

PATENT SPECIFICATION

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(54) DOCK GATE

(71) We, MITSUBISHI JUKOGYO KABUSHIKI KAISHA, a Japanese body corporate, of 5-1, Marunouchi 2-chome, Chiyoda-ku, Tokyo, Japan, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to dock gates.

According to the present invention there is provided a dock gate which comprises:

(i) a flap gate having a closed shell structure of substantially rectangular vertical transverse cross-section; and

(ii) a supporting element extending from the base of the flap gate at or near to each end thereof for pivotally supporting the flap gate along a horizontal axis; the arrangement being such that the width of the cross-section of the flap gate is not more than 1/16th the distance between the supporting elements.

Preferably, the width of the cross-section of the flap gate is not more than 1/20th the distance between the supporting elements.

The dock gate may include wooden seats arranged in one side of the flap gate for abutting against the walls of a dock. Preferably, a rubber member is secured to the wooden seat extending along the base of the flap gate for sealing with the bottom of a dock in a water-tight manner.

Preferably, the supporting elements are provided with a recess which is shaped so that the flap gate is urged against the bottom of a dock when the flap gate is raised.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to the accompanying drawings, in which:

Figure 1 is a front view of a known type of dock gate;

Figure 2 is a cross-section along the line A—A in Figure 1;

Figure 3 is an enlarged view of part of Figure 2;

Figure 4 is an enlarged view of another part of Figure 2;

Figure 5 shows diagrammatically the displacement resulting from a load applied to the dock gate shown in Figure 1;

Figure 6 shows diagrammatically the reaction force at the centre of the flap gate shown in Figure 1;

Figure 7 is a front view of a dock gate according to the invention;

Figure 8 is a cross-section along the line B—B in Figure 7;

Figure 9 is an enlarged view of a part of Figure 8; and

Figures 10 and 11 are a diagrammatic comparison of ballast loading in a known type of dock gate and in a dock gate according to the invention respectively.

There is shown in Figures 1 to 6 a dock gate having a main beam 01, vertical beams 02, pivotal supports 03 provided at the bottom edge of a flap gate on its left and right sides, side wooden seats 04, a bottom wooden seat 05, and a water-tight sealing rubber piece 08 fixedly secured to the bottom wooden seat 05.

The pivotal support 03 consists of a support receiver 011 fixed to the sea bed outside the dock bottom 07, a horizontal support shaft 09 secured to the support receiver 011, and a supporting element 010 attached to the lower end of the vertical beams 02 and having a recessed portion, while the flap gate can be raised or lowered with the support shaft 09 fitted in the recessed portion of the supporting element 010 and supported thereby. The width d of the recessed portion of the supporting element 010 is sufficiently large in comparison to the diameter of the support shaft 09, so that when the flap gate is in a vertical position, only the weight of the door body is transmitted to the support shaft 09, i.e. only vertical forces act on the support shaft 09.

In use the load applied from the side of the sea is transmitted via the door plate to the vertical beams 02, which are in turn supported by the bottom 07 of the dock through the main beam 01 and the bottom wooden seats 05. The main beam 01 is supported by side walls 06 of the dock via the side wooden

seats 04. The main beam 01 functions mainly as a bending member, and to reduce the effect of waves, a box type of cross-section is generally employed for its transverse cross-section configuration.

To obtain the required mechanical strength the width a' of the beam should only be about 1/10th the distance b' between the pivotal supports 03, while the height h' of the beam is determined so that the bottom surface of the beam is lower than the lowest water level of the sea.

The effect of applying a hydraulic pressure to the flap gate is shown in Figure 5. The middle portion of the flap gate is displaced from its normal position represented by solid lines 012 to another position represented by dashed lines 013. In Figure 5 reference numeral 014 designates an angle of rotation θ .

Since the main beam 01 has a box type of cross-section, which results in a fairly large resistance to torsional stress, the ends of the flap gate shown in Figure 1 also have a tendency to rotate. Because this tendency to rotate is increased substantially in proportion to the square of the distance b' between the supports exceeds a certain value then the torque of the reactive forces for preventing the rotation of the opposite side end portions is overcome by the torque generated from the hydraulic pressure and transmitted via the main beam 01, and consequently, the ends of the flap gate would rotate about a fulcrum point at its top edge P (see Figure 2). Thus, a water-tight seal may not be maintained, because the lower part of each end of the flap gate which normally makes contact with the edge of the bottom 07 of the dock, are caused to swing up.

The reaction force R exerted upon the central portion of the flap gate is shown in Figure 6, in which R represents the reaction force exerted from the bottom 07 of the dock, and L represents the distance from the support edges of the vertical beams 02 on the side of the main beam 01 to the line of action of the reaction force R. The bending moment about the support edges of the vertical beams 02 on the side of the main beam 01 is equal to $R \times L$. However, since the reaction force becomes zero at the opposite side end portions where the bottom ends swing up as previously described, the reaction force in the proximity of the midpoint is increased by a corresponding amount, and thus the bending moment in the proximity of the midpoint is increased accordingly. If the distance b' between the supports is increased, the tendency to rotate would increase, and therefore it becomes very difficult to limit the stress applied to the vertical beams to within an allowable range unless the cross-section area of the vertical beam is made sufficiently large. However, if the cross-section area of the vertical beam is enlarged, although the problem relating to the

stress is resolved, the weight of the entire dock gate is increased.

There is shown in Figures 7, 8, 9 and 11 a dock gate which comprises a flap gate 1 having a closed shell cross-section whose width is far smaller than the distance between the supports, pivotal supports 3 provided at the bottom ends of the flap gate 1, side wooden seats 4 provided on the opposite sides of the front surface E of the flap gate 1, a bottom wooden seat 5 provided along the bottom edge of the front surface E of the flap gate 1, a rubber member 8 fixedly secured to the bottom wooden seat 5 for sealing with the dock in a water-tight manner, and a duct 13 provided in the lower portion of the flap gate 1. Numeral 2 designates the sea, numeral 6 designates dock walls and numeral 7 designates the bottom of the dock.

The pivotal support 3 comprises two support receivers 11 fixed on the sea bed outside the bottom of the dock and having a horizontal support shaft 9 for supporting the flap gate 1 and a supporting element 10 mounted at the bottom of the flap gate 1 at its ends, which supporting element has a recessed portion 12.

The width a of the flap gate is not more than 1/16th, and preferably not more than 1/20th the distance b between the supports, and the height h is substantially equal to the height of the dock.

When the flap gate 1 is in a vertical position, that is when the dock is vacant and blocked from the sea water, the support shaft 9 makes contact with the right side face of the recessed portion 12 of the supporting element 10 as shown in Figure 9, so that the support shaft 9 is applied with a reaction force F from the right side face of the recessed portion 12, and thus the support shaft 9 and the supporting element 10 are engaged with each other so that the flap gate 1 does not separate from the bottom 7 of the dock.

In operation, when a hydraulic pressure is applied to the flap gate 1 under the condition of blocking the entrance of the dock, most of the hydraulic pressure load is borne by the bottom wooden seat 5 via the flap gate 1. A torque is exerted upon the flap gate 1 in such direction that the flap gate 1 is urged towards the interior of the dock. This torque is transmitted to the opposite ends of the flap gate 1 as a torsional shearing stress in the vertical transverse cross-section of the flap gate, and balanced by the torque of the supporting reaction forces exerted by the side wooden seats 4 and the support receivers 11. Thus the reaction force F is borne by the support shaft 9 so that no gap is produced at the bottom of the opposite side ends of the flap gate 1. By way of example, it is to be noted that in an embodiment having dimensions of $b = 100$ m, $a = 5$ m and $h = 12$ m, a force $F = 200$ ton resulted, and in another embodi-

ment having dimensions of $b = 80$ m, $a = 5$ m and $h = 12.85$ m, a force $F = 1400$ ton resulted.

More particularly, since the entire cross-sectional area of the hollow flap gate 1 is very large, its torsional rigidity is extremely high, and since the width a of the cross-section is small, its bending rigidity is very low. As described above, the rotation of the opposite side end portions of the flap gate 1 is restrained by the support shaft 9. The requirement that the width of the flap gate should not be more than $1/16$ th, and preferably not more than $1/20$ th the distance b between the supports, has been determined by both calculation and experiment. When the width a is reduced, the bending moment is decreased because the bending rigidity IE of the flap gate is proportional to the square of the width a . However, even if the width a is reduced, the high torsional rigidity JE can be maintained by selecting the height h sufficiently larger than the width a , because the torsional rigidity JE is proportional to the square of $a \times h$. If the height h is selected larger than about $2a$, then the internal force is mainly borne by a member having a torsional rigidity, and thus the flap gate can be designed principally on the basis of torsion.

As described above, according to the present invention, the flap gate is constructed to have a closed shell structure whose vertical transverse cross-section has a width of not more than $1/16$ th, and preferably not more than $1/20$ th the distance between the supports, and the pivotal supports for supporting the door body restrain the flap gate to prevent the bottom of the ends of the flap gate separating from the dock walls, and as a result, the following effects and advantages may result

from the present invention:

(1) Since the width of the flap gate is not more than $1/16$ th, and preferably not more than $1/20$ th the distance between the supports, the bending rigidity within a horizontal plane is reduced, and consequently, the bending moment becomes small. This is because the internal forces of the flap gate are indefinite in view of the theory of statics since the flap gate is supported along three edges, and because a torsional member having a high rigidity bears against a large internal force.

(2) The bottoms of the opposite end portions of the flap gate do not swing up as is the case with the conventional flap gate structure, and therefore, water leakage does not occur.

(3) Since the vertical beam portions in the prior art structure are eliminated, there occurs no problem relating to the bending moment, and further, since the width of the flap gate is made smaller than that of the prior art structure, the amount of excavation of the sea bed may be reduced.

(4) Inasmuch as the torsional rigidity is extremely high with respect to the bending rigidity, the thickness of the plate is determined by the torsional moment, so that the thickness of the plate used in the dock gate can be made about one-third that of the prior art flap gate, and consequently the welding work is simplified.

For comparison, the weight of the known flap gates in the prior art as shown in Figure 2 and the flap gates according to the present invention having the respective distances b' and b between the supports and the effective heights H of the water, equivalent gates are listed in the following table.

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No.	Distance between supports b (m)	Effective Height of Gate H (m)	Width of Gate a (m)	Dimension Ratio a/b	Dimension Ratio h/a	Weight		Weight Reduction Ratio W/W'
						Flap Gate in Fig. 2 W' (t)	Flap Gate of present invention W (t)	
1	100	13.5	5.0	1/20	2.4	1900	1270	0.67
2	90	13.0	5.0	1/18	2.6	1700	1100	0.65
3	80	13.0	5.0	1/16	2.5	1500	1000	0.67
4	55	8.0	2.5	1/22	1.8	410	201	0.49
5	45	8.2	2.5	1/18	2.0	300	229	0.76

WHAT WE CLAIM IS:—

1. A dock gate which comprises:
 - (i) a flap gate having a closed shell structure of substantially rectangular vertical transverse cross-section; and
 - (ii) a supporting element extending from the base of the flap gate at or near to each end thereof for pivotally supporting the flap gate along a horizontal axis, the arrangement being such that the width of the cross-section of the flap gate is not more than 1/16th the distance between the supporting elements.
2. A dock gate as claimed in claim 1, wherein the width of the cross-section of the

(5) With reference to Figures 10 and 11 showing the design of float and ballast sections in the flap gates according to the prior art and the present invention respectively. Each flap gate is provided with a float 14 or 14' for reducing the winch load of the flap gate and for repairing works, and also loaded with ballast 15 or 15' for bringing the centre of gravity of the flap gate to its centre of buoyancy. In the flap gate according to the present invention, the amount of the ballast can be reduced to a small amount because the centre of gravity of the flap gate without the ballast is closer to its centre of buoyancy than in the case of the flap gates in the prior art.



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1	100	13.5	5.0	1/20	2.4	1900	1270	0.67
2	90	13.0	5.0	1/18	2.6	1700	1100	0.65
3	80	13.0	5.0	1/16	2.5	1500	1000	0.67
4	55	8.0	2.5	1/22	1.8	410	201	0.49
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flap gate is not more than $1/20$ th the distance between the supporting elements.

5 3. A dock gate as claimed in claim 1 or 2 and including wooden seats arranged on one side of the flap gate for abutting against the walls of a dock.

10 4. A dock gate as claimed in claim 3, wherein a rubber member is secured to the wooden seat extending along the base of the flap gate for sealing with the bottom of a dock in a water-tight manner.

15 5. A dock gate as claimed in any preceding claim wherein the supporting elements are provided with a recess which is shaped so that the flap gate is urged against the bottom of a dock when the flap gate is raised.

6. A dock gate substantially as hereinbefore described with reference to, and as shown in, Figures 7, 8, 9 and 11 of the accompanying drawings.

7. A dock including a dock gate as claimed in any preceding claim.

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