INNOVATION
IN NAVIGATION LOCK DESIGN

By INCOM – WG29 (2006-2009)

PIANC Workshop
15-16th October 2009

By Ph RIGO
Univ of Liege- ANAST
Belgium

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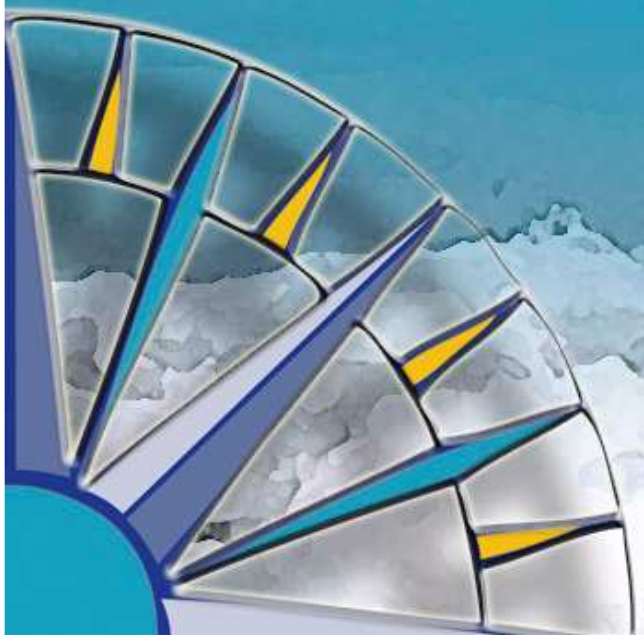

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Report n° 106 - 2009

Innovations in navigation lock design

PIANC
August 2009

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“Innovations in Navigation Lock Design”

PIANC Report n°106

Ph. Rigo
Chairman of INCOM WG29

and

E. Pechtold; P. Hunter; J. Bödefeld

PIANC WORKSHOP
– Innovation in Navigation Lock Design –

15th & 17th October 2009
in Brussels
(25th Anniversary of PIANC Belgian Section)

Workshop 15-17 Oct 2009, Brussels

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LOCK INNOVATIONS

The PIANC report n°106 (2009):

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

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NEW LOCK INNOVATIVE TOPICS

- Hydraulics (filling and emptying),
- Operations and Maintenance,
- Environmental,
- Design (concrete, foundation, gate,…),
- Construction Modes,
- Equipments,
- …..
- Design concept : Cost-Effective, Reliable,....

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WG29 – Navigation Locks

- Locks are key structures for the development of commercial and leisure navigation in rivers and canals.
- Locks are also strategic infrastructure for port development.
- In low-lying countries, locks have an important function in flood defence.

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Innovation applies to the big and fast…

GERMANY

PANAMA

… and the small and slow…

UK

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 AND OPTIMIZATION GOALS

Main design objectives governing the design of a lock are:

- Reliability - system, structures and operations,
- Reduced duration of a lock cycle times,
- Reduced water motions and mooring forces
- Avoid water resource problems (minimise water use)➔ Water Saving Basins
- Saltwater intrusion
- **Reduced life cycle cost**
- Minimizing energy use
- Avoid negative environmental impact
- Minimize impacts to navigation and local community
- Safety and Security

Early design stage

Key points at Early Design Stage are:

- Lock layout & Lock dimensions ,
- Life cycle of a lock ,
- Construction Modes or Methods,
- Layout of the hydraulic system,
- Lock structure concepts ,
- Salt water intrusion, Ice Control, Communication, Security and Safety, ...

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 (combined with physical model)

LAYOUT OF HYDRAULIC SYSTEM

Hydraulic systems for filling and emptying locks can be divided into two types:

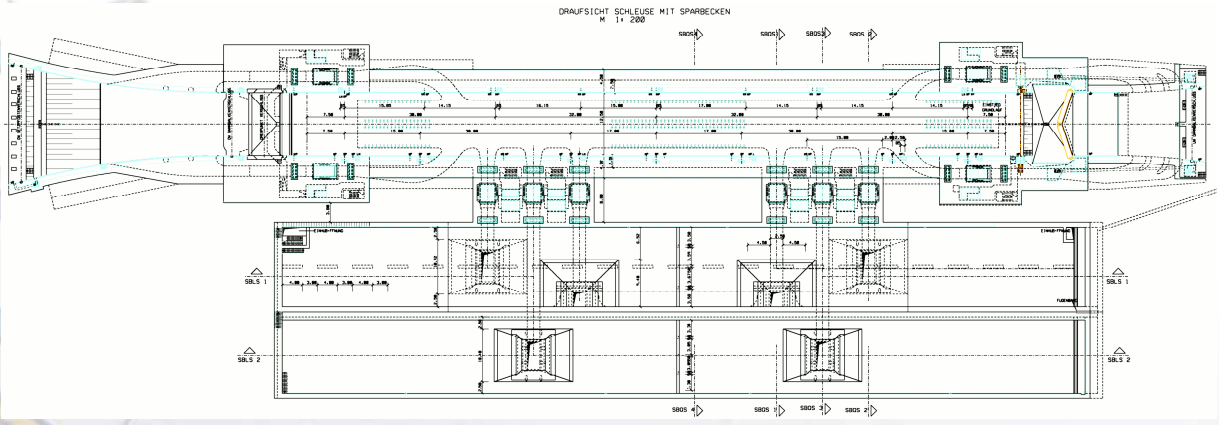
➔ *Through the heads*

➔ *Through longitudinal culverts*

Typical layouts of Longitudinal culvert system:

- *Wall culvert side port system*
- *Wall culvert bottom lateral system*
- *In-Chamber longitudinal culvert system (ILCS)*
- *Longitudinal culverts under the lock floor*
- *Dynamically balanced lock filling system*
- *Pressure chamber*

LAYOUT OF HYDRAULIC SYSTEM



Lock with Water saving basins located on the side of the lock
- Standard concept

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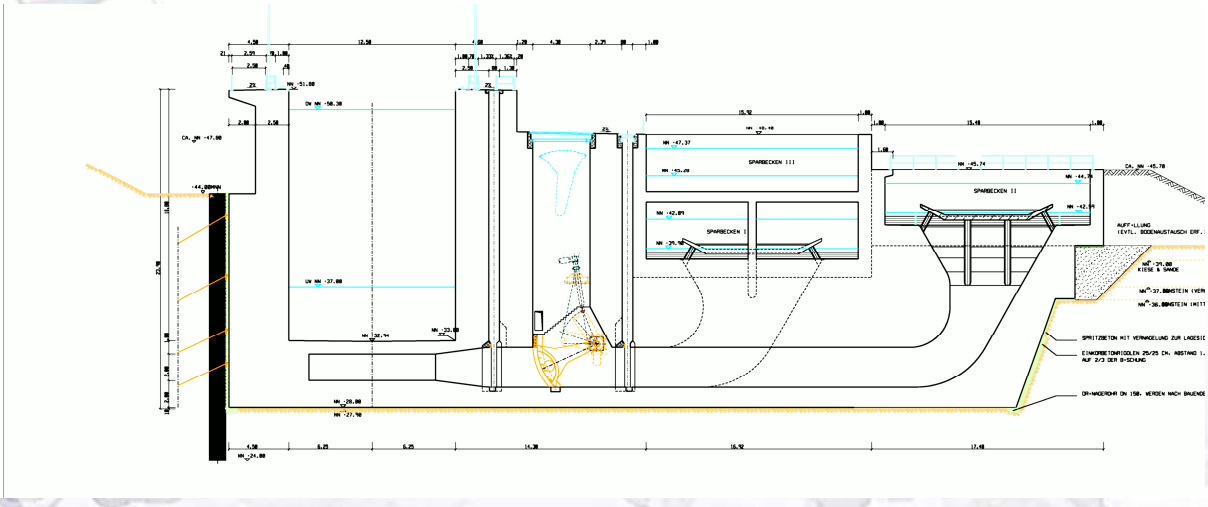
NEW LAYOUTS OF HYDRAULIC SYSTEM



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

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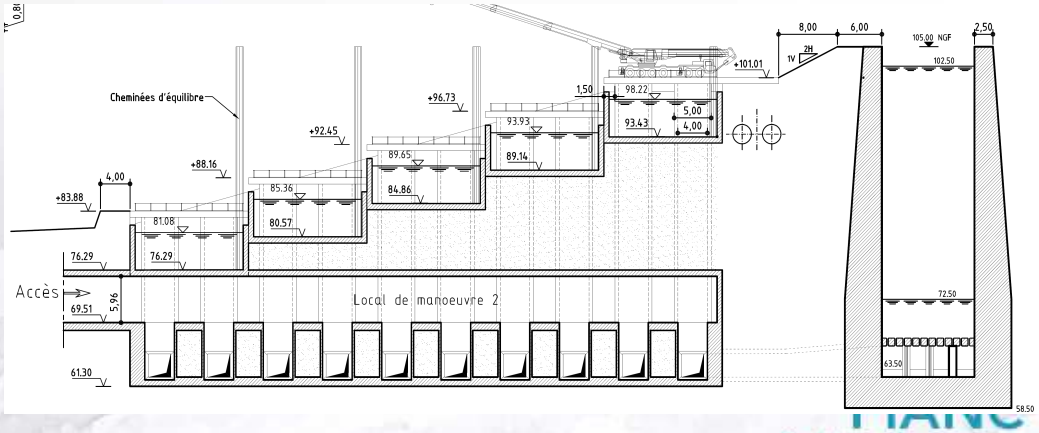
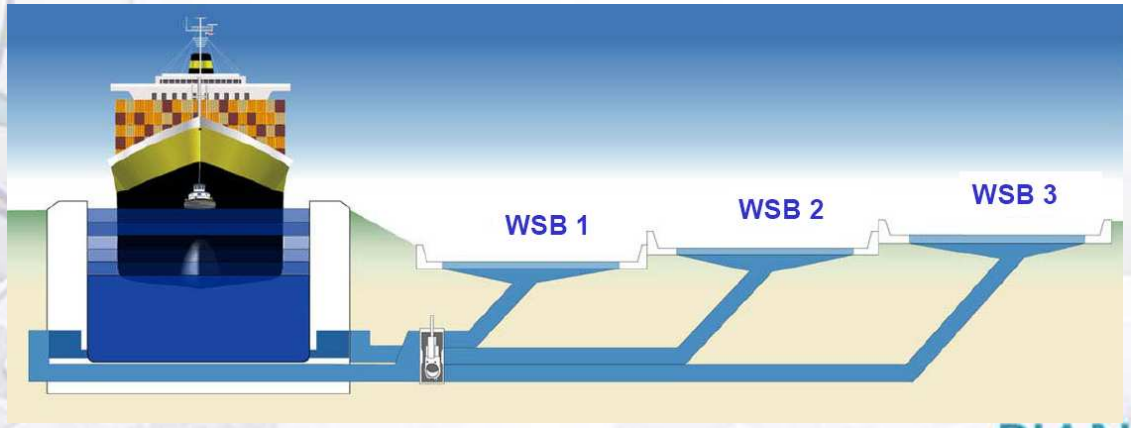
Water Saving Basins (WSB**s**)

Various types of Water Saving Basins.



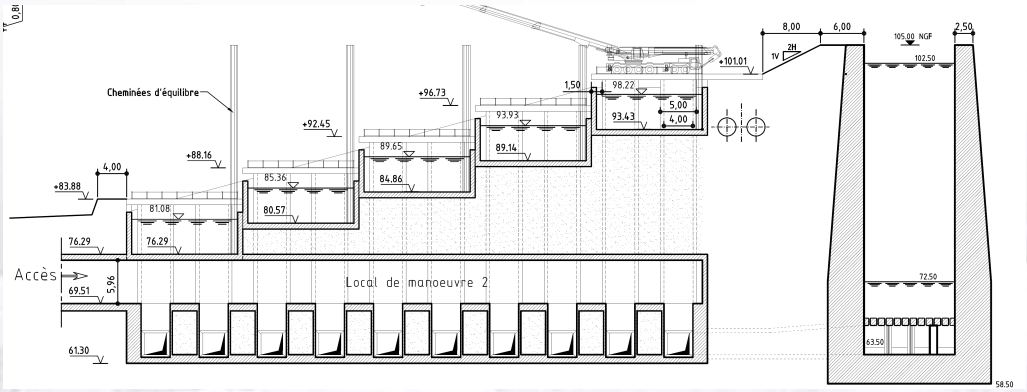
Water Saving Basin (WSB)

Locks with <u>separated WSBs</u> (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)



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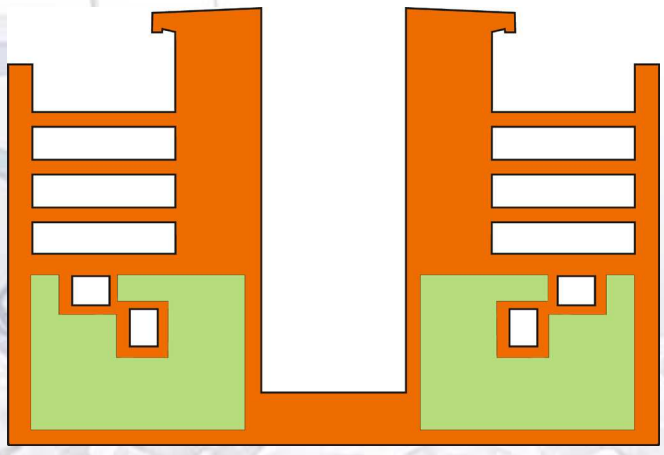
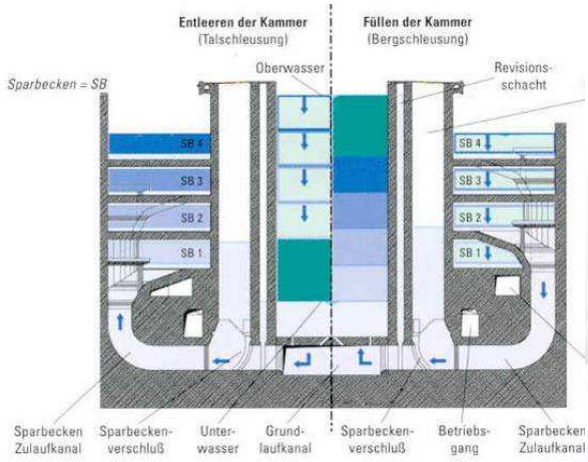
Integrated WSBs

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





Lock sidewalls with integrated WSBs

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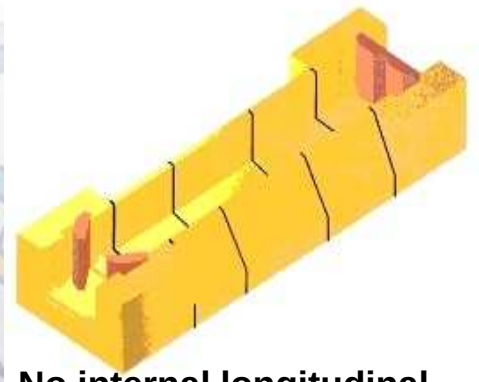
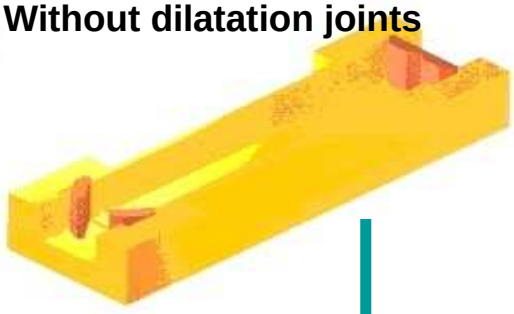
Monolith LOCK

Standard Concept
With dilatation joints

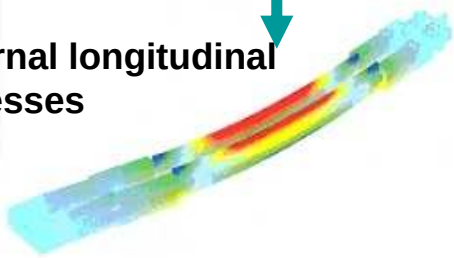


No internal longitudinal stresses

Monolith Concept
Without dilatation joints



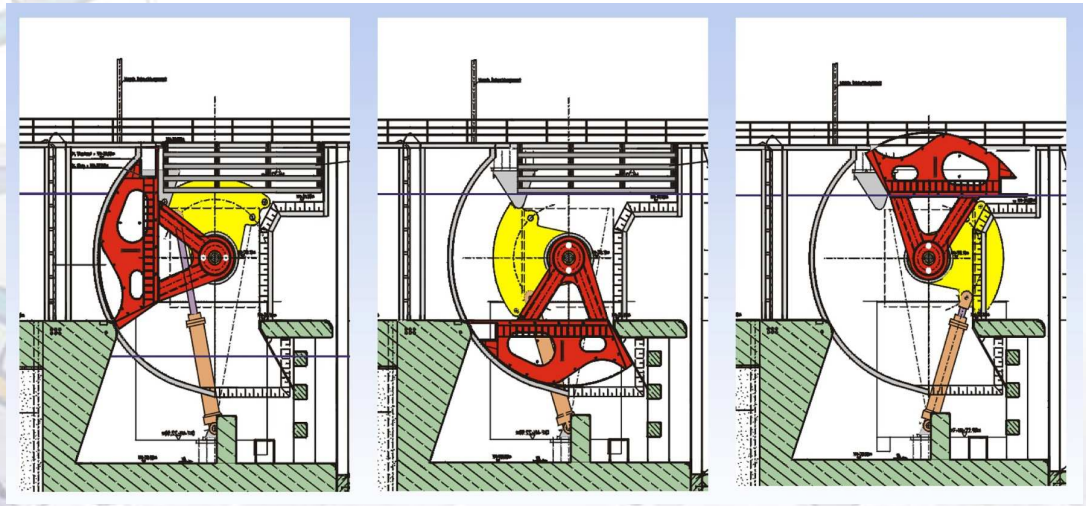
Internal longitudinal stresses



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



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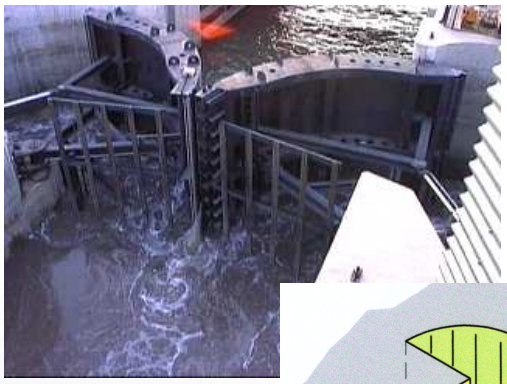
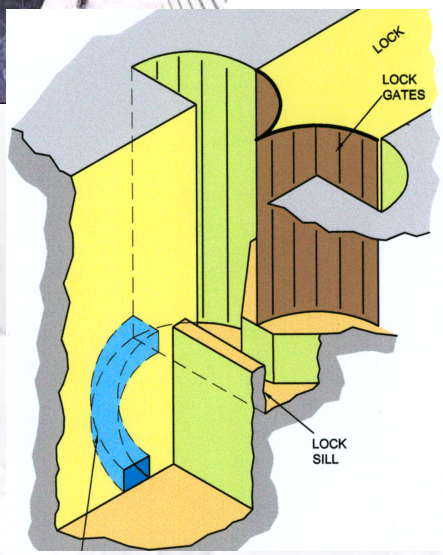
GATES AND VALVES





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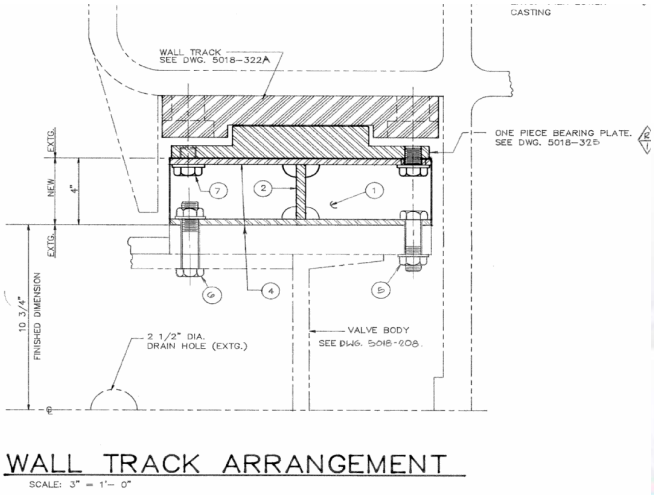
Mechanical devices

Actuator:

Sluice : Sliding vertical lift gate

UHMWPE : Ultra-high molecular weight polyethylene

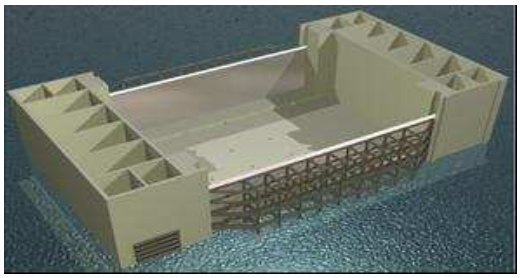


Construction Modes

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 CONCLUSIONS

Current Trade off problems in Lock Design:

➔ "HIGH RELIABILITY" is often associated with "PROVEN TECHNOLOGIES" (in Lock Design)

If true ➔ Is it a the place for innovation in lock?

WG29 ➔ Yes. Innovation is required to reach highly reliable infrastructures, to reduce cost (construction mode), fulfil new requirements (fast locking), non standard dimension,…

Do not be afraid by innovation. ➔ Promote innovation.

➔ **"RELIABILITY" versus "COST" (in lock design)**

Lock design is highly "Project Dependant".

Ex: "Panama Canal" versus the "Renovation of a small pleasure lock in Finland"

INNOVATIONS IN LOCK DESIGN

➔ FEW EXAMPLES

Magnetic Mooring System at KaiserLock Germany (*Cavotec Ltd*)

INNOVATION IN LOCK DESIGN

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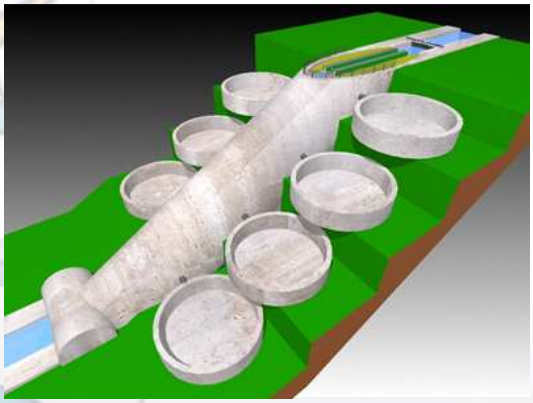
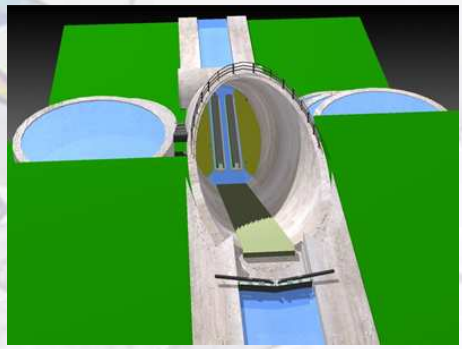
Locks Floating Pontoon (Fin)

INNOVATION IN LOCK DESIGN

Dream to Reality ?

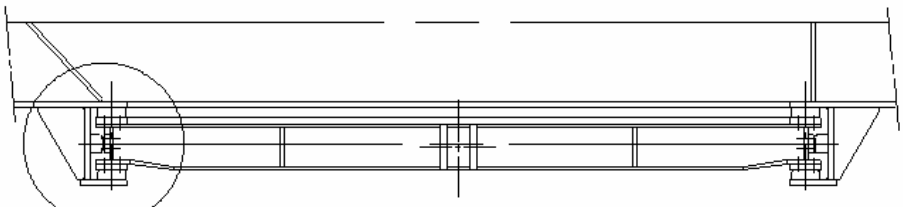




Diagonal Lock UK

Falkirk Wheel UK

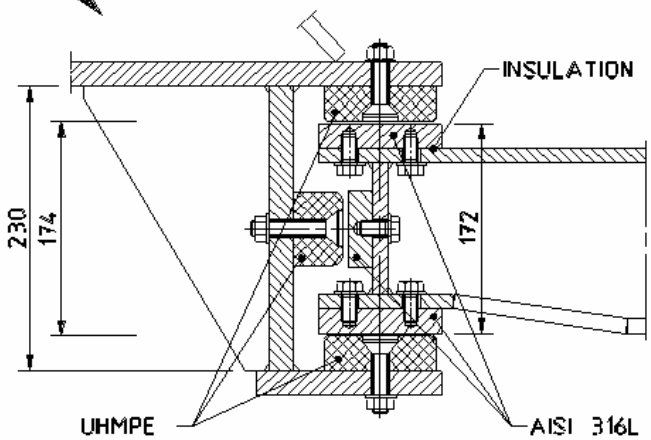
UHMPE sliding Gate/ Valves



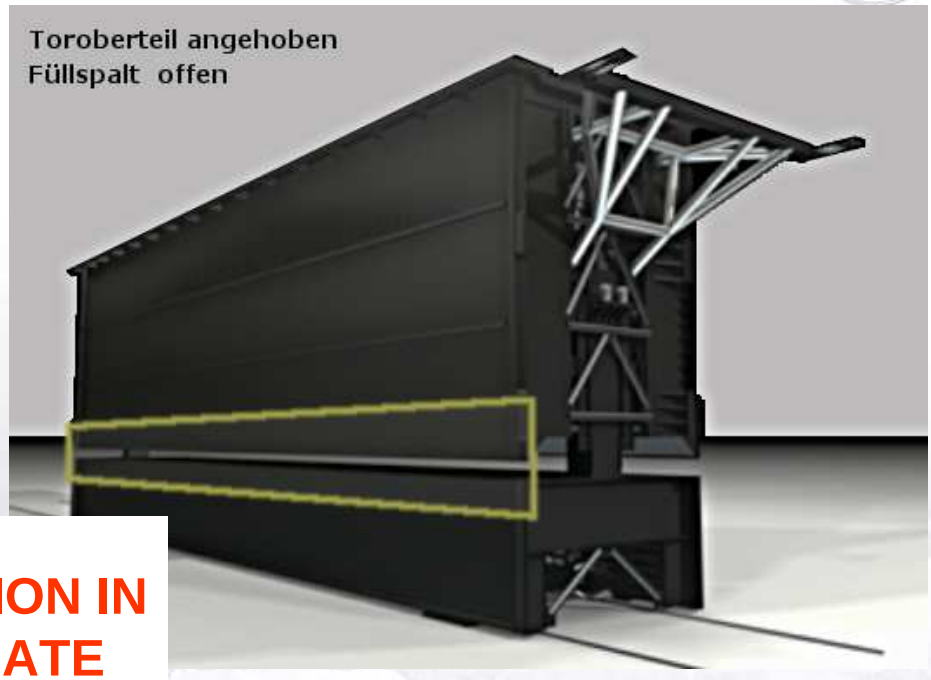
A-A

RWS NL

INNOVATION IN LOCK GATE



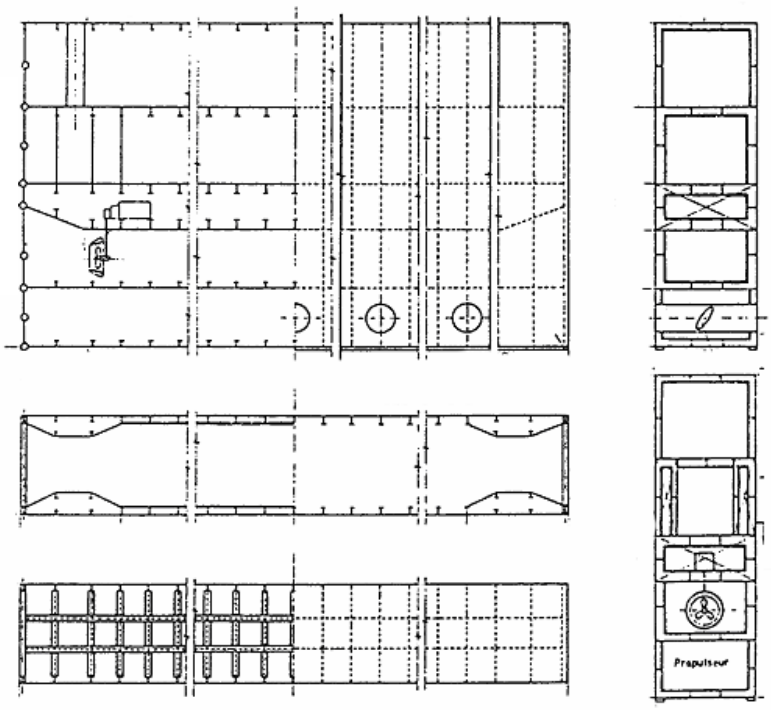
Kaiser lifting and sliding lock gate



INNOVATION IN LOCK GATE

Self-Propelled Floating Lock Gate (up to 70 m long)

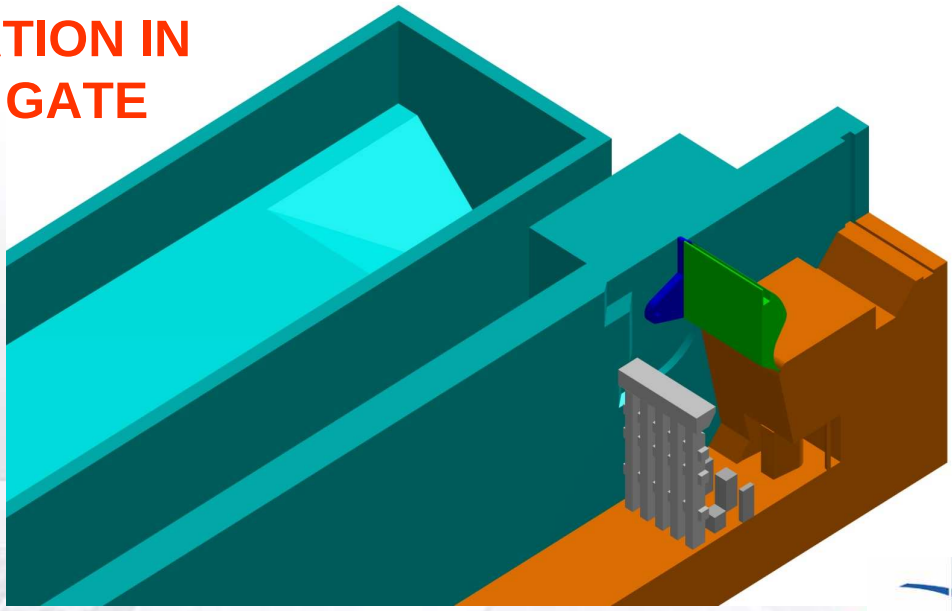
INNOVATIVE LOCK DESIGN



ANAST ULG (Belgium)

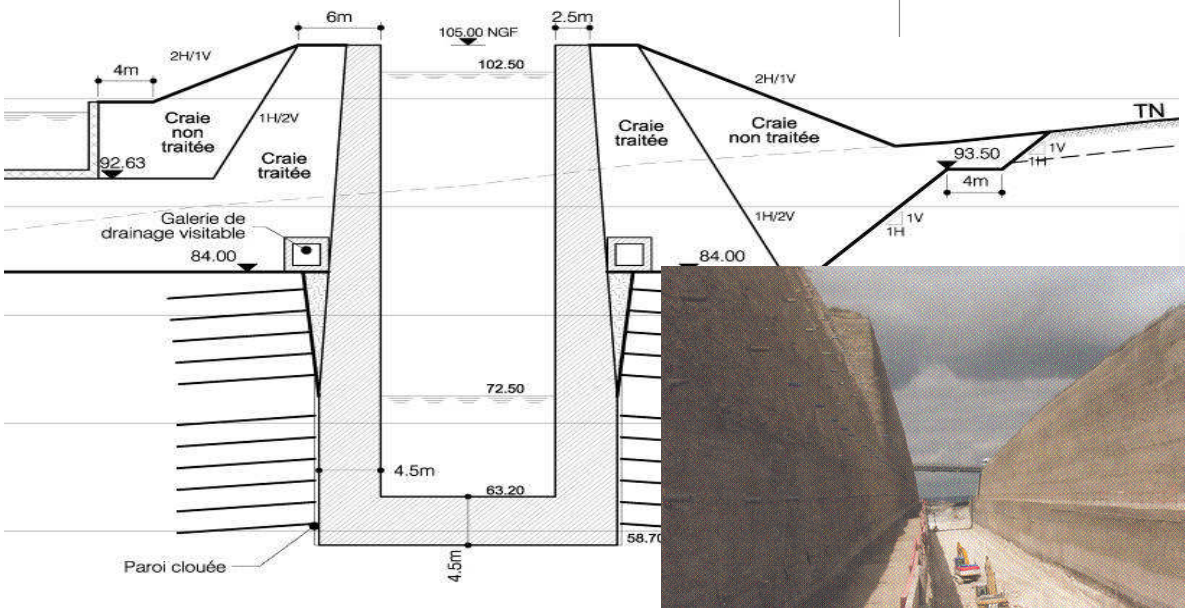
Promoting Innovation
➔ Lock in Bolzum (D)

INNOVATION IN LOCK GATE

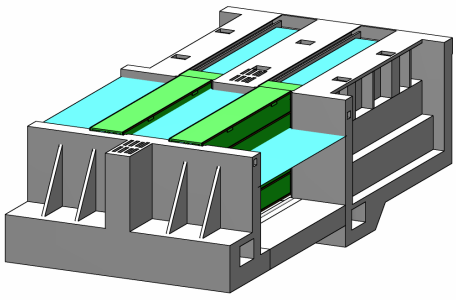


INNOVATIVE LOCK STRUCTURE

ARCADIS



Third lane of locks - Panama Canal



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PIANC REPORT N° 106

INLAND NAVIGATION COMMISSION

INNOVATIONS IN NAVIGATION LOCK DESIGN

2009

WG29: Lock Innovations

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US, NL, BE, Fr, Brazil

Corresponding members:
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