			
	Carry forward		25,000			

Quantity	Description of Work	Price	Amount Yen	Amount Sen	Total Yen	Total Sen
	Brought forward		25,000			
6	Sets Double purchase crab Winches to lift 3 Tons	60	360			
	Boats, Punts, Steam Tug and other vessels required, say		7,000			
6	Sets Concrete Wagons, slow frame Wrought iron Body Castion Wheels with bottom doors	125	750			
10	Iron iron Earth Wagons to hold ½ Cyd: with Turntable body	50	500			
	12,000 yards Contractors Rails at about 24lbs: per yard with spikes for Do					
150	Say 150 Tons	90	13,500			
Tons 2	Chains 1/4"	180	360			
" 3	Do ½"	120	360			
" 3	Do ¾"	110	330			
Coils 50	Rope 2"	18	900			
" 50	Do 3"	40	2,000			
" 50	Do 3½"	55	2,450			
" 20	Do 4"	45	1,500			
Inches 1000	Assorted Blocks	15	150			
			55,760			
	Deduct 25 % for value after Completion of Work		13,865		41,595	00
	Temporary Erections					
Cubes 140	2 Wooden sheds for Mortar Mills 100 feet x 50 feet	25	3,500			
	Carry forward		3,500			

Quantity	Description of Work	Price	Amount Yen	sen	Total Yen	sen
	Brought forward		3,500			
	Temporary Erections Contd:					
Nos 280	1 Store for Lime 200'x50'	25	7,000			
" 140	1 Do for Tools and spare Machinery 100'x50'	25	3,500			
" 50	1 Office 60'x30'	35	1,750			
" 100	Small sheds for workmen & various	20	2,000			
c/ft: 100,000	Wood work including driving & carpenter work in piles & platform to carry pile driving Machines, Concrete Mixers & Waggons &c say 3000' in length	Sen 60	60,000			
Cwt: 225	Iron straps & T Bolts in Do	10	2,250			
" 161	Do shoes for piles	5	805			
No: 5000	Do spikes 6"	Sen 30	1,500			
c/ft: 50,000	Wood work including driving & Carpenter work in guide piles planks for face of Concrete walls say 1000' in length	Sen 60	30,000			
Cwt: 400	Iron work in Bolts, Screws, plates in Do	10	7,000			
" 62	Iron shoes for piles	5	310			
	Scaffolding poles &c		2000			
			121,615	00		
	Deduct 25% for Value after Completion of Work		30403	45	91,211	25

Quantity	Description of Work	Price	Amount Yen	Amount Sen	Total Yen	Total Sen
	East Wooden Pier					
	Length 1300 feet average depth of water at low tide 4½ feet					
	Timber Work in Pier					
Lmft 21400	Driving 470 piles say 10' into the Ground	Sen 40	1,880			
Cft 10725	In Piles of Mats squared & dressed Length under 30 ft	" 45	4,826	25		
" 2364	Xo Xo Length under 40 ft	" 55	1,201	85		
" 4029	In Cross Walings Mats - Length of Wood say 30 ft	" 46	1,853	34		
" 4740	In Cross Diagonals Mats Length of Wood say 15 ft	" 33	1,564	20		
" 9954	In Length Diagonal Mats Length of Wood say 20 ft	" 33	3,284	87		
" 6,044	In Cross Beams Mats Length of Wood say 30 ft	" 46	2,780	24		
" 28,760	In Longt Beams Length of Wood say 50 ft	" 75	21,195			
" 17,172	In Planks 3" thick Mats planed & Dressed Length 30 ft	" 50	8586			
" 4,200	In Xo for raised platform at rails	" 50	2,100			
" 1,550	Kiaki Coping for pier on both sides in 30' lengths dressed	" 1	1,550			
" 821	Handrail at back of pier of Shenoki fitted together	Sen 75	615	75		
	Carry forward				5,955	45

Quantity	Description of Works	Price	Amount yen	Amount sen	Total yen	Total sen
	Brought forward		51,434	45		
	Timber Works in Pier. Contd:					
c/ft 525	Fenders Kiaki dressed & fitted in 15 ft Length	Sen 80	420			
" 300	Kiaki bleat at bottom of framework	" 85	255			
" 1005	X° at Top X°	" 85	854	25		
" 1760	Kiaki Corbels on top of piles	" 85	1496			
	Timber work in 2 sets of Steps					
c/ft 350	In Horizontal, Diagonal & upright supports for steps Hatz in 20' Lengths	" 35	185			
" 105	Planking of steps 3" thick Hatz	" 50	52	50		
" 24	Fenders dressed & fitted Kiaki	" 80	19	20		
" 180	Extra piles. Hatz average length 30'	" 45	81			
Lin ft 60	Driving Do. 10' into Ground	" 40	24			
	Iron Work in Piers					
Pcs 2510	6" Gal: iron spikes for planking	" 30	693			
" 90	12" X° X° for Coping	" 75	67	50		
lbs 53,990	Wrought iron straps at crossings of Lon: cross Beams	" 18	9,718	20		
" 1,098	Wrought iron straps for fixing fenders	" 18	197	64		
Cwt 99	3/4" F. Bolts for straps at crossings of Lon: & cross Beams	8	792			
" 45	1" F. Bolts for cleats at top of piles	8	360			
" 23	3/4" X° X° X°	8	184			
" 66	1" X° for Diagonals at X°	8	528			
" 66	1" X° for X° at bottom of framework	8	528			
	Carry forward		67,892	74		

Quantity	Description of Work	Price	Amount Yen	Sen	Total Yen	Sen
	Brought forward		6,592	14		
	Iron Work in Pier bented:					
feet 23	3/4" Bolts for Cleats at bottom of frame work.	8	184			
" 27	3/4" Do for Waling pieces	8	216			
" 15	3/4" Do for fixing handrail	8	120			
lbs 968	Straps for tops of Handrail	Sen 8	136	44		
feet 1¼	1½" Bolts for Do	9	11	25		
lbs 17550	Mooring Rings & fastenings 165	Sen 25	4,387	50		
feet 125	Pile shoes with Cast iron point 30 lbs. Weight 270 in all	5	630			
	Iron Work in 2 sets Steps					
Nos 28	6" Gal: Iron spikes for steps	Sen 30	8	40		
lbs: 440	Extra straps for crossings of Beams	" 18	79	80		
feet 1	Bolts for fixing fenders	8	8			
lbs: 80	Rings for Bolts on small fenders	Sen 18	14	40		
feet 1	3/4" Bolts for extra straps	8	8			
" 3/4	1" Do for cleats at tops of extra piles	8	6			
" 1	3/4" Do for Beams supporting steps	8	8			
lbs 720	Iron Railing at steps	Sen 25	180			
" 437	Chain 3/8" for Do	" 8	34	96		
feet 2	Pile shoes extra required (6)	5	10			
	Copper covering piles up to say 4' above low water line with Muntz metal weighing 19oz: to the sq: ft:					
lbs: 25588	B.W.O. 24	Sen 25	6,397			
" 2692	Copper tacks for Do	" 60	1	576	40	
	Carry forward				8,1,942	89

Quantity	Description of Work	Price	Amount Yen	Amount Sen	Total Yen	Total Sen
	Brought forward		81942	89		
	Tarring, Painting &c.					
Sqyd 52,333	Covering whole of Timber with 2 coats best coal Tar	Sen 12	6279	96		
" 5,233	Coating with Archangel Tar all joints Crossings, Bottom of planks &, all where Timbers Come in Contact with each other	" 12	627	99		
	Caulking all joints with Oakum		1,000			
" 1290	Painting 3 coats of Oil Paint Handrail at Steps & Railing at back of Pier	" 25	322	50		
	Labour					
	Carpenters works required in fitting & fastening Beams					
Yen 15000	100 Men for 6 Months	" 45	6750			
	Labourers for various purposes					
" 9000	60 Men for 6 Months	30	2,700			
" 500	Painters 10 Men for 2 Months	" 50	250			
	Blacksmiths for fitting Bolts &c					
" 1500	10 Men for 6 Months	" 50	750			
" 750	5 Foreman for 6 Months	" 75	562	50		
					101,185	84

185

Quantity	Description of Works	Price	Amount Yen	sen	Total Yen	sen
	East Concrete Pier					
	Length 2000 feet, average depth of water at low water spring tides – 21 feet					
C.yd. 9344	Dredging Trenches for foundation calculated at slopes of 1 to 1	Sen 30	2803	20		
" 9344	Depositing stuff in front of Pier	" 20	1868	80	4672	
	Concrete & Masonry					
	Concrete to be composed of 1 part of unslaked Lime ground in Mill – 1/2 part of Volcanic Sand ground in Mill – 1 part of clean sharp Sand – 4 parts gravel & broken Stones –					
	Cost of Do					
2/13 cyd:	Lime per cubic yard	4		6½		
1/13 "	Volcanic Sand "	2½		19¼		
2/13 "	clean Sand	Sen 38		6		
8/13 "	gravel or broken stone	1/2		92½		
	Grinding & mixing Cement in Mortar Mills 3/13 cyd: per cyd:	Sen 8		1¾		
	Mixing Cement, Gravel in Machine 1 cyd: C	" 15		15		
	Conveyance of Materials & depositing in place in Pier	" 20		20		
		for Cubic yard	Yen 2	25		
	Carry forward		88		4672	

Quantity	Description of Work	Price	Amount Yen	Sen	Total Yen	Sen
	Brought forward				1692	
Cyd. 55356	Liquid Concrete in walls	2.25	125,030	25		
" 3621	Concrete in Blocks in Parapet wall	3.00	10.863			
" 2760	Do below Roadway	2.50	6.900			
" 20170	Rubble backing in Stones of from 6" @ 1' dia:	1.30	26,221			
" 65,653	Filling in centre with Earth &c	Sen 40	25,453	20		
Cft. 18,882	Ashlar Copse on top of inside wall in Stones 4'×3'×1'6"	" 65	12,273	30		
" 18,882	Dressing & putting Do in place	" 30	5,664	60		
" 12,150	Ashlar Copse on top of parapet in Stones 4'×4'×1'6"	" 65	7,897	50		
" 12,150	Dressing & putting Do in place	" 30	3,645			
" 24,300	Ashlaring Course on outside wall 4'×4'×1'6"	" 65	15,795			
" 24,300	Dressing & putting Do in place	" 30	7,290			
" 2,924	Pavement on shelf of parapet in Stones 3'×1'6"×6"	" 35	1,023	40		
" 2924	Dressing & putting Do in place	" 25	731			
" 198	Pavement on 4 sets of steps of parapet 3' wide × 9" tread × 6" rise	" 35	69	30		
" 198	Dressing & putting Do in place	" 25	49	50		
" 192	Pavement on 2 sets of steps, Stones 4' wide × 9" tread × 6" rise	" 35	67	20		
" 192	Dressing & putting Do in place	" 25	48			
" 144	Ashlar at Corners of 2 sets of steps Stones 2'×1'×1'	" 35	15	40		
" 44	Dressing & putting Do in place	" 25	11			
	Carry forward		249,047	65	1692	

Quantity	Description of Work	Price	Amount Yen	Amount Sen	Total Yen	Total Sen
	To Brought forward		249044	65	4672	
Cft 8593	Masonry round Mooring Balls say 5 Tons in No. Stones 3'x2'x12"	Sen 35	3,007	55		
" 1,872	Ashlar foundations & Top Blocks	" 65	1216	80		
" 10,485	Dressing & putting in place	" 25	2616	25		
" 2,777	Gravel under Roadway	" 60	1,666	20		
" 36,703	Square Stones for Causeway 10"x6"x6"	" 35	12,846	05		
" 36,703	Dressing & putting in place grouting with Lime & beating firmly down	" 25	9175	75		
Syd: 3220	Coating all exposed concrete below high water with a layer of 3/4" thick of Roman Cement plaster mixed in equal proportions of Sand	" 32	1030	40		
" 6,695	Coating all Concrete above high water with a layer of 3/4" thick of Portland Cement plaster mixed in equal proportion with Sand	" 40	2677	20		
Barrels 500	Pointing Copes & pavements with pure Portland Cement	1	500			
					283	83 85

Cost of Cement Mortar per Sq. yd.

1/3 Bucket Portland Cement	0.33
1/3 Sand @ 3 Sen	0.01
Work Mixing & laying on	06
per Sq. yd. Sen	40

Larry Sawyer

288 455 85

Quantity	Description of Work	Price	Amount Yen	Sen	Total Yen	Sen
	Carry forward				278455	85
	1/3 Bushel Roman Cement : 75 Sen	.25				
	1/3 Sand 3 "	1				
	Working Mixing & Laying	6				
	per Square yard	Sen 32				
	Wood work					
c/ft 1363	Kiaki in fenders dressed & fitted in 15 ft lengths	Sen 80	1090	40		
" 1720	Kiaki joggles to go through all Coping stones at joints	" 85	1462			
" 819	Kiaki in mooring paths 3-2 in number 9 ft lengths	yen 1	819			
" 40	Kiaki in small fenders @ 2 sets of steps	Sen 85	59	50	3420	90
	Iron Work					
	Fastenings for fenders					
lbs 15890	Malleable Iron Brackets	20 ct	3174			
" 6490	Iron Bars - laid in concrete as fastenings for Bolts	Sen 18	1168	20		
" 3780	1" Bolts for fixing Do	" 20	756			
" 3928	Steel Keys for Do with Nuts	" 50	1864			
	Fastenings for small fenders steps					
" 454	Wrought iron dovetailed studs	" 18	81	72		
" 112	Lead Batting for top Do	" 10	11	20		
" 141	Steel Keys for Bottoms Do	" 50	70	50		
Cwt 1/4	3/4" Bolts for Do steps	Yen 8	2			
lbs 36	Mooring Rings for Do	Sen 20	7	20	7091	34
	Carry forward				291886	76

Quantity	Description of Work	Price	Amount Yen	Sen	Total Yen	Sen
	Brought forward		707	37	291886	75
feet	1/4 3/4" Bolts for mooring Rings & Bottom	8	2			
lbs.	425 Iron Railing round. 2 sets of Steps	Sen 25	106	25		
"	524 Cast iron sockets for Z Bs	" 15	78	60		
"	50 Wrought iron bats & Screw Bolts	" 25	12	50		
"	198 3/8" Chain	" 8	15	84	728	56
	Tarring Painting &c					
Sq. yds.	740 Covering fenders with 2 coats best Coal Tar	Sen 12	88	80		
"	165 coating inside of fenders where it comes in contact with pier with Archangel Tar	" 12	22	20		
"	20 Painting all iron work of fenders & hand Rails with 3 coats of Oil paint	" 25	5		116	
	Labour					
	Extra men required in carrying Material &c. for various purposes					
men	15000 50 Men for 1 year, Labourers,	" 30	4500			
"	1500 5 foremen for 1 year	" 75	112	5	5625	
					300912	31

Western Wooden Pier   Length 940 feet
average depth at low water Spring tides 15 feet

— Quantities Compared with East Wooden Pier —

	Plus		Minus	
In East wooden pier 10725 cft piles = 8.25 cft per lin foot				
" West " 10716 " " 11.40 " "				
Difference 3.15				
940' x 3.15 = 2961 cft extra piling @ 55 Sen —	1628	55		
Less for Curve at end next bend, Piles 2184 cft @ 45 Sen			982	80
" " " Crosswaling 714 " @ 46 "			328	44
" " " Diagonals 840 " @ 33 "			277	20
" " " Lon^l Do 1764 " @ 33 "			582	12
" " " Cross Beams 1071 " @ 46 "			492	66
" " " Lon^l Do 4860 " @ 75 "			3,645	—
" " " Planks 2953 " @ 50 "			1,468	
" 100 x 18 x 12 Raised Do at rails 300 " @ 50 "			150	
" " " Kiaki Coping 250 " @ 1 yen			250	
" " " Do Corbels &c 410 " @ 85 Sen			348	50
" " " 6" Spikes Doz 393 @ 30 "			117	90
" " " Straps 9570 lbs @ 18 "			1,722	60
" " " Bolts &c 68 Cwt @ 8 yen			544	
" " " Pile shoes 21 " @ 5 "			105	—
" " " Taring 10,000 Sq: yd: @ 12 Sen			1200	
" " " Archangel tar 1621 " @ 12 "			194	52
" " " Caulking joints			200	
Less Handrail at Back of pier 821 cft @ 75 Sen			615	75
" Iron work on Do			267	69
add Copper on extra piles 11844 sft: 197: lbs 1406.5 @ 25 Sen 351 25				
Carry forward	5,189	80	13492	18

		Plus	Minus
Brought forward		5187 80	1349218
Add for Mooring Rings		4387 50	
" Copper tacks 1519 lbs @ 60 Sen		911 40	
" Taring extra piles 1316 1914 yds: @ 12 Sen		157 92	
			32250
Less for painting Handrail		10646 62	1381468
			1064662
Difference			316806
East wooden pier = Total foot	101.185.84		
Deduct for difference of quantities between it & west wooden pier	3.168.06	9801778	
West wooden pier = Length 940 feet @ 75 Yen 47 7/11 Sen = Total foot		70946 50	
Western concrete pier - Length 1480 feet average depth at low water spring tides 21 feet			
East concrete pier = Total foot Yen 304434.51 or 152 Yen 45 7/11 Sen per lineal foot			
West concrete pier - Length 1480 feet @ 152 Yen 45 7/11 Sen = Total foot		22563666	

Quantity	Description of work	Price	Yen	Sen	Yen	Sen
	Railway					
Ton	230 Rails weighing 40 lbs: p lin: yd:					
	4 lines = 1289 3 yards	y 80	18400			
"	65 Fish plates & Bolts	100	650			
No	30 30 points & crossings	150	4500			
Set:	30 Fang Bolts 6" long x ½" dia No 10.288	9	270			
"	45 Do Do 9" " x ½" " No 10.288	9	405			
"	18 Wood screws for wooden pcs. 6" long x ½" dia: No 5000	12	216			
Cft	1607 Cross sleepers 5' x 6" x 3" No 2500	Sen 30	4821	0		
"	7752 Lon: Do 9' x 4½" x 2584 0'	30	2325	60		
yd:	5,800 Cost of laying per yard	25	1450		28698	40
	2 Capstans	y 250	500			
	2 Putting in place	50	100		600	
	2 Lighthouses shewing 5th Order Lights including apparatus and Buildings of Brick	5,000	10,000		10,000	
	14 Mooring Buoys say with 36" 2½" Chain = Rings, Shackles & Screws	650	11,050			
	17 Cost of putting do in place	50	850		11,900	
	Extension of Shore					
cyd:	229,000 Filling in earth in front of Bund	Sen 25	57,250			
	Cost of Mooring stones in present wall					
lineal:	920 & rebuilding 4th at outside	y 1.50	1380			
	Carry forward		58630			

Quantity	Description of Work	Price			
			Yen	Sen	Yen Sen
	Brought forward		58,650		
lin yds: 75	New wall at End	@ 5	375		
" 2,200	Making Drains & footpaths	" 75	1,650		
sq yds: 22,000	Making Roadway & lay do with 6" Broken stone	" 40	8,800		
c yd: 10,000	Filling in earth in widening of Longish Hatoba	" 25	2,500		
lin yds: 180	Cost of Mooring stones in present face wall of Ft & rebuilding same	@ 2	360		
cft 18,000	Extra pasing stones on roadway of Longish Hatoba	" 55	6,300		
" 18,000	Putting Ft in place	" 25	4,500		
lin yds: 2000	Wooden fences round garden plots				
sq yds: 24,000	Laying out Garden plots with Trees &c	" 50	12,000		96,055
	European Superintendence				
	1 Resident Engineers for 3 years				
months 36	@ $400 per Month	400	14,400		
" 96	4 Divers for 2 years	150	14,400		
" 36	1 Superintendent Carpenter for 3 years	150	5,400		
	2 Asst Masons for stone & Concrete				
" 48	for 2 years	120	5,760		
	1 General Superintendent of Machinery				
" 36	and dredging &c for 3 years	175	6,300		46,260

Abstract

Machinery	41.595	
Temporary Directions	91.211	25
East Wooden Pier	101.185	84
East Concrete Pier	304.914	31
West Wooden Pier	70.946	50
West Concrete Pier	225.636	66
Railway	28.698	70
Capstans	600	
Lighthouses	10,000	
Mooring Buoys	11,900	
Inspection of Shops	95,055	
Bureau Superintendence	46,260	
	1.029.003	26
Add for Contingencies 5%	51450	16
Total	1.080453	42

W. Henry Brunton

Estimate for

Pier at Yokohama