SESS. II.—1891.
NEW ZEALAND.

TIMARU HARBOUR

(REPORTS AND DISCUSSION THEREON).

PARTLY EXTRACTS FROM THE *TIMARU HERALD* OF 4TH APRIL, 1891.

Presented to both Houses of the General Assembly by Command of His Excellency.

A SPECIAL meeting of the Harbour Board was held on the 3rd April 1891, to receive the reports of the Commissioners—Messrs. C. Y. O'Connor and J. Goodall—appointed to examine into the shingle question, and make recommendations for dealing with it.

The letter appointing Commissioners to inquire into question is as follows:—

GENTLEMEN,— Harbour Board Office, Timaru, 21st March, 1891.

I have the honour, by direction, to advise you that the Timaru Harbour Board being of opinion that some danger exists to the harbour from travelling shingle, you are hereby appointed a Commission to inquire, examine, and report upon the subject. To state whether the danger can best be averted by the erection of permanent works or by the removal of the shingle. The Commission to have full scope to make any suggestions or recommendations they may deem advisable. To have the use of all surveys, plans, &c., the property of the Board, and the Board's engineer's services will be placed at the disposal of the Commission.

The Commission to report jointly or separately, as they may mutually agree.

I have, &c.,
W. J. TENNENT,
Secretary.

Messrs. C. Y. O'Connor and John Goodall, Ms.Inst.C.E.

The reports, which were read by the Secretary, Mr. Tennent, were as follows:—

TIMARU HARBOUR-WORKS.

Report of Commissioners.

[N.B.—This is signed by Mr. O'Connor only, Mr. Goodall sending in separate memorandum.]

Timaru, 2nd April, 1891.

SIR,— *Re* Timaru Harbour-works.

In compliance with request contained in your letter of 21st ultimo, I have the honour to enclose herewith a report on the matter therein defined, which I drafted for signature of Mr. Goodall and myself, and which I have now signed as fully expressing my views on the subject.

Though written in the plural number, however, this report cannot be taken as entirely concurred in by Mr. Goodall, who proposes sending you a separate memorandum indicating the points in which he disagrees. It should therefore be taken, in its entirety, as expressing simply my own views on the subject.

My only reason for retaining the plural number in the report is, that many of the views therein expressed, are the joint production of Mr. Goodall and myself, and also of Mr. Marchant in conjunction with us both, and I could not therefore properly lay claim to them as original conceptions fo my own.

I have, &c.,
C. Y. O'CONNOR, M. Inst. C.E.

The Chairman, Timaru Harbour Board.

Timaru, 2nd April, 1891.

SIR,— *Re* Timaru Harbour-works.

Having carefully studied the questions referred to us in your letter of the 21st ultimo, we have the honour to report as follows:—

As to whether or not the Danger from Travelling Shingle is Imminent.

We are clearly of opinion that the magnitude and velocity of shingle-travel is such, that it will inevitably overlap the works in a short time, if steps are not taken to counteract it.

During the last 4 years, ending January 1891, the accumulation has progressed 500ft. along the breakwater.

That this result is not spasmodic or exceptional, may be judged from the fact, that it almost exactly agrees with the calculation of probable result made in August 1881.

It was then estimated that the high-water line would reach to a point 800ft. from root of the breakwater by January, 1893.

As compared with this estimate, the high-water line had got to 560ft. from root of breakwater in January last; and, if it progresses for the next 2 years at same rate as during the last 4 years, it will have got to 810ft. from root by January 1893. Thus the calculation made 10 years ago seems likely to be very closely borne out.

It is true that the estimate made in August 1881, is not exactly verified by the results in all its details. The visible accumulation averages only 80,000 cubic yards per annum, instead of 100,000 cubic yards as estimated (a good deal of the balance having probably been carried round the breakwater in the form of sand) but, as against this, the triangle of gathering-ground, over which the shingle has spread itself, in the vicinity of the breakwater, is somewhat more acute than was estimated (also probably due to the grinding of the shingle into sand) and, as it happens, these two discrepancies very nearly balance each other, so that the position of the shingle along the edge of the breakwater itself, is, as already stated, almost exactly what was estimated.

The conditions on which these calculations of August 1881, were based, still continue to prevail, and, seeing that the calculations, so far, are fully borne out by the results, it would be deliberately shutting one's eyes to the inevitable, to ignore the probability of corresponding results continuing to accrue in the future.

That the progress during short periods of time is not regular and uniform proves nothing. It would; in fact, under the circumstances, be unreasonable to expect uniformity; and it is not inconsistent with the conditions that there should, at times, be retrogression, rather than accumulation.

There have been such retrogressions during the last 4 years, but we have nevertheless the fact, that the accumulation along the edge of the breakwater, during the first 2 years of these 4 years, was 260ft., and during the second 2 years 240ft.

This undoubtedly indicates a close approach to uniformity of progress, over reasonable intervals of time, and strongly supports the contention, already advanced, that the progress during the last 4 years should be regarded as probably normal and reasonable, rather than spasmodic or exceptional.

To be reasonably careful, therefore, it should be assumed that the rate of progress of shingle-accumulation, along the edge of the breakwater, will be fully 125ft. per annum, and that it is even quite possible that it may be considerably more than that.

The toe of the shingle spit is now within 530ft. of the end of the straight-out mole. Beyond that point there is a curve for 340ft., and a cant for 678ft., total 1,018ft., trending towards the north.

Presuming that the conditions up to the end of the straight-out mole remain as hitherto, the end of the shingle spit, advancing at the rate of 125ft. per annum, may be expected to reach the end of the straight-out mole in 4¼ years. There is, of course, no positive certainty that it will do so; but, on the other hand, there is no positive certainty that it will not, if unimpeded, get there very much sooner.

The volume of retarding influence, due to the back-wash from the breakwater, is continually getting less and less, and the triangle of gathering-ground may quite possibly become more acute, leading to the formation of a narrow spit, which would travel along the breakwater with great rapidity.

As to what value should be put upon the 1,018ft. of curve, and outer cant, in the way of postponing the time at which the shingle would begin to block the entrance to the harbour, it is difficult to say, but we cannot see our way to allowing much for it.

Under somewhat similar circumstances at New Plymouth, the accumulation of sand, which had taken several years to get to the end of the straight-out mole (1,400ft.) went on, the remaining 550ft., along curve and north-easterly cant, in about 4 months.

Also, where the the circumstances favour a rapid travel, as along the beach between Patiti Point and Timaru, it was found, by experiments made by Mr. Balfour, that boulders travelled from 500ft., to 5,000ft. in a day.

In view of all the circumstances of the case therefore, it is clearly evident that steps should at once be taken to avert the danger of the shingle overlapping the works, which seems to be at present imminent, and that the measures to be adopted should be such as to admit of this being carried out promptly, efficiently, and continuously, for many years, or possibly for generations. To wait longer before taking action would be very unwise.

In view of the uncertainties and contingencies involved in the situation, it is highly desirable to have an ample margin of time to come and go upon.

Best Means of averting the Danger.

Only two means of preventing destruction to the harbour from the growing accumulation of shingle appear to be practicable—namely, (1) the retention of the shingle at the south side of the breakwater, either by extending the mole in its original direction (or possibly in a direction a little more to the east) or by isolated groins; or else (2) the dredging of the shingle-accumulation as it accrues.

Of these alternatives, we may say at once, the dredging is the preferable one, as being the cheaper, and also the more likely to give satisfactory results, in view of all the circumstances of the case. It is desirable, however, that reasons should be given for this opinion, which we proceed to give accordingly.

Alternative No. 1.—Extending the Mole.

To prevent the shingle overlapping the works, by extending the mole, would involve a length being added each year, equivalent to the probable growth of the shingle bank, say 125ft. This, at the low price of £80 per foot, based on last contract, but allowing for rise in price of cement, would cost £10,000.

As against this, there would possibly be a credit from value of land reclaimed, but it is very difficult to say what it would amount to.

If triangle of accumulation preserves its present shape, the area of accumulation, between Rock Island and breakwater, due to each 125ft. of accumulation along the breakwater, would be about 3 acres. Of this, in view of the shape of the land, fully 1 acre would be required for streets, leaving 2 acres available for sale or lease. This, if worth, say, £2,500 per acre, would be value for £5,000.

The net cost of annual extension would thus be £5,000, which, as will be shown hereafter, is much more than the probable cost of equivalent dredging.

In addition to this, too, there are reasons why it would be desirable to dredge the shingle, and convey it round the harbour, rather than retain it all to the south of the work. As, for instance, the desirability of affording protection to the beaches to the north, which might otherwise become denuded. Also the desirability of avoiding an excessive grinding of the shingle into sand (probably becoming greater and greater the further it extends along the breakwater) which would involve the danger of shoaling outside the harbour, by the sand being carried in suspension by the sea.

It may possibly be claimed, that the cost of extending the mole should be subject to a rebate, on account of the advantage which it might have, towards a future extension of the area of the harbour; but we think very little could reasonably be allowed for this, in view, partly of the long time to look forward to before it would be utilised, but more especially in view of the direction which such extension would probably have to take, in order to be effective under existing circumstances.

Had the straight-out cant been originally prolonged in its original line, it would have been a different matter, as the cost of the works as a whole, including, say, 1,000ft. of mole extension, would thus have been some £50,000 less than if such extension were made now; but, taking the circumstances as they stand, an extension of the mole, for the stoppage of the shingle-travel (even omitting all consideration of its other disadvantages) could not well be justified (in view of its additional cost over cost of dredging) on the basis of any use to which it might be put, towards extending the harbour-area hereafter.

Alternative No. 1 (continued).—Groins.

As correlative to the alternative of extending the breakwater, another method which suggested itself, for stopping the shingle-travel, was to construct isolated groins, on the beach to the south of the breakwater. This, however, on investigation, turned out to have nothing to recommend it. While involving all the disadvantages which an extension of the breakwater would involve, it would at the same time be much more costly. That is to say, the cost of retaining a given amount of shingle, by means of such groins, would be considerably more than it would cost to retain the same quantity of shingle by lengthening the breakwater.

Alternative No. 2.—Dredging.

Coming now to the second alternative—namely, the removal of shingle by means of dredging, and conveying it to the northward, entirely clear of the harbour, say, to the vicinity of the Dashing Rocks—it appears, after a very careful study of the question, that this is by far the best means to adopt, and there seems to be no reason why it should not give satisfactory results for a moderate annual expenditure. That is to say, for an annual expenditure, which, in view of the interests at stake, may be looked upon as moderate.

It is only right to say, however, that the probability of being thus able to deal satisfactorily, and at moderate cost, with this shingle-accumulation, is due, in a great measure, to the recent invention, and progressive improvement, of pump-dredgers of large power and capacity; and that if such machines as have recently become obtainable were still in the womb of futurity, the existing and imminent danger from shingle-accumulation would be much more serious. There is also the great advantage in this case that the bed of the harbour affords good holding ground for piles of staging, which will probably be an absolutely necessary appliance towards the performance of the requisite dredging.

The amount of annual shingle-accumulation, which has to be dealt with, is not in itself an appalling quantity. The total retained between Patiti Point and the breakwater during the last 12 years, shows the average annual increment to be under 120,000 tons. To dredge that quantity during the 300 working-days in a year would only involve lifting 400 tons per day.

It is probable, however, that some of the annual accumulation of shingle, in the immediate vicinity of the breakwater, which is now ground into sand, and carried round the harbour in suspension, would be dredged up before being so converted into sand. It is impossible, of course, to say how much this would amount to; but, judging by the accumulation in Caroline Bay, and all other data available, it would probably be an excessive estimate to put it at 15,000 tons per annum. Taking it at that, however, so as to be on the safe side, the total annual quantity to be dredged would thus be 135,000 tons. That, for 300 days, would be equivalent to 450 tons per day.

To dredge 450 tons of sand in a day would be a very small matter, and require but a very small power of dredger, if it were possible to get at it conveniently, and every day; but, in this case, such cannot be expected, and it will consequently be necessary to provide appliances and machinery of ample power to do the year's work in much less than a year.

Taking all the circumstances into account, however, it is probable, that by adopting the plan which will presently be detailed, it would be possible to dredge at Timaru, to a fair percentage of efficiency, and in effective situations, during say, about half the year; and, if this were achieved, the dredge need only be capable of lifting say, 1,000 tons in eight hours.

A dredge capable of lifting 1,000 tons in eight hours might therefore possibly be sufficient; but, allowing for interruptions for repairs, and other contingencies, and in view of the magnitude and importance of the interests at stake, it would be desirable to provide machinery and appliances, in this instance, capable, if occasion requires, of lifting and disposing of as much as 1,500 tons in eight hours.

Details of Dredging-plant.

Having very carefully considered, and calculated the cost of, many methods which suggested themselves, or were suggested by your engineer, Mr. Marchant, by which the requisite dredging and conveying of the stuff might be carried out, it appears that the following is the most advantageous one, in view of the various and manifold requirements of the case, and it is therefore recommended for your approval and adoption, namely:—

A pump hopper-dredger, capable of lifting, under favourable circumstances, 400 tons of sand or shingle in an hour, and having hopper-capacity for 300 tons of sand or shingle; with compound surface-condensing engines indicating about 200-horse power. This vessel, while dredging, to lie within the harbour, alongside the breakwater wharf, in the vicinity of the tail of the shingle-bank, as indicated on the plan herewith, and to do its dredging through a pipe and nozzle of the usual form, but supported on a light timber-piled staging, outside the breakwater, as indicated on the plan and longitudinal section herewith. The pipe and staging to follow up the outer margin of shingle-accumulation, to such extent as may be necessary to render the dredging effective. That is to say, in order to dredge only what will be restored again by accruing accumulation, and not merely to make excavations in the interior of the existing shingle-bank, which might not be restored, as that would not be contending at all with the current accumulation.

In order still further to secure the result of only dredging what is necessary—namely, what would otherwise add to the area of accumulation—and also in order to dredge at the cheapest rate practicable, it would be desirable that the dredging, in the first instance at any rate, should be confined to the face of the shingle-bank, and be only carried down to, say, 6ft. below low water, as the shingle below that, when the backing is removed, would probably be cast up by the sea. If so, it could then be dredged at less cost, or, if cast up very high, it might not require dredging at all.

The nozzle of supply-pipe would be guided from staging by means of a hand-crane.

When hopper is filled, the vessel would, of course, go to sea and discharge its load, say, in the vicinity of the Dashing Rocks.

In addition to one or more pipes and nozzles for working on staging, the ship should also be provided with sufficient pipes and nozzles for dredging at sea, or within the harbour, and also with steam-crane jibs or other suitable appliances for guiding such nozzles when at work.

The cost of this vessel and staging, &c., would probably be about £10,000.

The interest, and depreciation in value of machinery, due to that expenditure, would amount, on the average, to, say, 11½ per cent.—namely, to £1,150 per annum.

The cost of the dredging, and depositing the stuff dredged, after making due allowance for contingencies, and including repairs of machinery, and all other expenses, would be about 4d. per ton, and this, for 135,000 tons, would come to £2,250 per annum.

The total cost, for dredging an average of 135,000 tons in each year, would therefore be about £3,400 per annum, and that would be equivalent to 6·04 pence per ton, including interest and depreciation on value of plant.

To describe herein all the other systems of dredging which have been inquired into, would make this report entirely too cumbrous. As it may be desirable, however, that a list of the most favourable ones amongst them should be furnished with the reasons for their rejection, this has been done, in an appendix, hereto attached.

If the machine which is recommended to be procured is approved of, it would be very desirable, in view of its being likely to be required to work continuously and permanently, that the best class of dredge procurable, of its kind, and having all the latest improvements, should be obtained; and, in order that this may be done, it is suggested that the Board should have complete drawings and specifications prepared, defining exactly the existing conditions, and the character and extent of the work required to be performed, and send the same to some qualified expert in London to do the best he can for them under the circumstances; or else, what would probably be the more satisfactory plan, for the Board to send some qualified person from here, whom you can thoroughly rely upon, and who is conversant with all the circumstances of the case, to visit some of the principal manufactories of such articles in England and Holland, and satisfy himself as to which is likely to produce the most satisfactory article, before letting a contract for its construction. One reason, amongst others, why this latter plan would probably be the most satisfactory one to adopt, is, that no matter how complete the drawings and specifications sent to England may be, it is impossible, in practice, to predicate all the questions that may arise, and to supply answers to them in anticipation. To a person unacquainted with the locality also, a machine might appear to be quite suitable, which, to one acquainted with the locality, would be evident at a glance to be unsuitable. Another reason is the rapid improvements now continually being made in these machines, which could not be predicated in any specification sent from here, and which might or might not be necessary or suitable for the Timaru work, and which an expert in England would not consequently

know whether to accept or reject. Altogether, therefore, it is probable that the cost of sending some one acquainted with the locality to England and Holland would be more than saved; if not in the procuring of a higher class machine, possibly in the rejection of some altogether unnecessary redundancy.

Dredging recommended in the Meantime, pending procuring the Plant herein described.

Whichever way the question is decided, however, it is evident, at any rate, that the procuring of the necessary machinery for the efficient performance of the work now required to be done will take a considerable time, and, as it is desirable that no time should be lost in meeting the shingle-accumulation danger, it is suggested, that in the meantime the Board's existing Priestman grab-dredger should be utilised, to such extent as this can economically be done, first, by working it on the edge of the breakwater, and afterwards, unless the shingle-accumulation keeps continuously progressing forward, on a staging of the character indicated on the section herewith, following the face of the shingle-bank to such extent as may be requisite. For some time, at any rate, it is probable that this process, though inadequate to keep pace with the annual accumulation, will not be more expensive per ton dredged than any other plan would be; in fact, while the circumstances remain suitable, it may possibly be the cheapest plan of all, so that nothing can be lost by adopting it, so far as it will act. No dredging, however, should be done where it will not be filled up again by the accruing accumulation, as this would not help to meet the difficulty in any way, and would merely be making holes in the area which might otherwise be utilised for various purposes.

Surveys.

To refer now, for a moment, to a subject which is of minor importance, but which we think should nevertheless receive attention, we would wish to take this opportunity of recommending, that periodical and systematic records should be kept of the progress of the shingle-bank, and of the sea-bottom for some considerable distance out therefrom (where sand-deposit is liable to take place) in order to be able to satisfactorily define and realise, from time to time, the changes which are gradually occurring; and thus, if possible, to trace their causes, and if possible counteract them, or some of them, when they are detrimental to the harbour. To do this satisfactorily will require the establishment of permanent marks, defining suitable base-lines for soundings, &c., which would thenceforward always be adhered to. This will, in the first instance, entail some little expense, but we feel satisfied that such expense is justifiable, and will probably lead to economy in the long run, even if only in the future cost of making the soundings and measurements, which will probably be made from time to time in some way in any case.

Conclusion.

In conclusion, we would wish to express our thanks to the Chairman and members of the Board, for the facilities which they have placed at our disposal, towards acquiring the information necessary for this report, and for explaining so definitely as they have done the exact questions which they wished to have answered; also to the officers of the Board for their willing and kindly assistance. This is especially so as regards your engineer, Mr. Marchant, whose careful and long-continued study of the questions referred to us, has given him most valuable and exhaustive knowledge and ideas on the subject, and these he most willingly and cordially placed at our disposal.

We have, &c.,

C. Y. O'Connor, M. Inst. C.E.,

The Commissioners appointed by the Timaru Harbour Board, by letter dated 21st March, 1891, to examine into, and report upon certain questions, concerning the Timaru harbour-works.

The Chairman, Timaru Harbour Board.

List of Plans herewith.

1. General plan—Showing harbour, and area of shingle-accumulation.
2. Longitudinal section—Showing progress of accumulation along line of breakwater.

APPENDIX TO REPORT BY MESSRS. O'CONNOR AND GOODALL, DATED 2nd APRIL, 1891.

List of some of the suggestions for dredging, which have been considered, and the reasons why they have been rejected.

Suggestion No. 1.

Priestman grab-dredgers (as many as may be found necessary) to work on the breakwater, and discharge into elevated bins, also on the breakwater. The stuff to be taken from thence by steam hopper-barge.

This would probably be a cheap process, but it had to be rejected, for the reason that it would only work satisfactorily, for any considerable length of time, in the event of the shingle-accumulation reaching the breakwater in a uniformly progressive manner. This it would not be at all safe to reckon upon. It certainly has not been so in the past. There is, however, more apparent probability of its being so in the future; and it is to some extent on the assumption that it will be so, for at any rate considerable periods at a stretch, that we have recommended the employment of the Board's existing Priestman grab-dredger, pending the procuring of a pump hopper-dredger.

Suggestion No. 2.

Priestman grab-dredgers, as before, but working on a piled staging outside the breakwater, following up the outer margin of shingle-accumulation to such extent as might be necessary, and discharging into trucks on staging alongside. The trucks to be run along staging and tipped into elevated bins or bin, on outer or inner side of breakwater and wharf, and the stuff to be taken thence by steam hopper-barge.

The reason for rejecting this suggestion was, the cost and inconvenience of trucking the stuff.

Suggestion No. 3.

Priestman grab-dredgers, working on piled staging as before, but discharging into an elevated bin, on harbour side of breakwater and wharf, by means of a band-conveyor, or pipe and water-jet.

This idea was given up, as we were unable to hit upon any means of making it work satisfactorily for moderate cost.

Suggestion No. 4.

Priestman grab-dredgers, working on piled staging as before, but discharging into side-tip trucks on locomotive line adjoining. The stuff to be thence carried by Government or separate railway to Dashing Rocks.

This plan has no doubt a great deal in its favour, but the frequent crossing of railway to shipping wharf would probably be an inconvenience, and the cost per ton dredged would be somewhat higher than the plan which we have recommended. Besides this too (and this applies to all the alternatives except the one which we have recommended) the appliances for this system could only be utilised to their full extent in one particular way; whereas the great bulk of the expenditure, for the system which we have recommended, would be on a vessel, which could be utilised in several different ways, both inside and outside the harbour.

Suggestion No. 5.

A pump-dredger, capable of lifting 400 tons of sand or gravel in an hour, working on piled staging, outside the breakwater, and discharging into an elevated bin at harbour side of breakwater and wharf. The stuff to be thence taken to Dashing Rocks by steam hopper-barge.

This is, we think, the best of all the alternatives considered, except the one which we have recommended. It would admit of a much smaller vessel (say, one of 150 tons, instead of 300 tons hopper-capacity) being employed, as it could get filled from a bin in a very few minutes, and could therefore keep on conveying stuff almost continuously, instead of intermittently with dredging operations intervening. There is, however, some objection in risking so expensive a machine on staging outside the breakwater, and the plant as a whole (as already mentioned) could not be utilised to the same extent, in various ways, as the plant which is recommended. Also, although the first cost of machinery, and consequent interest and depreciation, would be less than for the system which we have recommended, we doubt if the ultimate cost of work done would be any less, as there would be two machines to man, and keep going, in place of one.

Suggestion No. 6.

A pump-dredger, working on piled staging as before, but discharging direct on to the beach, in the vicinity of the Dashing Rocks, by means of a delivery-pipe, having a length of about 2 miles.

This, if it would act satisfactorily, would probably do the work required cheaper than any of the other methods which we have investigated. There is no certainty, however, that it would do the work required satisfactorily. Delivery-pipes of considerable length (we believe in some cases up to 2 miles in length) have, we believe, been successfully used in connection with pump-dredges, but the material dredged, in all such cases that we know of, has been fine sand. Whether or not equally satisfactory results could be obtained, with the character of stuff required to be dredged at Timaru, and how the cost of such dredging and delivery would compare, with the ascertained cost of dredging and delivering of fine sand, it is not possible to say, with the data at present at our disposal. The uncertainty about the matter generally is therefore so great, that we are not justified in recommending this process for adoption, in despite of its possible cheapness. As against this possible cheapness, too, there is the consideration, already alluded to, that the machinery thus provided could only work in one way, whereas the machine which we recommend to be procured, could work in many ways.

Suggestion No. 7.

A pump-dredger, working on piled staging as before, but discharging into side-tip trucks on locomotive railway alongside.

This idea has really nothing to recommend it, as the only object of railway line is to obviate difficulty of conveying stuff from staging to hopper-barge (or to elevated bin, on its way to hopper-barge) and, if a pump-dredger is employed on the staging, of course no such difficulty would arise. The cost of carriage by barge is cheaper than by railway, including, of course, in both cases, the cost of maintenance, repairs, and interest and depreciation, &c., so that it is only in the case where the cost of getting stuff from dredger to bin would be considerable, that the carriage-by-railway alternative seems to show any advantage at all. This statement, however, is subject to qualification to this extent: that, whereas it is not an absolute certainty that stuff can be placed by means of a steam-barge, in such a position, in the vicinity of the Dashing Rocks, that it will be thrown up on the beach, ready to be carried on by the waves, there is no doubt at all that stuff could be so deposited by means of side-tip trucks, working on a locomotive railway, in conjunction with a staging and shoots at the Dashing Rocks. There is, however, so very little doubt, as to steam-hopper acting satisfactorily in this particular, that we think such doubt may safely be disregarded.

Suggestion No. 8.

A ladder-dredger, working on piled staging, outside the breakwater.

This would involve nearly all the difficulties of getting rid of the stuff, which appertain to the Priestman process, with the additional disadvantage that it would be much more exposed to risk from the sea, and, being comparatively a very costly implement, that would be a serious disadvantage. If kept on very high and strong staging, to avoid this, of course the cost of such staging would be materially increased, and the height of lift, moreover, would be abnormal. The difficulty of travelling round sharp curves, in order to follow the shingle-face, with a machine of such length as a ladder-dredge must necessarily be, would also be very great. It is not, therefore, at all probable that this form of dredge would be found satisfactory.

Suggestion No. 9.

Dredging face of shingle-bank, in the open sea, from a vessel afloat.

To do this at Timaru, with a ladder-dredge, would, of course, be impracticable, even in the calmest weather usually experienced here, but it might at times be done by a Priestman or pump-dredge. The interruptions, however, would be so frequent, that it could not be relied upon to any considerable extent, and so cannot be recommended for general adoption; but, if the form of dredger which is recommended is procured, it might sometimes be found advantageous to use it at the face of the shingle-bank, when the conditions are exceptionally favourable.

As regards Dredging Proposals generally.

Many other proposals were suggested, and fully considered, but those above described seemed to be the only ones worth specially mentioning. C. Y. O'Connor, M. Inst. C.E.

Mr. Goodall's Report.

Timaru, 2nd April, 1891.

Sir,— *Re* Timaru Harbour-works.

I have the honour to acknowledge the receipt of the instructions, from the Secretary of the Timaru Harbour Board, appointing me a Commissioner, along with Mr. C. Y. O'Connor, to consider the "danger that exists to the harbour from travelling shingle;" to inquire, examine, and report on the subject, and to state whether the danger can best be averted "by erection of permanent works, or by removal of the shingle;" and beg to report as follows:—

The subject has been thoroughly, and exhaustively discussed and considered, between your engineer, Mr. Marchant, Mr. O'Connor, and myself, and the result has been retailed in the report signed by Mr. O'Connor; but, although Mr. O'Connor and I are agreed on main points, yet, necessarily, there are some points of difference between us, so I could not endorse the report. I, however, state that I agree in all that has been said in the report named, except in so far as I shall now explain.

I fully agree with Mr. O'Connor that it would be advisable to take steps to avert the danger of the shingle overlapping the works, but not from the consideration that there is imminent danger to the works for some years to come; but, as there is a probability of danger at some future time, and as it might be advantageous to restore the beach, to the north of Timaru, by allowing the shingle to travel northward from the breakwater, I consider it would be advisable to at once initiate works for removing an average yearly quantity of shingle from south of the breakwater to the north.

I cannot agree with Mr. O'Connor that there is an average of 80,000 cubic yards of accumulation per annum, and although his calculations have been based on figures taken from Sir John Coode's plan, I cannot consider that the result, as arrived at, gives an accurate amount. I consider that the records of Mr. Marchant, which made the accumulation for the last five years, 300,000 cubic yards, to be more reliable. This will give an average of 60,000 cubic yards per annum, equal to about 90,000 tons.

As for the rapidity with which the shingle may travel along the breakwater, I do not consider the circumstances cited at New Plymouth, can be taken in evidence as to what might occur at Timaru, the two cases being so widely different, and the experiments of Mr. Balfour cannot give data to be relied upon, and the rate of progress of the shingle along the breakwater yearly may soon be changed for the better, for, as the shingle creeps out, the line of beach would become more and more at right angles to the strike of the waves, and so the travel of the shingle would be slackened.

I agree with Mr. O'Connor that there are only two means of averting the danger to the harbour from the growing accumulation of shingle—(1) by extending the mole from the first cant in its original direction; or (2) by dredging the shingle-accumulation as it accrues, and I agree with him in the choice of the latter method.

Alternative No. 1—by Extending Mole.

I fully indorse all the reasons set forth for not recommending the extension of the breakwater, but cannot agree with Mr. O'Connor that, "had the straight-out cant been originally prolonged in its original line, it would be a different matter, as the cost of the works as a whole would then have been much less than if such extension were made now;" for had the cant to the north not been made, and the straight-out from the shore extended instead, a successful structure at a very low price, such as the present north mole, could not possibly have been erected to enclose the harbour, as it would not have been sufficiently sheltered, as there would have been no shelter from the north-east and only partial shelter from the south-east, a very expensive wall would have been required, and therefore the extension of the straight-out cant could not have cheapened the work as a whole. Besides which, unless the cant was made to the north, adequate shelter could not have been given to the mouth of the harbour, and the ocean range would have freely swept in.

ALTERNATIVE No. 2—BY DREDGING.

Although I have already stated that there are only 90,000 tons of shingle per annum to contend with, yet, to be quite safe, I am willing to presume that the amount may be 120,000 tons, or, say, an average of 500 tons daily to be removed in 250 working-days, which I take as a fair number of working-days that may be got out of a year.

I cannot agree to add 15,000 tons per annum for the accumulation of Caroline Bay, as it is not possible that the shifting of shingle at the south of the breakwater would prevent the usual quantity of sand from travelling round the breakwater and so increase the quantity to be shifted, for as soon as a ton of shingle is removed there will be another to take its place, to be subjected to the sand-making process; and the base of operations is so small that were it the case that it were so affected, the amount would be so insignificant that it would be inappreciable.

Nor can I concur with Mr. O'Connor that the dredging-capacity should be 1,500 tons per day of eight hours. One-half that capacity should be enough, as any unusual necessity for clearing away the shingle could be met by working extra hours.

I would therefore recommend the adoption of a pump hopper-barge capable of lifting 300 tons per hour, and having hopper-capacity for 150 tons of sand or shingle, with the best and most improved engines, indicating (50) fifty-horse power.

This vessel should be able to fill her hopper, proceed to opposite Dashing Rocks, discharge, and return, in about one hour and a half, including all necessary stoppages. This would be equal to five trips a day, or 750 tons gross daily. Such a barge and pump would cost about £4,000, and, with staging, hand-crane for suction-pipe, and contingencies included, the whole plant would not exceed £5,000. The cost of dredging and dumping the spoil, after taking into account every working cost, interest of capital, depreciation of plant, and contingencies, would be from 2½d. to 3d. per ton, and the total cost per annum for shifting 120,000 tons at 3d. per ton would therefore be £1,500 per annum, and I am fully convinced that this estimate is far in excess of the actual amount that will be incurred.

In all other matters I fully concur with Mr. O'Connor's views.

I have, &c.,

JOHN GOODALL, M. Inst. C.E.

DISCUSSION.

THE reports having been read, the Chairman said,—I see Mr. O'Connor makes an addition to the accumulation for a quantity ground up. Mr. Goodall declines to admit that addition. Both agree that preparation for action is immediately necessary, but Mr. Goodall is more moderate in his views.

Mr. Teschemaker: I understand Mr. O'Connor thinks that if we take away some shingle, there will be less sand to go round.

The Chairman: Yes; but Mr. Goodall says that though we do shift a quantity of shingle, we still leave a sea-face, and there would be the same grinding.

Mr. Stumbles quite agreed with Mr. Goodall there.

The Commissioners were then invited to attend, and a conference was begun by Mr. Teschemaker asking for an explanation of the difference between their estimates of the quantity of shingle to be dealt with.

Mr. O'Connor said he reckoned on an average of 80,000 yards a year, Mr. Goodall on 60,000. He (Mr. O'Connor) derived his information from Mr. Marchant, who made the average over a number of years 75,000 yards, and allowing a little margin, he (Mr. O'Connor) made this, in round numbers, 80,000 cubic yards. He had also checked this result by making independent calculations of the accumulation as it now stands. He did not know where Mr. Goodall got his 60,000 yards from. This was the chief difference between them. He (the speaker) made it 80,000 yards, on the average of the last 12 years.

Mr. Goodall said he arrived at his figures by taking Mr. Marchant's measurements for the last five years, as he did not consider the earlier measurements so trustworthy as the later ones, and five years was long enough time to found an estimate on. At the same time he was quite willing to provide for a larger quantity.

Mr. O'Connor said Mr. Goodall apparently took the measures of individual years as being more correct than the total to date. But these measures of individual years were only got by subtracting the measures of earlier years from the total at any time, and all were referred to Sir John Coode's plan as their base. Starting from the state of things shown on that plan, they found 900,000 cubic yards accumulated in twelve years, or 75,000 yards a year. The amount of accumulation fluctuated from year to year—in 1888 it was only 40,000 yards—so the average was taken over a long period of years.

In reply to questions by members, Mr. O'Connor said in some years much larger quantities might arrive. The calculations made in 1881 by Mr. Austin and himself were being proved to be fairly accurate, and this showed that the accumulation was proceeding steadily. The area of the gathering-ground was over-estimated in 1881; on the other hand the rate of accumulation had not been quite so great as was then reckoned on, but the two errors balanced, so that the progress of the shingle along the breakwater was just what was calculated.

Mr. Stumbles: You prefer to shift the shingle rather than extend the breakwater?

Mr. O'Connor: Yes; the figures in the report are in favour of that course.

Mr. Stumbles: But would it not be doing better with the money to spend it in a work which would be useful in the course of time, by sheltering the harbour?

Mr. O'Connor: The report deals with that question also. You would have to go out more than 1,000ft. before you increase the shelter at all. The breakwater already reaches to more than

1,000ft. from the bend, and that 1,000ft. gives more shelter than if it were straight out. That was the argument originally advanced for putting the curve in the breakwater. In 1881 he (Mr. O'Connor) advocated just what Mr. Stumbles was advocating now, carrying the breakwater straight out, for the reason that it would lengthen the time during which the harbour would be free of shingle; but the Board at that time did not adopt the suggestion, and the newspapers laughed at the reasons given for it. To do it now would cost £50,000 more than if done originally.

Mr. Stumbles believed, if the work was extended the back-wash would be restored.

Mr. O'Connor doubted it. The back-wash appeared to be connected with the shore or shoal water. There was less and less of it out to sea.

Mr. Stumbles concurred in this.

Mr. O'Connor said that it might not be necessary to go out 125ft. per annum with a wall, to keep ahead of the shingle, but it might be necessary to go a great deal more. He would not be surprised to see the shingle form itself into a narrow spit and run along the mole very rapidly. That was what he was afraid of at present.

To Mr. Wilson: The class of rubble required for an exposed structure would not be much, if any, cheaper than concrete, at the price of stone here.

To Captain Woollcombe: The reflected wave scarcely exists now, the shingle has gone so far out.

Mr. Stumbles pointed out that the shingle was a great protection to the work on the inner part of the wharf. It would be a good thing for the working if the breakwater were backed up all the way along.

The Chairman said the shingle was of value in that way, and they would like to be able to say "Thus far and no further."

Mr. Hill said he believed the shingle began to make up at the breakwater through the putting-down of random blocks breaking the run of the sea, and the taking-off the parapet blocks allowing the waves to run over into the harbour. Had the Commissioners any data placed before them to show how the bottom was making up in Caroline Bay?

Mr. O'Connor: Yes, we went there and saw it.

Mr. Hill: Will it take long to accumulate so as to bring it round into the harbour?

Mr. O'Connor could not say how long, but thought it would take a very long time.

Mr. Hill thought it would not take so very long. He believed the shingle would be brought back from Dashing Rocks.

Mr. O'Connor: We assume that the deposit in Caroline Bay has gone round the harbour.

Mr. Goodall said that heavy seas running past the end of the mole would always keep the bottom disturbed, and at a uniform depth. The Caroline Bay deposit might come further out than it is yet, but when it came under the influence of the southerly seas the silt could settle no further. A limit would be reached where no further settlement could take place, and that limit, he believed, was far to the north of the harbour. Perhaps the shingle in Caroline Bay came from Waimataitai Lagoon, where the beach was now protected from the southerly seas but exposed to the north-easters. It could not be from Dashing Rocks, as there the beach was under the influence of the southerly seas.

Mr. O'Connor said if the shingle was shifted, by barges or otherwise, it would of course be discharged at some point where there would be no doubt it would travel north—not south.

Mr. Flatman: If the amount stated is removed, will that prevent the spit travelling along the work?

Mr. O'Connor took it that the dredging would take place principally alongside the breakwater, and would of course prevent such a spit being formed. The essential difference between himself and Mr. Goodall was that Mr. Goodall assumed that the dredging machinery could be worked with moderate uniformity on a great many days in the year. He (Mr. O'Connor) did not think it safe to reckon on that. There would be many interruptions, many occasions when they could not work, just when they wanted to work. Mr. Goodall also assumed that the dredge would usually lift to its maximum capacity. Dredges never did that. If a dredge averaged 50 per cent. of its capacity throughout the day it did very well. Even at Lyttelton one often saw the dredge-buckets running empty, or nearly empty, and with the particular form of dredge they proposed to adopt at Timaru, it was more difficult to insure working to full capacity. This was the only practicable form of dredge for the purpose. The maker in his circulars gave an example of a machine "capable" of lifting 400 tons per hour, but he gave as its average work 200 tons per hour. As to the difference between his (Mr. O'Connor's) estimate of cost and Mr. Goodall's, he did not know the maker's price for a 300-ton machine, but he saw that a 50-ton dredge cost £1,000, and a 100-ton one £2,000, and he thought it fair to assume that other prices would be similarly proportionate to the power, so that a 300-ton dredge would cost £6,000, and the cost of the barge would be additional to that. Mr. Goodall estimated only £4,000, for barge and all. As to the barge, they could not reasonably expect to get the hull of a 300-ton hopper-barge for less than £2,000, and with the driving machinery (additional to machinery for pumping) it would cost probably £3,000. He had other data on the subject in the report by Sir John Coode and Mr. Blackett to the New Plymouth Board in 1889, in which they recommended a pump hopper-dredge, and the description given of that dredge showed that it was only expected to work up to half its maximum power of lifting. The cost of the dredge was put down at £11,000 delivered, and the cost of working at £4,500 a year, or (including interest and depreciation) 7d. a ton on the material to be shifted. Shingle would be more difficult to shift, and therefore a larger margin should be allowed. At New Plymouth there was 200,000 tons to shift annually, and Sir John Coode recommended a dredge of 400 tons hopper-capacity. Here there was not quite three-quarters of that quantity; but he (Mr. O'Connor) proposed a machine of three-quarters of that capacity, because the material to be shifted was not sand, but shingle. His figures were about three-fourths of Sir John Coode's.

Mr. Teschemaker: Then you say that the harbour can be kept going for £3,400 a year?

Mr. O'Connor: I think so; and if I were a landowner here I should think it a satisfactory result.

In reply to Mr. Wilson, Mr. O'Connor explained the arrangement of the dredging machinery, and to the chairman explained that separate dredges with barges do not work so cheaply as hopper-dredges.

In reply to a remark by the chairman,

Mr. Marchant said he would like to explain that the putting-down of the random blocks had not been the cause of the shingle making up to the breakwater. During the twelve months following October, 1885, the record plans showed that the shingle retreated 90ft. from the rock island and made 90ft. beside the breakwater, and that was before the random blocks were put down. At that time the breakwater was being under-scoured: 200ft. of it had caverns in it, and other parts showed signs of weakness. Mr. Goodall would tell them that there were often subsidences during construction, and that to cure them he put down random blocks. Those settlements were threatening the existence of the breakwater, he considered, and he recommended the Board to have some blocks put down—but only half the number the Commissioners had recommended for the outer portions. Mr. Blackett passed through after visiting Oamaru, and warned him not to spare the random blocks, as the want of them had caused a portion of the Oamaru work to be wrecked. As the blocks were put down, it was found they cut down the gorging wave which ran to the root of the breakwater, but they did not reduce the reflected wave. That was the history of the random blocks. Even supposing that the shingle would have been kept back if they had not been put down, the breakwater would have been wrecked by under-scour. But he did not think the random blocks were to blame for the change. Other explanations were, the change in the direction of the work, and the destruction of kelp about the rock island.

Mr. Hill: Was your attention called to the "range" within the harbour, and the possibility of constructing some slight work to prevent it?

Mr. O'Connor said that was not part of the reference to them. He saw that there was a range, but he did not see how they were to stop it without narrowing the entrance. That was a question of navigation. The best thing at present seemed to be to make a wharf along the north mole.

Mr. Manchester would like to know whether there was any danger of sandbanks being formed in front of the harbour-entrance, and whether the removal of the shingle would be a safeguard against them.

Mr. O'Connor said that that was one of the reasons why they recommended removing the shingle instead of impounding it. Evidently a good deal was converted into sand and carried away in suspension, and some of it might be dropped in front of the harbour. There was certainly a little accumulation, but at present there was not sufficient data to enable them to define the exact extent of it, and they therefore recommended systematic levelling, measuring, and sounding, and plotting the levels and soundings, in profile, on longitudinal sections of very distorted scale, so as to be able to record and realise the changes very distinctly.

Mr. Marchant (to the chairman) said he had reported that he found the water shoaled from 27ft. to 24ft. on a certain spot. This indicated a deposit of 3ft. The last sea had cut off the top, so that only 2ft. of the deposit was left. He had no doubt about the correctness of the soundings.

Mr. Hill said there was always a quantity of silt moving about the roadstead before the harbour was commenced. He could remember "sweeping" for slipped anchors in the old days, and finding the chains buried three or four feet by a single storm, and on another occasion a diver fell into a hole 8ft. deep scoured round an anchor.

No other questions being asked,

Mr. O'Connor briefly summarised the items in Mr. Goodall's memorandum, and his replies thereto, and repeated, after reference to Mr. Marchant's data, that they could not reckon having to shift less than 80,000 yards, equivalent to 120,000 tons, a year (1 yard equals 1½ tons).

The Chairman hoped every member would study the reports, and make himself fully acquainted with the views of the Commissioners before next meeting.

Mr. Morris moved, and Mr. Wilson seconded, "That the Harbour Board desire to acknowledge the skill, care, and attention, which have evidently been devoted by the Commissioners to the questions submitted to them." Carried unanimously.

Mr. O'Connor said he was much obliged to the Board, but he was scarcely entitled to any thanks, as he had simply done his duty. The subject happened to be rather an easy one for him, as he had had a good deal to do with it before. Nevertheless, he was much obliged to the Board for their kindness in passing the resolution.

Mr. Goodall also returned thanks. He was obliged to the Board for remembering him, and it was and always would be with him a labour of love to do anything for the Timaru Harbour.

The meeting then broke up.

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TIMARU HARBOUR WORKS

LONGITUDINAL SECTION ALONG LINE OF BREAKWATER

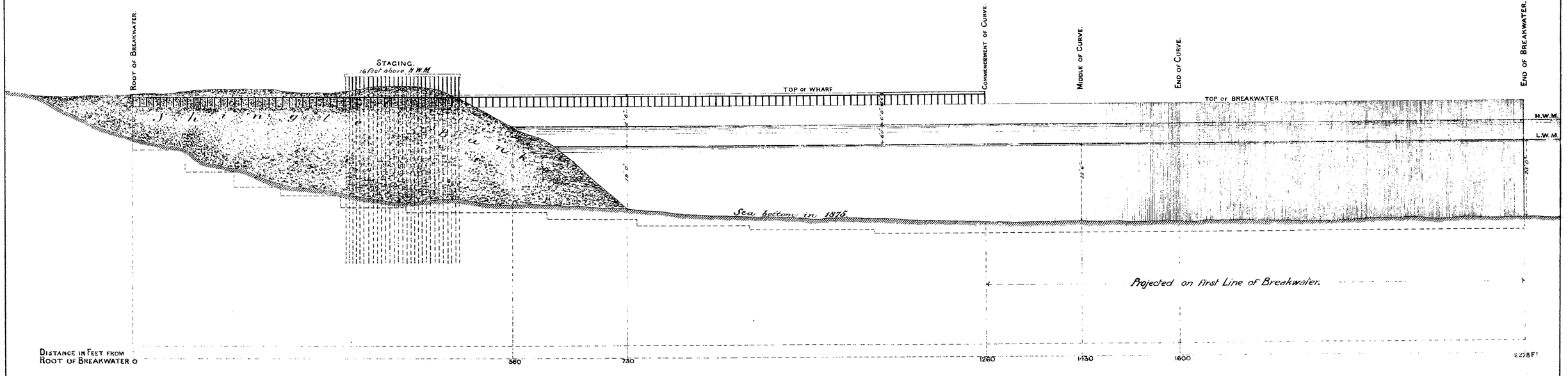
To accompany Report of Shingle Commissioners, dated 2nd April 1891

HORIZONTAL SCALE 100 FEET = 1 INCH.

Ft 100 50 0 100 200 300 400 500 600 Feet.

VERTICAL SCALE 20 FEET = 1 INCH.

Ft 10 5 0 10 20 30 40 50 60 Feet.



Printed at the General Survey Lithographic Office Wellington N.Z. May 1891

TIMARU HARBOUR WORKS

GENERAL PLAN

To accompany Shingle Commissioners' Report, dated 2nd April 1891.

SCALE 6 CHAINS TO ONE INCH.

Lk & Mos 0 1 2 3 4 5 10 15 20 25 30 35 40 Chs
Ft 100 50 0 100 200 300 400 800 1000 1800 2000 2500 Feet

Note! Soundings denote depths of Water in feet at Low Water Spring Tides.

CAROLINE BAY

3 Fathoms line

2 Fathoms line

1 Fathom line

High Water mark

MAIN LINE OF RAILWAY

NORTH MOLE

MOODY WHARF

Patent Slip

Baths

Flagstaff

Lighthouse

Dredge boat Steps

Breakwater

Root of Breakwater

2278 feet from root of Breakwater

1600 feet from root of Breakwater.

1260 ft: 24 from root of Breakwater

730 ft from root of Breakwater

360 ft from root of Breakwater

Present H.W.M. March 1891

Present Toe of Shingle Bank

Original L.W.M. 1875

Original H.W.M. 1875

Rock Island

STRATHALLAN ST

TIMARU RAILWAY STATION

GEORGE ST

BOROUGH OF TIMARU

REPORT OF ROBERT WILSON, Esq., F.R.S.E., M.Inst.C.E., and C. NAPIER BELL, Esq., M.Inst.C.E., ON HARBOUR IMPROVEMENTS AT TIMARU.

Sir,— Christchurch, 1st June, 1891.

In accordance with your instructions to report on the accumulation of shingle at the breakwater of Timaru, and the best means of dealing with it, we went to Timaru by the express on the 20th of May, and until the evening of the 22nd of May were occupied in examining the works, the beach to the south and north, in looking over the previous reports on this subject, and in taking the evidence of your Engineer and Harbourmaster.

The accumulation of shingle caused by these works is quite in accordance with the known effect of works of this character on beaches where the materials composing them are permanently in motion in one direction.

Sir John Coode, foreseeing this result, recommended an island harbour, which, if placed at a proper distance from the shore, would doubtless have been perfectly safe from travelling shingle. The Board, seeing the practical difficulties attending the building of such a harbour sought the advice of Messrs. Henderson and Heale, who in their report dated the 13th December, 1877, ignored the evidence previously obtained as to the travel of the shingle, and recommended the adoption of the present design. The result has inevitably followed, and the works are now threatened with destruction unless immediate means are devised to stop the accumulation of the shingle.

Messrs. C. Y. O'Connor and Goodall, in their report of the 2nd of April, 1891, have given full details of their observation of the rate of accumulation, and of the probable time when the works will be blocked up by it. We have investigated these calculations and fully agree with their view as to the urgency of the case. There is no doubt that in a few years the shingle will have advanced to the kant, or bend in the breakwater, and when this is the case a very short time will elapse before the entrance will be blocked up.

Mr. C. Y. O'Connor estimates about four years as the time it will take the shingle to reach the head of the breakwater; on the contrary, Mr. Goodall thinks the danger to be much further off, partly on the ground that the line of the beach is daily getting more at right angles to the "stroke of the waves." We attach no importance to such a trifling circumstance as the inclination of the beach in presence of so small an obstacle as the breakwater, and the great quantity of shingle yearly accumulating; we therefore agree with Mr. C. Y. O'Connor, that in view of the uncertainties and contingencies involved in the question, immediate steps should be taken to place the work in security.

The beach for many miles to the north of the breakwater shows abundant evidence that the safety of the breakwater is not the only consideration which your Board should attend to, the sea having stripped the beach of its covering of shingle, has now exposed the soft clay underneath, and is rapidly scouring it away, with the result that the sea will not be long before it encroaches on the fields and cultivated land, and no one can tell where this damage will stop if the original condition of things is not restored.

In considering the remedies which must be adopted to place the harbour in safety, and restore the north beach to its original condition, we have given careful attention to all the documents on the subject which were submitted to us, and to the well-considered report of Mr. C. Y. O'Connor.

Notwithstanding some yearly variations in the estimated quantity of accumulation, we consider the evidence is sufficient to prove that 900,000 cubic yards have accumulated in twelve and a half years, and that the average yearly accumulation is 72,000 cubic yards, or 108,000 tons. We consider it is only trifling with the danger to attempt to prolong the safety of the harbour by erecting additional works to stop the shingle. Mr. O'Connor has very clearly set forth the reasons he had against extending the works with this object. Opinions have been expressed in the papers, and are partly supported by Mr. Goodall in his supplementary report, that by extending the works further to sea the growing shingle-beach may adjust itself to the "strike of the waves" so as to stop further advancing accumulation at the breakwater, or that the backwash, supposed to have been destroyed by the random blocks thrown in to protect the foot of the breakwater, may be restored to beat back the shingle in its advance. We consider that to rely on such contingencies would be illusive; the adjustment of the line of beach to the "strike of the waves" would only be effectual in stopping the advance of the beach provided the shingle were turned into sand by the grinding action of the waves, and washed away by the shore currents as fast as the supply was brought up from the south, and we do not consider the breakwater, even when extended as far as the means of the Board may allow, would present an obstruction of sufficient magnitude to bring about such a result. For the same reason we consider the backwash of the reflected wave, even if allowed its utmost power by omitting the random blocks, would offer but a trifling obstacle to the advance of the shingle, which if driven in-shore by the reflected wave would form a spit along the neutral line where the direct and reflected waves meet; this advancing spit would soon shelter the hollow made by the backwash, and as soon as shelter was made the spit would close in on the breakwater, and thus the advance of the shingle along the breakwater would ultimately take place in spite of the backwash.

As to the fact of the beach to the north being stripped of its shingle, we notice the expression of opinion by a writer in the *Timaru Herald* of the 15th of May, which still attempts to dispute the continual travel of shingle in a northerly direction, and gives, as proof that it does not, the fact of Banks Peninsula not being surrounded by shingle.

The phenomenon of shingle and sand continually travelling in a certain direction on beaches is by no means peculiar to New Zealand; it has been observed in many countries, and abundant evidence has been shown to prove it. The evidence is equally conclusive which proves that all material of the sea-beaches of this coast of the South Island constantly travels towards the north, as a consequence of the prevailing southerly direction of the waves and winds. The occasional occurrence of east or north-easterly winds has very little influence in stopping this travel of the beaches towards the north. Great projecting headlands, such as the Dunedin and Banks Peninsulas, are equally powerless to stop this travel of the beaches; the only effect they have is to obstruct the advance of the heavier material until it is ground into fine sand, in which condition it travels round the headlands in deep water, carried along by the powerful shore currents which are set up by the prevailing direction of the waves in the miles of beach to the southward of the headlands, and prevented from settling and shoaling the water by the commotion of the waves along the steep rocky shores of the peninsulas. As soon as the headland is passed, the sand is washed ashore to form great deposits, until it has adjusted the beach to a suitable inclination to the prevailing winds and waves, when the sand again travels forward, leaving the form of the beach permanent, notwithstanding that its material within reach of the waves is constantly moving onwards. The sand travelling round Dunedin Peninsula is necessarily very fine, otherwise it could not travel the distance, and through such deep waters. It appears at the entrance to Port Chalmers, and there flows into the harbour and out again with the tides; but part of it is left to form shoals inside and the bar outside, which are always shifting and travelling. In like manner, the shingle of the Rangitata, Ashburton, and Rakaia Rivers travels towards Banks Peninsula, but is reduced to the size of peas by the time it reaches Lake Forsyth. Here the steep, rocky shores of the peninsula project nearly in the direction of the prevailing waves; the shingle and heavier sand is therefore beaten back, and subjected to the grinding action of the waves until it is reduced to the finest sand, in which condition it is easily carried by the shore currents round the entire length of the peninsula, being kept "alive" by the violence of the waves against the rocky coast until it reaches Sumner, where it has formed very extensive deposits and sandhills as far as the mouth of the Waimakariri. This beach is now adjusted to the prevailing direction of the waves and shore currents, and the sand which continually travels round Banks Peninsula moves onwards along this beach, or is blown ashore to form sandhills. The travelling sand does not fill up such openings as Port Chalmers, Akaroa, and Lyttelton, because the sand is very fine, and the strong currents in and out of these harbours are sufficient to free them from deposit.

In attempting to draw an analogy between these natural effects, and the features presented by the Timaru breakwater, it at once suggests itself that the obstacle of the breakwater is not nearly large enough as regards the supply of travelling shingle with which it has to contend, and that the phenomena observed at such great headlands will not be reproduced by the Timaru harbour works however far they may be extended, but, on the contrary, the works will be buried by the shingle in the course of a few years.

But meantime the beach to the north is being stripped of its covering of shingle, the spit which encloses the Washdyke lagoon is slowly being eaten away. The sea has already breached it in many places, and is washing the remaining sand and shingle into the lagoon, and in time it will be washed on to the western shore of the lagoon, which will then be the sea beach: the beach for miles north of this lagoon is also entirely stripped, so that the soft clay is exposed to the action of the waves, and is being rapidly worn away and formed into a cliff by the part from high to low water being scoured away. This damage may extend as far north as the Rangitata, as the Opihi brings very little shingle to protect the beach, and the extent of damage to the shore cannot be foreseen.

We were informed that there was a feeling with some of the members of the Harbour Board, and with the public, that if the south breakwater were extended from its present end, and in the direction of the straight out kant, it would give sufficient protection from the encroaching shingle, and afford an opportunity to enlarge the harbour in the future. Mr. O'Connor's report shows that on economic grounds it would not be advisable to thus extend the breakwater, and he has shown reasons against attempting to retain the shingle to the south of the work for fear of shoaling the water in the offing. We think, in addition to these considerations, that there is little practical use in looking forward to a future extension of the harbour for the following reasons: The water in the offing is too shallow to permit of Timaru becoming a safe place of call for very large steamers; there is only 27ft. of water at 3,000ft. out, and a ship was recently lost by grounding on her anchor in the roadstead; whenever the sea is rough it breaks nearly a mile from shore, and at such times a large steamer would not dare to approach the harbour, but must wait on the weather and the tide.

It seems to us that to extend the breakwater with the object of getting into water deep enough to obviate the above objections would be a gigantic work, but if the object aimed at were merely to ensure a future enlargement of the harbour to accommodate a growing traffic, it does not appear to us that there are any grounds for this projected enlargement.

When the present harbour is fully made use of by extending the wharfage, as shown in the plan herewith, it will be capable of holding six large steamers and four sailing ships, or coasting steamers, and it will have an annual tonnage capacity of 807,000 tons. The tonnage at present is 140,000, so that the harbour as it is can accommodate five times the present tonnage. The tonnage of Lyttelton is about 650,000, so that the present harbour of Timaru is capable of doing more shipping business than is now done by Lyttelton. We think, therefore, that there is ample capacity in the harbour of Timaru for any increase of business that can be reasonably foreseen.

From the above considerations, we are of the same opinion, as Mr. O'Connor has expressed in his alternative No. 2, that means should at once be taken to clear away the same amount of shingle that is calculated to accumulate yearly, and that this should if possible be done by suction-dredge, which from the evidence of Mr. Wellman is much the cheapest way of disposing of it.

We had a long discussion with Mr. Wellman, and criticised as fully as we could his assertions as to the capabilities and advantages of his system of suction-dredging. We think there is sufficient evidence to justify us in recommending the adoption of the plant detailed in Mr. O'Connor's report; that is, a suction hopper-dredge capable of lifting from 1,200 tons of shingle per day; the capacity of the hopper to be 300 tons, on a draught of about 7ft., and a speed of six miles an hour, provided with surface condensing-engines of ample power and all latest improvements.

The capacity of this plant is apparently considerably in excess of the requirements; but, considering that there is some uncertainty as to the amount of dredging that the Board may find it necessary to do, both on the shingle accumulation and the sand in the harbour, and that there is a probability of shoals being formed outside the harbour by contending currents, we think it is advisable that the Board should have ample dredging power at its command. A suction-dredge of the above power, with a hopper-barge of the capacity for 300 tons, will, we think, insure every reasonable chance of being able to deal with all contingencies that may arise.

We annex a sketch-plan of the most suitable method of working this dredging-plant, the suction-pipes being extended from the hopper-dredge to the beach on staging arranged as shown on plan; this would command a length of 700ft. of the beach, and would be sufficient, in our opinion, to prevent any increase in the accumulation of shingle. There are, however, some points in the details of this arrangement which can only be decided by actual experience, the principal of which is in the effect of dredging a large basin or hole in the shingle at the water edge, and the manner in which the waves will re-fill such an excavation; in other words, in what manner will the sea "feed" a stationary dredge; and, if not satisfactory, then what amount of travel in the suction-pipes is it necessary to provide for daily or weekly? Your engineer, Mr. Marchant, as well as Mr. Wellman, concur in the necessity for having some experience as to the action of the sea under these circumstances, and we fully agree in the advisability of having some preliminary dredging done before committing the Board to a large expenditure on plant.

The Board has a steam hopper-barge of 100 tons capacity, and a Priestman dredge of the largest size. Mr. Marchant represented that for an expenditure of £300 or £400 he could commence dredging shingle on the beach near the breakwater at the rate of from 300 to 500 tons per day, and at a cost of about 3¾d. per ton dredge and discharge at Dashing Rocks. This is a very reasonable cost; indeed, it is less than we would have thought possible by a Priestman dredge, and we would strongly recommend that dredging by this machine be commenced as soon as possible, and from the observed results the requirements of the suction-dredge can then be more fully determined.

We recommend the Board to instruct the Engineer, Mr. Marchant, to visit the locality where Mr. Wellman is working with his suction-dredge, and inspect its working. We should have expected that there would be excessive wear on the pipes and pump from the friction of the shingle and sand. Mr. Wellman assured us that the wear was trifling, but it would be as well to make sure of this before determining on the adoption of the suction-dredge.

As it is impossible for us to assure the Board that the system of suction-dredge advocated by Mr. Wellman, and recommended by Messrs. O'Connor and Goodall, will work satisfactorily under the peculiar conditions existing at Timaru, we would take the precaution to advise your Board to make such an arrangement with Mr. Wellman that the liability of proving the suitability of his dredge for this kind of work shall rest with him: for this purpose he might arrange to erect the plant and maintain it at work for six months, when, if satisfactory, the Board would take it over; but if not, he should be required to remove it at his own expense, or make such modifications as experience pointed out to be required.

The Board being provided with dredging-plant above indicated, and having to dredge every year the calculated quantity of, say, 120,000 tons of accumulated shingle, will be in no worse position than many important harbours which are only kept open by continual dredging, often of far greater quantities than is calculated as necessary in this case. The breakwater now being constructed at Napier is subject to the same trouble from travelling shingle, and anticipated damage to the coast north of it.

Before this work was commenced, Messrs. C. Napier Bell and D. H. Scott were called to report on the scheme, and pointed out the risks to which the work would be liable from the travelling shingle; on which subject the report (dated the 23rd May, 1884) shows that "all the anticipated effects consequent on the stoppage of the shingle by the construction of the breakwater might be remedied by excavating the shingle which accumulates on the windward side of the breakwater, and transferring it to the exposed part of the coast on the lee side." In the case of Napier the annual cost of thus removing the accumulation was estimated at £4,700 a year, which has not deterred the Napier Harbour Board from undertaking the work.

In order to be able to give an approximate estimate of the cost of the plant and fixed work which would be required to carry out the dredging by suction-dredge, we have, in consultation with Mr. Wellman, prepared a sketch-plan of the staging and other erections to be put up on the beach, from which it appears that the plant, steam screw hopper-barge to carry 300 tons, with suction-dredger, piping and fixed staging on the beach, would cost about £14,800, and the yearly expense of working would be £3,971; half of this cost would be chargeable to dredging shingle, and the other half to whatever other work the dredger should be employed on when not dredging shingle; thus the cost of dredging 120,000 tons of shingle would be about 4d. per ton.

It is possible that when details of construction of plant are drawn out and drawings made for the necessary staging, that your Engineer may be able to see his way to somewhat reduce the estimate of cost here given; and in order that he may fully investigate our figures, we have sent herewith all the details and calculations on which we have founded our estimate of cost.

Your Harbourmaster kindly gave us some particulars respecting the "range," that is, the wave undulation inside the harbour, which is found to be troublesome to vessels moored at the

wharf. Usually there is only an insignificant disturbance, and the Harbourmaster thought that about once a month on an average it was serious; when it is so, vessels have to be removed from the wharf and fastened to buoys in the harbour.

Many otherwise first-class harbours are subject to this trouble, and it often is the case that it cannot be cured. We do not think that it can ever be entirely abolished at Timaru. However, we agree with the suggestion of your Engineer and Harbourmaster that a projecting groin, placed as shown on the plan herewith, will most probably mitigate this cause of annoyance; and by constructing and using the wharf on the opposite side of the harbour the "range" will give very little trouble. On the plan we have indicated a length of 200ft. of loose concrete-blocks thrown into the sea, which would greatly assist in destroying the "range" in the harbour, and would, in addition, have a beneficial effect in placing the entrance in smoother water. This might, however, be extended in the form of the upright-wall of the breakwater as already constructed; but in either case we think the large sum of money it would cost might be more judiciously spent in transferring the wharfage and ships' berths to the opposite side of the harbour, where the "range" will be very little felt.

We beg to be allowed this opportunity of expressing our appreciation of Timaru Harbour as now completed. Apart from the danger to which it is exposed from the travelling shingle, it appeared to us a most commodious and useful little port, the full benefit of which will be apparent when your Board shall have completed all the wharfage for which there is space within the enclosure of the breakwater, and it will then, we think, be suitable and large enough for any traffic which may reasonably be anticipated in the future from the limited district which it is meant to serve. Of course, its prospects depend entirely on your being able to cope successfully with the encroaching shingle, and to this end we may be allowed to urge your best consideration with the least possible delay.

Our thanks are due to your Engineer and Harbourmaster for the willing assistance and information which they were kind enough to give us.

We have, &c.,

ROBERT WILSON, F.R.S.C.E., M.I.C.E.
C. NAPIER BELL, M. Inst. C.E.

The Chairman, Timaru Harbour Board, Timaru.

TIMARU HARBOUR.

Estimate of Time of Working Dredge.

	Days.
One year	365
Less Sundays	52
	313
Less holidays (say)	10
Men's pay for days	303
Machine working	303
Less range days...	24
	279
" time repairing, &c. (say)	19
Working days of machine	260

Cost of Working One Week.

Men—1 captain	£3	12	0	
1 engine-driver	3	0	0	
3 deck hands at 8s.	7	4	0	
1 crane-driver	3	0	0	
2 men on staging	4	16	0	
Cost of labour per week	£21	12	0	× $\frac{303}{6}$
" per year				£1,091 0 0
Cost of machine—Coals, 13 tons at 22/6 per ton...	£14	12	0	
Waste, oil, tallow, &c. (say) ...	3	8	0	
	£18	0	0	× $\frac{260}{6}$ 780 0 0
Total yearly cost...				£1,871 0 0

Cost of Dredging Plant.

Engine and pump	£3,000	0	0
Hopper barge to carry 300 tons, with screw propeller and all fittings	6,500	0	0
Fixed staging to carry crane, travelling pipe, carrier pipe, and wharf carried up on the beach for safety in bad weather ...	7,500	0	0
Contingencies, 10 per cent.	1,700	0	0
Total cost of plant	£18,700	0	0

At first the whole extent of staging will probably not be erected. The first outlay will therefore be—

Barge and pump as above	£9,500	0	0
Fixed staging first required	4,000	0	0
Contingencies, 10 per cent.	1,300	0	0
	£14,800	0	0

The annual cost of working will be—

Interest and depreciation 12½ per cent. on £14,800	£1,850	0	0
Labour, fuel, stores, &c.	1,871	0	0
Putting hopper on slip and cleaning	100	0	0
Repairs, wear of ropes, and other materials	150	0	0
	£3,971	0	0
Total annual cost of working	£3,971	0	0

Time working at shingle removal = ½ total time that $\frac{260}{2}$ = 130 days.
Cost chargeable to same $\frac{3971}{2}$ = £1,985 10s., which on 120,000 tons is, per ton, 4d.

Approximate Cost of Paper.—Preparation, nil; printing (1,500 copies), £10 5s.

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