1892.
NEW ZEALAND

THE NEW PLYMOUTH BREAKWATER.

Return to an Order of the House of Representatives, dated 3rd August, 1892.

Ordered, "That the following documents be laid before this House (1.) Plans of the New Plymouth Breakwater, P.W.D. 6129, No. 1 plan showing section of above, P W.D. 6129, No. 2 report of Engineer-in-Chief, specification of breakwater; estimate of cost of same, order of Governor in Council approving same. (2.) Plans of New Plymouth Breakwater, M.D. 253 and 255, specification of same report of Engineer-in-Chief estimate of cost order of Governor in Council approving of same all other documents relating to same. (3.) Plans of New Plymouth Breakwater, M.D. 404, 405, 406, and 407, report of Sir John Coode report of the Engineer, New Plymouth Harbour Board report of the Engineer-in-Chief; estimate of cost order of Governor in Council approving of same. (4.) Prospectus issued in floating the £200,000 loan for the construction of the New Plymouth Harbour."—Mr. McGuire.

SCHEDULE

A.

ORDER OF GOVERNOR IN COUNCIL APPROVING PLANS P W.D. 6129, NOS. 1 AND 2.

Wellington, 21st January, 1878.

HIS Excellency the Governor is respectfully advised to approve the specification and two accompanying plans marked P W.D. 6129 for harbour-works at New Plymouth, in accordance with the provisions of "The Harbour Works Act, 1874."

Public Works Office, Wellington, 21st January, 1878. G. S. WHITMORE.

Approved.—N (in Council, 27th February, 1878).

IRWIN C. MALING, Acting-Clerk of the Executive Council.

SPECIFICATION FOR NEW PLYMOUTH HARBOUR WORKS.

General Description.

THE works will consist of a mole of rubble finished with a concrete parapet and flooring. It will extend from the cliff on the mainland opposite Mikotahi, one of the rocky islets known as the Sugar-loaves, to a depth of about 43ft. at low-water springs.

A trig. station is fixed on the summit of Mikotahi. The commencing-point of the breakwater bears from the said station S. 15½° E (true and is distant therefrom 660ft. The first length of the mole will bear N 43½′ E. (true) from the commencing-point; the second length will bear N 70° E. (true), and will be so placed that the centre-line of it, if extended backwards, would pass 132ft. seaward from the before-mentioned trig. station on the top of Mikotahi. Its extreme end at formation-level will be distant 1,000ft. from the point where the before-mentioned first length of the mole would intersect the second length. The two lengths will not, however be carried to an intersection, but will be joined by a curve of 20 chains radius.

Centre-line and Formation-level.

The centre-line is shown by a red line on plan and section, and is midway between the top of the inner and outer slopes.

Formation-level is the level of the top of the concrete floor as shown on sections.

Quarrying

The materials for the mole will be taken from Paretutu, and from the rocks lying to the north-eastward from it. In quarrying only very large blasts will be allowed, so that the rock will be got out in the largest pieces possible, and no stone weighing 25 tons or less which may be quarried shall be broken up into smaller pieces. The largest blocks shall be reserved to form the sea-facing of that portion of the mole above the level of 6ft. below low-water springs, and, unless it is found that more than a sufficiency of large blocks is procurable for this purpose, those that are procured shall be stacked until required. The hearting and inner slope to be of the smaller materials, and the whole of the material quarried is, large and small, to be used up in the work.

Form of Mole.

The mole will be 30ft. wide on top at formation-level the slopes will be such as the material will take under the action of the waves. The drawings show a slope of 5 to 1 for the outer slope, and 2 to 1 for the inner, down to 6ft. below low water. Should the stones be of large size steeper slopes will be practicable, thus decreasing the bottom width.

After the mole has been completed up to the level of the under-side of the concrete floor it shall be left until it has become consolidated by the action of the waves. It shall then be levelled off and all the interstices filled up with rock-spalls and rammed solid, when the concrete will be put on.

Concrete.

A floor of concrete of the full width of top of mole, and of the form shown in section, will bring the work up to formation-level. A parapet of concrete 6ft. high, 6ft. wide at base, and 4ft. wide at top will be placed on the floor of the seaward side of the formation.

The concrete to consist of one part, by measure, of Portland cement of the best quality, two parts of clean, sharp sand, and five parts of broken stone or quarry-chippings. It shall be set in layers not more than 6in. thick, and well rammed. It shall be placed in lengths of not more than 30ft. long, each length to be completed before the next is begun, the parapet to be completed on each length in advance of the flooring.

Railway

A double line of railway shall be laid in the concrete floor in the manner shown in drawing, the rails to weigh 52lb. per lineal yard, and fished at the joints.

Tramways.

The dotted red lines on the general plan indicate the position of two tramways which are to be made for conveying stone from the quarries to the works. The one to Paretutu can be arranged as a self-acting incline, the other will require locomotive-power They will be 7ft. gauge, with rails not less than 70lb. per lineal yard.

JOHN CARRUTHERS.

REPORT ON NEW PLYMOUTH HARBOUR WORKS.

SIR,—

I have the honour, under your instructions, to report on the New Plymouth Harbour works, as provided in "The New Plymouth Harbour Board Ordinance 1875 Amendment Act, 1877"

The mode of executing the works is finally defined and determined by the detailed plans and specifications marked P W.D 6129, and which His Excellency the Governor was advised to approve in a memorandum dated the 21st January, 1878, and which he has approved.

The estimated cost of the works therein specified is £160,000 sterling.

JOHN CARRUTHERS,
Engineer-in-Chief.

The Hon. the Minister for Public Works.

B.

COPY OF REPORT BY MESSRS. CARRUTHERS AND BLACKETT.

SIR,— Public Works Office, Wellington, 27th November, 1875.

In accordance with your instructions, we have the honour to submit the following report on the proposed harbour of New Plymouth in connection with the establishment of a central prison for New Zealand:—

Former Reports.—On the 17th May, 1865, Messrs. Balfour and Doyne reported to the Provincial Government of Taranaki on the subject of a harbour for local purposes, and a copy of their report is herewith enclosed. Numerous soundings and measurements were then taken, which work, on inquiry, we found to have been very carefully done, and we have therefore adopted it as the basis of our report. Before, however, work is actually commenced, we should recommend a resurvey, as a means of insuring complete accuracy A tracing showing the soundings and the position of the several works described is herewith enclosed.

Messrs. Balfour and Doyne have reported on two sites—one at the Sugarloaves, and the other in front of the town, near the present landing-place.

Sugarloaf Site.—This, the first of these sites, is not recommended by them, and in this conclusion we agree, as the sheltered area enclosed by the works would consist almost entirely of shallow

water, although the works themselves would necessarily be carried out in deep water, and would therefore be very costly

Town Site.—The second site which was recommended by them for adoption near the town has many drawbacks, but these would to a certain extent be counterbalanced by its proximity to the present town, supposing its size to be limited to the requirements of coasting-steamers and small craft alone. It would, however, be quite unsuitable as a harbour of refuge, and could only be entered by foreign-going ships during fine weather

The area actually sheltered by the works would consist almost entirely of water of a less depth than 4 fathoms, so that a sailing-ship drawing, say 18ft. to 20ft. could not, if a stiff breeze were blowing, be brought up in time to prevent its running aground.

To remedy this obvious fault Messrs. Balfour and Doyne recommended a future extension of the work—namely, the lengthening of the western mole to a total of 83 chains. This would only partially remedy the defect, whilst the same length of mole at the site we recommend below would give a first-class capacious harbour capable of accommodating the largest vessels, and in any number likely to arrive.

Another objection to the town site is the badness of the holding-ground, the bottom consisting of patches of very rough and jagged rock, slightly covered in places with sand. The existence of these rocks practically lessens the available depth of water, and their positions being uncertain would render them dangerous to any vessel drawing nearly the amount of water shown by the soundings.

It will be seen also by reference to the plan that the river Huatoki empties itself into the space embraced by the harbour-works, and all sand, silt, and *débris* would thus be delivered within the harbour-area, and ultimately have an injurious effect.

The entrance is also in very close proximity to shoal-water to eastward, and, as strong westerly winds prevail throughout the year, the entering or leaving the harbour would generally be attended with some risk.

For the above reasons, and on account of its distance from the only available quarry, and its great cost if carried out in its entirety, we do not recommend the adoption of the town site.

Sites now proposed.—A better harbour than that last described could be constructed at about the same cost at the old whaling-station near the Sugarloaves. This site we recommend as the best on all accounts except its distance from the town, which will be about two miles, and the consequent necessity of the extension of the railway On every other ground we are of opinion that there can be no comparison between this and the town site, it is close to the quarry, and the work could therefore be carried on more expeditiously A much greater length of quay-room, with depth of water sufficient for large vessels, would be available. The holding-ground is better the access of the harbour would be safe in westerly weather, and, finally the whole of the works would be protected by the natural barrier formed by the Sugarloaves, which would break the swell of the westerly and north-westerly seas, these being the heaviest to which the coast is exposed.

This harbour would be sufficient for all local requirements. Seeing, however, that national as well as local interests must be considered, we do not hesitate to recommend a larger harbour at the same site, suitable for a harbour of refuge as well as for local trade. This could be obtained by placing the mole further to seaward in deeper water, and increasing its length by about 10 chains.

Proposed Works.—Town sites These would consist of a mole extending from the shore for a distance of 60 chains into 5 fathoms at low water Whaling-station site (small harbour) A similar mole of 70 chains long would be required at this site, extending into 5 fathoms at low water Whaling-station site (large harbour) Here a similar mole of 80 chains will be required, extending into 7 fathoms at low water

At all the above sites it is possible that an eastern mole will also be found necessary, although we are of opinion that the western mole in each case will be sufficient, but there is a greater probability that it will be required at the town site than at the others. The moles would consist of random rubble, thrown in with an inner slope, varying from 1½ to 1 to 2 to 1, and an outer slope, such as the nature of the material may demand, varying according to the sizes of the rocks obtainable, averaging 5 to 1, to a depth of 6ft. below low water, and 1½ to 1 below that depth.

The eastern mole, if found necessary, might be constructed with an inner slope of 1½ to 1, and an outer slope of 2 to 1. The top of the western mole would be 20ft. above low water, and 30ft. wide on top, with a parapet of concrete 6ft. high on the outer edge.

On account of the cost we have not provided for vertical inner walls to act as quays. It will be cheaper to erect quay-accommodation hereafter of wood or iron, from time to time, as occasion may require.

Quarry.—The material to be used in the construction of the moles would be procured from the landward Sugarloaf (Paretutu), which consists of vertical cliffs of hard volcanic rock from 200ft. to 300ft. high, their base being at an elevation of about 200ft. above sea-level. The material appears to be admirably adapted for the purpose, and in sufficient quantity It is probable that it may be quarried in such large blocks that steeper slopes to the moles than we have estimated for may be found workable. The loose stones on the beach might to a certain extent be used in the works, but the quantity is not sufficient to reckon as a principal source of supply The material will be brought down direct to the work by self-acting inclines should either of the whaling-station sites be adopted. Should the town site be adopted, haulage by locomotives for two miles and a half will be necessary

Costs Areas, and Quay-accommodation. In the subjoined table are shown the respective costs, areas, and lengths available for quay-room in the three harbours under report. It will be seen that the harbour at the town site would cost, if completely carried out as proposed by Messrs. Balfour and Doyne, £738,000. The large harbour at the whaling-station site would cost only £550,000, although it would be a very much better harbour, enclosing more than double the area, and with four times the quay-accommodation suitable for large vessels.

There can therefore be no doubt to which of these preference should be given should it be decided that the works shall include a harbour of refuge. Should it, however be considered that a harbour only suitable for local traffic will be sufficient, the proposed extension of the mole at the town site, estimated at £345,000, might be omitted, thus reducing the cost to £393,000. The small harbour at the whaling-station would cost £395,000, including a railway to town, so that these two harbours may be considered to cost practically the same. Its size as compared with that of the town site is nearly the same, being 129 acres as against 123. It has, however three times the room available for quay-accommodation for large shipping, as well as a larger amount for coasting-steamers, in the proportion of 16 to 11. Its other advantages have been already described.

The practical inconvenience of having the harbour two miles from town would not be found very great, as is evidenced by the experience of other ports in New Zealand.

TABLE of Costs, Area, Etc.

—	Town Site.	Whaling-station (Small Harbour).	Whaling-station (Large Harbour).
	£ s. d.	£ s. d.	£ s. d.
Western mole ..	238,920 0 0	274 820 0 0	414,000 0 0
Eastern mole	93,000 0 0	45,000 0 0	50,000 0 0
Proposed extension	345,000 0 0		..
Railways at quarry and to town, plant and other works, contingencies	61,000 0 0	75,180 0 0	85,920 0 0
Total	738,000 0 0	395,000 0 0	533,000 0 0
Areas of harbours—	A. R. P.	A. R. P.	A. R. P.
Between 1 and 2 fathoms at low water	35 0 0	38 0 0	52 0 0
" 2 " 3 "	30 0 0	40 0 0	70 0 0
" 3 " 4 "	40 0 0	30 0 0	45 0 0
" 4 " 5 "	16 0 0	21 0 0	41 0 0
Above 5 fathoms at low water	2 0 0	..	50 0 0
Total area	123 0 0	129 0 0	258 0 0
Length available for quays not reckoning 10 chains from entrance—	Chains.	Chains.	Chains.
Between 2 and 3 fathoms at low water	11	16	16
Over 3 fathoms at low water	8½	23	36
Total .	19½	39	52

Prison Labour.—The above estimates have been framed as if the works were to be carried out by free labour There will be an economy in using the labour of convicts, but it is very difficult to say to what extent. In order to save time, a large amount of preliminary work must be done before the prisoners can be located. We are of opinion that at least two years will elapse before the necessary buildings can be constructed, and this time should be employed in constructing roads, tramways, inclines, &c., and the necessary rolling-stock and machinery, so that on the prisoners being domiciled the actual work of harbour construction may be commenced at once.

Whilst on this subject we deem it necessary to make a statement of the probable expenditure that will be required to accomplish this, viz. :—

	£
Surveys and contingencies	1,000
Making tramway with gear and plant, cranes, tools, and workshops, &c.	21,000
Roads, fencing, water-supply, and purchase of land (for road only)	3,000
Prison-buildings (of these we cannot form any correct estimate, but assume that the cost will not be less than)	35,000
	£60,000

Should the town site be adopted a further immediate expenditure of £20,000 will be required for the tramway into town, making a gross total of £80,000.

A certain proportion of free labour must necessarily be employed during the whole of the time. This cannot be estimated at less than £4,000 per annum. Beyond this an annual charge of about £75,000 will be required for tools, powder, &c.

A site for the prison-buildings may be found immediately inland of the large Sugarloaf (Paretutu), and distant from it about 20 chains. This consists of an elevated piece of tableland, covered with grass, having an area of about 2 acres. It is at a considerable elevation above sea-level (about 250ft.), with a good view of the surrounding country, and its near proximity to the quarry renders it a desirable site. Another site, on a lower elevation (about 50ft. above sea-level), is situated about 45 chains eastward from the quarry, and immediately overlooking the sea-beach. The former we believe to be a Government reserve, the latter being private property, would have to be purchased.

Sites nearer to the quarry might, by an expenditure of a few hundred pounds, be procured by excavation and filling, but would be liable to the inconvenience of being invaded by drifting sand.

The position of the work is well suited for prison labour, being isolated, and at a considerable distance from town, or any other dwellings. If, however the town site is adopted, a large proportion of free labour must be employed, or the prisoners, as many as may be required, brought into town every day This would be inconvenient and unsafe, and would tell against the town site as compared with the others.

Time of Completion.—Assuming that the harbour-work is to be done by prison labour, and that an average number of a hundred and fifty men will be available, it will take about six to seven years after the completion of the tramways and prison-buildings to run out the western mole of the large harbour to a depth of 4½ fathoms, and for the small harbour about the same time. At the town site it will take about six years with the same amount of labour to reach the same depth. In each case this would give sufficient shelter for local steamers, and large vessels could also be unloaded during ordinarily favourable weather The remainder of the works, assuming an average of two hundred men, would occupy a further period of ten to twelve years for the large harbour at the whaling-station, and six to seven years for the small harbour for that opposite the town.

Having now laid before you all the information we have collected, and having given the subject in all its aspects the most careful consideration, we have no hesitation in recommending the adoption of the large harbour at the whaling-station, and next to that, should the Government consider it too large a work to undertake, the lesser harbour at the same site.

Waitara River

During our stay in New Plymouth we examined the Waitara River, with a view of determining whether the river was capable of improvement. It is one of the numerous class of rivers having a shifting bar at its mouth, composed of shingle and sand, the depth varying from 8ft. to 14ft. at high water according to the tides and the occurrences of freshes in the river In order to improve the entrance, it would be necessary to build two parallel guiding-piers, reaching from the shore almost out to the bar This would probably secure a depth of 12ft. at high water, but, should it be required to increase the permanent depth beyond this, further protection would be necessary, in the shape of a breakwater or mole on the western side, the cost of which would exceed that estimated for the harbour-works at New Plymouth above described.

Owing to the absence of any abundance of suitable material the cost of the guiding-piers would be very great, but, as we have not sufficient information as to soundings and distances, &c., we cannot give an estimate.

Conclusion.—In conclusion we beg to express our thanks to his Honour the Superintendent and other provincial authorities for the courtesy with which information and plans, &c., were furnished for our assistance.

We have, &c.,

JOHN CARRUTHERS.

Hon. the Minister for Public Works. JOHN BLACKETT.

Enclosure.

REPORT ON THE PROPOSED HARBOUR AT TARANAKI, NEW ZEALAND.

SIR,— Wellington, 26th December, 1866.

In considering the question on which you have requested us to report to you—namely, the practicability and probable cost of providing harbour-accommodation at New Plymouth, in the Province of Taranaki—the following desiderata have been kept prominently in view First, the selection of a site upon which a perfectly safe harbour, possessing the qualities of a harbour of refuge, and those necessary for the ordinary provincial trade, can be constructed. Second, the site so selected to afford such natural advantages as will enable the works to be constructed for a sum not exceeding about £300,000 or £350,000. Third, the works to be so designed that they can be carried out in parts, without materially increasing the cost, while each part shall constitute a useful and integral portion of one great plan, to be carried on as the resources of the province may permit. Fourth, the first section to give a good landing-jetty at which the ordinary shipping business of the province (including the discharge and loading of ocean-going vessels) can be carried on at high water during fine weather, for a sum not exceeding £100,000.

As requested by your Honour Mr Balfour visited New Plymouth in May last for the purpose of collecting data by soundings, and superintending the making of a general survey of the roadstead by the surveyors in the employment of the Government, the results of which survey are shown in the accompanying plan, sheet No. 1 (though to prevent confusion the actual soundings are not given, and only contour-lines for every fathom are shown) and, on the information then and previously obtained, the conclusions put forward in the following report are based.

1 Selection of Site.

In selecting a site our attention was first directed to that under the lee of the Island of Moturoa, a preliminary examination of the locality having induced us to believe that the facilities offered by the island for procuring material, and the great natural protection afforded by it in breaking the worst sea, might be turned to profitable account in the design of the works, and, indeed, this would have been the case had not the soundings proved that the area, already partially sheltered by Moturoa, is much shallower than we had believed it to be, so that nothing short of works so extensive as would more than counterbalance the apparent advantages of this site would shelter a reasonable area of water of sufficient depth.

Bearing in mind, therefore, the comparatively limited expenditure to which we are restricted by the circumstances of the case, we have been compelled, after careful consideration, to abandon this site for one where a better result can be obtained for the sum proposed to be expended.

The reasons which have led us to reject the Moturoa site are as follows We are of opinion that no expenditure there which should fall short of closing the entrance between Mikotahi and

Moturoa would be of any real use, and that the outlay necessary for this purpose would be far too great when compared with the result obtained. For this work we should not feel justified in recommending the construction of a breakwater of less strength than either of the alternative designs shown on the drawing, Sheet No. 2, Figs. 1 and 2 and either of them, with a railway and other appliances rendered necessary by the distance of the harbour from town, we believe, would cost, at least, from £150,000 to £200,000. This alone, when completed, could only be used as a pier in fine weather and then only for vessels of comparatively light draught.

To completely enclose this harbour, a mole projected in an easterly direction from Moturoa, and curving to south-east, would have to be constructed, in an average depth of from 40ft. to 45ft. of water, for a length of, say 800 yards. This, we estimate, would cost from £400,000 to £500,000. To these two amounts has to be added the cost of the eastern mole projected from the mainland in a northerly direction, which, with sundry other items of expense, would bring the total amount up to at least £750,000.

There are other considerations, irrespective of cost, affecting the merits of the harbour when constructed, as, for instance, the comparatively small area of deep water which could be enclosed even at this large expenditure. But, in view of the facts here adduced, we deem it unnecessary to enter into further details of this project, and conceive that it may be at once dismissed as impracticable.

After a close investigation we have decided to recommend the adoption of a site opposite to the Town of New Plymouth as the one best suited to all the requirements of the case. By adopting this site we avoid the necessity for constructing a railway Its proximity to the town will be convenient to the transaction of business, while at the same time diminishing the cost of carriage of goods, and we believe the whole cost of a good harbour on this site may be kept within the limits of £300,000. On referring to the plan, sheet No. 1, your Honour will see the general outline of the harbour which we propose to construct on the town site, and also, for the sake of comparison, the outline design on which our estimates for a harbour at Moturoa were based.

The main objections to the town site are twofold. First, the bottom there is much more rocky and irregular than near Moturoa, at which place there is a coating of greater or less thickness of sand, mud, and clay overlying the rocks second, the entrance will be more leeward in westerly gales.

The disadvantages arising from the more rocky nature of the bottom are not of sufficient importance to affect our preference for the town site. We need scarcely point out that this formation will necessitate constant modifications, during construction, of the designs accompanying this report. These it would be impossible for us to provide for in detail with our present information, but such modifications are only usual during the execution of similar works, and the designs we furnish may be accepted as a fair approximation to those which we consider should be adopted, and are, in our opinion, amply sufficient for the general guidance of any competent engineer who may hereafter be intrusted with the conduct of the works. After the completion of the piers, the only objection to the rocky nature of the bottom is the fact that it offers inferior holding-ground to vessels anchored under the shelter of the breakwater, but this difficulty can easily be overcome by laying down fixed moorings.

The leewardliness of the entrance is a more serious objection, as vessels failing to take it properly would require to be very smartly handled to prevent them going ashore. The entrance is, however, designed so as to be very easy to take, and, even if missed, a well-handled craft could, we think, be put on the other tack, if necessary, by club-hauling in time to save her. The somewhat less advantageous position of the entrance is, in short, one of the modifications which we have considered it right to recommend on economical grounds.

On the other hand, it is in favour of the town site that the piers cross the contour-lines nearly at right angles, so that the sheltered area is as deep, or even deeper, than the water in which the works are proposed to be constructed. This arrangement is greatly in favour of economical construction, and cannot, from the nature of the bottom, be adopted near Moturoa.

By the system of construction hereafter to be described, a portion of the western wall of the town harbour may be made to serve as a useful jetty to commence with, at a cost of about from £75,000 to £85,000 and the completion of the whole of this pier as shown on the plan would give, at a total cost of £250,000, a fair harbour of refuge for ordinary vessels, and would enable them to lie alongside for a great majority of days in the year and at all times to hold on safely to fixed moorings, while the completion of the whole work contemplated, at an expenditure, as stated above, of £300,000, would give a very snug harbour with about 120 acres total area of still water of the depths named in the following table:—

Between 1 and 2 fathoms	35 acres.
" 2 " 3 "	30 "
" 3 " 4 "	40 "
" 4 " 5 " ..	16 "
Over 5 fathoms ..	2 "
	123 acres.

A slight modification of the design is shown in red lines, which might be adopted at scarcely any increase of cost, as shown dotted. This modification admits of easy future extension should it be required, so as to form a perfectly safe refuge for vessels even of the largest class, and so to shelter the entrance to the harbour proper as greatly to obviate the objection as to its leewardly position. We have not minutely estimated the cost of this possible extension, but we believe that, even if it formed an integral portion of the design, the whole work could be completed within the sum at which we have estimated the cost of a harbour at Moturoa, while there can be no doubt that it would form a better and more convenient harbour

Before quitting the question of site, we may add that our attention has not been directed exclusively to those two, into the particulars of which we have entered above, but that no other presented itself possessing sufficient natural advantages to require any notice at our hands.

(2.) Design of the Works

Having determined on the site to be adopted, we propose to commence the construction of the western pier by building a causeway of large boulders taken from the reef to a level of 6ft. above high-water spring-tides, extending from the shore to low-water mark, with a protecting parapet. The design for this causeway is shown on the drawing-sheet No. 2, Fig. 7 From this, to extend a peir into 2 fathoms (12ft.) at low-water, by means of a timber framing filled in with stone, and constructed as shown on sheet No. 2, Fig. 6, omitting in the first instance the *béton* covering.

This would provide, at a cost, as we have estimated above, of from £75,000 to £85,000, a useful jetty, with a maximum depth at high water of 25ft., at which vessels could lie alongside in fine weather, until such time as the financial arrangements of the province would enable the works to be extended, when this portion of them could be rendered permanent by the addition of the *béton* covering—first on the outside and afterwards on the inside—bringing up the total cost of this portion of the work to about £125,000.

As we consider the extension of this framed timber pier beyond the point we have named would be to a certain extent experimental, we have included in our gross estimate an expenditure necessary to build the remainder of the western pier of stone, in the form of *pierre perdue*. At the same time we think it possible that it may be found practicable during construction to extend the timber jetty to a greater depth than we have ventured to positively recommend, thus effecting a considerable saving, but this is a question which can only be decided by actual experience. We have a precedent to some extent for the use of the timber pier in that constructed at Blyth. It is in about 20ft. of water at high tide, and has stood the full force of the north-east gales without any protecting-works, but we have yet to learn whether it can be extended into deeper water An average section of the western pier, which may be adopted, is shown in Fig. 5, Sheet No. 2. This section, however, may be modified to have a perpendicular inner face, similar to that shown in Fig. 2, for a length sufficient to give berths for large vessels, without much increasing the cost. The section we recommend for the eastern mole is shown in Fig. 4. This is composed entirely of *pierre perdue*, and will be the last to be constructed. The reefs in the immediate neighbourhood of the works will probably produce a sufficient amount of material to meet the demands of the case on the plan proposed, but, in the event of its proving otherwise, abundance of material can be procured from Mikotahi and its vicinity, at the cost of laying down a temporary tramway, which, by concentrating the sources of supply, would not seriously increase the expense.

Recapitulation.

Having now explained the general conclusions at which we have arrived after a careful examination of all the facts in our possession, we may shortly state the results as follows First, that, in our opinion, the most suitable site for the proposed harbour is that opposite the Town of New Plymouth, second, that a good harbour, fit to be run to as a refuge by all but the largest ships, and possessing all the qualifications for carrying on the provincial trade, may be there constructed for a sum of about £300,000, third, that the works may be executed in part according to the resources of the province, and that each additional portion will increase the value of the harbour in proportion to the sum expended, fourth, that the completion of the first section will give a useful jetty, sufficient in fine weather for the accommodation of the ordinary shipping business of the province at a cost of from £75,000 to £85,000, fifth, that the work may be so laid out, if required, that the western pier may be susceptible of still further future extension, so as greatly to increase the already large area of sheltered water, and render the harbour a safe refuge for even the largest vessels.

It now remains for us to offer to your Honour a few suggestions as to the financial policy to be pursued in connection with this work. We have had the honour of pointing out in our preliminary report, dated the 17th May, 1865, that the construction of this harbour must be viewed as a national work, and one of the highest necessity to the whole colony, from the absence of any natural harbour of refuge on the whole extent of the west coast of New Zealand for a distance of nearly 700 nautical miles, or any port in which a ship can in safety ride out a westerly gale, with the sole exception of the anchorage in Cook Strait, to run to which, even if they could always be "made," would in many cases involve a great sacrifice of time and westing." We, therefore, consider that the province has a very strong claim on the General Government for financial assistance in carrying out this project, and would suggest the following as a basis of arrangement: Debentures to be issued with a General Government guarantee for, say, £350,000, a block or blocks of the confiscated land in the province of that value being set apart as a security for the repayment of the capital amount. As this land is sold the proceeds to be devoted to the repayment of the loan. In the meantime the interest on outstanding debentures to be borne equally by the General and Provincial Governments. The debentures to be issued by instalments as opportunity may occur for placing them advantageously, and the work to be proceeded with in corresponding sections.

We may here point out the great advantages which will arise to the province by reducing the present expensive landing-charges, and by diminishing the risk of damage to perishable goods by water, and we would especially call attention to the great benefit accruing from the facilities which would be afforded by the harbour for sending and receiving shipments direct to and from England and the other colonies, in place of the present tedious and expensive system of transhipment by local vessels. Your Honour will be in a position to calculate the value of these advantages, which would undoubtedly be very great. A considerable revenue would also probably be derived from the customary harbour dues, and wharfage and other charges.

We append to this report a plan (Sheet No. 1) of the roadstead, showing the two projects we have considered, and sections (Sheet No. 2) of the various moles, &c., referred to in this report.

While preparing these designs and estimates we have carefully consulted all the first authorities on marine engineering works, and studied the designs of the great harbours and breakwaters of the world, besides drawing on our own experience of similar works in Great Britain.

Our estimates we consider are ample, and are not likely to be exceeded.

We have, &c.,

(For Balfour and Doyne),

His Honour the Superintendent, Taranaki, New Zealand. JAMES M. BALFOUR.

C.

ORDER OF GOVERNOR IN COUNCIL APPROVING PLANS M.D 253 AND 255.

Approving Plans of Breakwater at New Plymouth.

HERCULES ROBINSON, Governor

Order in Council.

At the Government House, at Wellington, this twelfth day of August, 1879.

Present His Excellency the Governor in Council.

WHEREAS certain plans of a breakwater and other harbour-works to be constructed at the Port of New Plymouth have been submitted by the New Plymouth Harbour Board for the approval of the Governor in Council, in accordance with the provisions of "The Harbours Act, 1878," and it having been made to appear to the Governor in Council that the said works will not be or tend to the injury of navigation

Now, therefore, the Governor of the Colony of New Zealand, by and with the advice and consent of the Executive Council of the said colony, doth hereby approve of the plans of a breakwater to be made at New Plymouth, shown as the western breakwater, design A of the plans marked M.D. 253 and M.D 255, as far as the line marked YY, the said plans being deposited in the office of the Marine Department, Wellington the design of the breakwater as shown on the said plans being a modification of that shown on plans marked P W.D. 6129, drawings Nos. 1 and 2, which were approved by the Governor in Council on the twenty-seventh day of February, one thousand eight hundred and seventy-eight.

FORSTER GORING, Clerk of the Executive Council.

NEW PLYMOUTH HARBOUR.

Marine Department, Wellington, 11th August, 1879.

I HEREBY certify that, in my opinion, the proposed western breakwater, design A, as shown, as far as the line marked YY on plan M.D. 253, and in cross-section on plan M.D 255, will not be, or tend, to the injury of navigation. JOHN BLACKETT, Marine Engineer

FORSTER GORING, Clerk of the Executive Council.

D.—REPORT BY SIR JOHN COODE, C.E

SIR,— 5, Westminster Chambers, London, S.W., 28th February, 1879.

I have now the honour to submit my report on the improvement of the harbour of New Plymouth.

In addition to the personal examination I made in May last, I have had before me the reports prepared by Messrs. Balfour and Doyne in 1865, and by Messrs. Carruthers and Blackett in 1875. The joint recommendation of the latter gentlemen received the approval of the Government, as required by the Act under which the Harbour Board derives its authority, but I understand that the Commissioners have decided to suspend operations until the receipt of this report.

Views as to Harbour of Refuge at New Plymouth.—So far as I could learn at the time of my inspection there seemed to be some difference of opinion as to the expediency of constructing a harbour of refuge at New Plymouth. I ascertained by inquiry from Captain Holford, the Harbour-master, that vessels from Europe, India, &c., approach this part of New Zealand from the south-west, and, inasmuch as by far the greater number of these are bound for Wellington, Nelson, or elsewhere within the Straits, it would, as a rule, be more advisable in bad weather for them to run for shelter into Blind Bay, or some of the sounds on the north side of the South Island, than to make for New Plymouth. It appears, therefore, that the provision of a sheltered anchorage at this site would be of value to sailing-vessels employed in the coasting trade of this part of the colony, rather than to vessels engaged in ocean traffic.

Necessity for providing Harbour-accommodation for Present Trade.—From a clear and comprehensive memorandum furnished to me at the time of my visit by Mr. Kelly, the Chairman, I learn that the Harbour Board desires to obtain the greatest possible present benefit in harbour-accommodation from the expenditure of a sum not exceeding £200,000, which is the maximum amount now available. Mr. Kelly states that the Board "objects to sacrifice the convenience of the present generation for a greater possible benefit to a future one, but is quite willing that the money available should go in the construction of part of a large scheme of harbour-works, provided that its expenditure produces an immediate benefit as the work proceeds. The general soundness of these views cannot, I think, be questioned.

Future Development.—Looking to the probable future development of the resources of this very fertile district, I have regarded it as an essential feature in any design for harbour-works at New Plymouth that, whilst nothing should be done to sacrifice present convenience, or to incur an expenditure which will not result in the greatest possible benefit at the earliest practicable date, the necessity for future extension should be kept prominently in view The harbour-works now to be undertaken ought therefore to be so arranged that they will admit of additions hereafter as and

when required, and so that incongruities, or the necessity for removing any portions of the executed works, may be avoided. In this way only can a complete and comprehensive scheme be ultimately produced.

Previous Designs.—The merits and demerits of the designs by Messrs. Balfour and Doyne for works both at the Sugarloaves site and opposite the Town of New Plymouth have been clearly pointed out by Messrs. Carruthers and Blackett in their report of the 27th November, 1875, it is unnecessary, therefore, to enter upon them here. In the same report Messrs. Carruthers and Blackett fully and fairly describe the relative advantages and disadvantages of the Sugarloaves site and the town site in the following terms They say "This [the Sugarloaves] site we recommend as the best on all accounts, except its distance from the town which will be about two miles, and the consequent necessity of the extension of the railway On every other ground we are of opinion that there can be no comparison between this and the town site it is close to the quarry, and the work could therefore be carried on more expeditiously A much greater length of quay-room, with depth of water sufficient for large vessels, would be available, the holding-ground is better, the access to the harbour would be safe in westerly weather and, finally, the whole of the works would be protected by the natural barrier formed by the Sugarloaves, which would break the swell of the westerly and north-westerly seas, these being the heaviest to which the coast is exposed." Concurring in these views, I have confined my attention to that part of the bay which lies between Moon's Reef on the east and Mikoti (Mikotahi) and Moturoa on the west.

Accompanying this report are two illustrative drawings, viz. No. 1, a general plan of the roadstead, the foreshores, and the features of the adjoining country, extending from the Town of New Plymouth to the coast-line outside Paretutu, reduced from the complete special survey made by Mr E C. Jones in 1877 No. 2 is a plan, on a large scale, also prepared from Mr Jones's survey, extending from Moon s Reef on the east to Paretutu on the west. The respective proposals are shown by distinguishing colours on each of these drawings, as hereinafter explained.

Character and Exposure of Roadstead.—The roadstead at New Plymouth is at present quite open for rather more than one-fourth of the compass—*i.e.*, from W by S. to N The heaviest seas are said to proceed from about W and W.S.W When from the southwards of this quarter the seas on this part of the coast are stated to be not nearly so heavy as from the northward of that point up to W.N W With winds from the northward of this the seas are never very heavy The bottom of the bay generally consists of by no means good holding-ground, the sand being in patches, with boulder-stones occurring frequently This, although prejudicial to the site as a roadstead for anchorage, will not constitute a serious objection when the area is sheltered from the heavy westerly seas.

Work shown on Drawings.—Bearing in mind the view I have previously expressed as to the paramount importance of providing the largest possible amount of present accommodation for the expenditure of the money now available, I have framed and had under consideration the two designs marked A and B respectively on drawing No. 2. Design A is indicated by red colour and red lines, whilst design B is shown in brown. Upon this drawing the full extent of the harbour projected by Messrs. Carruthers and Blackett is also denoted by green dotted lines and green colour

Design A.—It is proposed to construct in the first instance a west breakwater or mole commencing at the salient point on the foreshore to the southward of Mikoti marked A on the drawing, near high-water level, and extending thence in a N.E by N. ½ direction for a length of 1,315ft. The work would then trend to the eastward by a curve of 1,500ft. radius for a further length of 700ft., terminating with a straight arm or cant 690ft. long, pointing N.E by E The total length of the breakwater to be executed under this section of the design would thus be 2,705ft., and the line would correspond with that proposed by Messrs. Carruthers and Blackett, and approved in Council on the 27th February, 1878.

The mode of construction I should recommend for the breakwater above described is shown upon the cross-section annexed to this report. A work of this type is well adapted for the utilisation of local materials and labour, and would necessitate only a very limited amount of diving operations. It also offers advantages over every other system for the successful employment of convicts. Seeing that it has been, and I presume still is, proposed to use convict labour to a large extent in the execution of harbour-works at New Plymouth, it is essential that the mode of construction to be adopted should be of the simplest possible character, and dependent to the smallest extent upon the aid of skilled operatives.

The breakwater should therefore be formed of rubble-stone, quarried at Paretutu, about 700 yards south-west of the starting-point, and conveyed thence over a self-acting incline, and deposited as *pierres perdues* from four lines of railway, carried upon a suitable timber staging of the type shown on the cross-section. The materials would be distributed and consolidated by the waves until the normal angle of repose has been produced on the seaward face. This would be found to correspond very closely with the profile of the mole shown on the section. A protection parapet or bank of stone would be tipped along the crest of the breakwater, and faced on the south or harbour side by a substantial dry rubble wall, skirting a roadway of 30ft. in width formed throughout the entire length of the work. On this road, and flush with its surface, there would be two permanent lines of railway of the colonial gauge.

Upon the annexed section the profile of the rubble mound, as proposed by Messrs. Carruthers and Blackett, is shown by green dotted lines. It will be seen that there is a general similarity between the two sets of slopes.

There are two matters in connection with the proposed mode of construction which require a few words of explanation—first, with regard to the permanence of the mound and its sufficiency to resist the impact of the heaviest seas, and, secondly, as to the necessity for depositing the material from a timber staging. Upon the first of these heads, I may remark, after having carried out extensive works in a similar manner at Portland (England) and Table Bay (South Africa), that it will be quite practicable to form a mound of the character recommended, which will prove perfectly stable when the sea-slopes have assumed their normal angle. The material available from Paretutu,

a hard trachyte porphyry, is admirably adapted for a work of this class, and the wave-stroke is not as great as at Table Bay, hence there can be no doubt as to the sufficiency and permanence of the proposed mound at New Plymouth. Whilst, however, expressing the fullest confidence in the permanent stability of the work after the slopes have been flattened down to the inclination shown, I desire to point out that during execution some fears will almost inevitably be engendered as to the sufficiency and ultimate permanence of the structure in consequence of the occasional and recurring flattening-down of the slopes by heavy gales during the process of forming the mound. But it must be borne in mind that the agency by which the material is distributed and trimmed to a proper slope is one of wave-action, the operations of the workmen being confined to depositing the stone so that it shall ultimately produce a mound when "clawed" down by the sea, with the least possible waste of material, a matter requiring care and judgment where the quantities to be dealt with are so vast.

However much the apparent dislocation of the mound during progress may appear from the surface, it may be taken for granted that the action of the sea will only tend to distribute the rubble over the area required for the base of the work, and that the mole when finished will, as I have explained, partake very closely, if not actually, of the profile shown on the cross-section, although the seas of several winters would be necessary for the production of the ultimate slope as shown. In the meantime rubble would be tipped on the top of the bank for the subsequent "feeding" of the slopes by the sea.

With regard to the necessity for a temporary staging from which to deposit the materials, it seems desirable that I should explain the reasons which have led me to recommend this mode of procedure, seeing that Messrs. Carruthers and Blackett proposed to form their mole of rubble without any such provision, and I speak after thirty years' experience in works of this particular class. Notwithstanding that the adoption of the stage would necessitate the employment of a special class of skilled labour and be more liable to damage by seas of exceptional severity than any other portion of the work, nevertheless great ultimate economy would result from the facilities it would afford under all circumstances for depositing the rubble, layer upon layer, with a long flat slope at the outer end during progress, and for "feeding" the sea-face throughout the length of the mole, as may be required from time to time. Coupled with this there must be a considerable saving of material consequent upon a smaller section of mound, which would more than compensate for the cost of the temporary staging by reducing the expenditure on the permanent work. Moreover, it should be remembered that if made as a "flying tip"—the alternative mode of depositing the rubble, as compared with dropping from a stage—the slopes of the mole when first formed from the wagons would be, as in the case of a railway embankment, at a steep angle, and thus subject to a much greater disturbance by heavy seas than would be the case were the bank to be deposited to flatter slopes, which could be readily done from a stage. For these reasons, the adoption of the stage would, as I have said, result in a smaller ultimate section for the mound, and consequently in a saving in material as compared with the system of direct tipping from wagons running on tramways laid on the bank itself. I may further remark, with regard to this subject, that attempts have been made to form a mound of the character proposed without a stage, but the results have finally led to the adoption of a stage as absolutely necessary for the economical and satisfactory progress of the work. The outer end of the mole would be protected by blocks of cement concrete, each about 80 tons weight, formed *in situ*, and allowed to settle down by the action of the sea on the rubble on which they would rest. There would be a small cast-iron lighthouse at a convenient distance back from the end slope.

It will be readily understood from the description above given, coupled with the particulars furnished on the annexed cross-section, that no quayage-accommodation for vessels would be afforded by the proposed breakwater itself. Shelter would be available under the lee of the work at all times for steamers and sailing-vessels of the class engaged in local trade, the depth covered by the breakwater at low water of spring-tides being 24ft. at the outer end, while a considerable proportion of the area protected would be in from 12ft. to 24ft. at low water, or 24ft. and 36ft. at high water, the rise of tide at springs being taken at 12ft.

As the most ready means of providing berthage, I have laid down on the drawings three jetties, each of 500ft. in length, extending in an E.S.E. direction from the harbour-edge of the proposed roadway along the breakwater The outer of these jetties would consist of cribwork formed of piles, braces, and a decking of totara wood, filled in with rubble-stone from the proposed quarry at Paretutu, and arranged for berthing vessels along either face in fine weather, although on some occasions, owing to "scend" or undulation, it would not be practicable to use the outer or north-east side. The further shelter which would be afforded by this cribwork structure would enable the berthage on both faces of the two other jetties (which should be of open timber piling and framing, also of totara), to be used on all occasions.

An approach to the breakwater from Barrett's Road would be formed somewhat in the manner shown on the drawings. The precise line for this new road can best be determined on the ground, seeing that sufficient details of the configuration of the site are not at hand here. It is not improbable, therefore, that the line I have sketched may require some modification.

I am informed by the Resident Engineer, Mr. Irvine, that the quantity of stone in Paretutu available for the purposes of the works is far in excess of that required. It will be well before commencing operations that this point should be again looked into, and clearly established, as the section I have proposed is of greater bulk than that recommended by Messrs. Carruthers and Blackett.

I may mention that the construction of the mole from A to B, on drawing No. 2, will require about 800,000 cubic yards of rubble-stone, measured in the mound. Moreover, the disposition in the hill of the stone suitable for the proposed breakwater may be such as to render it desirable to modify the level of the top of the self-acting incline, and this can only be determined with certainty by opening out the face of the rock and the cubic quantity of stone of proper quality above the level of the head of the incline, at least approximately ascertained.

It has been suggested that an opening, bridged by a viaduct, might be left between the coast-line and the inner end of the western mole, with a view, I presume, of promoting tidal circulation within the area under the lee of the work, and so to prevent silting. A viaduct spanning an opening of this kind would prove a constant trouble and source of anxiety and would necessitate raising its roadway to a much higher level than would be desirable along the solid work, hence requiring an inclined approach to connect with the road on the mole, and consequently interfering with traffic. Moreover, by dealing with the sand-drift in the manner hereinafter described, the necessity for the opening would be removed, and under the altered conditions it would certainly do more harm than good.

An extension of the west breakwater from B to C for a length of 1,050ft. in a N.E. by E. direction, in prolongation of the outer arm before described, is shown by red cross-lines on the drawings. The execution of this work in the same manner as the mole shown on the annexed cross-section would form the first instalment of extended harbour-accommodation when the requirements of the port shall have outgrown the facilities which would be afforded by the breakwater and jetties previously described.

The second extension, also shown by red crossed lines, should consist of an eastern arm commencing near high-water mark at the point D on drawing No. 2, about 450 yards to the eastward of Bayly Road, and extending thence in a N W by N direction for a length of 2,430ft., terminating with a cant W by N ½ N., and 655ft. long, so as to leave an opening or entrance of 500ft. in width, measured to the low-water edge of the harbour slope of the western mole. It will be seen that a most extensive harbour having an area of 130 acres outside the 1 fathom contour-line, would thus be formed the shore end from D to E would consist of a rubble embankment, but from E to the outer end at the point F the work would be formed of blocks of concrete, set as masonry, and adapted for berthing vessels along the inner face.

The following table gives the acreages, depths, and lengths of berthage afforded by this design when fully completed :—

Areas within the Harbour

At Low-water Spring-tides.	One Fathom and Upwards at Low Water.	Two Fathoms and Upwards at Low Water.	Three Fathoms and Upwards at Low Water.	Four Fathoms and Upwards at Low Water.	Five Fathoms and Upwards at Low Water.
162 acres.	130 acres.	98 acres.	46 acres.	20 acres.	5½ acres.

	Lin. ft.	Lin. ft.
Berthage—		
West breakwater (No. 1 jetty)	1,000	
" (No. 2 jetty) ..	1,000	
" (No. 3 jetty)	1,000	
	——	3,000
East breakwater pier, inner face, E to F ..		1,800
Total berthage ..		4,800

Although I have described the works necessary for the full completion of design A, I have not done so with a view to recommending them for adoption now nor indeed, for many years to come, seeing that their cost would be altogether beyond the sum now available for works at New Plymouth. My object has been merely to indicate the character of the extensions, and the order in which they should be undertaken, as and when required.

Design B.—In the early stages of my consideration of this subject it appeared to me that some saving in first cost might possibly result from the adoption of a work commencing just to the westward of the whaling-station, and extending into 3 fathoms at low water which, if thoroughly sheltered, would have been sufficient for the accommodation of the local trade hence it was that design B was framed, and sections and estimates prepared for comparison with those of design A. On drawing No. 2, design B is shown by brown colour and lines, the portion which corresponds with the western mole and jetties of design A being tinted, whilst the extensions are etched. It will be seen that the western arm of this proposal would commence on the foreshore at the north end of Barrett's Road, marked G, and extend N ½ W for 1,300ft., thence N.E. by N ½ N for 600ft., and again N.E. ½ E. for 800ft., making together a work of 2,700ft. from the starting-point. At 100ft. back from the extreme end there would be a jetty 270ft. in length at a right angle to the protecting work to prevent "run" or undulation along the harbour-face. From G to H the shore-end would be formed of rubble-stone, deposited as an embankment but the remainder from H to J, and also the jetty would consist of blocks formed of Portland cement concrete, built as masonry, the former being a solid structure set off the end by means of a Hercules, or special setting-machine, whilst the jetty, which would be sheltered, would be formed with main and cross-walls, filled in with a hearting of rubble-stone. The whole of the masonry face would be available as quayage, alongside which vessels could be berthed.

The extensions of design B should be undertaken simultaneously. They would consist of the prolongation of the outer cant of the western arm from J to K (on drawing No. 2) for a length of 200ft., and the construction of an eastern arm commencing at the point L on the foreshore, 300 yards eastward of Bayly Road, proceeding from thence as a rubble embankment in a N W by N direction 1,225ft., and thence as a masonry work from M to N in a W by N direction for a further length of 700ft., terminating at a point 300ft. distant from the south-west end of the jetty, so as to form an entrance to the harbour of that width.

The following table shows the acreage of sheltered water, and the lengths of the quayage which would be afforded by this design :—

Areas within the Harbour

At Low-water Spring-tides.	One Fathom and Upwards at Low Water.	Two Fathoms and Upwards at Low Water.	Three fathoms and Upwards at Low Water.
50 acres.	30 acres.	18½ acres.	1¾ acres.

	Lin. ft.
Berthage—	
West pier jetty, both sides	540
" inner face, H to K	1,560
East pier, inner face, N to M	700
Total berthage ..	2,800

Estimates.—I estimate the cost of the works above described as follows

	£
Design A—	
1. The breakwater complete to XX on drawing No. 2, being 1,920ft. from the starting-point, and a jetty of cribwork and rubble-stone, on the line of No. 3, including approach-road and self-acting incline, &c.	197,240
2. The breakwater complete to YY on drawing No. 2, being 2,220ft. from the starting-point, and a jetty of cribwork and rubble-stone on the line of No. 2, including approach-road, incline, &c. ..	237,960
3. The breakwater complete from A to B, with a jetty of open timber framing and piling on the line of No. 2, including approach-road, incline, &c.	284,230
4. The breakwater complete from A to B on drawing No. 2, including approach-road, incline from quarry, &c.	267,800
5. Jetty No. 1, constructed of cribwork filled with rubble-stone, including formation of masonry, abutment, &c.,	34,500
6. Jetty No. 2 of open timber framing and piling, including formation of masonry, abutment, &c.	16,430
Design B—	
West pier complete from G to J on drawing No. 2, with jetty of masonry, incline road from quarry, &c.	295,400
Extensions—	
Design A—	
Extension of west mole from B to C	182,300
East breakwater pier from D to F, and approach-road complete	427,700
Design B—	
Extension of west pier from J to K, and formation of east pier from L to N, with approach-road	211,700

The above estimates include a fair allowance for contingencies and supervision, also of permanent railways of 3ft. 6in. gauge, and are based upon the assumption that the works are executed by free labour in each case.

Mode of Procedure recommended.—The point now to be determined is which of the two western works—viz., that of design A or of design B—should be adopted. I think there can be no doubt that the balance of advantage is in favour of design A, coloured red on the drawings. Not only would this design afford a greater area of shelter in deeper water than design B, but the mode of construction proposed would be better adapted for the utilisation of convict labour than the masonry pier and jetty contemplated in the latter design. Moreover, without desiring to lay undue stress upon the importance of providing for future extensions, it will be evident that design A is incomparably superior to B in respect of the scope which it offers for future development.

The alternative modes of procedure are as follow If the amount which can be raised for the purposes of the works will not exceed £200,000, and convict labour will not be available, then the execution of the west mole to the point XX on Drawing No. 2, together with the construction of a jetty of cribwork filled with rubble-stone, might be undertaken in accordance with estimate No. 1.

The employment of convicts will cheapen construction, although it is impossible now to determine to what extent, seeing that the number of convicts, and the degree to which the works would be debited on their account, cannot be stated. Much also would depend upon the length of the sentences of the men, long-sentenced convicts, by reason of the experience they gain upon the works, being far more useful than men who are imprisoned for short periods. With regard to the terms upon which convict labour is usually obtained on colonial works, I may remark that I am at present engaged in carrying out marine works where convict labour is largely employed, the works being debited only with the cost of the barracks, and with such special overseers as may be required. In these cases a slight gratuity, termed "exertion money, is given to the convicts as a reward for extra work. If convict labour can be had at New Plymouth upon this basis the cost of the work will

be reduced, and it is not improbable that the breakwater might be completed to YY, with a jetty of cribwork and rubble-stone on the lines of No. 2 for the sum of £200,000. In either of the above cases, whether the mole terminated at XX or YY, a jetty for berthing vessels would be provided, although in the former case, with a jetty on the line of No. 3, the depth alongside would be only 13ft. to 14ft. at spring-tides, and consequently the accommodation thus afforded would be limited. There is yet another mode of procedure—viz., to carry the breakwater as far as practicable for the sum of £200,000 upon the line laid down, obtaining berthage hereafter, and I should prefer this course to stopping the work at XX, with a jetty on the line of No. 3.

Recapitulation of Recommendations.—I have thought it desirable to go thus fully into the alternative proposals in order to anticipate points which might be raised in the colony Briefly, however, I may summaries the recommendations as follows If convict labour be available, and the amount to be expended on the works £200,000, then I would advise that the work should terminate at YY, with a jetty on the line of No. 2. If convict labour be not available, and the sum to be expended is also £200,000, then the breakwater should be carried as far as practicable for that amount without a jetty, in which case the work would terminate at about the point marked YY

In addition to the mode of construction herein recommended, I have carefully considered whether the work could not be cheapened by the adoption of some other type of section, but upon taking out quantities, and preparing estimates of cost, I find that the system proposed, and before described, is undoubtedly the most economical under the circumstances.

Drifting Sand.—To the southward and eastward of Paretutu there is, as shown upon the plans, a considerable area of ground covered by loose sand, which, during strong westerly winds, drifts towards the bay It will be an important preliminary step to adopt measures for preventing further accumulations, and for fixing the sand which may be on the surface. I would, therefore, recommend that the *débris* from the quarrying operations should be run out from Paretutu, in the form of a high embankment, in a southerly direction (on a line to be hereafter determined), with the view of deflecting the travel of the sand. The whole of the sand-covered area should be planted at the proper season of the year with seeds of *Arundo arenaria*, or some other species of bent grass adapted for fixing the sand. With the same objects in view, but as an additional safeguard, I would further recommend that seeds of *Pinus maritimus* should be planted, in the form of a belt, along a line running S.W from the centre of Paretutu. In each case the seeds should be protected by a light covering of bush spread over the entire surface of the ground. If the above precautions are adopted there will be no reason to apprehend a reduction of the depth of sheltered water under the lee of the proposed work from blown sands.

Conclusion.—I desire, in conclusion, to express my thanks to Mr Kelly (then Chairman of the Harbour Board), as also to Mr F A. Carrington and Mr Weston, who, at the time of my visit to New Plymouth, afforded me every assistance. Mr C. D. Irvine, Resident Engineer, and Captain Holford, Harbourmaster, attended to my wishes, and met all my requirements.

At New Plymouth, as at all the other ports inspected in New Zealand, I had the privilege of being accompanied and aided by Mr Blackett, Marine Engineer of the colony and to him my obligations are especially due. It would scarcely be justice to Mr Blackett if I omitted to mention the fact that, although he had accompanied me on my tour of inspection for some weeks previously, it was only on arrival at New Plymouth that I became aware of the circumstance of his having taken any part whatever in proposing a plan for the harbour-works at this place.

I have, &c.

The Secretary, Marine Department, Wellington, New Zealand. JOHN COODE.

E.

ORDER OF GOVERNOR IN COUNCIL APPROVING PLANS M.D. 404, 405, 406, AND 407

JAMES PRENDERGAST Administrator of the Government.

Order in Council.

At the Government House, at Wellington, this twenty-eighth day of September, one thousand eight hundred and eighty

Present, His Excellency the Administrator of the Government in Council.

WHEREAS certain plans of a breakwater to be made at New Plymouth by the New Plymouth Harbour Board, shown as the western breakwater, as far as YY of the design A of the plans marked M.D 253 and M.D. 255, were approved by the Governor in Council on the twelfth day of August, one thousand eight hundred and seventy-nine And whereas it is proposed by the New Plymouth Harbour Board to alter the design of the said breakwater and build it in concrete in lieu of rubble And whereas they have submitted plans for so doing for the approval of the Governor in Council, in accordance with the provisions of "The Harbours Act, 1878 " And whereas it has been made to appear to the Governor in Council that the said works will not be or tend to the injury of navigation

Now, therefore, the Administrator of the Government of the Colony of New Zealand, by and with the advice and consent of the Executive Council of the said colony, doth hereby approve of the plans marked M.D. 404, 405, 406, and 407 for a breakwater built of concrete at New Plymouth, the breakwater to be carried out to the line marked YY on the said plan M.D 404, the line of said breakwater being the same as that shown on the plan marked M.D. 253.

Provided, however, that the Harbour Board aforesaid may if they think fit, make that portion of the breakwater which extends to low-water mark of ordinary spring-tides in rubble, in accordance with the cross-section shown on plan M.D. 255 aforesaid.

FORSTER GORING, Clerk of the Executive Council.

REPORT OF MARINE ENGINEER.

Marine Department, Wellington, 27th September, 1880.

I HEREBY certify that the construction of a concrete breakwater at New Plymouth, as shown on the plans marked M.D. 404, 405, 406, and 407, will not be or tend to the injury of navigation.

—— JOHN BLACKETT, Marine Engineer

FORSTER GORING, Clerk of the Executive Council.—28th September, 1880.

F.—REPORT BY SIR JOHN COODE, C.E.

5, Westminster Chambers, London, S.W , 17th March, 1880.

SIR,— *New Plymouth Harbour*

Adverting to previous correspondence, I have now the honour to inform you that, after receiving from Mr Rees particulars of the relative proportions of stone of different sizes procurable from, and in the vicinity of, Paretutu, which particulars were supplemented by the Board's telegram of December, it became evident that the stone available in the locality was not suitable for a rubble mound section as had appeared to be so probable.

The information supplied by Mr. Rees was to the effect that the trials had proved that seven-tenths of the stones would be of less size than 20cwt. two-tenths from 20cwt. to 30cwt., and one-tenth over 30cwt. Under these circumstances, there was no other course open than that of altering the mode of construction by substituting a concrete work for one of rubble-stone—*à pierres perdues*—a course which I felt should only be adopted as a matter of necessity, arising from the proved deficiency of stone of suitable sizes, knowing, as I did, that such a change must inevitably lead to considerable additional expenditure for a given length of work. I may remark that the result has fully demonstrated the propriety of making the preliminary investigations recommended in my report of 28th February, 1879, with a view to determine the quantity and quality of the stone that would be available.

Acting upon the instructions contained in your letter of 3rd October ultimo, and after due consideration of the whole matter I have prepared such designs as I have considered to be necessary to meet the requirements of the case—that is to say that, whilst the works I have now to recommend are of sufficient strength to resist the force of the seas to which a breakwater in such an exposed situation must of necessity be occasionally subjected, they possess a proper, but not more than a proper, margin of safety to resist exceptional gales. I have, at the same time, so arranged the form and details of the structure that for the whole of that portion of its length which is in more than 9ft. at low water of spring-tides the profile on the inner or harbour-face will serve as a quay adapted for the berthage of vessels, and for discharging and taking in cargoes, or landing and embarking passengers, when lying alongside, protection being afforded as far as practicable by a sheltering parapet on the seaward face. A line of railway would be laid throughout the whole length of the pier and along the berthage portion a second line would be provided, these would, I apprehend, be connected with the general railway system of the colony The position and direction of the breakwater pier as now recommended are precisely the same as proposed for adoption in my report of the 28th February, 1879.

A section formed of concrete blocks, set with sloping bond, is not, in my opinion, adapted to meet the requirements at New Plymouth. This system has its advantages in some positions, in fact, I am at present carrying out an extensive breakwater of this character in one of the Crown colonies, but it is not, in my view, adapted for a work which necessitates the provision of a high sheltering parapet, which latter would inevitably be seriously cracked and dislocated were it to be erected on a base specially subject to, and adapted for settlement, as in the case of a structure arranged with sloping blocks. I therefore propose, as will be seen from the drawings, in such portion of the pier as would be formed with a vertical face, and adapted for berthage, to employ massive concrete blocks, placed as "headers" throughout, having horizontal beds, with both longitudinal and transverse bond.

The mode of construction I have to recommend for adoption is fully set out on the seven sheets of drawings, and described in the specifications sent herewith.

The extent of the work recommended for execution is coloured red on drawing No. 1. The letters YY on this sheet correspond in position with similar letters on the plan which accompanied the report of the 28th February, 1879.

From the starting-point out to about low water the root and harbour-walls would consist of concrete deposited in mass, a sufficient quantity of Portland cement for which can, I understand from Mr Rees, be obtained in the colony These walls might be started on the return of the Resident Engineer, in anticipation of the arrival of the special plant. During the execution of this part of the pier and the formation of the workyard, shops, and sheds, the special plant (the designs for which have been matured) might be proceeded with, so that upon the arrival in the colony of the machinery the pier proper seaward of the root, might be forthwith commenced and carried on in accordance with the drawings and specifications.

It will be seen that the section next beyond the root consists of a substructure of bags of concrete, which would be deposited in suitably-contrived boxes of the character shown on drawing No. 7, and thus brought up to low-water mark, and there levelled off to receive the superstructure formed of massive blocks of Portland cement concrete. The adoption of bags of concrete for the underwater portion of the pier will afford considerable advantages over the employment of blocks, as they would readily conform to the shape of the bottom upon being deposited, and would admit of being placed in position from the top with but little aid from divers, a point of considerable importance near the shore, where on most occasions there would be a belt of surf, which would considerably interfere with diving operations.

From the termination of the mode of construction last alluded to, the pier would be formed entirely of concrete blocks, except the foundation layer which would consist of bags of Portland cement concrete, carried up to a sufficient extent only to form a level bed to receive the foundation blocks.

Simultaneously with the construction of the root, the laying-out of the workyard should be proceeded with, in the manner shown on drawings Nos. 1 and 5, and described in the specification. It will be observed that the position of this yard has been determined so as to remove it as far as practicable from the influence of sand-drift. Immediately to the south-west of the southern portion of the yard, where in all probability some bare sand will be found to exist, I would recommend that this surface should be covered with quarry *débris* as the excavations are carried on, the planting of the remainder of the sands being proceeded with as early as practicable thereafter The covering of these bare patches with quarry *débris* will prevent the passage of drift-sands over that portion of the point which lies to the south-west of the workyard.

On the general drawing No. 1 I have shown by dotted lines an extension of the breakwater to the same point as indicated on the plan which accompanied my report of the 28th February 1879. I have also laid down the position of three jetties, which correspond with regard to sites, lengths, and widths with the jetties shown on the report plan last referred to. It must be borne in mind, however, that the plan now proposed will provide a fendered quay of 1,500ft. in length along the harbour-face of the pier from the inner boat-steps to the seaward termination. Jetty accommodation for berthage purposes is not therefore required in this design, as in that which accompanied my report of February, 1879, although a solid jetty formed so as to shelter the inner face of the pier would be of great service during north-east winds, and would also serve to cut off the "range" which would otherwise be experienced along the quay when the sea is coming home directly on to the work. In the absence of a jetty of this character some temporary inconvenience from wave "scend" and undulation will occasionally be experienced but, seeing that a suitable work, if placed in the position of the outermost jetty, or somewhat more to the north-east, and nearer the end of the pier, would require to possess considerable strength in order to adapt it for resisting the heavy seas to which it would be exposed, the provision of such a jetty would largely increase the expenditure, and I have therefore considered that the question of jetty-accommodation should be determined hereafter upon the completion of the pier to YY when the demands of the trade may be sufficient to justify the further outlay which would be required. In the meantime any temporary inconvenience from range during gales must be borne with.

The design for the pier has been arranged so that the permanent railways and the parapet can be completed step by step as the pier advances. It would thus be available for trade purposes as it proceeds. The steam setting-machine for laying the blocks and bags will be adapted for travelling from the shore to the outer end, after the parapet has been formed, and over special rails laid on the pier for its accommodation. I look upon it as a matter of great importance in a work of this magnitude that provision be made for its utilization as it advances seawards. In order, however, that this may be accomplished the parapet and road-surface must follow on the block-setting.

The course I would propose to adopt with regard to the supply of Portland cement is that which is observed by the Crown Agents for the Colonies in similar cases—viz., to issue invitations towards the end of each year for the supply of such cement as may be required during the then succeeding year, provision being made for the testing of each cargo according to the terms and conditions of the specification by a competent Inspector before its shipment. I am confident that by the observance of this mode of procedure not only will the cement be delivered at a less cost, but the quality will be beyond question, a sufficient quantity will be assured at all times, and disputes with the contractors cannot arise, having regard to the provisions of the specification.

The main items of special plant required in this case are—one large overhanging setting-machine, or Hercules, to be employed for placing in position the heavy blocks from the "scar" end of the work, and constructed to meet the several conditions of this case as regards "plumb, radiation, and lift, two travelling concrete-mixing machines, adapted for the block-yard as designed, and a large traveller, or Goliath, suited to the weight of the blocks and the span of the yard as now determined. The course which I unhesitatingly recommend the Board to follow for obtaining these machines, as being decidedly the best, is that competitive tenders be invited from not less than three of the firms of largest experience and highest reputation as makers of this kind of plant, the tenders being based upon drawings and specifications prepared by me for the purpose, and the lowest tender accepted. In this way the best attainable guarantee would be secured for the supply of the most effective appliances for carrying out the work, and I need not here enlarge upon the great importance of employing only such appliances, knowing, as I do, from extensive experience, how greatly the economical and expeditious execution of works of this class depends upon the use of machines specially adapted to secure the object in view

The tenders for the plant should be sent by the contractors to the Agent-General for the colony, if arrangements can be so made, and payment might be effected through him, or by a financial agent of the Board, as may be preferred.

The course which I have here indicated is that which is invariably adopted for harbour-works in the Crown colonies, and in every case experience has fully confirmed the wisdom of this course.

I have taken it for granted that, as Mr. Rees himself suggested to me, the Board will not incur the expenditure requisite for procuring the special plant until the modified design has been submitted to and approved by the Governor in Council. In order therefore, to save time whilst this is being done, I have arranged (Mr Rees concurring in the view that this is the best course under the circumstances) that the drawings for the special plant shall in the meantime be advanced to completion, and specifications prepared ready for inviting tenders, as hereinbefore indicated, immediately, that your Board may write or telegraph if they decide to act upon the recommendations hereinbefore made. I may mention that the leading features of these machines have been neces-

sarily considered and settled in their earlier stages simultaneously with the drawings of the works to be executed by them.

Estimate.—I estimate the cost of the breakwater, pier, and root, if executed to the extent coloured red on drawing No. 1, which corresponds with the length out to YY referred to in my report of February, 1879, at £285,800. If the expenditure is confined to £200,000, then the pier can, for this amount, be carried only to a point 1,420ft. from low-water mark of spring-tides, or 565ft. short of YY

The above amounts include the cost of all plant, and provide a sufficient allowance for contingencies, sea-risk, and supervision. They are, however exclusive of the outlay already incurred in the colony in works executed to this date, and do not cover the cost of the excavation necessary for the formation of the workyards, as shown on drawing No. 5, sufficient particulars in the way of levels not being available here to enable the quantities to be ascertained, neither is the preparation of the surface of the workyard included, nor the erection of the sheds, workshops, nor the railways in the yard, the permanent lines on the pier and root have, however, been provided for in the amounts named.

I have, &c.,

The Chairman of the Harbour Board, New Plymouth. JOHN COODE.

G.—SPECIFICATION FOR BREAKWATER PIER AND OTHER WORKS CONNECTED THEREWITH.

SPECIFICATION of Works to be executed in the Construction of a Breakwater Pier, Workyard, Root, and Aproaches at New Plymouth, in the Province of Taranaki, New Zealand, for the Harbour Board of that Port, in accordance with the Modified Design and Working Drawings prepared by the Consulting Engineer, Sir John Coode, dated March, 1880.

IT is understood to be the wish of the said Commissioners that the works should be carried out departmentally and without the intervention of a contractor The following specification has therefore been framed in this sense, and does not include binding and other clauses as to qualities of materials, workmanship, &c., which it would have been necessary to introduce were the works to be executed under a contract. The materials and workmanship throughout are to be the best of their respective kinds, the operations being carrried on as hereinafter more particularly described.

Drawings.

There are seven sheets of drawings accompanying this specification, giving full details of the permanent works, to which will be added hereafter in due course, the contract drawings and designs for the plant. No. 1 is a general plan showing, by red colour, the position, form, and extent of the intended pier and works, with soundings, reduced to a common datum of low-water of an ordinary spring-tide. The termination of the coloured portion of the pier shown on this sheet corresponds with the point YY on the report-plan of the 28th February, 1879. No. 2 shows a general plan and distorted elevation of the pier, with large scale sections and details of the root. Nos. 3 and 4 give full details of the pier and its fittings from the root seawards. No. 5 furnishes particulars of the proposed arrangement of the workyard and buildings, with outline views of the block-making and lifting machinery No. 6 shows details of a typical block mould, and of the T-head lifting-bars, core-boxes, &c. It is assumed that the wood- and iron-work for the whole of the moulds will be prepared in the colony, in accordance with this drawing, modifying the dimensions of the sides to provide for the different sizes of blocks. No. 7 gives details of a wrought-iron box, in which the bags of concrete to form the substructure and foundations of the pier to the extent shown on drawings 2, 3, and 4 would be lowered into position from a portable overhanging machine, the latter being used also for setting the concrete blocks. The drawing of this box has been furnished now in order that two of them might be prepared in the colony, should the Commissioners so desire, in preference to sending them out from England.

General Levels and Dimensions

All the drawings are referred to a common datum of low water of ordinary spring-tides, which tides are assumed to rise 12ft. above that level.

The total length of the root, to be constructed in accordance with the details on drawing No. 2, from the starting-point of the pier just above high-water mark to the abutment near low water, is 335ft. From the abutment to 805ft. from the starting-point the section will be in accordance with Fig. 1, drawing No. 3, modified to suit the varying conditions of depth. From 805ft. to the point YY the pier will be of the character indicated on Fig. 1, drawing No. 4. The total length of the permanent work from the starting-point to YY is 2,320ft.

It will be seen that the section from the root abutment out to 805ft. from the starting-point 30ft. wide over all at the coping-level, having a quay-surface of 23ft. in width within the parapet, whereas the remainder of the pier seawards will be 34ft. wide at the coping-level, and the quay will be 25ft. between the edge of the coping and the inner face of the parapet. The junction between these two widths is to be formed in the manner shown on drawing No. 3, the difference on the harbour-face being made good by a flight of boat-steps (see Figs. 1, 3, and 4)

The finished level of the workyard, from C to D, drawing No. 5, is to be 10ft. above high-water spring-tides, or 22ft. above datum. From D to E the yard will fall over a length of 150ft. at a gradient of 1 in 75, so that the point E will be 8ft. above high-water spring-tides, which will be the level of the edge of the coping on the harbour side throughout the entire length of the pier

Plant and Machinery

In addition to the plant which has already been ordered by the Resident Engineer, it will be requisite to arrange for the preparation of the special machinery adapted for dealing with the manufacture, lifting, and setting of the bags and blocks of concrete, of which the permanent work will consist.

As the Resident Engineer has intimated the importance of obtaining the approval of the modified design by the Colonial Government and Commissioners before taking any steps in the ordering of this special plant, it has been decided that the Consulting Engineer shall proceed with the preparation of such detail drawings and specifications for this plant as will enable competitive tenders to be obtained for the supply of the same, the said documents being proceeded with during the return to New Plymouth of the Resident Engineer with the drawings, &c., of the permanent works herein referred to. Acting upon this arrangement, the Consulting Engineer is preparing designs for the following articles, so that upon the receipt of a telegram from the Commissioners they may be placed before contractors, from whom tenders would be obtained in the manner described in the accompanying report.

1. One 30-ton portable steam overhanging setting-machine, or Hercules, travelling on a railway of 15ft. gauge, centre to centre of rails, and adapted for placing in position in the pier the bags and blocks of concrete. The framing of this machine, as well as of the radiating truss, would consist largely of timber firmly tied and braced together and it would be specially adapted for dealing with the requirements of this work in a ready and economic manner

2. One 30-ton travelling steam Goliath, adapted for lifting blocks of concrete off the making-floor in the yard, and either stacking the same in the manner shown on drawing No. 5 or of loading them on to trucks for conveyance to the setting-machine at the end of the work.

3. Two steam portable concrete-mixers, each of 1 cubic yard capacity, with hopper, derrick-crane, service and supply water-tanks, and all necessary conveniences for readily mixing the concrete and discharging the same when mixed directly into moulds of the character shown on drawing No. 6.

4. Three Blake's patent stone-breakers with movable faces to the jaws.

5. One hank locomotive-engine, having four coupled wheels, adapted for dealing with the heavy blocks and for conveying stone, sand, and cement upon incline of 1 in 35 at the back of the shops and sheds, as shown on drawing No. 5.

6. One semi-portable engine for driving stone-breakers, with shafting, couplings, plummer-blocks, and riggers complete, also belting and lacing for same.

7 Ten wrought-iron skips for conveying the dry material from the cement-shed and from the sand and broken stone floors to the concrete-mixers (see drawing No. 5) each skip to contain 1 cubic yard.

8. Three sets of double and one single diving apparatus, with pumps and all proper outfit for each set complete.

9. Six wrought-iron tipping-boxes for loading wagons in the quarry

10. One Michell's cement-testing machine and two gun-metal split moulds.

The block and skip-trucks would, it is assumed, be prepared by the Resident Engineer in the colony

Materials.

Portland Cement.—The Portland cement throughout is to be of the best quality, uniformly burnt, and finely and evenly ground. It must be packed in strong barrels, lined with waterproof paper Contracts for a supply of this cement, to extend over a period of twelve months, would be let towards the end of each year, tenders being invited upon a detailed specification. Acceptance and delivery of the cement would be subject to the approval of an Inspector acting under instructions from the Consulting Engineer

Standard Shingle.—The whole of the sand to be clean, sharp grit, gathered during favourable opportunities when it may be thrown up by the sea. The shingle must also be perfectly clean, both to be conveyed in wagons to the sandfloors shown on drawing No. 5, and there tipped for subsequent filling into the skips referred to in item No. 7 in the foregoing list of plant.

Rubble-stone.—The stone to be broken for concrete material is to be specially selected as being the hardest and cleanest that can be procured in the quarries, and on no account must soft or friable pieces be sent to the breakers that for forming macadam is also to be broken by the machines, and should likewise be selected for hardness. The hearting of the root between the sea- and harbour-walls to consist of the general yield of the quarry, care being taken that it does not contain a preponderance of soluble material.

Timber.—The timber for fenders and sleepers to be of colonial growth, of the respective descriptions referred to on the drawings, all to be sound, well seasoned, free from sap, shakes, and other defects.

Iron.—The iron for straps, bolts, &c., to be of B.B.H. or other approved iron, and galvansied where hereinafter described.

Workyard.

Upon the arrival of the Resident Engineer in the colony, he will proceed with the preparation of the workyard, in accordance with drawing No. 5. The site of this yard has been determined—first, as being most convenient to the proposed pier, and, second, as being removed as far as practicable from the influences of the sand-travel across the point south east of Paretutu. Where the sand is bare to the north-west of a line stretching from the southern end of the workyard, it must be coated at the earliest practicable moment with quarry *débris* for a thickness of 6in., so as to prevent blown sand passing across the line of the workyard. South and south-east of the area so covered the bare sands are to be planted with bent grass, &c., as recommended in the report of February, 1879.

The respective levels of the workyard are shown on drawing No. 5. The surface of that portion of it which is described to be metalled must be coated with broken stone to a depth of 6in., spread over a base of rubble of 9in. thick, the macadam to be broken to pass through a 2in. ring, and evenly spread to the levels and gradients indicated on drawing No. 5. The area of the block-making floor—700ft. in length, 17ft. 8in. in width between the longitudinal sleepers—to be coated with

concrete, composed of one portion of Portland cement to eight of broken stone, gravel, and sand, run in solid to fill the interstices between a base of clean rubble spread evenly over formation-level for a depth of 9in., so that the concrete shall be thoroughly incorporated with the stone, and that the entire surface on which the blocks are to be formed shall be finished to an even, true, and smooth face.

The lifting and stacking steam Goliath of 55ft. gauge, centre to centre of rails, will run on whole timbers of colonial growth, firmly bedded on the rubble base before described. The longitudinal sleepers for the portable concrete mixers, one on each side of the block-making floor are likewise to be of colonial growth, 10in. by 10in., all to be in convenient lengths, and packed hard underneath the bed. Proper drains and culverts to be provided throughout the yard for unwatering its surface. The service and other lines shown on the drawings are to be of the colonial gauge of 3ft. 6in., and to be laid at the radii indicated on the plan, Fig. 3, drawing No. 5. Service main-pipes, consisting of 4in. pigot and faucit pipes, in 9ft. lengths, with well caulked and leaded joints, to be laid along the seaside of the block-making floor, with hydrants conveniently arranged for attachment by means of a flexible hose to a vertical delivery-pipe, connected with the machines for supplying with fresh water the service-tanks on each of the mixers, the source of supply to be the stream 200 yards westward of and parallel to Barrett's Road.

It will be observed that the concrete materials are to be conveyed over an incline of 1 in 35 at the back of the workshops, and at the top thereof shunted on to a level line, the stone being tipped therefrom on to an upper floor for the purpose of feeding three of Blake's 15in. x 9in. patent stone-breakers, arranged for crushing different sizes of material. The cement would be discharged from trucks in casks into the cement-shed, and the sand and shingle tipped on to a special high-level floor The cement may be retained in the casks until required for use, the latter being rolled to a hopper and the contents discharged therein There would be three of these hoppers in the shed, placed 25ft. from each end, and 50ft. apart, centre to centre, each fitted with a rectangular trunk proportioned to contain 4 cubic feet of Portland cement, being the exact quantity required for 1 cubic yard of concrete at the proportion of one of cement to eight of broken stone, shingle, and sand.

The top and bottom of this trunk to be fitted with slides, so as by withdrawing the upper and closing the lower one the said trunk can be filled and discharged upon the application of a reversed process. The floor of the cement-shed to be finished with concrete in the manner previously described for the blockyards. The masonry foundations of the shed to consist of flat bedded rubble-stone, laid in local lime mortar The copings to be of concrete formed *in situ*, and the floors also of concrete, laid on *débris* filling, in layers, well punned. The depths of the foundations of the walls indicated on the drawings are subject to variation, dependent upon the nature of the bottom, as demonstrated when the excavations are made. The sea-face of the yard to be formed on the line shown on Fig. 3 of the same sheet, and also on the general drawing No. 1, care being taken to select the largest of the stones for deposit on the outer face. The details of the timber work of cement-sheds, shops, and offices to be prepared by the Resident Engineer in the colony

The dry materials to form the concrete would be conveyed from the cement-shed and floors to the portable concrete-machines in special wrought-iron skips, each to contain 1 cubic yard, two skips being placed on each truck. The truck, with the empty skips thereon, would be drawn to the sand-floor, where each skip would receive its due proportion of sand and shingle, to be ascertained by gauging with a special rod the depth of the unfilled portion of the skip above the surface of the sand. After being thus partially filled with sand, the skips would be pushed underneath the cement-hoppers previously described, where each would receive its proper supply of cement, after which they would be further moved on and filled with broken stone, the object being to confine the cement between the layers of sand and stone, so that the wind would not act thereon, either whilst standing in the yard or during the process of tipping into the hopper of the mixer

Root.

Simultaneously with the execution of the workyard, and as soon as practicable after the return of the Resident Engineer to the colony, arrangements should be made for proceeding with the execution of the root of the pier, as shown on drawing No. 2. This root to consist of a sea-wall of the section on Fig. 3, commencing at a point 50ft. landward of high-water spring-tide, and extending therefrom for a length of 335ft. in a line with the sea-face of the pier, from whence there would be a return or abutment of the section indicated by cross-lines on Fig. 4, and from the latter, running landward in a curved direction, there would be a harbour-wall of the dimensions shown on Fig. 3, 250ft. in length, finishing at the inner end with a short return. The sea-wall to be stiffened with four counterforts, 6ft. thick at the top, and 8ft. at the base, placed 30ft. apart, centre to centre, as shown. The sea- and harbour-walls and the counterforts throughout to consist of cement-concrete, composed of one portion of Portland cement to eight of broken stone, shingle, and sand, the latter in such relative proportions, dependent upon the respective quality of the materials, as will insure a perfectly compact mass, free from voids and vacuities, all to be deposited *in situ*, in courses of 4ft. 9in. in height, to correspond in length with the courses of the masonry of the pier. Clean rubble may be incorporated into the heart of the courses of concrete, care being taken that the stone is well rubbed into and packed around with the concrete material. The face-joints, both horizontal and vertical, to be chamfered in the manner indicated, to correspond with the joints of the blocks in the pier The bottom course will rest on a foundation of compact boulders, which it is assumed will be obtained throughout the width of the foreshore, between high and low water, underneath the sand, which latter must be removed so as to lay bare the compact foundation , this, having been prepared and freed from gravel or other friable material, is to form the bed for the concrete superstructure. Should the bottom, in the opinion of the Resident Engineer, be of such a character as to justify the anticipation of disturbance, or scour, through rebound or otherwise, from the face of the wall on the seaside, he will, simultaneously with the putting-in of the lower courses of the sea-

wall, form an apron *in situ* of 6 to 1 Portland cement concrete, as shown by dotted lines on Fig. 3, and explained in the note referring thereto. It is highly important that this apron should be provided if the bottom, when bared, previous to the putting-in of the lower courses, appears to be of a character which may be subsequently disturbed by the sea.

Upon the completion of two courses in height throughout the extent of the root, the space between the walls is to be filled in solid with a hearting of rubble-stone, and, simultaneously with the execution of the superincumbent courses, the rubble hearting is to be again deposited, layer by layer, until it reaches the formation-level of the concrete protective skin, where it must be trimmed off to receive the latter, which is to be 20ft. in width from the back of the sea-wall, commencing 30ft. seaward of the starting-point, and terminating at the junction with the pitched surface 230ft. therefrom. This protective skin, or paving, to consist of 8 to 1 Portland cement concrete, run in solid amongst clean rubble-stone, so as to form a skin of at least 15in. thick for the outer portion of the paving, decreasing gradually to 9in. in thickness at the commencement, 30ft. from the starting-point. Seaward of the concrete pavement, and commencing 230ft. from the starting-point, the surface of the rubble between the sea and the harbour walls of the root to be coated with 8 to 1 Portland cement concrete, deposited as described for the concrete paving of the inner portion, finishing at the level shown on Fig. 3, drawing No. 2, and paved with hammer-dressed stone to adapt it for cart traffic, resting upon the bed of concrete and run in solid with Portland cement grout, broomed into the joints. Previous to the laying of the pitching, the longitudinal sleepers of matai wood (see Fig. 8, drawing No. 3) are to be bedded into the concrete to receive the rails for the Hercules, or portable overhanging setting-machine, and for the block road to feed the same. These sleepers throughout to be 12in. wide at the top, and 6in. thick, sawn on all four sides, and tapered ¾in. on each, so as to leave the concrete freely for renewals, and the upper arrises chamfered to receive the pitching-blocks, the sleepers to be in such lengths as can be conveniently obtained in the colony

Breakwater Pier

The pier proper will commence at the root abutment, at 335ft. from the starting-point, and proceed therefrom for a length of 470ft., in accordance with Fig. 1, drawing No. 3. From this latter point seaward the section will be as shown on Fig. 1, drawing No. 4.

Bagwork.—The substructure of the pier, from the bottom to the level of 1ft. 9in. above low-water spring-tide, for that portion of the work shown on Fig 1, drawing No. 3, over the length just described, and also the foundations where the section of the pier is to be of the character shown on Fig. 1 drawing No. 4, are to consist of concrete, composed of one part of Portland cement to six of broken stone, shingle, and sand, arranged in proper proportions to form a compact mass free from vacuities, deposited in bags of jute sacking, made from material weighing 20oz. per lineal yard for a width of 27in., sewn with double flax, 10lb. tarred twine, with sailmakers double seams throughout. The bags are to be deposited in wrought-iron boxes, of which two will be required of the character shown in drawing No. 7 the bags being made somewhat larger than the box, so as to obviate as far as practicable their bursting on being discharged therefrom. The maximum weight of the bags of concrete when the box is filled to the depth of 3ft. 6in. will be 14 tons. Compensation layers will, however, be introduced where required to make up inequalities, by partially filling the box, and also by the use of 2-bushel and 4-bushel bags. The top or flap of the jute sacking to be in one piece with the back, and to be securely sewn to the sides along the top edge after the concrete has been filled into the box. The bag-boxes would be lowered into position from the jib of the portable setting-machine referred to in item 1 of the foregoing list of special plant.

The information now available as to the nature of the bottom along the line of the pier is not sufficient to enable a determination to be arrived at as to the necessity or otherwise for excavating the surface of the sand with a view to the bagwork being carried down to the boulder or other compact foundation therefore, prior to the commencement of the bag-laying, careful borings or probings must be made along the site, so as to determine at what depth the solid bottom may be reached. Upon the receipt of these particulars as to the precise character of the bottom, the Consulting Engineer will be in a position to determine the expediency or otherwise of excavating a portion of the surface-sand, and in what manner this can best be done, with a view to the lowering of the foundations below the present sea-bed, in the manner shown on Fig. 1, or possibly to a greater extent should the data then available show this to be necessary

Upon the bag substructure, Fig. 1, drawing No. 3, being raised to the surface, the work would be levelled off by the deposit of smaller bags, and the high places in the large bags scappled down, so as to form a level bed to receive the superincumbent blocks. Along that portion of the pier where the foundations are to be levelled under water, in the manner shown on Fig. 1, drawing No. 4, the bags, which will be placed in position with a view to being in themselves approximately level, will be coated with a layer of broken stone, which latter would be formed to an even and true bed to receive the blocks, sealing or long bags of concrete being placed in position previous to the lower course of blocks being laid thereon, as shown.

Upon the completion of that portion of the pier shown on Fig. 1, drawing No. 3, it will in all probability be desirable to employ in connection with the diving operations necessary for the preparation of the bed to receive the bags for the work shown on Fig. 1, drawing No. 4, and also for the deposit of these bags, and for the levelling skin of rubble, a barge with suitable overhead frame and gearing, having a central well through which the bag-box could be raised and lowered, the said barge being adapted for containing a sufficient quantity of concrete materials for a day's consumption.

For the reasons above referred to, as to the absence of precise data with reference to the character of the bottom, it cannot now be determined whether or not it will be requisite to protect the seaward toe of the foundations with an apron in the manner shown on Fig. 1, drawing No. 3, and Fig. 1, drawing No. 4, but, should the examination along the site of the pier referred to above

show that it will be impracticable to carry the foundations down to the solid bottom, then the apron of concrete in bags, Fig. 1, drawing No. 3, will be imperatively required to prevent disturbance of the footings by rebound from the sea-face, but should it, on the other hand, be shown that it is practicable to carry the foundations down to a compact bottom, and one which will not be likely to be afterwards disturbed by rebound, then the apron of the concrete in bags may be dispensed with. This question of the provision of the apron or otherwise must therefore remain in abeyance until the results of the examination above alluded to are at hand.

Concrete Blockwork.—The whole of the superstructure throughout, from the top of the bagwork (Fig. 1, drawing No. 3), and from the levelling skin of rubble (Fig. 1, drawing No. 4), in each case, to the underside of the parapet, to consist of concrete blocks of the forms and dimensions shown on the drawings, all to be chamfered on the outer face to the extent of 3in., measured vertically and horizontally (see details of the moulds, drawing No. 7) All to be laid as long and short headers, breaking joint, both vertically, as indicated on the sections, and horizontally, as on the plan (Fig. 4, drawing No. 4) The whole of these blocks above the level of the low-water course to be set in 1 to 1 Portland cement mortar, and the joints run in solid with Portland cement grout, care being taken to point the face of the joints for a suffiicient interval to insure the setting of the pointing prior to the running-in of the grout.

The concrete for the manufacture of the blocks is to be of a uniform quality, composed of eight parts of broken stone, shingle, and sand to one Portland cement, the relative quantities of the three first-named materials being proportioned so as to produce thoroughly solid work, all to be machine mixed, in the most thorough and perfect manner, gauged with fresh water and deposited within moulds or boxes of the requisite sizes and shapes, constructed in accordance with the design shown on drawing No. 7. The moulds to be carefully wrought on the inside to an even, true, and smooth surface. The sides to be secured by bolts welded to a 3in. by 3in. flat bar and travelling in slotted holes, sufficient play being provided to enable the mould to come free from the block without taking the former apart. When the moulds have been "set up," and before the concrete is deposited within them, the inside faces are to be well painted, on each occasion of their being used, with a composition of soap, boiled down to a jelly, and well rubbed into the grain of the wood, the object being to produce a smooth face and to prevent the adhesion of concrete to the mould.

The concrete materials will be conveyed to the portable mixing-machine in skips, as before described, each skip containing the materials, with the proper proportions of stone shingle, sand, and cement necessary to produce 1 cubic yard of concrete. Generally thirty revolutions of the cylinder will suffice for the proper admixture of the ingredients. Care to be taken that the concrete is thoroughly packed against the moulds so as to give uniformly clean faces to the blocks; for this purpose a man should be kept in the mould during the whole of the time that the block is being made, and he should trim the concrete as it is deposited, and thoroughly pack and work it against the sides with a shovel, so as to produce a smooth and even face when the block is stripped.

The holes for lewises of the size shown must be formed by fixing in the moulds core-pieces, tapered, and of the dimensions figured on the drawing. The blocks must be shipped or freed from the moulds at about the third day after making, and on no account are they to be lifted until at least six days have expired from the time of their manufacture, when they may be stacked by means of the steam traveller, in the manner provided for on drawing No. 5. The date of manufacture must be marked on the back of each block, with the letter of the course for which it is intended, corresponding with the letters on Fig. 1, drawing No. 3, and Fig. 1, drawing No. 4.

When the blocks are being made pieces of hard and clean rubble-stone may be placed in the heart of the mass so as to economize the concrete material, care being taken, however, that the stones are well rubbed and bedded into the concrete so as to produce perfectly solid and compact, blocks, free from interstices.

The blocks would be loaded on to trucks in the yard by means of the steam traveller and conveyed therefrom by a locomotive passing underneath the portable setting-machine at the scar end, where they would be lifted off by the latter machine and placed in position thereby The outer blocks, both on the sea- and harbour-faces, to have joggles inserted into the joints in the manner shown. Details of these joggles are given on Fig. 3, drawing No. 5 they are to consist of one part of Portland cement to six of small stone, gravel, and cement, well rammed into the moulds, and allowed to become thoroughly hard and seasoned before being placed in the work, the space between the joggles and the blocks to be run in solid with 1 to 1 Portland cement grout for those joints which are above low-water spring-tide, and in the case of those below that level, with fine gravel, packed in by divers directly the joggles have been placed in position.

Parapet.—The parapet throughout is to consist of 8 to 1 Portland cement concrete deposited *in situ* in 12ft. lengths, arranged to break joint with the blocks, a sham joint being introduced intermediately so as to show joint-lines 6ft. apart, centre to centre, along the parapet on its sea- and harbour-faces. The bull-nose course to be formed by means of a properly-shaped face-mould, wrought to a smooth surface, and coated with a composition similar to that previously described for the blocks, before the concrete is deposited. The blocks to form the upper course, on which the parapet will rest, must be provided with tooth-stones of hard, clean rubble, arranged so as to be incorporated for half their depth into the block and half into the masswork. The parapet would return around the end at the point YY unless it should be decided before the work reaches that point to prolong it further seaward in the direction of the extension shown by dotted lines on drawings Nos. 1 and 2. The parapet to be formed as the blockwork is brought up to the requisite level.

Steps.—Form four flights of boat-steps and two of parapet-steps in the positions indicated on the general plan and distorted elevation, drawing No. 2, and in accordance with the details on drawings Nos. 3 and 4, all to be made of 8 to 1 Portland cement concrete, deposited *in situ*, with fine 6 to 1 material packed against the face of the moulds to form the threads and risers.

Grooves.—Grooves to be formed in the face-blocks on the harbour side for the reception of the fenders in the manner indicated on Fig. 6, drawing No. 3.

Sleepers.—Simultaneously with the advancement of the works seaward, the sleepers of maitai wood, of the dimensions and form shown on Fig. 8, drawing No. 3, are to be laid in the positions indicated in the cross-sections, and resting on the blocks. These sleepers may be in such lengths as can be conveniently obtained in the colony

Concrete-in-mass Roadway.—Concrete-in-mass, composed of one part of Portland cement to eight of broken stone, shingle, and sand, must be deposited between the sleepers last described in the manner shown on the sections, and brought up to an approximately true surface, having a gradient of 1 in 60, falling towards the coping, at a depth throughout of 8in. below the finished surface of the roadway

Pitch-paving.—Step by step as the work is carried seaward the pitch-paving between the rails and the seaward rail and parapet must be laid as shown on the sections, so as to render the work available for use to the fullest extent during progress. This paving to consist of selected stone from the quarry, hammer-dressed, laid on edge, and grouted so as to form a suitable surface for cart and other traffic.

Fenders.—Provide fenders of totara wood throughout the harbour-face of that portion of the pier where formed in accordance with Fig. 1, drawing No. 4. Each fender to consist of a whole-timber inner piece, and a half-timber facing securely trenailed thereto, both to be sawn on all four sides and the face-pieces chamfered at the front arrises. 4in. by $\frac{7}{8}$in. galvanised wrought-iron bands to be provided and securely bolted with 1$\frac{3}{8}$in. jagged bolts, having upset ends, for holding back the inner pieces into the grooves previously specified to be formed in the concrete blocks, the back of the inner piece being splayed $\frac{1}{2}$in. on each side to fit the groove.

Bollard-cases.—Provide cast-iron bollard-cases to fix on the fender-piles at intervals of 60ft. apart, centre to centre, measured along the pier Each bollard to be secured by a pair of 1$\frac{3}{4}$in. anchor-bolts passing through pipes introduced into the blocks for the purpose, and drawn up tight on the inside by means of a nut bearing on a cast-iron washer and hardwood block the upper end of each bar to have an eye for the reception of a 1$\frac{1}{2}$in. bolt for attachment to a 4$\frac{1}{2}$in. by $\frac{5}{8}$in. wrought-iron strap passing around a collar in the bollard (see Fig. 5, drawing No. 4) Provide solid wrought-iron rail standards and bars of the character shown on Fig. 7, drawing No. 3, at the boat-steps, each to be attached to the coping by means of a jagged toe-bolt 12in. long, having an upset end running down in a hole bored in the coping for its reception, the latter having two small chases into which grout would be poured, care being taken that the standards are temporarily secured, pending the setting of the cement.

Railways.—The arrangement of the permanent railways on the pier are shown on the general drawing No. 2 these consist of a line on the colonial gauge, to be used as a block service road during the construction of the pier out as far as the boat-steps between the junction of the two sections (Fig. 1, drawing No. 3, and Fig. 1, drawing No. 4) from which point there would be a double lone on the 3ft. 6in. gauge. In addition to these roads a railway 15ft. centre to centre would be laid throughout the length of the pier for the portable setting-machine, the harbour rail of which would be utilised as the seaward rail of the inner permanent line, on the 3ft. 6in. gauge above referred to (see Fig. 1, drawing No. 2, and Fig. 4, drawing No. 3) All the lines of rails to be of steel, 53lb. per yard, colonial section, those for the setting-machine being of steel, and 70lb. per yard, switchers and crossings to be provided at the points indicated on the drawing.

JOHN COODE.

H.—BILL OF QUANTITIES FOR WORKS PROPOSED BY SIR JOHN COODE IN HIS REPORT DATED 17TH MARCH, 1880.

Bill of Quantities of Work to be executed if Pier is completed to the Full Extent coloured Red on Drawing No. 1—viz., to YY—exclusive of Formation of Workyard, and the Shops, Sheds, and Railways thereon.

Root, from starting-point to low-water spring-tide—

259	cub. yd. excavation for walls.
3,371	" concrete-in-mass above low-water
95	" " under pitching of roadway
137	" concrete paving.
9,600	" filling.
485	cub. ft. timber in longitudinal sleepers.
190	(number) cross-sleepers.
331$\frac{1}{4}$	cwt. steel rails.
12$\frac{1}{2}$	" fish plates.
11$\frac{1}{2}$	" bolts and spikes.
4	(number) sets switches and crossings.
81	cub. yd. pitching.
385	" road-metalling,

Breakwater pier from low-water spring-tides out to YY on drawing No. 1—

12,764	cub. yd. concrete in bags below low water
3,421	" " apron below low water
895	" broken stone for levelling below low water.
1,566	sq. yd. levelling bags above low water
27,888	cub. yd. concrete in blocks below low water
44,101	" " " above low water.
4,864	" " masswork parapet.
595	" " " under pitching of roadway
4,931	cub. ft. timber in longitudinal sleepers.

1,556¾ cwt. steel rails.
58¼ „ fish-plates.
54½ „ bolts and spikes.
7 (number) sets switches and crossings.
1,151 cub. yd. pitching.
3,591 cub. ft. timber in fenders.
307¾ cwt. wrought ironwork.
190¼ „ cast-iron.
1 (number) light and lantern.

The estimated cost of the works comprised in the above quantities is £285,800, as stated in the report referred to above, which sum includes the provision of plant and a sufficient margin for contingencies, sea-risk, and supervision, but is exclusive of the sum expended up to date on works executed in the colony

Bill of Quantities of Work to be executed if the Expenditure on account of the Root and Breakwater Pier is limited to £200,000, exclusive of the Sum expended up to Date on Work executed in the Colony, and the Formation of the Workyard, Shops, Sheds, and Railways thereon.

Root, from starting-point to low-water spring-tides—
259 cub. yd. excavation for walls.
3,371 „ concrete-in-mass above low water.
95 „ „ under pitching of roadway
137 „ concrete paving.
9,600 „ filling.
485 cub. ft. timber in longitudinal sleepers.
190 (number) cross-sleepers.
331¼ cwt. steel rails.
12½ „ fish-plates.
11½ „ bolts and spikes.
4 (number) sets switches and crossings.
81 cub. yd. pitching.
365 „ road-metalling.

Breakwater pier, from low-water spring-tides out to 1,420ft. from that point, or 1,755ft. from the starting-point—
9,242 cub. yd. concrete in bags below low water
2,477 „ „ apron below low water
563 „ broken stone for levelling below low water
1,566 sq yd. levelling bags above low water.
15,000 cub. yd. concrete in blocks below low water
31,325 „ „ „ above low water
3,045 „ „ masswork parapet.
428 „ „ „ under pitching of roadway
3,484 cub. ft. timber in longitudinal sleepers.
1,100 cwt. steel rails.
41 „ fish-plates.
38½ „ bolts and spikes.
5 (number) sets switches and crossings.
822 cub. yd. pitching.
2,223 cub. ft. timber in fenders.
189½ cwt. wrought ironwork.
121¾ „ cast-iron.
1 light and lantern.

The estimated cost of the work comprised in the above quantities is £200,000, as stated in the report referred to above, which sum includes the provision of plant, and a sufficient margin for contingencies, sea-risk, and supervision.

I.—Report by the Engineer to the Harbour Board.

Sir,— New Plymouth Harbour Board Offices (Engineer's Office) 28th August, 1879.

I feel I should fail in my duty to your Board did I not record for their information my estimate of the cost of the proposed harbour-works as designed by Sir John Coode, and at the same time to point out that possibly a more economical section might be adopted.

I have entered upon this course with considerable diffidence, and, in consequence, have not hastily arrived at conclusions, but have accepted the figures and calculations of well-known civil engineers, whose statements have been subjected to the criticism of the Institution of Civil Engineers at their meetings 1st February 1876, and 9th November, 1875, presided over respectively by G R. Stevenson and J E. Harrison, presidents of the institution.

Having now examined Sir John Coode's plan and report (since their return from Wellington), with a view of ascertaining the probable quantity of rubble-stone, &c., required for their completion, I find that to build the western mole from A to YY will take 545,000 cubic yards, and this quantity is arrived at in the following manner viz. The quantity of rubble, according to Sir John Coode's report, required to complete from A to B is 800,000 cubic yards, measured in the mound, and the calculated quantity from the drawings between YY and B is 119,000 cubic yards, thus leaving 681,000 cubic yards to complete from A to YY but as 16 cubic feet of stone measured in the solid will occupy 20ft., or about, when in the mound, 545,000 yards will be required to complete to YY

I think, in forming an estimate of the probable cost of this work, labourers' wages should be calculated at not less than 7s., and quarrymen's at 7s. 6d. per diem, and at these rates, if the same economy in working be practised as was observed at Holyhead breakwater—namely, 3s.5d. per cubic yard for the first 2,200ft., with labourers wages at about 3s. per diem, as given by H. Hayter, Esq., M.Inst.C.E., but according to Sir John Rennie, in his treatise on harbours, the cost of Holyhead rubble is stated at 5s. 6d. per yard—would give (according to Mr Hayter's figures) with wages at 7s. per day, 8s. per cubic yard, allowing that the cost of staging here does not exceed the cost of that used at Holyhead—namely 5d. per ton of stone. But I estimate the staging for the New Plymouth Breakwater will cost £40,000, or 1s. 1d. per ton, being at the rate of 1·46s. per cubic yard of stone. This item will give an additional charge against the stone of about 8d. per cubic yard, or a total cost of 8s. 8d. per cubic yard, or £236,166.

The foregoing only takes into consideration the difference of, between here and Holyhead, wages and cost of staging, but there are other items of expense which will show an equally wide margin of difference.

Again, there is yet another item of cost to be considered. I refer to the loss and re-erection of staging, and the displacement of material during heavy gales. I do not think it necessary to prove that the stone once shifted beyond the limits of the mound will be entirely lost to the work, and should this loss not exceed 5 per cent. the work may be considered fairly successful in this respect. This, then, will add 27,250 cubic yards at 8s. 8d., or £11,806 + £236,166 = £247,972, as the cost of the work to YY, without any accommodation whatever for loading or discharging, based upon the supposition that the quarry at Paretutu will prove as easy to work as the Holyhead Mountain. But this supposition is, I fear, open to grave doubts.

The quarries at Holyhead consisted of quartz, compact, with well-defined joints, the quarry faces having a height of about 120ft. In the proposed quarries at Paretutu (which must form the principal source of supply) we have exactly the opposite of these conditions—namely, excessive heights (exceeding 300ft.), the material shattered throughout, and no well-defined joints, with limited face and excessive stripping.

In the foregoing the figures are based upon the known cost of one of the largest works of its class in the world, costing £1,295,000 (Holyhead breakwater), and in a country where every facility was at hand to enable large works to be economically carried out.

In taking this subject into consideration, it may be of service to you to bear in mind the probable cost of an alternate section, for which purpose I beg to submit to you the following estimate for a western mole of concrete blocks and rubble combined, and also an estimate for the same work, but built entirely of concrete blocks.

Section A, from A to YY.—(Concrete Blocks and Rubble combined.)

	£
From A in Sir John Coode's plan to 9ft. at low water 87,000 cubic yards of rubble at, say 8s. 6d. per cubic yard	36,975
From 9ft. at low water to YY 1,610ft. of concrete blocks, 59,607 cubic yards, at £1 10s. per cubic yard	89,410
Staging from A to 9ft. at low water 726ft. in 25 bays	4,116
Plant ..	50,000
Preliminary charges Offices, sheds, &c. ..	10,000
Landing-stage and roadway ..	14,000
	204,501
Contingencies ..	10,000
	£214,501

Section B.—(Entirely of Concrete Blocks from A to YY, with 1,000ft. of Stage and Roadway).

	£
73,885 cubic yards of concrete at £1 10s.	110,827
Landing-stage and roadway	14,000
Plant	44,000
Preliminary expenses	10,000
	178,827
Contingencies ..	17,000
	£195,827

The price of concrete blocks, cost of plant, &c., is derived from the report on the Kurachee Harbour works by Mr W H. Price, M.Inst.C.E., read before the Institute of Civil Engineers, 9th November, 1875, and, as the report above referred to gives detailed cost of each particular part of a large work successfully completed, a better guide in the matter could not be obtained.

I may add that in estimating the cost of Sections A and B I have added 8s. 3d. per cubic yard to the cost of the concrete block-making and setting at Kurachee, so as to allow a very fair margin for contingencies.

The cost of Portland cement at Kurachee was £4 3s. 9d. per ton, landed here, the cost would be £4 2s. 6d.

Should your Board deem it expedient to go further into this matter I will prepare the necessary plans and detailed estimates of the probable cost.

The estimates herewith have been prepared from sketch sections and plans, which have enabled me to give you a reliable estimate.

I have, &c.,
J R. Rees,
Engineer to the Board.

The Chairman, New Plymouth Harbour Board.

J.—Report by the Engineer in Chief, 13th September, 1880.

Hon. Minister having charge of the Marine Department.

Re *New Plymouth Breakwater*

I have read this correspondence, and can see no objection to the works being executed in concrete instead of rubble, on the same line as originally determined on as for the latter

The Engineer to the Harbour Board points out where certain savings may be made in the cost as estimated by Sir John Coode, who apparently formed his estimate on prices then current in the colony These savings would notably be—first, in wages, say 5s. or 6s. instead of 7s., but these of course would be liable to fluctuations, second, in Portland cement, which will cost in New Plymouth 17s., instead of £1 per cask third, in adopting a cheaper site for the making of the concrete blocks, and from which the blocks could be more cheaply taken to the works.

In addition to these, I think a saving could be effected both in time and money by making the first section of the work 335ft.—that is, from about high-water to low-water mark, or even further, according to the original design for a rubble breakwater In this way it would be ready by about the same time that the block-making yard and machinery were complete for block-making.

13th September, 1880. John Blackett

K.—Copy of Prospectus issued in floating the Loan for £200,000 for the Construction of New Plymouth Harbour.

[Extract from London *Times*, 6th September, 1879.]

New Zealand.—Provincial District of Taranaki.—New Plymouth Harbour Board Six-per-cent. Loan of 200,000 in Debentures to Bearer of £100, £250, and £500, secured on the Entire Revenue of the Board.—Issued under Authority of an Act of the General Assembly of New Zealand intituled "The Harbours Act, 1879."

The Bank of New Zealand, as financial agents of the New Plymouth Harbour Board, are empowered to negotiate the sale of the above loan, being the full amount authorised by "The New Plymouth Harbour Board Ordinance 1875 Amendment Act, 1877," and forming a first charge upon all moneys in the harbour fund.

The debentures are of thirty years' currency bearing date the 1st May, 1879, and are repayable to the bearer on the 1st May, 1909, at the office of the Bank of New Zealand, in London, where the interest coupons are payable half-yearly on the 1st May and the 1st November Interest will commence on the 1st November, 1879.

This loan is to be applied to the harbour-works at New Plymouth, the chief town in the Provincial District of Taranaki, situate on the west coast of the North Island of New Zealand. There is no harbour of any importance on the west coast of this Island from Kawhia Harbour, which is still in the hands of the Natives, to Wellington Harbour in the extreme south—a distance of about 300 miles.

The Taranaki District contains some of the finest lands in the colony but its progress has hitherto been retarded by the want of harbour-accommodation.

The Government, recognising the necessity and importance of this work from a national point of view, have endowed the Harbour Board with one-fourth part of the gross revenues arising from the sale, occupation, or other disposal of the waste lands of the Crown within the provincial district. This subsidy commenced in the year 1875, and the proportion of the proceeds of land-sales so appropriated to the harbour fund has been been duly paid by the Colonial Treasurer to the credit of the Harbour Board with the Bank of New Zealand from time to time. Future payments of revenue from this source will be set apart in order to provide, in the first instance, for interest and sinking fund.

The area of waste lands at present held by the Crown within the provincial district consists of about 758,000 acres, representing a value of about £1,400,000.

The service of the loan is further secured by the rating-power vested in the Board to the extent of 1s. in the pound upon property within the rating district, the present rateable value of which is £62,559 3s. 8d., and will increase as the settlement extends, but, as the revenue derivable from the before-mentioned endowment is deemed much more than sufficient for the purpose, no rate has been struck, nor is it expected that any such rate will be required.

Sinking Fund.

"The New Plymouth Harbour Board Ordinance 1875 Amendment Act, 1877," section 19, provides that all land revenue which the Board may receive under the provisions of "The Financial Arrangements Act, 1876," shall be set aside for the payment of interest and sinking fund on any loan obtained by the Board, and for no other purpose, and this section proceeds to define the manner of appropriation of the land revenue set aside for a sinking fund in purchase of the debentures in the open market, or investment in colonial Government securities.

"The Harbours Act, 1878," defines the harbour fund as consisting of the moneys arising from the following sources (1) Harbour dues and pilotage rates, and all other dues which the Board may be empowered to levy or receive, (2) harbour improvements, (3) rents and profits of land vested in the Board, (4) proceeds and profits of land set aside as endowments (5) all other moneys which may be received by or become the property of the Board under the authority of that or a special Act.

Security and Recourse of Debenture-holders

By "The Harbours Act, 1878," sections 175 to 180, it is provided that the Board shall cause its accounts to be balanced to the 31st December in each year, and cause a statement to be drawn out, which is to be printed, and to be open to every holder of debentures, creditor, or any other person, and every holder of debentures, or creditor, is to be entitled to a copy on demand. By section 202

the Board are authorised permanently to appropriate any unappropriated part of the harbour fund for the creation of a sinking fund. By section 208 it is enacted that if any debenture or coupon be not paid on presentation when due the holder may apply for relief to a Judge of the Supreme Court. Section 209 authorises the Judge to order that the whole or part of the lands vested in the Board shall be sold, and the proceeds applied in payment of the expenses of the proceedings, and the amount due on such debentures. Section 210 authorises the Judge to appoint a receiver of the rents and profits arising from land vested in the Board, and of all money receivable by them. Section 211 enacts that the principal secured by every debenture, and the interest thereon, shall, when the same shall become payable, be a debt of the Board to the holder, which shall be recoverable by action against the Board.

The Bank of New Zealand, as financial agents of the New Plymouth Harbour Board, invite tenders for the whole or any part of the above issue of £200,000. Such tenders are to be made on the form hereunto annexed, and to be lodged with the bank on or before Monday the 15th September, 1879, not later than 12 o'clock at noon, at which hour they will be opened in the presence of any applicants who may think proper to attend. The price of issue is to be paid as follows, viz. £5 per cent. on the amount applied for to accompany the tender, and the balance on the 31st October, 1879, when the debentures will be ready for delivery

Interest on the debentures will accrue from the 1st November, 1879. Both interest and principal will be payable at the office of the Bank of New Zealand, in London.

The debentures will be allotted to the highest bidders, provided the rates offered are not below £95 for every £100 tendered for The bank reserve a right to reject tenders which for any reason they may consider unsatisfactory, and, in the event of tenders at the lowest rate securing an allotment being in excess of the debentures left at their disposal, a *pro ratâ* distribution will be made as far as practicable. The bank do not undertake to allot debentures of the several amounts of £100, £250, and £500 in rateable proportion, but reserve the right of free action in this respect. In the event of the balance not being duly paid, the allotment in respect of which such default is made will be cancelled, and the previous payment made thereon will be liable to forfeiture. Forms of tender may be obtained at the London office of the Bank of New Zealand, where the following documents referring to the present issue of debentures may be inspected, viz. (1) Harbour Boards Act, 1870, (2) New Plymouth Harbour Board Ordinance, 1875 (3) Abolition of Provinces Act, 1875, (4) New Plymouth Harbour Board Endowment Act, 1874· (5) Financial Arrangements Act, 1876, (6) Public Revenues Act, 1876, (7) Financial Arrangements Act 1876 Amendment Act, 1877, (8) New Plymouth Harbour Board Ordinance 1875 Amendment Act, 1877, (9) Financial Arrangements Act, 1878, (10) Repeals Act, 1878, (11) Harbours Act, 1878, (12) The Rating Act, 1876, (13) Treasury Voucher, dated 23rd November, 1878, (14) Certified Copy of Solicitor-General's Opinion (15) Certificate of the Chief Surveyor of the Provincial District as to the extent of Government Lands, (16) Statement of Receipts and Expenditure of the Board from 19th May to 31st December, 1878 (17) Certificate of the Chairman and Secretary of the Board, dated 17th June, 1879, that the Board was free from Debt, (18) Declaration verifying Statements of Revenue and Value of Rateable Property

Bank of New Zealand, 1, Queen Victoria Street, Mansion House, E.C. 6th September 1879.

New Plymouth Harbour Board Loan.—£200,000 in 6-per-cent. Debentures.—Form of Tender

To the Bank of New Zealand, London. No.

I hereby tender for £ debentures of the New Plymouth Harbour Board 6-per-cent. loan of £200,000, in accordance with the terms of the prospectus dated the 6th September 1879, at the price of £ per cent., and undertake to accept the same, or any less amount that may be allotted to , and to pay the balance in conformity with the said prospectus. I hand you herewith £ , being deposit of £5 per cent. on my application.

Signature
Name in full
Address
Date 1879.

NEW ZEALAND.—£100,000 New Plymouth Harbour Board 6-per-cent. Debentures (Part of Total Loan of £200,000, specially endowed by the New Zealand Government, secured on the Entire Revenue of the Board, and forming a First Charge on all Moneys in the Harbour Fund).—In Debentures to Bearer of £100, £250, and £500.—Issued under Authority of an Act of the General Assembly of New Zealand intituled "The Harbours Act, 1878."

MESSRS. J and A. Scrimgeour are prepared to receive subscriptions for the above £100,000 debentures at the price of £100 per £100 bond. Interest is accrued on these bonds from 1st November last, at the rate of 6 per cent. per annum.

The following is from the original prospectus of the Bank of New Zealand "The Government, recognising the necessity and importance of this work from a national point of view, have endowed the Harbour Board with one-fourth part of the gross revenues arising from the sale, occupation, or other disposal of the waste lands of the Crown within the provincial district. This subsidy commenced in the year 1875, and the proportion of the proceeds of land-sales so appropriated to the harbour fund has been duly paid by the Colonial Treasurer to the credit of the Harbour Board with the Bank of New Zealand from time to time. Future payments of revenue from this source will be set apart in order to provide in the first instance for interest and sinking fund.

"The area of waste lands at present held by the Crown within the provincial district consists of about 758,000 acres, representing a value of about £1,400,000.

"The service of the loan is further secured by the rating-power vested in the Board to the extent of 1s. in the pound upon property within the rating district, the present rateable value of which is £62,599 3s. 8d., and will increase as the settlement extends, but as the revenue derivable

from the before-mentioned endowment is deemed much more than sufficient for the purpose, no rate has been struck, nor is it expected that any such rate will be required.

"*Sinking Fund.*

"'The New Plymouth Harbour Board Ordinance 1875, Amendment Act, 1877,' section 19, provides that all land revenue which the Board may receive under the provisions of 'The Financial Arrangements Act, 1876, shall be set aside for the payment of interest and sinking fund on any loan obtained by the Board, and for no other purpose, and this section proceeds to define the manner of appropriation of the land revenue set aside for a sinking fund in purchase of the debentures in the open market, or investment in colonial Government securities."

The debentures are of thirty years' currency, bearing date the 1st May, 1879, and are repayable to bearer on the 1st May, 1909, at the office of the Bank of New Zealand in London, where the interest coupons are payable half-yearly on the 1st May and 1st November

Subscriptions will be received at the National Provincial Bank of England on Tuesday next, the 17th instant, and will close on or before Saturday, the 21st instant, 5 per cent. to be paid on application, and the balance on the 1st March, when the debentures will be deliverable.

In the event of the applications exceeding the amount offered, allotment will be made as nearly as possible *pro ratâ*.

18, Old Broad Street, London, E.C., 14th February 1880.

New Plymouth Harbour Board Loan.—£100,000, in 6-per-cent. Debentures (Part of Total Loan of £200,000).—Form of Tender

Loan of £200,000.—Form of Tender.

To Messrs. J and A. Scrimgeour 18, Old Broad Street, London, E.C. No.

Having paid to the National Provincial Bank of England for account of the New Plymouth Harbour Board the sum of £ , being the deposit of 5 per cent. on the present application, I hereby tender for £ debentures of the New Plymouth Harbour Board 6-per-cent. loan, in accordance with the terms of the prospectus dated the 14th February 1880, at the price of £100 per cent., and undertake to accept the same, or any less amount that may be allotted to and to pay the balance in conformity with the said prospectus.

Signature
Name in full
Address
Date , 1880.

Banker's Receipt.

No. 1880.

Received of , the sum of £ being deposit of £5 per cent. on application for £ debentures of the New Plymouth Harbour Board 6-per-cent. loan.

For the National Provincial Bank of England

£

L.—Report by Sir John Coode and Mr. Blackett, 12th August, 1889.

Westminster Chambers, 9, Victoria Street, London, S.W , 12th August, 1889.

Sir,— *New Plymouth Harbour Works.*

In accordance with the arrangement contemplated in your letter of the 28th June we have carefully considered the documents recently received bearing upon the accumulation of sand around the breakwater in course of construction at New Plymouth, and now beg to present the following report:—

Previous Report by Mr Blackett.—In March of last year the growth of sand at the New Plymouth works was investigated by Mr Blackett, Marine Engineer for the colony, who reported thereon to the Minister having charge of the Marine Department, under date the 10th April, 1888, to the effect that, after the erection of a portion of the breakwater, sand began to accumulate on the rocky reef between the works and Mikotahi. As the works progressed this accumulation increased in width and height up to the date of Mr Blackett's examination, when it presented the appearance of a broad bar or bank of sand extending from the root of the breakwater to the island, the top of the bank being considerably above high-water level, and the sides of it, respectively, forming flat sloping beaches to the east and west. The accretion on the west extended along the sea-wall of the blockyard, whilst on the east the sand had gathered along the outer face of the breakwater, and thence around the end of that work, where a spit had formed practically at a right angle to the breakwater, extending towards the shore and across the entrance to the harbour for a length of 450ft., and barring to a certain extent the direct approach of vessels to the wharf.

A further deposit of sand had occurred along the inner face of the breakwater, having apparently been carried over that work during storms. This deposit extended for a length of about 900ft., with a width varying from 100ft. at the outer end to 70ft. or 80ft. at the inner end. The deposit was several feet in depth along the breakwater, decreasing towards the wharf, where it had not affected the facilities for loading.

At the date of the report above referred to the breakwater had been completed for a length of 1,950ft., the total expenditure up to that time by the Harbour Board on the breakwater wharf, and all works carried out by them being £220,000.

Mr Blackett then recommended, as a means of temporary relief, the construction of a groin or wall to connect Mikotahi with the mainland. He also advised, for the more effectual trapping of the sand, which it was presumed travelled northward from the sandy beaches lying to the south and west of Paretutu, that the groin above named should be prolonged beyond Mikotahi to the Lion Rock, a distance of about 1,400ft., and eventually from thence to Moturoa, a rocky island about 250ft. distant, thus making a protective groin, including the island of Moturoa, of about 3,000ft.

The estimated cost of the works described above, which had for their special object the prevention of the passage of sand from the south on to the sea-bed, at the back of the breakwater, was as follows:—

	£
Rubble-stone groin between mainland and Mikotahi ..	1,000
" " Mikotahi and the Lion Rock	56,000
" " the Lion Rock and Moturoa	10,000
Plant and contingencies	11,000
Total ..	£78,000

Present Condition of Sand-growth.—The most recent condition of the sandspit under the lee of the outer portion of the breakwater is indicated on a trace attached to Mr Blair's memorandum, dated the 29th May last. It shows the spit to have grown in length from 450ft., as named in Mr. Blackett's report of the 10th April, 1888, to 850ft., measured in a southerly direction from the end of the breakwater Again, the extreme breadth of the growth within the 10ft. contour-lines is now 600ft., whereas on the plan which accompanied Mr Blackett's report the maximum width was 120ft.

In a report by Mr Humphries, the Chief Surveyor, dated the 30th March last, on soundings taken at New Plymouth with a view to ascertain the extent of the sand-accumulation near the breakwater, attention is called to an alleged formation, which is described as "another spit" or "deposit of sand, running directly out to sea due north from the end of the breakwater for 1,400ft. At 1,000ft. out the deposit is 4ft. 6in. thick, but, being in 5 or 6 fathoms of water will not be disturbed again. Out from the end of the breakwater, and in the direction of the proposed ultimate extension, the sand-deposit is thin, and runs out at 900ft."

Mr Humphries further observes, "On the outer or seaward side of the breakwater the sand is banked up against it at the outer end as much as 15ft. above the base, and rarely in any case less than 10ft. throughout the whole length, leaving no more than 2ft. 6in. of water a few feet from it for the whole of the outer 1,200ft. Nearer in it is, of course, less. This bank slopes seaward, running out about 500ft."

Erosion of the Coast-line East of the Breakwater.—Simultaneously with the growth of the sand-deposits, to which reference has been made in the foregoing remarks, the coast-line has been wasting during the same period to the east of the breakwater, commencing about 25 chains from that work, and extending to the railway-station, a distance of about two miles. Mr Blair, in his memorandum, states that the foreshore has here been denuded of sand, sometimes to a depth of 6ft., and points out that what five years ago was a fine sandy beach is now rocks, boulders, and coarse gravel. It would also appear that the coast-line has been encroached upon for a width of from 30ft. to 50ft., more particularly in the vicinity of Moon's Reef. The boat-shed and bonded store at the old boat-landing were undermined, and have consequently been removed.

Recommendations

Construction of Groin from Mikotahi to the Lion Rock to be abandoned.—At the date of Mr Blackett's report, in April of last year, there was an undoubtedly ample justification, from the information then available, for recommending the construction of a rubble groin or mole from Mikotahi to the Lion Rock. The object of such a work, as previously explained, was to trap the sand in its passage from the south, it being believed that the pocket or receptable for sand, which would be formed to the westward of the proposed groin, would be of sufficient extent to postpone indefinitely the occurrence of further trouble from these accumulations.

The soundings and observations which have since been taken throw further light on the sand movement. They show, without doubt, that large growths have occurred immediately at the back of the breakwater, and at the same time the bulk of the spit, shoreward of its outer end, has been greatly increased. It is considered, therefore, as proved that the magnitude of the sand movements justifies the abandonment of the suggested rubble groin between Mikotahi and the Lion Rock, seeing that were that work to be constructed the interval that would be required to fill the trap so formed to the westward would be much less than formerly contemplated, and therefore at no very distant date other expedients to cope with the difficulty would have to be adopted. Moreover, the uncertainty which exists as to the alleged extensive deposits some distance seaward of the breakwater, and independent of the undoubted growth immediately at the back of that work, raise questions as to the effect of the proposed groin thereon, and the information now available is not sufficient to enable these questions to be determined with such precision and certainty as are desirable. Under all the circumstances, therefore, we do not hesitate to recommend that the proper course to adopt will be to consider that the construction of the proposed groin seaward of Mikotahi should be definitely abandoned.

Proposed Dredging.—After having sections plotted of the accumulations which have already occurred, we have arrived at the opinion, judging from the data at hand, that if means were provided for the convenient removal of, say 200,000 tons of sand per annum, the harbour-bed under the shelter of the breakwater could be maintained at its original depth. To perform this dredging, we would recommend that a pump hopper-dredger, of the character successfully and extensively used in Holland, and in some of the French ports, should be provided. Such a vessel would be about 135ft. long, 27ft. 3in. beam, and 10ft. 8in. depth of hold. She would be furnished with compound surface-condensing engines, indicating about 275-horse power The hopper would contain 380 tons of sand, which would be filled by the pumps in about one hour

The dredger would raise sand from the spit and from the seaward approach to the breakwater, and convey the same to the eastward of the work, where it would be dropped from the hopper in such a position that, by the action of the sea, it would be thrown upon the beach, and there be subject to the normal action of travel along the beach, which existed before the breakwater was erected, and which action, being restored, would render unnecessary a continuation of expenditure for the maintenance of the foreshore.

We are of opinion that with a dredger of this character, of the working of which we have results of ample practical experience before us, there should be no difficulty in raising and depositing, as described above, 1,000 to 1,400 tons of sand per diem, thereby maintaining the depth in the harbour unimpaired, and leaving an ample margin of time for contingencies and repairs.

Such a dredger would be furnished with sufficient power to steam to the colony, and would be quite seaworthy for the voyage.

It would, after being put together complete, and tested at the maker's works in Holland, be equipped for the voyage to New Plymouth.

We estimate the cost of a pump-hopper dredger of the character described, delivered at New Plymouth ready for work, at about £11,000. The cost of working and maintaining this craft—viz., wages of crew, fuel, stores, repairs, &c.—may be put down at about £4,500 per annum, and at least twelve months would be required for construction and delivery at New Plymouth.

The first cost and working charges of the pump dredger will compare favourably with the estimated outlay on the rubble groin from Mikotahi to the Lion Rock, and thence to Moturoa, together with the plant and contingencies for the entire works, amounting to £77,000, as previously estimated.

Taking the annual working charges as £4,500, and the quantity raised as, say, 200,000 tons, and allowing for interest and depreciation on plant, we should have an average cost of about 7d. per ton of sand raised and deposited, which agrees with the actual rate, as shown by the working of a pump hopper-dredger under somewhat more unfavourable conditions in one of the colonies.

Periodical Soundings.—We entertain considerable doubt as to the alleged extensive growths of sand for some distance seaward of the breakwater, and to the north-east thereof, as described in the Chief Surveyor's memorandum of 30th March, 1889. Upon comparing sections plotted from the soundings on Mr Jones's survey of 1877 with the soundings taken by Mr Humphries in March last, we have arrived at the conclusion that some of the differences which have been attributed to deposits of sand are due to discrepancies in sounding, which are to some extent inevitable when fixing the position of isolated depths over such a large area as that of the original survey.

It is most important that this matter should be cleared up, and we therefore recommend that soundings be taken every six months over the standard lines indicated on the annexed trace, and numbered from 1 to 21. The manner in which these soundings should be taken is described in a note on the trace. The result should be plotted in section form, so that the changes produced may be clearly seen therefrom. Cases might be quoted in which similar allegations of deposits have upon investigation proved to be entirely due to discrepancies in soundings.

With regard to the existence of a spit, and a high bank immediately at the back of the breakwater, there can, of course, be no doubt or question.

As to the Source from which the Sand comes.—From Mr Blair's memorandum it appears that the breakwater was completed in May, 1887 to its present length of 1,950ft. Sand was then just beginning to show at the commencement of the curve, 1,400ft. out from the shore. It edged gradually along the back of the breakwater and in September, 1887 after about six weeks of continuous south-west weather, it appeared at the end of the structure.

At first the sand formed a small spit in line with the breakwater, then it moved gradually round to about the direction which it at present occupies.

We have no doubt that the sand, both in the spit and at the back of the breakwater, was derived from the sea-bed and foreshores west of Mikotahi, and more particularly from the great accumulations on the shore and in the sandhills south of Pokoroa.

The sand from these sources, stirred up during south-west gales, would be carried northward, in suspension by wave-action, and by the north-easterly current, which, according to the *New Zealand Pilot*, runs at fully a knot and a half per hour after south-west gales, a velocity sufficient to transport and carry northward large quantities of sand when violently agitated by the sea. Moreover the prevailing winds and heaviest seas are from the south-west.

Temporary Relief.—The most recent information shows that the southern point of the spit is gradually working across towards the Hawea wreck, and closing the approach to the wharf. Some relief in this respect may be afforded by the employment of the grab dredging-crane now on the works in the removal of the sand from the southern extremity of the spit, where the machine could be more advantageously employed, than in an attempt to form and keep open a channel through the spit itself.

We would therefore strongly recommend that this dredging-crane be applied forthwith, and kept continously employed at this spot until the pump-dredger above described has been brought into operation.

Conclusion.—In our opinion, the proposed outlay on the pump hopper-dredger, and its maintenance and upkeep, would be fully justified under the circumstances. Its adoption would not be associated with operations of an experimental character, and satisfactory results can be confidently looked for from its employment. It cannot fail to maintain the depth in the harbour, notwithstanding the movements of sand which have been shown to be in operation, a similar assurance could not be given under any other treatment or mode of procedure.

The works as completed, if kept free from the incumbrance of sand, would afford excellent accommodation for discharging and loading such vessels as trade between the provincial ports, and we therefore strongly recommend that the mode of procedure we have put forward for adoption be approved.

We have, &c.,

JOHN COODE.
JOHN BLACKETT.

Approximate Cost of Paper.—Preparation, £25; printing (1,200 copies), £17 6s.

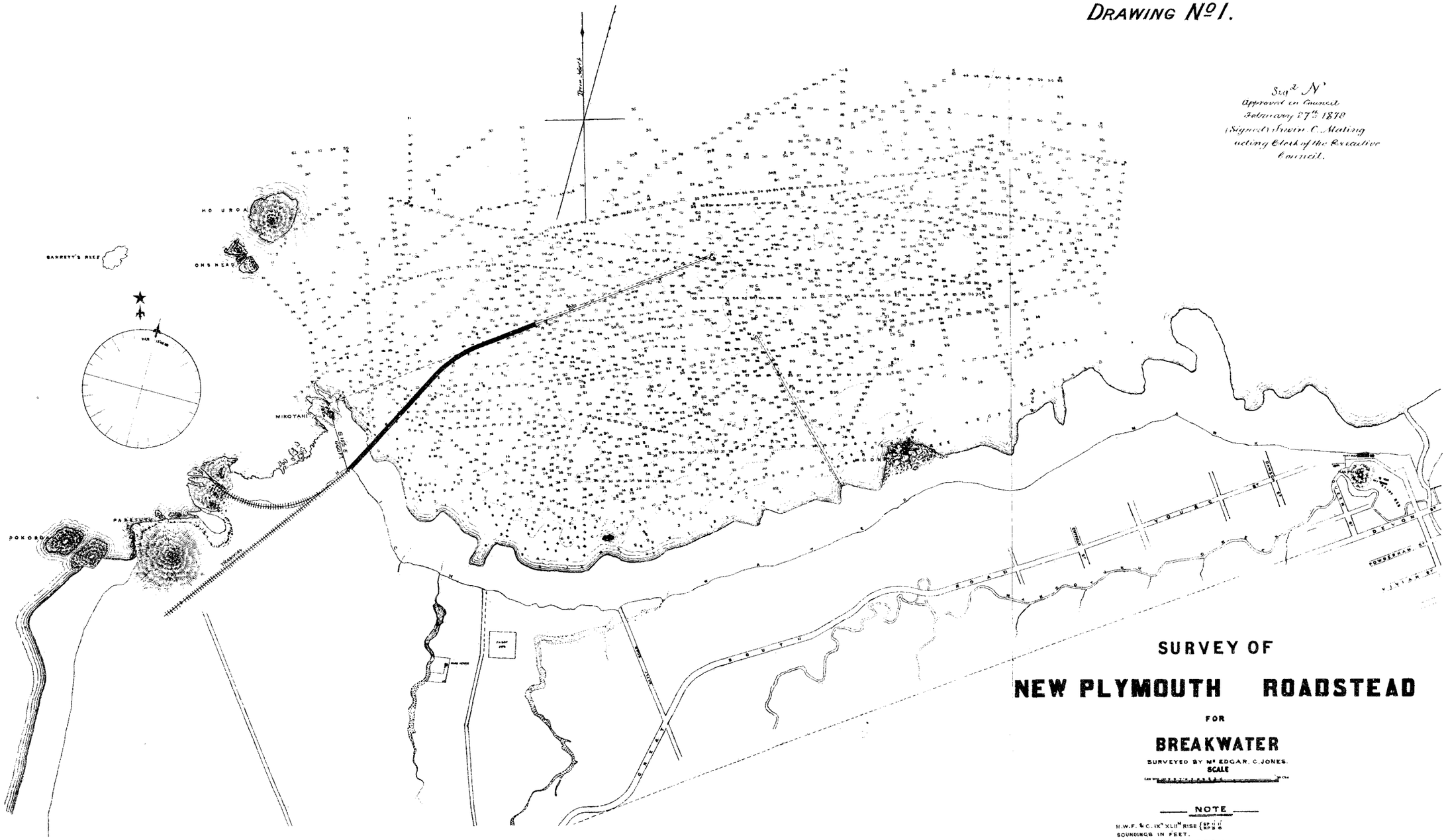
By Authority: GEORGE DIDSBURY, Government Printer, Wellington.—1892.

Price 2s. 6d., with plans.]

NEW PLYMOUTH HARBOUR WORKS

DRAWING No 1.

Sig.d N°
Approved in Council
February 27th 1878
(Signed) Irwin C. Mating
acting Clerk of the Executive
Council.



SURVEY OF

NEW PLYMOUTH ROADSTEAD

FOR

BREAKWATER

SURVEYED BY Mr EDGAR. C. JONES.

SCALE

NOTE

H.W.F. & C. IX^h XLII^m RISE (SP. H.W. / SP. R.)
SOUNDINGS IN FEET.
SP. SPRINGS. N.P. NEAP TIDES.
TIDES. THE TIME OF HIGH WATER AT THE FULL AND CHANGE IS
EXPRESSED IN ROMAN FIGURES
G. GRAVEL. GN. GREEN. GY. GREY. M. MUD. R. ROCK. S. SAND. SH. SHELLS.
GENERAL NATURE OF BOTTOM IS ROCKY LEDGES WITH COATING OF SAND.

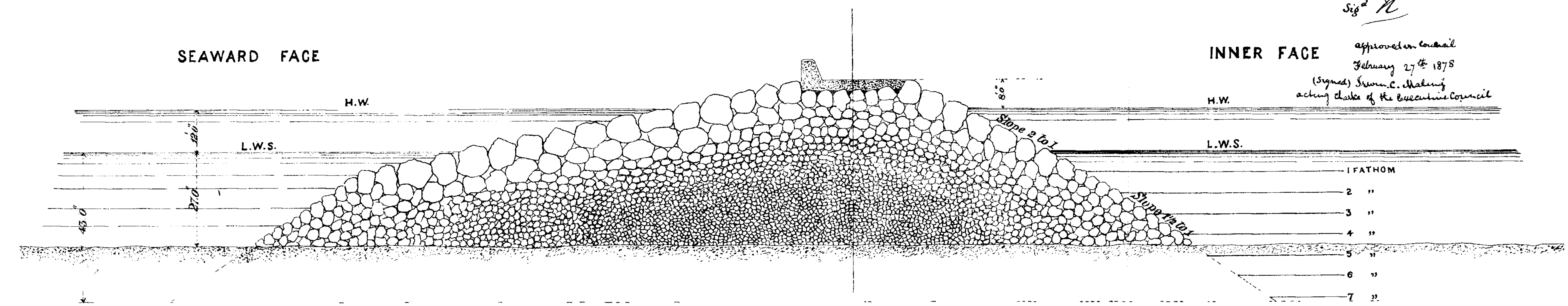
COPY OF P.W.D 6129

NEW PLYMOUTH HARBOUR WORKS

DRAWING No. 2

Sigd R

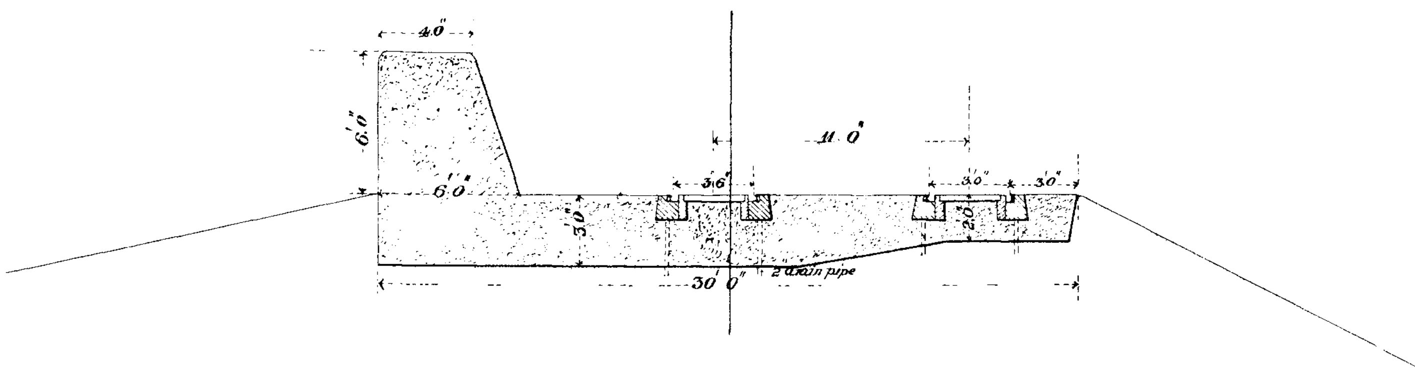
approved in council
February 27th 1878
(Signed) Forster C. Maling
acting clerk of the Executive Council



SECTION OF MOLE

Scale 32 feet = 1 inch

Inches 12 10 5 0 10 20 30 40 50 60 70 80 90 100 110 120 Feet

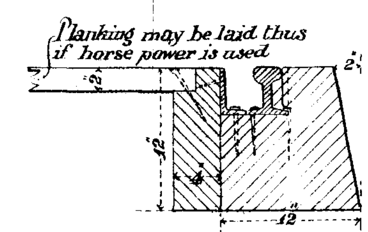


SECTION OF CONCRETE FLOOR AND PARAPET

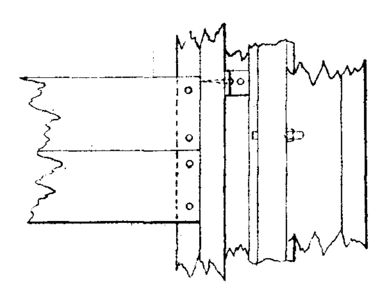
Scale 8 feet = 1 inch

Inches 12 10 9 8 7 6 5 4 3 2 1 0 10 20 30 Feet

DETAIL OF RAIL BEAMS &c



SECTION



PLAN

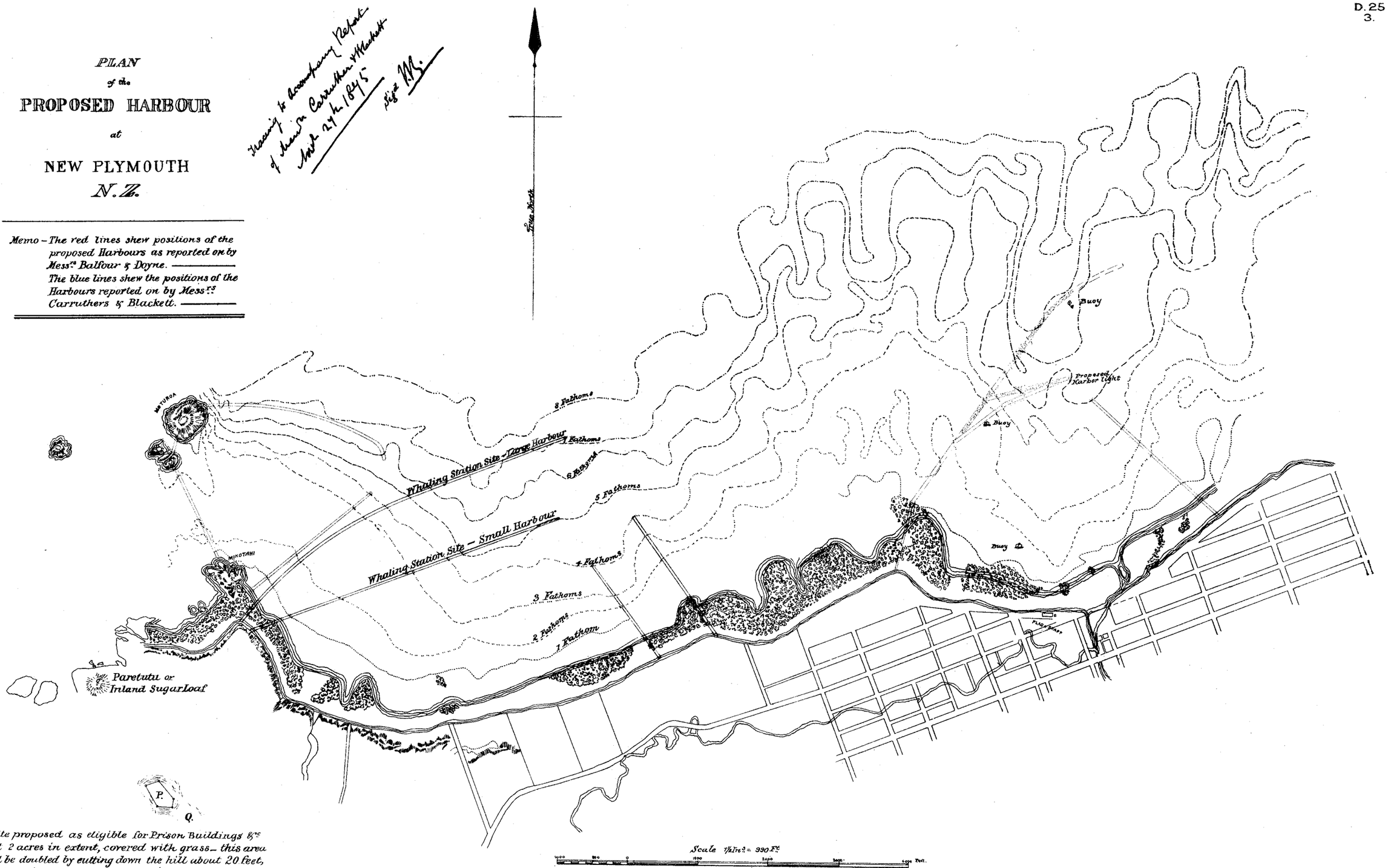
COPY OF P.W.D. 6129.

D. 25
3.

PLAN
of the
PROPOSED HARBOUR
at
NEW PLYMOUTH
N. Z.

Drawing to accompany Report of Messrs Carruthers & Blackett dated 24th 1845
Sigd J.M.

Memo – The red lines shew positions of the proposed Harbours as reported on by Messrs Balfour & Doyne. ——
The blue lines shew the positions of the Harbours reported on by Messrs Carruthers & Blackett. ——



P. – Site proposed as eligible for Prison Buildings &c about 2 acres in extent, covered with grass – this area could be doubled by cutting down the hill about 20 feet, or by terracing the ground around it – the outlying space Q. could also be made available.

COPY OF **M.D. 253**

Drawing Nº2.

Note. The Works recommended for construction in the first instance, are described as 'Design A' and are coloured Red.
The extensions of these Works, should such be hereafter required, are crossed by dotted Red lines.
The smaller and alternative Proposal, described as Design B, is indicated by Brown colour and its extensions by crossed Brown lines. Barrett's Reef Covered at ¾ Flood
The full extent of Messrs Carruthers' & Blacketts design is shewn by dotted Green lines.

NEW ZEALAND
NEW PLYMOUTH HARBOR

Plan shewing Works recommended by

Sir John Coode

in his Report of 28th February 1879.

The proposed Works are shewn by Red lines.

Note. This Plan has been prepared from the Survey made by Mr E.C. Jones in 1877.

References Soundings are in Feet below Low Water of an Ordinary Spring Tide.
High Water Full and Change IX hrs 42 m Springs rise 11 ft 11 in Neaps 9 ft
m mud r rock s sand sh shells g gravel

SCALES

This is the Plan marked M.D. 253 referred to in Order in Council bearing date 12th day of August, 1879
Approved in Council.
(Signed) Forster Goring
Clerk of the Executive Council.

MOTUROA or Centre Sugar-loaf

LION'S HEAD

SUGAR-LOAF ISLANDS

NGA MOTU OR THE SUGAR-LOAF ISLANDS

MI-KOTI

POKOROA

PARARAKI

PARETUTU or Main Sugar-loaf

Tide Gauge

House at top of Incline.

INCLINE 1 in 10 FROM OUTART to Bottom of Incline

SANDHILLS

MOTUROA LAGOON

BARRETT'S ROAD

FARM HOUSE

PROPOSED PRISON SITE

SITE OF PROPOSED TOWN OF WHITELEY

Old Whaling Station

MOON'S REEF

MONCATUKA CREEK

GREAT SOUTH ROAD

To New Plymouth

To Waiwakaiho Stream about 3½ Miles

EXTENSION OF DESIGN 'A'

Full extent of West Breakwater proposed by Messrs Carruthers & Blacketts

WEST BREAKWATER DESIGN 'A'

JETTY No 1

JETTY No 2

SUGGESTED LINE OF EAST PIER DESIGN 'A'

EAST PIER DESIGN 'A'

EAST PIER DESIGN 'B'

SUGGESTED LINE OF EAST PIER DESIGN 'B'

EAST PIER AS PROPOSED BY MESSRS BLACKETT

'DESIGN A' PIER

'DESIGN B' AREA 30 ACRES

130 ACRES

FOOTWAY

ROAD

RAILWAY

HIGH WATER ORDINARY SPRING TIDES

LOW WATER ORDINARY SPRING TIDES

Alphabetical Points & Lettering

(Signed) Jno Coode

T.M. Grant. delt.

DRAWING Nº 1

NEW ZEALAND
NEW PLYMOUTH HARBOUR

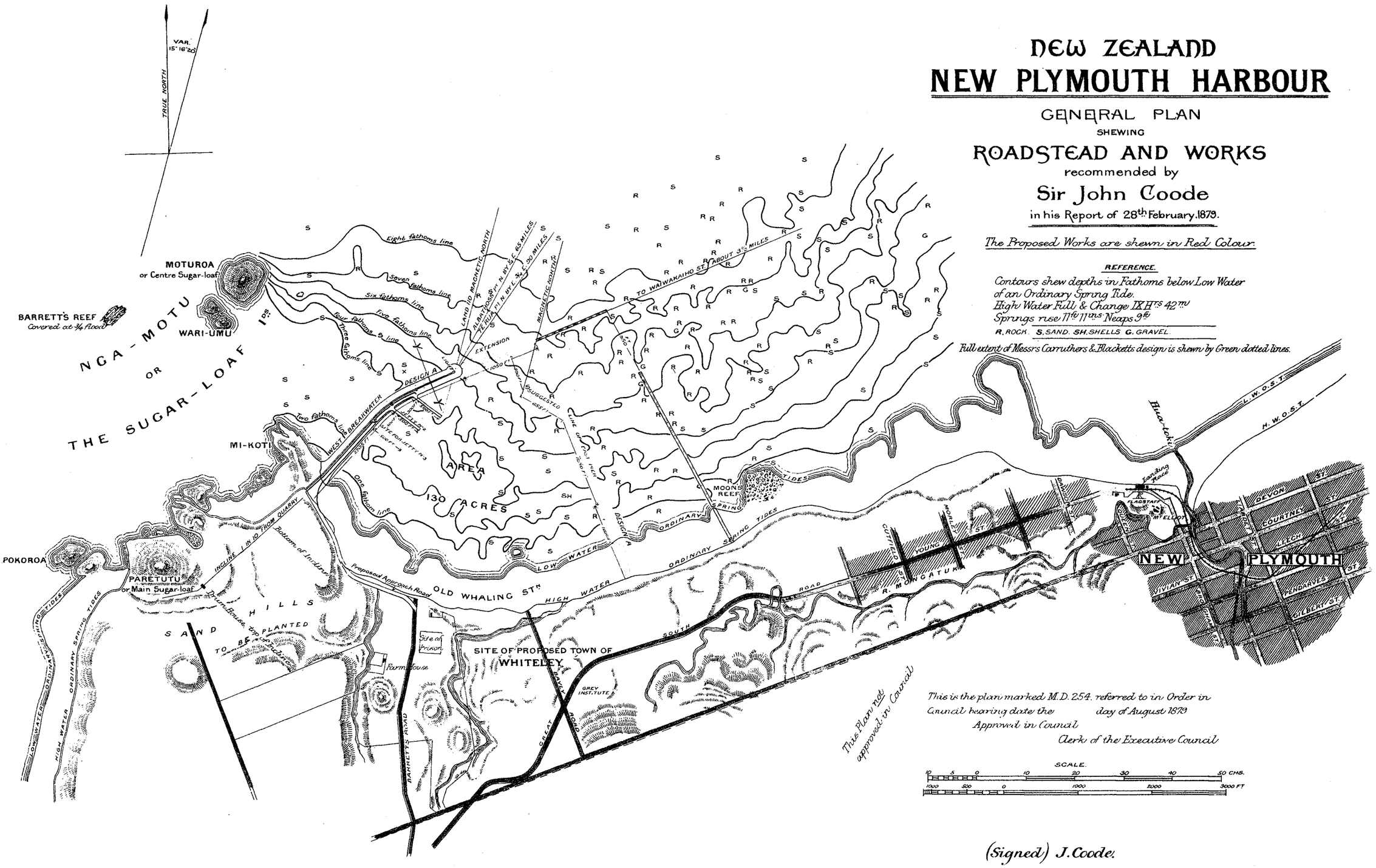
GENERAL PLAN
SHEWING
ROADSTEAD AND WORKS
recommended by
Sir John Coode
in his Report of 28th February. 1879.

The Proposed Works are shewn in Red Colour.

REFERENCE.

Contours shew depths in Fathoms below Low Water of an Ordinary Spring Tide.
High Water Full & Change IX Hrs 42 m
Springs rise 11 ft 11 ins. Neaps 9 ft
R. ROCK. S. SAND. SH. SHELLS G. GRAVEL.

Full extent of Messrs Carruthers & Blacketts design is shewn by Green dotted lines.



This Plan not approved in Council

This is the plan marked M.D. 254. referred to in Order in Council bearing date the day of August 1879
Approved in Council
Clerk of the Executive Council

SCALE.
10 5 0 10 20 30 40 50 CHS.
1000 500 0 1000 2000 3000 FT

(Signed) J. Coode.

T. M. G. DELT. 28.11.92.

COPY OF MD. 254

NEW ZEALAND HARBOURS

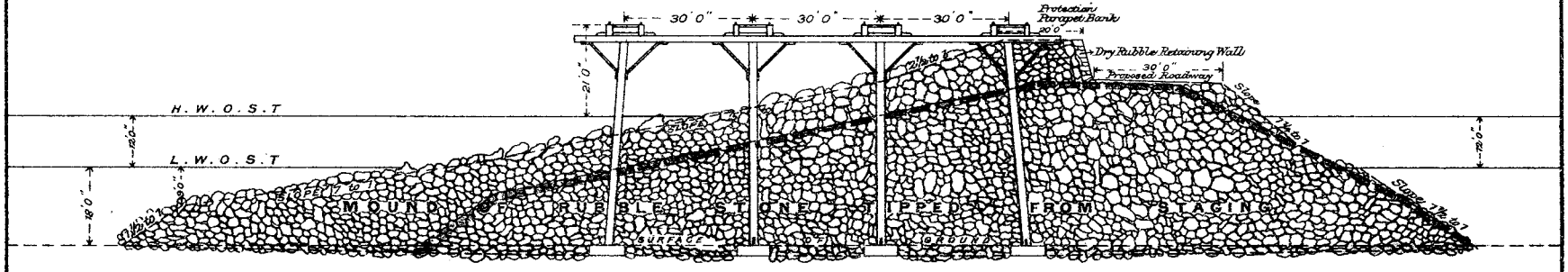
NEW PLYMOUTH

CROSS SECTION OF PROPOSED BREAKWATER
DESIGN A ON LINE XX. DRAWING No 2

This is the plan marked **M. D. 255** referred to in Order in Council bearing date the day of August, 1879.

Approved in Council
(Sd) Forster Goring
Clerk of the Executive Council

To accompany Sir John Coode's Report
Dated 28th February 1879.



NOTE.

Gross Section of West Breakwater as proposed by Messrs Carruthers and Blackett shewn thus

Scale. 1 Inch = 40 feet.

40 35 30 25 20 15 10 5 0 40 80 feet

(Sd) John Coode.

NOTE.

The Gauge of the Railways on the stage and of the lines leading from the Quarries will be 7 feet in order to admit of the discharging of large blocks between the Longitudinals from special waggons such as were used at Table Bay and Portland.

Drawn by H. McCardell, Dec, 1892.

COPY OF M.D. 255

COPY OF M.D. 404.

Drawing N° 1.

NEW ZEALAND HARBOURS

NEW PLYMOUTH

PLAN SHEWING BREAKWATER AND OTHER WORKS

AS DESIGNED BY SIR JOHN COODE

1880

This plan has been prepared from the Survey made by Mr E.C. Jones in 1877

The Intended Works are shown by Red colour

SCALES

This is the plan M.D. 404 referred to in Order in Council of even date herewith

(Sgd) Rowland Goring
Clerk of the Executive Council
28th Sept. 1880

(Signed) Jn° Coode

T.M. Grant. delt.

MOTUROA or Centre Sugar-Loaf

LION'S HEAD

Barrett's Reef
Covered at ¾ Flood

SUGAR-LOAF ISLANDS

NGA MOTU OR THE

MI-KOTI

Deposit of soft yellow sandstone above h.w.m.s.

7 FATHOMS CONTOUR

6 FATHOMS CONTOUR

5 FATHOMS CONTOUR

4 FATHOMS CONTOUR

3 FATHOMS CONTOUR

6 FATHOMS CONTOUR

6 FATHOMS LINE

7 FTHS LINE

5 FATHOMS LINE

4 FATHOMS LINE

3 FATHOMS LINE

2 FATHOMS LINE

1 FATHOM LINE

Lighthouse

FUTURE EXTENSION

Temporary Light

FUTURE JETTY

FUTURE JETTY

BREAKWATER

PIER

Tide Gauge

STANDARD OF PORT

BOULDERS OF VOLCANIC FORMATION OVERLYING PLATEAU OF SOFT SANDSTONE

POKOROA

PARARAKI

TRACHITE PORPHERY

PARETUTU or Main Sugar-Loaf

INCLINE LINE FROM QUARRY

House at top of Incline.

Sand drift coated with Quarry waste north of this line. Sand drift to be planted. (See Report of 20th February 1877)

LOW WATER ORDINARY SPRING TIDES

HIGH WATER ORDINARY SPRING TIDES

SAND HILLS

APPROACH ROAD

MOTUROA LAGOON

BARRETT'S ROAD

FARM HOUSE

PROPOSED PRISON SITE

Old Whaling Station

SITE OF PROPOSED TOWN OF

WHITELEY

MOON'S REEF

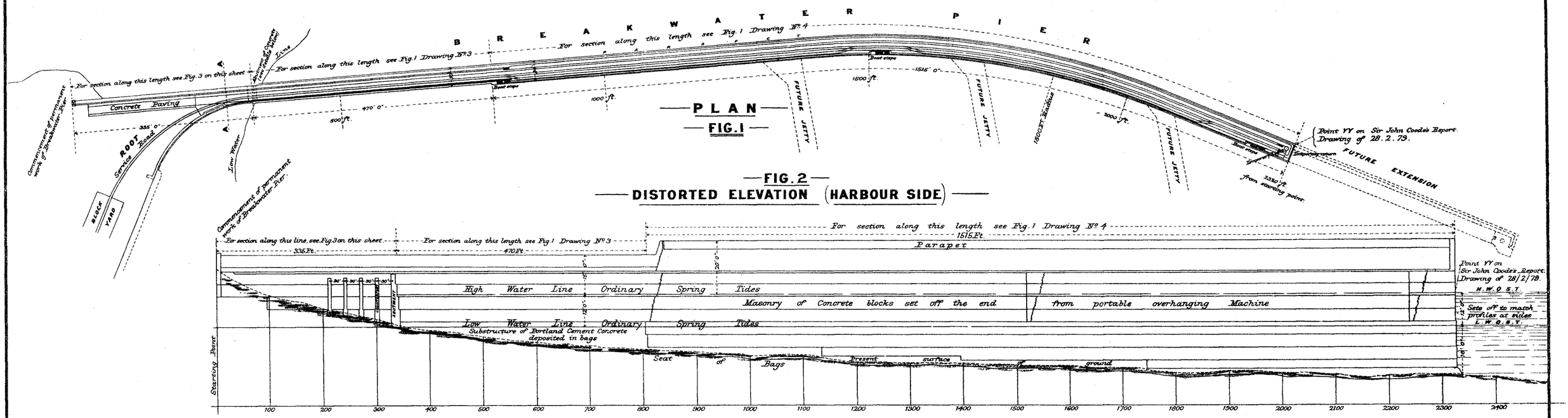
GREAT SOUTH ROAD

MONGAIUKA CREEK

To New Plymouth

NEW PLYMOUTH HARBOUR N.Z. — PLAN & ELEVATION OF BREAKWATER PIER & DETAILS OF ROOT.

DRAWING Nº 2



PLAN

FIG. 1

FIG. 2

DISTORTED ELEVATION (HARBOUR SIDE)

This is the Plan M.D. 405 referred to in
Order in Council of even date herewith.
Sd. Foster Goring
Clerk to the Executive Council
September 1880

FIG. 3

CROSS SECTION ON LINE AA (FIG. 1)

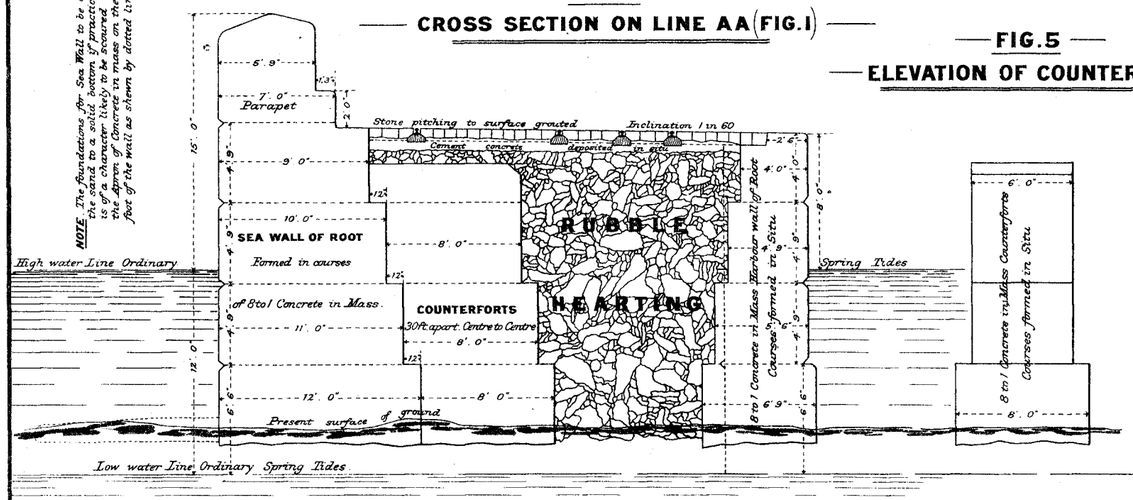


FIG. 5

ELEVATION OF COUNTERFORT

FIG. 4

PART ELEVATION OF HARBOUR WALL SHEWING JUNCTION OF ROOT WITH PIER

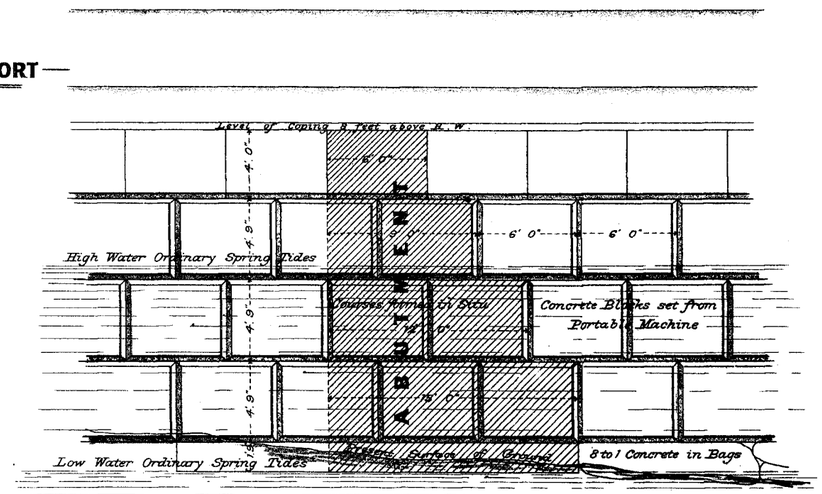
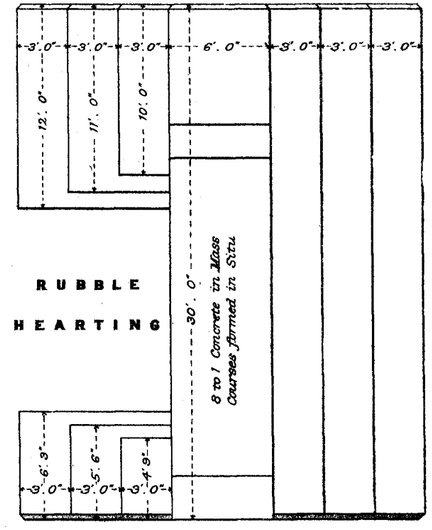


FIG. 6

PLAN OF ABUTMENT

JUNCTION OF ROOT WITH PIER



Scale for Fig. 1 & Horizontal Scale for Fig. 2 — 1 Inch = 160 Feet.
100 50 0 100 200 300 400 500

Vertical Scale for Fig. 2. — 1 Inch = 30 Feet.
10 5 0 10 20 30 40 50 60 70 80 90 100

Scale for Figs. 3, 4, 5 & 6 — 1 Inch = 6 Feet.
Ins 12 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 Ft

COPY OF M.D. 405.

NEW PLYMOUTH HARBOUR N.Z. — BREAKWATER PIER.

DRAWING Nº3.

FIG. 5
DETAILS OF CONCRETE JOGGLES.

Plan.

Elevation.

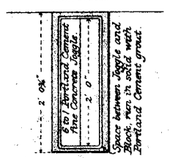
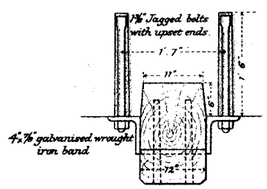
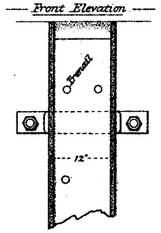


FIG. 6
DETAILS OF FENDERS.

Plan.



Front Elevation.



Side Elevation.

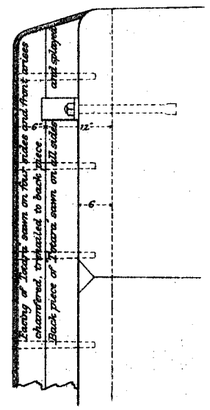
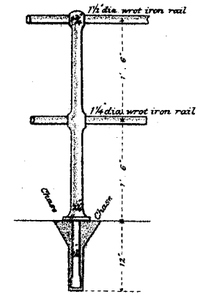
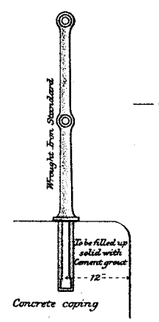


FIG. 7
HAND RAILING.

Front Elevation.



Side Elevation.

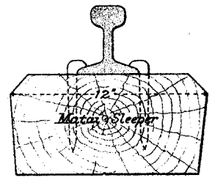


This is the Plan M.D. 406 referred to in Order in Council of even Date herewith.

Sd. Foster Goring
Clerk of the Executive Council
25th September 1880.

FIG. 8
CROSS SECTION OF RAIL & SLEEPER.

53 lbs Steel Rail Colonial Section.



Scale, 3 Inches = 1 Foot.

FIG. 4
PLAN OF JUNCTION.

Between the work shewn on Fig. 1 on this sheet & that shewn on Fig. 1 on Drawing 4 at 805 Ft. from starting point.

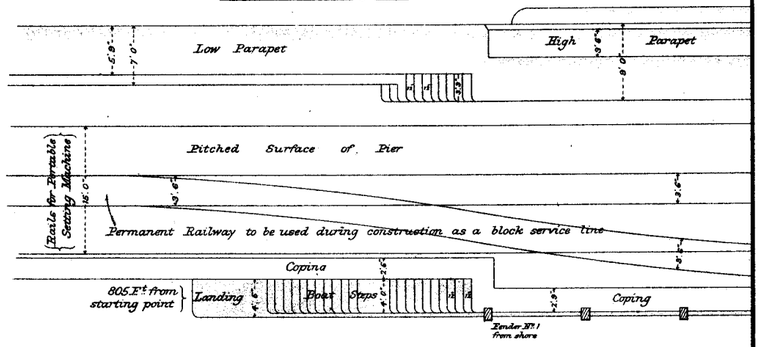


FIG. 2
ELEVATION OF SEA WALL
AT JUNCTION SHEWN ON FIG. 4.

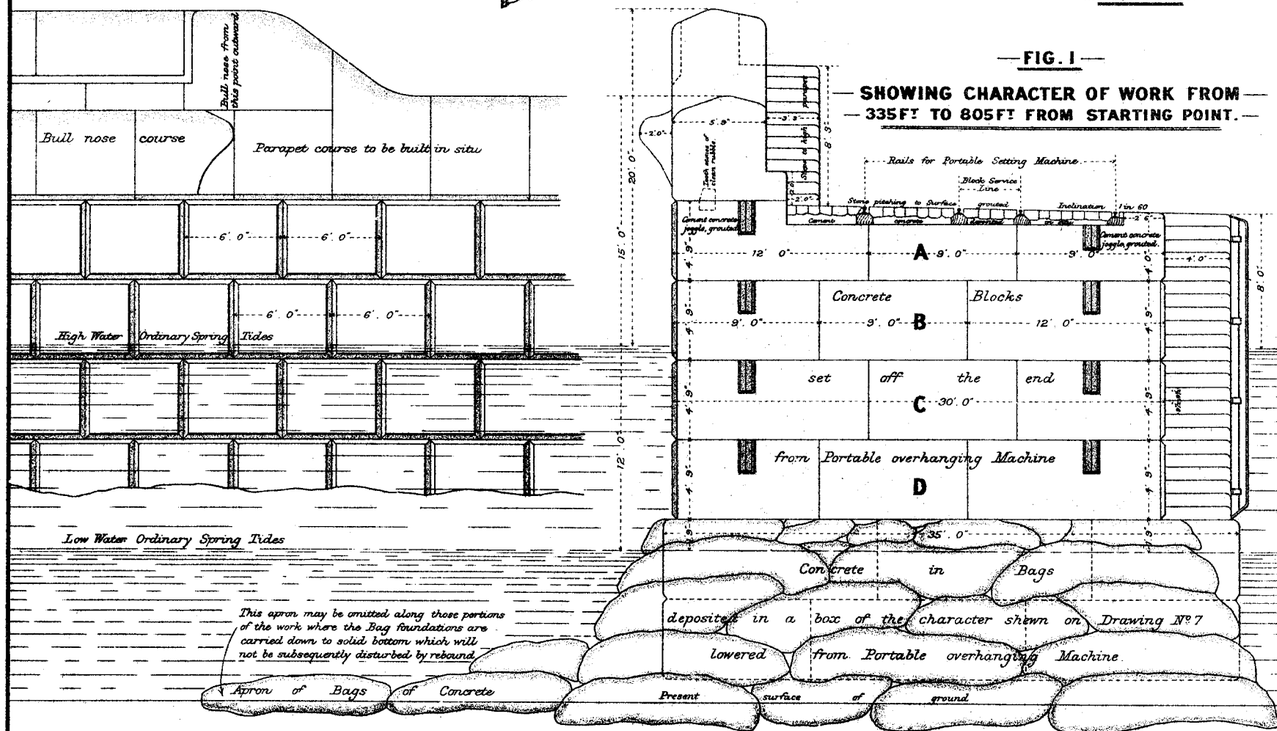
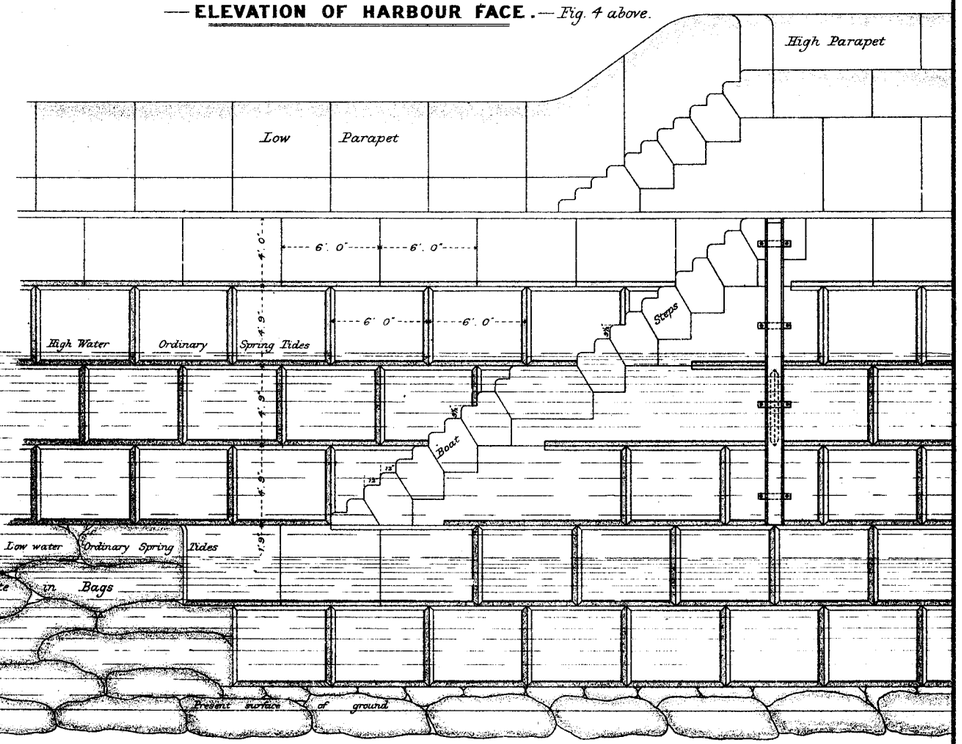


FIG. 1
SHOWING CHARACTER OF WORK FROM 335 FT TO 805 FT FROM STARTING POINT.

FIG. 3
ELEVATION OF HARBOUR FACE. — Fig. 4 above.



Section of work as Fig. 1 on this sheet, Section of work as Fig. 1. Drawing Nº4

Scale for Fig. 4 1 Inch = 16 Feet.

Scale for Figs. 1, 2 & 3 1 Inch = 8 Feet.

Scale for Figs. 5, 6, & 7 1 Inch = 2 Foot.

G.P. WILSON, DELT.

COPY OF M.D. 406.

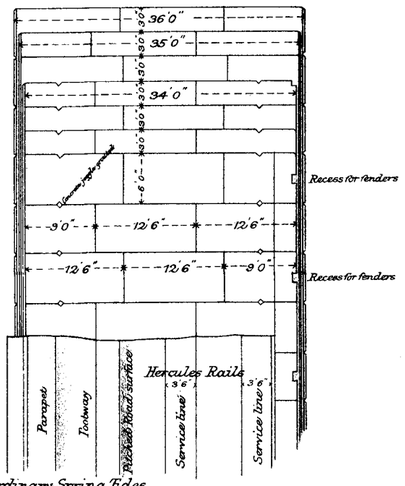
NEW PLYMOUTH HARBOUR N.Z.

BREAKWATER PIER

DRAWING No. 4

FIG. 4
PLAN

Showing Scar ends of work and character of Bond



This is the Plan M.D. 407 referred to in Order in Council of even date herewith.

28th September 1880. (s.d.) Forster Goring
Clerk of the Executive Council

DETAILS OF BOLLARDS AND THEIR ATTACHMENTS
PLAN

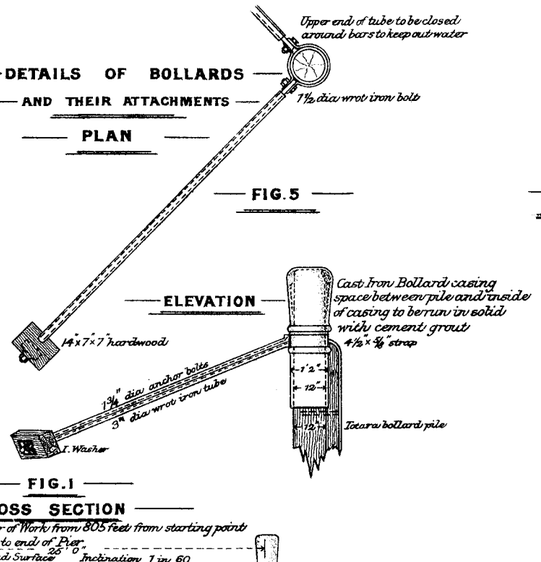


FIG. 5
ELEVATION

FIG. 1
CROSS SECTION

Showing character of Work from 805 Feet from starting point to end of Pier.

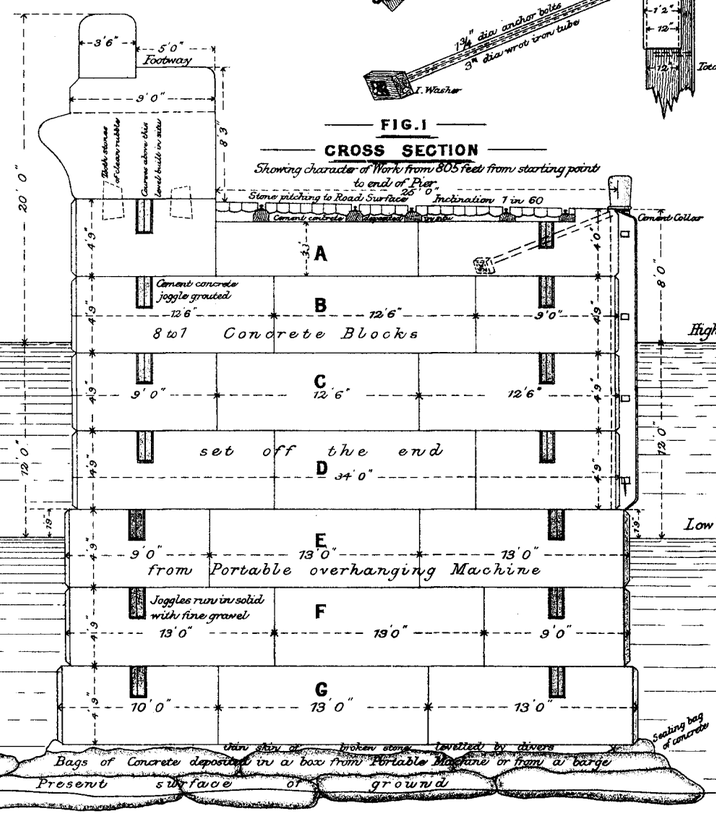


FIG. 3
PLAN OF OUTER BOAT STEPS

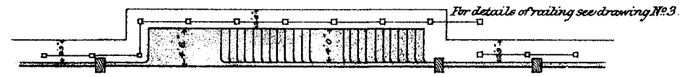
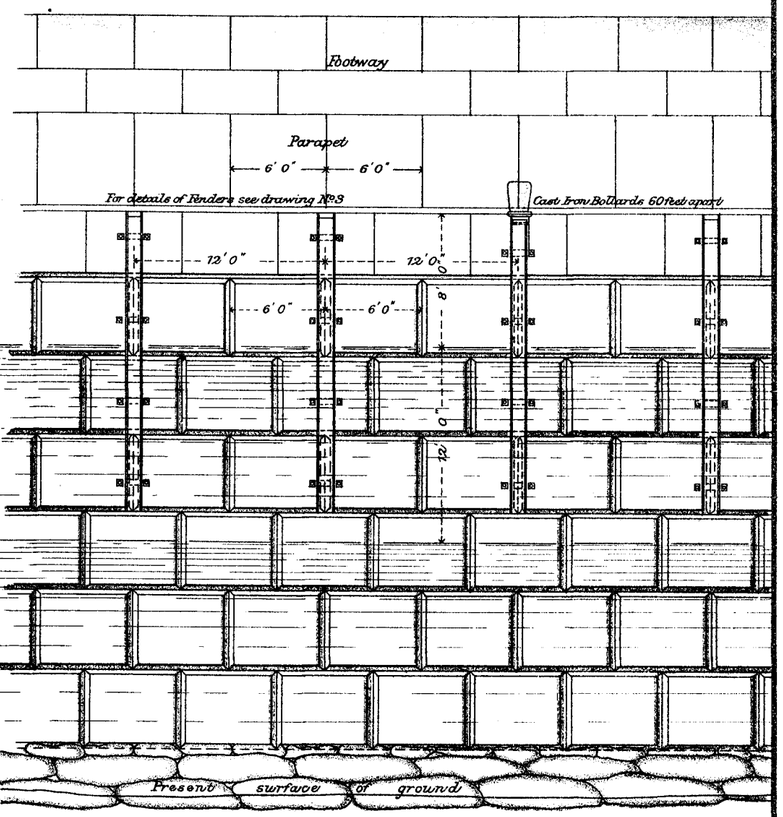


FIG. 2
ELEVATION OF HARBOUR FACE



Scale for Figs 3 and 4. 1 Inch = 16 Feet
16 12 8 4 0 16 32 Feet

Scale for Figs. 1 and 2. 1 Inch = 8 Feet
8 6 4 2 0 8 16 Feet

Scale for Fig. 5. 1 Inch = 4 Feet
4 3 2 1 0 4 8 Feet

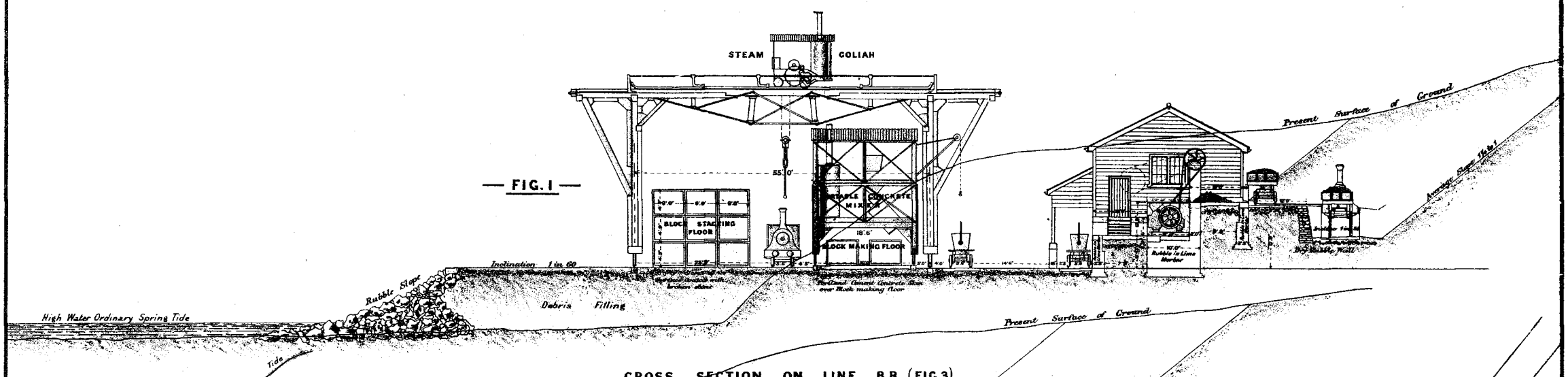
Drawn by H. McCardell.

DRAWING No. 5

— NEW PLYMOUTH HARBOUR N.Z. —

GENERAL ARRANGEMENT OF BLOCK MAKING YARD

CROSS SECTION ON LINE A.A (FIG 3)



— FIG. 1 —

CROSS SECTION ON LINE B.B (FIG.3)

— FIG. 2 —

PLAN OF WORK YARD AND BUILDINGS

— FIG. 3 —

NOTE - The figures in black on the Contour Lines represent the Levels of the present surface above datum, those in brown give the height above finished surface of Work Yard.

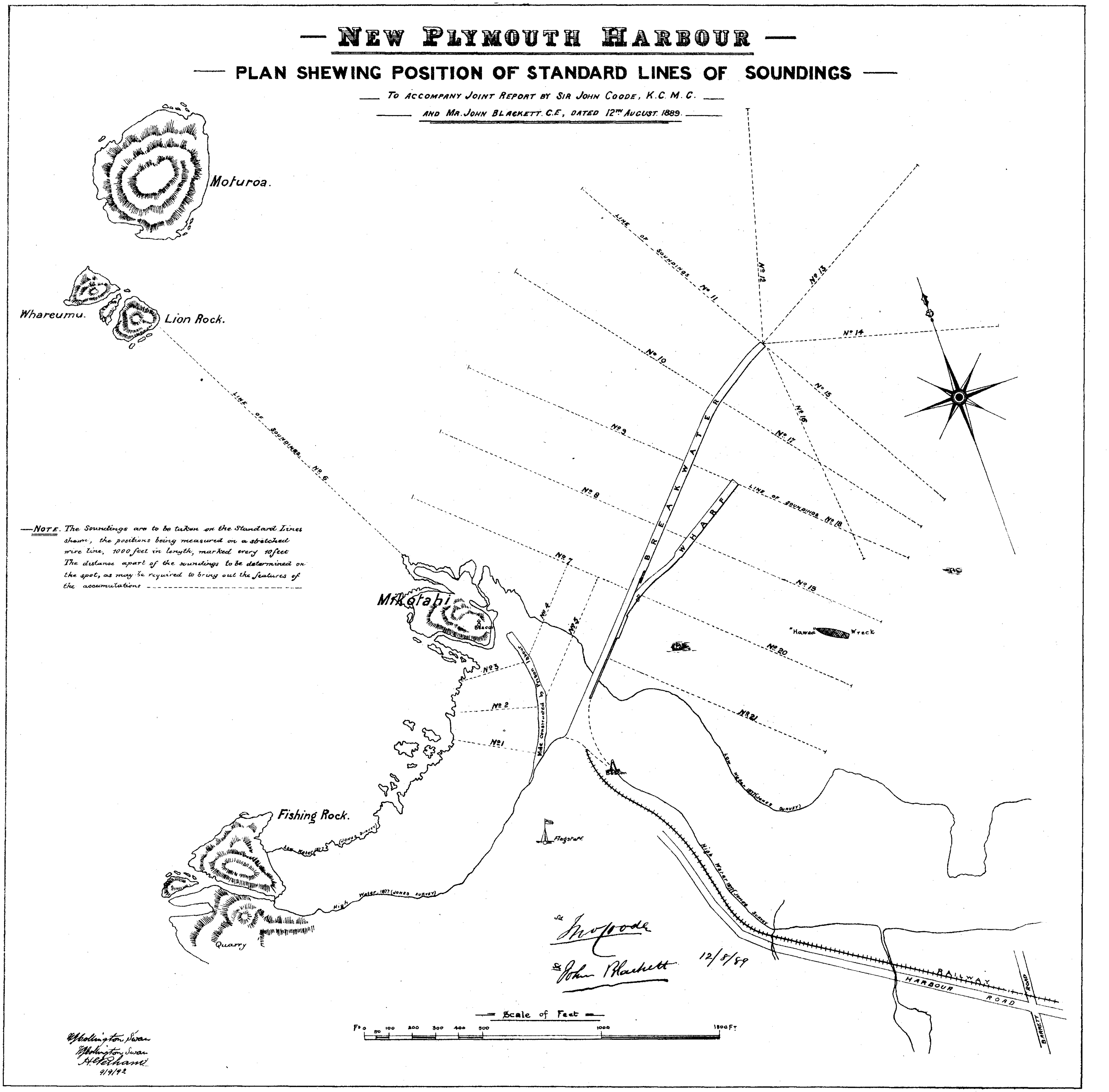
NOTE - The surface of the block stacking floor between C and D Figure 3 is to be 10 feet above H.W.O.S.T. from B to E over a length of 150 feet, the surface of the Yard is to fall at a gradient of 1 in 75 until reaching the Level of 8 feet above H.W.O.S.T. which is to be the finished Level of Breakwater Pier throughout its entire length seaward of that point.

This Plan not approved for Council

— Scale for Figs 1 and 2 1 inch = 8 feet —

— Scale for Fig 3 1 inch = 50 feet —

COPY OF M.D. 408



NEW PLYMOUTH HARBOUR
PLAN SHEWING POSITION OF STANDARD LINES OF SOUNDINGS
TO ACCOMPANY JOINT REPORT BY SIR JOHN COODE, K.C.M.C.
AND MR. JOHN BLACKETT. C.E, DATED 12TH AUGUST. 1889.
Moturoa.
Whareumu.
Lion Rock.
LINE OF SOUNDINGS No 6
LINE OF SOUNDINGS No 11
No 12
No 13
No 14
No 10
No 15
No 16
No 9
No 17
No 8
LINE OF SOUNDINGS No 18
No 7
No 19
No 20
No 21
No 4
No 5
No 3
No 2
No 1
BREAKWATER
WHARF
Mt Eliot
Mikotahi
Beacon
"Hawea" Wreck
Fishing Rock.
Quarry
Flagstaff
Low Water 1877 (Jones Survey)
High Water 1877 (Jones Survey)
RAILWAY
HARBOUR ROAD
BARRETT ROAD
NOTE. The Soundings are to be taken on the Standard Lines shewn, the positions being measured on a stretched wire line, 1000 feet in length, marked every 10 feet. The distance apart of the soundings to be determined on the spot, as may be required to bring out the features of the accumulations
Sd Jno Coode
Sd John Blackett
12/8/89
Scale of Feet
Ft 0 50 100 200 300 400 500 1000 1500 Ft