Engineering Services for Additional Studies and Technical Assistance for New Locks
PANAMA

Study and 3D modelling of density and discharge currents of the third set of locks

CEDA – presentation 19 May 2011

Mark Bollen – IMDC
Conceptual Design

- Approach Wall
- Lock head
- Lock Wall
- Approach Wall
- WSB
Discharge and density currents

- Aim of the study
- Study approach
- Data collection
- Modeling of present situation
- Modeling of future situation
- Conclusions
Aims of this study

• To better understand flow and salt exchange between chamber and the ocean during leveling (spilling) and after opening the gates (density current);
• To determine the velocities caused by density currents that effect ship navigation;
• To recommend alternatives, that mitigate or eliminate the adverse effect of density currents on navigation and throughput;
• To generate current maps (vectors) at different water depths in the vicinity of the locks up to 5 km from the new locks for SIDMAR Ship Simulator.
Study approach

- Site visit & measurement campaign
- Analysis of field data and measurements
- Understanding of phenomena
- Set-up, limited calibration & validation of far-field model
- Set-up, calibration & validation of detailed model
- Include and extend for future situation in Third Lane model
- Run various scenarios for design of the approach channel
- Prepare current maps
Site visit & measurement campaign

Current Measurements – RCM9

- RCM-9
- selflogging
- multi-probe
- Current
- Magnitude
- Direction
- Conductivity
- Temperature
- Depth
- Turbidity
Stationary Measurements: Location & Schedule

Marker buoy with anchor chain and anchoring block according to local regulations.

- **Subsurface floats**: 1m chain + 2 shackles (stainless steel)
- **Instrument**: 2m chain + 2 shackles (stainless steel)
- **Concrete anchoring block**
Site visit & measurement campaign

Current Measurements - ADCP

Unmeasured Near-shore Discharge

Unmeasured Area Due to ADCP Depth and Blank After Transmit

Area of Measured Discharge

Unmeasured Area Due to Side-lobe Interference

Site visit & measurement campaign

Current Measurements - ADCP

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Salinity Measurements – SiltProfiler

High Frequency (100 Hz)

Wireless (acquisition & transmission)

Freefall Profiling

3 Silt sensors:
   1 Seapoint BS sensor (0-700 mg/l)
   2 Transmittance Extinction Sensors (500-5000 mg/l & 5000 – 35000 mg/l)

CTD sensor + backup sensor
Site visit & measurement campaign

Mobile Measurements: set-up

Throughtide measurement: velocity + salinity structure
* Duration = 12.5 Hrs (one tidal cycle)
* Location = Fixed transect (Cross section) left bank - right bank
  4-5 fixed stations along transects

* 1 cycle - ADCP transect left to right bank
  - Siltprofiles right to left bank at locations 5, 4, 3, 2, 1

Single cycle duration = approx. 30 minutes.
Far-field model

- Understanding of the flow and density structure in estuary
- In particular the average effect of spills and exchange currents on the far-field salinity gradients
- Compute density currents and cross-currents in far-field (up to 5km from locks; available up to Bridge of the Americas)
- Generate boundary conditions for detailed models
Near-field model functionality

- Understanding of local flow and density structure
- In particular the momentary effect of spills and exchange currents on the velocities in the vicinity of the locks
- Compute density currents and cross-currents in near-field
- Testing of alternative approach channel designs for future situation
Computational grid and bathymetry

3D model
Density effects
Culverts

Miter gates
East Tailbay
West Tailbay
Center wall
Near-Field: Longitudinal transects, spill

Measured

Model

Model - Salinity
Model set-up third lane lock

- Sliding doors
- Culverts
- Center wall
- Bifurcation point
- Tail bay
Scenarios studied

Base line scenarios

• To study the effect of the permeability of the center wall
• Invisible wall without and with Water Saving Basins

Closed center wall  No center wall  Permeable wall
Surface velocity 10 minutes after start spill

closed center wall  no center wall  permeable wall
Longitudinal profile
Scenario

Ship waiting 90 meters from knuckle (stationary)

- 12,000 TEU design vessel (Flanders Hydraulics)
  - 366 m length
  - 48.8 m beam
  - 15.2 m draft
Scenarios: Shape of bifurcation point

- To create symmetrical flow in tail bay Third Lane
- To minimize impact on navigation in present channel

reduced  extended  submerged (weir)
Scenarios: discharge points

- To spread-out a less confined spill discharge
- To demonstrate the effect of navigation in present channel
Conclusions

• The 3D numerical model of the Third Lane approach gives detailed information on the flow structure resulting from the spill and density exchange currents;
• The model confirms that the ‘invisible’ wall leads to a symmetrical flow structure in the tailbay;
• Results of the model can be used to assess forces on the vessel while in the tailbay and the current fields can be imported in the Ship Simulator;
• Where the Third Lane approach connects to the present channel, complex flow patterns may be expected, that could negatively influence navigation to Miraflores locks;
Ervaringen bij Werken aan het Panamakanaal

Mark Bollen – mbo@imdc.be