

11TH MAY, 1899.

RECENT IMPROVEMENTS TO MORT'S
GRAVING DOCK, BALMAIN,

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Over forty years have passed since Mort's Graving Dock was constructed; since then it has gone through many developments to suit the requirements of the shipping industry of the port of Sydney. The little primitive dock of forty years ago, with its few sheds and machines, has developed into a large dock, and perhaps the largest and best equipped engineering establishment in the Southern Hemisphere for its particular purpose, viz., the repairing of ships.

He had no intention of giving the history of the dock from the days when a 500 ton sailing vessel was considered a large ship, and the ocean liners were about the size of our present intercolonial steamers to the present time when 3,000 ton sailers and 10,000 ton steamers were ordinary visitors to our port, but he wished to describe the latest development of Mort's Graving Dock.

The shipping industry of Sydney had been steadily increasing both as regards tonnage and the size of vessels, and during the wool season the docking business was gradually getting into a somewhat congested condition. The Mort's Dock and Engineering

Co., Ltd., during the past few years had been lengthening and improving the dock to suit the increased size of vessels, but this did not help much during the wool season when the number of vessels, not their size had to be considered, they therefore about two years ago decided to lengthen their dock so as to be enabled to dock two vessels at once. This had now been accomplished and been working successfully during the past twelve months.

Five years ago the dock was 410 feet long, and the depth of the floor below the sill was 2 feet. The accompanying plan, Plate III., showed the dock in its present condition. The dock is now 640 feet long, and the depth of the floor below the sill is 4 feet 6 inches. There are three cheeks or fits for an intermediate caisson, so that if the full length of the dock was not required the caisson could be put in either of the fits and save pumping, or a vessel could be docked at the upper end for repairs and still leave the lower portion of the dock free for the ordinary run of work.

Communication tunnels fitted with sluice valves passed behind the caisson fits for flooding the upper portions of the dock or for drainage purposes. At the upper end of the dock an additional drainage pump had been erected in order to pump out any leakage that might pass the intermediate caisson when in any of its positions.

When the Caisson was in the upper or No. 1 fit there was a clear space at the upper end of 200 ft., this would be suitable for small vessels but was principally intended for reducing pumping, and left the dock 424 ft. long at the lower or entrance end. No. 2 fit made the upper dock 320 ft. long and was suitable for any Intercolonial Steamer leaving the lower dock 304 ft. long. No. 3 fit made the upper dock 360 ft. long and was suitable for all the American

Mail Boats, except the "Aorangi" and left the lower dock 264 ft. long.

The dock floor was originally 2 ft. below the sill, this had now been deepened to 4 ft. 6 in., which allowed the keel blocks to be kept at a good working height and still be below the sill level, thereby giving all the advantage of the water on the dock sill for floating in deep vessels.

As the dock was originally only a small one, its position although suitable enough for small ships, made it rather inconvenient for large vessels, but this had now been largely obviated by cutting away a corner of the Entrance Pier so that vessels up to 430 ft. keel could now be floated in without trouble. The cutting away of masonry and rock was done by boring holes with a steam drill and splitting off by means of plugs and feathers. The cleared space for the new wall was filled up with blue metal concrete to low water level and above that with heavy free-stone masonry.

The caisson fits were made exactly to the same form and dimensions except in height as the fit for the entrance caisson, in order that the intermediate caisson could be used in the entrance should the main caisson require repairs or overhauling. These fits were partly cut out of the solid rock and partly built up of heavy masonry where the rock had been previously excavated. This masonry was checked 21 inches into the solid rock and grouted up solid with Portland Cement. The meeting faces were made of Iron-bark securely bolted to the rock and masonry and grouted up with Portland Cement.

The Pumping Plant had been increased by a 20 inch centrifugal pump driven by a pair of high pressure engines. The pumping installation (having a 5000 gallon Gywnne Pump in reserve) was capable of

emptying the dock, without a ship, in 4 hours, this it was found was quite quick enough to ensure the vessels being thoroughly scraped and cleaned.

The whole of this work had to be done without any stoppage to the working of the dock was successfully carried out without an accident.

The caisson for dividing the dock into two portions is of the floating or ship kind, but the arrangements for sinking or raising are different from any caisson in Australia. It had been suggested to him, that, as caissons are seldom built here, and that consequently some of our members had not had the opportunity of making themselves conversant with their working, that he would, previous to describing this new caisson, describe the methods generally adopted for sinking and raising floating caissons, in order to better appreciate the advantages of this new arrangement, he had, therefore, prepared some diagrams to illustrate some of the different methods in common use.

Fig. 1 Plate IV. showed a longitudinal section of one of the most primitive caissons. It would be observed it was simply a plain ship loaded with ballast to the required depth suitable for the depth of water on the dock sill. To sink this caisson a sea valve was opened and the water was thus allowed to flow inside and fill the caisson which of course then sank. To raise the caisson the water in the inside was emptied into the dock, the dock was then flooded and when there was sufficient water the caisson would float. In using this kind of caisson the dock could only be flooded at low water for the caisson to act properly without being pumped out, but if it was desired to flood the dock after low water a certain amount of water must be left inside the caisson to keep it down otherwise it would jump and cause a sudden inrush

of water into the dock which might cause serious damage. The amount of water required to be left inside depended upon the height of the tide, but as this amount had to be settled on perhaps two hours previous to the time when the caisson was required to float the amount of water left in was dependent entirely on the judgment of the Dockmaster as to the height the tide would be at a given time. If too much water had been run out the caisson would jump, but if on the other hand, too much water had been left in, the caisson would not float and consequently had to be pumped out, generally the Dockmaster erred on the right side and pumped the caisson out, as in fact he had to do that in any case either at the time of flooding or afterwards. The weakness of this system was.

- (a) The dock could only be flooded at low water for the caisson to act properly without pumping.
- (b) The great loss of time caused by having to pump the caisson out.

A caisson of this type is in use at Fitzroy Dock.

Fig. 2 Plate IV. showed a longitudinal section of a caisson a stage in advance of the previous example, in this case it would be seen that there was a lower deck or what was called the water deck, ballast was placed in the lower compartment until the caisson floated at a suitable draught of water. To sink the caisson the water was allowed to flow into the lower compartment until the water deck was under sea level when the water was allowed to flow into the upper compartment to complete the immersion. The upper compartment valves on the sea side were sometimes kept open so that the tide rose and fell inside this portion of the caisson, but generally the valves were shut at high water. To raise the caisson the water in the lower compartment was run into the dock previous to

it being flooded. When the dock was flooded the upper compartment valves were opened and the water allowed to flow out, the caisson would then float and as the water continued discharging the caisson would continue rising until the whole of the upper compartment water was discharged. This caisson like Fig. 1 acted best when the dock was flooded at low water but it had this advantage that owing to the upper compartment water being above sea level the lower compartment could be emptied up to about half tide, but if the flooding had to be done after that some of the water would require to be left in the bottom compartment and pumped out afterwards in which case the remarks applied to Fig. 1 had equal force. A caisson of this kind is in use at Mort's Dock.

Fig. 3 Plate IV. showed a longitudinal section of a caisson a stage in advance of Fig. 2. In this caisson there were three decks, the pumps being worked from the middle deck, leaving the upper or roadway deck perfectly clear and free for traffic. The system of sinking and raising was the same as Fig. 2. This type of caisson was in very common use and was the style adopted at the Lyttleton Dock, New Zealand.

Fig. 4 Plate IV showed a longitudinal section of a still later type of caisson, it is divided into three main compartments and in addition had also a water ballast tank placed under the upper or roadway deck. The caisson was ballasted by water and generally some other heavy ballast in the lower compartment so that it floated at about 3 inches below the second deck level. To sink the caisson water was pumped into the upper water ballast tank which was so proportioned that the caisson would then float with its second deck a few inches under water. To complete the immersion, water was allowed to flow from the sea into the upper compartment when the caisson sunk

as the water flowed in. To raise the caisson the upper water ballast tank was emptied and the caisson would then float, raising the water in the upper compartment a few inches above sea level. The valves connecting this compartment with the sea were then opened when the water would flow out and as the water flowed out the caisson would keep rising until the compartment was empty and the caisson again floating at her light draught viz., 3 inches below the upper water deck. This kind of caisson could be used at any state of the tide, the weakness of the system being in having to pump the water for the upper ballast tank to commence the immersion, and the raising of the centre of gravity unduly, making caissons of this description rather unstable. A caisson of this class is used at the Williamstown Dock, Melbourne.

Fig. 5 Plate IV show a longitudinal section of the new intermediate caisson now in use at Mort's Dock and Fig. 6 is a transverse section. This caisson like that shown by Fig. 2 Plate IV is divided into two main compartments but has in addition a water ballast tank or buoyancy chamber placed under the water deck. The upper compartment is subdivided into four divisions by means of one longitudinal and one transverse bulkhead and each of these divisions is connected to the sea by an independent valve, by this means there is an absolute control of the water inside the caisson either in sinking or raising. The buoyancy chamber is connected to the sea by two valves, one on each side, the caisson is ballasted by heavy ballast in the lower compartment and floats with the water deck 3 inches above sea level. To sink the caisson the water is allowed to flow into the buoyancy chamber which contains 940 cubic feet, this has the effect of sinking the caisson until the water deck is $10\frac{7}{8}$ inch under water. The upper compartment valves are then

opened and the water flowing in completed the immersion. The inflowing water rises more rapidly inside than the caisson sinks owing to the space taken up by the structure, so that when the caisson touches bottom the water is only $5\frac{3}{4}$ inches below sea level, and the extra water runs in after bottom is touched is simply extra weight to keep the caisson down. To raise the caisson the water in the buoyancy chamber is run into the dock previous to flooding and this allows it when the dock is flooded to float sufficiently high to raise the water in the upper compartment $8\frac{1}{2}$ inches above sea level, the sea valves are then opened and the water flows out, and as the caisson is being relieved of its load keep rising, it virtually pumps itself out until the whole of the water is discharged when it will again be floating at its light draught viz., 3 inches below the water deck. The advantages of this system are—(1) The caisson can be floated out at any state of the tide, (2) There is no pumping required and (3) its action is absolutely certain, nothing being left to the judgment of the Dockmaster.

The time required to sink or raise the caisson depends on the state of the tide and varies from 3 to 7 minutes. The caisson illustrated by Fig. 2 required 30 minutes to sink.

Having now, he hoped, made himself clearly understood as to the manner in which this caisson is worked he would endeavour to describe its construction.

From the diagrams Plate V. it would be seen that the caisson is practically made in two portions, the lower portion up to the water deck being what might be termed the ship or floating part, and the upper or water ballast chamber, the superstructure. Generally caissons are built in a dock and floated when finished, as owing to their extreme proportions and

great weight (caissons having to be ballasted previous to floating to give them stability) would render it very risky to attempt to launch them like a ship. As this caisson had to be built at Mort's Shipbuilding Yard and launched, it was built up to the water deck only previous to launching, afterwards building the superstructure when afloat adding ballast as required to balance the top weight.

There was no difficulty in launching when built in this way as she was merely a punt about 65 ft. long by 16 ft. beam by 15 ft. deep. It was also cheaper to build in this way as the vessel was hauled along side of the Boilershop Wharf where cranes could be utilised in building the superstructure instead of having to heave all the material up from the yard by means of derricks, besides saving the time of the men in climbing up the gangways.

The caisson is built entirely of iron except the roadway deck which is of kauri pine. The length over the plates at the top is 68 ft. $10\frac{3}{4}$ inches and 49 ft 0 inches at the bottom and the depth from the top of upper deck beams to underside of keel plates is 28 ft. 9 inches, the beam at the water deck is 16 feet and at the upper or roadway deck 12 ft. the overall length is 71 feet $6\frac{3}{4}$ inches, and the total height 30 feet $3\frac{1}{2}$ inches. The lower portion is built somewhat after the style of a plate keel ship having three tiers of beams. The frames, which are spaced 21 ft. apart and 5 inches x 3 and a-half inches x $\frac{1}{2}$ -inch angle iron extending from the intercostals to the water deck beams. The floors run right across, and are 27in. deep by $\frac{1}{2}$ in. thick, having double reverse bars of $3\frac{1}{2}$ inches x $3\frac{1}{2}$ x $\frac{1}{2}$ inch angle iron. An internal stem is fitted at each end, forming a continuation of the intercostals 21 in. x $\frac{1}{2}$ in. These are fastened to the skin and floors by double angles 5 in. x $3\frac{1}{2}$ in. x $\frac{1}{2}$ in. The intercos-

tals and stems are all fastened together by double angles 4 in. x 4 in. x $\frac{1}{2}$ in., riveted to the intercostals, floor reverse bars and stems extending up to the water deck. There are eight frames in each end of 5 in. x $3\frac{1}{2}$ in. x $\frac{1}{2}$ in. angle iron kneed to fit and floors and stiffened by $\frac{1}{2}$ in. gussets. The corner angles are 5 in. x 5 in. x $\frac{1}{2}$ in. The water deck beams are 8 in. x $6\frac{1}{4}$ in. x 9-16 in. T bulb. The lower beams are 7 in. x $3\frac{3}{4}$ x $\frac{1}{2}$ in. bulb angle. All the beams are fastened to the frames by 27 in. x 24 in. x $\frac{1}{2}$ in. gussets. There are three sets of stringers extending right round the vessel 27 in. x $\frac{1}{2}$ in., diminished at the ends to 18 in. These are fastened to the beams and stiffened on the outer edge by a $3\frac{1}{2}$ in. x $3\frac{1}{2}$ in. x $\frac{1}{2}$ in. angle iron, and attached to the skin and frames by $3\frac{1}{2}$ in. x $3\frac{1}{2}$ in. x $\frac{1}{2}$ in. angles. The beams, which are on alternate frames, are each supported by a 3 in. diameter solid iron stanchion and two diagonal stays of 5 in. x $3\frac{1}{2}$ in. x $\frac{1}{2}$ in. angle iron. The gunwale angles are 5 in. x 5 in. x $\frac{1}{2}$ in. The water deck is made of 7-16 iron plate, and is double riveted throughout, the butts being fitted with single buttstraps. The shell plating varies in thickness from $\frac{3}{4}$ in. at the bottom to $\frac{5}{8}$ in. at the top. All the joints are lapped, the longitudinal joints being double riveted, and the vertical joints being treble riveted.

The buoyancy chamber is supported on the lowest tier of beams, which are spaced here on every frame, and is 16ft. long, that being the width of the caisson by 7ft. wide by 8ft. 6in. deep. The sides and bottom are made of $\frac{3}{8}$ in. iron, the sides being stiffened by $3\frac{1}{2}$ in. x $3\frac{1}{2}$ in. x $\frac{1}{2}$ in. angle. Access to this compartment is rendered possible by a manhole on the water deck. There are four air pipes in this chamber carried up to the underside of the upper deck.

The upper portion of the caisson or water ballast chamber has a breadth of 12ft., and was erected on

the water deck after the lower or floating portion of the caisson was launched. The frames which are pitched the same as in the lower portion are 4in. x 3½in. x ½in. angle iron, kneed to connect to the water deck and beams, and are stiffened by 7-16in. gusset plates.

The beams, which are fixed on alternate frames corresponding with the beams in the lower portion are 7in. x 3¾in. x ½in. T bulb, and fastened to the frames by 7-16in. gussets. The deck stringer is 18in. x ⅜in., and the stringer bar is 4in. x 4in. x ½in. angle. The deck beams are thoroughly tied together by diagonal bracing of flat bars 4in. x ⅜in. The side plating varies in thickness from 9-16in. at the bottom to 7-16 at the top, and is lap jointed and double riveted throughout. The bar connecting the plating to the water deck is 3½in. x 3½in. x ½in. angle iron. In order to have thorough control over the water in this chamber, it is divided into four compartments by means of one longitudinal and one transverse bulkhead. The longitudinal bulkhead is made of 5-16in. iron, and is fastened to the water deck and upper deck beams by double angle irons 3½in. x 3½in. x ½in. There is also a vertical stiffening angle under each beam and diagonal and horizontal struts of 4in. x 4in. x ½in., all fastened together at their junction by a ⅜in. plate. The horizontal struts are fastened to the frames by ⅜in. gussets. Side stringers are laid on top of these struts 18in. x 7-16in., stiffened on the outer edge and attached to the shell and frames by 3½in. x 3½in. x ½in. angles. The transverse bulkhead is made of 3-16in. plates, stiffened by 3½in. x 3½in. x ½in. angle. Access to the lower hold is made by two trunk hatchways 3ft. x 2ft., made of ⅜in. plate, the corner angles being 3½in. x 3½in. x ½in. The upper deck is of Kauri pine 3½in. thick. The handrailing is made to fold down in six sections on each side. The false keel and stems which

take the whole thrust of the pressure of water on the caisson are made of $\frac{3}{4}$ in. plates stiffened on the outer edge by double angles 4in. x 4in. x $\frac{1}{2}$ in., and fastened to the hull by double angles 4in. x 4in. x $\frac{1}{2}$ in., and forty-nine brackets made of $\frac{5}{8}$ in. plate, with double angles 4in. x 4in. x $\frac{1}{2}$ in.

The meeting face is made of ironbark 9in. thick, worked true to correspond with the faces in the dock, and form a watertight joint.

The sea valves are of the conical type, made of cast iron, with gun metal faces, and are worked from the upper deck by means of screw gear. The buoyancy chamber valves are nine inches in diameter, and the upper chamber valves 15 inches diameter.

The pressure of the water against the caisson at high water is about 530 tons.

In conclusion, he desired to state that the improvements to the dock have been an immense advantage to the Company in enabling them to dock a large number of vessels during the wool season in a very limited time, and also in being able to carry on heavy repairs in the upper end of the dock, and at the same time carrying on the usual docking in the lower end. In one week during the last wool season eleven vessels were docked, having an aggregate tonnage of 22,000 tons. This was the largest week's docking ever done at Mort's Dock, and he merely mentioned it to show what the place was capable of doing. The wisdom of having the dock fitted with an intermediate caisson was fully exemplified by the work done in the dock during the present year, the steamer *Ouraka* having been docked at the upper end for five weeks undergoing extensive repairs, without causing any stoppage to the docking of the usual run of vessels, and the German cruiser *Cormoran*, after being ashore on Whirlwind Reef, had now been in dock three weeks without in any way interfering with the ordinary run of work.