GEOtechnical Factors in DREDGeABiLity (DREDGABL)

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SJS, Inc., In memoriam…

Outline

- Knowledge Based Expert System
- Background on DREDGABL
- Dredging Analysis Example
- Live demo
- Summary

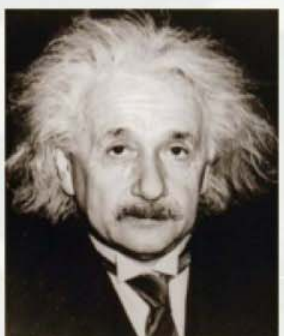
Artificial Intelligence (AI)

Computer software/hardware that mimics subjective & objective reasoning of human brains

https://pixabay.com/en/photos/artificial%20intelligence/?orientation=&image_type=&cat=&colors=&q=&order=popular&pagi=2

Artificial Intelligence Applications

- Puzzles & Games
- Expert Systems (ES)
- Knowledge Based Expert System (KBES)
- Decision Support Systems
- Pattern Recognition
- Neural Networks
- Fuzzy Logic
- Virtual Reality



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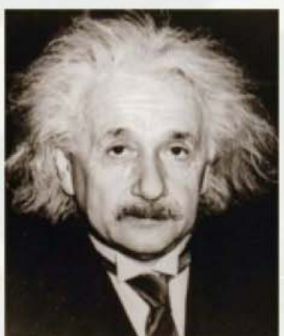
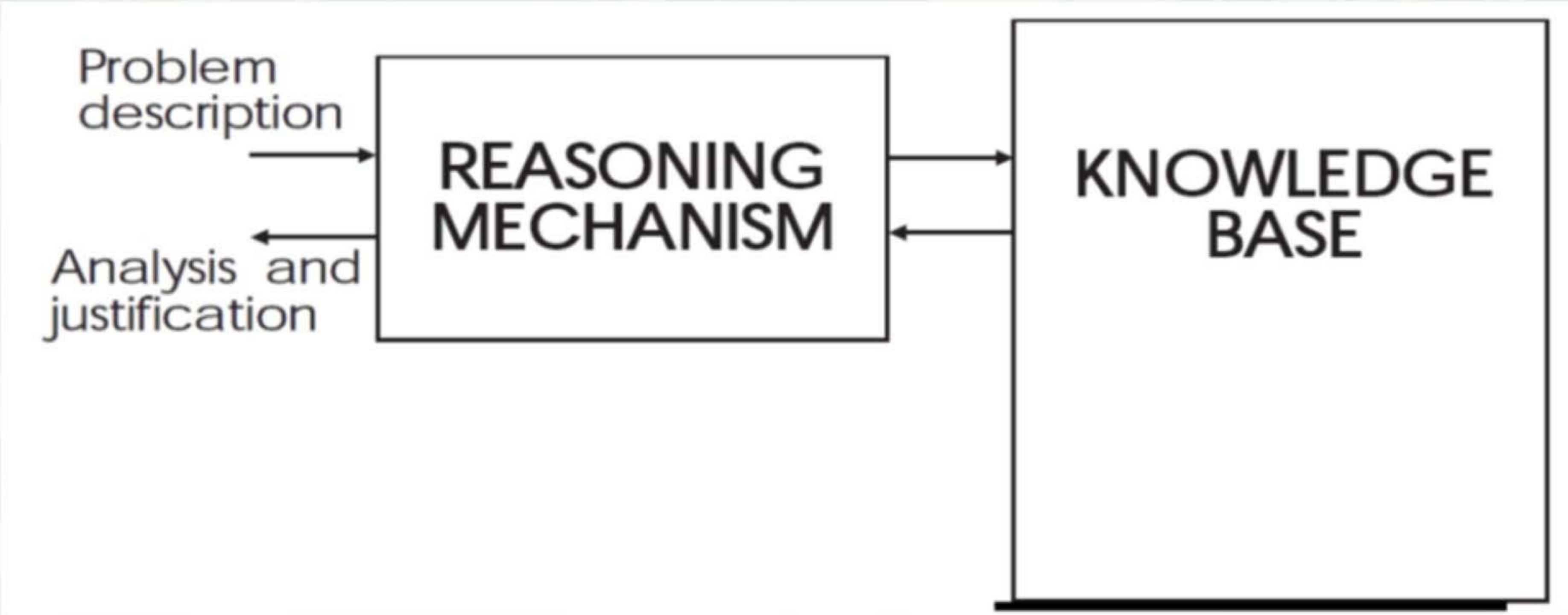





Knowledge-Based Expert Systems

- Preserve knowledge & experiences (subjective & objective) of experts in the field
- User-friendly interface that allows for interaction between the user & knowledge base
- Uses expert-derived rules for its reasoning
- Incorporate & process judgment, experience, empirical rules of thumb, proven functional relationships & experimental evidence

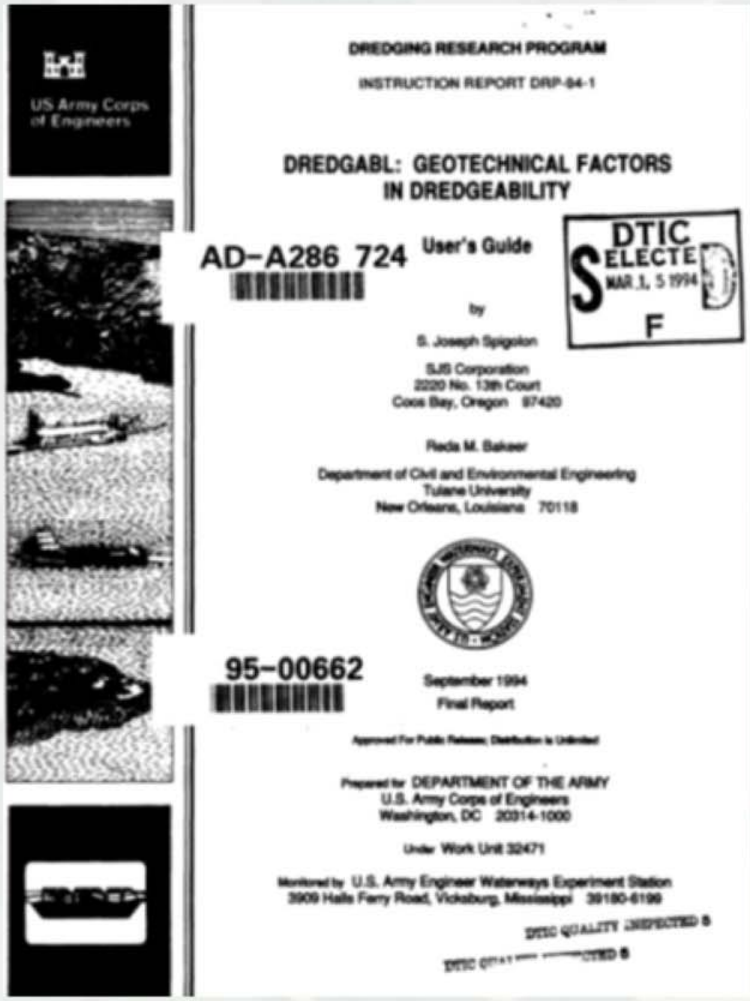
Knowledge-Based Expert Systems



Knowledge-Based Expert Systems

- Applied to a wide variety of problem domains
- Once a system is developed, it should be verified in real world by outside experts
- Used to:
  - Preserve & transfer knowledge
  - Train new & unskilled workers
  - Enhance decision making process (DSS)

DREDGABL



US Army Corps of Engineers

DREDGING RESEARCH PROGRAM

INSTRUCTION REPORT DRP-94-1

DREDGABL: GEOTECHNICAL FACTORS IN DREDGEABILITY

AD-A286 724

User's Guide

DTIC ELECTE MAR 1 5 1994 S F

by

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95-00662

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Final Report

Approved For Public Release; Distribution is Unlimited

Prepared for DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under Work Unit 32471

Monitored by U.S. Army Engineer Waterways Experiment Station
3909 Halls Ferry Road, Vicksburg, Mississippi 39180-6199

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GEOtechnical Factors in the DREDGeABiLity of Sediments

DREDGING RESEARCH PROGRAM

CONTRACT REPORT DRP-93-3

GEOTECHNICAL FACTORS IN THE DREDGEABILITY OF SEDIMENTS

Report 1

GEOTECHNICAL DESCRIPTORS FOR SEDIMENTS TO BE DREDGED

by

S. Joseph Spigolon

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2220 No. 13th Court
Coos Bay, Oregon 97420-3018

November 1993

Report 1 of a Series

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DREDGABL

- Serve as a “electronic geotechnical engineering consultant”
- Provide guidance regarding “dredgeability” of sediments described in the contract document
- Dredgeability is defined as the ease with which an underwater soil or rock can be excavated, removed, transported & deposited using specific dredging equipment & methods
- Beyond sediment characteristics, does not evaluate project conditions that can impact dredge suitability (waves, transport distance, etc.)

DREDGABL

- Intended as a training/scoping tool & not for use in formal engineering designs
- Intended users (USACE and beyond)
- Developed through established literature & interviews with experts in the field (knowledge acquisition)
- Verified through field trials & workshops
- Limited use by USACE in the 1990's
- Originally DOS on disks

DREDGABL

DRP

1990's

SJS, Inc.

&

2008-2016

Dredging Research Program (DRP)
Dredging Operations & Environmental Research Program (DOER)

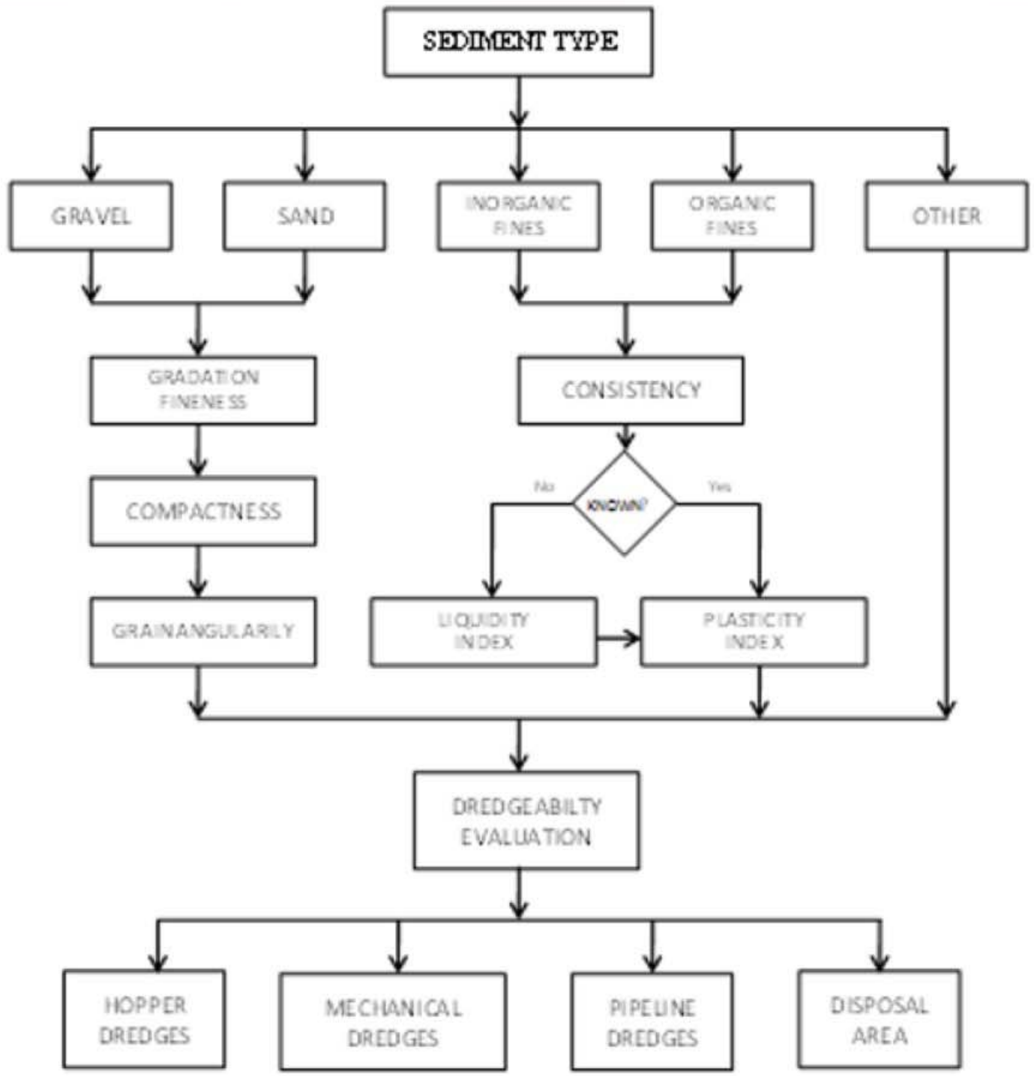
DREDGABL

Accessible on Computers and Smart Phones

http://spatialdata.sam.usace.army.mil/DREDGABL/#

or just search for DREDGBL
or on DOER website
or on DOTS website
or in CE-Dredge

DREDGABL "Flowchart"



Welcome

DREDGABL

Geotechnical Factors in Dredgeability

Scoping-Level Geotechnical Engineering Guidance for Evaluating the Dredgeability of Sediments

US Army Corps of Engineers (USACE)
Engineer Research and Development Center (ERDC)
Dredging Operations and Environmental Research (DOER) Program

Build 14.1.5410.14565

Warning: The detailed evaluation of the dredgeability of sediments for different types of dredges depends on numerous dependent and independent variables. This program is intended for scoping- or conceptual-level applications ONLY where the purpose is to determine if a certain type of dredge has the general potential to become a viable equipment alternative. While every effort has been made to ensure the accuracy of this guidance, the obligations of the regulated community are determined by statutes, regulations, or other legally binding requirements. In the event of a conflict between this guidance and any applicable statute or regulation, this guidance would not be controlling, nor is USACE responsible for any mishap to which a user is exposed by applying this guidance.

Begin Evaluation

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Begin Evaluation

Contact

Which of the following General Sediment Types best describes the layer or deposit being evaluated?

Special
Rock; Shale; Shells; Debris; Cemented Soil; USCS: None

Gravel
Gravelly coarse-grained soils; USCS: G-series

Sand
Sandy coarse-grained soils; USCS: S-series

Organic Fines
Organic fine-grained soils (Silt; Clay; Peat); USCS: O-series or Pt

Inorganic Fines
Inorganic fine-grained soils (Silt; Clay); USCS: C or M-series

Discussion

Discussion of General Sediment Types

The various types of natural sediments expected to be encountered in a dredging project may be grouped as follows:

- **Gravel**: Coarse and Fine (see Unified Soil Classification System definition)
- **Sand**: Coarse, Medium, and Fine (see Unified Soil Classification System definition)
- **Inorganic Fine-Grained Soil**: Silt, Clay (see Unified Soil Classification System definition)
- **Organic Fine-Grained Soil**: Organic Silt, Organic Clay, Peat (see Unified Soil Classification System definition)
- **Rocky Sediments**: Rock, Coral, Shale, Cemented Soil, Boulders, Cobbles
- **Fluid Mud**: Generally composed of clay, silt, and fine sand and having a fluid consistency.

Coarse-Grained Sediments

Which of the following General Sediment Types best describes the layer or deposit being evaluated?

Special
Rock; Shale; Shells; Debris; Cemented Soil; USCS: None

Gravel
Gravelly coarse-grained soils; USCS: G-series

Sand
Sandy coarse-grained soils; USCS: S-series

Organic Fines
Organic fine-grained soils (Silt; Clay; Peat); USCS: O-series or Pt

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Coarse-Grained Sediments

USCS Classification

Inorganic Fines »

What is the USCS Classification and name of the Inorganic Fines sediment?

- **ML**
  Silt (with sand and/or gravel); Sandy silt (with gravel); Gravelly silt; Gravelly silt with sand.
- **MH**
  Elastic silt (with sand and/or gravel); Sandy elastic silt; Sandy elastic silt with gravel; Gravelly elastic silt; ...
- **CL-ML**
  Silty clay (with sand and/or gravel); Sandy silty clay (with gravel); Gravelly silty clay (with sand).
- **CL**
  Lean clay (with sand and/or gravel); Sandy lean clay (with gravel); Gravelly lean clay (with sand).
- **CH**
  Fat clay (with sand; with gravel); Sandy fat clay (w/gravel); Gravelly fat clay (with sand).

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Relative Consistency

Inorganic Fines » CL »

Which of the following descriptors of relative consistency best fits the deposit being evaluated?

- Very Soft
  0-25 kPa (0-0.25 T/sf)
- Soft
  25-50 kPa (0.25-0.5 T/sf)
- Medium
  50-100 kPa (0.5-1.00 T/sf)
- Stiff
  100-200 kPa (1.00-2.00 T/sf)
- Very Stiff
  200-400 kPa (2.00-4.00 T/sf)
- Hard
  > 400 kPa (> 4.00 T/sf)
- Unknown
  Unknown

Discussion

Relative consistency of cohesive soils

The consistency of cohesive (clayey) soils is defined in terms of the unconfined compressive strength (USAEWES 1953):

Relative Consistency Term	Unconfined Compressive Strength: kPa	Unconfined Compressive Strength: Tons/sq. ft.
Fluid*	< 0	< 0
Very Soft	0-25	0-0.25
Soft	25-50	0.25-0.50
Medium (Firm)	50-100	0.50-1.00
Stiff	100-200	1.00-2.00
Very Stiff	200-400	2.00-4.00
Hard	> 400	> 4.00

* See discussion of Fluid Consistency below.

Estimating consistency using the SPT

Terzaghi and Peck (1948) presented an empirical relationship between the SPT N-value and unconfined compressive strength of cohesive soils. Sowers (1979) later modified this relationship to correct for plasticity of the cohesive soil, based on extensive field and laboratory correlations. The relationships for fine-grained soils contain a considerable amount of test scatter and are, therefore, only marginally precise.

Based on Sowers' (1979) correlations, the following tabulation may be used to estimate the unconfined compressive strength and the relative consistency of clayey soils from the SPT:

Relative Consistency	SPT (blows/30 cm or blows/ft) for Plasticity*: Avg**	Low	Med	High
Very Soft	0-2	0-3	0-2	0-1
Soft	2-4	3-7	2-3	1-2
Medium	4-8	7-13	3-7	2-4
Stiff	8-15	13-27	7-13	4-8
Very Stiff	15-30	27-53	13-27	8-16
Hard	> 30	> 53	> 27	> 16

* Low: liquid limit is less than 30
Medium: liquid limit is between 30 and 50

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- **Hard**
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- **Unknown**
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Plasticity Index

Inorganic Fines » CL » Medium »

Which of the following plasticity index values best fits the layer being evaluated?

< 22
These soils will not form clay balls nor will they be sticky.

22 - 38
In this range, clay balls form only for high in-situ compressive strengths.

Unknown
Unknown

Discussion

Plasticity of the fine grained soil fraction

The Plasticity Index values used to indicate the properties of a cohesive soil are based on the following categories:

- PI < 22; this is the upper limit of silt (ML) soils; generally, these soils will not form clay balls nor will they be sticky.
- PI = 22 to 38; in this range, clay balls form only for high in-situ compressive strengths
- PI > 38; lean clays (CL) are not found above PI = 38; these soils tend to stickiness and to severe clay ball formation.

Plasticity of clays

A distinction exists between the terms clay sizes and clay minerals. The clay size fraction is determined by an appropriate gradation (sedimentation) test and includes all particles smaller than a given size, usually taken as 0.002 mm (2 micron). The engineering behavior of the fine fraction depends to a great extent on the mineralogical composition of that fraction, i.e., the type of clay minerals. The Atterberg limits, discussed below, represent a simple, easily performed set of tests for estimating the clay mineral type, especially if paired with a determination of the percent clay (-0.002 mm) fraction.

Atterberg limits

The Atterberg limits, ASTM Method D 4318 (ASTM, 1993) indicate the range of water content over which the portion of a soil finer than the No. 40 screen (0.425 mm) behaves in a plastic manner; the range is affected by the type and amount of clay mineral finer than 0.002 mm is present. The upper limit of the range is defined as the liquid limit (LL) and the lower limit is defined as the plastic limit (PL). The LL is the water content at which a groove in the soil will just begin to flow when jarred in the prescribed manner. The PL is the water content at which the soil will just begin to crumble when rolled into threads 3 mm (1/8-inch) in diameter. The plasticity index (PI) is calculated as the difference between the liquid limit (LL) and plastic limit (PL) water contents:

```
PI = LL - PL.
```

References

ASTM. 1992. "Natural Building Stones; Soil and Rock; Geotextiles" 1992 Annual Book of ASTM Standards, Volume 04.08, American Society for Testing and Materials, Philadelphia, PA.

Casagrande, A. 1948. "Classification and Identification of Soils," Transactions of the American Society of Civil Engineers, American Society of Civil Engineers, New York, NY, Vol 113, pp 901-930.

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Dredgeability

Inorganic Fines » CL » Medium » 22 - 38 » Unknown »

Which information would you like to review?

- Suitability of Hopper Dredges
- Suitability of Mechanical Dredges
- Suitability of Pipeline Dredges
- Sediment Properties in Disposal Area
- Summary of All Properties

Dredgeability

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- Summary of All Properties

Inputs

Category:	Inorganic Fines
Consistency:	Medium
Liquidity:	Unknown
Plasticity:	22 - 38
USCS Class:	CL

Mechanical Dredges

The suitability of Mechanical Dredges is:

Backhoe:	Fair digging; medium suction.
Bucket Ladder:	Fair digging; medium suction.
Clamshell:	Fairly hard digging.
Dragline:	Fairly hard digging.
Power Shovel:	Fair digging; medium suction.

Because the Excavation Properties are:

Cuttability:	High	Fairly easy cutting; medium strength.
Flowability:	Low	Probably stable to medium height bank.
Scoopability:	Medium	Moderate suction; little loss of fines.
Scourability:	Very low	Too much clayey cohesion to erode.
Suctionability:	None	High shear strength; will not flow.

And the Removal and Transport Properties are:

Stickiness:	High	Soil is wet and sticky.
Turbidity:	High	50-90% dispersed fines; settle slowly.

Dredgeability

Inorganic Fines » CL » Medium » 22 - 38 » Unknown »

Which information would you like to review?

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- **Suitability of Hopper Dredges**
- **Suitability of Mechanical Dredges**
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Evaluation

Inputs

Category:	Inorganic Fines
Consistency:	Medium
Liquidity:	Unknown
Plasticity:	22 - 38
USCS Class:	CL

Hopper Dredges

The suitability of Hopper Dredges is:

Bucket Hopper:	Fair digging; medium suction; medium overflow losses.
Plain Suction:	Not suitable--sediment is too firm to be suctioned easily.
Trailing Arm:	Easy excavation; use jets/rippers; high overflow losses.

Because the Excavation Properties are:

Cuttability:	High	Fairly easy cutting; medium strength.
Flowability:	Low	Probably stable to medium height bank.
Scourability:	Very low	Too much clayey cohesion to erode.
Suctionability:	None	High shear strength; will not flow.

And the Removal and Transport Properties are:

Bulking:	Not applicable	Will not settle fast enough in hopper.
Clayballing:	Medium	Plasticity index is medium; density high.
Pumpability:	Very high	Viscous if slurry density > 1200 gr/litre.
Sediment Rate:	Very low	About 5-10%; only sand/flocs will settle.
Turbidity:	High	50-90% dispersed fines; settle slowly.

Dredgeability

Inorganic Fines » CL » Medium » 22 - 38 » Unknown »

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Category:	Inorganic Fines
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Liquidity:	Unknown
Plasticity:	22 - 38
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Pipeline Dredges

The suitability of Pipeline Dredges is:

Bucketwheel:	Well suited--medium cutting energy; easy pumping.
Cutter Suction:	Well suited--medium cutting energy; easy pumping.
Dustpan Suction:	Not suitable--too much cohesion to scour easily.
Plain Suction:	Not suitable--sediment is too firm to be suctioned easily.

Because the Excavation Properties are:

Cuttability:	High	Fairly easy cutting; medium strength.
Flowability:	Low	Probably stable to medium height bank.
Scoopability:	Medium	Moderate suction; little loss of fines.
Scourability:	Very low	Too much clayey cohesion to erode.
Suctionability:	None	High shear strength; will not flow.

And the Removal and Transport Properties are:

Abrasiveness:	Negligible	Fine grains cause almost no abrasion.
Clayballing:	Medium	Plasticity index is medium; density high.
Pumpability:	Very high	Viscous if slurry density > 1200 gr/litre.
Turbidity:	High	50-90% dispersed fines; settle slowly.

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Disposal Area Properties

Probable bulking rate in the disposal area:

Very low to low About 1.10-1.15; bucket deposition only.

Mechanical compactability in the disposal area:

Good to fair Use sheepsfoot roller; control moisture.

Sedimentation rate in the disposal area:

Few days Only sand and flocs will settle rapidly.

Expected turbidity in the disposal area:

High 50-90% dispersed fines; settle slowly.


LIVE
DEMO

Use of DREDGABL

- For Scoping-Level applications
- A guide, or computerized mentor, for persons lacking knowledge & experience in dredgeability analysis of geotechnical data for dredging projects.
- An educational aid in the training of new planners, estimators, administrators & stakeholders
- Peer review, where knowledgeable & experienced personnel can consult with other experts for review & to check their work

DREDGABL

http://spatialdata.sam.usace.army.mil/DREDGABL/#

or just search for DREDGBL
or on DOER website
or on DOTS website
or in CE-Dredge

Questions?