in cubic feet per minute through a *very wide notch* in a vertical thin plate, when H is the height from the vertex of the notch up to the water level in inches, and when the slopes of the notch are each m horizontal to 1 vertical.

As to the confidence which may be placed in this formula, I think it clear that, for the case in which the notch is so wide, or what is the same, the slopes of its edges are so slight that the water may flow over each infinitely small element of the length of its crest without being sensibly influenced in quantity by lateral contraction arising from the inclination of the edges, the formula may be relied on as having all the accuracy of the Lowell formula from which it has been derived; and I would suppose that when the notch is of such width as to have slopes of about four or five to one, or when it is of any greater width whatever, the deviation from accuracy in consequence of lateral contraction might safely be neglected as being practically unimportant or inappreciable.

This formula for wide notches bears very satisfactorily a comparison with the formulas obtained experimentally for narrower notches, as described in the foregoing report. For slopes of one to one the formula $Q = \cdot 305\ H^{\frac{5}{2}}$, and for slopes of two to one the formula was $Q = \cdot 636\ H^{\frac{5}{2}}$. To compare these with the one now deduced for any very slight slopes, we may express them thus:—

For slopes of 1 to 1 . . . . . $Q = \cdot 305\, m\, H^{\frac{5}{2}}$
And for slopes of 2 to 1 . . . $Q = \cdot 318\, m\, H^{\frac{5}{2}}$
While for any very slight slopes, or for any very wide notches, the formula now deduced from the Lowell one is . . $Q = \cdot 320\, m\, H^{\frac{5}{2}}$

The very slight increase from ·318 to ·320 here shown in passing from the experimental formula for notches with slopes of two to one, to notches wider in any degree—that slight change, too, being in the right direction, as is indicated by the *increase* from ·305 to ·318 in passing from slopes of one to one to slopes of two to one—gives a verification of the concluding remarks in the foregoing report; and this may serve to induce confidence in the application in practice of the formula now offered for wide notches.

Structures in the Sea, without Coffer Dams: with a Description of Works of the New Albert Harbors at Greenock. By D. Miller.

From the London Artizan, May, 1863.

It was stated that the immediate object of this paper was to treat of the various methods of constructing the foundations of quays, walls, piers, or breakwaters, for the formation of docks and harbors in deep water; and to describe works of this kind which have been carried out on principles different to those usually practised, and to point out the further application of those principles to other structures of a similar nature. The plans which had chiefly prevailed were, founding upon piling carried up to about the level of low water, constructing within caissons or coffer-dams, or building under water by means of diving apparatus. Instances of the failure of the first of these methods, which was believed to be inapplicable where there were marine worms, were given. The second was most effectual, but was generally expensive, and often attended with danger. The last was also costly, besides being subject to delay in the progress of the works. In bridge building of late years, the plan of forming enclosures of close piling, of the shape of the pier, and filling in with hydraulic concrete, had been pursued by French engineers; and the substitution of iron for perishable timber piling, in the construction on this plan of the piers of the Chelsea and Westminster bridges, by Mr. Page (M. Inst. C. E.), was considered to be a successful departure from stereotyped rules.

Although the value of beton, or hydraulic concrete, was now appreciated in this country as a substitute for masonry, and had been employed in some important works, yet its use was chiefly confined to forming a homogeneous and monolithic bearing stratum for foundations, and not, properly speaking, as a constructive material. The modes in which concrete had been applied for constructive purposes were, building it dry in mass, and allowing it to set before being placed in the work, as had been adopted in the construction of the walls of the Victoria and of the London Docks; preparing it first in blocks, and allowing it to harden before being used as employed at the Dover breakwater, and for the new sea forts at Portsmouth and Plymouth; and depositing it in a liquid state, and allowing it to set under water, as practised at the Government Graving Docks at Toulon. The facilities for making beton, which had the invaluable property of setting under water, and of thus forming an artificial rock or stone, were very great; as it might be made either from the naturally hydraulic limes, the artificially hydraulic limes, or cement, or from the rich or non-hydraulic limes, rendered hydraulic by the admixture of other substances, such as Puzzolana, minion, or iron mine dust. Various examples were adduced of the application of concrete, on a large scale, prepared from these different materials, especially at the Mole of Algiers, at the breakwater at Marseilles, and at other French ports, as well as in the Pont d'Alma over the Seine, in which case both the arches and the piers were formed of rubble concrete.

As Engineers-in-chief for the new harbor works for the port of Greenock, the author and his partner, Mr. Bell, had an opportunity of introducing a system of constructing sea walls and quays in deep water, without the aid of coffer dams, diving apparatus, or other means equally expensive. These works were situated on the west side of the town, and had been projected almost entirely beyond the high water line into the sea. The outer pier would ultimately be upwards of 3000 ft. in length and about 60 feet wide at the top, with quays on both sides. Within this there would be space for two harbors, each 1000 ft. in length, 15 ft. deep at low water, and 25 ft. at high water, with entrances 100 ft. wide, and ample room for the construction of graving docks, for the storage of timber, and for the erection of sheds. At present it was only proposed to erect about one-half of the sea pier, and to form one harbor or tidal dock. In the design of these works, it was suggested that the walls under low water should consist of a combination of cast iron guide piles in the front, with a continuous stone facing, slid down over and enclosing these piles, timber-bearing piles being used in the body of the walls where required, and concrete backing being deposited in a soft state; and that the upper part of the walls should be built of masonry in the usual manner. The first operation, when the water was not sufficiently deep, was to dredge two parallel trenches to the required depth, 17 feet below low water, for the foundations. A staging of timber piles was afterwards erected in the line of the pier over its whole breadth, for carrying the tramways traveling cranes, and piling engines. The cast iron guide piles were then driven from the staging, with great precision, 7 feet apart in the line of the face of each quay wall. These piles were driven until their heads were near to the low water line, by pile engines, furnished with long arms projecting downwards, strongly stayed by diagonals, and forming a trough, into which the pile was placed, and from which it was shot, like an arrow from a cross-bow. The piles were connected at the top transversely by wrought iron tie-rods stretching through the pier. When the piling was driven, a bed of hydraulic concrete, 3 feet thick and 20 feet wide, was deposited in the trenches to form a base for the wall, and to give a large bearing surface. Into the grooves formed by the flanches of the iron piles, large granite slabs from the Ross of Mull, from 18 inches to 2 feet thick, were slipped, the bottom one resting on the concrete base, and on a projecting web cast on the piles. This constituted the face of the wall, and in each compartment between the piles, 16 feet in height and 7 feet in width, there were only three stones. Behind this facing hydraulic concrete was lowered, under low water, in large boxes having movable bottoms, and was discharged in mass to form the body of the wall. To confine this at the back before it had set, loose rubble stones were deposited. The hearting of the pier consisted of hard till, stones, and granite up to the level of low water. When the whole of this mass was consolidated, the heads of the iron piles and the granite facing blocks were capped by a granite blocking or string-course, and the upper portion of the walls was built in freestone ashlar and rubble. The remainder of the hearting between the walls was then filled in, and the whole finished with a granite coping and causeway. The walls were 33 feet in height from the foundations, 11½ feet thick at the concrete base, diminished by 5 feet at the top. In the part of the work already executed, the outer flanch of the iron piles was exposed to the action of the salt water. In future it was intended to reverse this plan, and to make grooves in the stone facing, so that it should overlap the iron piles, filling in the grooves from the top with cement. When the whole extent of the seaward pier was completed, the interior operations for the harbor would be proceeded with; this pier serving as the principal coffer dam, and a short dam, about 100 ft. in length, closing the entrance. It was stated that this method of constructing walls in deep water without coffer dams had been most successful, and that a sea-pier of great solidity and durability had been formed in deep water at a comparatively moderate cost. The works of the Albert Harbor were being executed under the superintendence of Mr. John Thompson, as resident engineer, by Messrs. W. & J. York, contractors.

The application of this system to the construction of breakwaters and harbors of refuge, was then noticed, reference being first made to the principal modes of construction hitherto adopted, and to the peculiar phenomena by which such structures were affected. The usual method of forming breakwaters was by the *pierre perdu*, or long slope system, as carried out at Plymouth, Cherbourg, and Holyhead. Where stone was most abundant, a vertical wall was built from the bottom by means of diving apparatus, of which the breakwater at Dover, now in course of construction, was the most prominent example. Besides these systems, which might be taken as the extremes, an intermediate form of section, combining both, that was to say, a rubble mound to a certain depth under low water, and a vertical wall above, had been carried out at Alderney. From an examination of the general principles which affected breakwaters, and the modes of construction usually adopted, the conclusion arrived at was, that the vertical system was that which had best resisted, or rather averted, the destructive action of the sea, and required the smallest amount of material. Both the long-slope and the vertical systems, as at present carried out, were expensive, from the quantity of material used in the one case, and the costliness of the material and the mode of construction in the other; the former might be characterized as involving the maximum in quantity, and the minimum in cost of material; the latter, on the contrary, the minimum in quantity, and the maximum in cost of material. The object sought to be attained in the new system was to effect a minimum, as far as possible, both in the quantity and in the cost of the material. Breakwaters might be thus constructed, either wholly vertical from the bottom, or partially vertical, springing from a rubble mound. The principal feature of the new plan was a framework of iron piles, or standards, and ties, which would serve during the construction as the staging, and would afterwards form an essential portion of the structure, by binding together a strong casing of stone, or other sufficiently durable material, which would enclose and form the facing of the breakwater, the interior being filled up with loose rubble, cemented into a solid mass by liquid concrete. As soon as a pair of piles transversely had been fixed, rubble would be deposited up to, say, 18 feet under low water. Strong casing blocks, either of stone or of *beton*, made to enclose the iron standards, would then be lowered, the blocks being locked or arched into each other, so as to resist pressure from behind, and made to break bond, if thought desirable. The hearting of the work would be proceeded with simultaneously with the building of the casing, and would consist of rubble in the centre, and of hydraulic concrete behind the stone casing. It was believed that such a structure could be erected in a depth of 6 fathoms, with a range of tide of 15 feet, for £190 per lineal yard, without a parapet, and at £200 per lineal yard, including a parapet. The economy of this system would arise from the smallness in quantity and the cheapness of the bulk of the material. It would also possess the advantage of rapid execution, as the mass of the material could be deposited without any tedious operation being necessary over a great length of the work at one time.

The author was of opinion that the system which had been described admitted of being applied for the construction of the works under low water, of marine fortifications, as well as of breakwaters, piers, quay-walls, lighthouses, and other similar structures. He considered that, although the mode of constructing an engineering work must be determined greatly by local circumstances, this system presented the following advantages: great economy, combined with strength and durability; facility and rapidity of execution; and adaptability to situations where the present modes of construction would be inapplicable.

MECHANICS, PHYSICS, AND CHEMISTRY.

For the Journal of the Franklin Institute.

Notes of Shipbuilding and the Construction of Machinery in New York and vicinity.

(Continued from p. 348.)

The Steamer George Washington.—Hull built by Roosevelt, Joyce & Co., New York. Machinery constructed by Pusey, Jones & Co., Wilmington, Delaware. Route of service, New York to New Orleans. Owners, H. B. Cromwell & Co., New York.

Hull.—Length on deck, 180 ft. Breadth of beam, 39 ft. Depth of hold, 11 ft. Do. to spar-deck, 18 ft. 6 ins. Draft of water, 15 ft. 6 ins. Frames—molded, 13 ins.—sided, 7 ins.—apart at centres, 24 ins. Rig, brig. Tonnage, 1256 tons.

Engines.—Vertical direct. Diameter of cylinders, 45 ins. Length of stroke of piston, 4 ft. 6 ins.

Boilers.—One—tubular—located in hold; does not use blowers. Has water bottom.

Propeller.—Diameter, 13 ft. 6 ins. Pitch, 19 ft. Blades, 4. Material, cast iron.

Remarks.—This vessel is constructed of white oak, chestnut, &c., and square fastened with copper and treenails. Around her frames, which are filled in solid, iron straps, double and diagonally laid, 3½ by ⅝ inches, extends, making them very secure. There is also a head strap of iron of the same dimensions placed around the head of frames. Under both decks knees are placed; her bunkers are of wood, and she has water-ways on both decks. She is supplied with one independent steam fire and bilge pump, and fitted with bilge injections and bottom valves. She has an independent rudder post, and cabin on deck. The whole construction of the *George Washington* is highly creditable to the skill of Messrs. Roosevelt, Joyce & Co., and gives great satisfaction to her owners.

The Steamer Mary Powell.—Hull built by B. C. Terry, Keyport, N. J. Machinery constructed by Fletcher, Harrison & Co., N.Y. Route of service, New York to Newburgh. Owners, A. L. Anderson & Co.