Center for Ecological Engineering of Tartu

STUDY FOR LOCAL LIGHT CLAY MATERIAL OPPORTUNITIES

By Mikk Suursild

May 2001

INTRODUCTION

This research intends to demonstrate the usefulness of a simple local material, concentrating primarily on clay as a well-known building material in Southeast Estonia. Modern opportunities for the reuse of clay are bound up with natural fiber as wood chips and the cattail reed or cane biomass from the wetland treatment systems. Light clay is highly estimated in ecological construction for its good value of isolation. Progressive wetland plant cultivation (40 tons dried biomass per hectare) together with water cleaning can be one of the ways in ecological building.

OBJECTIVE

The objective of this paper was to study different light clay mixtures and test the durability of dried light clay bricks. This study must give base information of light clay material use opportunities in reality and create first presumptions for blueprint.

METHODOLOGY

Test samples

37 different light clay mixtures were prepared. Each mixture was formed to 4 bricks (15*15*30cm). For the load-deflection test all the bricks were bisected with saw.
Light clay was mixed in special clay mixing machine with horizontal axle and spiral paddles. All the bricks were formed in special wooden frames using maximum similarity for filling up the forms. Practice shows that the similar pressure and techniques influence bricks durability. All the bricks were drying for 6 weeks at 20 °C before the load-deflection tests.
Density of the test samples varies between 334-618kg/m3 (average 497kg/m3).

Mixture components and mixture variations

Light clay components

- Clay
- Sand
- Cat-tail cane chips
- Wood chips

- Reed
- Wood slivers
- Water

Clay 2-7% (wet) of mixture (average 4%)

Sand 2-5% of mixture (average 3%). Medium-sized, clean and dry sand.

Clay and sand together 4-9% of mixture (average 8%)

Cat-tail chips added to 15 mixtures. 17-91% of mixture. Dry biomass (mainly cane and lives) harvested in winter and cut into 5-10 cm pieces.

Wood chips added to 34 mixtures. 44-87% of mixture. Medium-sized conifer chips. Bark was removed.

Reed added to 10 mixtures.17-85% of mixture. Harvested in winter. Cut into 5-10 cm pieces.

Wood slivers added to10 mixtures. 8-17% of test mixture. Dry conifer slivers.

Water 3-6% of test mixture (average5%).

Load-deflection tests

The bricks were tested in the laboratory of Estonian Agricultural University.

Expectedly, the light clay is very stable. Light clay is hard to disintegrate in high compression. Material deforms and bears very heavy weight. Depending on the components and compression light clay material can also be resilient material.

To explain material behavior under load conditions the following methodology was used: 15*15*15 test sample were compressed until the deformation of 50 mm. After every 10 mm deformation the load data (kN) was recorded.

Photo 1. First load deflection test

Photo 2. Light clay is hardly disintegratable in high compression

Photo3. Stable light clay plate after the load deflection test.

Photo 4. Deformation measuring system

RESULTS

50 mm deformation and the load

For 50 mm deformation 13,8-63,8 kN power was used (4,5 times differences). Average is 37,5 kN.

Load deflection dependence on density

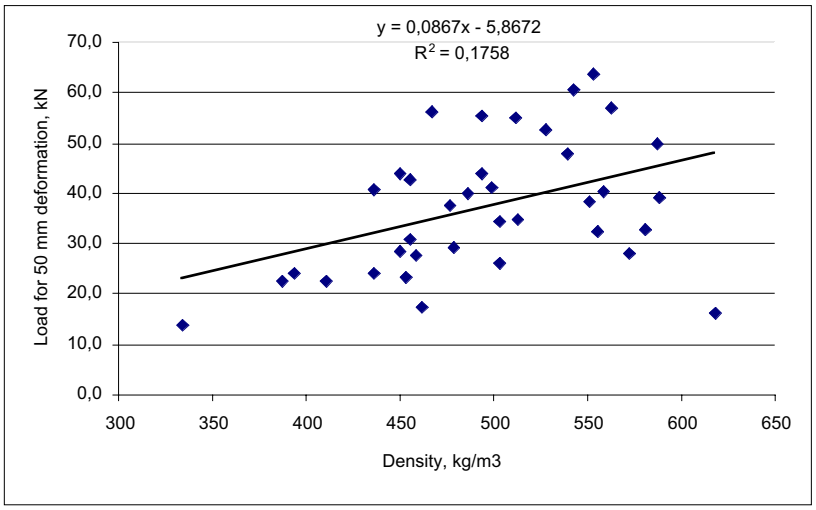

Figure1. Light clay density and load-deflection.

Obviously, higher density bricks are deforming less at the same load. But it is not good at all. One very high density (618 kg/m3) brick was smashed already after 16,4 kN load. (Figure 1. point in right corner). The above mentioned brick was mixed mainly with reed (85% reed, 6% clay, 3% sand, 5% water). This example demonstrates the essentiality of base material for the stable quality.

Wood chips and load-deflection

High content of wood chips cause higher durability (less deformation).

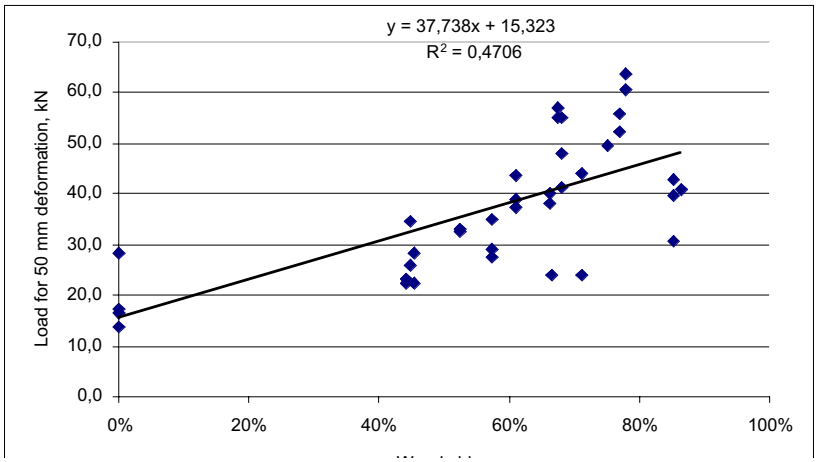

Figure 2. Wood chips quantity in light clay mixture in correlation with load-deflection

Wood slivers and load-deflection

Obviously, the best mixture outcome was somewhere in the middle of the wood sliver use (ca 7%). Instead of linear equation wood sliver dependence is characterized by polynomial equation. Materials without wood slivers and the materials with high contend of wood slivers are easily deformed (17%).

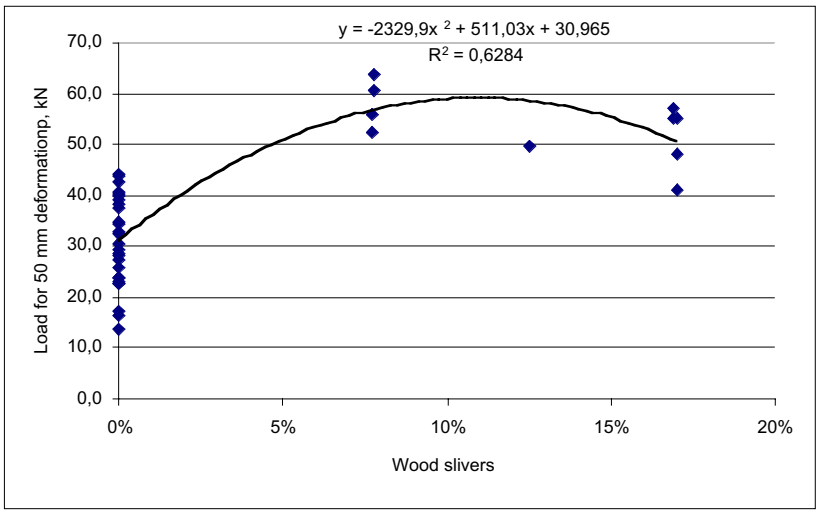

Figure 3. Wood slivers quantity in light clay mixture in correlation with load-deflection.

Wood chips and wood slivers on load-deflection

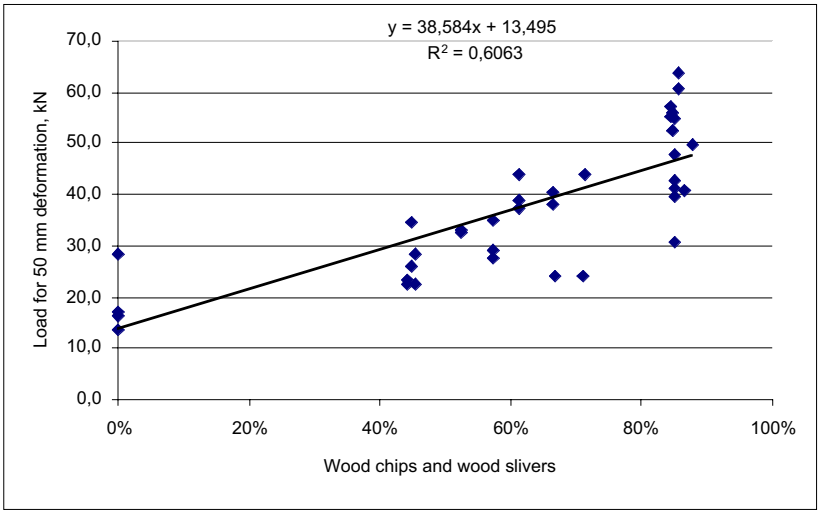

Figure 4. Wood chips and wood slivers quantity in light clay mixture in correlation with load-deflection.

Cat-tail chips and load-deflection

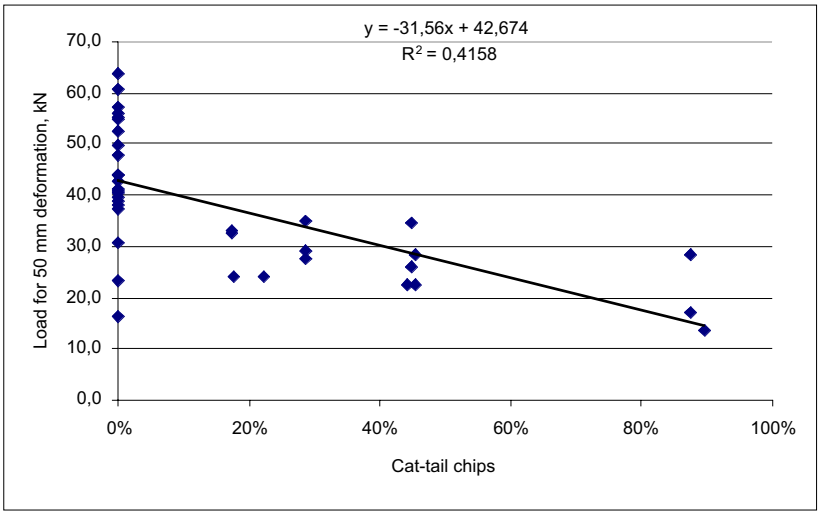

Figure 5. Cat-tail chips quantity in light clay mixture in correlation with load-deflection

Reed and load-deflection

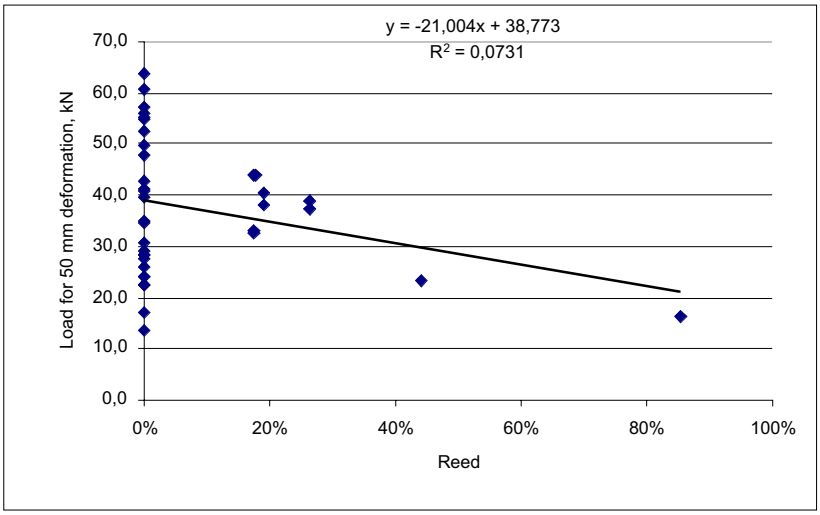

Figure 6. Reed quantity in light clay mixture in correlation with load-deflection

Clay and load-deflection

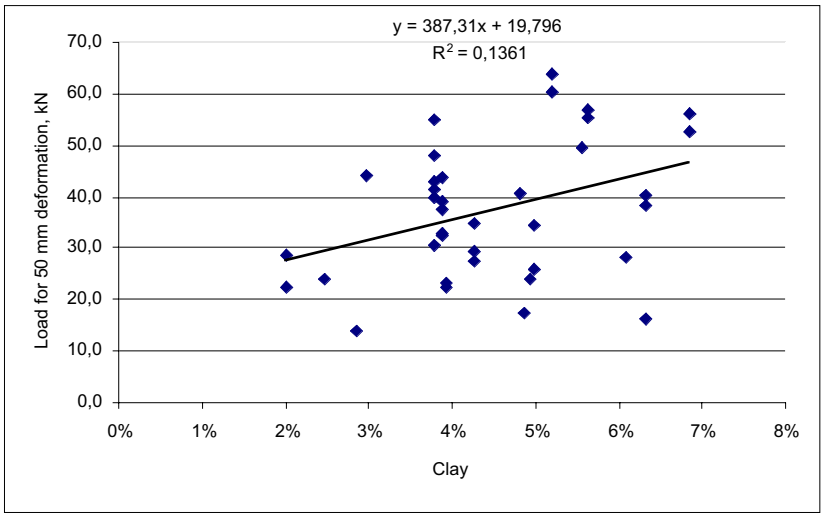

Figure 7. Clay quantity in light clay mixture in correlation with load-deflection

Sand and load-deflection

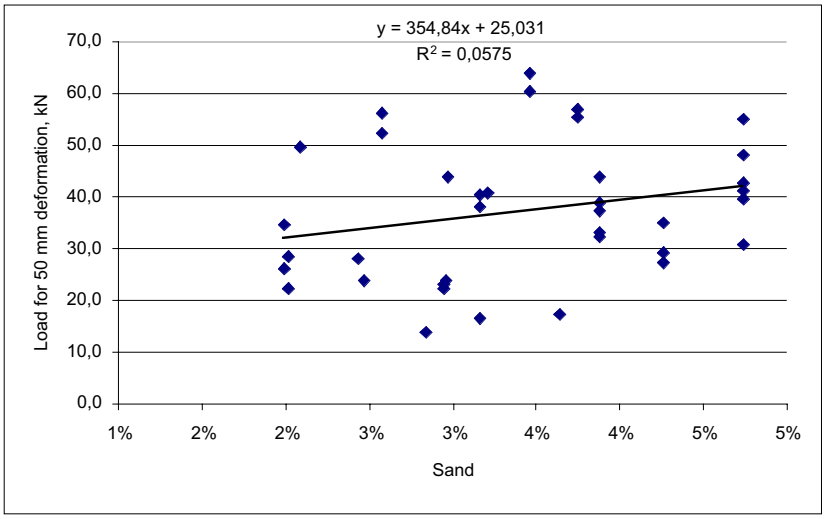

Figure 8. Sand quantity in light clay mixture in correlation with load-deflection

Sand and clay on load-deflection

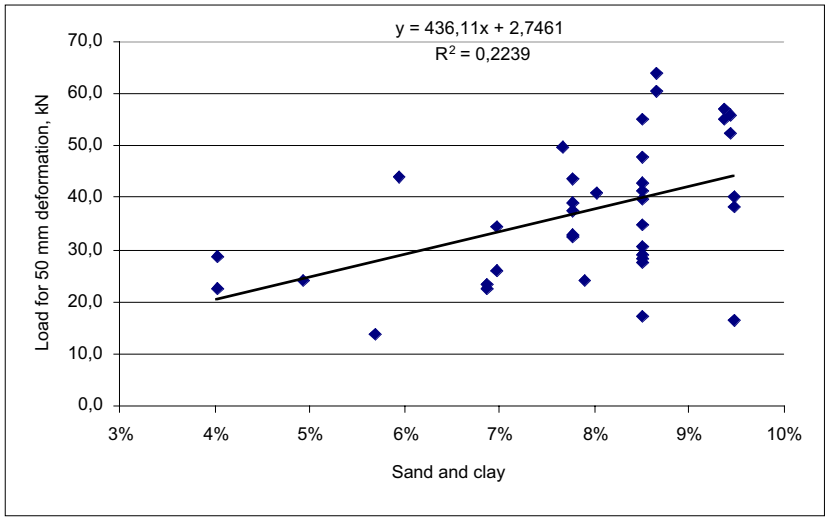

Figure 9. Sand and clay quantity in light clay mixture in correlation with load-deflection

Water and load-deflection

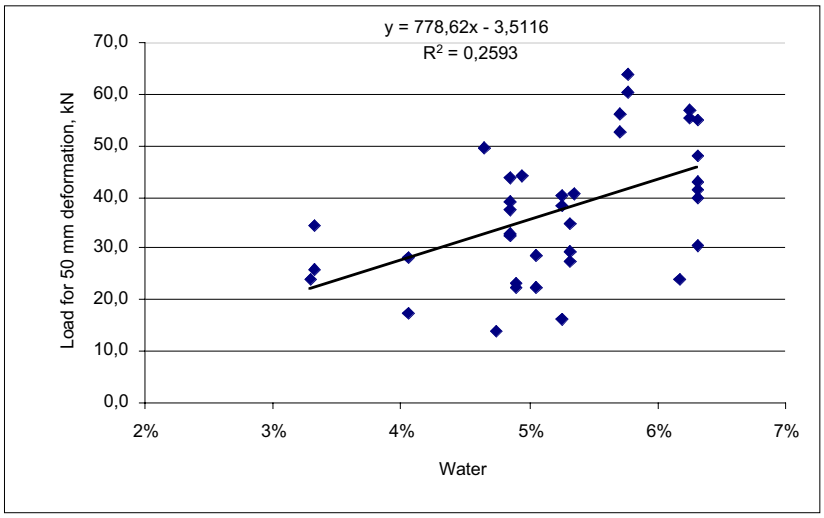

Figure 10.Water quantity in light clay mixture in correlation with load-deflection.

Various components of mixture and density

On the following figures it is illustrated how different materials influence light clay brick density. Obviously, high density materials are bound up with high quantity of sand and clay. Higher amount of reed and cat-tail cane gives the lightest density materials. As regards the wood chips and wood slivers, this kind of relation is not very remarkable.

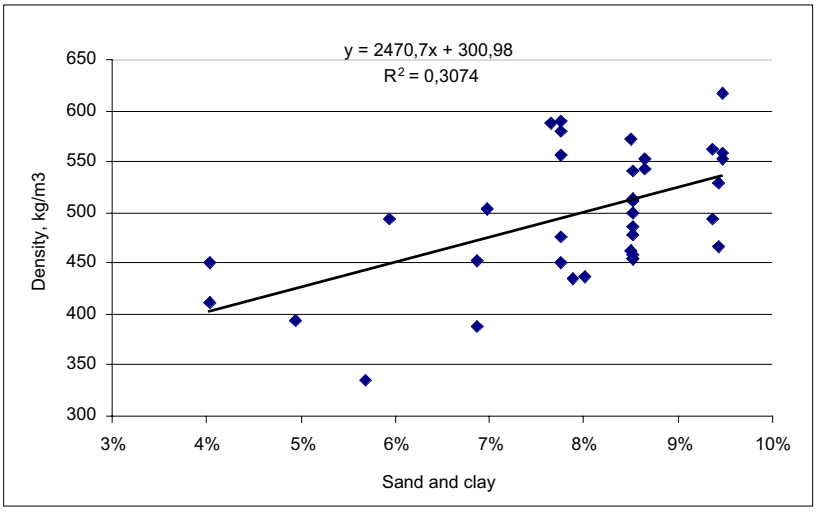

Figure11. Correlation between light clay mixture (sand and clay) and material density.

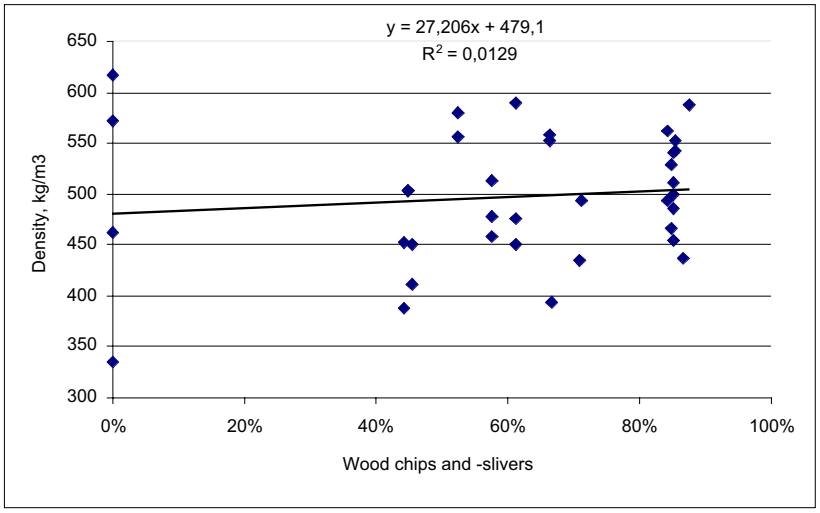

Figure12. Correlation between light clay mixture (wood and sliver chips) and material density.

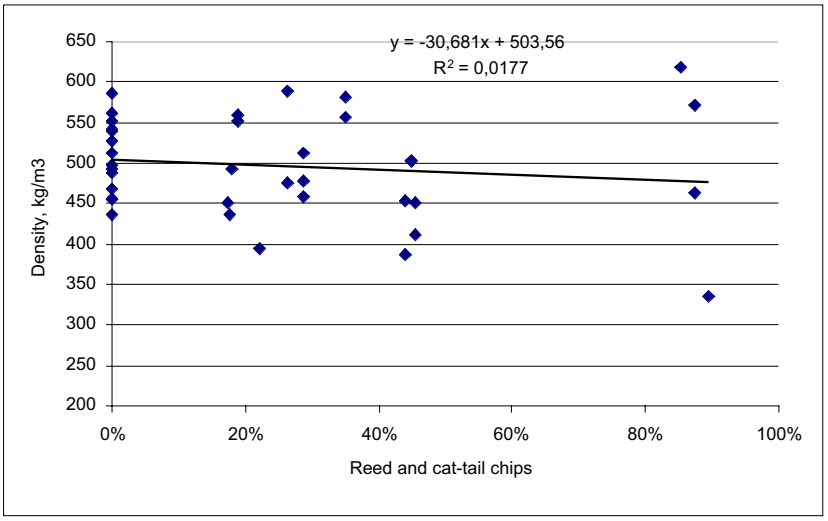

Figure 13. Correlation between light clay mixture (reed and cat-tail chips) and material density.

SUMMARY

Test results indicate that material quality under load conditions are very dependable on the different natural fibers. Besides simple and expected relations (higher quantity of minerals gives better load durability etc) and quantification of base material one can draw next conclusions:

- Reed has negative impact on material steady.

- Cat-tail gives good quality for the material. Beside low density and high durability, this material is resilient.

- More stable are materials with varied components. Especially important in this case is the moderate quantity of wood slivers to embody the mixture.

-Too much sand raises density, but does not show better load durability.

REFERENCE

- Clay as base material must be carefully selected and tested. Small fraction (under 0,002mm) gives real strength for the light clay material. To much sand gives heavy weight and brittle bricks. Correlation between clay and sand determine brick deformation in drying period (it can be remarkable). Before the construction works it is

- It is hard to mix light clay material in casual mixer, rather it is easier to do it with pitchfork and watering-can. For bigger works there is special clay mixing machine with horizontal axle and spiral paddles.

- When making the bricks it is important to fit mixture properly into the forms and press it lightly. Hard brick crushing highly impacts the drying period and density. In order to achieve the best result, one has to practice several times.

- After the form is removed, the bricks must stay without any movement. Untimely moved brick can cause micro rifts. The time for final drying depends on temperature, air movement and therefore the best time for light clay works is summer. In the cool room without air movement the trying period can be extremely long.