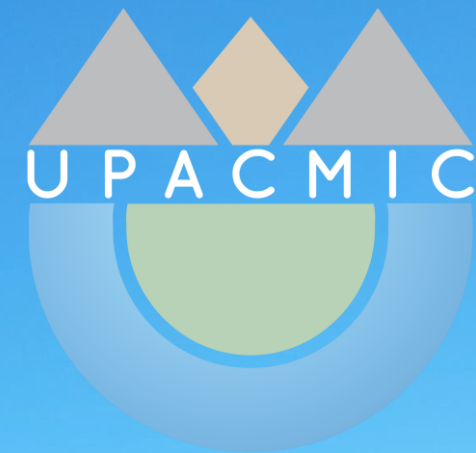


# UPACMIC – Layman's report

## Utilisation of by-products and alternative construction materials in new mine construction



In cooperation with:



Pyhäsalmi Mine

feasib



UNIVERSITY OF OULU



# HUESKER  
Ideas. Engineers. Innovations.



LIFE12 ENV/FI/000592



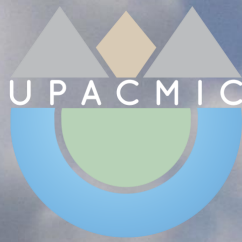
Ympäristöministeriö  
Miljöministeriet  
Ministry of the Environment

RAMBOLL

skarta

fortum  
For a cleaner world

# PROJECT SUMMARY



## Project overview

- Duration 2013-2022
- Project partners: Ramboll Finland, Skarta Finland, Fortum Waste Solutions
- Initial problem: Establishing and closure of mines consumes high volumes of aggregates. Meanwhile, many industrial processes produce suitable waste material for earth construction.
- Area: secondary materials in mining sector

## Project objective

- Rise awareness about the utilization of alternative materials in mining sector
- Verify that the new solutions are effective, competitive and environmentally friendly.
- To utilize alternative recycled materials and save natural non-renewable resources.
  - Co-operation between industries and mining sector.

## Information about the project

- All material and project deliverables are published on project's website:  
<https://projektit.ramboll.fi/life/upacmic/>
- Project video:
  - [https://projektit.ramboll.fi/life/upacmic/mat\\_sku/UPACMIC-ENG-H264.mp4](https://projektit.ramboll.fi/life/upacmic/mat_sku/UPACMIC-ENG-H264.mp4)
  - <https://youtu.be/VwMSopTNfx0>



**Poor material efficiency**



**Better material efficiency**

## BACKGROUND

- On the EU level, it has been estimated that more than 400 million tons of waste from the mining industries is generated annually. It has been estimated that mining operations in Finland alone result in 50 million tons of mining waste every year.
- In mining construction, the harmful effects of mining waste must be minimized with protective bottom structures. Some of existing mines does not have such structures as they have been established according to the old legislation. Eventually when mining actions are finished, mining operator has responsibility to construct closing and landscaping structures. Careful closing is especially needed when the waste is hazardous and pollutants can be leached from it by rain water. Non-hazardous wastes such as waste rocks need to be landscaped. Protective structures and landscaping demands a lot of materials with diverse properties.
- Industry, for example power generations furnaces and paper mills, produces a lot of material suitable for ground works. These by-products are called alternative materials. These materials can replace non-renewable natural resources such as eskers and moraines, as well as commercial sealing products like bentonite products or other geosynthetic materials. Utilization benefits also the industry by reducing the waste management costs. Utilization of these alternative materials is reasonable if they are produced at moderate range to the construction site, to keep the transportation costs and emissions low.
- The alternative materials have beneficial properties for different applications. Some industrial wastes, such as fiber clay, have low water permeability properties and therefore they are suitable for sealing structures. Some wastes with beneficial chemical properties, such as limestone, can be used for water treatment. For example an anaerobic digestion residue can replace materials taken from nature in the growth layer.

### By-products from various industries:



Waste gypsum



Fiber clay



Biomass fly ash



Waste lime



Foundry sand



Anaerobic digestion residue

# FROM MATERIAL SURVEY TO APPLICATION

- Material survey is needed to compare the quality, quantity available, and costs of suitable materials.
- Material testing is essential to verify the suitability of the material for the designed application.
- Piloting verifies the functionality of the applications.

Pyhäsalmi mine in Pyhäjärvi

Hitura mine in Nivala

Sorsasalo industrial landfill in Kuopio



Survey of the possibilities and limits of local materials: availability, quantity, quality, costs, timetable



Laboratory testing and designing (technical properties and environmental suitability)



Pilot testing in field conditions (the most potential materials for structures)



Full scale pilot construction (best material for the structure)

# MATERIAL TESTING

Material testing is essential to confirm suitability of the material for the designed structure.

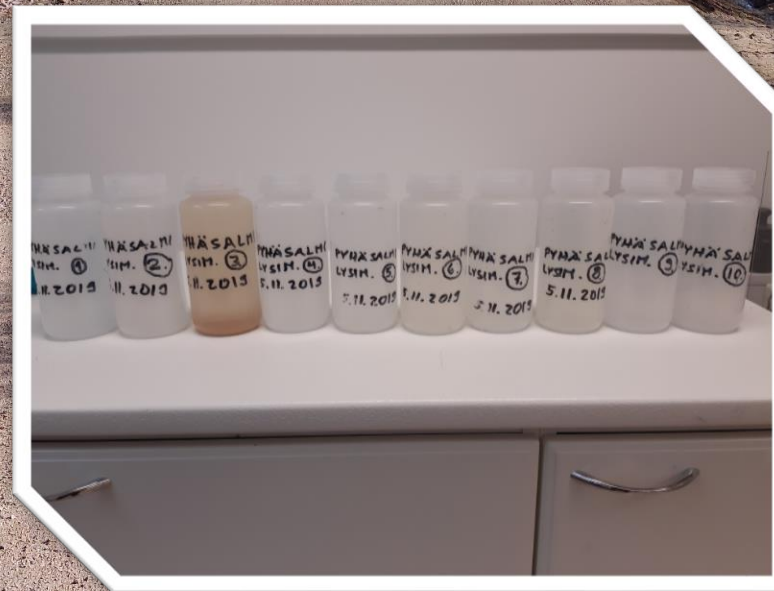
Tested properties:

- water content
- pH
- grain size
- compression strength
- water permeability
- frost susceptibility
- leaching test
- reactivity

Material testing was executed in two phases:

1. individual materials
2. material mixtures

- Low water permeability values are demanded from sealing materials. For example, if local moraine does not fulfil that demand, it's properties can be improved by mixing alternative materials like fly ash with it. This makes the utilization of local soil possible.



# PILOTING OF NEW SOLUTIONS



## Cover structure field tests in Pyhäsalmi mine 2016 – 2019

- Testing of new covering materials for tailing basins in field conditions. Covering structures duty is to prevent oxidation of tailings.
- Tested materials: gypsum, ash and those mixed with moraine or tailings.
- Large cylindrical structures where lysimeter on the bottom collecting the percolated water. Follow up by water sampling during 5/2016-8/2017.
- Results:
  - Gypsum is difficult to compress when layer is thick (500 mm ) but compresses well when layer is thin (150 mm).
    - Water permeability is low when compacted well.
  - Ash didn't protect tailings from oxidation in this pilot case.



## Reactive structure field tests in Nivala Hitura mine 2021-2022

- Leaching water from mining waste area is acidic and polluted by metals.
- Testing passive water treatment: Pond system where water flows passively by gravity and materials react with hazardous substances.
- Reactive materials (crushed limestone, geopolymers) and commercial product (adsorption mat) were used in new conditions.
- Results:
  - Passive water treatment proved to be suitable for acidic leaching waters.
    - Metal concentrations of water decreased and pH reached the neutral level.
  - Limestone barrier worked in field conditions for about 1,5 month.
  - Geopolymer showed promising results.
  - Commercial mats worked in field conditions for about 2 months.



## Cover structure, Nivala Hitura mine 2017-2018 and 2021

- Cover structure 1: Cover structure of tailing basin (26,5 ha) consists of two layers: slightly permeable sealing layer and protective growth layer. 56 % of the sealing layer was constructed using fibre clay and rest with suitable soil. Fibre clay is secondary material from paper industry.
- Cover structure 2: Landscaping cover structure for 3,3 ha pre crushing site using surplus soils. Utilization of local surplus soils (0,3 km) is more climate friendly and cost efficient than for example local excavated soil (16 km) or fibre clay (167 km).
- Results:
  - Pilot proofs that fibre clay can replace traditional moraines, and then half as much water seep through the sealing layer.
  - Utilisation of fibre clay saved 30 000 m<sup>3</sup> of natural moraine resources.
  - About 26 000 m<sup>3</sup> of various waste materials suitable as growth platform were utilized in the growth layer of tailings pond cover structure.
  - Fibre clay can cut emissions if utilized closer to the production facility.
  - 20 000 m<sup>3</sup> of natural moraine has been saved by utilizing surplus soil in cover layer.
  - Surplus soil utilisation can cut emissions and costs.



Fibre clay sealing layer



Surplus soil cover

## Vertical sealing barrier, Kuopio Sorsasalo landfill area 2020-2022

- Vertical sealing barrier (150 m) between two landfill areas was constructed. It's average height is 14 m. Purpose of the barrier is to prevent water seeping from hazardous waste area to non-hazardous waste area. The barrier is constructed almost 100% from recycled materials.
- Results:
  - About 24 000 m<sup>3</sup> of natural moraine has been saved and structure works as intended.



Vertical sealing barrier

# PROJECT OUTCOMES

- All the obtained information and experience collected during material testing and piloting will serve the future needs in the development of mining industry.
- Awareness about the utilization of alternative materials in mining sector has risen.
- The project served the needs of developing the European and national environmental legislation and policy on better resource and waste management practices.
- In total about 100 000 m<sup>3</sup> of natural material was saved. (That is equivalent to even layer of 2 m on top of 7 football pitch's area.) Same volume of landfilling as waste was avoided.
- Several material mixture recipes were evaluated and suitable solutions for different circumstances were found.
- Passive water treatment method was proved to be suitable for neutralising acidic leaching waters.

## Dissemination to stake holders and target groups:

- 42 live and online event participations.
  - 2 workshops organized
  - 3 conference presentations
- 4 conference articles published
- 5 newsletters
- 3 interviews
- 10 news articles
- Article in a professional magazine, *Materia-lehti* 7/2022
- Guideline *Utilization of alternative materials in mining cover structures*

