in2Dredging
Solutions adding value

Rock Dredging

Principal Dredging Consultants

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ECAAS ISO 9001 CERTIFIED QUALITY MANAGEMENT
ECAAS ISO 14001 CERTIFIED ENVIRONMENTAL MANAGEMENT
ECAAS ISO 45001 CERTIFIED SAFETY MANAGEMENT

PIANC APAC Conference 12:20 – 12:45 5 September 2022

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in2Dredging Dredging Consultancy

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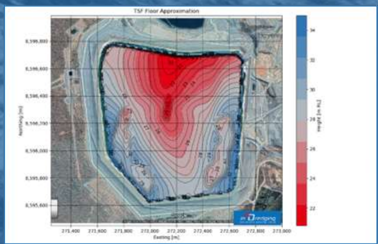
- A team of international and independent dredging consultants
- Academic knowledge combined with extensive field experience
- Research and development forms a solid foundation and has resulted in the development of specialised off-the-shelf tools
- ISO certified integrated management system



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Introduction to Rock Dredging

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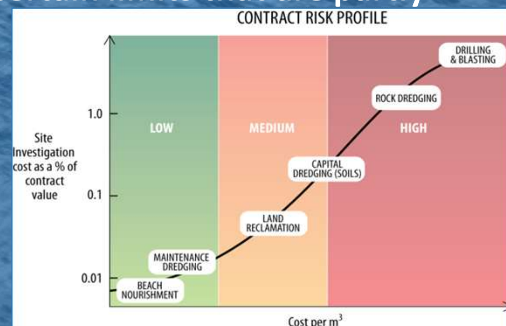
- Rock dredging is inherently high risk
- All dredging techniques are based on cutting, except drilling and blasting
- Only productive and economical within certain limits that are partly determined by the type, power and size of the dredger
- Regardless of the dredger's productivity and efficiency, loss is experienced in harder rock
- Drilling and blasting is a solid backup



Adverse Physical Conditions (David Kinlan, 2014)

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Rock Cutting

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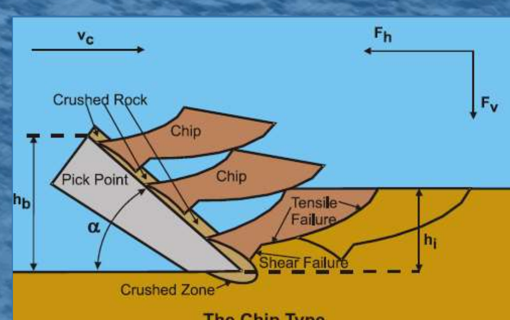
- Pushing a tooth through rock is hard
- Generates large vertical and horizontal forces
- Chipping requires sufficient penetration
- Chips are the main production unit
- Creating chips by tensile failure is energy efficient, as the rock tensile strength is typically ~15% of compressive strength
- Cutting energy efficiency also affects the dredges production rate
- Crushing or scraping rock with insufficient penetration is energy inefficient, but also results in large wear and tear per m^3



The Delft Sand, Clay, & Rock Cutting Model (Miedema, 2014)

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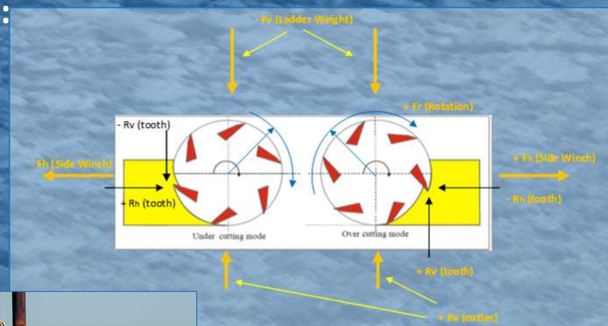
Rock Cutting Force Balance

- Tooth penetration can be resolved into a balance of applied forces
- For a CSD these are predominantly :
  - ◊ Rotation - cutter motor
  - ◊ Longitudinal – spud hold force
  - ◊ Lateral - side winches
  - ◊ Vertical –ladder weight



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Subsea Rock Cutting (SRC v1.3.8) Tool Simulation

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Cutting Force Characteristics and Consequences

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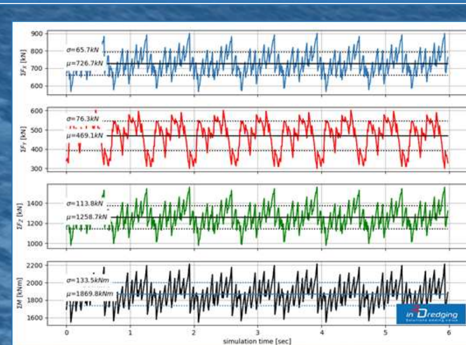
- Forces increase in stronger rock and exceed installation capacity causing non-linear productivity loss
- Teeth are mostly blunt during their lifespan making it hard to push into rock
- High impact loads on dredger cutting teeth make brittle wear resistant materials useless
- Higher wear and tear of teeth in stronger rock, resulting in more teeth and cutterhead replacement delay
- Teeth are a significant cost item



Results of Subsea Rock Cutting (SRC v.1.3.8) tool

Efficiency
Vessel delay: 20.2 h/wk
Teeth change delay: 20.8, 31.4, 38.2, 43.3 h/wk
Cutter change delay: 5.0, 8.3, 10.8, 13.0 h/wk
Anchor move delay: 3.3, 1.5, 0.8, 0.5 h/wk
Efficiency: 70.7, 63.5, 58.3, 54.2 %

Results of Estimator for Cutter Suction Dredger (E_4CSD v.2.1.29) tool for UCS of 5 to 20 MPa

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Rock Quality

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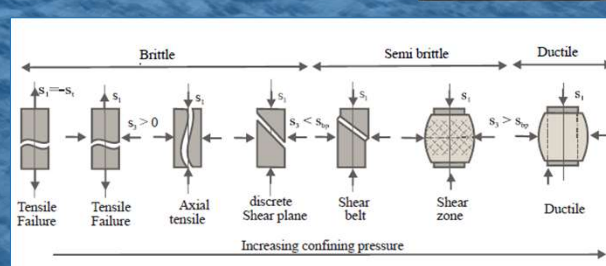
- Primary rock parameters:
  - ◊ Unconfined Compressive Strength
  - ◊ Rock Quality Designation
  - ◊ Brazilian Tensile Strength
  - ◊ Quartz versus carbonate content
- Secondary rock parameters:
  - ◊ Point Load
  - ◊ Porosity and in situ density
  - ◊ Shear wave velocity
  - ◊ Resistivity
- Key Points
  - ◊ Brittle or ductile
  - ◊ Solid or fractured
  - ◊ Shear wave or resistivity for quantity



Cutting of Rock (Vlasblom, 2014)

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Indicative Limits for Dredgers

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Dredgers	Unconfined Compressive Strength [Mpa]	
	Economical Limit	Physical Limit
Drilling and Blasting	Unlimited	
Cutter Suction Dredger with rock cutterhead	20 - 30	40
Cutter Suction Dredger with milling head	N/A	60
Trailer Suction Hopper Dredger with ripper draghead	5 - 15	20
Backhoe Dredger with rock bucket	5 - 10	15
Backhoe Dredger with ripper	10 - 20	25

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Discussion and Conclusions

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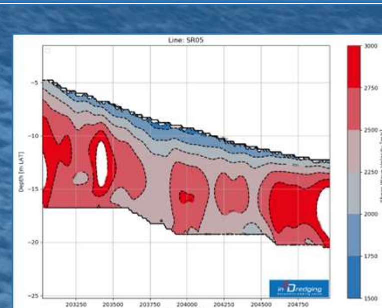
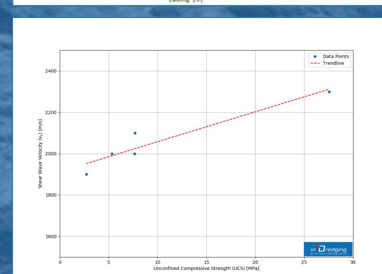
- Geophysical and geotechnical campaigns are of paramount importance:
  - First geophysical than geotechnical to determine the sample locations
  - Geophysical used to determine rock quantity and quality between sample locations
- Rock dredging economics depends on type and size of dredger
- Drilling and blasting are not restricted by rock strength, making it a solid backup
- Wear and tear can be extreme
- Scraping instead of cutting rock burns time, teeth and fuel whilst dredging little rock





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