Recent structural developments in miter gates for navigation locks

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Construction of navigation locks enjoys renewed interest of inland waterways and sea harbors administrations. This also includes the upgrading and refurbishment projects at many existing lock sites. The reasons for this renewed interest are complex and can be associated with a number of world-wide developments and concerns, like:

- Globalization of world economy and more demand for waterborne transport.
- The resulting growth of both number and sizes of vessels in navigation locks.
- Environmental advantages of inland navigation versus land transport.

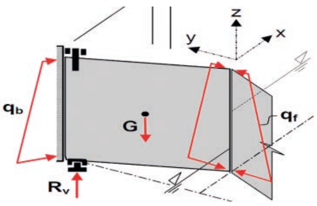
– Impact of processes associated with climate change, like sea level rising and extreme weather conditions on inland waterways.
– Growing significance and requirements of recreational navigation.

This stimulates the development of lock closures, which are often seen as the most technically demanding systems in navigation locks. Miter gates are by far the best known and usually the most efficient type of such closures. It should, therefore, not surprise that PIANC, the World Association for Waterborne Transport Infrastructure, established a Working Group to bring a report on the newest state-of-art technology in this field. This Working Group, abbreviated as WG-154 of the PIANC Inland Navigation Commission (InCom), has recently completed its proceedings. The final report [1] was presented on a workshop in Brussels on November 6, 2017. The author of this article was a member of the Working Group and would like to share some conclusions of the report with the readers of our magazine.

MITER GATE CONCEPT AND MAIN FEATURES

Let us use the American spelling "miter gate" instead of British "mitre gate", simply because most of the world largest gates of this type operate in the United States today. Miter gates are generally seen as a lock gate system on its own – to be distinguished from other systems, like vertical lift gates, rolling gates, sector gates etc. However, the unquestionable advantages of this system earned it a strong position in hydraulic engineering, re-

Table 1. Advantages and disadvantages of miter gates



Advantages	Disadvantages
• The most frequently used type of a lock gate – very well-proven technology	• Single-sided operation, although low reverse loads can be carried under some provisions
• Sustainable principle of operation: "water head itself fixes and seals the gate"	• Double gates required when high water heads can occur from both sides
• Many different structural systems possible – nearly all in proven technology	• Not economical for very wide navigation locks (e.g. in sea harbors), wider than about 40.0 m
• Construction and maintenance costs low or moderate in a wide range of dimensions	• Closing under flow very difficult
• Gate recesses along the lock chamber → small space consumption	• Number of system components relatively high due to two sets of gate leaves and drives → increased risk of failure
• No limit to overhead space for navigation → fit for locking ships of any height	• Necessity to synchronize the motion of leaves
• Opening and closing times low or moderate	• High motion resistance in wide locks → high drive energies and powerful drives required
• Can be constructed with an entirely free lock deck – valued by special transports, mooring of large ships, emergencies, etc.	• As above, with as a result slower gate opening and closing
• Symmetric flow patterns during opening and closing – favored by navigation	• High loads on gate hinges during motion → wear problems by intensive operation
• Gate hinges can be released to pass hydraulic loads to the heel posts (free-hinged gate)	• Some transfer of hydraulic load through gate hinges inevitable (fixed-hinged gate)
• Filling and emptying devices easy to fit to gate and accessible for small maintenance	• Gate locking necessary if water head can appear on any of the two sides
• Less vulnerable to sediment and sunk obstacles than rolling gates (but care required)	• Gate locking against alternating water heads difficult and not leak-free
• Gate locking possible to carry limited water heads in reverse direction	• Hydraulic load transfer not entirely in plane of chamber walls → massive crowns required
• In double-sided service, lock crowns can be shorter than for double sets of miter gates	• Very sensitive components (bottom pintles) practically inaccessible for maintenance
• Relatively easy in transport and installation due to compact dimensions of components	• Gate major maintenance in site possible only after (partial) dewatering of lock chamber
• Architectural advantage of free horizon	• Operation in winter (ice floes) and in situations with floating debris can present a problem

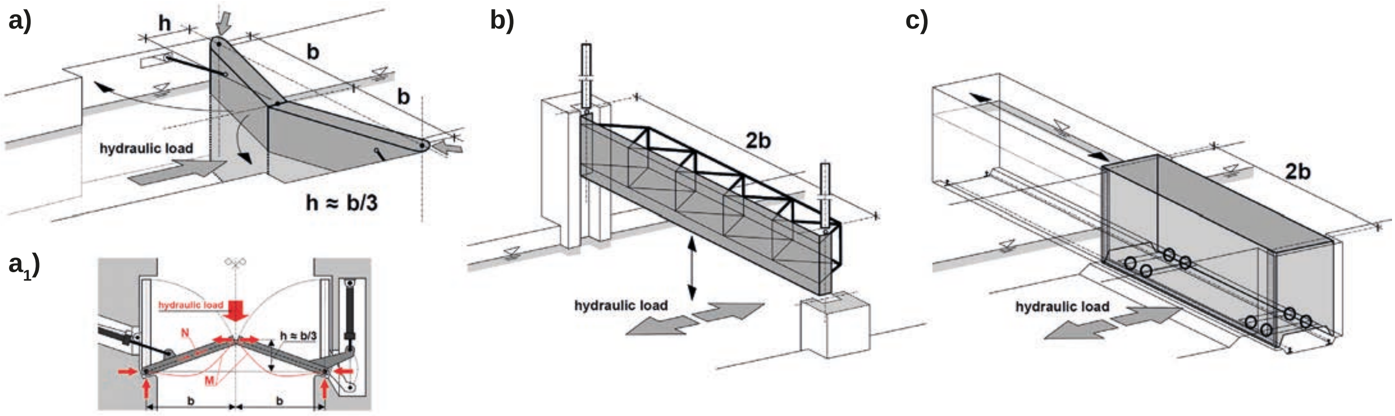


Fig. 1. Three most frequently utilized types of lock gates

sulting in the development of several sub-systems of miter gates. The common properties of all these sub-systems are:

- Miter-like shape of the two gate leaves in the top view;
- Hydraulic load transfer by both bending moment and normal force in gate leaves.

The above is illustrated in Fig. 1, which schematically shows three most frequently used types of gates in navigation locks. Note that in the vertical lift gate (b) and rolling gate (c) hydraulic load is globally carried only by the bending moment, while in the miter gate (a) it is indeed carried by both bending moment and normal force. This combination (a_1) makes miter gates very economical when compared to most other gate types used in navigation locks. The main disadvantage is, however, that a miter gate can basically be loaded at one side only, while the other two gates pictured in Fig. 1 can carry hydraulic loads at both sides. This has also been indicated in the drawing. In addition, two different drive arrangements for a miter gate are shown in sketch (a_1), which will be discussed later in this article.

Obviously, miter gates have more advantages and disadvantages than mentioned above. A more complete list is presented in Table 1 after the author's book [2] that will soon be available in bookstores. The reader should keep in mind, however, that general evaluations of this nature cannot be point-to-point applicable for all projects or studies. Local conditions may lead to other assessments. Nevertheless, this list can be used as guidance while weighting the pros and cons of miter gate application for a particular project.

SHORT HISTORY

The structural system of a miter gate has a long and stunning history in hydraulic engineering. As far as traceable, it was probably first introduced in Italy. The basic concept of a miter gate is already to be seen in the early drawings by Leonardo da Vinci dating from the late 15th century. However, the PIANC Working Group could not trace whether he or another Italian engineer, Bertola da Novate, can be credited with the first realization of such a lock gate. The historians are also not unanimous in this matter. The fact is that miter gates were constructed on the water supply side canals to Navigilio Grande. These canals were also used to supply stones for the construction of the Milan Cathedral. The engraving in Fig. 2a shows an early Italian navigation lock with a miter gate [3].

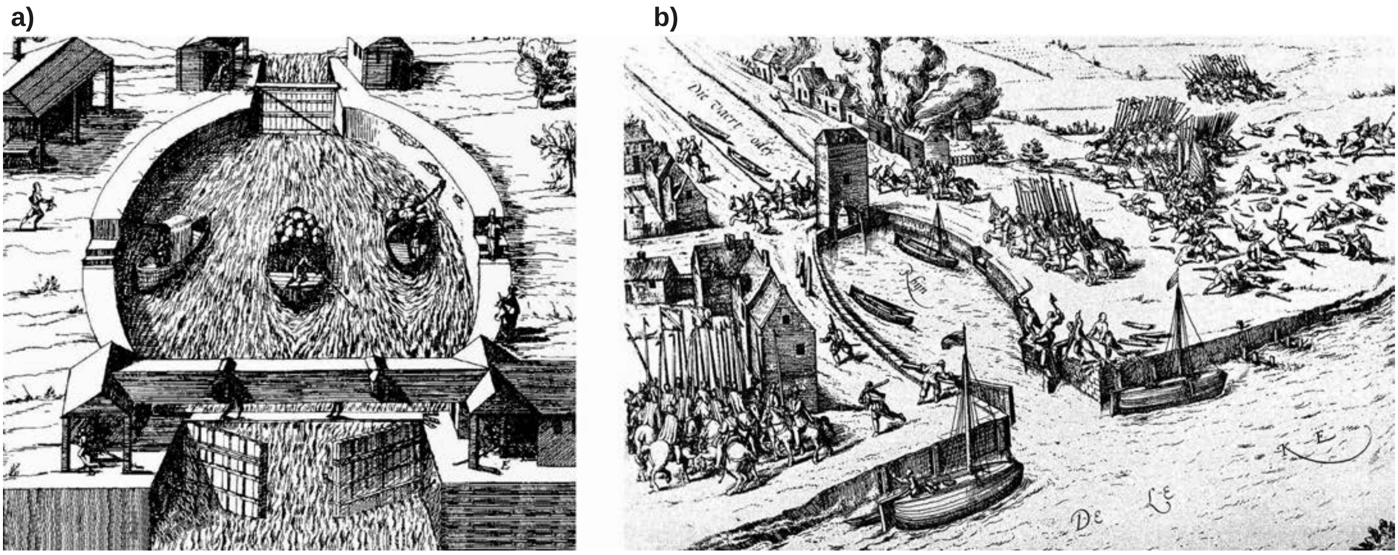


Fig. 2. Engravings of early locks with miter gates
a) early 16-century Italian lock with a miter gate, b) late 16-century lock in Vreeswijk, the Netherlands, under siege

After that, miter gates made an impressing career in hydraulic engineering. Their advance can be seen in many countries, including the Netherlands (Fig. 2b) [4]. The chamber widths that could be closed by the gates of this type steadily grew. Today the world's widest miter gates are the old (already replaced) gates of the Portbury Lock (width 42.7 m) at the entrance to the Bristol harbor docks in England. The early gates of this lock were built by Isambard Kingdom Brunel, enabling him to launch his great steamers *SS Great Western* in 1838 *and SS Great Britain* in 1843 in the Bristol docks. The best known, however, are the old miter gates of the Panama Canal in its Gatun and Miraflores Locks. They are shown in Fig. 3 while locking *Crystal Serenity*, the largest cruise ship that has ever navigated the Northwest Passage. Yet, these 33 m wide miter gates are not the largest in both Americas. Several miter gates in the Mississippi, Ohio and Tennessee River are comparable or slightly larger (Fig. 4).

Modern European miter gates are, in general, smaller than in America, but the very concept of this gate type is also favored in most navigation locks on our continent. This particularly applies to inland navigation waterways. There has also been much improvement, innovation and application of new materials in this field in recent years. Both Europe and America benefit from each other's experience, but the engineers of the two continents also maintain some traditionally different design views and preferences. These and other developments are discussed in the Working Group report [1].

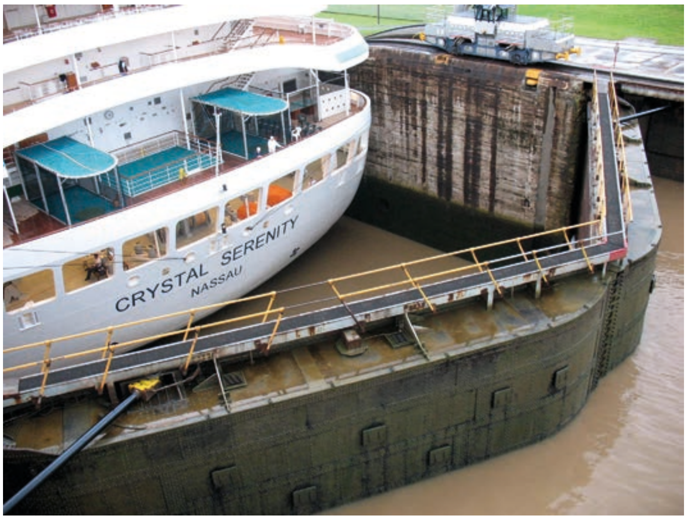


Fig. 3. Old miter gates of the Panama Canal, photo author


Fig. 4. New gates of Mississippi Lock 19, Keokuk, Iowa, courtesy USACE

STRUCTURAL SYSTEMS, CLASSIFICATION

The relative success of a miter gate concept resulted in the development of several structural systems for such gates. These systems can be classified with respect to a number of distinctive properties. There are some differences in the ways in which most European and American engineers view this issue. The prevailing American view is to consider the direction of main girders as the only criterion that determines the systems. The prevailing European view is to recognize several such criteria. Below is the list of some most distinctive properties and the resulting miter gate systems. It includes – so far – 19 structural systems, denoted (a) through (s), which is one more than distinguished in the report. The discussion and assessment of these systems was one of the main issues in the proceedings of the Working Group. It is also the main subject of this article.

- Character of hydraulic load transfer:
  - a) free hinged (load transfer through heel posts)
  - b) floating pintle (load transfer through heel posts)
  - c) fixed hinged (load transfer through hinges)
- Direction of main girders:
  - d) horizontally framed
  - e) vertically framed
- Arrangements for skin plate location:
  - f) plate girders with skin upstream
  - g) skin plate double-sided
  - h) plate girders with skin downstream
  - i) fold plate and other systems
- Arrangements for vertical load transfer:
  - j) bottom pintle – top hinge
  - k) bottom hinge – top pintle
  - l) support or suspension outside hinges
  - m) buoyancy tanks
- Drive connection:
  - n) direct to (top) girder
  - o) indirect through drive arm

The focus in all the structural systems mentioned above has been put on the properties of the gate structure, i.e. not of the drive mechanism. When the drive mechanism is concerned, the following systems can additionally be identified:

- Drive mechanism:
  - p) manually driven (directly or geared)
  - q) electro-mechanically driven
  - r) electro-hydraulically driven
  - s) hydrostatically or otherwise driven

This list may look somewhat abstract, therefore the main differences between these structural systems are presented on drawings and shortly discussed in the following sections. Obviously, it is possible to consider still more criteria as distinctive properties. One can, for example, focus on the gate material (steel, timber, composite, …), shape of its skin plate (plane, curved, …), hydraulic loads carried (single-sided, double-sided, frequent, occasional, …) or presence of filling and emptying valves (in gates or in culverts). Such distinctions cover, however, fewer substantial differences in terms of gate systems.

SYSTEMS IN VIEW OF HYDRAULIC LOAD TRANSFER

Perhaps the most essential is the gate classification in view of hydraulic load transfer. After all, receiving and passing hydraulic loads is what all lock gates are made for. The drawing in Fig. 5 schematically presents the systems with respect to hydraulic load transfer. Hydraulic load can, generally, be passed through the gate heel posts (also called “quoins”), hinges and the bottom edge. The schemes in Fig. 5 show a number of possible choices in this field.

By far the most practiced is the system with hydraulic load transfer through heel posts. This can either take place in the form of continuously distributed compression (schemes a_1, a_3 and b) or at a number of compression blocks (“saddles”) located along the heel posts (scheme a_2). Note that in most cases engineers do not take account of an additional load transfer to the bottom sill. In the real world, some load transfer through the gate bottom edge will take place and the sill designers must account for that, but the gate designer should better not do that. The reason is that it makes the system statically indeterminate. This is not a problem when a structure remains in one position during its service life. Hydraulic gates, however, frequently move, are exposed to hinge wear and other geometric distortions, which makes that the sill contribution to load transfer is uncertain.

An exception is the gates that are deliberately designed to pass hydraulic loads to the bottom sill and are flexible enough to adapt to the changing support conditions. Such gates are, for example, the American vertically framed miter gates that are discussed later in this article. In this case, the sill contribution to the load transfer is essential.

Obviously, special arrangements must be made to let the hydraulic load, while it builds up, release the gate hinges and move to the heel posts. European designers usually do it by providing sufficient clearances in the gate bottom pintles and carefully shaping the heel post contact surfaces. American designers use sometimes so-called “floating pintles” shown in scheme (b) in Fig. 5, which allow their base plates slide a little preventing the response to hydraulic load. This solution is, however, vulnerable to pollution and other external factors. It is, therefore, not recommended for new projects in the USA any more [5].

The last possibility, practiced mainly in Europe, is to pass the hydraulic loads through the gate hinges and their anchorages. The gate leaves are then fixed in their hinges, there is no need for hinge clearances to enable load passage to the heel posts; and the entire system is, so to say, “clearer”. The heel posts of the resulting, so-called “fixed hinged” gate can then be light, as they only stiffen the structure and hold its vertical seal. An example of pintle assembly in such structures is shown in photos (a) in Fig. 6. However, while there is nearly no clearance between the pintle and its cap (here with synthetic bushing), a careful observer will notice some clearance between these items in the pintle in photos (b). This pintle represents a typical American arrangement, called “fixed” by the engineers in the USA. In European view, it is still called “free”, as it allows for some slip and load transfer through the quoin.

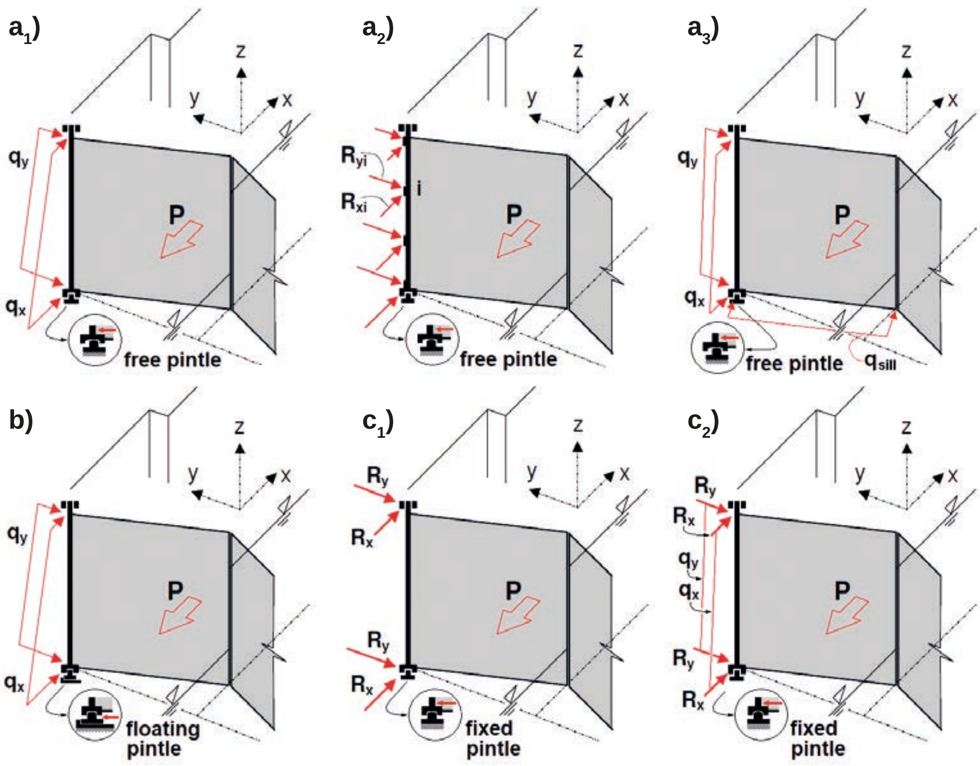


Fig. 5. Hydraulic load transfer by miter gates [2]

a) b)

Fig. 6. Pintle assemblies in a European and American miter gate
a) Naviduct Enkhuizen, the Netherlands, photos author; b) Ohio River Louisville Lock, courtesy USACE

SYSTEMS IN RESPECT OF MAIN GIRDERS DIRECTION

Miter gate leaves can statically be seen as plane structures, but they carry loads both in plane and out of plane. In this sense, their framing combines the features of plane frames and grids. As the normal compression force *N* from Fig. 1 has a horizontal direction, the most logical choice is, normally, to let the main girders run horizontally. The resulting gate system is then called "horizontally framed". Hydraulic load acting on the gate skin plate passes then through the stiffeners and (in larger gates) crossbeams to the horizontal girders that, in turn, pass it to the lock crown. The latter happens either directly at compression blocks or in the form of a line load along the gate heel posts. The second option is favored in recent decades, because the heel post lining, for example of hard timber, not only spreads the load but is also capable of some adaption to local surface deviations in concrete.

The described system becomes, however, inefficient when the gate has to close a very wide and relatively shallow opening. The common way to deal with such conditions in Europe is to choose another gate type, for example a vertical lift gate or rolling gate, see Fig. 1 (b) and (c). However in America, inland navigation locks are wider and engineers are more committed to miter gates. They invented the gate framing that better suits such conditions and called it a "vertically framed" gate. The idea is to let a gate pass a major part of its load to the bottom sill rather than to side walls of a lock crown. This is obtained by vertical girders and one, very stiff horizontal girder at the top of the gate leaves. The vertical girders span the top girder with the bottom sill, passing about 2/3 of hydraulic load to the bottom and 1/3 to the side walls. As their span is relatively short, the whole structure can be significantly lighter and, therefore, more economical than a horizontally framed gate of the same dimensions.

Fig. 7 shows the main components of both systems, drawn after the USACE design manual [5]. According to the same manual, the vertically framed miter gates represent an economical choice when the height to width ratio of a gate leaf is less than about 0.5.

The latter almost does not happen on European inland waterways, therefore the development of miter gate framing in Europe went somewhat different. The horizontal and vertical girders are usually seen as more equivalent components, often having the same structural height. Pre-tensioned diagonals that are crucial in the gates from Fig. 7, are often either replaced by rigid sections in the plane of girder rear flanges, or unnecessary for other reasons. An example of the framing in recently constructed wide miter gates in Europe is presented in Fig. 8. Note that the gate torque stiffness is obtained here by using box sections.

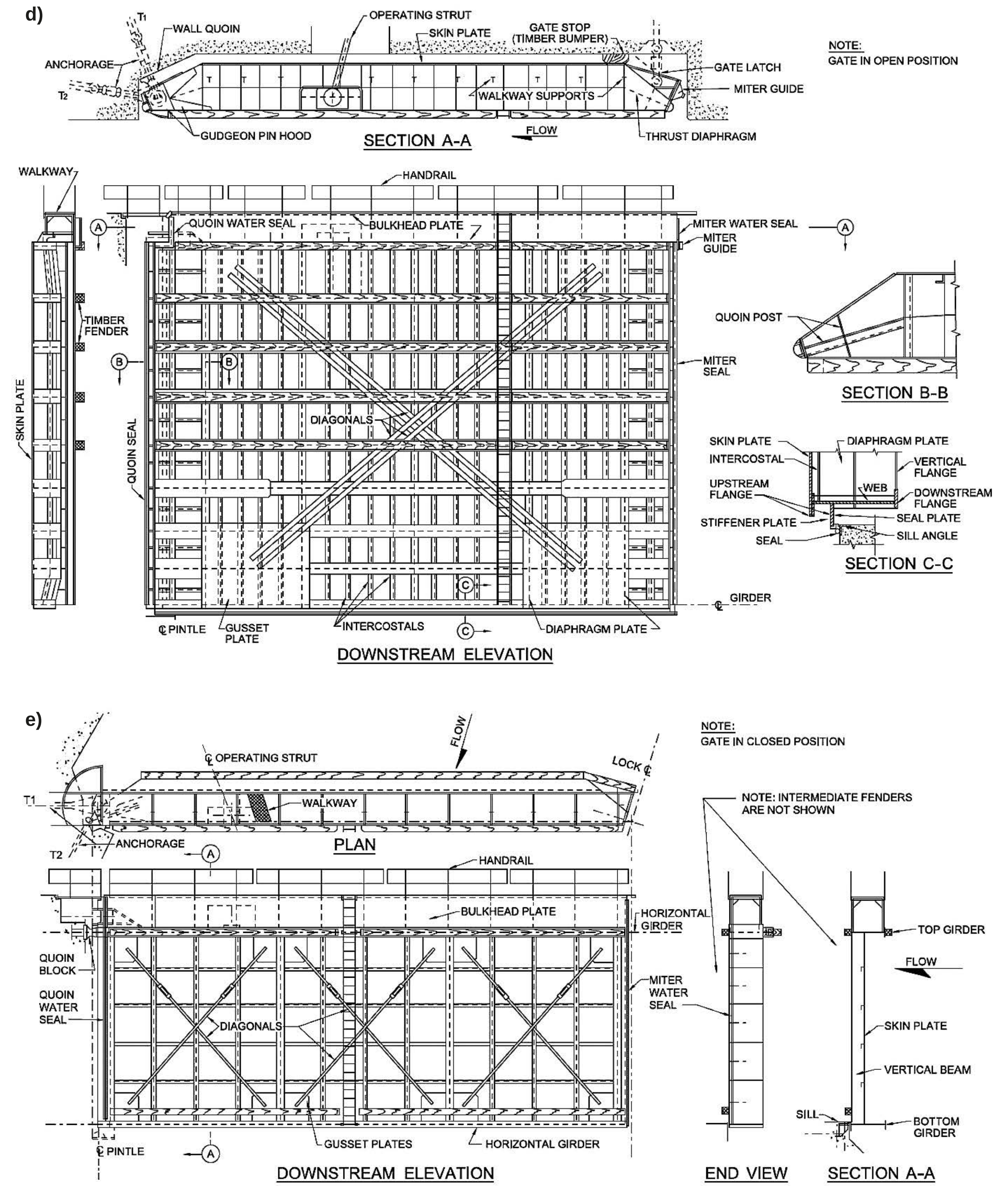


Fig. 7. Horizontally (d) and vertically (e) framed miter gate, drawn after [5]

SYSTEMS IN VIEW OF SKIN PLATE LOCATION

In most cases, miter gates are designed with a single skin plate that is located either on the upstream or on downstream side of the gate. Exceptions to this rule apply when the gate contains buoyancy tanks or chambers that must be accessible for some reason. In those cases, the hydraulic load can be carried at both sides of such tanks or chambers, which can be seen as a double skin plate. There also exist gate systems, in which the skin plate and girders are integrated in a single component.

Fig. 8. New gates of the Kattendijk Lock in Antwarp, Belgium, courtesy Dept. MOW

Other skin plate locations are only occasionally practiced and can be disregarded here. This makes the total number of basic systems in this respect 4, which is schematically shown in Fig. 9. The schemes in this figure also indicate the resulting differences in the action of vertical hydraulic load.

Until some 20 years ago, the most common choice was to locate the miter gate skin plate on the upstream side, as in sketch (f). However, this induces an alternating lift force on the gate, that in turn leads to unfavorable, strongly varying loads on the bottom pintles. The problem was investigated in the Netherlands [6, 7], which resulted in a general preference for the downstream skin plate location (h). Obviously, high uplift forces appear also in a gate with double skin plate (g); and do not depend there on the differential water head. The system (i), often used in Germany [8], is a cold folded plate structure that integrates the function of gate skin plate and girders, resulting in a substantial decrease of welding costs. It also reduces the uplift force, but it does not entirely remove it.

One concern related to the uplift force was the so-called "thread-shaped wear" of the gate pintle bearings. It occured on manganese steel caps and sockets that were utilized in hydraulic gate bearings in Europe since the 1950's. The idea to apply manganese steel for these items originated from mining industry and quarries, where this material proved to be both hard and wear resistant. What the engineers did not consider, however, was that both hardness and wear resistance resulted from the so-called "strain-hardening" of directly loaded areas; and were not everywhere the same. This might not matter much in quarry machine scoops, but it produced the thread-shaped wear in gate pintles, as shown in Fig 10. When the gate vertical reaction strongly varies due to the lift force, the gate may even repeatedly "climb up" the wear groves and then fall down with a shock. This was, in fact, experienced on a number of locks in the Netherlands, with various damages and malfunctions as a result. It also inspired engineers to apply other materials in gate pintles, like the hard synthetic bushing pictured in Fig. 6.

The described phenomenon does not appear on most American miter gates. There are two reasons that prevent this: First, the pintle heads of these gates are usually spherical rather than cylindrical, so there is almost no vertical contact surface to "climb up". Second, the gates often contact their bottom sills not

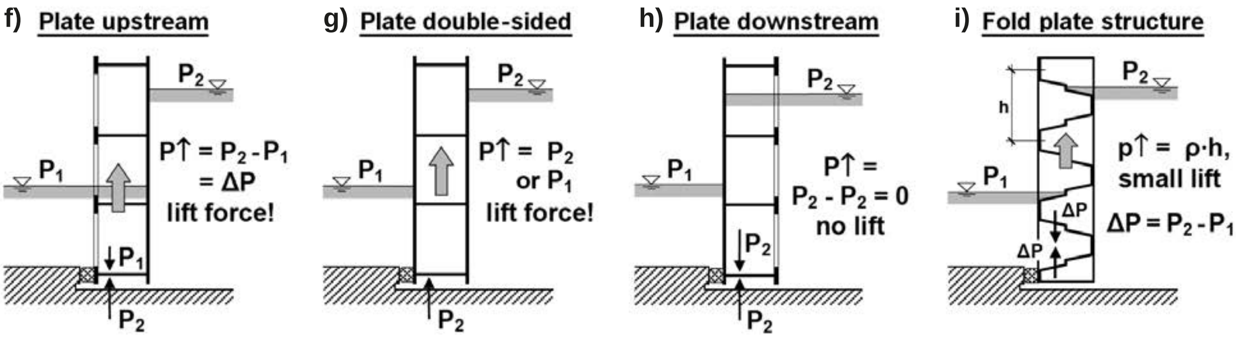


Fig. 9. Skin plate locations in miter gates [1]

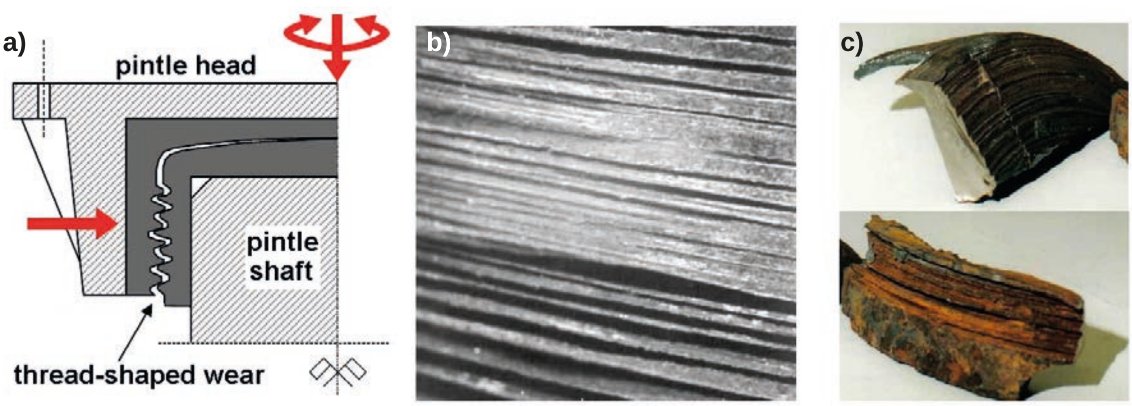


Fig. 10. Thread-shaped wear in gate bottom pintle [7])

in their front plane, as on the schemes in Fig. 9, but in their rear plane. This can be observed by comparing the Mississippi lock gate from Fig. 4 with the Belgian miter gate from Fig. 8. Note that the first gate will actually overlap the sill edge when closed, while the latter will not. The American lock gate will, therefore, experience very little uplift load variation.

SYSTEMS IN VIEW OF VERTICAL LOAD TRANSFER

The dominant vertical load of mitre gates is their own weight. Let us ignore other vertical loads (like buoyancy, ice, sediment etc.) at this moment for the reasons of simplicity, although they do exist and require consideration in detailed design. In regard of vertical load transfer, the designer can then choose between the mitre gate systems (j) through (m) mentioned earlier in this article and schematically drawn below in Fig. 11.

By far the simplest and most frequently used is system (j), in which vertical load is passed through the bottom pintle. It can even be called a "standard" solution for a miter gate, which is the reason why all examples discussed in this article until now represent this system. Other systems have, however, also been used or at least studied in diverse projects.

System (k), with a vertical support at the gate top hinge [9], becomes more and more popular in the Netherlands in recent decades, as it gives a better maintenance access to control the hinge wear. System (l_1), with an additional roller support, has not been practiced for a long time, but it did enable the construction of some very wide miter gates in the 19th century, like in the Avonmouth Lock in Bristol (UK). System (l_2), with a vertical suspension of the gate, was designed to rigorously reduce the hinge wear [10]. It has thoroughly been studied but not applied yet in the Netherlands. System (l_3), with an inclined gate suspension, has frequently been used in flood gates, for example in New Orleans (USA) [11], [12]. System (m), vertical load transfer through buoyancy tanks, is usually seen as an auxiliary measure reducing the gate reactions rather than a system on its own. Buoyancy tanks are often used in large miter gates, like the gates shown in Fig. 8 earlier in this article.

Examples of gates representing systems (k) and (l_2) from Fig. 11 have already been presented by the author in Poland, e.g. in [13]. Two examples of gates that pass parts of their vertical loads outside the hinges, representing respectively systems (l_1) and (l_3) are shown in Fig. 12. The first of them is the old miter gate in the Bristol Avonmouth Lock. That gate, shown in photo (a), was additionally supported by a roller (b) at the bottom of its miter post. The idea was to decrease the hinge reactions that indeed were large in this 30.5 m wide sea lock. The solution was not perfect and it required frequent cleaning of the roller and its bottom track due to large amounts of sediment carried by the tides. Nevertheless, it operated nearly 100 years and was replaced by conventionally hinged gates in 2004 [7]. The gate shown in photo (c) is one of many flood gates in the New Orleans area that utilize inclined suspension. It is a single leaf swing gate, but there also exist miter gates of this system. Its main benefit is the entire elimination of drive devices. Under normal conditions, the far end of the open gate rests on a concrete foot. In the case of a flood alarm, the cable stays are manually tightened, which lifts the far end of the gate and enables its (also manual) closing. This procedure takes about 10 to 15 min., which is largely satisfactory considering the early warning procedures.

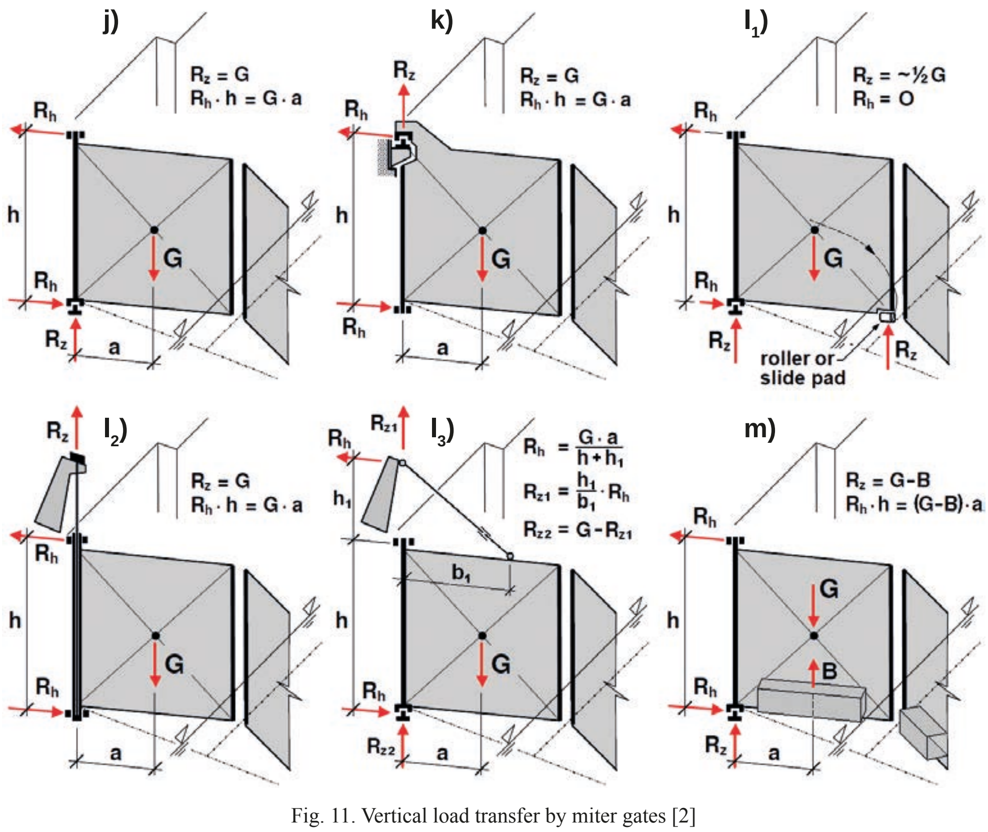


Fig. 11. Vertical load transfer by miter gates [2]

Fig. 12. Gates passing parts of vertical loads outside hinges
a) and b) former Avonmouth Lock gates in Bristol, UK; c) floodgate for railway passage in New Orleans, USA

SYSTEMS IN VIEW OF DRIVE CONNECTION

Unlike most other structures, hydraulic gates are only capable of performing their function if they can be moved. This means that the gate system must comprise a device that drives the gate, or, at a minimum, enables driving it by an external actuator. Obviously, two sets of such devices must, normally, be provided for a miter gate although there have been attempts to partly integrate the drives of both leaves.

The place and manner in which the miter gates are connected to their drives can also be seen as a system distinguishing property. Two most frequently practiced drive connections have schematically been shown in sketch (a_1) in Fig. 1, earlier in this article. The left leaf in this sketch is driven by a hydraulic cylinder hooked to the gate top girder; while the right leaf is driven by a cylinder hooked to a drive arm, rigidly connected to the gate. One might expect that the system on the left side is older, since a great majority of the operating miter gates are driven in that way. This is, however, disputable, which can be observed in the photos (a) through (d) in Fig. 13.

Note that applying a drive torque through a lever arm originates from a very early system of manually driven timber gates, shown in photo (a) in Fig 13. In Poland, a number of lock gates driven in this way still operate in the Augustowski Canal. That arrangement could not bring large gates in motion. Therefore various kinds of manually powered mechanical devices – like winches and rack-and-pinion drives – took this task over when the waterways grew wider in the 19th century. An example is the connection of rack-and-pinion drives to the gate mitering posts in photo (b). The arrangements of this kind precede the currently used mechanical drive connections to the top girders of gate leaves. This applies in both historical and mechanical sense. Photo (d) presents one of many kinds of such arrangements in the navigation locks of today. Note that the drive strut is now connected at a short distance from the leaf rotation axis, and not at its far end as in photo (b). This is simply because the machinery, in this case the so-called "Panama wheel", is capable of delivering much higher forces than what a man could do. The drive struts of the gate in photo (d) are additionally provided with shock absorbers, here of the so-called Belleville type.

Incidentally, the limit to "what a man could do" does not necessarily apply to a woman, which can be observed in Fig. 14. Although this issue falls beyond the scope of the article, engineers should, perhaps, begin to question the sense of large-scale mechanization and automation in hydraulic structures of today. In particular, the general tendency to develop remote controls of these structures raises questions in many fields. More discussion of this issue will soon be available in [2].

Fig. 13. Some connections of manual and mechanical gate drives: a) miter gate near Falkirk Wheel, Scotland; b) manually driven gate of the Stolwijkersluis, Netherlands; c) gate with drive arms in the Orange Locks in Amsterdam, d) Panama wheel strut connection to the gate of the Born Lock in the Meuse, Netherlands

Fig. 14. Miter gates of the Borki Lock in Augustowski Canal, Poland

The applications of drive arms to mechanically driven gates, like those in photo (c) in Fig. 13, are relatively new. Their idea is to place hydraulic cylinders or other actuators in machine rooms, which makes them less vulnerable to impact loads, ship collision, pollution, extreme weather conditions and the like. It also makes the entire drive system better maintainable and by that cleaner for the environment. In the countries like the Netherlands, where gate drives must occasionally hold the gates against reverse water heads, these advantages are particularly welcome. They increase the reliability of gated closures and the safety of lock operation.

A remarkable structure containing miter gates with drive arms is the twin lock on an aqueduct in Enkhuizen, the Netherlands, called "Naviduct". This structure, its design and construction have already been presented in our magazine, see reference [14]. Fig. 15 shows a side view of the Naviduct (a) and a layout of miter gates in one of the two crowns (b). Note that each chamber has only one miter gate, pointing outside, although high water can in this case appear from both sides. This means that one lock crown always carries a reverse ("negative") load. To prevent that this load opens the gate, the hydraulic drive cylinders pre-stress the gate in closed position. The system operates satisfactory since April 2003. Its operation conditions are, in fact, similar to those of the lock in prospective canal through Vistula Spit (Mierzeja Wiślana) that is being designed at the time of

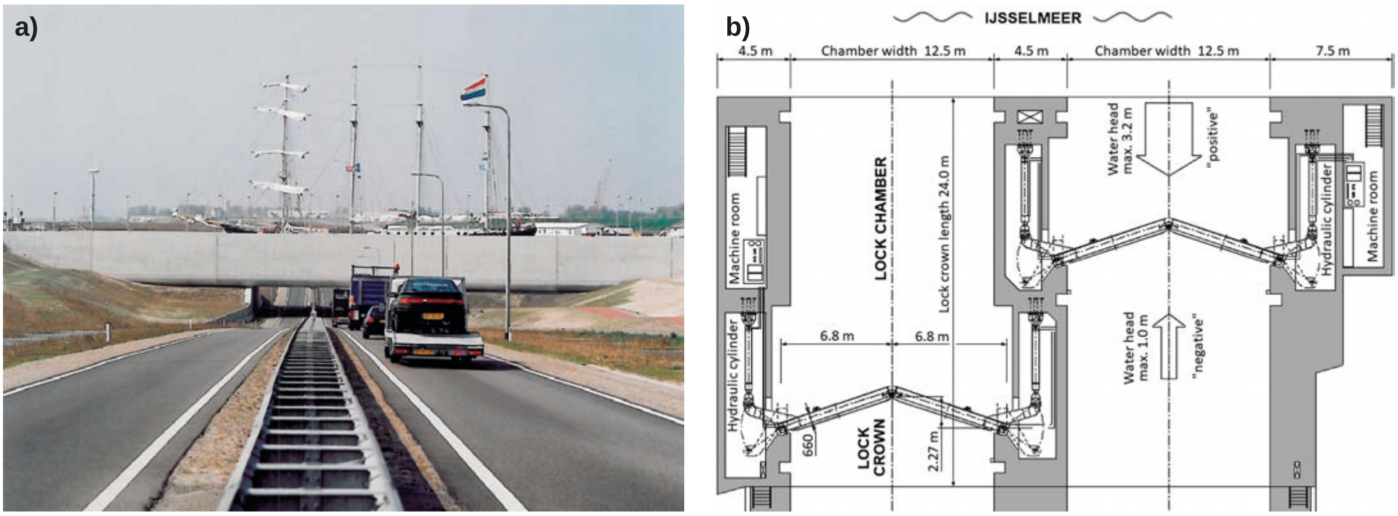


Fig. 15. Naviduct Enkhuizen and its lock gates: a) 4-masted schooner passing the Naviduct; b) layout of miter gates on the IJsselmeer side

writing this article [15]. In the author's opinion, it is regrettable that a similar, collision-free solution has not been considered for this project.

CONCLUDING REMARKS

The discussed report of the PIANC Working Group 154 "*Mitre Gate Design and Operation*" contains, obviously, more than the classification and general presentation of miter gate types. It is impossible to address every chapter of such a report in a single article. The readers of *Inżynieria Morska i Geotechnika* are encouraged to take notice of the whole report, that will soon be available on the PIANC website www.pianc.org.

It should, however, also be mentioned that reports – no matter how detailed – never contain the amount of scientific and technical expertise that has been shared during the meetings of international working groups. Not to mention the social contacts that arise during physical meetings, and help keeping the knowledge of participating organizations up to date. This applies particularly to maritime nations that, by nature, owe large parts of their wealth to international contacts. In this view, the Polish participation in the work groups of PIANC is, unfortunately, very small. To say it plainly, this does not suit a maritime country. One may hope that the recent years of some renewed interest in the inland and maritime navigation in Poland will gradually improve this situation.

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