Minimizing Harbor Siltation

Working Group 43

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WG-43 REPORT OBJECTIVES

- Promote Sound, Economical, Physics-Based Solutions
- Advance Concepts that Keep the Sediment in the System (KSIS)
- Encourage Comprehensive Sediment Management Considering:
  - Life-Cycle Economics
  - Environmental Impacts/Benefits
HOW CAN WE MINIMIZE SILTATION IN HARBORS?

• Build In Naturally Deep Water

• Otherwise:
  
  ➢ Keep Sediment Moving (KSM)
  
  ➢ Keep Sediment Out (KSO)
  
  ➢ Keep Sediment Navigable (KSN)

• KSM & KSO Involve Managing Flow, KSN, Sediment Density
DEEP WATER CONSTRUCTION

Berth Parallel To Flow

Wilmington, Delaware, USA
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Distance From Shore (m)

Maintenance Dredging
Initial Dredging
Causeway
Total Dredging
Total Cost

$1,200,000
$1,000,000
$800,000
$600,000
$400,000
$200,000
$0

$200,000
$400,000
$600,000
$800,000
$1,000,000
$1,200,000
$1,400,000
$1,600,000
$1,800,000
$2,000,000
$2,200,000
$2,400,000
$2,600,000
$2,800,000
$3,000,000

0 100 200 300 400
KSM IN FLOW-THRU HARBORS & CHANNELS

Strategy is to:

- Increase velocity in deepened area
  - Channel or harbor basin realignment
  - Flow Training Structures that Maintain Velocities
  - By flow augmentation with prop/scour jets
  - Injection dredging
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Training Dikes, Magdalena River, Colombia
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supporting organizations:

AAPA
Maltiet & Michel

Estimated sediment accumulation over time at different locations within the harbor, with the color scale indicating depth with respect to the mean sea level.
Yangtze River, China
Fig. 1 Plan view of the first phase of deep navigation channel in the Yangtze River Estuary, Yangtze River, China
Yangtze River, China
KSM - SCOUR AND PROPELLOR JETS

KSM - PROPELLOR/SCOUR JETS

- Systems Have Been Installed:
  - King’s Bay, GA
  - Savannah, NC
  - Linden, NJ
  - Gray’s Harbor

- Each Installation Has Eliminated Dredging
- Best-Suited For Berthing Areas
- System Keeps Sediment In the Natural System
Simplified Physics of Sedimentation in Basin Harbors

\[ \text{siltation rate} = p \times Q \times c \]
1. Horizontal Eddy Exchange (Can Be Reduced)

2. Tidal Exchange (Cannot Be Changed)

3. Density Currents (Can Be Reduced)
**Horizontal Eddy Exchange**

![Graph showing horizontal exchange coefficient](image)

**Equation:**

\[ Q_h = f_h \times u \times A \]
Even a Small Change In Salinity (i.e., 1-2 ppt) Can Exchange A Very Large Volume Of Water, More Than Tide or Eddy Exchange!!
METHODS TO REDUCE EXCHANGE (KSO)

- Narrow Entrance
- Use Only 1 Entrance
- Change Entrance Orientation
- Use of Structures
  - Pile Groin
  - Current Deflecting Wall (CDW)
  - Modified CDW For Density Currents
SEDIMENTATION REDUCTION 67%
CURRENT DEFLECTING WALL TO REDUCE EDDY EXCHANGE
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Kohlfleet Harbor Basin
Hamburg, Germany
CURRENT DEFLECTING WALL - KOHLFLEET BASIN
Petroleum Haven 2e, Port of Rotterdam

8%  13%  79%

- Tidal Prism Exchange
- Density Exchange
- Horizontal Exchange

~8% reduction
CURRENT DEFLECTING WALL FOR DENSITY CURRENTS
CURRENT DEFLECTING WALL FOR DENSITY CURRENTS

- Creates a Helical Flow Across the Entrance during Flood Tide

- Model tests suggest that the system reduces Flood Exchange by 70%

- Not Yet Tested in Field Conditions
PORT OF EMDEN, GERMANY - FLUID MUD PROBLEM
FLUID MUD THICKNESS PORT OF EMDEN, GERMANY

FLUID MUD IS IN EQUILIBRIUM WITH RIVER/SEDIMENT CONDITIONS. THICKNESS REMAINS CONSTANT OVER TIME!
In-Situ Treatment, PORT OF EMDEN, GERMANY

- The Deposit Starts As Fluid Mud & Eventually Consolidates

- In the past, dredging of 2.5 M cubic meters per year (deposited upland and/or offshore) was required

- IST: Remove Sediment From the Bottom into a Dredge Hopper, Exposing it to Oxygen, and then Depositing it Back on the Bottom

- Ships Sail Right Thru The Fluid Mud

- IST, Performed Every 3 Months, Eliminated the Need For Dredging
PUMPING SYSTEM- PORT OF LEER, GERMANY
CONCLUSIONS

• Minimizing Harbor Siltation should be key element of Dredged Material Management Plans

• Siltation Is Governed by Basic Physics

• Fundamental Strategies Exist For Reducing Sedimentation

• The Best Strategies Keep Sediment In the System (KSIS)

• Strategies Can Be Cost-Effective and those Based on Physics Are Universally Applicable