PIANC InCom – Work Group 29

Innovations in Navigation Lock Design

- Report n°106, 2009 -

Prof. Philippe Rigo
Chairman WG29
University of Liege, Belgium

WG29 - LOCK INNOVATIONS

The PIANC report n° 106 (soon published):

- **Complement to PIANC 1986 report.**
- **Targets: innovations and changes occurring since 1986**

NEW LOCK INNOVATIVE TOPICS

- Hydraulics (filling and emptying),
- Operations and Maintenance,
- Environmental,
- Design (concrete, foundation, gate,…),
- Construction Mode,
- …..

WG29 - LOCK INNOVATIONS

Major changes in design since 1986 concern:

- **Maintenance and Operation aspects,**
- **New goals** at the conceptual design stages of a lock
  - ➔ RELIABILITY , LIVE CYCLE COST, …
- **Renovation and rehabilitation** of existing locks are also key issues for the future.

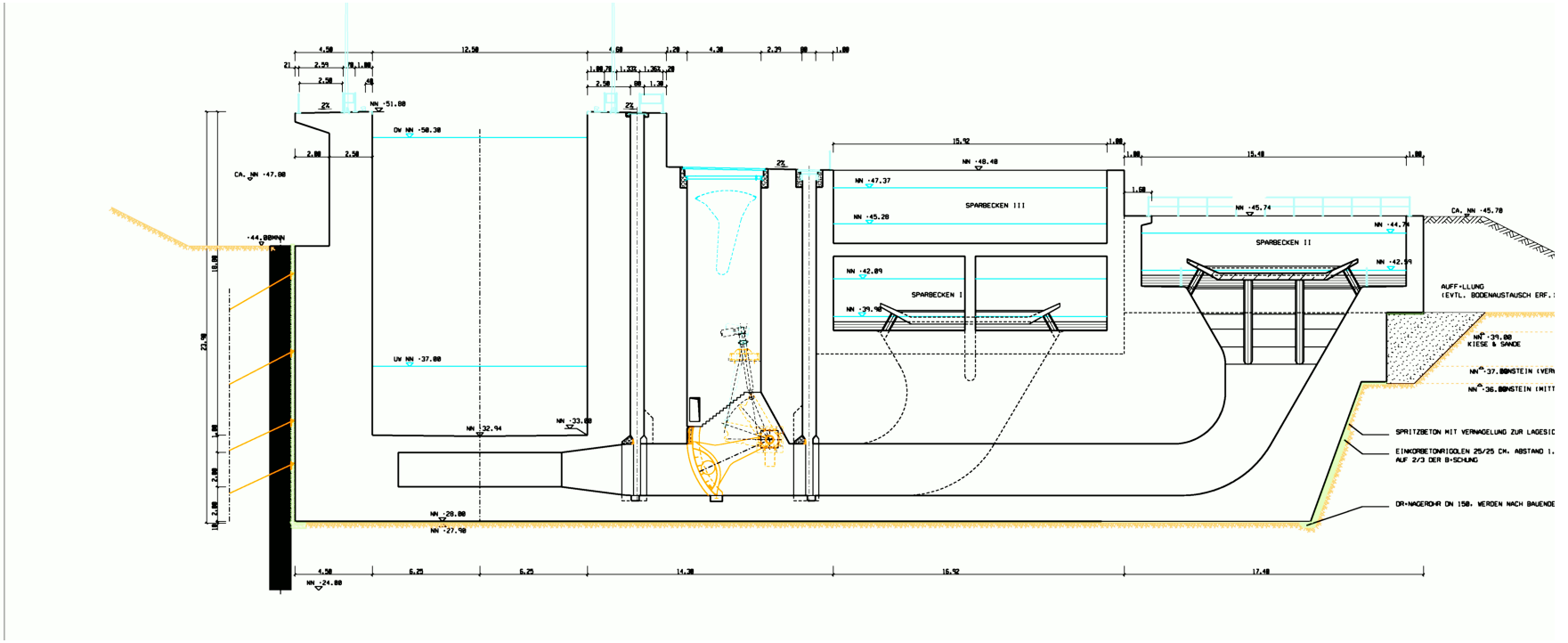
DESIGN PRINCIPLES

1. "**Risk based design**" versus "Deterministic approach"

2. "**Life cycle cost optimisation**" versus "Least construction cost"

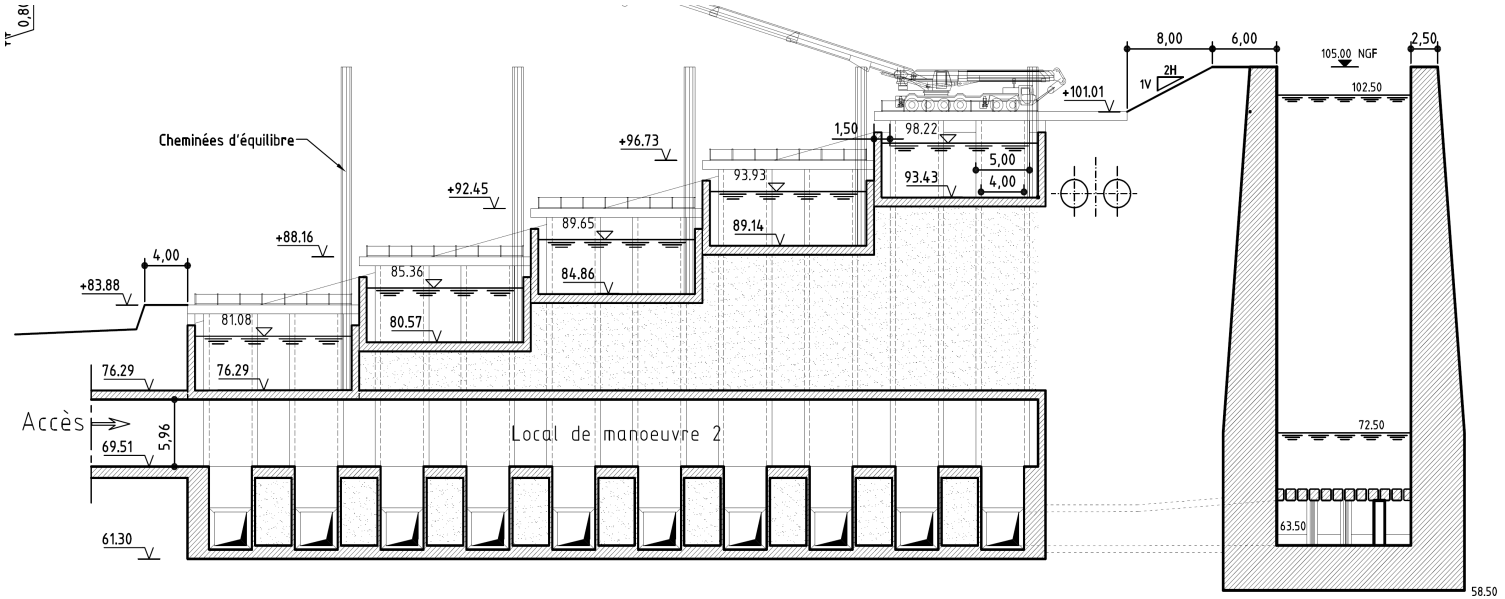
3. Use of "**Numerical Modelling**" as design tool

NEW LAYOUTS OF HYDRAULIC SYSTEM



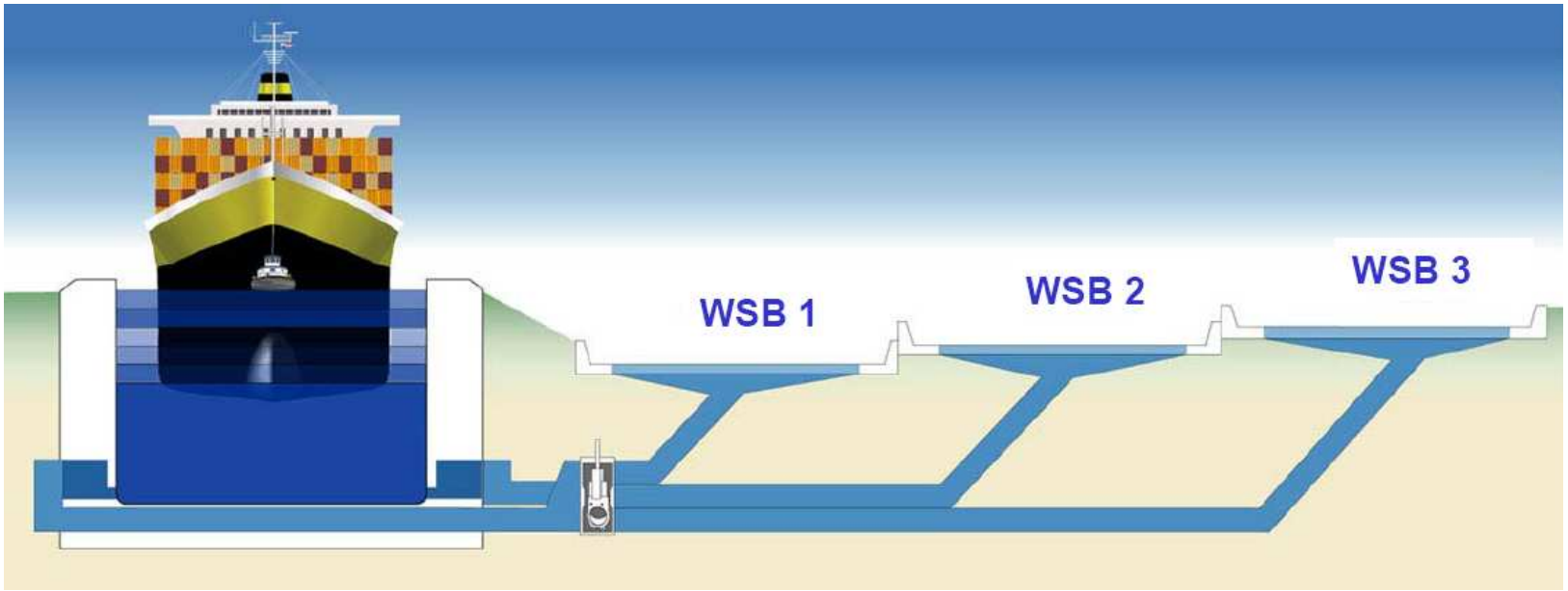
Connection of pressure chamber to WSBs basins (upper) and to main chamber (lower)➔ Germany

Various types of Water Saving Basins.



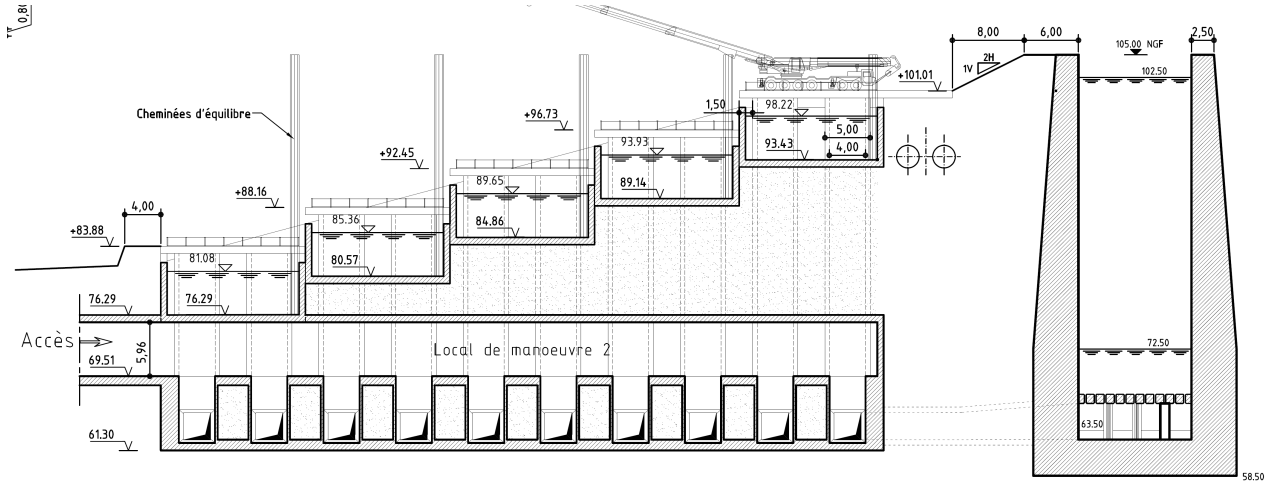
Water Saving Basins (WSBs)

Locks with separated WSBs (located on one side or both sides of the lock, on a series of steps)



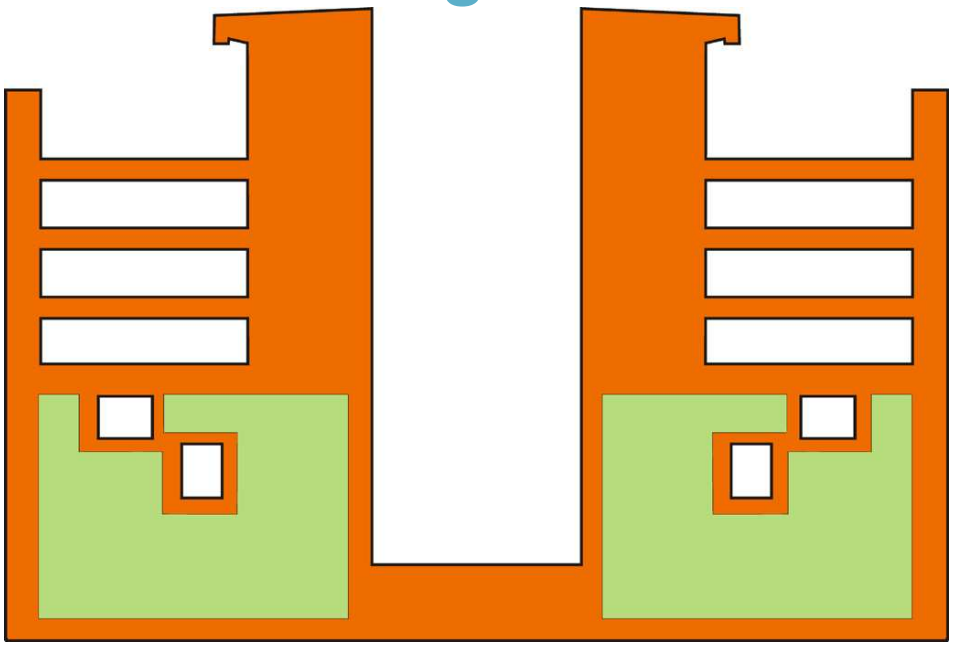
Water Saving Basins (WSBs)

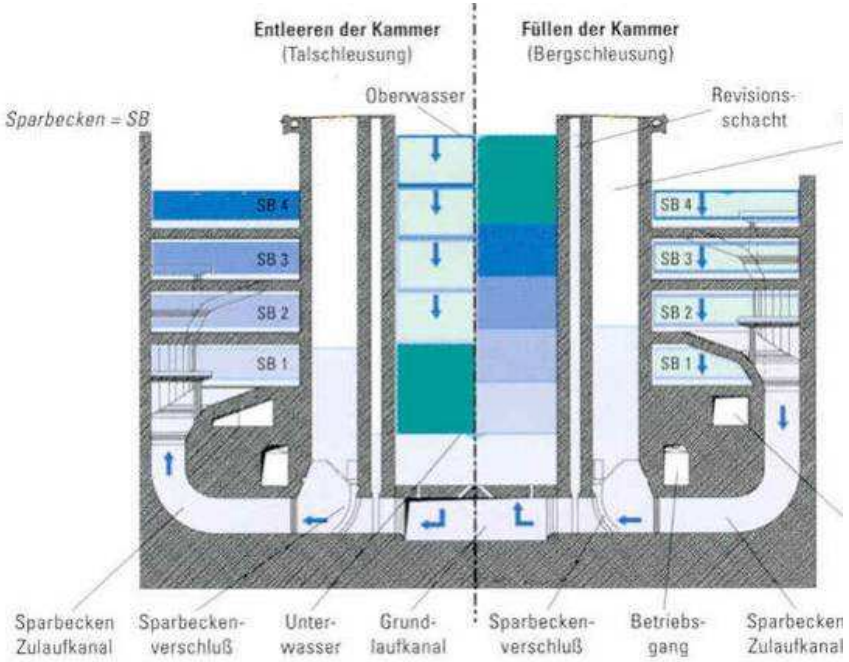
Cross-sections in a lock with 5 standard laterally located Water saving basins (filling through the pressure chamber in the lock floor)



Integrated WSBs

The integrated system which integrates the WSBs in the two side walls, and makes the lock structure more stiff, compact and less land consuming.





Cross-sections in lock sidewalls with integrated WSBs

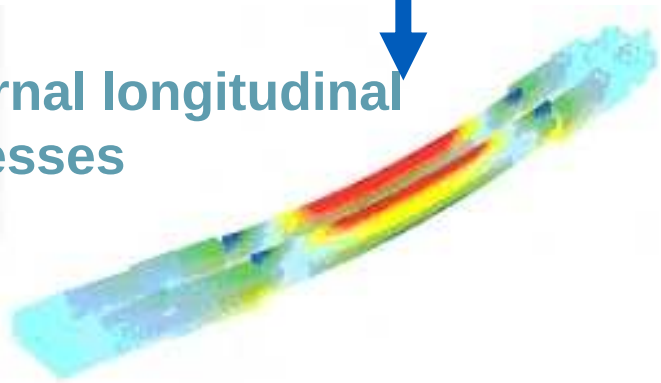
Monolith LOCK

Standard Concept
With dilatation joints

No internal longitudinal stresses

Monolith Concept
Without dilatation joints

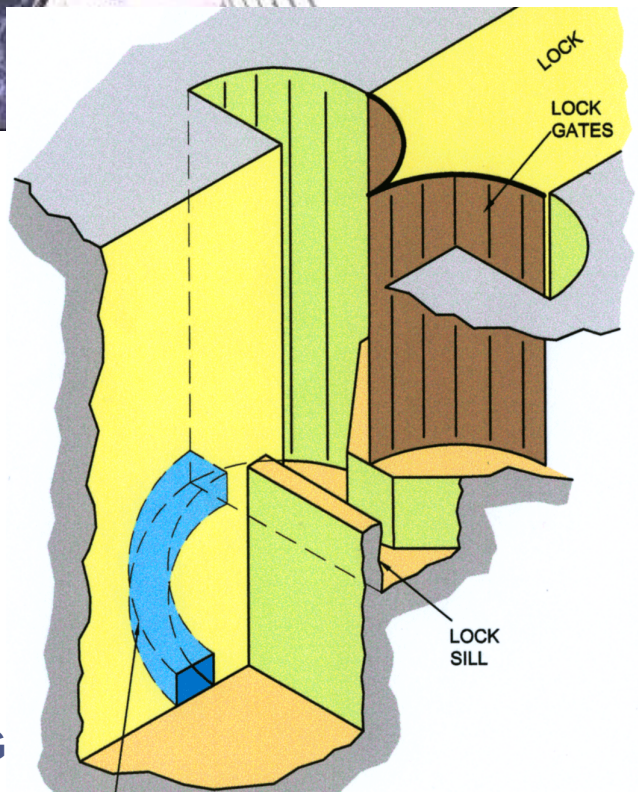
Internal longitudinal stresses



Complementarities between modeling

STEP	PHYSICAL MODEL	NUMERICAL MODEL
1	Definition of the problem	
	Identification of the essential acting forces	
2	Formulation of similarity requirements	Formulation of sets of equations
3	Formulation of boundary conditions	
4	Construction of a model	Development of a numerical solution scheme
5	Calibration of the model	
	Variation of roughness	Variation of coefficients
6	Measurements & solution	Calculation and solution
7	Optimization of the solution according to problem formulation	
	Model geometry variations	Variation of input data
8	Transfer of results from model to prototype	
	and examination by field measurements	

GATES AND VALVES

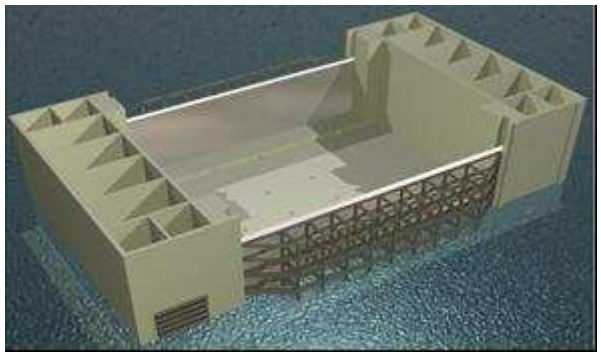


Construction Modes

The lock chamber is constructed on the ground surface.

When complete the soil is removed beneath the lock chamber and it is lowered into its final position.

Prefabrication



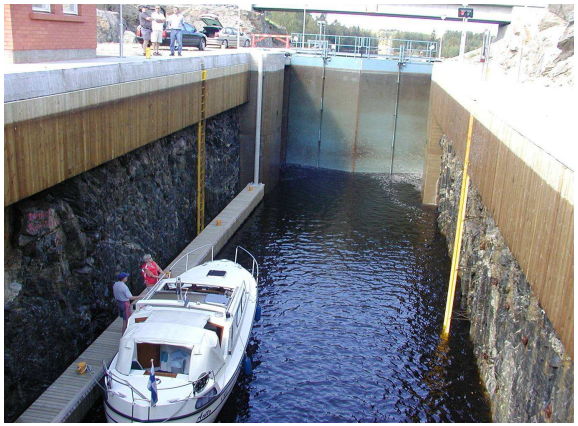
InCom WG 29 Members

BÖDEFELD J. & THORENZ C. (Germany)
BOS J., HIJDRA A., PECHTOLD E. (The Netherlands),
CLARKSON J., MILLER D., TARPEY M. (USA),
DALY F., PICHON N., POLIGOT-PITSCH S. (France),
HIVER J-M., RIGO Ph. (Belgium),
FERNANDEZ José (Spain),
HOLM Olli (Finland),
HUNTER Peter (UK),
SARGHIUTA Radu (Romania),
WONG Juan (Panama) and WU Peng (China)
+ Support Groups (BE, Brazil, NL, Panama, USA)

+ Sponsors

PIANC WORKSHOP
– Innovation in Navigation Lock Design –

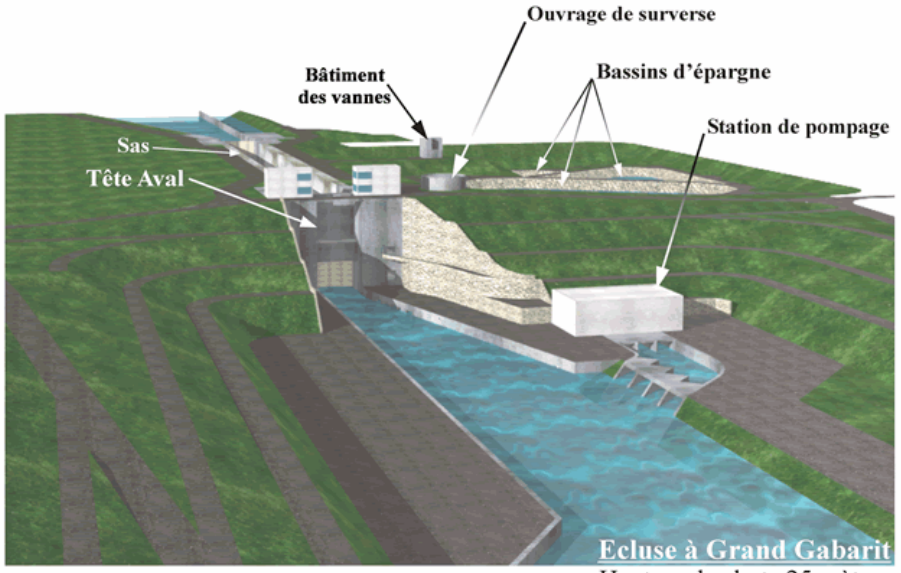
15th & 17th October 2009
In Brussels
(25th Anniversary of PIANC Belgian Section – Sponsor)



PIANC WORKSHOP – 15 & 17th Oct 2009 -Brussels – Innovation in Navigation Lock Design -

9:00- 10:00 **Innovations in Navigation Lock Design -**
Presentation of the new PIANC Report n°106 on LOCKS

10:00 – 10:45 **The locks of the Seine Nord Europe Canal -**
Key note speaker 1
by B. DELEU (VNF, France)



PIANC WORKSHOP – 15 & 17th Oct 2009 -Brussels – Innovation in Navigation Lock Design -

11:15 **Innovations in lock filling and emptying systems**
State of art
by J. HITE (USA, Corps of Engineering.)
Discusser: Wu PENG (China)

15:00 **25th Anniversary of Belgium Section** – TERVUREN -Brussels (ceremony)

19:00 **Dinner** – TERVUREN (sponsored by PIANC Section)

PIANC WORKSHOP – 15 & 17th Oct 2009 -Brussels – Innovation in Navigation Lock Design -

16th October : Morning

The new locks of the Panama Canal

Key note speaker:

Mr Juan WONG

ACP, Panama

16th October- 10:00 am

Salt Water Intrusion in Navigation Lock
Mooring Forces and Ship Behaviour-

➔ State of art

➔Panel Discussion

Chairman : J. BOS

Panel of experts:

T DE MULDER, M SAS, A VRIJBURCHT, A. HIJDRA, …

PIANC WORKSHOP – 15 & 17th Oct 2009 -Brussels – Innovation in Navigation Lock Design -

16th October, Afternoon

- ➔ **Lock Gates - State of art by Ph. RIGO (Belgium)**
- ➔ **Computer Fluid Dynamics (CFD) in Lock Design - State of art by C. THORENZ (Germany)**
- ➔ **Numerical simulations and Experimental models: How to choose?**

  Panel Discussion: Chairman: Jean- Michel HIVER (SPW, Belgium)

  Panel of experts: C. THORENZ (D), S. ROUX, O. CAZAILLET(*), A VRIJBURCHT
- ➔ **Closure by the PIANC President, Mr Eric VAN DEN EEDE and a Representative of DG Transport (European Commission)**

17th October, Morning

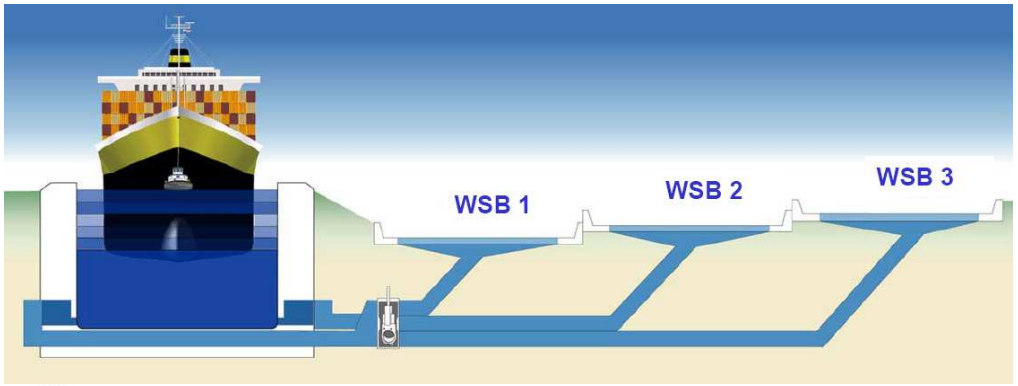
Technical visit at the Van Cauwelaert Lock in Antwerp

which is a sea lock under renovation

Thank you and welcome

At the PIANC WORKSHOP
– Innovation in Navigation Lock Design –

15th & 17th October 2009
In Brussels - Belgium



Examples of Project Reviews

Self Propelled Floating Gate (1-03)

Innovation

Alternative concept to the standard rolling gates (wheelbarrow, hydrolift) for large maritime locks.

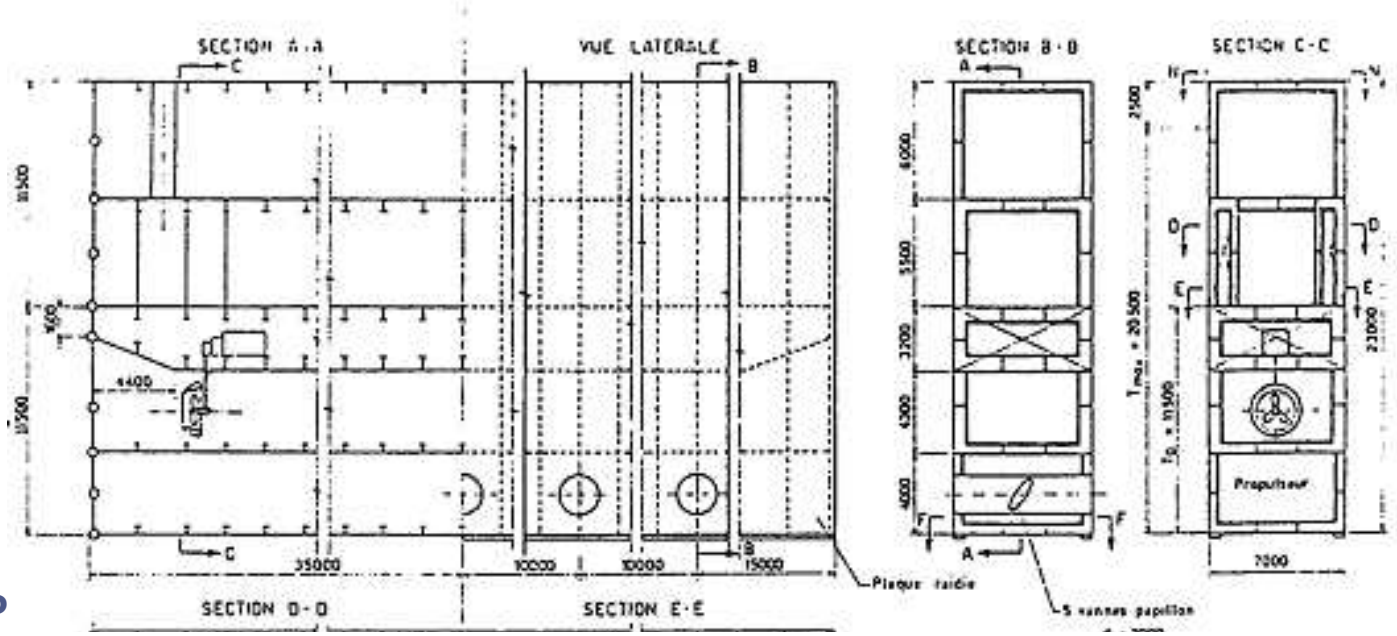
The idea is to use a floating gate that is self propelled to close/open the lock (as a transversally rolling gate does).

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length:	**NA**	Lift:	2-10 m
Width:	20 to 100 m	Depth:	10-20 m



P

Brazil Waterways (2-01)

A presentation of the state of inland navigation for Brazil and a discussion of the issues to be overcome to improve waterborne transportation in Brazil.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	N/A	Lift:	N/A
Width:	N/A	Depth	N/A

Juankoski Canal (4-01)

Locks built in rock.

Instead of building concrete lock walls anchored to the rock, a floating pontoon was designed inside the lock for the mooring of the boats and to protect the boats against collisions to the lock walls. With this design solution, the lock walls could be left with a rock surface, which led to significant cost savings.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	35 m	Lift:	6 – 6.5 m
Width:	8 m	Depth	2.4 m

Keitele Canal (4-02)

Project Description

Lock gates are **sector gates**. The fall heights vary from 2.5 m to 7.8 m. The filling and emptying of locks is done with the gates. The gate drive system is electro-mechanical.

a. Lock Design Methodology:

The locks are designed for both timber floating and barge traffic. The design barge is Europe II-type push-barge. The design timber raft is 22 bundles long and 4 bundles wide (one bundle is approx. 5 x 2.5 m). The bundles are floated trough the locks with a current created by opening upper or lower gate somewhat.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	115 m	Lift:	
Width:	16 m	Depth	4 m

Saarikoski Canal (4-03)

A timber lock with a caisson structure.
Opened in 1905 and restored in 1998.

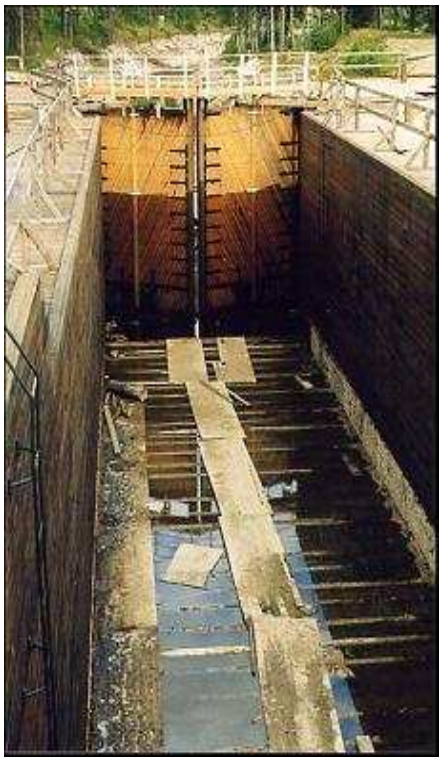
Caissons filled with rock, and the lock wall structure allows the water to run through the lock walls to the sides of the lock.

Gates are miter gates, and filling and emptying done with valves in the gates.

All lock operations are done manually with manpower.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc



Lock Dimensions

Length	30 m	Lift:	
Width:	6 m	Depth	1.8 m

Golbey Gate Replacement (5-01)

Gate composed of a circular-shaped skin plate made of glass fibres reinforced polymer (GRP or CVR = composite verre-résine) stiffened by blocks of sandwiched CVR and foam. The sluice gates are stainless steel plates. The gate is hinged to the old masonry by adjusting stainless steel frame as U form supporting hinges.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length		Lift:	
Width:		Depth	

Seine-Nord Europe (5-07)

A new canal 106 km long with seven locks as standardized as possible. One lock will be (low lift), six locks from 15m to 30 m lift.

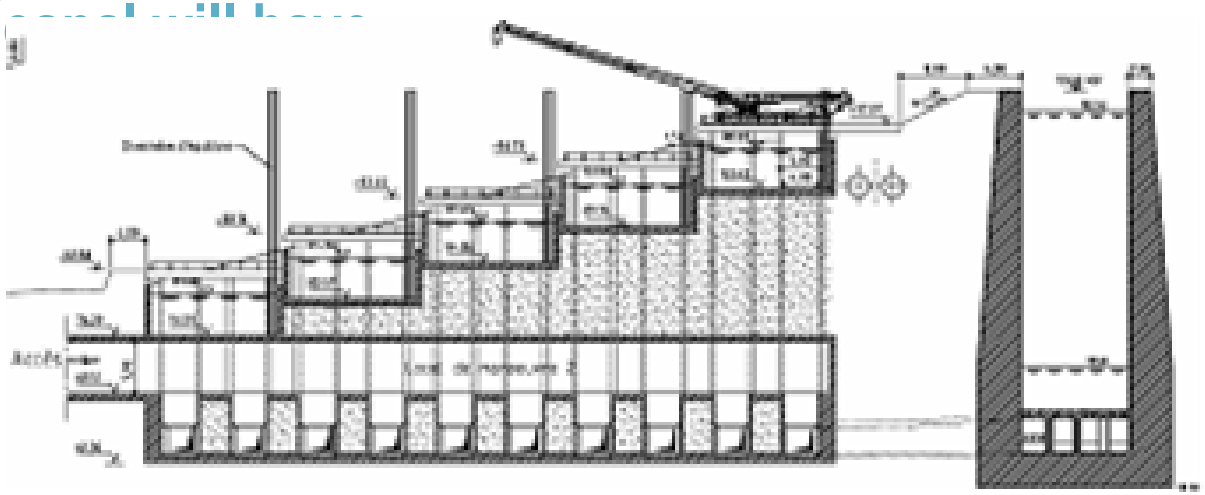
One of the main challenges is water resources management. That explains the use of water saving basins and pumping plants in the locks. Moreover, the canal will have to be very watertight.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	106 km	Lift:	15 – 30 m
Width:	12.5 m	Depth	



Hohenwarthe (6-03)

The double lock at Hohenwarthe:

- has a high static load because of its enormous permanent weight, because of the high and large-area embankment and the water load.
- During design, settlement calculations showed that a design with expansion joints creates settlement differences which cannot be handled with conventional waterstops
- Solution: to construct a monolithic bottom plate, 250 m long, 55m wide and 5.5 m high.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	190 m	Lift:	
Width:	12.5 m	Depth	

Naviduct Krabbersgat (7-03)

The ‘Naviduct’ at ‘Krabbersgat’ at Enkhuizen is a combination of a double navigation lock that includes an underpass for road traffic.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	160 m	Lift:	
Width:	42 m	Depth	

Suspended Mitre Gate (7-05)

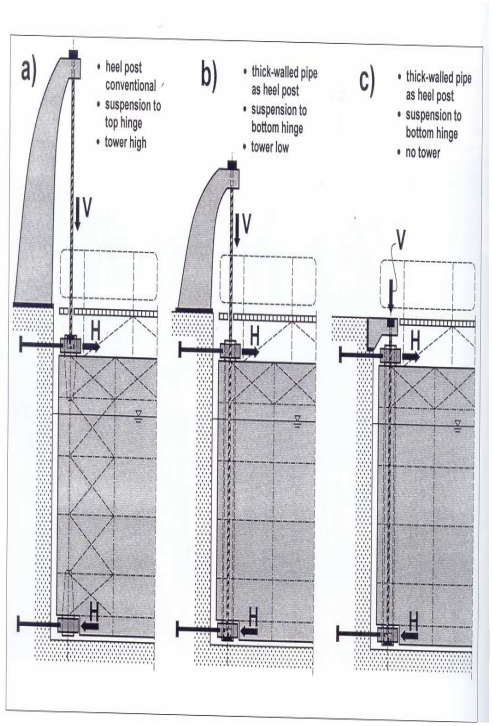
This paper outlines problems with mitre gate pintles and evaluates potential methods to mitigate the problem.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	N/A	Lift:	N/A
Width:	N/A	Depth	N/A



Panama Canal Expansion (8-01)

The unique Panama Canal Third Locks Project:

- Three-step locks,
- Each with 3 water saving basins
- Side filling and emptying system
- Non-dimensional hawser force parameters for large ocean-going vessels
- fresh and salt water on the lock limits
- lock structures sitting on two different foundation conditions
- Seismic design
- **365/24/7 uninterrupted use**

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

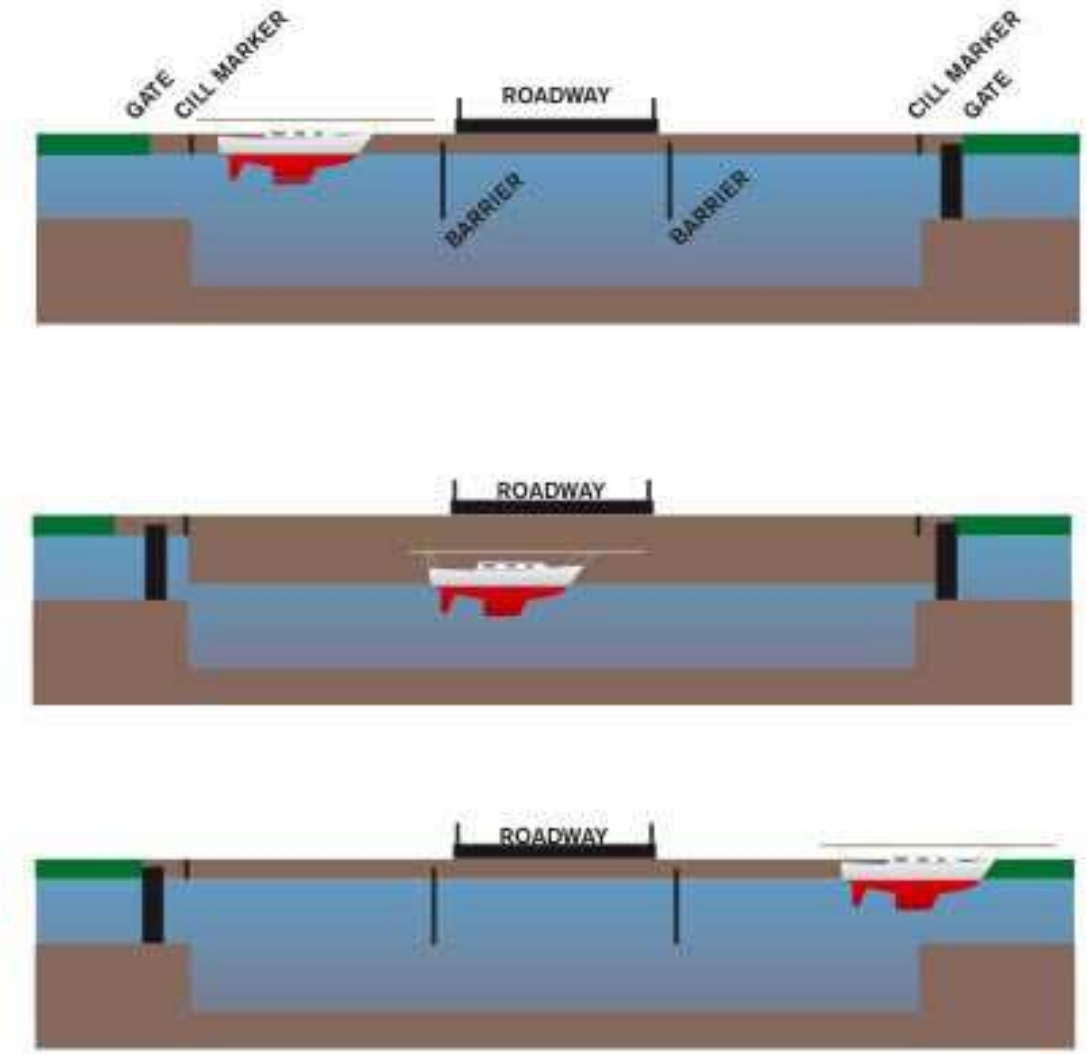
Lock Dimensions

Length	1281 m	Lift:	27m
Width:	55 m	Depth	18.3 m

Dalmuir Drop Lock (10-03)

The project consists of a long lock chamber allowing the canal surface beneath a major road to be lowered

to allow vessels to pass beneath the road



Falkirk Wheel (10-04)

Project Description

Two gondolas act as moving lock chambers mounted on the opposite ends of rotating arms centered on a central axle with a diameter of 35 metres.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length:	22	Lift:	33.5m
Width:	6	Depth	1.5

Braddock Dam (11-01)

Replacement of an existing lock and dam was completed by precasting and floating the new dam into place.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

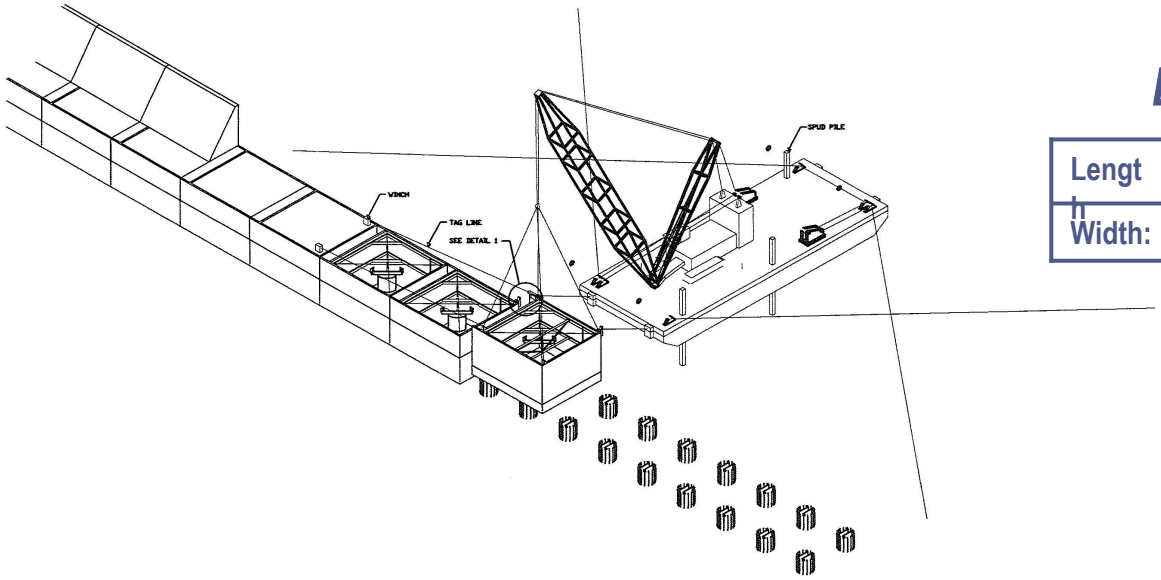
Length	182.8 m	Lift:	
Width:		Depth	

Chickamauga (11-03)

Lock renovation and expansion using lift-in construction techniques to work with difficult geological conditions and to maintain operation during construction.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc



Lock Dimensions

Length	183 m	Lift:	
Width:	34 m	Depth	

Inglis (11-05)

This innovation resulted in construction of a smaller lock inside a larger lock to save operating and maintenance costs, save fresh water, and improve manatee protection.

Areas of Innovation

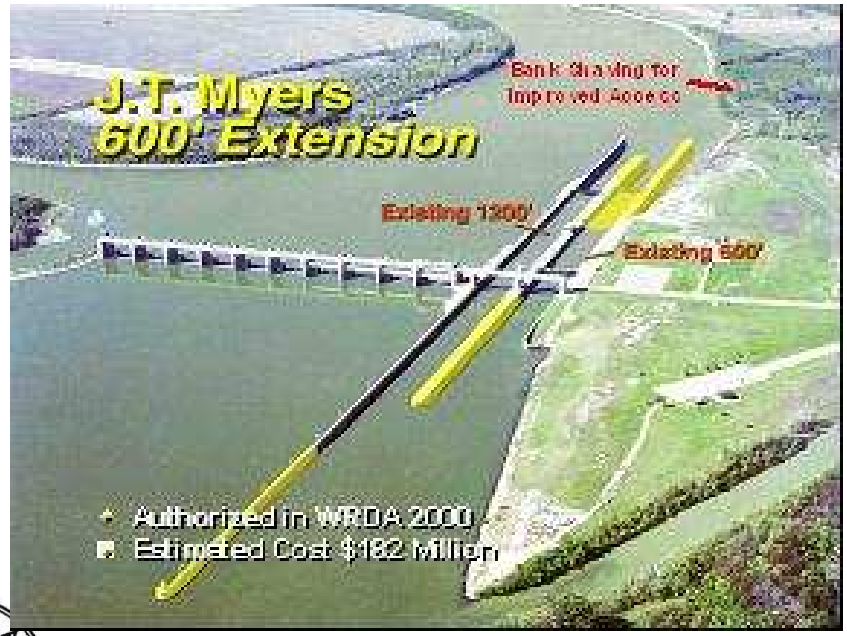
Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	50 m	Lift:	
Width:	12.2 m	Depth	

J.T. Meyers (11-07)

This project extends an existing lock from 34 m to 366 m ***using float-in construction for the approach walls*** *and supplemental thru sill filling system for newly extended chamber.*



Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	366 m	Lift:	
Width:	34 m	Depth	

McAlpine Lock (11-10)

*Use of **roller compacted concrete (RCC)** for the new lock walls.*

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length		Lift:	
Width:		Depth	

Troy Lock (11-12)

Deteriorated lock walls were retrofit with precast panels.
Resulting in a savings in cost, construction, and a potentially higher quality finish.

Areas of Innovation

Hydraulic	O & M	Environ	Design / Construct	Misc

Lock Dimensions

Length	150 m	Lift:	
Width:	13.5 m	Depth	4.9 m

Thank you and welcome

At the PIANC WORKSHOP
– Innovation in Navigation Lock Design –

15th & 17th October 2009
In Brussels - Belgium