Use Of Paste Technology For Sediment Transport and Disposal

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INTRODUCTION

Paste technology is often used in mining applications where tailings are transported by pipeline and placed at high solids concentrations. The same technology can also be used for transport and disposal or beneficial reuse of dredged sediments. Hydraulically dredged sediment is often pumped at a solids weight concentration of less than 12%. Mechanically dredged sediment can often be pumped at higher concentrations (up to around 35% solids) utilizing a centrifugal pump, but in some situations pumping with even less water is needed. Utilizing positive displacement pumps can allow paste pumping at a much higher sediment solids content at or near the in-situ solids content of the sediment.

Paste flowing from pipe

PUMPING SYSTEM COMPONENTS

Because of high frictional losses within the pipeline, a positive displacement pump is typically needed to pump paste. The pump shown below is one of the largest pumps available and can pump up to approximately 500 cy/hr. Pump discharge pressures can reach well over 1,000 psi, typically requiring a pipeline made of steel pipe.

Positive displacement pump

Other system components include a hopper to allow feeding the system using mechanical equipment and a mixing unit that homogenizes the sediment and allows addition of dilution water, if necessary. These units can be situated directly above the positive displacement pump as shown in the picture to the right.

Combined hopper, mixing unit and positive displacement Pump

Mixing unit

BASIC REQUIREMENTS

To allow sediment transport as paste, the sediment needs to be sufficiently fine-grained and exhibit non-settling, non-segregating behavior. Because of its non-settling, non-segregating characteristics, paste can be transported at low velocities without particles settling on the pipe invert.

For dredging projects, paste technology is only viable in conjunction with mechanical dredging. Hydraulic dredging produces low-concentration slurries that would need to be thickened significantly to allow transport as paste, in which case pipeline transport as low-concentration slurry in conjunction with mechanical dewatering is typically a better option.

Upfront capital costs for pumping equipment and a pipeline are in the millions of dollars. Only very large dredging projects generate the dredge volumes required to achieve viable unit costs for transport as paste. Projects with less than 500,000 to 700,000 cy of dredging are not likely candidates for application of paste technology.

SUMMARY OF BASIC REQUIREMENTS

Consideration	Requirement
Sediment Type	--Fine grained --Non-settling / non-segregating
Dredge Method	Mechanical dredging
Dredge Volume	Large volume

PASTE CHARACTERISTICS

Paste is a high-concentration, non-settling, non-segregating slurry with non-Newtonian flow characteristics. As opposed to lower-concentration slurries typical for hydraulically dredged sediments with Newtonian flow characteristics, paste exhibits a relatively high yield stress that has to be overcome in order to initiate movement. Because of its non-settling, non-segregating characteristics, paste can be transported at low velocities without particles settling on the pipe invert. Because of its relatively high yield stress and high frictional losses, paste typically needs to be pumped using a positive displacement pump, instead of a centrifugal pump typically used for hydraulically dredged sediment.

DESIGN PROCESS

- Establish production rates; generally based on dredge production, but also on the maximum rate of transloading from dredge scows to the pumping system
- Determine pipeline route (length and profile)
- Establish paste flow behavior (laboratory testing, pipe loop tests)
- Perform hydraulic analysis
- Perform mechanical design of piping and piping support system
- Determine mothballing procedure, if system will be used for several dredging seasons
- Determine sediment deposition design

SEDIMENT TRANSLOADING

Mechanical equipment is best suited for excavating dredged sediment from a dredge scow and feeding the pump. This operation is generally similar to transloading performed on various projects in the world such as the Hudson River PCB Superfund Site. A material handler (example shown below) is the ideal equipment for transloading because of its reach, precision, and lift capacity. Cranes with wire-operated buckets are more difficult to operate and may not provide the needed precision to feed a hopper. Transloading has to be evaluated carefully to ensure the rate of transloading can keep up with the pump and that equipment has the right reach and lift capacity. Because of the non-settling characteristics of paste, pumping can be stopped for relatively long periods to allow changing out dredge scows, without the need to flush the pipeline.

Sediment transloading via material handler at Hudson River PCB Superfund Site

LABORATORY TESTING

Basic geotechnical testing including determination of the in-situ moisture content/solids concentration, grain size distribution, specific gravity, and Atterberg limits should be performed to determine suitability for paste transport.

The high frictional losses during pipeline transport of paste are a function of the paste's yield stress and viscosity. A viscometer is often used to measure both of these rheological parameters at a range of solids concentrations. The in-situ concentration of the sediment should be used as the upper end of this range. Lower concentrations should be tested as well to establish rheological parameters as a function of solids concentration to support the design process, which could require some dilution of the dredged sediment.

Other tests often include slump tests and small- and large-scale pipe loop tests.

Viscometer for measuring viscosity and yield stress

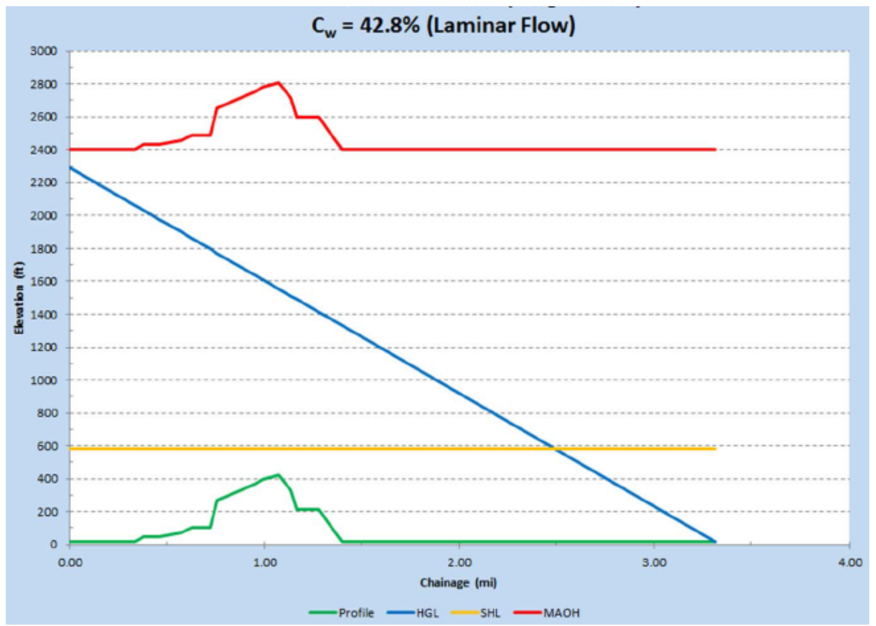
SYSTEM OPTIMIZATION

Pump and pipe sizes are determined by performing hydraulic analyses and are a function of the required throughput capacity, pipeline length, pipeline profile, and paste flow behavior.

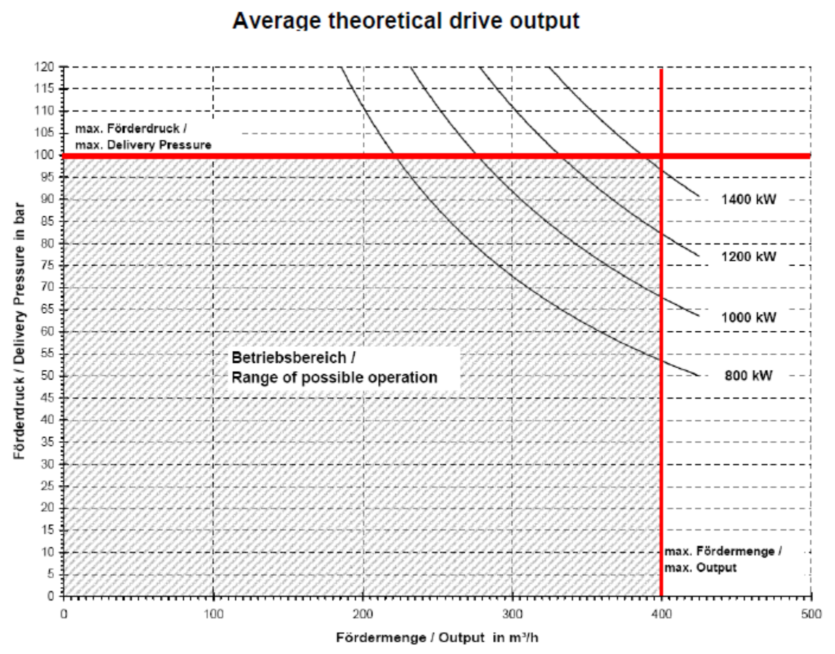
Because of the high pressures involved in paste pumping, steel pipe is typically needed to withstand these pressures.

Because of the relatively high cost of positive displacement pumps, the number of pumps would likely be limited to one pump for a typical dredging project. For long pipelines, this may require dilution of the mechanically dredged sediment to reduce frictional losses, but dilution should be minimized to the extent possible to reduce water treatment volumes. System optimization is typically an iterative process.

If desired, reagents such as Portland cement can be mixed into the sediment as part of the mixing and pumping process to modify the sediment characteristics such as strength.



Example output from Hydraulic Analysis



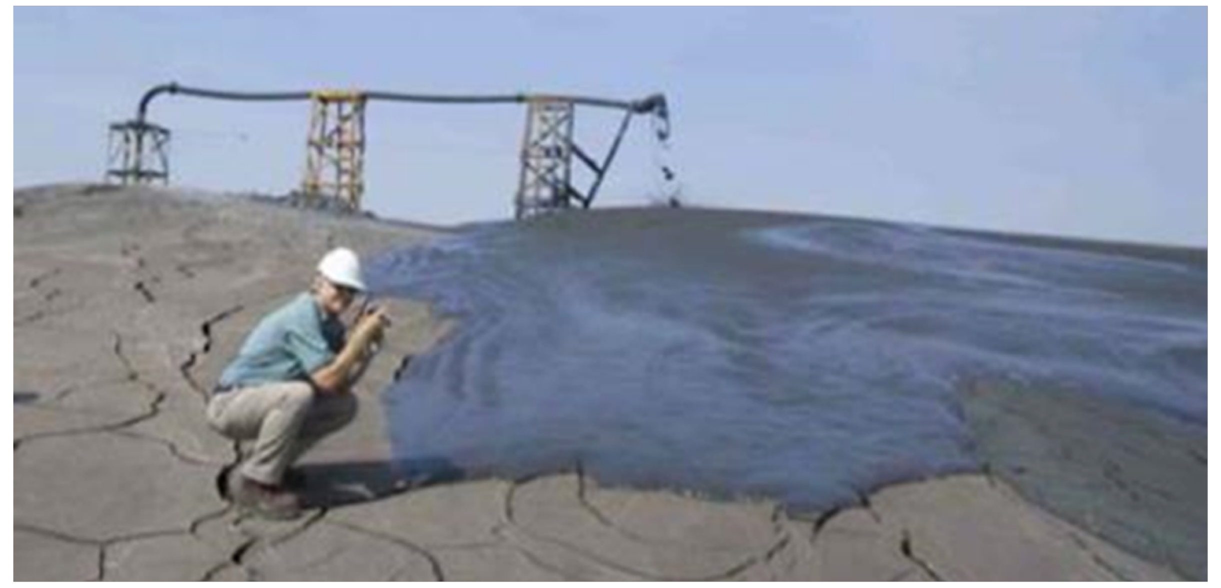
Pump output chart

SEDIMENT DEPOSITION

Depending on the characteristics of the paste, typical deposition beach angles range from approximately 3% to 6% (high slump paste) to approximately 6% to 10% (low slump paste).

For typical deposition scenarios, deposition towers can be used with a vertical riser pipe. The paste flows out of the riser pipe and then distributes laterally forming a "mud volcano" around the deposition tower.

Valves in the pipeline system can be used to strategically pump to several deposition towers to distribute the sediment. This deposition scheme can be used at the final disposal site or a dewatering/processing pad. Other deposition schemes are also possible using the flow of the sediment paste. Direct deposition can potentially eliminate or reduce double handling of sediment.



Mine tailings deposition at Bulyanhulu Mine in Tanzania

SUMMARY

- Paste technology can be used to transport mechanically dredged sediment by pipeline without the need to significantly reduce the solids concentration of the sediment.
- Sediment can be pumped from the dredge scow-to-pipeline transloading operation directly to the disposal site.
- Small water treatment volumes can typically be achieved.
- Pumping can be stopped for hours at a time without clogging of the pipeline (e.g., when no dredge scow is available for transloading).
- Can easily add reagents to sediment (e.g., to increase sediment strength or reduce free water after deposition).
- Can use flow characteristics of paste to place sediment directly from strategically placed discharge points without use of mechanical equipment.

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