SKANDINAVIENS NORDLIGASTE
tekniska universitet

Dammvallar av slaggrus

Askprogrammets seminarium

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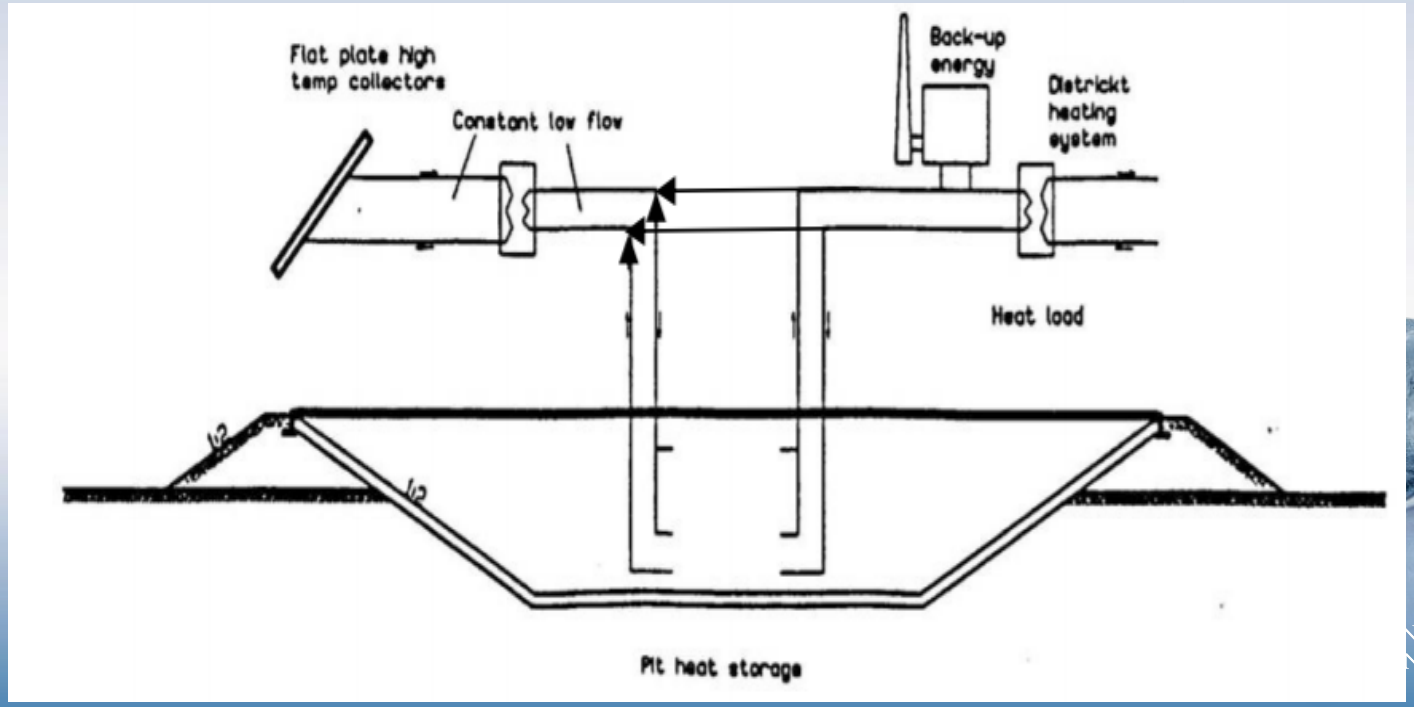
Varför dammvallar av slaggrus?

Gropvärmelager kan vara en metod att ta till vara överskottsvärme under sommaren



Gropvärmelager behöver vara stora 100 000 till 200 00 m3

- Totalt djup: 15-20 m
- Höjd dammvall: 4-15 m
- Volym dammvall: 50 000 – 500 000 m3
- Årsproduktion slaggrus: 50 000 m3/år

Kan vi använda slaggrus för att bygga dammvallar?

Avsättning för materialet

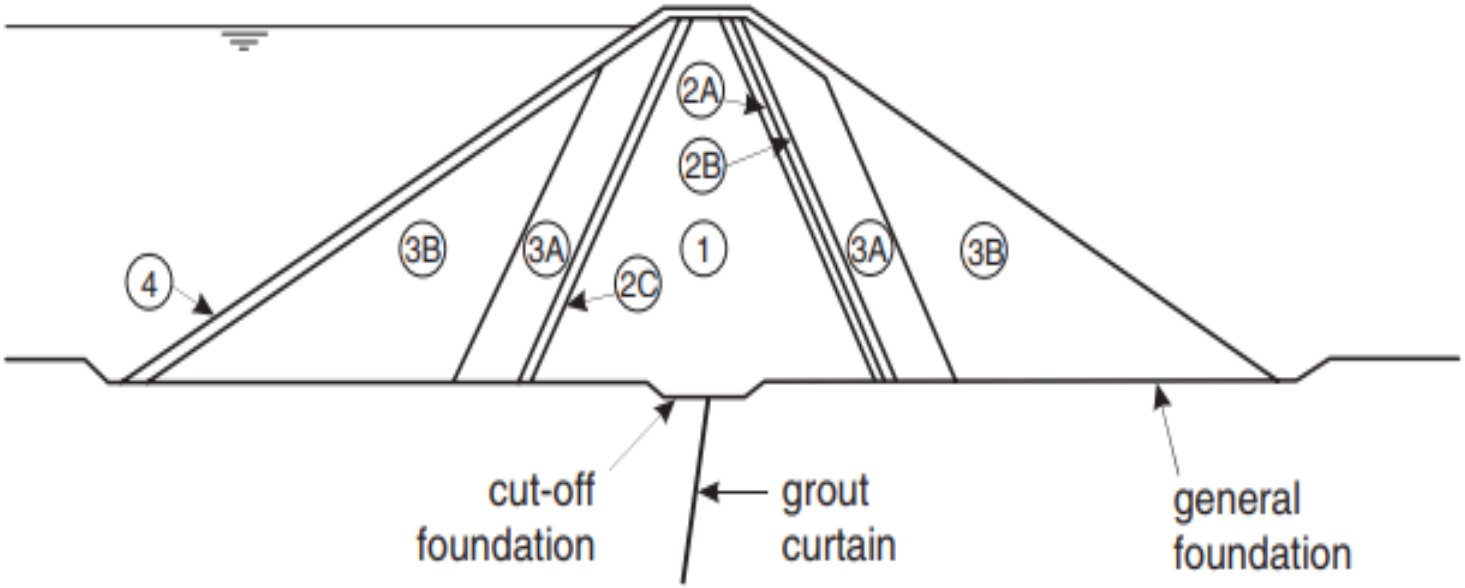
Ingen deponiavgift

Slippa anskaffa nytt material

Bättre ekonomi

Etc

Vad är en dammkonstruktion?

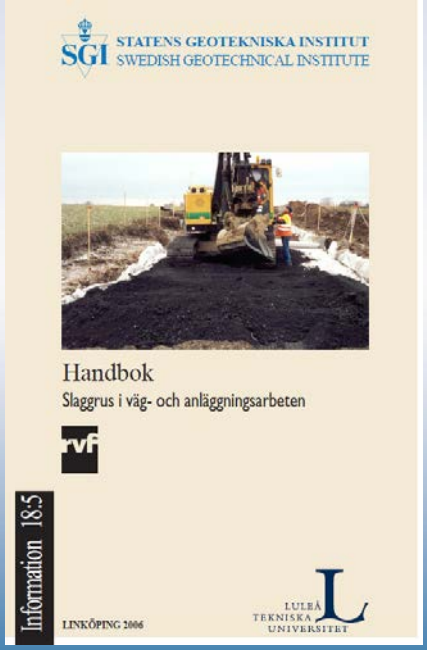


Vad har vi gjort?

- **Literature study**
  - Engineering properties
  - Chemical properties
  - Pre-treatment options
  - Restrictions and laws
  - Previous applications
- **Identified challenges**
- **Research suggestions**
  - General material properties
  - Properties regarding the application and construction practices
  - Properties related to temperature changes
  - Foundation of the embankment

Previous applications

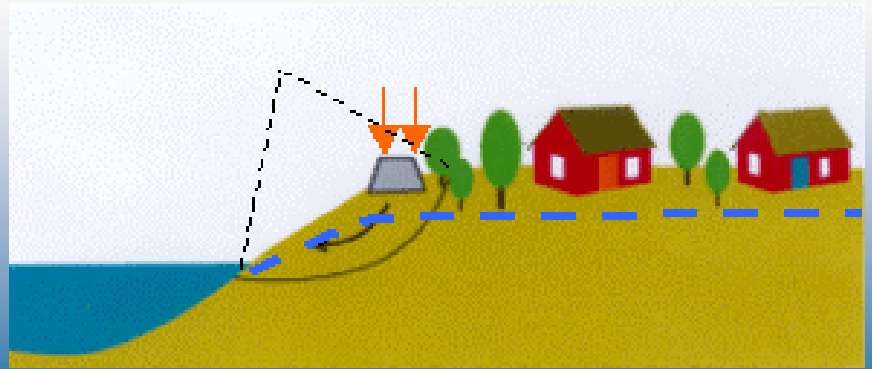
- Test roads across Sweden
  - Dåva road compares bottom ash to gravel
  - Most of the leaching occurs in the first few years of application
  - Malmö- bottom ash maintained its integrity throughout 8 years of application

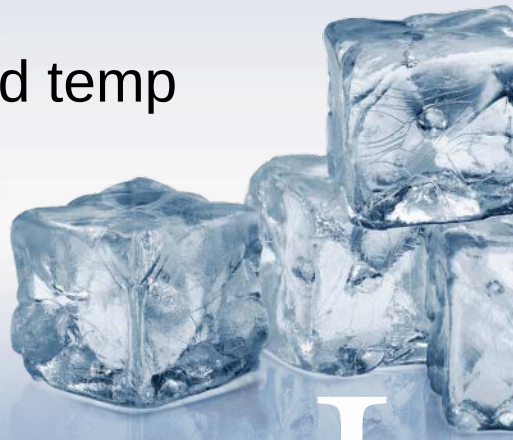


- Embankment in the Netherlands
  - 10 m high- practical experience constructing a high embankment using MSWI bottom ash
- Tailings dam in USA.
  - Coal bottom ash relatively similar to MSWI bottom ash
  - Roller compacted concrete- increased stability of embankment, decreased mobility of heavy metals

Identified challenges

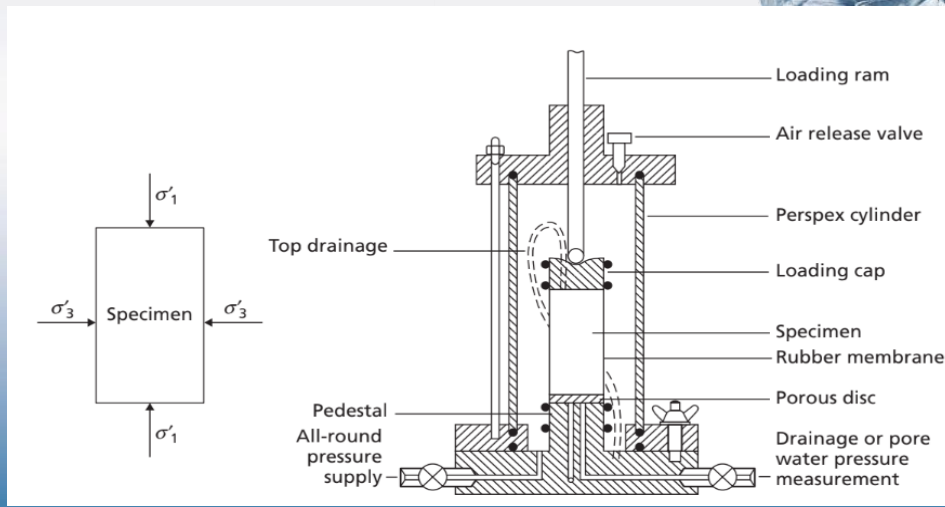
- Large variation in material
- Slope stability of the embankment as well as excavated pit (under added load of embankment)
- Deformations and settlements in embankment and foundation
- Leaks in liner - stability problems, additional leaching
- Degradation during compaction
- Changes in engineering properties with time and temp
- Amount of bottom ash needed



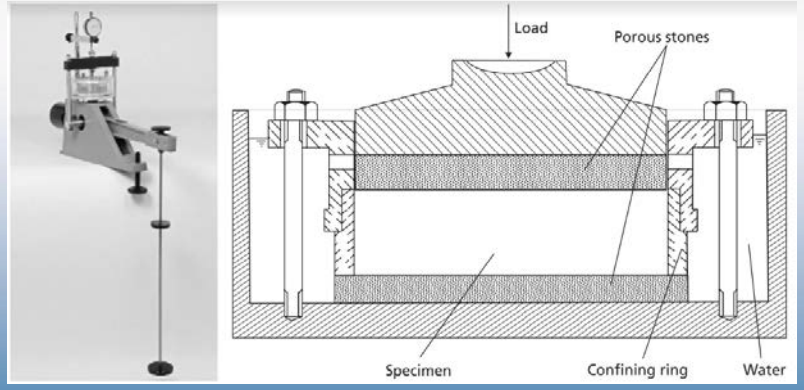


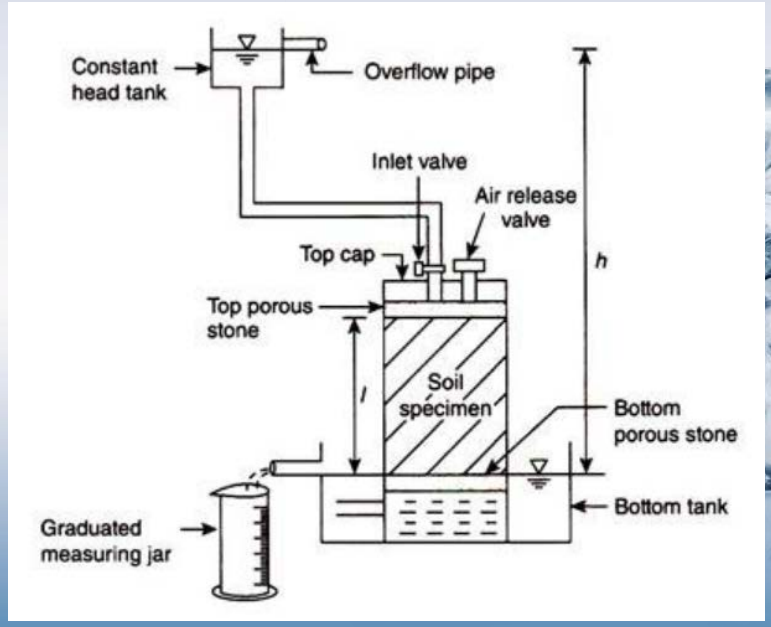
Main research suggestions

- Potential for internal erosion and internal stability
- Potential for filter material
- Thermal properties
- Mechanical properties at elevated temperatures
- Freeze-thaw characteristics and degrading when subjected to freeze-thaw cycling.
- Surface erosion
- Crushing during compaction
- Mechanical properties, triaxial testing etc
  - Friction angle
  - Dilatancy
  - Critical void ratio



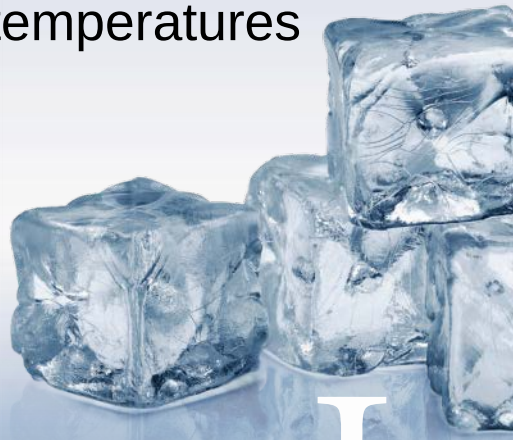
- Settlement characteristics
  - Stress vs strain
  - Elastic modulus, Poissons´s ratio - triaxial testing
- Hydraulic conductivity- constant/falling head test
  - In relation to compaction, degree of saturation and temperature
- Erodibility
  - Surface erosion
  - Internal erosion





Properties related to temperature changes

- Temperature changes in the embankment in relation to:
  - Diffusivity- water transport due to temp. gradient
  - Creep
- Water content changes in the embankment in relation to:
  - Thermal properties
  - Degradation of particles during freeze-thaw cycling
- Potential for high pore water pressures due to high temperatures
- Sub zero temperatures
  - Frost penetration
  - Thawing
  - Stability problems



Går det att använda slaggrus för denna sak?

JA!

Men det kräver en hel del undersökningar och fördjupade studier

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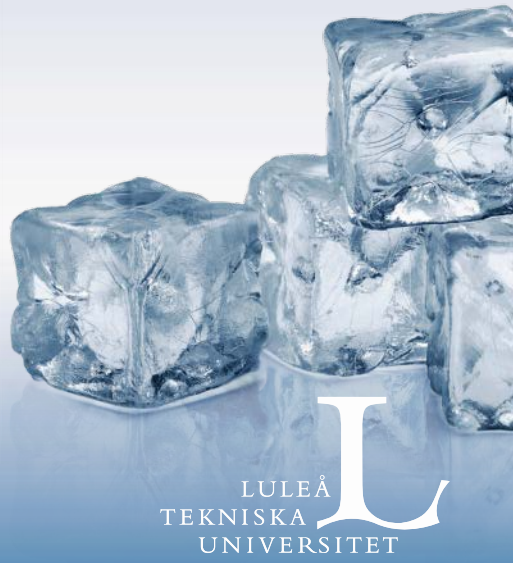

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Preliminary description of MSWI bottom ash

- Large variation in properties depending on the origin of MSWI bottom ash
- **Engineering properties, based on literature**
  - Particle size distribution- between sand-gravel, porous
  - Dry density 1200-1800 kg/m3 (lower than natural sand/gravel)
  - Large variation in shear strength (friction angel 24º-59º)
  - Elastic modulus dependent on confining pressure and compaction degree, varies greatly (10-100 MPa reported)
  - Organic matter cont. 1-15%, <5% for construction purposes
  - Large range in permeability, upper end- sands and gravel mixtures; lower end- clays and clay-silts
  - Moderately susceptible to freeze-thaw cycling, loss of mass 4% for 10 cycles
  - Thermal properties- mostly unknown, porosity of the material possible advantage
  - Potential for erosion- mostly unknown

Preliminary description of MSWI bottom ash

- **Chemical properties**
  - Varies depending on the origin and incineration plant facilities
  - Potentially high amounts of leachable heavy metals (Cu, Pb, Zn, etc.)
  - Components are released from MSWI bottom ash in higher concentrations than from conventional construction material during application
  - Require monitoring, legislation and pre-treatment

Pre-treatment

- Pre-treatment of bottom ash can be used to improve certain properties, but this can in turn affect other desirable properties and prove costly
- Depending of the origin plant some of the methods can already be applied
- Weathering-storing bottom ash for 1-3 months before operation, chemical reactions, metalloids less reactive, decrease of pH
- Crushing- Change particle size distribution, increased amount on fines
- Sieving- Change particle size distribution
- Washing- decrease amount of metals and fines, contaminants now in liquid form
- Separation of metals (both ferrous and non ferrous)- decrease amount of metals

Restrictions/laws

- Regulations mostly based on leaching limits
- Many EU countries have specific criteria for use of MSWI bottom ash in construction applications
- Sweden does not have a criteria specifically addressing MSWI bottom ash
- Swedish environmental agency: Handbook regrading recycling of waste in construction work (2010)- According to this bottom ash does not comply, based on total content of

Properties regarding the application and construction practices

- Degradation of particles depending on:
  - Dynamic loading
  - Compressive stress (static)
  - Shear stress and stain
- Mechanical properties depending on density/degree of compaction
  - Shear strength, permeability, settlement etc.
- Changes in material over time
  - Degradation of particles
  - Cementation potential
- Application of constitutive models based on laboratory testing-capture material behavior, can be used in future numerical models

Foundation of the embankment

- General characteristics of material- particle distribution, water content, density etc.
- Necessary to analyze settlement characteristics
  - Possible triaxial and oedometer testing to estimate settlements under added load
  - Estimate effect of settlements on stability of the embankment
- Slope stability of the pit under additional load (construction period)
  - Shear strength of the material by the means of direct/simple shear, and/or triaxial apparatus.
- Changes in initial stress state due to excavation, additional load of the embankment, load from water in the reservoir
- Investigation of the foundation by e.g. CPT-testing, vane test etc.
  - Results verified by laboratory tests if possible