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“On the New Steel Dock Gates of Limerick Floating-Dock.”

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In this communication the Author submits a detailed description of the new steel cellular gates which have been fixed in the entrance to the floating-dock at Limerick.

The old gates were designed and constructed in 1852, by the late Mr. Robert Mallet, M. Inst. C.E., and were almost identical in form with those of the Dublin Graving Dock, erected about six years later, with the exception that they were somewhat larger, each gate measuring, from the centre of hinge pintle to the intersection of the axes of the gates at the mitre-posts, 42 feet 7 inches, the height being 25 feet 6 inches, and the width 3 feet. They were of wrought-iron, the inside and outside plating being parallel except at the mitre- and heel-posts, towards which the inside plating curved. On the dock-face the plates were vertical, while those on the outside, or river-face, were horizontal, all being butt-jointed with cover-plates. The horizontal joints were made at the cell floors. Each gate was divided into twelve horizontal cells, running the entire length, the upper compartment being 3 feet high, while all the others were 2 feet each. The water was excluded from the four lower cells, but was allowed free access to the upper cells through a valve in the river-face of the fifth cell, and thence through manholes placed about the centre of the floors. Each gate worked on a bottom pintle, and rested at its outer end on a roller working on a segmental traverse-plate fixed in the floor of the gate-chamber in the entrance. The upper hinge anchor was merely for the purpose of keeping the gate upright. The foot-roller was seated in a carriage hinged on at one end, and held at the other by a vertical rod controlled from the top of the gate. The gates were worked by crab-winches, placed one on the gangway of each gate, the chain for opening and closing being carried round the barrel in opposite directions, and the ends passing down the sides of the gate, through guide-rollers to ring-bolts leaded into the ashlar masonry of the entrance.

The entrance to the dock is 70 feet wide. The depth of water on the sill is 4 feet 3 inches at low-water, and 23 feet 6 inches at high-water of ordinary spring-tides. The versed sine of the gates is about one-fourth of the span. The construction and erection, so far as the Author can learn, cost something over £5,230. Each gate weighed approximately 51 tons.

About the year 1867 the bottom plates were unaccountably injured; the air-cells filled with water, which it was found impossible to eject, as no provision had been left for pumping. The result was a total loss of buoyancy, the whole weight of the gates being thrown on the bottom pintles and rollers.

Temporary repairs to the damaged plates were effected by divers, and sluice-doors were placed over the inlets on the river-face, so that the effect contemplated by the designer was reversed, the air-cells and water-cells changing their functions. This arrangement was partly successful, but had the disadvantage of imparting such an excess of buoyancy to the gates that during rough weather at spring-tides they were nearly floated off the hinges, whilst at neaps as many as twelve men were often required to move them. The state of things was becoming worse, for the roller-carriages became disabled under the undue stress, causing the gates frequently to jamb in closing, allowing the water to leave the dock. From examinations made internally and externally, it was calculated that to thoroughly repair the gates would cost about £1,100. For this purpose it would have been necessary to remove them to the graving-dock, and to substitute for them a pair of temporary timber gates, at a further cost of £1,763. Under the circumstances, the Author decided on constructing a new pair of gates, built somewhat on the lines of the old ones, but with the following important modifications:—1st. The number of cells was reduced from twelve to ten, varying in height from 2 feet at the bottom to 3 feet at the top. 2nd. The number of air-cells was increased from four to five, and direct communication made with them from the deck by a central trunk or shaft, the tidal water being allowed to enter the five upper cells at each side. The intercostal sides of this shaft also served as vertical stays. 3rd. The toe-roller was done away with, and the gate supported by the upper hinge. 4th. The chains were conveyed along the deck to gearing on shore, worked by hydraulic power, or by a capstan, at will.

Should a leak unfortunately occur in any part, the particular cell can be at once isolated, and a sufficient quantity of water excluded from the upper cells to balance the loss of buoyancy caused by the leak. It is calculated that the weight on the upper hinge does not

at any time exceed $1\frac{3}{4}$ ton, while that on the pintle may be set down as not exceeding $2\frac{3}{4}$ tons. Each gate can be easily worked by one man.

The following detailed account of the construction will best convey an idea of the work. The plates, angles, and rivets are of Siemens-Martin mild steel. The hinges, top and bottom, are of cast-iron. Each gate consists of ten tiers of cells on each side of a central passage or trunk, making twenty cells in all. The lower divisions are water-tight one with another, and each is connected to the central trunk by manholes and drainage holes. The inside shell consists of eight strakes of flat plates and one strake of bilge-plates, forming the bottom, each strake being formed of four plates, varying from $\frac{1}{2}$ inch to $\frac{3}{8}$ inch in thickness. The outside surface of the gates consists of eight flat strakes, each being formed of three plates.

The butts and seams are single-riveted, except when connected to fender angle-bars, when they are double-riveted; when connected to angle-bars joining the top and end plates they are riveted zigzag.

The floors of the cells consist of shell-plates single-riveted and lap-jointed, those of the lower five compartments being $\frac{7}{16}$ inch thick, of the upper four $\frac{5}{16}$ inch thick. The top of the gates has one plate, next the hinge, $\frac{5}{16}$ inch thick; the next $\frac{7}{16}$ inch thick, and the outer plate $\frac{5}{16}$ inch thick. Care was taken that they broke joint by at least 15 inches one over the other. The top plating is riveted zigzag to the side and end angle-bars. All joints of the angle-bars were made good with doubling-pieces 18 inches long.

The intercostals are arranged for stiffening the construction vertically, and to form a water-tight trunk or passage-way for access to the cells, which are provided with manholes into each, all of which are in duplicate, so that the doors are transferable. The intercostals on the side of the trunk-way are perfectly water-tight. Limber-holes 1 inch in diameter are provided through all the intercostals within the cells. The thickness of the plates in the bottom cells is $\frac{1}{2}$ -inch, and the angles are 3 inches by 3 inches by $\frac{5}{16}$ inch. From the second to the fifth cells the plates are $\frac{7}{16}$ inch thick, and the angles 3 inches by 3 inches by $\frac{5}{16}$ inch; from the sixth to the tenth cells the plates are $\frac{5}{16}$ inch thick, and the angles 3 inches by 3 inches by $\frac{7}{16}$ inch. The intercostal angle-bars have welded or doubled corners and are single-riveted. The end plates are $\frac{5}{16}$ inch thick, in two lengths, and are double-riveted to fender angle-bars, zigzag riveted to corner angle-bars,

and with double-riveted butt-joints, having straps $\frac{8}{16}$ inch thick. The angle-bars for securing wood fender-pieces are $4\frac{1}{2}$ inches by $4\frac{1}{2}$ inches by $\frac{1}{16}$ inch, with the corners welded, the joints being made good with doubling-pieces not less than 18 inches long. Liners were used where the angle-bars passed over laps of the plating. No liner was shorter than would take four rivets.

The riveting throughout is $2\frac{1}{2}$ -inch pitch by $\frac{3}{4}$ -inch diameter, except that for fender angle-bars which is $2\frac{3}{4}$ -inch pitch, with $\frac{7}{8}$ -inch rivets, all having cheese heads and taper necks. All external work is countersunk for the full thickness of the plate.

After the mountings had been connected, each of the lower cells was tested separately with a water pressure of 12 lbs. per square inch, and made perfectly tight, after which all the lower cells, including the trunk, were tested together to 6 lbs. on the square inch; and lastly, the top cells to 6 lbs. per square inch, the testing being continued till all parts were perfectly tight. The scale and rust were now removed, and pure Portland cement-wash was run into all the seams and joints of the cells, the utmost care being taken that it penetrated everywhere. When this was thoroughly set, the corners where floors and shell meet were covered with pure Portland cement and sharp river sand in equal proportions. Subsequently, the whole interior received two coats of pure Portland cement-wash. Externally, the whole of the ironwork received four coats of paint, consisting of best white and red lead mixed in equal parts with boiled linseed oil, all rust blisters and flakes being carefully removed by pumice stoning after each operation, and finally a coat of black varnish was laid over all.

The top and bottom hinges are of cast-iron. All bolt-holes were drilled through the iron first, and then, with the hinge temporarily bolted to the gate, the holes were bored through the plating with a parallel drill. The castings were finally secured in their places with bolts having hexagonal heads and nuts. The lower hinge is formed with a socket having a cast-iron liner, to make up for wear on the pintle. Three disks for each gate, of different thicknesses, were provided for the points of the pintles to bear against, so that the height of the gate could be adjusted. The top hinge carries the guide-rollers for the working chains. The rollers above water-line are bushed with brass, and all have steel pins. The anchors had new caps fitted, secured by bolts. The anchor-bolts were carried back 30 feet, and divided into two parts 21 feet and 9 feet respectively, hinged at their junctions, where a saddle of cast-iron was inserted; the longer piece was carried diagonally to the anchor-washer 7 feet below the surface of the ground.

The space between the anchor-plates and the inside of the quay wall was filled in with solid concrete masonry for the full depth of the washers. The concrete consisted of 5 parts of broken stone, 2 parts of sand and 1 part of Portland cement. The gangways were made with red pine $1\frac{1}{2}$ inch thick, 6 inches wide, and laid $\frac{1}{4}$ -inch apart. The working chains are of the best short-link pitch-chain, made of $\frac{3}{4}$ -inch iron, having one shackle at each end and two shackles in the middle of each length, together with two swivels. The sluice-valves are fitted at each side of the trunk on the river face, 3 inches above the floor in the sixth cell from the bottom, and are 4 inches clear in inlet, with a guard-plate; the valves, facings, screws, and nuts, are of brass. The valve-rods are worked by handles from the top of the gate, and placed one on each side of the central trunk. Air-pipes and 3-inch bore drain-pipes of wrought-iron are fitted two to each gate. The nozzles of the air-pipes have brass caps, secured with jack chains, and with screw holes and plugs to suit the union of the diver's hose, for the purpose of ventilating the cell during the periodical examination. A brass pump is supplied which fits in any of these pipes. Six steel manhole doors are provided for each gate. The manways into the upper side cells have a combing formed of angle-iron welded and riveted on the top plate, and a light dished cast-iron cover. A drain leads into the lowest point of each of the lower cells opening into the central trunk. Two eye-plates and rings are riveted on the top, and at 3 feet from the bottom on each side of the gate, as stand-by gear for opening and closing them, in case of derangement of the machinery on shore. The side fenders are of Rangoon teak, and the sill fenders of pitch-pine; all are secured by screw-bolts spaced 18 inches apart, put in while hot after having been dipped in pitch. All the fenders were carefully fitted with scarfed joints and bedded in thick red and white lead paint. The joints between timber and iron were caulked with three strands of oakum well payed with pitch. The supporting gear is fitted to act as a slide in the same manner as the bottom roller of the old gate, in case of accident to the hinge covers, and is formed of wrought-iron, the rod being well stayed and carried up to the level of the top of the gate.

The gates are worked from the shore by capstans; the gearing being enclosed in a water-tight cast-iron tank. The capstans can be worked by hand or by hydraulic power, and can also be used for wharfing by disconnecting them from the gate machinery.

Owing to the peculiar construction of the heel-post, the hinges were not made to fit accurately, lest at any time the heel-post

should come to a bearing before the sill and the mitre, or meeting-posts, thereby subjecting the hinges to severe stress as the tide fell and the pressure increased on the back of the gate; for this purpose and to avoid risk, a fair amount of play all round was left, namely, $\frac{7}{8}$ -inch on the bottom hinge, and $\frac{1}{8}$ -inch on the top hinge, thus allowing the gate to adjust itself.

The old gates were removed in the following manner:—Being water-logged, and so far injured in their lower compartments that they could not be floated by pumping, they were raised by passing timber beams through holes cut for the purpose, and placing barges, one on each side, which lifted with the tide. They were then removed to the graving-dock, where they were subsequently broken up. As each gate was thus removed, the new one was floated into position. With 20 feet of water on the sill of the gates, there are 20 feet of water over the blocks of the dry-dock. It was necessary so to ballast the new gates that they should float level and upright, and for this purpose two bottom compartments were filled with water, which was pumped out after fixing. On the removal of each old gate the divers ascertained the condition of the pintle. Both pintles were fortunately in good order and very little the worse for wear. On the first trial for fitting it was found that some irregularities in the sill caused a leak at the bottom of the gates. Each gate was again floated, and the defects were made good in one tide. They were then permanently fixed and now fit perfectly, except when some sunken chips happen to lodge between the meeting-posts, or between the fenders and the sill or abutments. The effect is, however, insignificant. The capstans, leads, &c., were first placed in position, and the chains made ready for use, so that the gates were worked without delay.

The hydraulic gear consists of one of John Ramsbottom's hydraulic three-cylinder engines to each capstan. The cylinders are 4 inches in diameter by 9 inches stroke. The engines are coupled to the capstan spindles with cast-iron bevel-wheel and steel pinion. All levers and wheels are kept under ground level when the handles are removed, and all openings are fitted with hinge-doors.

Considerable difficulty was experienced in making and verifying the measurements below low-water level, owing to the muddy condition of the water, but all fortunately turned out to be correct. The dock was worked during the whole time.

The total cost of the gates, including accessories, was £2,750 10s. or at the rate of £1 5s. 4d. per square foot of gate area. The cost

per square foot of the entrance was about £1 10s. 9d. The quantities of material were:—

	Tons.	cwt.	qrs.	lbs.
Steel plates, angles, and rivets . . .	79	9	3	24
Mountings	6	19	2	7
Teak fenders.	3	9	3	8
Bolts for the same, &c.		2	1	0
Chains	1	3	2	0
Pine gangways		19	3	0
Portland cement	2	17	0	0

The following were the test results:—

	Dimensions.			Breaking-strain.		Elongation.	
	Breadth.	Thickness.	Area.	On Piece.	Per Square Inch.	On 8 inches.	
	Inch.	Inch.	Square Inch.	Tons.	Tons.	Per cent.	
Plates	1·27	0·42	0·533	16·0	30·00	27·0	Max.
(33 Tests)	1·25	0·52	0·662	17·8	26·80	26·0	Min.
	1·25	0·35	0·437	12·4	28·30	25·0	Average.
Angles	1·20	0·52	0·624	19·5	31·20	27·0	Max.
(13 Tests)	1·20	0·49	0·588	16·7	28·20	24·5	Min.
	1·20	0·47	0·564	16·8	29·70	24·0	Average.
Rivets.	..	..	0·196	..	30·99	60·7	Average.

The Contractors were Messrs. Kincaid and Co., of the Clyde Foundry, Greenock.