Earthen construction in future urban area

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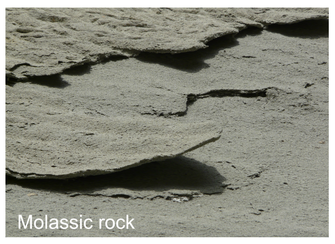
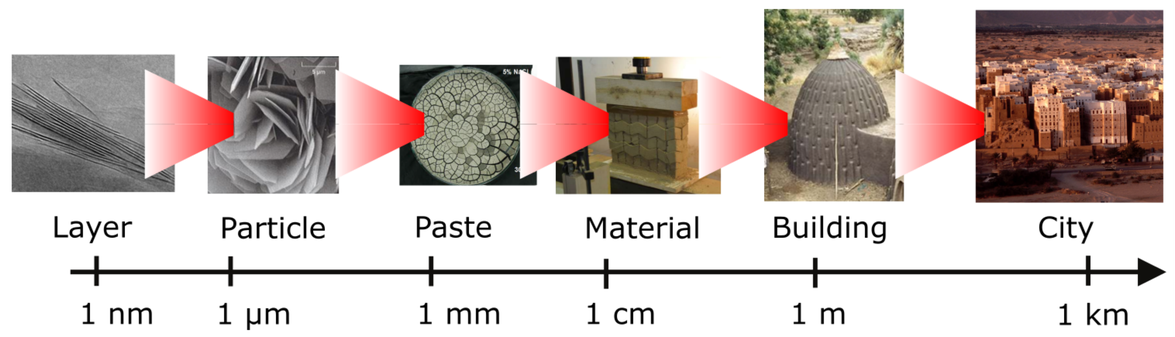
Major component of raw earth construction, natural and reusable material, clays act as a binder in earthen materials and have enabled the building of cities since the beginning of the Neolithic revolution. However, their high sensitivity to the environment impacts the durability of clay-rich materials such as earthen ones. Alluvium is a project bringing together economists, architects, researchers of historical sites and engineers to develop, test and apply at different scales reinforced earthen materials. The properties improvement is obtained by the addition of biopolymers or surfactants. Our project aims to demonstrate the potential of earthen construction in future urban area as well as in the conservation of a traditional cultural heritage.

Alluvium Project

- Clay based building materials
  - Low environmental impact
  - Without cement stabilization
- Excavated soils
  - 43 billion tons for the Grand Paris Train line
  - Low valorization – Waste
- Developing countries
  - Fast growth of urban population
  - Vulnerability to erosion



- A multiscale approach



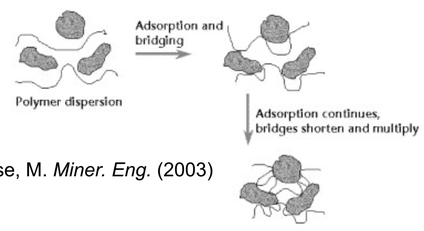
Molecular simulation ; Physical-chemistry experiments ; Rheology; Mechanical tests; Architecture studies ; Econometry

Improve clay based material for mechanical strength and water resistance

Properties improvement

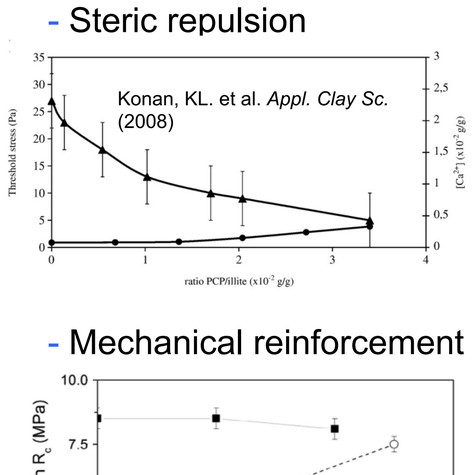
Mechanical reinforcement with biopolymers

- Bridging / Flocculation

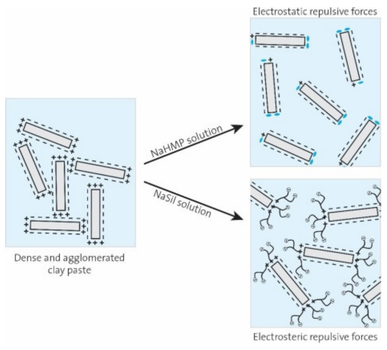


Pearse, M. *Miner. Eng.* (2003)

- Steric repulsion

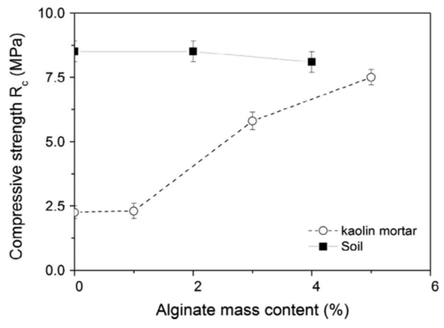


- Charge screening



Landrou, G., Brumaud, C., Plötze, M. L., Winnefeld, F. & Habert, G. *Colloids Surfaces A.* (2018)

- Mechanical reinforcement



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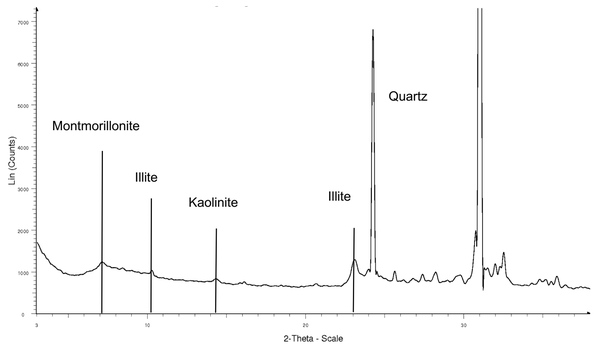
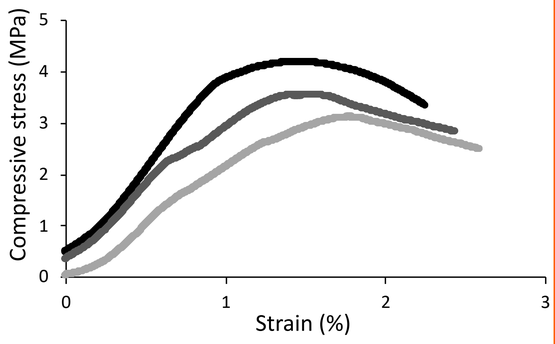
- Goals
  - Understand interactions between clays and biopolymers (adsorption, covalent link)
  - Improve Grand Paris earth with green wastes (paper, agriculture)

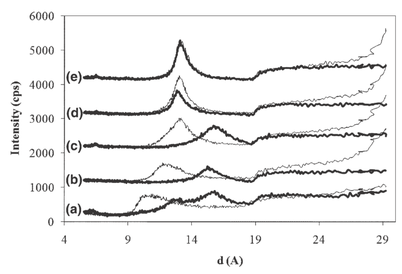
XRD



Compressive test



Stabilization against water with surfactants



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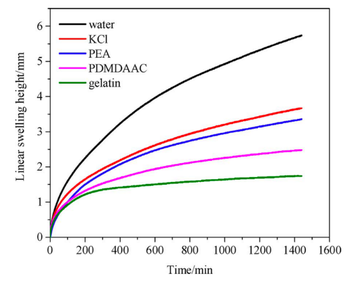
Fixation in the interlayers



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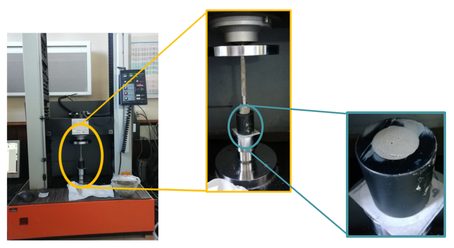
Less swelling with humidity

- Goals
  - Understand mechanisms (pore blocking/cation exchange) and measure physical properties (surface tension, compressive strength)
  - Resistance to moisture (humidity/dry cycles)
  - Durability under liquid water (lixiviation, crumb test)
  - Optimize the treatment (pH, temperature, mix-design)

- Preparation protocol



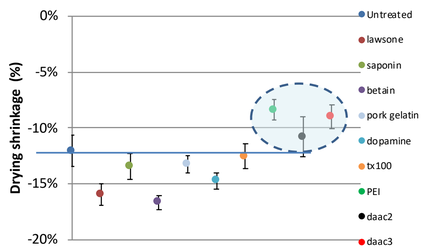
Specimen manufacturing using mechanical press (molding)

demolding

5 days drying
(23°C – 50%RH)

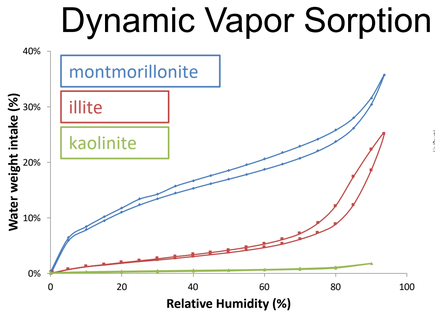
H = 45 mm
Diam = 22 mm

Volumic drying shrinkage



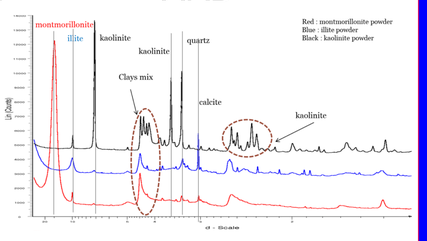
With Amine addition less drying shrinkage

Dynamic Vapor Sorption



Large variability between clay minerals

XRD

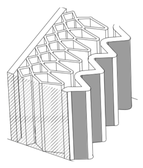


Majority mineral phase with some quartz, calcite, other clay phase

Outlook

- Environmental tests at scale 1

- 3D printing of building materials



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