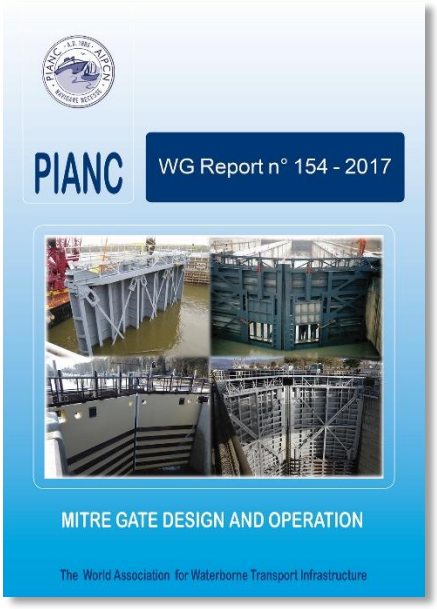
PIANC WORKSHOP

'MITRE GATE DESIGN and OPERATION'



6 November 2017

Brussels – BELGIUM
PIANC Headquarters:
Ferraris Building,
Boulevard Albert II, 20 – 1000 Brussels

In the framework of
the PIANC InCom Report n°154

A similar conference (in French) will be organised in Paris on 7 November 2017, with most of the same speakers.
For more info contact: Mr Fabrice DALY - fabrice.daly@vnf.fr

!!! Maximum 80 participants including a maximum of 20 YP's/students!!!

The workshop on 6th Nov. is a one day event to launch and promote the new PIANC Report n°154 on **Mitre Gate Design and Operation** (published by PIANC in August 2017).

We will start by a presentation of the new PIANC Report by the members of the WG (focusing on the new innovative concepts – with an updated state of art), followed by an open forum with worldwide experts discussing about the lessons learnt from mitre gate failures that happened recently in several navigation locks.

REGISTRATION

http://www.workshopregistration.pianc.org/workshopmitregate.htm

AGENDA

8:00 Arrival - PIANC Headquarter Brussels

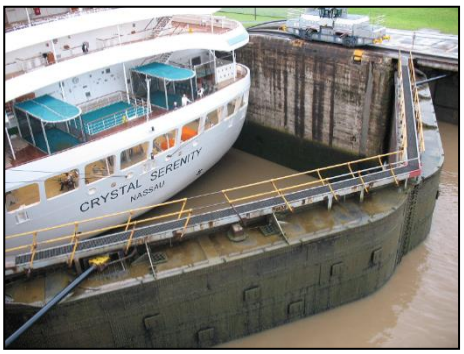
8:20 **Welcome** by Philippe Rigo, PIANC InCom Chair

8:30 - 10:00 **MITRE GATES DESIGN AND OPERATION – Part 1**

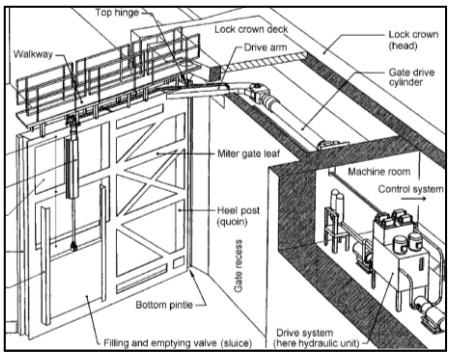
Presentation of the PIANC Report n°154 on Mitre Gates (*)
Chair: Fred Joers, Moderator: Philippe Rigo

Focus on the new innovative concepts & updated state of art by

- Fred Joers (USACE, USA): Introduction
- Ryszard Daniël, PhD. Eng. (RADAR Structural, NL): Load transfer, Hinge, Pivot, …
- Joshua Repp (Bergmann Assoc., USA) – Mitre Gate Design



Mitre Gates of the 1st & 2nd Set of Miraflores Locks, Panama



10:45 - 11:15 Break

11:15 - 12:30 **MITRE GATES DESIGN AND OPERATION – part 2**

Presentation of the PIANC Report n°154 on Mitre Gates (*)
Chair: F Joers, Moderator: Ph Rigo

- Jos Vorstenbosch (RWS, NL) – Materials & Use of FRP in MitreGates
- Eric Johnson (USACE, USA) – Mitre Gate Seals
- Yvan Cordier (VNF, FR) – Operations and Maintenance and Ancillary Components

12:30 - 14:00 Lunch

14:00 - 17:30: **Expert Panel**

Exchanges of experience & lessons learnt from the failures happened recently at few mitre gates,

Introduction by Fred Joers, WG154 Chair

14:00 - 15:30 **PRESENTATIONS OF THE STUDY CASES (lessons learnt)**
Moderator Ph Rigo

The following speakers will present the

- Lanaye Mitre Gates (BE), by David MONFORT, Bureau Greisch (BEG)
- Ivoz-Ramet Mitre Gates (BE), by Stéphane BARLET, SPW
- Evergem Mitre Gates (BE), by Jeroen VERBELEN, W&Z
- Cracking of USA Mitre Gates, by Eric JOHNSON, USACE, USA
- Cracking of Embedded Anchorage, by Fred JOERS, USACE, USA
- Maasbracht Lock Gates, by Jos VORSTENBOSCH, Rijkswaterstaat, NL

15:30 - 16:00 Break

16:00 - 17:15 **OPEN DISCUSSIONS**
Moderator Ph Rigo, InCom Chair, Prof. ULg

Expert Panel composed of:

- Rigoberto H. Delgado V., Panama Canal Authority
- James Costello, TetraTech, USA
- David Monfort, Bureau Greisch (BEG), Belgium
- Stéphane Barlet, SPW, Belgium
- Jeroen Verbelen, W&Z, Belgium
- Uwe Enders, BAW, Germany

and the PIANC WG 154 Members (*)

17:15 - 17:30 **CONCLUSION:**

Ph. RIGO, INCOM Chairman, and
Fred JOERS, WG154 Chairman on Mitre Gates (2017)

17:30- 18:00 Drink

(*) With the support of the WG 154 members:

- Frederick Joers, Eric Johnson, John D. Clarkson and Thomas Hood, USACE, USA
- Andrew Bator, St Lawrence Seaway, Canada
- Yvan Cordier, VNF, France
- Richard Daniel, RADAR Structural, NL
- Jos Vorstenbosch, RWS, NL
- Michael Hough, TetraTech (USA)
- Joshua M. Repp, Bergmann Associates, USA
- Juan Ollero, INROS LACKNER, Germany,
- Joris Meersschaert and Dieter Gevaert, SBE, Belgium

EXPERT PANEL (from 2 pm to 5:30pm)

Exchanges of experience & lessons learnt from the failures happened recently at few mitre gates

PRESENTATIONS OF THE STUDY CASES (lessons learnt)

1) Lanaye Mitre Gates (BE),

greisch

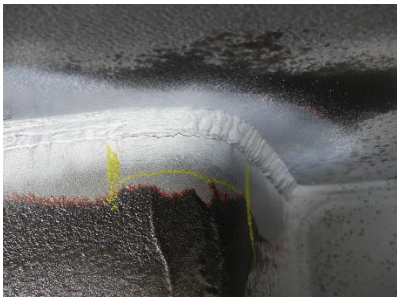
Speaker:

Name: David MONFORT
Position: Head of Department of infrastructures
Company: Study Office Greisch, (BEG)

Title: Crack Initiation on stiffeners & repair method, Downstream mitre gate - 4th lock of Lanaye (BE)

The new class VIb lock of Lanaye (225mx25m) is equipped with a downstream mitre gate. The lock water head is 14 m. The lock was inaugurated in July 2015.

One year later, a series of cracks were detected along the vertical stiffeners of both leaves of the miter gates.



A close collaboration started straight away between all the involved services (Public Administration, Contractors, Study Office, Supervising Office and Insurance). A series of investigations and additional calculations were performed (residual stresses due to welding method, combination of bending and shearing effects in the stiffeners, fatigue induced cracking,...).

The technical explanation was found out a few weeks later: the filling and emptying cycles of the lock generate a repeated local distortion of the horizontal box girders, whose webs are directly connected to the vertical stiffeners (U-rib). Local bending stresses appear and lead to fatigue cracking (oligo-cyclic phenomenon).

2) Ivoz-Ramet Mitre Gates (BE)

Speaker:

Name: Stéphane BARLET
Position: Civil servant - Project Engineer
Administration: SPW – Waterways of Liège, Belgium

Title: Ivoz Ramet (BE) - Two locks equipped with mitre gates - Two modes of transmission of the forces

The Ivoz-Ramet lock site has two locks equipped with mitre gates. The problems met in these 2 locks relate both to the transmission of the forces coming from the mitre gates to the sidewalls. Indeed, the transmission mode of the forces to the sidewalls depends of the orientation of the contact surfaces of the support blocks. When closed (under differential water level), the gates of the 1st lock transmit a part of the water pressure to the support blocks and the other part to the hollow quoin and the bottom sill ("mixed solution").

The gates of the 2nd lock transmit all forces to the support blocks only ("pure solution"). This means that the support blocks are oriented to take all the forces. Each concept has advantages and disadvantages, which may induce troubles.

Indeed, the mixed solution (1st lock) allows a better sealing but the large number of degrees of freedom reduces the control of the behaviour. At this 1st lock, an upper tie rod breaks (Figure 1) and the seal (glue) using to fix the neoprene on its supports does not resist, allowing the neoprene moving (Figure 2), inducing navigation interruption. Corrosion of the spring washer, small ship impacts and manufacturing defects (neoprene sealing) are at the origin of successive failures (problems).

On the other hand the pure solution (2nd lock) requires more precise adjustment and is very sensitive.

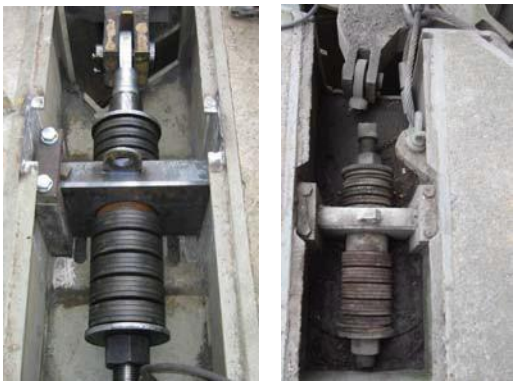


Figure 1: The "Belleville springs" elastic connexion (of the upper tie rod with the gate), which failed (cracks occurred in the springs).

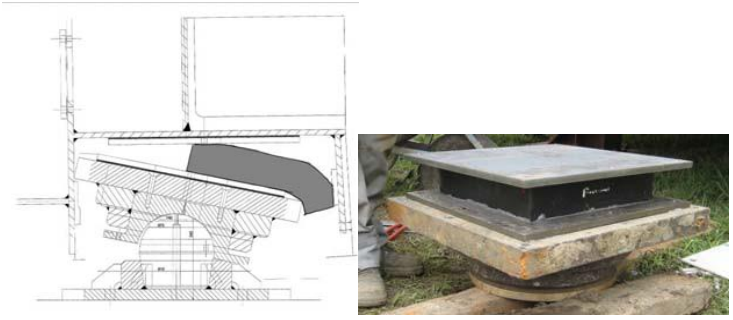


Figure 1: The lower support with the pintle (rotation around vertical axis) and a neoprene support (as in bridge) to allow heeling and a small horizontal displacement

3) Evergem Mitre Gates (BE)

Speaker:

Name: Jeroen VERBELEN
Position: Project Engineer
Administration: Waterwegen & Zeekanaal NV (W&Z)
Dpt. BovenSchelde, Flanders/Belgium

Short presentation of the technical problem(s) which occurred, the possible reasons (causes) and how the problem(s) where solved:

(5-15 lines: Start by giving the lock name (close City, Country), lock dimension and water head and explain the problem that occurred – please use pictures and drawing)

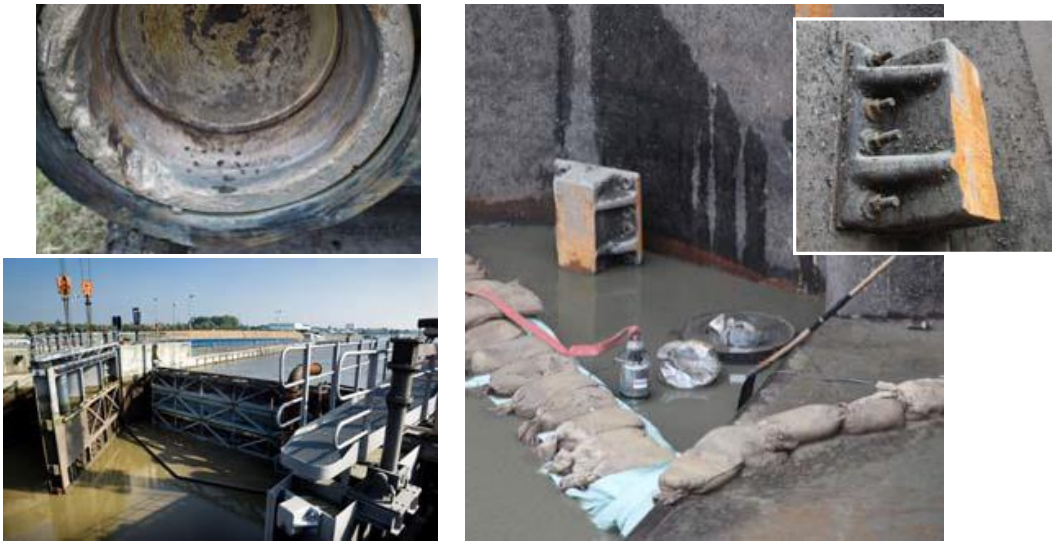
Title: Failure and adjustment of the gate alignment, Upstream and downstream mitre gates; 2nd lock of Evergem (BE)

The new class VIb lock of Evergem, near Ghent, was inaugurated in 2009. The lock has identical pairs of steel miter gates with a single leaf dimension of 14m x 8m and weight of 90 tons. The design lock water head is 3m.

In 2014 significant problems occurred when the gates reached the closed position only under a higher force (jacks). As part of a first repair was performed in March 2014. It concerned the upper connection between the gate and the pivot, which was strengthened on all gates, after a diving inspection had pointed out that almost all bolts of the upper connection were cut off. Several theoretical calculations and field investigations were made.

In August 2014 similar problems occurred during the closing of the gates. In addition a cracked pivot and some support blocks that was torn off the wall where observed. On all gates the support blocks at the back post showed severe wear. The repair strategy was threefold. First a detailed 3D alignment survey was carried out. Subsequently a virtual geometric simulation indicated that an unhindered gate motion was not possible. Finally the alignment of the rotation axis and all support blocks and seals were adjusted on all gates.

At present the lock is in full operation. The necessity of final adjustments is under investigation. Meanwhile a lawsuit against the contractor is ongoing.



4) McAlpine and Lower Granite Mitre Gates (USA),

Speaker:

Name: Eric Johnson
Position: Structural Engineer
Administration: US Army Corps of Engineers

Title: Cracking of USA Mitre Gates near the Pintle (Bottom Pivot)

In the USA, there has been widespread problems with miter gates cracking near the pintle (bottom pivot) of the gate. The main cause is lack of bearing contact of the gate-to-wall contact blocks. When contact is lost, the large hydrostatic forces acting on the gate are transferred horizontally along the gate through the main framing beams into the pintle (pivot) instead of into the wall bearing area. This causes large localized stresses in the pintle region which when coupled with poor material fracture toughness and poor geometrical detailing leads to cracks.

In 1998, cracks were discovered in the skin plates and bottom girders of both gate leaves at the Lower Granite Lock on the Snake River in the state of Washington (See figs on the right). A variety of repair techniques were used to get the gate back into operation.

In 2004, in the McAlpine Lock on the Ohio River cracks were found, which lead to emergency repairs and temporary lock closure. The lock gates were repaired using large patch plates (See Fig bottom left.

5) Poe Lock at Soo Locks Complex (USA)

Speaker:

Name: Frederick Joers
Position: Director, Inland Navigation Design Center
Administration: US Army Corps of Engineers

US Army Corps of Engineers®

Title: Cracking of Mitre Gate Embedded Anchorage (Top Hinge)

The Soo Locks are located on the St. Marys River at Sault St. Marie, Michigan, on the international border with Canada. There are two operating locks at the Soo, the MacArthur Lock, (1943) and the Poe Lock (1968). They are critical locks since half of all steel produced

in the U.S. is manufactured with domestically mined ore and over 92 % of the iron ore mined in the U.S. traverses through the Soo Locks.

The miter gate embedded anchorages were being studied as part of a Rehabilitation Report. An analysis revealed a potential near-term risk of failure in the upper region of the embedded anchorage. The study concluded that Embedded Anchorages exceeded their life expectance and would likely perform until they experience a "SUNNY DAY" brittle failure with little to no outward signs of distress or warning – resulting in mitre gate collapse.

Based on the study findings, concrete was removed to uncover and inspect the anchorages. Inspection found cracks where the analysis predicted. All the embedded anchorages at the lock were rehabilitated to keep lock in good operation condition.

6) Maasbracht Lock Complex (The Netherlands)

Rijkswaterstaat

Speaker:

Name: Jos Vorstenbosch
Position: Senior Consultant
Administration: Rijkswaterstaat

Title: Maasbracht Lock Gates

The Maasbracht Locks (Sluizencomplex Maasbracht) located on the Juliana Canal in the Netherlands. A variety of interesting issues will be discussed including hinge design using FRP, anchorage failure, fatigue design of welded connections, and contact blocks using FRP.