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Clay Wallpaper: science or fiction ?

Simone Ruschmeier

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ECOLE NATIONALE SUPERIEURE D'ARCHITECTURE DE GRENOBLE

Mémoire du
Diplôme de Spécialisation et d'Approfondissement – Architecture de Terre
Mention Patrimoine
DSA-Terre 2016 – 2018



CLAY WALLPAPER
Science or Fiction ?

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Septembre 2019

Ministère de la Culture
Direction générale des patrimoines

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CLAY WALLPAPER
Science or Fiction?

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CLAY

WALLPAPER

SCIENCE OR FICTION...?

ACKNOWLEDGEMENTS

MY MANY THANKS FOR THEIR SUPPORT, COFFEE AND PATIENCE GO TO

MIKK LUTH & MARKKO KIKAS AND ALL OF EESTIMAAEHITUS AND SAVIUKUMAJA

PETER BREIDENBACH, ULI RÖHLEN, HARTWIG BALLIS & IRIS HARTMANN AND ALL OF CLAYTEC

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THIERRY JOFFROY AND ALL AT CRATERRE

AS WELL AS ALL THE PEOPLE WHO HAVE PUT ME UP IN THEIR LOFTS OR SPARE ROOMS AND HELPED ME OTHERWISE ON MY QUEST TO LET THIS BOAT TO WATER

YOUR FAITH, TIME AND MATERIALS WILL NOT HAVE BEEN WASTED ;)

RÉSUMÉ

CLAY WALLPAPER - SCIENCE OR FICTION ?

PAPIER PEINT D'ARGILE – SCIENCE OU FICTION?

Mon travail sur le sujet des papiers peints en argile s'est déroulé comme toutes les bonnes choses qui arrivent dans la vie. On ne les appelle pas, elles viennent à vous et, à peine s'est-on aperçu de ce qui se manifeste comme opportunité, on se retrouve déjà plongé dedans.

Tout a démarré alors que j'étais en train de réfléchir à comment faciliter l'introduction du matériau terre « sur le marché ». Une des idées était alors de proposer un produit pré-fabriqué pouvant se substituer à l'application d'enduits. Et c'est à ce moment-là que je suis entré dans le royaume du papier peint et ce avec l'idée qu'il devrait être facile de remplacer avec de l'argile les matériaux conventionnels avec lesquels les papiers peints d'aujourd'hui sont faits. La question était de vérifier cette théorie par la mise en pratique. C'est ainsi que j'ai profité de l'opportunité de plusieurs stages pour expérimenter avec des professionnels séduits par l'idée et son originalité. Le fait est que : le plus j'ai pu chercher, le plus j'ai trouvé. Et ce que j'ai pu trouver a fini par apporter plus de réponses que de portes fermées.

Portée par mes premières petites réussites, j'ai poursuivi mes recherches en complétant mes savoirs lors de formations portant sur des savoirs anciens, presque perdus pouvant me faire comprendre les matériaux et ainsi m'aider à trouver les formulations et techniques appropriées. Ainsi, j'ai appris comment faire des papiers peints avec des « oreilles de bois », et mélangé de l'argile avec la pâte des ocre qui pègue. J'ai aussi visité des musées dans lesquels j'ai compris comment les japonais arrivent à de telles finitions pour leurs enduits en terre.

Toutes ces expériences m'ont permis de faire des progrès ce qui me permet aujourd'hui de faire état de résultats tangibles qui sont présentés dans ce document. Pour cela, il rassemble toutes les informations sur les expérimentations faites, avec leurs descriptions techniques et les résultats, et des photographies permettant de comprendre les procédés de mise en œuvre utilisés.

Ce mémoire est enfin conclu par des pistes de recherche que je me propose de poursuivre dans le futur, en espérant aussi susciter d'autres vocations et initiatives qui permettront à terme d'aller plus loin en termes d'applications concrètes de nouvelles solutions. Il est en effet urgent de mieux valoriser la terre et d'autres matériaux naturels ou recyclés pour apporter des réponses concrètes et largement diffusables à la nécessité d'adopter des modes de vies et pratiques plus frugales permettant de vivre tout aussi confortablement mais avec un meilleur respect des ressources que porte notre planète. J'espère que ça donne envie de me rejoindre dans la recherche pour trouver des nouveaux ou bien révolutionner les vieux applications et usages pour la terre.

Bonne lecture!

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1 INTRODUCTION

1.1 BIRTH OF AN IDEA

WHY WOULD ANYONE WANT TO MAKE WALLPAPER FROM CLAY?
AND HOW WOULD ANYONE EVEN COME TO IMAGINE IT?

Having first trained as an architect before the times that *ecological building* made it into the university lecture halls as a standard given, I had already gone through some trouble to give myself an eco-up-grade during five years of practical studies of building with strawbales, before I turned to looking into the possibilities offered by building with crude earth. I had first encountered crude earth employed as a natural render for straw walls, but as the versatility and viability of the material dawned on me, I applied and enrolled at ENSAG, CRAterre, in order to further my knowledge on crude earth architecture in general, its traditions, its current use and, in particular relevant as an incentive for this study, its future.

In the course of the studies for the DSA-terre, the students are invited to run or participate in workshops at the annual earth building festival, "Grains d'Isère". The first year that our course was hosting the festival (2017), the theme under which its workshops were run, was to investigate possibilities for creating pre-fabricated building materials or products from crude earth, to facilitate launching the material on the current mainstream construction market. Staying true to my initial interest, which was being able to use the earth sourced on site to render straw walls of new buildings with, I enrolled in the 'plaster and finishes' group.

Once the workshops were under way, it was while playing around inventing acoustic and thermally insulating clay panels that could be stuck or screwed to walls, I had the notion to see if making *wallpaper* from clay would work just as well...?

Making thermal and acoustic insulating wall coverings while



+

inspiration from exhibits at Grains d'Isère 2017



=

1.2 THE CONCEPT EXPLAINED

The initial incentive to develop the idea of producing clay wallpaper into an initiative was that, if it were possible to produce a clay-bound wallpaper, firstly, a clay finishing coat could be applied to walls that would, for one, dry faster than a fresh clay finish would, because it would not be as wet to start with and secondly, people who do not think they could apply a plaster finish to a wall to meet their own expectations, but would however say that they are very well capable of applying wallpaper to an acceptable standard, would then also be able to give their brick and concrete homes a beautiful and healthy clay finish, without having to make a big thing of it, i.e. spending extra money on asking professionals in to do it for them. Of course, the more skilled, not-so-rare-anymore type of modern eco-self-builder would also be welcome to flick through a hopefully thick catalogue of clay wallpaper designs and apply the naturally stylish papers him- or herself.

A clay wallpaper would ideally require no more than wetting with water on the backside and applying to an also more or less humid surface, then allowing to proceed to apply as one would with any other wallpaper; arrange to make sure the joins don't show up, press on, step back and enjoy!

Later on during the research a myriad of other applications and benefits to be obtained from clay wallpaper emerged, but the basic concept of the clay wallpaper, in a nutshell, is to be able to buy a ready-made wall decoration material which is essentially a dry roll of a thin sheet of clay and fibre, that can be applied, ideally singlehandedly, with either water or a clay slip, as applicable, to any surface that would otherwise be decorated in a non-ecological product.

..... *First Clay Wallpaper at Grains d'Isère 2017*



2 HISTORY AND SCIENCE

2.1 ROOTS AND FRUITS

A GLANCE INTO THE PAST ... ROOTS WITH A PINCH OF SALT

As can be learned from visits to ancient castles and various open air museums that in the present the habits and habitat of long gone inhabitants and their various habits, also referred to as cultures, people seemed to use to hang carpets on the walls for insulation purposes as well as to cut out draft, and last but definitely not least, because these carpets would have cost an eye, as decorative and representative purposes. But, is there more to the beginnings of wallpaper?

In search for answers for why wallpaper was first invented and what stages of development it has gone through to arrive on the screens of mobile phones today, the following provides a brief and sporadic dip into the long and surprisingly eventful history of wallpaper, as found searching the internet. As with all historic facts, some are established based on written or otherwise documented facts, and some are deduced, usually with the best intentions but always filtered by the viewpoint of the originator. Also, some facts may have been overlooked, and are thus yet to be uncovered...

On the website of “wallpaper-installer, Rebecca Schunck” for instance, backed by information given on the Wikipedia site explaining “wallpaper”, a detailed history of wallpaper is on offer that seems plausible enough, but lacks details I found in the wallpaper exhibition in *Maison Bergès*, near Grenoble.

Anyway, making the best of what’s available, in the following I present a summary.

According to the above websites, wallpaper originated a good 2000 years ago in China, where pictures drawn on rice paper were glued to walls, as they say, primarily for decoration and representative purposes. I would like to suggest considering the possibility of the Chinese using the “wallpaper” to prevent or disguise cracks in their earthen walls, and making the most of it, using the opportunity to add some decoration to their walls. But that is just a thought.

During the 9th century, Chinese papermakers divulged their artisan knowledge to the Arabs while imprisoned there. The Chinese had already evolved the papermaking from using rice-paper to using old clothes rags (linen) and other waste textiles already 100 bc, but the Arabs then developed the production and produce further by using local timber (kokka) and bamboo fibre instead, thereby achieving a finer graded paper.

Glued and rolled prints, as seen at Musée Maison Bergès



When it arrived in Europe, wallpaper quickly became very fashionable among the French, the Polish and Italian aristocracy, but it was the English who came up with the idea of gluing the bits of it together and rolling it in the 18th century, as can be read in the “papier-peints” exhibition at Maison Bergès, in Villard-Bonnot, France. However, French King Louis XI had reportedly already asked painter Jean Bourdichon to prepare and paint 50 rolls of portable (re-applicable?) wallpaper with angels on a blue background for him in 1481, which he then took with him when he changed residence between his various castles.

Picking up the baton from the English, everyone contributed to help wallpaper through various steps of development with regard to printing and processing, gaining speed and altitude since the 1940s, making wallpaper became more "sophisticated", furnished with a washable surface or displaying photographic prints, culminating in today's enhanced versions embossed with holographic effects or laser-jetted with nano-print technology, making 2D the repeat-pattern and the hand-painted original but a memory.

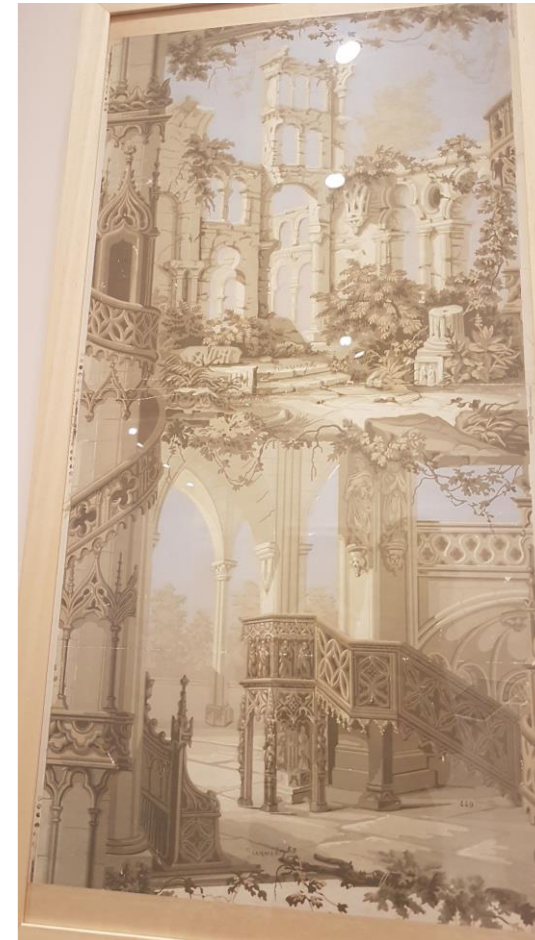
According to the information given at the guided tour of the “papier-peints” exhibition at Maison Bergès, in the beginning, wallpaper came in sheets of roughly 60cm by 60cm and was stuck to walls using animal hide glue (sourced from rabbit skin), which would have smelled terribly for a good long while. In the 18th century, however, with progressing industrialisation of the farming industry, a less pungent but possibly more prone to go mouldy starch glue, made from plain flour and possibly a drop of oil replaced the hide-glue. In the early 20th century, a German company “Henkel”, released a cellulose based glue to the market, which dried faster, presented a less interesting base for mould and other forms of life which soon replaced previous glues. Modern papers I am sure need other kinds of glue, just to tap another vein of possible incomes, but that is a wild stipulation.

It may be interesting to consider, just for a moment, not the wallpaper and the glue, but the history of evolution of the substrates that they would have been applied to. Whereas in the Far East the substrates may have been stone and earth, or bamboo and straw to begin with, in Western Europe the substrate for the wallpaper would most likely have been stone or timber, as well as earthen walls, bare, or covered in a gypsum, earth, lime or later, in both, or rather nearly all parts of the world, increasingly so, cement plaster.

Whilst the first specimen of wall paper were painted by hand, which would have been tedious and required time and highly skilled craftsmanship, but progressively this process was taken through stamp- and roll- printing to stencilled painting which led to a multi-layered printing method to be developed. According to the guided tour at the Maison Bergès, the most luxurious pieces would have had up to 500 stencils used on it. Due to the nature of the making, the hand painted versions depicted more fluid scenes and bespoke motives, whereas the printed versions would be limited to repeat pattern designs. Lithography helped the industry along a long way in the early 18 hundreds, and plane symmetry patterns, of which, according to Evgraf Fedorov, 1891, there are only 17 possible designs¹, were applied and imprinted on the rolls. Having taken efficiency of printing and design to a thus scientifically defined limit, development has taken a turn towards the origins, as in the more recent past, using digital inkjet printing technology, wallpaper was returned to depicting a scene rather than a pattern (photographs printed to cover walls).

¹ https://en.wikipedia.org/wiki/Evgraf_Fedorov

Below: Glued and rolled painted sheets



Below: Embossed paint, thickened with bone glue, as seen at Musée Maison Bergès.





Throughout history, the colours used were mineral based paints, enhanced with various additives to speed up or retard the drying, to give the paint a gloss finish, or a thicker body, or a satin shimmering finish, etc. The details of the recipes unfortunately remain to be researched. That said, it must be stressed that these additives of the long gone past, maybe less than those of the recent past and as in use today, would have hindered or even inhibited the breathing capacity of the substrate/wall, since they would have had to also trap the mineral, synthetic and/or metal content, thus requiring a more complex glue than simply water to hang the papers.

Taking a step back to look at this development of paper making, the paint, the motifs and patterns, the substrate and glues, I would like to return the focus on what caused the insurrection of wallpaper in the first place? Why would there have been a market for hanging ready-painted pictures arguably interminably on walls? Was it the inconvenience of having the painter round for a couple of days until the picture was finished? Was it the quality that the silken background would have given to the picture? Was it cheaper?

In my opinion, it should be considered that, since the wallpaper originated in a country with plenty of seismically active zones, the silk and rice paper paintings may have had a reinforcing, crack-preventing or cover-up job to perform, while also beautifying the then ubiquitous clay infill in the timber framed walls, albeit this is just hypothesis. Furthermore, I suggest that even in the more recent past, as recent as the 20th century (picture on left), it can be assumed that wallpaper was used to perform jobs as well as decorate a space. Here, I assume, the woven cloth covering at the base of the wall would allow the moisture escape from the walls where it accumulates, the horizontal piece would be a continuous band of painted paper along which it would be easy to run a duster or even wet cloth to clean the protective skirting at backrest level, also giving a neat edge to the wallpaper strips that cover the large area of the walls.

Incidentally, Wikipedia.org offers a comforting list of emerging “functional” wallpapers that are currently being released onto the market:

- a high-tech paper that shields the room from electromagnetic waves using a silver ink to block electromagnetic signals;
- high-tech wallpaper, that serves as a computer screen, using projectors, webcams etc.;
- a seismic paper, that prevents masonry walls from falling in an earthquake by inclusion of multiple layers of glass fibre mesh. (This may be a hint as to where the circle closes...).
- Wallpaper has already launched a series of thermally and acoustically insulating wall papers, as well as an eco-range²

Original wallpaper at Musée Maison Bergès: 3 types of paper doing 3 jobs (see text)

² https://www.archiproducts.com/de/wallpepper/produkte/kategorien_tapeten

VISIONS OF THE FUTURE ... FRUITS WITH A PINCH OF PEPPER

Further to the short list of new inventions that already rattle the bare bars of the cage of interior wall decoration (see above: a high-tech paper that shields the room from electromagnetic wave, one that acts as a computer interface and the anti-seismic paper is quite extraordinary in itself) it becomes clear, the ground is set, wallpaper design and material make up is feeling the ripple caused by the rattle, and we are experiencing the beginning of a wave of a function-led re-invention of what we refer to as wallpaper.

The new age wallpaper could, or should be doing various jobs at once, instead of just hanging there, as your conventional wallpaper does or did. Clay wallpaper should accordingly pick up the baton handed by the fast moving market and be formulated and applied to perform highly functional and beneficial tasks, improving the space quality not just visually, but instead, by tapping into the various qualities of the main ingredients (clay and fibre) it would be possible to amplify the required characteristic and quality to suit the situation and requirement.

But can we detect an actual need or it, now or in the predictable bit of the future?

Well, I think that we don't need to venture too far into the unknown, but simply dare to think outside the box, the box of samples that already exists. Looking at clay and its most prominent qualities, there is no harm done in tapping these and putting them to use. Quite to the contrary. Who would not want a wallpaper that can store heat, sequester toxins your MDF furniture exudes, insulate cold concrete walls, buffer humidity, or sprout a spot of green? How boring would a future without it be?

On a more serious note, is there a construction based need visible on the horizon? And I think yes, the anti-seismic wallpaper has already been invented and the electromagnetic shielding too. But why should these not be made of clay?

Other applications for which a need may be only emerging as we speak, may be found for instance in the realm of emerging straw construction, where it is (usually) recommended to apply a jute or flax-fibre mesh to the earth plastered walls before applying the finishing coat. This layer of mesh is applied to prevent shrinkage cracks from forming, protect from future damage from mechanical impact, as well as it provides a nice grip for the finishing layer to hold on to. Were it not a great time saving aspect if those two last steps of finishing the walls could be summarised in one?

Yet another aspect important to mention at the outset is that a clay wallpaper does not necessarily need to be bought. Its production can be taught and personalised designs and variations produced to embellish walls in people's homes, mirroring their individual preferences and skills. Not only would a self-made clay wallpaper be facilitating a physical and meta-physical re-claiming of homes by the people who live in them. The act of designing and becoming active in the work involved in building, repairing or embellishing one's own home is a very important aspect of rooting and adapting ones nest to best nourish and accommodate the occupiers' soul. Especially today, in the times of quick-lived, throw-away identities, expressing and displaying one's personal space to suit the personal preferences can help to strengthen roots, and maybe even more so tomorrow.



Loadbearing strawbale building site in Romsey, UK: Window reveals in straw wall receive bonding coat, then body coat, then jute mesh and then finishing coat.

Making your own wallpaper does not require a large area, nor complicated power tools, or PPE to maintain your personal health and safety. First samples, Grains d'Isère 2017



Allow me to elaborate a little on the above with the following thoughts...

There is a definite tendency for a dissociation of the individual with the value or significance of what used to be called “home”, not even referring to the place where you were born, but any one place you decide to retreat to, to recharge batteries, to feel safe and comfortable in, no matter for how long or short. Coming ‘home’ and recognising one’s own fingerprint on the personalised environment raises the feedback that nourishes the soul and triggers an awareness and responsibility for the space, site or building. And if nothing else, making your own wallpaper is less likely to cause harm or damage, but more likely to inspire and nurture spiritual growth, or simply have a laugh. Unfortunately I have no reference to tag on this matter, but having spoken to various people who have at least helped to build their own homes (in most cases these were made of straw) have a very deep connection to their house, they seem less likely to sell it on a whim, in exchange for another that simply has a bigger balcony, so to speak.

Last but not least, I would like to add, that as a child of the seventies, I am painfully aware that one of the best aspects of wall-paper was, is and probably always will be, that it can be removed and replaced with something new. Although the patterns and designs were very entertaining at times, one might have wondered if a future without wallpaper would be granted one fine day.

However, as we grow, we tend to surround us with images and colours that reflect our personal state of development, or, as fashion would have it, to celebrate the passing seasons. In the world of interior design, it would be convenient to be able to apply quick and easy wall finish that can be removed and reused or disposed of without worrying about the waste (see also IKEA, removable latex wall Graffiti). The alternative that we are living today, is painted walls that will receive layer after layer of some chemical lacquer sealant, conveniently wash-off-able, which nobody ever does, inhibiting the walls from breathing or perspiring, with sometimes costly consequence to the building fabric. Since most of the clay wallpaper I’ve experimented on so far can literally be “re-moved”, i.e. taken down in one piece, and, if a mesh was used to reinforce it be stuck again elsewhere, whereas others can be scraped off, re-mixed, dried and “stuck” again in a new design, colour or pattern, I believe the horizon that we set out to scan for visions, is ablaze.



*Experimenting with clay painting on fibre substrate:
Clay with mineral pigments and egg yolk on aquarelle paper (pencil), Mooste, Estonia. SR*

2.2 PHYSICS IN FAVOUR

To ensure that the idea of a clay wallpaper is not a natural ‘red herring’, in other words, just another product to enter the market with a green label, but has not much quality to show for it, I ventured an investigation into the matter and asked the world of numbers a couple of questions.

1. WOULD A WALLPAPER WITH AN ASSUMED THICKNESS OF NO MORE THAN 3MM HAVE A POSITIVE EFFECT ON THE HUMIDITY CONTENT OF A ROOM IT IS APPLIED IN?

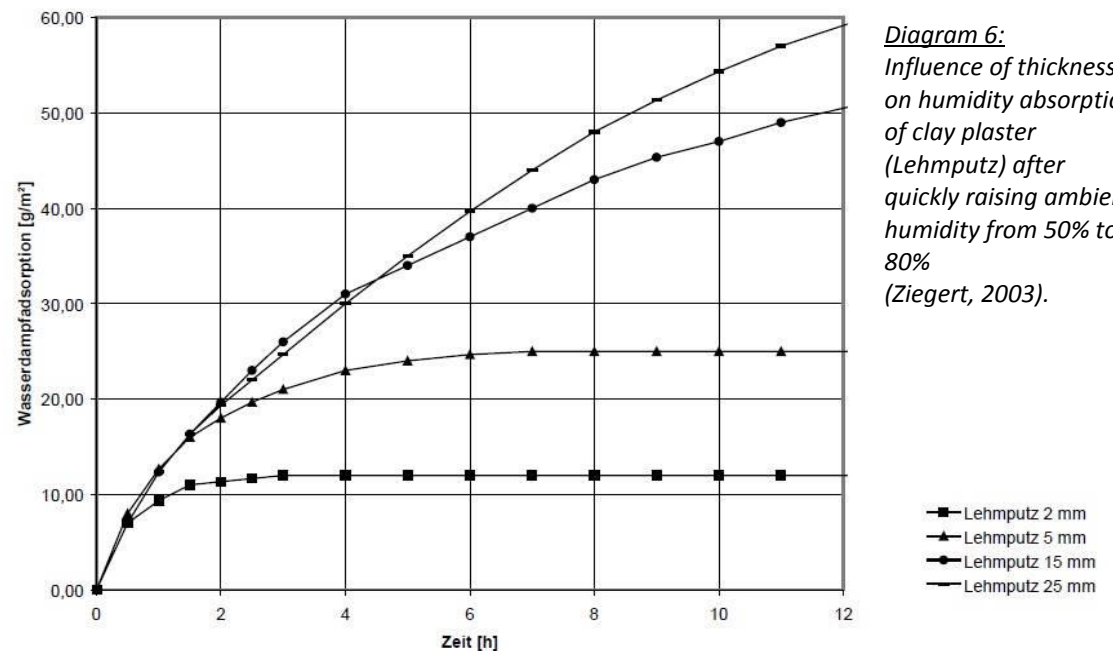
An answer to this can be found, for instance, in an article by Wulf Eckermann und Christoph Ziegert, 2006, entitled “Auswirkung von Lehmbaustoffen auf die Raumluftfeuchte”, on the influence that clay construction materials have on the indoor climate.

According to this study a 2mm clay finish will absorb 1/5 of the total amount that a 25mm of clay plaster will absorb in 12hours. Since 2mm is a lot less than one fifth of 25mm thickness, it can be said that the decrease of the absorption total per volume and depth within the material is not linear and therefore the first 2mm of a plaster finish do more work than any other 2mm in the plaster. Furthermore, their findings show that during 12 hours of exposure to a humidity that has been raised from 50% to 80%, a period which corresponds to an assumed rhythm of recurring action with effect on the climate in a room, only a depth of 1.5cm up to 2cm of any plaster finish will be active in the intake of this airborne moisture. The rear 5mm only come into action if the exposure continues.³

Thinner layers obviously have less physical storage capacity to absorb humidity, simply due to lack of material. However, in a thinner layer the capacity of the material to do so, will be used more efficiently. As can be seen on the graph, the absorption activity is greatest in the surface of a plaster finish and fizzles out towards the inside of the plaster.

Thinner plasters therefore do a lot of the absorption, but the point of saturation will be reached sooner. Consequently desorption, once it sets in, and which notably always takes longer than the absorption phase, will also happen more quickly, which means that the humidity storage buffering time is also reduced.

According to diagram 6 (name as in original document), a 2mm clay cover will have reached its maximum absorption capacity after about 3 hours, while humidity intake in the 15 to 25mm thick plasters has not reached saturation point time was called on the exposure to the rhythmic rise in humidity that was assumed for the experiment.



*Diagram 6:
Influence of thickness
on humidity absorption
of clay plaster
(Lehmputz) after
quickly raising ambient
humidity from 50% to
80%
(Ziegert, 2003).*

³ “Auswirkung von Lehmbaustoffen auf die Raumluftfeuchte”, by Wulf Eckermann and Christoph Ziegert, 2006

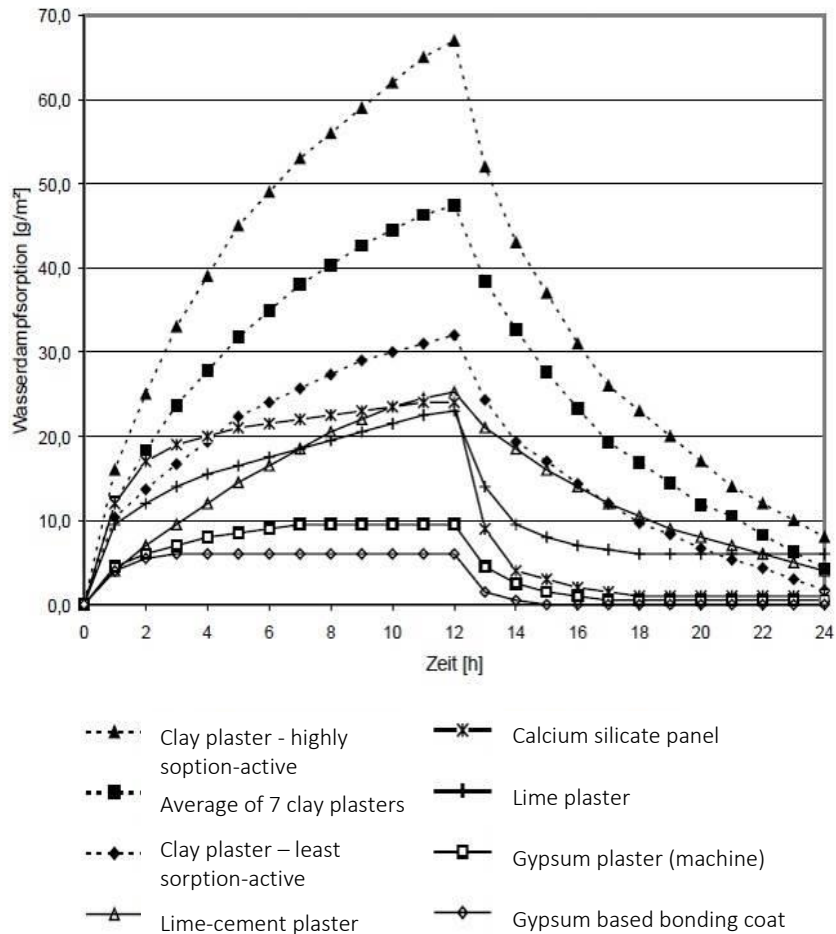


Diagram 4:
Reaction of various plaster finishes to varying relative ambient humidity (sorption capacity). During the experiment the temperature was kept constant, but the humidity was raised spontaneously from 50% to 80%, and after 12 hours reduced back to 50%. (Eckermann u Ziegert)

As an aside, diagram 4 on the left (name as in original document), shows how the study also puts other plaster materials in comparison, with respect to absorption rates and capacity, comparing the various sorption capacities of the different clays as well as lime and gypsum based plasters.

This shows that on the one hand there is a wide range of absorption capacities in the varieties of clays tested, but it also shows that even the least active (high content of Illit) is more active than any of the plasters they were compared with: lime plaster, lime-cement plaster, gypsum plaster or Calcium silicate plasterboards. Further to this it is mentioned that according to findings from more tests performed on the usual wall make-ups in current use:

- A clay panel backing, which implies a fibre content of some sort in the substrate, will raise the total absorption value of the 3mm clay finish, in which this fibre content in the panel is a factor to consider. (diagram 5 on next page, name as in original document)
- With the same 3mm clay finish, a gypsum plasterboard will buffer half the amount of that of a clay panel, whereas the plasterboard without the clay finish will absorb only one third of that of the clay panel without the 3mm clay finish.
- Varying the type of fibre and additives added to the same clay influences the humidity intake of the material mix significantly.

Important to this study is mainly the difference of adding cellulose which increases the total humidity absorption capacity of the clay by roughly one fifth, whereas adding methyl-cellulose (wallpaper glue) reduces it by roughly one fifth, see diagram 1.4-8, p.11. This information is backed by diagram 5 (next page), where a common woodchip paper glued on with cellulose glue reduces the absorption capacity of the wall significantly.

Looking at the difference in buffering times relative to the thickness of the material, suggests that thicker walls will be able to buffer seasonal humidity variations, due to the prolonged periods of ab- as well as de-sorption, while clay plaster of a thickness of 15mm thick, will be able to buffer daily humidity variations, i.e. variations that periodically originate from use of an indoor space requiring this period of time to get back to a neutral state. (see also diagram 1.4-6, p.11)

Interestingly, that means that a wallpaper will accordingly be able to buffer spontaneous boosts of humidity (kettle, shower, etc) while they happen and release the extra moisture quick enough to allow the evacuation of an important part of this humidity by opening the window while you're getting dressed. Whereas thicker plasters will still be releasing this humidity back into the space while you're having your first, and even your last cup of tea at the office.⁴

The de-sorption time can be quite important with respect to the registered increase in mould occurrence in new, as well as renovated buildings⁵. This development seems to be due to use of materials that retain humidity thus presenting perfect conditions for mould growth, a more controlled interior climate or eliminated if not massively reduced natural air change (aggravated by the airtightness craze, as instigated by the passive house movement). Although not blatantly important to this study, another factor that encourages mould growth is our angular building designs, enforced by use of pre-fabricated angular components, where air sitting along the inside edges of corners stagnates, which hinders evaporation and again promotes growth of mould. The recent rise of particular mildew and mould is an aggravation of a previous given, incurred by (human) habits of use of the building and rarely due to rising or falling damp in walls or other construction based causes that then paradoxically is countered by insertion or wrapping of more non-breathable layers of various types of plastic. We can all see where this is going?

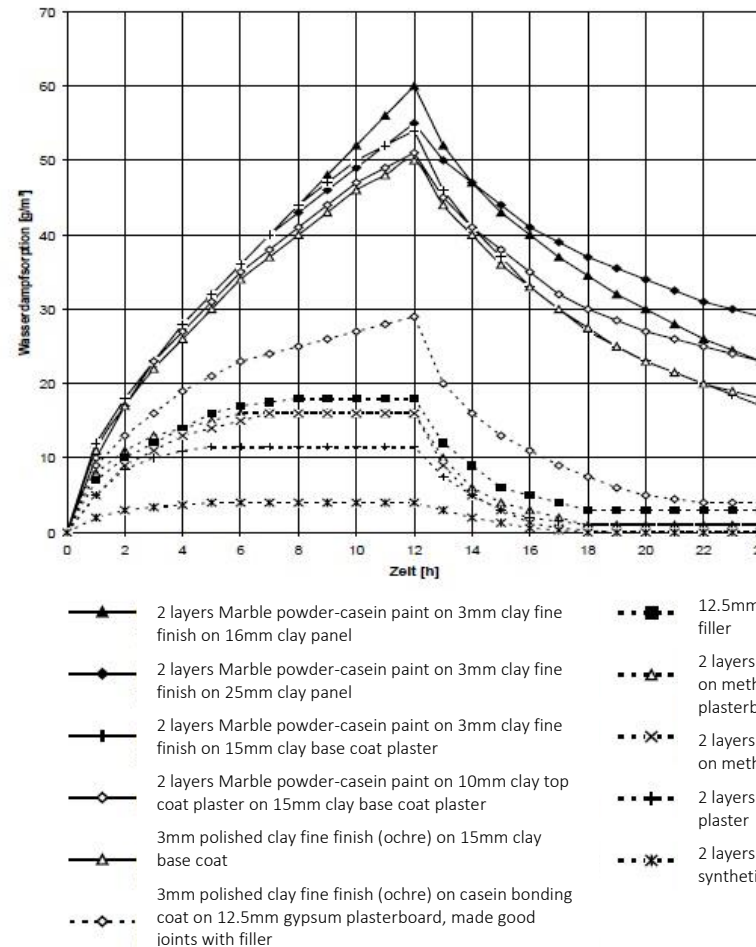


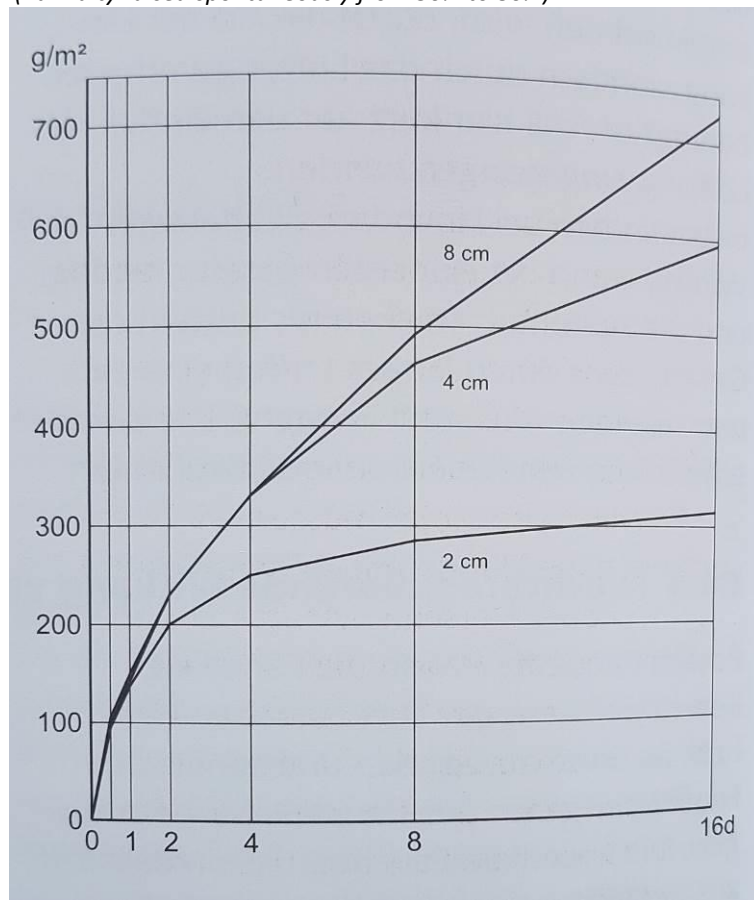
Diagram 5:
Summary of various conventional wall make-ups in comparison to some clay based wall make-ups where room facing surface was exposed to a spontaneous rise in ambient humidity from 50% to 80% for a duration of 12 hr, then reduced back to 50%, while the temperature is kept constant. (Ziegert, 2003)

⁴ "Handbuch Lehmabau", Prof. Dr. Ing. Gernot Minke, 2012, p.14

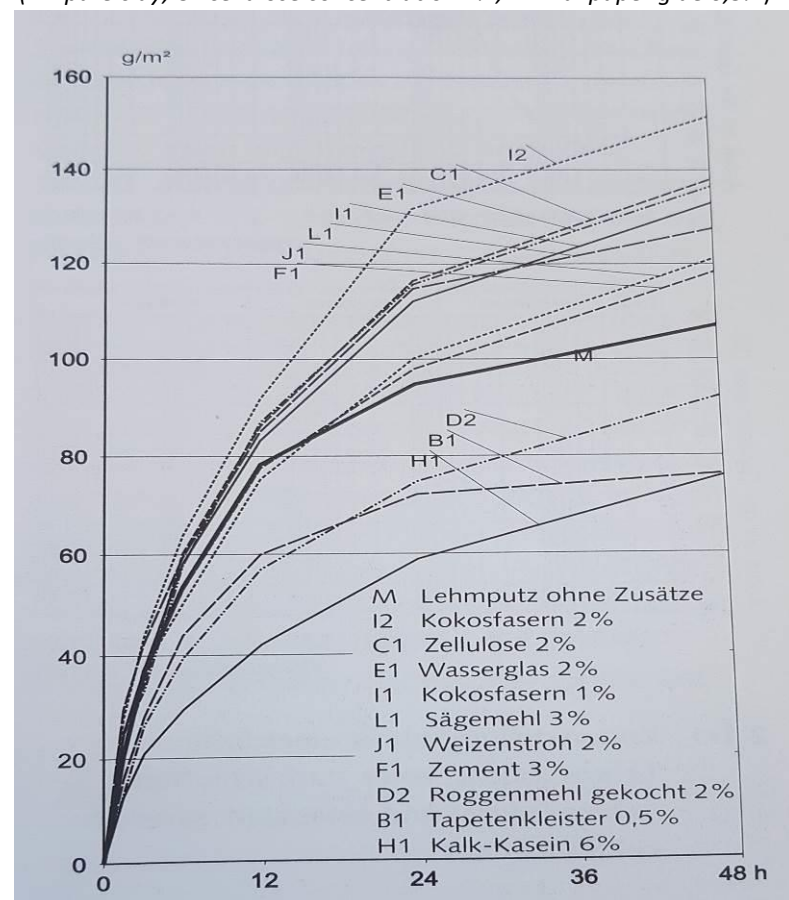
⁵ "Auswirkung von Lehmabau auf die Raumluftfeuchte", by Wulf Eckermann and Christoph Ziegert, 2006

A clay wallpaper will therefore be able to buffer immediate peaks of humidity, and thus give meaningful protection for underlying materials that are otherwise prone to grow mould if exposed frequently to humidity in excess of 80%. In combination with letting any non-clay substrate transpire previously absorbed humidity and thereby avoiding retention of absorbed moisture in its pores, where mould growth would consequently be triggered, the natural fibre content in the clay wallpapers also promises to increase the buffering capacity relative to its thickness. Not using cellulose glue to stick the wallpapers on whatever substrate, will also activate the vapour diffusion capacity in underlying substrate, rather than, as common in contemporary construction, have it sealed off with dispersion paints, resin bound plaster or – in the case of vinyl wallpaper, cellulose glue.

Minke, Diagram 1.4 – 6
Humidity absorption of clay plaster relative to thickness
(humidity raised spontaneously from 50% to 80%)



Minke, Diagram 1.4 – 8
Humidity absorption of clay with a variety of additives
(M- pure clay, C1 cellulose concentration 2%, B1 wallpaper glue 0,5%)



2. WHAT IS THE RANGE OR LIMIT OF FUNCTIONALITY REGARDING HUMIDITY OF CLAY AS A WALL FINISH?

Prof. Dr. Ing. Gernot Minke is a clay specialist, who has helped the use and the knowledge about the physical spectre and characteristics of clay along the way a great deal, and is recognised for his work in Germany, as well as abroad. In his handbook on building with clay, “*Handbuch Lehmbau*”, 2012, p.12, he lists few more very interesting physical facts that speak in favour of using clay-fibre wallpaper to sanitise and embellish an indoor space.

These qualities and aspects can be summarised as follows⁶:

- Shields from high frequency radiation
(Example: This was picked up by a team, led by Jan van der Linden, NL, that submitted a clay designed object to the Terra Migaki Design Competition in 2019: picture *Mobile coffin* – a clay box to put the mobile phone into, if not wanting to turn it off, but no signals are to be send or received)⁷
- High thermal storage capacity
- Thermal buffer/insulation
- Absorbs and locks in water soluble toxins and odours
- Acts as acoustic insulation
- Humidity regulating capacity
- Conserves timber (timber has a specific humidity of 8 – 12% of its dry weight, while most clays range around 0.4 to 6% of moisture content, which means that the clay will keep dry any timber covered in it, and thus help to reduce humidity content in timber structures etc. Mushrooms require a moisture content of above 20% of the dry weight in wood in order to grow.)
- Clay lends itself for use in self -builds
- Clay is usually available from local sources
- A load of clay requires approximately 1% of the energy required to produce fired bricks or reinforced concrete (current: 2012)
- Clay is infinitely reusable/recyclable

The MONK is a design object for your bedside. In today’s ever bustling world, with plenty of technology, full connectedness, impulses and triggers at any given hour, it can be useful to have a MONK at your bedside.

The MONK is a block of earth made to put your phone inside at night. Ones the phone is inside, you can have a rest, read a book or have a talk. The earth was used to function as a buffer between the phone and you; for the electromagnetic radiation, sound and light of your phone. This way it transforms into a phone vault.

Meanwhile, the MONK includes a built-in lamp, so that you can focus on your analog activities such as reading a book.



⁶ “Handbuch Lehmbau”, Prof. Dr. Ing. Gernot Minke, 2012

⁷ <https://terramigakidesign.com/competition-2019/> - first prize went to Jan van der Linden and team for MONK

Tabelle 3.2: Wärmedurchlasswiderstand von Lehmbaustoffen (Beispiele)

Lehmstoff	Rohdichte (kg/m³)	Wärmeleitfähigkeit (W/mK)	Schichtdicke (cm)	Wärmedurchlasswiderstand (m² · K/W)
Stampflehm Rammed Earth	2200	1,40	24	0,17
			36	0,26
			48	0,34
Wellerlehm Cob	1800	0,90	24	0,27
			36	0,40
			48	0,53
Wellerlehm Cob	1600	0,70	24	0,34
			36	0,51
			48	0,69
Strohlehm Straw Clay mix	1500	0,65	24	0,36
			36	0,55
			48	0,74
Strohlehm Straw Clay mix	1400	0,60	24	0,40
			36	0,60
			48	0,80
Strohlehm Straw Clay mix	1200	0,50	24	0,48
			36	0,72
			48	0,96
Lehmsteine	1500	0,65	11,5	0,18
			24	0,37
Leichtlehmsteine Adobe	1200	0,50	11,5	0,23
			24	0,48
Leichtlehm-schüttung Adobe with fibre	800	0,25	12	0,48
			24	0,96
Leichtlehm-schüttung Light clay fibre, loose	400	0,12	12	1,00
			24	2,00
Lehmplatte	1500	0,65	2,5	0,038
Beispiele der Berechnung des Wärmedurchgangskoeffizienten U (früher k)				
Stampflehm, Rohdichte 2200 kg/m³, 0,48 m Schichtdicke: $1/0,34 = 2,941 \text{ W/m}^2\text{K}$				
Strohlehm, Rohdichte 1200 kg/m³, 0,48 m Schichtdicke: $1/0,96 = 1,042 \text{ W/m}^2\text{K}$				

Table from "Lehmbauarbeiten Praxis", Kurt Schönburg, 2008
 CLAY: Thermal conductivity (W/mK) and resistance to thermal conductivity (Km²/W), relative to material density (kg/m³) and thickness of layer (cm)

Although the above are well known facts amongst the professionals, and I find myself preaching to the converted, I would just like to go into a little more detail on the bullet point mentioning thermal storage capacity and thermal buffer and insulation properties. Everyone is familiar with the comparison that explains the difference between thermal storage and insulation, where one imagines sitting down on a block of concrete and then, to contrast it, sitting on a straw bale. Obviously the sensations will be concrete – cold bum after not long at all and you'll be trying to sit on your fingers instead, whereas on the strawbale – you'll simply not want to get up from. While the strawbale will not conduct the air from your bum off into the bale, mainly because there is no continuous material bridge, and therefore your bum receives the heat it gives off straight back, on the denser material, concrete, the opposite happens. The heat from your bum is sucked into the block, and it is a big block. Even a 3cm concrete render is a lot of material to heat up, especially if the only source is your bum. The concrete will pass the heat on to where there is less until the conditions outside are colder which will trigger release of the stored heat. And why am I explaining this? Because Clay Wallpaper is not just clay, but clay and fibre. Clay-based building material can have a density of up to 2000kg/m³ giving it a lambda value (heat transmission coefficient) of 1.1W/mK, which is a lot, where your average concrete weighs in at 2400kg/m³, making the heat-sucking quality yet stronger. This translates also into a great thermal storage capacity, which incidentally comes in as a handy extra when clay is applied as a plaster on a wall made of straw. However, mixing clay with fibre, as is the case in the clay wallpaper, reduces the density of the material and this is where the German literature comes in handy, because they have numbers for everything. Clay mixed with fibre is referenced as a building material in both reference books mentioned above, down to a density of 500kg/m³ where the lambda value, the rate the material steals your bums heat is reduced to 0.14 W/mK, which is within the realm of insulating materials. If we now apply even a thin layer of this clay-fibre mix onto a concrete wall, the surface of the concrete is not in contact with the air anymore and can only take the heat the insulating wallpaper is able to pass on. The insulation factor for a simple clay-fibre wallpaper would not be very high, but having experimented with clay-coated felts as well, it is a factor to be considered.

Finally, just a mention that, in his book on building practice working with clay, Kurt Schönburg refers to the absorption capacity for toxins as applied "Raumhygiene", which translates into 'space hygiene'. Furthermore, clay itself offers no base for bacteria, fungi or algae to grow on, and can therefore be considered safe.⁸

Armed with this encouraging information, clay wallpaper seems to be well worth investigating.

⁸ "Praxis Lehmbauarbeiten", Kurt Schönburg, 1. Edition, 2008

3 THE SMALL PRINT

3.1 AIM OF THIS MÉMOIRE

With the vast field of possibilities for the development of this product spread out before our feet, I am neither looking for, nor have I been able to come up with one single recipe and a ready to use production line. Nor have I, as yet, registered a branded product to be discussed in this paper. The scope of this mémoire can therefore only be a summary of my initial experiences and findings to date. It can but indicate the myriad of applications and potential uses for what started out as a very simple idea. Bearing in mind that the product definition and description of the product is to be kept as open and flexible as possible, so as not to impede derivatives and improvements from surfacing or shut out other options and opportunities for its use that may yet arise, this mémoire will not attempt to pass a thumbs-up or-down judgement on any of the results obtained and presented in the following.

The general aim of this mémoire is to inform about the practical and theoretical research undertaken to date, setting up anyone interested to look further into the possibility of making clay wallpaper a commonplace option available to all.

OBJECTIVE, OR HOW I WILL GO ABOUT ACHIEVING THIS AIM

Hopefully achieving to set a comprehensive frame of information, through which this product can be assessed, this paper describes the material potential and deficits discovered and known, the legal and normative framework, gives an overview of the consumers preferences and fears today, as well as it offers a glimpse into the social and environmental aspects to be tapped.

Having already set the scene, giving the background and reasoning behind the idea, as well as a solid foundation of research into **history** and semi-stipulated looks into the future, backed or potentially supported by the analysis of the **physics at work**, this chapter explains the logic behind the sequence in which information is given and what this information hopes to achieve with the reader. To make absolutely sure what has been written will not be misinterpreted, the terms used are also discussed briefly.

Following on from here, the work that has gone into the study is listed, as is any other **activity, research or experience** that has fed and furthered the study, some of which will not feature in the detailed Chapter. This overview may raise questions but it may also explain why some experiments were done as they were done and not differently. Before diving into the **nitty gritty**, suitably named is the main body of the mémoire, where the mixes and the results are detailed, results from the **market research** are presented and evaluated and **the legal framework** as applicable or not presented.

This sets us up for the main body of work. Instead of whittling a humongous range of possibilities down to one optimal solution, the results from various experiments will be presented on a purely factual basis, so as to not to limit the range of applications before they have been recognised. In order to provide a base for further research, this paper points out and emphasizes any result that sticks out from the rest, in whatever way.

Clay slip on spider web mesh wallpaper falls outward to form a lampshade



Since the greater part of people who are likely to be reading this transcript of my experiences will already be familiar with clay and fibre, this mémoire will also not try to explain the detail of the physics or chemistry at work, but concentrate on picking out the practical aspects of the results deduced and the potential contained.

Finally, this mémoire will present a summary of what has been learned to this point and, with reference to the possibilities at hand, outline which stones have as yet been left unturned and what kind of research could be undertaken to push earth as a building material onto the market, in this case, in the form of a pre-fabricated clay wall finish.

3.2 TERMINOLOGY AND GENERAL INFORMATION

Talking about clay wallpaper to people with no previous knowledge about earth and clay, I have been asked to explain the terms I use in more detail, in order to clarify what each term does and doesn't apply to, what it implies as well as what it doesn't. Therefore, in order to avoid confusion and misunderstandings even with colleagues, the following explains the way I understand and use the subject related terminology.

DEFINITION OF „WALLPAPER“, AS FOUND IN THE ON-LINE VERSION OF THE COLLINS ENGLISH DICTIONARY

British English:

1. paper usually printed or embossed with designs for pasting onto walls and ceilings
2. something pleasant but bland which serves as an unobtrusive background

American English:

Wallpaper is thick coloured or patterned paper that is used for covering and decorating the walls of rooms.

“PREFAB RENDER” EXPLAINED

Render is usually applied to a minimum thickness of 1.5 to 3 times its thickest ingredient, usually in a more or less plastic state. Relative to its moisture content and the nature of the substrate, the plaster will take more or less time to dry. Depending on the material the render is made of (e.g. cement, lime, gypsum plaster or clay) the application may also require special tools, professional work and protective gear.

A pre-fab render would be a dry, ready to fit variation of this finish, reducing the time spent on application and drying, while also eliminating the need for “dirty work” on site and ideally the unhealthy aspects of the work involved in rendering (in the case of cement), as well making redundant the involvement of a costly professional.

A possible version of a pre-fab render would be dry pre-fabricated panels that can be stuck or fixed mechanically to an existing surface. By definition, a panel would have a stiffness and a thickness comparable to that of a dried render and therefore corresponds to the render best in those respects.

However, between the panels, which, in order to be manageable in size and weight per unit, are of finite extent, there are joints to be handled in a follow-up procedure, which distances the product from the uniform wall finish of the seamless render, as well as from the pre-fab advantage of saving on work, especially wet work, on site. Panels would, on top of having to have the joints dealt with (unless these are to produce a designed pattern) need to be covered with another layer of something or other to hide the joints.

CLAY WALLPAPER AS A "PREFAB FINISH" EXPLAINED

The finishing layer is thinner than the render, unless the render is well finished and does not require a finishing layer, and should look its very best. For a long time.

One possible pre-fab version of a wall finish is wallpaper. To achieve its flexible property that allows it to be called a paper and also facilitates single-handed application, a wallpaper will not be as thick as your average render. The pre-fab finish would be able to produce, in one go, with no "dirty work" in sight, a seemingly continuous wall finish without having to rework the surface in a second step of work. The drying time would ideally be zero, or as close to it as possible. In the case of clay wallpaper as a pre-fab finish, the drying time is minimal as compared with that of a thin plaster finish, or a paint finish, because, other than the use of a sprinkle of water to activate the clay on its backside, it is used and applied in a dry, non-dusting state.

Since very few renders are applied to serve another use than to cover up joints and inaccuracies and prepare the surface to receive the finish, this layer may be still indispensable. However, usually the plaster or paint finish is only intended to smooth over an undesired look of the render below. The provision of functions that the wallpaper could perform while hanging there, is an optional bonus. Depending on what the use of the wall finish is to be, functional layers to suit requirements could be either integrated in the wallpaper or could be added prior to or after application of the wallpaper.

The argument that the thin clay wallpaper cannot be as effective as the thicker clay plaster with respect to humidity buffering, is of course true. However, the finish is not in competition to the base, although it needs to be said that, according to a study by Wulf Eckermann and Christoph Ziegert (see original document on USB in appendix), the distribution of effectivity of humidity absorption in a clay plaster is by no means linear and the clay wallpaper on its own can be expected to be effective in benefitting a room, albeit to its capacity.

As for the design aspect, it can be said that most of the finishes that any other product can have, can be emulated in a clay wallpaper.

EARTH OR CLAY WALLPAPER?

When is a material earth and when is it clay?

While, technically speaking, "clay" is a term used to describe the smallest mineral particles that are contained in earth, that through their specific flat shape and layered internal structure offer a glue like property, it also describes a material mix that includes the silts, which are still extremely small ($0.08 > \text{silts} > 0.002\text{mm}$) and only the next size up from clays ($0.002\text{mm} > \text{clay}$) and not of that particular flat shape and multi-layered makeup. Loosely speaking, a clay can also refer to a material mix which includes fine sands and sands or even small gravel, as in "clay plaster".

Earth on the other hand is used to describe a mix including the above clay, but possibly, however not necessarily also organic material, like roots, decomposing leaves, mushrooms, microorganisms, animals (dead or alive), plant fibre, as well as the larger mineral components, like gravel and stones. However, the clay component does not necessarily have to feature in the mix. For instance, when talking of top soils, one might also be using the term "earth", but top soils don't necessarily have a clay component.

Although it may be the case that for some specific wallpapers the use of the term "earth" may be appropriate, the main component that is necessary to make up the wallpaper and glue the paper to a substrate is the clay, so the name refers to its clay content. Hence: Clay Wallpaper.

WHAT'S THE FIBRE INGREDIENT?

Any really! Very superficially speaking, fibre is a term describing a long and thin piece of material. These fibres can be of organic, i.e. natural or synthetic source. While synthetic fibres are usually made of polyethylene, polypropylene or silicones, there are also those synthetic fibres that use organic cellulose fibres as a base to produce a synthetic product, like in viscose.

One difference between, for instance cellulose fibre and synthetic fibres (apart from the environmental impact inflicted in their making and

disposal), is that while cellulose fibres are tubular vessels, i.e. pipes or rods with a hollow middle, synthetic fibres are, in general, solid, i.e. like a rod. The outer surface of the fibres can vary from being smooth, through rough, to being fibrillated which means they have a lot of arms or bits sticking out, and look like microscopic trees.

Organic fibre can be sourced from plants, or animals, mushrooms or humans. The fibre obtained from humans, like hair for instance, is usually very smooth and covered in multiple coats of silicone and other chemical agents from shampoos, conditioners and colouring. Some animal hair, like that sourced from pet dogs for instance tend to show the same problem. Untreated animal hair, like pig bristles or fur of cows or calves on the other side, are usually naturally rough and covered in a waxy grease, like sheep wool is covered in a coat of lanolin.

Most plant fibre contain cellulose. The fibre can be sourced from different parts, like for instance the stem and bark (bast fibre), the leaves or even the seeds (reed buds, poplar fluff) or the fruits (coco nuts). Depending on where the plant grows it will have developed specific characteristics and protective traits to ensure its survival. Plants growing in swampy areas for instance can show a higher content of silicates in the outer layers of the stem and the seed cusps, while plants that are otherwise a source of food can be subjected to a fermentation process before application in or with clay to effect a better workability and quality of connection effecting in a stronger surface to mechanical impact, wear and tear. It is also worth noting that the length of fibres cannot be seen as proportional to their effectiveness of reinforcement, as well as that micro-fibre (nano-fibre) is in effect shorter than its tubular shape is wide.

Finally there are also a type of plant sourced fibres that I have not yet used in my experiments, like nettle or sponge-like mushrooms, which incidentally don't grow in long thin threads. The fibre chosen to act as the tendons of the paper will also influence the capacity of moisture intake, as well as weight of the product.

WHAT'S THE MINERAL INGREDIENT?

Also here, the choices are many! The mineral materials that can be added to a clay fibre mix in order to influence its characteristics vary not just in size and shape, but also physical and chemical composition. While the range of grains, from silts through sands, and gravel to stones refer to their size, the sands, for instance, vary in chemical composition according to their source (geographical and geomorphological provenance, waste product from industry) as well as in shape (rounded or sharp edged) which makes them useful for one or the other application. There are sands that are amorphous minerals, like diatomaceous earth or of active or latent calcareous content which will influence the ambience in the mix or facilitate the formation of salts that help liaise between the organic (ligneous) fibre and the clay. Mineral ingredients can however also be chosen simply as a pigment.

WHAT'S THE LIQUID INGREDIENT?

Liquid additives (as opposed to solid, i.e. including pastes and jellies) are, for instance, essences or oils, juices or sap, wax or syrup, glues and gels etc. These 'liquids' too can be of natural (plant or animal) or synthetic origin. A variety of books on hand-made natural paints and varnishes as well as traditional floor or wall finishes in various cultures already suggest a multitude of possibilities to enhance one or another characteristic of the mix at hand, but other substances may be tested to see if in combination with the mix at hand a change in properties can be traced.

According to my experiences for instance, clay will adhere reasonably well to cold-rinsed sheep wool. If however the lanolin has been removed from the fibre, the connection of the clay to the fibre becomes more brittle. If the lanolin is added again to the mix at a later stage, rather than being left on the fibre, the clay will not bond well with the fibre at all.

4 THE WINCH, THE COGS AND THE FUEL

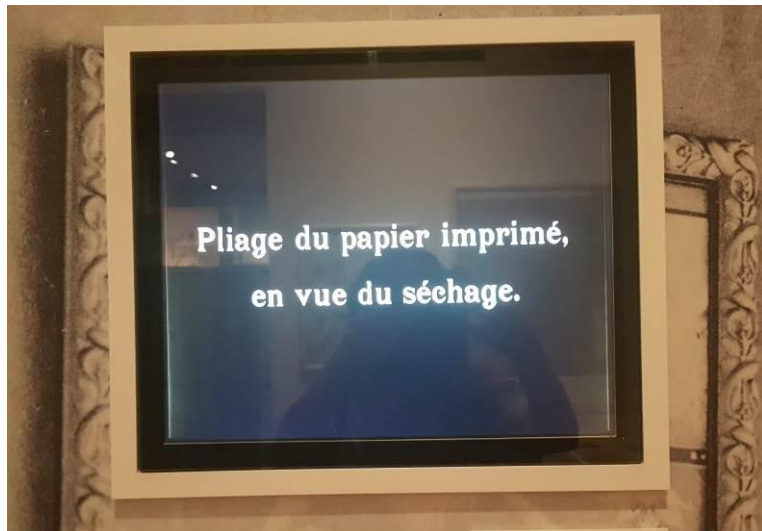
In the following I would like to only outline and introduce the various types of work done, research conducted, courses taken and experiences made that have worked as winch and cogs in driving the idea into becoming a product, as well as the fuel, the supportive feedback, the pats on the back that I have admittedly asked for, but also obtained, which did a great deal to encourage the continuation of the work to date.

Only the most relevant of the research and experiences outlined in the following will be described in detail in the *Nitty Gritty*, Chapter 6.

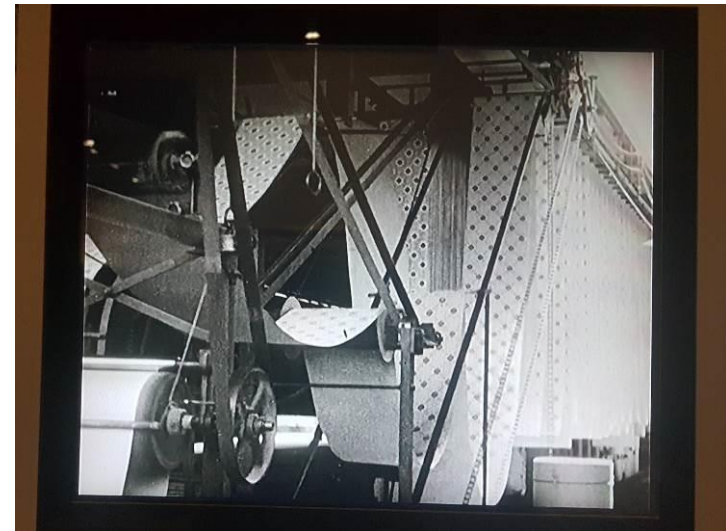
4.1 INTERNSHIPS AND ACTIVITIES VIA CRATERRE

A series of three internships and various practical and theoretical research has fed into my study, looking not just at the physical possibility of making clay wallpaper, but also looking at the situation, possibilities and inspiration from related crafts around. While most of the intellectual revenue has been useful in some way, for instance by helping to set a mark and re-focus the process of investigation, not all of the information gathered will make it into this memoir. The following list mentions only the most relevant of the experiences to be detailed later on.

Caption and scene from a still movie shown at exhibition on the history of wallpaper at Musée Maison Bergès



Insight into industrial scale wallpaper making industry, as exhibited at the Musée Maison Bergès.



GRAINS D'ISERE 2017, - FESTIVAL OF CONSTRUCTION METHODS EMPLOYING CRUDE EARTH

Using the materials provided at the earth-building festival, a variety of panels were produced to elaborate on the idea of prefab-plaster. Going off on a whim, I experimented with layering jute mesh that had been dipped or smothered in a clay-fibre mix and left to dry. The elements produced contained 1 to 3 layers of mesh and a variety of clays. Methods for spreading out the mass were also experimented on (trowel, hand). After drying, the samples were plucked from the plastic sheet they had been made on. The results were from slightly brittle to slightly flexible mats of a smooth bottom surface with more or less of the integrated mesh showing through on top. The most flexible version was then applied to a short wattle and daub wall. The clay and straw infill panel with the rounded top had dried up already and was re-humidified with a wash of water, as was the back of the sample mat. Upon laying the mat onto the wall, the thirsty wall sucked up the mat. As the excess moisture traversed the matt, it became flexible enough to roll over the rounded top to fit snugly and give it a sleek finish.

No testing was done on the samples and this experience will not be detailed in the following.

*Samples in the making
Top: 1 mesh
Middle: 2 mesh
Bottom: 3 mesh*



Clay wallpaper sample applied to lumpy straw clay infill wall at Grains d'Isère 2017

First set of clay wallpapers made from various clays available were thin mats



SAVIUKUMAJA, ESTONIA

Saviukumaja is a clay plaster and clay paint producing company based in south-eastern Estonia. I was very lucky that Saviukumaja was immediately interested in supporting my research and offered me an internship when I talked to them about it. They invited me to see if I would be able to produce something wall-paper-like, based on their materials. To my own surprise, very soon after beginning the experiments, I already had a handful of very promising results. In order to be able to trace the effects of varying ingredients and method in any further experiments, I decided to choose and stick to using one and the same clay throughout the range of experiments that I was going to do.

In the following 3 months, I tried to find a possibility of influencing the flexibility of the samples by adding a variety of fibres, mixing various fibre types and lengths and treating the fibres differently before mixing with the chosen clay. I also experimented with mineral and liquid additives, mapping any effect on the flexibility and other characteristics of the samples produced.

In the course of this research a variety of wallpaper types were produced, some of which I was able to show at an eco-building fair “ECO mess 2017” in Tallinn.

For details jump to Chapter 6.2, p.37

Workshop and sales area at Saviukumaja, 2017



Saviukumaja Workshop and Showrooms at Mooste Manor, Estonia



CLAYTEC, GERMANY



With a box containing the most interesting samples, I then left Estonia to continue research at Claytec, a well-established producer and merchant of clay based building products based in Germany. Here, like in Estonia, the first round of experiments went into sampling the types of clays and clay based ready mixes made available, to find the one that would be best suited to continue my research on. Once the choice was made, the focus moved to defining a concept, a red thread to follow in further research, and after an analysis of all promising results to that date, a threesome of product types were identified to find mixes for. It was decided to try to come up with at least one pleasing example for each of the following categories:

THE BASIC PRODUCT: The cheap and cheerful: simple design, cheap in the making and to buy, woodchip paper look-alike

THE FUNCTIONAL PRODUCT (HUNG/STUCK): The wallpaper that will actively enhance the space: thermal and/or acoustic insulating, humidity and/or 'other' regulating, impact buffering, filtering, sprouting, trapping, shielding, (light and sound) guiding, active/reactive etc.

THE DESIGNED PRODUCT (HUNG/STUCK): 3D surface, layered, plucked or perforated, patterned, printed, stencilled, varying widths/edges etc.

At the end of the internship at Claytec, three types of wallpaper had been tested in application and removal trials on a clay plastered wall in the workshop. However, time flies when you're having fun, and finally only the *basic* product and the *designed* version were produced to be applied on a larger surface. Both of these types of wallpaper were produced to suit Claytec's design preferences. Both papers were made using the same clay, and experimenting with application and removal and re-application. Finally one wall was wallpapered with the most extravagant of the samples.

For details jump to Chapter 6.3, p.52

Workshop area at Claytec, 2018



Storage, mixing and sales area at Claytec, 2018



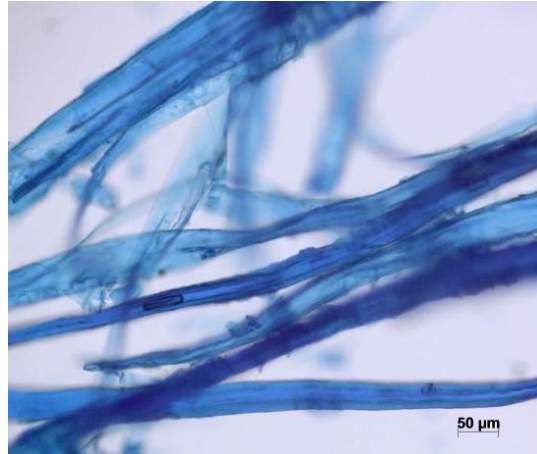
CNRS & CTP, FRANCE

An internship centred on the research of viability of thin clay panels reinforced with recycled fibre. Working with the Centre for Paper Technology on the Campus of the University of Grenoble, and the Laboratory of the National Centre for Scientific Research, I had the opportunity to investigate the make-up, shape and differences between some fibres types in various states. This research is on-going and its results will be important to evaluate in order to be able to understand why and how particular fibres do what they do in combination with the various clays. Unfortunately, the complete set of results from analysing the fermented fibres will not be available on time to feed into this memoire.

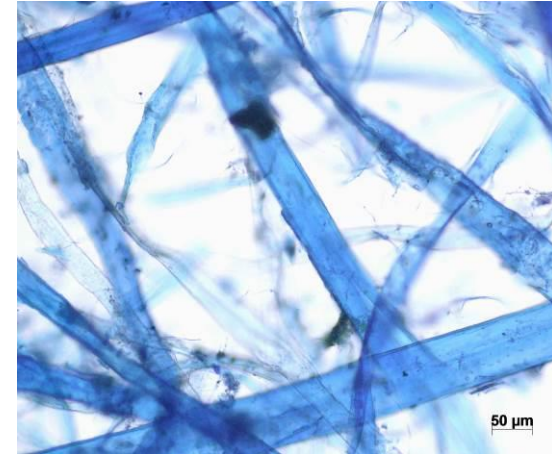
Long Softwood fibre in weak soda ph8 (x20)



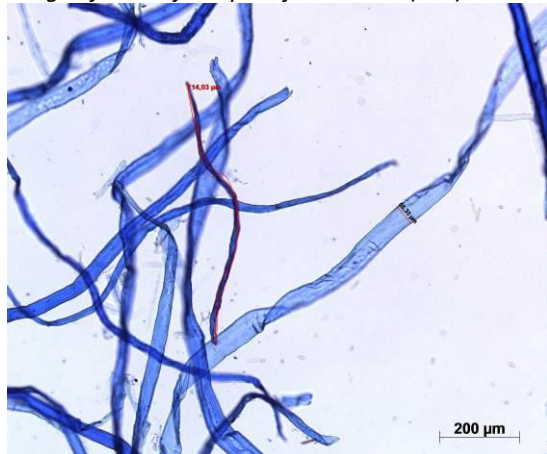
TMP fibre in weak sodaph8 (x20)



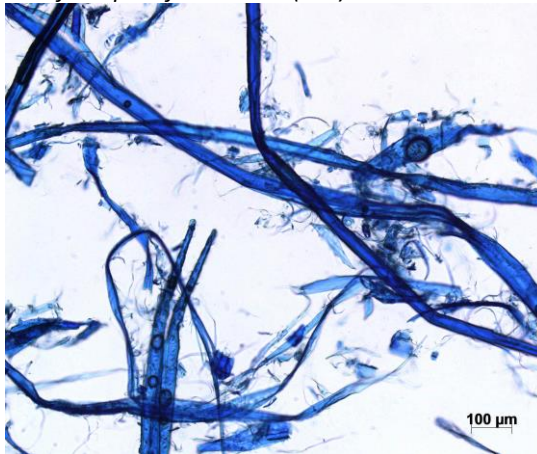
Recycled newspaper in weak soda ph8 (x20)



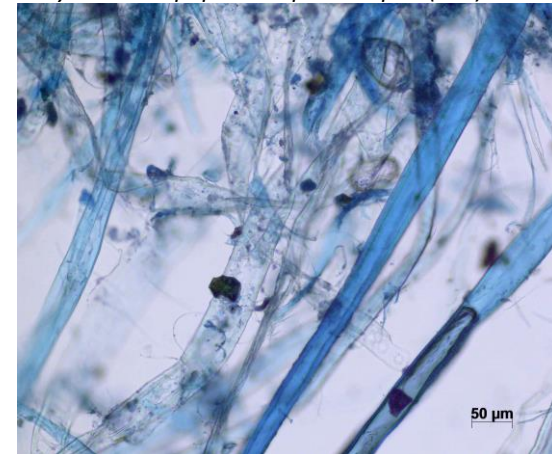
Long Softwood fibre part-fermented (x20)



TMP fibre part-fermented (x10)



Recycled newspaper in tap water ph6 (x20)



4.2 PRIVATE RESEARCH, WORK AND EXPERIMENTS

KREENHEINSTETTEN (PRIVATE STRAWBALE INFILL BUILDING SITE IN GERMANY)

On a strawbale construction site that I was accompanying at the time as an architectural consultant, one room in the basement was to be transformed into a natural cellar, with a 40cm thick clay floor and clay plaster on the walls. Before this was done, I performed the sticking and removing experiments with samples representing each category of wallpaper. These tests were also repeated on gypsum fibre boards.

Various glues were tested to stick samples on these surfaces, to varying effect. Once dried, the samples were then removed from the surfaces, revealing the difference in quality of adhesion of each glue on each surface.

For details jump to Chapter 6.4, p.78

Going off on a tangent, but based on the mat like samples produced at Grains d'Iserre 2017, I ventured to try a different kind of production process. Using the Claytec rammed-earth (fine) product, which was kicking about on site, and using 3 different types of mesh, a variety of rammed earth look-alikes of max 3mm thickness were produced (see picture below). Unfortunately these samples were too brittle and fragile to manipulate and perform the sticking and removal tests on.



Going off on another tangent, my experimentation went into producing the thinnest samples possible, by dip-soaking a random nylon mesh into a fibrous clay slip, which resulted in a particularly thin and spider web-like sample. This prototype had many holes where the slip had separated the fibres. Playing on the range of possible uses for the "clay wallpaper", this sample was tested for use as a lampshade. (There is a picture of it at the end of p. 14)

This work will not be detailed below.

Left: Various wallpaper samples stuck to concrete and gypsum fibre board with a choice of clay based glues as well as simply water.

Below: Rammed earth sample strips laid out to dry



CAMPUS GALLI, MESSSTETTEN, GERMANY (A MEDIEVAL BUILDING SITE FOR A CATHEDRAL)

During a volunteering stint at Campus Galli, a building site that endeavours to build a cathedral including its satellite village according to an original plan from the 9th century, using only the tools and the materials that would have been available at the time, I experimented with the clays sourced and used on the site. The clay used on site is dug up by hand, and the process of identifying the clay and preparing it for use would be relevant to the self-builder who wants to make his own wallpaper from his garden clay.

My official and in-official mission was to identify the clay, in order to improve on shrinkage cracks and dis-colourations that frequently appear during the drying process. Length and types of the fibre available and used in the mix for the wall infill featured in the analysis and were also drawn upon to provide a solution. The experiences made were noted and remain ready to feed into a next, new phase of clay wallpaper making.

Various mixes with the local clays had already been tried out



One of the pits on site the potter's clay is sourced from, all of which are also used for construction purposes



4.3 WORKSHOPS AND SEMINARS

TERRA MIGAKI DESIGN WORKSHOP ON JAPANESE CLAY PLASTER FINISHES, MILAN, ITALY

At the Terra Migaki Design Workshop for Japanese Clay plaster finishes, in Milan during the 2019 Milan design week, we were taught, amongst other fascinating layer mixes, to prepare a *hikitsuchi*, a clay-based finish to seal clay plaster, which bore some enlightening insights as to how the Washi-cellulose fibre (mulberry tree fibre) and clay can be made to work together even better.

The importance of separating the fibres meticulously and soaking them prior to mixing, as well as the potential benefit to be had from adding lime in small to very small quantities are aspects I consider worth looking into further.

Cutting Washi-paper into small pieces before soaking in water and using the blender on it



My own attempt at making and applying Hikitsuchi, a cellulose enforced clay finish



EELGRASS REINFORCED CLAY ON LÆSØ, DENMARK

Having come across eelgrass on various beaches of the Baltic already, I was still surprised to see it reappear in an experimental clay brick, produced by Triin Pruul in Estonia. Fascinated by the fibre and its uniqueness, I signed up as a volunteer for a two weeks thatching experience with eel grass on the Danish Island Læsø.

Talking to locals and looking at the ancient buildings on the island of Læsø, Denmark, I realised the fibre may have qualities that could feature in the designed version of the wallpapers, as well as providing a fibre alternative that would be able to offer properties no other fibre has. I produced a first simple version and left the sample with Henning Johansson, the main eelgrass thatcher on the island, for reference and inspiration. This work will not be detailed below.



Eel grass thatch

Capsil® clay wallpaper sample with eel grass



Wall paper sample containing eel grass



4.4 COMPETITION

TERRA MIGAKI DESIGN COMPETITION 2018, MILAN, ITALY

Encouraged by the organisers, in spring 2018, I submitted my early clay wallpaper samples that had been produced at Saviukumaja in Estonia under the name of ClayPer. I presented them loose like textile samples attached to a metal ring to facilitate touching and manipulating the papers, as well as stuck to small bits of plasterboard to show the visual effect in use. The Terra Migaki Design Competition 2018 panel recommended the incentive and presented me with a certificate pronouncing my product a proud winner of a “special mention” for innovative design.

The poster submitted to present the product



The certificate obtained



The samples submitted to present the product at the competition



4.5 EXHIBITION AND PUBLICATIONS

ECO MESS, ECO BUILDING FAIR, TALLINN, ESTONIA 2017

With said handful of first successful samples of clay wallpapers produced at Saviukumaja, I was invited to present my product idea at the ecological building fair, the “ECO Mess” in Tallinn, Estonia, in September 2017. Due to a bit of a language barrier, the conversations with the surprisingly numerous and very curious visitors were mostly held by my colleagues at Saviukumaja, but a very encouraging interest in the product could be detected in this exchange.

In the wake of the fair, the organiser of the event was interviewed on Estonian TV-Tallinn and he chose to wave a sample of the clay wallpaper at the camera, reportedly saying that a multitude of innovative and promising products had been on display, amongst which the clay wallpaper would be one to look out for. Unfortunately the link to the clip is no longer live...

<https://www.tallinnatv.eu/uudised/uudised/14774-2017-09-22-oekomass-ohutab-ka-linnas-keskkonnasaastlikult-ehitama?fbclid=IwAR1C30eCPIkru4Eeh6hIkEhzVfawAxG1iOVJx6T14alfOlp4WLjHFvjmxWl>



The table and board exhibiting the clay wallpaper at the ECO Mess, Tallinn, 2017



The table exhibiting the clay wallpaper at the ECO Mess, Tallinn, 2017

PUBLICATION IN BOOK ON EARTH DESIGN: TERRA BOOK, SERGIO SABBADINI

The Terra Migaki Design Competition takes place every year to coincide with the Milan Design week, and as an extra incentive to participate in the competition, the entries get displayed to the public roaming Milan in search of novelty design. Accordingly, the clay wallpaper samples submitted were displayed under the name of “ClayPer”.

To round off and summarise the exhibition as part of the design week, the organisers publish a book called “TERRA book”, explaining the use of earth as a building material and giving examples of the entries that spearhead the development of earth-based products on the market. ClayPer is displayed on page 91, and the book can be purchased for 50€.

Page 91 in Sergio Sabbadini’s book “TERRA book”, dedicated to ClayPer



4.6 OTHER VISITS AND EXPERIENCES

RESEARCH INTO POSSIBILITIES FOR PRODUCTION ON A 'BIGGER' SCALE

The following lists a few visits to paper-making factory, artisan workshops and museum, etc, where I went for inspiration and to investigate facts surrounding the history and present processes for making of paper and printing.

- TRIP TO A LOCAL PAPER MILL, RÄPINA, ESTONIA. MACHINERY TO SHRED AND PULP FIBRES AS IN USE TODAY AND HISTORICAL. Viewed cardboard manufacture in use. (picture top left)
- TRIP TO TARTU, ESTONIA, „PAPER AND PRINT MUSEUM“. Variety of machines to press and roll pulp, also various printing devices from previous and current centuries. Made my own sample of recycled paper-based paper with print. Museum workshop also experiments with other fibres and has started using shredded clothes for alternative fibre. What this visit made clear was that the storage and shredding and other preliminary processing of the materials to be used, then the mixing of these, processing of the pulp, spreading and controlling quality and pattern, the drying and storage and packaging as well, would require a bigger space than would be available for testing purposes only. Anywhere.
- TRIP TO “LABORA”, TALLINN-BASED ARTISAN PAPER-MAKERS, ESTONIA. They already manage to produce a seed containing paper that will sprout flowers or greenery when wet. (picture middle left)
- TRIP TO “MAISON BERGES”, EXHIBITION: “PAPIER PEINTS, TOUT UN ART”, WALLPAPER EXHIBITION WITH SAMPLES FROM THE LATE 18TH CENTURY THROUGH TO THE EARLY 20TH CENTURY. Viewing early samples that used to be glued with a glue made from rabbit skin, showed a fantastically encouraging colour range and intensity. Later versions that were long enough to be transported in rolls, also used mineral pigment based colours, and were glued with starch glue, mostly made from flour.
- USING A STEAM MANGLE TO BEND CLAY SHEETS at discretion of great aunt Hildegard, Germany (picture right)
For details jump to Chapter 6.4, p.80
- USING A PASTA MAKER TO ROLL FIBROUS CLAY PASTE INTO SHEETS, at Laboratory of CRAterre (picture bottom left)
For details jump to Chapter 6.4, p.81



Top left:

Rolls from 19th century still at work in paper factory in Röpina, Estonia

Mid-left:

Seeds sprouting vegetation from paper sample by LABORA, Estonia

Bottom left:

Some results from using a pasta maker to produce thin clay fibre sheets

Right:

Great aunt Hidda, feeding a dry sheet of clay wallpaper into the mangle

5 THE PUBLIC AND THE LEGAL ASPECTS : SUPPORT OR HINDRANCE?

5.1 MARKET RESEARCH

QUESTIONS AND ANSWERS

TRADE FAIR 'ECO MESS', TALLINN, 22ND AND 23RD SEPTEMBER 2017 &
CUSTOMERS AND ESTONIAN CLAY-PROFESSIONALS IN SAVIUKUMAJA SHOWROOM:

For the Estonian trade fair for ecological building products "ECO Mess 2017" the organisers offered for me to host a stand, where I could demonstrate and introduce clay wallpaper and test the market response. In return I held a presentation on the various straw building methods and techniques currently exercised and developed further throughout world. Having builders and self-builders, artists and passers-by to inspect the clay wallpaper on display, I tried to get answers to some of my questions. Where language barriers appeared, the staff of Saviukumaja kindly helped out translating.

However, I found that just as much information can be gained, if not more, by documenting the kind of questions the public wanted to ask me in return, once having been confronted with the product.

The following questions were asked most frequently:

- Is there a portfolio or a samples book?
- Is it possible to buy clay paper as rolls?
- How does it work?
- What's in it?
- Which "glue" is needed for sticking the product on walls?
- Can I use my tools on it?
- Would it be possible to remove or paint over?
- What is the price and the lead time for availability?

After the ECO building fair I spent three months working and displaying my work in the Saviukumaja showroom, which gave me the opportunity to talk to professional as well as private clients and non-suspecting touristic visitors.

All in all, there was a lot of curiosity and a lot of positive feedback for the basic idea on the product, and the questions I was asked matched those I had collected at the fair.

From the questions collected I deduct that the public wants to believe in the product and that there is a desire to use it as well. Also, a very important point to be retained is that the public are weary of thing being too complicated to use. They like the idea of wallpaper, but are scared it will not be possible to apply like wallpaper. The tools and the methodology would have to be possible to transfer from one to the other, if anything making it simpler, rather than more complicated.

MARKET RESEARCH AT THE FESTIVAL DE TERRE, GRAINS D'ISERE 2019:

At the Festival of building methods using crude earth in Villefontaine this year (2019) I had an opportunity to mount and display one of the bigger samples of clay wallpaper produced at and with Claytec materials. Unfortunately, this was of the only kind that I had produced using a synthetic fibre. After mounting and letting it dry, I was unfortunately not able to hang around much to speak with the visitors. However, those whom I did speak to generally said they were keen to see it in the shops.

Questions that were asked (other than: where did I buy it?) were focussed on what the ingredients were, and why I used polypropylene fibre, what the limits for the product design were and where my production plant is based.

After publishing pictures of the exhibition on the clay paper web page, I have had two more enquiries come in, mainly regarding as to what the prices would be if bought in bulk. Both of these enquiries were from companies producing prefab-eco-homes.

Other feedback I had was mainly to do with the design of the particular piece hung out to display, which went down very well with people from Great Britain, also Eastern Europe and young people in general. The Mid, Western and probably South European public would, it seems, have preferred a more accomplished design.

WHAT DOES THE CLIENT WANT?

The client wants design. Safe and fool proof to apply, cheap and diverse. Upon probing, the client would be interested in functional wallpaper as well, but hadn't thought of it. True eye-catchers, the mossy and hairy versions of the presented samples attracted the most attention. However, the simple version would be welcome to replace common wood chip paper, if it didn't cost more than the original.

In a conversation with a visitor a question arose, as to whether it would be possible to cover rocket stoves (wood burning stoves) in a reinforced wallpaper, to avoid further or cover up existing fissures and cracks. (This remains to be tested)

Over all, the clients voiced an interest and willingness to try out the product, but for wider acceptance, it would need to be recognisably similar to usual wallpaper, visually and in terms of application, at least to start off with. Also, a lack of understanding of the characteristics of clay as a material became apparent, also in clients already subscribed to using eco-products. A successful product would therefore have to be made user-friendly and self-explanatory to avoid mistakes in installation and future maintenance, re-decoration.

Also, it has to be mentioned that for most clients spoken to, unfortunately the eco-aspect is not as important as the novelty effect.

WHAT DOES THE PROFESSIONAL WANT?

The professional is interested in speed and ease, so one recurring request was to enable single-handed application.

It would also need to come with straight or frilled edges, since the method of overlaying two runs and cutting down the middle and removing the cut-off ends would not work on the clay versions.

The product should be easy to cut (top and bottom) to avoid tearing and smearing. And finally it should be able to be stored lying down and stood upright, possibly stacked, be as light as possible, have a minimum length of 5.25m per roll and, of course, meet the requirements and standards of national or international rules, norms and regulations, so that architects and designers could specify it without compromising their insurances.

WHAT DOES THE PRODUCER WANT?

Both companies I worked at during the research internships, were in principle interested in going on to produce clay wallpaper. Both also emphasised the need for the product to be fabricated by use of machines, requiring as little personnel to run as possible. The various designs and versions should ideally be possible to be produced on the same machines, requiring again as little as possible work to change the set up. Furthermore, the product should be possible to wrap or package using the means and facilities in place already, so that storage and shipping would not require adapting. Meaning, wrapping in cling film and stocking on pallets or in pallet sized boxes on pallets.

WHAT DOES THE DEALER WANT?

Acting also as dealers, both Saviukumaja and Claytec voiced no extra expectations to consider here.

Talking to Mr. Kerres, the owner of the biological building products shop in Pfullendorf, Germany, a trader of Claytec (and other) products, an aspect surfaced that may need to be investigated further from a certification aspect etc. Would the clay wallpaper need to be issued with a “best before” date? If so, this would render the product slightly more problematic to order and store.

The staff at a wallpaper and carpets store I walked into and asked their thoughts on the product, was extremely concerned that it would be crumbling and dusty and that would be something they would not want to put up with.

ONLINE RESEARCH AND SOCIAL MEDIA

Internet based research on existing wallpaper, as well as other closely related postings came up with e.g.:

- Paperclay pages, detailing recipes and methods for shaping and drying or baking (too many to reference)
- Japanese Clay Wallpaper, Japanese paper coated in clay⁹
- Wallpaper has already launched a series of thermally and acoustically insulating wall papers, as well as an eco-range¹⁰

Trend research of current wallpaper designs is an ongoing job, as the fashion for interior design changes almost as quickly as that for the content of most wardrobes. The important fact to retain here seems to be, however, that there always is a fashion trend for wallpaper.

The facebook page under “Clay Paper, Savitapeet, Lehmtapete” which I instigated as a platform to communicate to the public any news I may have on the development, has been “followed” by over a hundred and sixty people. On the grand scale of things, this is not a lot at all, but considering that I have already had enquiries to buy the product via this page, it should not be left unmentioned as a gauge for interest.

⁹ <http://www.japangarden.co.uk/Buy-Japanese-Wall-Coverings-c-623.html>

¹⁰ https://www.archiproducts.com/de/wallpepper/produkte/kategorien_tapeten

INTERIOR DESIGN EXHIBITIONS AND MAGAZINES

Flicking through the images in trends setting interior design magazines, high end as well as broad spectre, reading the write-ups of the big interior design events and speaking to visitors as well as exhibitors, where possible, a trend for wallpaper to make a return, possibly more in its original ornamental version, featuring an oversized image or pattern to highlight a part of a wall and fulfilling more than one purpose seems to be on the cards.

- Interior Design Exhibitions Habitat 2017, Milano Design week 2017/19
- <https://www.museepapierpeint.org/fr/papiers-peints-du-futur/>
- http://www.lemonde.fr/m-perso/article/2017/05/11/le-grand-retour-du-papier-peint_5126242_4497916.html
- Interior design Magazines: e.g. 'Living At Home', 'Schöner Wohnen', 'Wallpaper*', the Ikea catalogue, etc

An overall increasing, if fluctuating, number of rooms depicted, in which a life style is to be conveyed, are embellished with wallpaper, showing simple to floral and exuberant designs in pattern and colour.

With functional wallpapers not likely to feature in high-end interior design magazines, the research found that on the surface, wallpaper was/is experiencing a *design*-led surge and is gearing up to becoming an increasingly popular trend. There are no design preferences detectable, meaning, everything is allowed. The published versions suggest that, the wilder the better! That said, colours are kept natural organic or shimmering metallic, which makes unusual combinations possible without provoking a clash. The Retro-look in terms of the world of construction, with featured cracks and strange patches, creating an antique or ruin-like charm, are favourably applied in public areas, like low- to high-end restaurants and cafes. Intricate as well as large pattern designs, geometric and organic, textured or smooth, of pastel to piercing bright colours, with glitter or natural inclusions like flower petals or coloured sea shell glitter are favoured to accentuate individual walls.

Basically, it seems like the wallpaper is increasingly used as an attention-grabbing scene-setter, an oversized modern replacement for wall hung-pictures and other ornament, that can easily and frequently be changed or up-dated.

5.2 RESEARCH INTO EXISTING RULES AND REGULATIONS

Governments and regional councils as well as manufacturing and trade consortiums have established sets of standards, guides, rules, norms, regulations and certificates that are intended to guarantee the market will receive a safe product with respect to any hazard or defect. With respect to wallpapers, these documents and stamps prescribe minimum levels of resistance to fire, maximum rates for release of Volatile Compounds (organic or other, in use or when actually burning), level of resistance to mould and guarantees for colourfastness, etc. in order to ensure the client/ specifiers/ users/ professionals/ traders interests are safeguarded when buying, applying and enjoying the product in use. Research into French, UK, German and finally European regulations on what a wallpaper should and shouldn't do, has been undertaken primarily on-line and came up with the following.

GUIDES, RULES, NORMS AND REGULATIONS

FRANCE:

NF DTU 59.4: Mise en oeuvre des papiers peints, cahier des clauses techniques ¹¹
(giving technical specifications for contract work (NF P 74-204-1) and private application (NF P 74-204-2))

UK :

Building Regulations Part B (fire), E (sound transmission) and L (Conservation of fuel and power) contain articles that are or may be relevant to wall coverings and therefore may apply to wallpaper. ¹²

GERMANY:

DIN 18366/18550/4102/3755/13914 (most of these can be considered simply as guidelines, because clay is not covered by them as an agent for sticking things to other surfaces, i.e. as glue)¹³

Quality certificates are issued by various laboratories, but do not exist for the product, as yet. There are various certificates for clay finishes as well as for conventional wallpaper, but none apply directly to clay wallpaper.

German Technical standards and as well as norms and guidelines exist. The prominent ones have been converted into Euro-Norms, EN 233, EN 235, EN 266 and EU-guideline 2005/84/EG.

¹¹ <https://www.batirama.com/article/20820-dtu-59.4-mise-en-uvre-des-papiers-peints-et-des-revetements-muraux.html>

¹² <https://www.gov.uk/government/collections/approved-documents>

¹³ <https://www.baunormenlexikon.de/vob/790c3496-6cce-4a27-9a6b-b39270dab6cc>

EUROPEAN NORMS (EN) AND REGULATIONS :

DIN EN 233 Wandbekleidungen in Rollen - Festlegungen für fertige Papier-, Vinyl- und Kunststoffwandbekleidungen
(wall-dressings: regulations for rolled materials based on paper, vinyl and plastic)

DIN EN 234 Wandbekleidungen in Rollen - Festlegungen für Wandbekleidungen für nachträgliche Behandlung
(wall dressings: regulations for rolled material, to be finished at later stage)

DIN EN 235 Wandbekleidungen - Begriffe und Symbole
(wall-dressings: terminology and symbols)

DIN EN 259-1 Wandbekleidungen in Rollen - Hoch beanspruchbare Wandbekleidungen
(wall dressings: high levels of use)

DIN EN ISO 10456 Baustoffe und Bauprodukte - Wärme- und feuchtetechnische Eigenschaften - Tabellierte Bemessungswerte und Verfahren zur Bestimmung der wärmeschutztechnischen Nenn- und Bemessungswerte
(building materials and building products, heat/humidity regulating methods and means of determination to meet standards)

DIN EN 15102 Dekorative Wandbekleidungen: Rollen- und Plattenform
(decorative wall-dressings : on rolls and as panels)¹⁴

These technical, methodological and material guides, rules, norms and regulations are offered or imposed to provide a standard to ensure compliance with environmental and health and safety regulating concerns, that apply during production, application and in use.

While a large percentage of the above only apply to the vinyl and synthetic predecessors of the clay wallpaper, they mention a multitude of aspects of concern, that are to a greater part irrelevant for the clay/fibre product but worth bearing in mind when continuing development.

With clay currently being assessed in order to be validated as a fire proofing material (as per info from DFL Germany), its capacity to lock-in toxins rather than release them, to store heat and to shield from noise while naturally storing 6 to 8% of its own weight in humidity (70gr of humidity on 1sqm of 1.5cm thick clay) and releasing any extra again as the moisture content in the ambient air drops, most of the regulations above only help to emphasise the quality of the product, rather than restrict or even inhibit its use.

However, furthering the product will require more in depth research and required standard will need to be met.

¹⁴ <https://standards.globalspec.com/>

6 THE NITTY GRITTY

6.1 OVERVIEW OF RESEARCH CONDUCTED TO DATE

PHASE 1 _ testing clays, fibre, liquid additives for effects

Saviukumaja is a company producing clay and lime-based building products, bricks, panels, plasters, finishes and paints. They also offer courses and professional tuition for professionals in new and old techniques, taught by the professionals at Saviukumaja themselves or international experts who are invited to teach particular skills.

At Saviukumaja the following research was done:

1. The clays available were tested for suitability, and one was chosen to continue work with.
2. Various fibres were tested in combination with the chosen clay, woven, fleeced and loose, with and without other mineral, animal or plant sourced additives.
3. The chosen clay was tested in its original and in its refined states (sieved out lime sand) with a multitude of liquid additives to test for a positive effect on the flexibility of the dried clay sample.

PHASE 2

Claytec _ focussing tests to achieve looks and performance

Building on a basic range of recipes previously established, the challenge was to push the research to produce at least one prototype, using Claytec materials.

4. The rather large range of pure and pre-mixed clays available were tested and whittled down to one most suited to use in the consequent testing.
5. A variety of three types of wallpaper was defined and one to represent each category was developed.
6. The samples were tested in application to a wall (clay plaster) as well as removed and re-hung again where possible.

PHASE 3

Continued Research in private experiments

7. sticking to various samples using various clay-based glues, removing and reapplying
8. rolling clay paper in a steam press
9. running paste through lasagne pasta maker

PHASE 4

Internship at CNRS and CTP

Research nature of cellulose fibre fresh, in alkaline solution and fermented

Rolled sample with "Latvian red"



Samples applied at Claytec during 2nd work stint



Fibre for fermentation



Attempts at making mousse



6.2 PHASE 1 – Saviukumaja*

6.2.1 SUMMARY OF EXPERIMENTS AND TESTS PERFORMED

After a series of simple field tests, a red clay from northern Latvia was decided to run the experiments with. This earth contains a kind of clay with granular inclusions of which some are limestone sand of up to 2mm in size. In order to get to know the clay that was chosen, more experiments and tests were undertaken in the following order:



Test 1



Test 2



Test 3



Test 4

1. experiments with chosen clay (analyse characteristics)
2. experiment with chosen clay (test workability)
3. experiments with chosen clay and added sand (test potential to enhance clays by adding quartz/ limestone sands)
4. a) 10 experiments with mixes of clay with sand and fibres, each at three different ratios: linen stalks (4cm to 1cm), wood shavings (1 to 2cm), chopped straw (~1cm), wood wool (pavatherm), hemp hairs (10 to 20cm), chopped hemp (5 to 8mm), cellulose (<5mm), cats tails/ bulrush (Estonian version), part-fermented grass (horse dung), hemp wool (~2cm), toilet paper, jute and linen mesh
- b) 4 experiments with mixes of best fibres from test 4a, but without sand in the mix
- c) 4 experiments on versions of 7 mixes of best fibres from above tests, without sand and without a mesh as a skeleton



Samples testing fibrous mixes with and without fibre mesh as a reinforcing substrate

*Saviukumaja is now called "UKU pure earth"

5. 12 experiments with mixes of fibres and lipids and glues (no sand, no jute mesh)
6. 21 experiments with mixes of fibres (pure and with pre-soaked/boiled/fermented fibres, soap, egg and nano-cellulose)
7. experiments with category a)14 b)8 c)5 d)10 e)12 f)15 mixes with non-fibre additives
8. experiments with fibres soaked and boiled in acid and lye/fleeced in various liquid agents/treated with detangling agents/tests with new fibres
9. experiments with different Estonian earths
10. experiments with synthetic (Polyethylene) fibres (no table with information available)

Test 8 results from boiling fibre in acid and lye



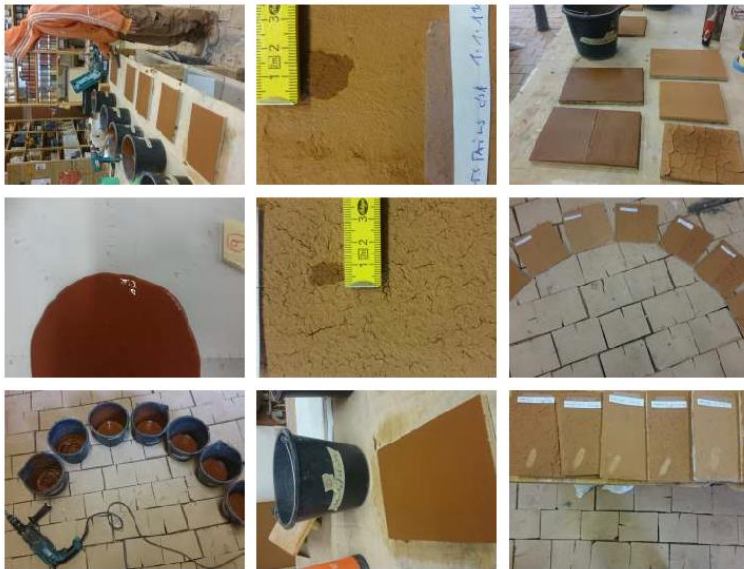
Test 10 result using synthetic fibre in clay mix



Test 7 A variety of chemical laxatives and smoothing agents for hair was tested

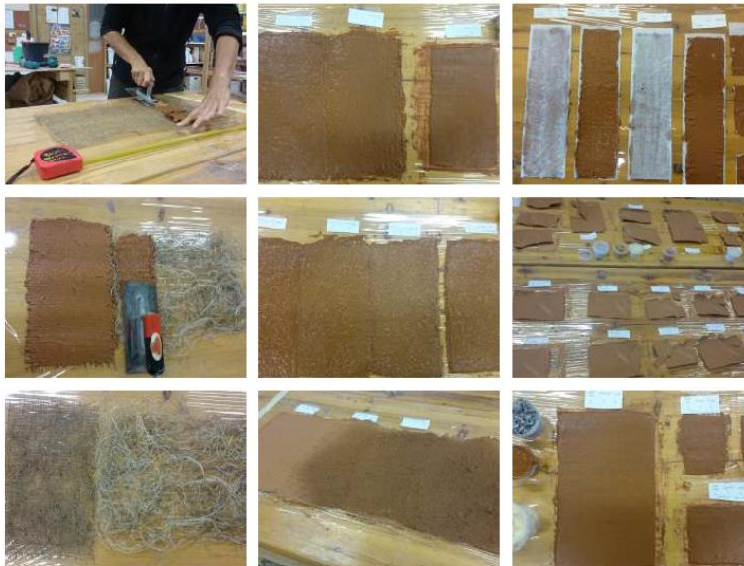


6.2.2 SUMMARY OF RESULTS



Page above (as in appendix) showing various episodes of Clay Test

Page below (as in appendix) showing various episodes of Fibre Test



Overview of materials and complete tables of results can be found in the appendix & on the attached media:

A - List of Materials

B - Tests 1 to 4 _ testing clay, fibre, sand and mesh

b – Test 9 _ with other Estonian clay

C - Test 5 _ lipid and glue agents

D - Test 6 _ manipulated fibres, nano-cellulose and egg

E - Test 7 _ all agents tested

F - Test 8 _ Fibres

f - Test 8 _ Fibres comments

1. Testing CLAYS

The clay was analysed and found to be strong and sticky but prone to shrinkage in drying to a level that requires mediation, slightly acidic albeit with a considerable granular lime content. Ingredients were tested in the mix, on their own, at different mixing ratios, and in combination with one another.

The first tests were aimed at identifying the qualities of the various clays and the sands usually used with these clays. The tests then proceeded to question the need for any sand at all in the mix, bearing in mind the desired qualities of a final product.

THE CLAYS

Coarse red Latvian – slightly acidic clay, with lime inclusions, grains of <2mm, strong, considerable shrinkage, little cracking

Light red Latvian – slightly acidic clay, some warping and shrinkage, dries within one day, hard but brittle, no cracking

Tap Water used – slightly alkaline (ph indicator strips used showed ph8)

TEST 1 TO 4

For complete results see appendix B

These tests were done with varying ratios of fibre contents. The samples were prepared using a mix for a base coat plaster: clay+ sand+ various fibres. The samples were produced leaving out either the sand or the application on a jute mesh.

COMPARING RESULTS FROM THE TABLE IN APPENDIX B, IT SHOWS THAT GENERALLY:

With sand, but no mesh:

- samples are more likely to remain flat in drying if they have a sand content
- samples with sand are less likely to show fissured or cracked surface with higher fibre content
- the diameter of a stain left by a drop of water absorbed by the sample containing sand reduces with increased fibre content
- flexibility (tolerance to bending) of sample increases significantly if no sand is used in mix
- with rigid fibres (stalks and shavings) the flexibility decreases with higher content
- sand content reduces surface integrity as grainy content rubs off

With fibre mesh but no sand:

- a fibre mesh base increases flexibility significantly
- a fibre mesh also prevents material from fissuring and
- a fibre mesh reduces crumbling or friable edges
- glass fibre mesh not suited for flexing clay
- a clay mix containing long and thin fibre is more likely to be difficult to apply to mesh

In general:

- woolly fibres produce a smooth paste with a tendency to knot if 'rubbed the wrong way'.
- while stalks are easier to work with in application, the shorter they are...
- ...rigid or flat fibres, like (wood-)shavings, produce a putty of average workability and tend to present problems in achieving a smooth surface.

Evaluation of samples without sand and without jute, shows that hemp wool works best, while second best is wood wool followed by cat tails (bulrush):

- Hemp wool shows some fissuring but best resistance to scratching, bending, tearing
- Wood wool looks ok, tears a little less easy and fissures a little less. Samples show a smooth surface, reasonable resistance to scratching, crack when bent, little resistance to tearing
- Cat tails (bulrush) looks best but cracks when bent, tears easily. Samples have a smooth surface but are brittle in bending, their resistance to scratching is ok, but lack resistance to tearing

Conclusions from the results and defining the next step

From the experiments it has become clear that sand is a hindrance to bending the dried samples. It has also become clear that the use of a mesh as a base will allow bending while also stabilising edges and reducing fissuring. As for the fibres various qualities were noted, each of which may be of use in some way or another in future applications.

For the next set off experiments it is therefore decided to leave out both, sand, due to its rigidifying effect, and the mesh, due to its favourable influence that masks the effect of the loose fibres.

Set up for one of the fibre tests



Same clay mix applied to mesh and loose fibre



Below: various fibres mixed into samples to achieve a better grading of fibre for clay to attach to



2. Testing FIBRES

Having eliminated the sand from the equation, I then focussed on the fibres available to experiment with. The various types at hand were tested in various mixing ratios and matter states, from dry, through wet, to partly fermented. The same fibre was added at different fibre-lengths, individually and in combination with each other, as well as experiments with mixes with different types of fibres in the same mix were conducted. The difference in behaviours of the fibres in the mix, their „spread-ability“ and finally the effect the fibre has on the dried sample, with regard to physical resistance to tearing, abrasion and bending was noted, as well as any alteration in initial water resistance. A visual inspection was also conducted to determine rates of discolouration, surface defects like bubbling or streaks, cracking or fissures as a result from shrinkage.

TEST 5 AND 6

For complete results see appendix C and D respectively

The experiments included no sand, no jute, but a variety of fibres mixed with a limited set of liquid additives (liquid olive oil soap, soapy wax, washing up liquid, linseed oil and algae glue). In test series 6 the additives were left out and the clay ratio varied.

COMPARING RESULTS FROM THE TABLE IN APPENDIX C, SHOWS THAT GENERALLY:

- no unifying conclusion is deductible from the results of adding the chosen wax/oil, soaps or glue, which seems to imply that characteristics tested for each of the samples does not depend primarily on these additives but mainly by choice of fibre used
- the addition of cat tails (bulrush) results in increased rigidity
- the addition of hemp wool effects an increase in flexibility
- using industrially prepared recycled cellulose in a mix will significantly increase the amount of mixing water required

COMPARING RESULTS FROM THE TABLE IN APPENDIX D, SHOWS THAT GENERALLY:

- higher content of recycled cellulose increases drying time
- fermenting fibre prior to mixing with clay improves workability, but increases drying time and risk of stains on dry sample
- sheep wool samples show very little to no warping/undulating edges
- long smooth fibre, like linen wool and sheep wool facilitate thinner samples
- applying the clay mix to loose fibres works well, but when clay is applied to, for example, a sheet of recycled cellulose paper, (picture to right) the result shows up the different characteristics and sample curls and materials separate

Conclusions from the results and defining the next step

The test series 5 seems to suggest that no agent used will improve the characteristics of the samples regardless of other components. It can also be deducted, mainly from series 6, that the fibre is essential in providing the desired qualities, where loose fibres can have a similar effect to that of mesh.

For the consequent tests, the fibres will be left out or added only where lecture of already approved recipes (see Bibliography in Annex) recommends adding fibre, or, as one might put it, on a whim.

Below: Clay paste applied to recycled paper and left to dry



3. Testing liquid* ADDITIVES

Although some of the fibres tested already came up with very promising results, I was keen to investigate if an agent could be found that would be able to increase the elasticity of the dried clay sample, in order to reduce material defects like cracking and material loss from sample caused in the process of physical manipulation.

TEST 7

For complete results see appendix E

Generally leaving out all other ingredients, a range of non-solid additives was mixed with into both, the red Latvian and light red (sieved) Latvian clay and left to dry.

COMPARING RESULTS FROM THE TABLE IN APPENDIX E:

In order to provide a framework to enable deduction of a pattern of results from the tests, the following presents a short introduction to the main types of bio-polymer additives and their expected respective effect on clays, as per the book on natural stabilising agents and their use in traditional recipes for clay plasters and other uses “*argiles & polymers*”, CRAterre. Please note: not all additives tested were possible to fit into these categories, so most of those were listed among “others” at the end.

POLYSACCHARIDES¹⁶ (plant fibres, rubbers, glues and starches)

Long molecular chains form a reinforcement-like network. Used to reinforce, strengthen, and consolidate earthen materials. When mixed with water they form a gel-like lubricant between the minerals and thus facilitate better workability already in a dryer state.

- **GELATINE** gives sample jelly-like texture in mixing and makes sample slow to dry. Sample turns out somewhat puffy, with lots of web-shaped cracking. Colour of sample changes where rubbed.
- **CORN STARCH** turns mass very pasty and unwieldy. Dry samples have a leather-like surface, warped but with only a little cracking along the edges. They show a very strong resistance to breaking by bending, increased initial resistance to water penetration. Sample disc is discoloured and cracked in multiple pieces. Nb: MOULD!
- **PLANT FIBRE** (cellulose) tends to increase strength but the finer the more, as in nano-cellulose, also shrinkage
- **NATURAL LATEX** – is difficult to mix, as it coagulates on contact with the clays (or the water in the clays), but samples obtained had an oily kind of shine and a slight elasticity



Various mixes with agents (as in appendix)

Three mixes with natural Latex



¹⁶ “argiles & polymers”, CRAterre, 2017



LIPIDS¹⁷ (natural oils, fatty acids and waxes)

Bi-polar molecules of which the bulky end is attracted to water while the other thread-like end is not. Insoluble in water, lipids make earth materials more waterproof, thereby also reducing their breathability. Used to increase water resistance and to consolidate earth materials.

- **LINSEED OIL** increases viscosity of paste, makes it streaky and oily in application, resulting also in increased cracking. Slightly enhanced water resistance.
- **COCONUT OIL**, containing fatty acids, renders mass very smooth and creamy, revealing the lumpy content in the clay to protrude like goose bumps in a very thin spread. Dry sample shows warping of edges of up to 4cm, cracks along thin edges, discolouration of and around lumps indicating a reaction has occurred with the lime content in the lumps of the clay. An increased water resistance can be noted and the sample disc (pastille) shows a slightly reduced surface integrity, however with a shiny finish.
- **SOAPY WAX** (cire saponifié) turns mix pasty, and facilitates extremely thin plastering. Dried sample is warped with cracking along edges, although disc (pastille) measures to show a reduced shrinkage.

PROTEINS¹⁸ (casein, collagen, egg white)

Long, curly-twisted, snake-like molecules that form fluffy balls. The fibres-like molecules are also amphi-phile (hydrophobe and hydrophile). Used in earth to glue earth molecules together, and raise resistance to water.

- **CASEIN**, added as a powder, thickens clay to a crumbly paste, water needs to be added, after which sample is very slow to dry. Dry sample looks smooth but grainy, with craters from (presumably) dissolved lime. A water drop leaves a visible mark on the sample surface. The plaster sample shows cracking throughout, slight warping along edges and discolouration of white powder (salt) on pastille. Plaster sample is hard to break, increased water resistance.
- **EGG WHITE** makes clay smooth and runny and slow to dry. Plaster sample turns out smooth but showing grainy content as lumps. Samples are warped with cracking in centre, and the initial resistance to water is increased considerably. Although putty is not puffy, the sample disc (pastille) turns out porous.

Set up for various agents tested on red Latvian and light red Latvian earth

¹⁷ "argiles & polymers", CRAterre, 2017

¹⁸ "argiles & polymers", CRAterre, 2017

OTHERS

TANNINS AND RESINS¹⁹

While the organic part of the tannins, for instance, help to disperse (some) clay mixes, the iron-ions glue the clay together and make it water resistant.

- used in the dark red clay, **TANNINS** enforce the colour, make sample stronger, increase water resistance but increase warping in drying process (picture top right)
- **PINE TAR** (from resin) effects an increased strength and a leathery surface in samples, as well as great adherence to substrate (here: cling film, others to be tested), will dissolve in water, best results when pine tar used in combination with ammonium solution. (picture second down)

YET MORE OTHERS

Anything not mentioned above, that came up with an interesting result.

LEMON JUICE – reduces shrinkage and cracking, lighter samples

BIRCH TREE JUICE – solid paste but workable. Dried sample is smooth with a few tiny pores in surface (acid reacting with lime?), 3cm warping along edges, diffuse cracking. Plaster sample is extremely thin and shows considerable resistance to breaking by flexing, stronger in colour. (picture second up)

TALCUM POWDER – makes clay paste thicker and creamy, very, very smooth to work with. Dried sample shows warping of max 1cm with slight cracking along the very thin edges, a slight discolouration as sample is lighter than original and a reduced surface and edge integrity, but disc (pastille) doesn't break.

SHOE CREAM – good surface integrity for red clay, smooth but velvety soft surface on both clays which can be polished to a shine

EGG YOLK – very pasty then oily texture of clay paste, slow to dry. Dry plaster sample shows web-like cracking throughout and a discolouration in that the colour is more intense and brighter. The sample shows a considerably increased water resistance, increased strength but disc cracked clean in drying process. (bottom)

EGG WHITE (WHISKED) – slightly mousse-like in mixing, slow to dry. Dry sample retains bubbles and rippled puffiness. Plaster sample is cracked throughout with a little warping, but shows considerably increased water resistance. Samples are darker and disc doesn't break in flexion test.

COTTAGE CHEESE – clay mix is a puffy mousse-like paste, not showing cottage cheese bits. Dried sample is porous like volcanic stone, curls inward from edges. Plaster sample is slightly tenacious and shows an increased water resistance. Sample disc has imploded but is held together by crystal threads, was very slow to dry (5 days), slightly darker, and holes/porosity reduce material integrity.



Above: samples from top to bottom show mixes with Tannins, Pine Tar, Birch Tree Juice and Egg Yolk

¹⁹ "argiles & polymers", CRAterre, 2017

Conclusions from the results and defining the next step

In the course of the experiments with additives to the effect of obtaining flexibility, many results were surprising and extreme to one or the other extent, but unfortunately not one of the over 50 agents tried out in the course of the experiments came up with the result hoped for. Cottage cheese may have a toe in the door by rendering the plaster sample somewhat tenacious. The others however, seem to be suited to call upon for achieving special effects.

4. Testing FIBRES, manipulated and new

Finally, with time running out, a last set of experiments was undertaken with mixes of promising fibres manipulated by boiling or soaking in aggressive liquids prior to use with the clays. These fibres as well as new ones were then used in combination, with one another as well as with a new set of synthetic fibres, which had only just come in. Liquid, synthetic detangling agents were used on some. On the final day I also tried some of Estonia's own clay fine-finish pigments in clay, in a tried and tested set up, also playing about with other mineral agents.

TEST 8

For complete results of see appendix F, for a summary of results see appendix f. This last series of tests focussed on manipulating fibre prior to use in the clay mix, like soaking or boiling a fleece of the fibre in acid or lye and applying the clay to it. Experimenting with combinations of old and new fibres.

COMPARING RESULTS TEST 8 FROM THE TABLE IN APPENDIX F, SHOWS THAT

- in general: no pre-treatment (soaking or boiling in acid or lye) of fibres gives better results
- do not boil sheep wool. Although a fleece may be obtained using this method, boiling seems to inhibit the fibre from connecting with clay
- boiling linen in vinegar makes fleece stiffer and reduces fluffiness from 8mm to 6mm
- boiling linen in lye makes fleece even stiffer and reduces fluffiness of fleece from 8mm to 4mm
- lye makes fleece sample darker and it takes longer to dry (also sheep wool fleece slower to dry)
- vinegar makes lime react to produce white crystal rash along edges (on fleece sample) and makes samples darker



Top to bottom: Linen felt
boiled in alkali, in water, in acid



(Mis-)treated fibre samples...

TEST 9 AND 10

The so far best fibre combinations were used and new fibre added agents added to achieve a better detangling of the fibres in the mix. The Estonian clay samples were not tested, as they had only dried completely on the last day.

COMPARING RESULTS FROM THE OLD AND NEW FIBRES TESTED SUGGESTS THE FOLLOWING RATING:

PP ADFIL **FIBRILLATED FIBRE 6MM** (PP=POLYPROPYLENE)

At 1:100 (mass) shows as spot-glitter, very good cohesion, good surface integrity, no real flexibility (holds on to fibre)

PP ADFIL **MONOFIBRE 6MM**

At 1:100 (mass) shows as long-glitter, very good cohesion, and flexibility for medium radius

PP ADFIL **MONOFIBRE 3MM**

At 1:100 (mass) shows as spot-glitter, very good cohesion, good surface integrity and small radius flexibility

RECYCLED TEXTILES

Generally – adding textile shreds (thirsty) to mix makes sample fluffy while moist, smoother when dry, increases resistance to tearing, but increases rigidity, rather than flexibility

HEMP STUFFING (LONG FIBRE)

Generally – adding hemp wool (thirsty) to mix results in better uniformity with regard to rigidity/cohesion, material is more flexible on a larger scale (i.e. flexible sheet of paper not sheet of card), flexibility beyond bending line

TREE MUSHROOM

Generally – adding mushroom based material into mix, improves mixing properties of other fibres in mix but takes longer to dry, sample is darker and may have dark edges and tips, raises resistance of surface, makes sample more brittle, but once manipulated sample more flexible while stable. Samples tend to smell slightly sour

SHEEP WOOL

Generally – adding sheep wool to mix, significantly improves flexibility, but sample prone to losing material if clay cannot stick to wool

RECYCLED CELLULOSE (ISOFLOC, PROCESSED NEWSPAPERS AND JOURNALS)

(NB: RECYCLED PAPER PULP MAY CONTAIN FIRE RETARDENTS THAT PRODUCE TOXIC FUMES WHEN EXPOSED TO HEAT > 300°C!!!)²⁰

Generally – adding coarse or shredded cellulose will show as specs in sample, tendency to produce lumpy surface, improved sample stability, and improved flexibility, but only limited resistance to tearing

Generally – adding very fine cellulose (nano sample from university of Helsinki) will make sample more rigid but also brittle, and increase its resistance to tearing, smoother surface

LEATHER

Adheres well to back of leather. Different leather colours give varying results. Further testing necessary with fibres.



Set of synthetic fibre samples drying



Tree mushrooms for paper making

²⁰ CONSTITUANTS FIBREUX DES PATES PAPIERS ET CARTONS – PRATIQUE DE ANALYSE, Y.AITKEN & E CADEL & C. VOILLOT, 1988 – 1ERE EDITION

6.2.3 CONCLUSIONS AND NEW QUESTIONS

Summary of the conclusions from the above:

Test 1 to 4:

From the experiments it has become clear that sand is a hindrance to bending the dried samples. It has also become clear that the use of a mesh as a base will allow bending while also stabilising edges and reducing fissuring. As for the fibres various qualities were noted, each of which may be of use in some way or another in future applications.

Test 5 and 6:

The test series 5 seems to suggest that no agent used will improve the characteristics of the samples regardless of other components. It can also be deduced, mainly from series 6, that the fibre is essential in providing the desired qualities, where loose fibres can have a similar effect to that of mesh.

Test 7:

In the course of the experiments with additives to the effect of obtaining flexibility, many results were surprising and extreme to one or the other extent, but unfortunately not one of the over 50 agents tried out in the course of the experiments came up with the result hoped for. Cottage cheese may have a toe in the door by rendering the plaster sample somewhat tenacious. The others however, seem to be suited to call upon for achieving special effects.

Test 8:

The tests performed on the fibres may have been too extreme (boiling in soda and alcohol vinegar) and may give a different result if done in a more subtle manner, however, the results suggest that natural fibres need to be added in a fresh/dried state, or fermented, to obtain favourable results for the objectives set.

Test 9:

A variety of fibres were tested and unfortunately it has to be said that the PP fibres bonded well with the clay and gave astonishing results, leaving what some might think is a beautiful glitter effect. But other fibres too had positive qualities, the details of which can be read above. Tree mushroom, could be mentioned as being a promising source, if the smell can be handled. And any recycled cellulose needs to be handled with care, especially if it has been processed to be used as a blow in material, because it will develop poisonous fumes if heated above 300°C.

However, it needs to be kept in mind that the clay that was used in the experiments is not your usual refined and washed clay from the quarry around the corner, and the tap water used was measured to be slightly alkaline.

Luckily, the research undertaken in Phase 1 has not only revealed answers, but also given rise to new questions to take me into a next phase...

Some of the questions that arose during the test evaluations may be solved with testing yet more different ingredients on the basis of what has been found:

- the only ingredients showing slightly promising results with regard to an increased flexibility is latex and possibly cottage cheese (0.1%). An alternative to latex is also the sap of dandelions and other plants. Bearing in mind the adverse effect on breathability for this mix, it should be looked into further.
- Nettle fibres and rice straw were not available for testing, nor was dried seaweed, or fibrillated leather all of which may bring interesting results to the table.
- the range of the additives tested was wide but still limited. Are there other additives to influence flexibility and material integrity?
- try adding different lengths of hemp, nettle or rice straw fibre in the same mix
- try putting tree mushroom fibres through meat grinder or pestle and mortar, instead of the coffee grinder, to make fibres more flexible
- try different lengths, different sources and different types of sheep wool, and test again if theory on lanolin holds up
- vary the amount of time the fibres are allowed to sit in the clay before application to test if there is an effect

Other questions may be solved by varying methods and tools for production:

- how to deal with, avoid or reverse knotting of fibres?
- how to stabilise crumbling and friable edges when not using a mesh?
- How to avoid or reverse warped edges?

(for details and photos on all of the above, refer to appendix A to F and experiments log on USB)



*Clay painting on fibre substrate
(aquarelle paper)*

6.2.4 PHASE 1 – EVALUATION AND OUTLOOK

EVALUATION

The Latvian red clay I chose to experiment with, in hindsight, was not the easiest to use for the purpose, with its tendency to shrink and with its prominent lime inclusions and its acidic character, since the results would not be easily transferable to other clays. However, when it became clear that in order to inspire confidence in the product in the public, the wall-paper would have to be made available and sold in rolls, just like the common wallpaper, at least to begin with, the choice turned out handy, as later tests would show. Since it would also, with regard to storage and transport, be a good idea to maintain the rolled form, as well as it is a real advantage for handling on site and in the process of application, it does nonetheless put another twist on the set of expectations to be met.

This aspect of „roll-ability“ initiated the series of tests with additives while omitting any kind of fibre content, in order to see if I could find an agent that would render the clay flexible, or elastic, even if only slightly. Research into Japanese recipes²¹, where clay rendered buildings in earthquake prone areas might have wanted to have renders with a little give, to allow movement below without immediately cracking, and recipes for clay render on wood burning stoves, that would have to absorb considerable expansions and contractions from quick thermal changes in the substrate, had brought up nothing but the usual ingredients: fibres to resist the cracking, and glues or starches to make it stronger, but no agent that would give the clay an elastic quality.

Basically, and understandably, the research into the Japanese renders came up with the answer that they would have been looking to supply an extra little strength in the renders to help stabilise the individual parts, and cracks were probably desired, in order to point out where damage may have occurred. Kyle Holzhueter, one of the most knowledgeable Japanese plasterers I was able to contact on the issue, recommended I try to experiment with shikkui plaster for instance, which keeps the clay malleable for some time but will then set stronger and more resistant to the elements than normal plaster.

The test results were not always distinct and easy to categorise. With only a magnifying glass and simple tools at hand, the testing methods I devised would not stand up to guarantee qualification for any sort of certification, however, since the tests were always taken in the same manner, by the same person, the assessment of the results will give a general tendency value for the tested quality. Also, there was a learning curve in both the method of preparing and of testing the samples (how to prepare the mixes and which tests to do, and in what order) as well as in logging the results too (the first set of tests were not labelled and photographed as well as the later ones, which means that to be entirely accurate, some of the tests would have had to be redone, in order to be able to prove I am comparing like for like.

As time ran out toward the end of November and a final set of tests on fibre mixes and experiments with additives and fibres to produce a predictable result would have taken place, my attention was required to stray to the Saviukumaja business aspect of the internship, and I found myself doing the acquisition and setting up for a lime-plastering project in Qatar, and the ultimate experiments to produce the proto-types envisaged, had to be dropped.

With my huge thanks to Saviukumaja for allowing me to hi-jack their work-shop showroom for the better part of three months, I am very happy to have had the chance to organise a few series of tests, to define a set of criteria to decide which experiments and tests to do, and which to leave out, or postpone to a later stage. It was the first episode of a learning process, and although in the beginning the work may have suffered confusion and lack of documentation, I am sure I have deducted the lessons available from it to present here.

²¹ Kyle Holzhueter of <http://japaneseplastering.blogspot.com/>

It was also a challenge to set up these experiments in the form of a presentation of an experimentation-workshop, arranging the experiments in the showrooms of an up-and-running trade business, trying not interfere with the business going on around, but instead raising curiosity in the visitors who come into the shop, by stimulating an interest and both tapping and expanding the minds of the clients in dialogue and deed. A clean workplace is a must, in order to keep the subject accessible especially to the general public.

Unfortunately there are some aspects I could have done better, spent less time on, or dwelled on a bit longer in order to be more efficient in the long run, but I think altogether the result has brought me and clay wallpaper forward by a big step.

OUTLOOK

Having proved to myself and sceptical lookers-on that clay can be rolled, if mixed with the right kind of fibre, the next step would be to test the idea on different clays. In order to set up the experiments with a view to long term relevance, it seemed sensible to look for a constant supply of good quality material (no unpredictable contaminants) to do my next set of experiments on, which would be more focussed on achieving a set aim, instead of simply mixing ingredients and recording an outcome.

In a future internship I was therefore keen to further my so far very promising wallpaper experiments to define and produce one prototype at least, with which I would ideally then be able to enter for a clay products competition by Terra Migaki in April 2018, and hopefully perform some experiments on applying to walls of various make-ups.



Choice of samples prepared at Saviukumaja presented at Claytec to apply for an internship



Sample with various Estonian clays (Test 9)

6.3 PHASE 2 – Claytec

My experiences at Claytec were split into 3 work stints. After each work stint Claytec would evaluate the outcome of my experiments and decide whether to go forward with the research or not.

Initial scope: 1st work stint

Intrigued by the wallpaper product, Claytec invited me to research my wallpaper ideas using their materials and gave me one month to come up with something that they would consider worth further investigation.

I started by testing their pure clays of various types and colours as well as some of their basic mixes with and without mesh, then went on to test some of their more substantial mixes for plaster, also with and without mesh, as well as with and without additives.

After this first month I presented the most promising results, and was invited back to develop a choice of three types of these into something that could be produced to a convincing standard and applied single-handedly.

Extended scope: 2nd work stint

Based on the chosen samples, I developed three recipes that gave samples that were hung up on clay plastered walls, using only water as a sticking agent. Based on the performance of these, larger strips were produced, tweaking the recipe to achieve an agreed surface design. These were to be hung on a clay plastered wall in the changing rooms of the main building on site.

Final Piece: 3rd work stint

From the three 1:1 mock-ups in the new changing rooms, one was to be chosen, to be produced and applied to an area of 2.1 x 3m in a last session on site.

Sample 1.5.1 made it into contention for finals to be applied on walls at Claytec



6.3.1 1ST WORK STINT – PRELIMINARY TESTING

CLAY DESCRIPTION AND TESTING

For detailed information and results please refer to Claytec Tables b (1_Material glossary_Clay description, only on media) & f (2_Claytec Wallpapers_Clay tests) as well as the technical data sheets in the appendix.



Workspace

Pure clay samples left to dry



THE PLAN:

In order to reduce the time spent on tests that would result in data that would not be transferable to another situation and also to reduce the margin for misinterpretation of the results achieved, I decided to again fix one parameter in the recipes. Just one clay product by Claytec was to be used to base my investigations on, while others would just be used to verify assumptions on reaction as an aside.

In order to decide which clay to use, I had to find out which of the many materials made available would be the most suitable to continue the experiments with.

The first step defined, it was also clear that at the end of the month I would have to have at least three convincing samples to

present, in order to make sure I would be invited back to continue the research. Tests were run on the pure basic clays through to the ready mixed base coats and finishes.

THE RECIPES:

Knowing it would be a fruitless exercise to try the pure clays for flexibility without any additional ingredients, I decided to add to each mix a fixed amount of short and very short cellulose fibre, as this would give a minimal amount of positive effect, and would show up if suitable clays were amongst those tested.

The pre-mixed materials I was testing were treated in the same way, based on the assumption that the materials were mixed to be strong and resistant instead of flexible and adaptive.

THE MIXING PROCESS:

Small quantities of the clay samples were mixed by hand, first just adding water to see how the clay behaves in contact with water, (tap water here, slightly acidic: pH6) then adding the fibre. The mass was then split in half, and based on my experiences working with savon noir in the mixes in Estonia, a minimal amount of it was added to one half of the samples.

MAKING OF SAMPLES:

As before, I spread cellophane on a relatively smooth table and taped it down around the edges. Onto this, I taped three different runs of 10cm wide mesh, made of glass fibre, flax and jute. The pure mix (no savon noir) was first applied with a trowel to the mesh and a separate small area covered in the mix at minimal thickness, without mesh. Then, next to it, working from left to right, the mix containing savon noir was applied to the mesh and one splotch without mesh.

The samples were left to dry, noting the time it took (where possible) and, put through a series of tests to evaluate their suitability for use in further testing.

DESCRIBING AND TESTING THE FINISHED SAMPLES:

The samples were described with respect to appearance (shape, colour, surface, etc), abrasion resistance (rubbing vigorously with a finger leaves patch? Material lost?), tearing (pinch between two fingers of each hand and pull apart while trying not to flex it), and bending (samples without mesh judged separately from samples on mesh). In these early stages, the samples without mesh were destroyed in the bending test, meaning the evaluation on “material loss in bending” refers to the samples on mesh only. The bending of samples with mesh was then continued to enable judgment of the durability of the sample. Finally the samples without mesh were tested to see what happens if a drop of water is placed on the surface (does it stay intact on the surface or does it get absorbed and does it leave a stain once dried up, or does the material even show signs of disintegration?)

Pure clays



Top to bottom:
Green clay on glass fibre, flax and jute mesh



Claytec premixed clay plasters
primers and mortars



CLAY TEST RESULTS

MIXING

- Green, yellow and red clay form jelly-like mass upon mixing with water (pH6), while grey and black clays are extremely sticky in mixing, and the white clay reacts as normally expected.
- Green and red clay react to addition of savon noir (alkali) by curdling, then smoothing out to become a coherent non-sticky mass.

DRYING

- While pure clay samples dry in just over 28 hours, the more complex mixes of *SanReMo* and *mineral 06* took up to and above 40 (48) hours to dry.
- No tendency could be detected as to savon noir having an effect on the drying time.

VISUAL

- Pure clays and mixes without sand are prone to warping in the drying process, and CMC and FIC cellulose are not offering enough structure to stop the fissuring and/or cracking. (an excess of CMC increases brittle properties)
- Surprisingly, out of the range of pure clays the black (bentonite) looked best, with the least lumps, least warping, least holes and fissures, followed by white clay (Capsil®²²), Lehmspachtel (clay putty mix) both showed no lumps, no warping, no holes and no fissures, followed by the more complex clay mix samples, that tended to be less warped and less fissured.

RESISTANCE TO ABRASION

- Pure clays perform well (except Lasko), while sandy mixes tend to lose the grainy content.

RESISTANCE TO TEARING

- Out of the pure clays, the yellow clay has a very good resistance to tearing, as does pure Lasko, while bentonite performs worst.
- Out of the pre-mixed clays tested most performed well, but nB: here, the addition of savon noir seems to generally reduce the resistance to tearing.

RESISTANCE TO BENDING

- Yellow clay is the only clay to allow a slight flexibility both with and without savon noir. Fibre content increases integrity, even if material has cracked. Contrary to test results in Estonia, savon noir generally increases resistance i.e. makes samples stiffer.

RESISTANCE TO BENDING ON MESH? MATERIAL LOSS? FLEXIBILITY ACHIEVED?

- On jute, pure clays are immediately flexible to a small degree. Green clay also shows slight flexibility on flax. White clay suffers least material loss. Lasko and Bentonite perform worst.
- Generally, pure clays (and most of the complex mixes) separate from glass fibre mesh in the shrinking process during drying and upon manipulation completely loose contact with the mesh.
- All sandy clays perform surprisingly well on jute, Lehmfügenfüller (mastic/joint filler) performs well - even on glass fibre mesh.

²² <https://icspecialties.com/de/produkte/F%C3%BCllstoffe/Capsil®/> Capsil® is a product containing mainly a mix of kaolinit with Siliciumdioxide

REACTION TO WATER

- Pure clays soak up drop to saturate the area of contact, then slow the process, but don't show any resistance, while white clay with savon noir resists initially. Interestingly, pure Lasko resists for up to 90mins, whereas its mix with savon noir holds out just 20mins.
- Pre-mixed clays perform better when mixed with savon noir, retaining the drop on its surface for one to five minutes, however tend to disintegrate in the process thereafter, leaving a powdery patch.

CLAY RESIDUE

FACTS TO RETAIN

- Pre-mixed clays with grainy content show great flexibility on jute and some also on flax.
- Savon noir can increase cohesion while allowing flexibility, increase resistance to water, but also weaken the structure.
- Glass fibre mesh is inadequate for flexing and stretching purposes. Material in general readily loses contact upon manipulation.
- Lasko is the most prominent of the clays, performing best here and worst there. To be handled with care...
- The yellow pure clay, Claytec basic clay, white clay primer, clay putty and clay joint filler perform best with respect to attributes expected to be important in clay wall-paper, like retaining material integrity upon manipulation, a balance of water adsorption and resistance, as well as workability.

For more details please refer to tables, pictures and product data sheets in appendix.



Workspace at Claytec



Series of loose fibres with various pre-mixed clays

FIBRE DESCRIPTION AND TESTING

For detailed information and results please refer to Claytec Tables c (1_Material glossary_Fibre description, only on media) & g (2_Claytec Wallpapers_Fibre tests) as well as the technical data sheets in the appendix.

THE PLAN:

Depending on the fibre, testing only one size of it in a mix does not always make sense, therefore a variation of combinations was tested, and pure mixes only prepared where it was deemed appropriate. The fibres were tested to reveal their most prominent or obvious qualities (visual effect/ flexibility/ quality of bond with clay).

THE RECIPES:

Applying the assumption that a stepped “granulometry” of fibre (originally, sizes of grain, here: varied fibre types, lengths and shapes) would also benefit flexibility while minimising material loss, most tests were performed mixing in a fixed set of smaller fibres with those that were to be tested. The clays used with the fibres to be tested varied according to their suitability as deduced from previous tests, and a good portion of gut feeling.

THE MIXING PROCESS:

The clay paste was prepared first, the fibre added, adding more water in the process, as and if required.

MAKING OF SAMPLES:

Cellophane was laid on a relatively smooth table and taped it down around the edges. Onto this, 3 runs of 10cm wide mesh were stuck made of glass fibre, flax and jute. The mixes were then applied to the various mesh. Some fibres were dipped in the clay paste, some were smothered with it. Very unwieldy as well as some promising fibrous mixes were also applied without mesh.

The samples were left to dry, noting the time it took (where possible), then put through a series of tests.

DESCRIBING AND TESTING THE FIBRE MATERIAL AND FINISHED SAMPLES:

The fibres were described with respect to length and appearance, and behaviour in water (cold and hot and boiling), as well as its impact on mixing characteristics when added to clay. Noting the time it took for the samples to dry, the samples were then described with respect to the effect the fibre has on visual appearance, water absorption, resistance to abrasion (rubbing vigorously with a finger), tearing (pinch between two fingers of each hand and pull apart while trying not to flex it), and bending (samples without mesh judged separately from samples on mesh). Based on this, the samples were inspected to evaluate the adherence of the clay mix to the fibre itself.



Same set, different angle

FIBRE TEST RESULTS

MIXING AND DRYING TIMES

- Out of the fine plant fibre tested, the main points to retain are that the longer the fibre, the less easy to mix into clay paste, while also the more thirsty the fibre, the more water needs to be added to mix, thus increasing liability to fissure in drying process and increasing drying times generally to range between less than 40 and 58 hours. With the exception of the weathered, long fibre flax wool (left open to the elements for probably years), which in combination with Fermacell powder (sawdust from gypsum-fibre board) and wood shavings (fine) dried in half the time compared to the other samples.
- Out of the animal fibres tested, sheep wool seems the most complicated (contrary to my experience with sheep wool from Estonia) as it tended to knot and tie itself up in inseparable lumps. Although quite stiff, cut calf hair also has a tendency to form knots, whereas pig hairs are very stiff, and tend to be rather unwieldy in the mix and application for their tendency to stick out (application by trowel). The drying process was not monitored in the early hours, but it can be stated that the animal fibre probably takes less time but certainly does not take longer to dry than the plant fibre does.
- Lime tree tea makes the clay turn slimy in the mix, and smooth in the dry sample
- Adding typha (Senegalese bulrush) makes the clay paste creamy, no matter if mix beforehand was too dry or too wet. Fermacell sawdust/powder is easy to mix in with paste but tends to produce a crumbly result.

APPEARANCE OF DRY SAMPLE

- Fibre generally visible according to length and size, however, difference between grey (weathered) flax wool and fresh flax wool is that grey flax wool less visible in mix. Attn: all flax wool samples in this phase happened to stink even when samples were dry. (material made available for experiments must have already have started rotting in storage)
- While sisal, Japanese hemp and bamboo all resemble each other in the dried samples, their flexibility differs and bamboo appears as stiff sticks, sisal thinner and slightly bent and hemp flexible enough to form knots. typha makes surface look streaky.

RESISTANCE TO WATER

- All samples containing wood shavings (beech) retain a drop of water on their surface for at least a couple of minutes.
- Sisal and bamboo seem to effect a slight delay in the absorption of the drop, while both lose that quality if dowsed in boiling water prior to adding into clay mix.



Sisal and Bamboo fibre samples after manipulation

Water retention capacity of cork fibre mix





Patch of pig hair with Baulehm

SURFACE INTEGRITY (ABRASION) AND ADHERENCE OF CLAY TO FIBRE

- Samples containing Fermacell powder seem to have less surface integrity and clay rubs off when finger is rubbed over its surface.
- Mixes containing yellow “Baulehm” and no extra fine fibre also tend to have less resistance to abrasion.
- Adhesion to seagrass is not good, but may be improved by adding savon noir to mixing water.
- Bamboo shows better adhesive qualities when dowsed in boiling water before use in mix.
- For Japanese hemp the best results are in samples with very fine fibre in base mix.
- For both lime tree tea and typha it is impossible to judge, but it seems that adhesion is good, if not very good, and material breaks around fibre not off from it.
- Clay mix seems to not adhere well to all three, calf hair, pig hair and sheep wool.

RESISTANCE TO TEARING

- Resistance generally better when pulled in direction of fibre, rather than perpendicular to it.
- Long plant fibre seems to be less resistant (more give?), but although flax wool tears readily this can be improved by mixing it with shorter but strong fibre eg Japanese hemp. Seagrass also tears relatively easy, unless mixed with shorter fibre. Lime tree tea and typha tear easily. Both typha and lime tree tea seem to make the sample brittle.
- The animal fibres tested generally perform well, with sheep wool fleece proving impossible to tear, and calf hair performing very well even in small quantities. Pig hair improves resistance to tearing with increasing hair content.

RESISTANCE TO BENDING/FLEXIBILITY ACHIEVED

- Generally all mixes perform better on jute than flax mesh. Exceptions are bamboo, and Japanese hemp with black putty (bentonite). Bending perpendicular to especially long fibres will result in more damage than bending in line with their lengths. “Table scrape” (a manner of making sample flexible by pulling at an angle over edge of a table) incurs more damage to shorter, bulky fibre like hemp chips, on thin flax mesh, while no damage occurs on jute.
- While wood shavings bear no tolerance to bending, cork seems to add a little give to samples. Sisal will bend more if boiled previous to mixing and samples with flax wool disintegrate as fibres liberate themselves in manipulation. Interestingly, hemp chips with typha seem a good mix on jute, while typha on its own allows no flexing at all. Bamboo is easier to bend when boiled, while seagrass is very flexible but does not hold on to the clay cover too well. Better with savon noir. Japanese Hemp shows off flexible qualities of clays, in that mixed with black clay putty (bentonite) it is only mediocre but with off-white clay putty (Capsil®) it is convincingly flexible (earmark for further research...). Out of the plant fibres only sisal and seagrass performed well on bending without mesh.
- Animal fibre without mesh: pig hair as well as calf hair can be manipulated to flexibility but radii are limited to ~10cm. Calf hair cut to smaller lengths will bend to smaller radius. Sheep wool will improve flexibility for any mix added to, as it seems, which is useful if knotty bits are avoided and a better adhesion (to match Estonian samples) is achieved.
- Fermacell sawdust mixes initially seem to work better with sheep wool, however, manipulation in “table scrape” manner damages sample.
- Two samples came up with perfect results: Baulehm with lime tree tea on jute and Fermacell sawdust with all of the following, Lasko, Bentonite, mastic filler and cellulose on jute.

FIBRE RESIDUE

FACTS TO RETAIN

- Lime tree tea seems to be doing incredible things, but unfortunately is not a product for use on a grander scale.
- Seagrass and sheep wool are really good for flexibility but need agent to better adhere to clay.
- Fermacell works well with artsy plastic mesh, and seems to speed up drying process, at the cost of surface integrity.
- Animal hair and bristles are stiff but work well, however need agent to better adhere to clay.
- Japanese hemp is easy to work with and mixes well with clay as well as other fibre. Best results with off-white clay putty.
- Recycled textile gives sample more volume, while FIC makes it fluffy and porous.

For more details please refer to tables, pictures and product data sheets in appendix.

Set up for fibres tests, loose and on mesh





Worktop set up for testing clays fibres and additives

ADDITIVES DESCRIPTION AND TESTING

For detailed information and results please refer to Claytec Tables a (1_Material glossary_Additives description, only on media) & e (2_Claytec Wallpapers_Additives tests) as well as the technical data sheets in the appendix.

THE PLAN:

Based on simple mixes from before, the various additives were tested on and off the mesh. A description of the plant or animal sourced and the mineral additives is assembled in the additives description table. Those that have not been tested before (saponin, which is soap-stone powder, and Kieselgur, which is diatomaceous earth) are also documented with respect to their effect on samples of various clays.

THE RECIPES:

The tests with saponin and diatomaceous earth were conducted adding equal amounts of the ingredients to a variety of clays. The remainders of the materials were mixed together (equal parts) and tested in combination.

MIXING PROCESS:

The clay paste was prepared and the additives added to it.

MAKING OF SAMPLES:

The paste was applied to jute and flax mesh, as well as on its own (without mesh) on cellophane spread and glued on a table top.

DESCRIBING AND TESTING THE ADDITIVES AND FINISHED SAMPLES:

The samples were described with respect to workability and drying time. Once dry the samples were judged on appearance, surface integrity, bending and flexibility, resistance to tearing and water absorption.

ADDITIVES TEST RESULTS

MIXING AND DRYING

- It seems impossible to create general rules for the individual additives with reference to drying time. Too many factors could be responsible for varying times.
- Savon noir generally makes the mix more creamy (except green clay which curdles on impact, but then relaxes again) but then makes it easier to spread thin. Saponin generally makes the paste more creamy too and lighter in colour (but reacts with the green clay to make it first creamy, then runny, leaving a thin soup with knotted fibres in). Kieselgur (diatomaceous earth) requires additional water to the mix, grainy texture helps to dissipate fibrous knots in paste and generally makes pastes darker.
- Cellulose as an additive, CMC 300P (methylcellulose), generally turns mix jelly-like, very thirsty but non-sticky. FIC 500P cellulose fibre turns mix into a fluffy, thirsty paste. Fermacell as an additive comes into this category as well, as it renders mix with a jelly-like texture.
- Lanolin and savon noir have comparable characteristics, as well as saponin, as in that all of these make pastes more creamy and workable.
- The grainy mineral additives like diatomaceous earth and the various quartz sands, generally make the pastes thicker, more pasty, where diatomaceous earth is more thirsty than sands due to its porous structure.
- Additives that contain lime, like the chalk from the Baltic and from China, as well as the Tadelakt imitation “Gekolakt”, by saviukumaja, have different effects on the clay mixes from each other. While chalk from china smoothens the pastes, the Baltic makes it stiffer, and Gekolakt initially makes it stiffen up a lot, but only needs a tiny bit of water to relax again.

VISUAL

- Generally, grainy additives result in a sand-paper like surface, which can be softened for instance with an addition of micro-fibrous cellulose. Otherwise impossible to generalise.
- Saponin turns out darker than pure samples, although the paste was lighter in the mix to start with. Diatomaceous earth has a grainy appearance too, no effect on colour when dry, surface prone to fissuring from shrinkage in drying process (least so in CAPSIL®) and a less grainy effect in Lakso and Bentonite.
- Additives with a lime content tend to make samples smoother, Baltic chalk extra smooth with a glossy shine, and china chalk extra white.

RESISTANCE TO WATER:

- While micro-fibrous cellulose FIC500P increases the speed of absorption, no effect can be noted for the additives methylcellulose or savon noir, nor diatomaceous earth or the quartz sands.
- China chalk and Gekolakt have shown effects on prolonging resistance to water to around 5 minutes in combination with saponin and lanolin.



Red clay with mineral additives



Bentonit retains drop of water when mixed with saponin and diatomaceous earth

SURFACE INTEGRITY (ABRASION) AND ADHERENCE OF CLAY TO FIBRE:

- While methylcellulose and larger cellulose increase integrity, cellulose in Fermacell powder (gypsum content) increases rub off.
- As for the mineral ingredients, the diatomaceous earth additive is the only one that can be said to decrease the integrity. Maybe, like with all lime containing additives it needs another additive to prevent resulting in a crumbling effect.
- Saponin generally increases resistance to abrasion.

RESISTANCE TO TEARING

- Additives cannot be traced to be responsible for any change in resistance to tearing. This aspect is highly dependent on fibre and mineral content. Although the linkage of clay to fibre can definitely be manipulated by addition of plant or animal or mineral or synthetic ingredients, this has not been researched enough to venture guesses on.

RESISTANCE TO BENDING/FLEXIBILITY ACHIEVED

- Plant based additives like fine (micro-)cellulose tend to reduce cracks to fissures, and even to invisible fissures, while savon noir can help produce the same effect, especially with mixes containing lime, but Fermacell powder can work against flexibility if overdosed. Too much Fermacell powder will make sample crumble, too much lime content too, but too much savon noir can make it brittle.
- Lanolin also needs to be well dosed, as too much will turn sample brittle and show cracks (discolouration).
- The mineral ingredients diatomaceous earth and saponin work to a certain degree to allow flexibility but samples containing either of these will deteriorate further if manipulation continues. Exception to the rule: saponin in Lasko. Works well, and maintains stable flexible state when manipulated further.



Various pure clays with mineral additives on mesh and without

ADDITIVES RESIDUE FACTS TO RETAIN

- Both saponin and savon noir, as well as possibly lanolin will work to activate lime content in mix, but all of them make samples darker, sometimes with a yellow tinge (lanolin).
- None of the tested additives will simply result in flexibility or waterproofing, or resistance against tear and abrasion. More research needs to be undertaken.
- Savon noir will, if dosed correctly improve sample performance
- Sand, foamglass granules and diatomaceous earth can give body without bringing stiffness, while lime content seems to be able to break up the mineral stiffness in the sample body, to give individual mobility to parts. Further research is needed.
- The ph-value of the mixing water has an influence on ease of mixing, and drying process and consequently the result.

For more details please refer to tables, pictures and product data sheets in appendix.

Working area at Claytec



MESH DESCRIPTION AND TESTING

For detailed information and results please refer to Claytec Tables d (1_Material glossary_Mesh description, only on media) as well as the technical data sheets in the appendix.

DESCRIBING AND TESTING THE MESH:

The textile webs that were used to experiment with as possible skeletons for the clay paper mass were made of jute, flax, glass fibre and polypropylene. The choice of mesh available for use unfortunately did not comprise of any kind of fleece, nor a variation of mesh/holes size.

The suitability for and benefit of using the mesh was tested in analysing the previously described tests for clay, fibre and additives qualities and their suitability for the purpose at hand deducted.

AVAILABLE MATERIALS, SIZES, UNIT

- Jute : mesh: 4,5x 4,5 mm, weight: 120 g/m², size: 100cm wide, 50m long, on roll.
- Flax : mesh: 5 x 5 mm, weight: 45 g/m², 100cm wide, 100 or 35m long, on roll.
- Glass fibre: 5.5 x 5.5 mm, weight: 65 g/m², 100cm wide, 100 or 35m long, on roll.
- Sizoweb/Sizoflor: Polypropylene, length: 25m, breadth: 19cm, 30cm or 60 cm, on roll



MESH TEST RESULTS

SURFACE INTEGRITY (EXPOSED TO MOISTURE) AND ADHERENCE OF CLAY TO FIBRE

- Jute more prone to warping in drying
- Jute more prone to cracking, probably due to extra thirst and thickness, giving more body to clay that needs to be bent
- Jute more likely to show through as texture in dried sample as a pattern
- Flax (treated?) not as good as jute for clay to stick to (tests of washing flax prior to use not promising option, see tests Phase 1))
- Glass fibre does not give clay surface to adhere to, fissuring and dissociation
- Polypropylene of Sizoweb and Sizoflor better for clay to stick to but has no eco credentials
- Sizoflor too small mesh to allow clay to filter through to backside on a continuous scale, resulting in a patchy coverage of clay i.e. not enough available on back side to activate to stick sample to wall with
- Sizoweb bigger gaps between fibre but in bigger gaps no material to glue, so ok

RESISTANCE TO TEARING/ BENDING/ FLEXIBILITY ACHIEVED

- Jute and flax bend similarly, plastic mesh possible to crease, while glass fibre mesh bends well but disqualifies itself by not holding on to clay during this manipulation
- None of the mesh tested is possible to tear

4 main types of mesh made of (from top to bottom)

Glass fibre, flax, jute and flat on the table sizoweb (white) and Sizoflor (green)

MESH RESIDUE FACTS TO RETAIN

- A thinner type of jute seems to be the best mesh to use, if any.
- For lack of availability, the thicker jute mesh or the thinner flax mesh are best to continue research with.
- Glass fibre mesh was considered not suitable.

For more details please refer to tables, pictures and product data sheets in appendix.

Set up for all tests from which fibre qualities have been deducted



SUMMARY FROM PRELIMINARY TESTING

Having identified some materials that would be interesting to continue research with, I decided to take the shortcut through the options, put all my eggs in one basket and run with the white clay (off-white, Capsil®), which, if successful would be the easiest colour to excite the public with. In order to reduce the amounts of additives I needed to juggle to get a working mix, I decided to use the off-white (Capsil®) clay putty (Lehmfarbspachtel) from the YOSIMA range by Claytec that already has a pre-set fibre content.

In order to investigate the extremes before settling for something that will work for sure, I decided to set up a first series of tests (Test Series 1.1) to produce samples without mesh, and then elaborate on the best results thereof. The test would be basic mixes with mineral additions only: series 1 with various sizes of granules of Poraver (foamglass granules), series 2 with fine quartz sand and Baltic chalk, series 3 with fine quartz sand and Chinese chalk, series 4 fine quartz sand with diatomaceous earth and series 5 same as 4 with bigger sand grains (testing the limits to see why in Phase 1 sands needed to be eliminated).

Out of the above the best, most promising samples were chosen to continue research on by varying additions of further ingredients.

The chosen samples were:

- 1.1 – Yosima coloured clay putty + Japanese hemp fibre + Poraver (foamglass granules)
- 3.1 – Yosima coloured clay putty + Japanese hemp fibre + Chinese Chalk
- 3.2 – Yosima coloured clay putty + Japanese hemp fibre + Chinese Chalk + Baltic Chalk
- 4.1 – Yosima coloured clay putty + Japanese hemp fibre + Quartz sand (0.05mm)
- 5.1 – Yosima coloured clay putty + Japanese hemp fibre + Quartz sand (0.05mm)+(1mm)
- 5.2 – Yosima coloured clay putty + Japanese hemp fibre + Quartz sand (0.05mm)+(1mm) + diatomaceous earth



Samples of Lasko, Baulehm and Capsil® with and without mesh

These mixes were used as basic recipes for Test series 1.2, producing samples without mesh, varying additional ingredients to mitigate shortcomings in original samples.

Out of these mixes, the most promising and intriguing mixes were chosen to produce bigger samples to decide on whether research was to continue or not.

The categories for which one sample each was presented were: the designed look, the smooth look and a grainy surface look.

At the meeting the samples were also tested as to their capacity to be rolled to a very ambitious diameter of 5cm.

For more details please refer to tables, pictures and product data sheets in appendix.

6.3.2 2ND WORK STINT – DEVELOPING PROTOTYPES

THE PLAN:

Based on the samples that were presented and the comments they had harvested, three recipes were chosen to continue with, in order to find the chosen look/ surface design (see table: “3 chosen recipes 1_2_3 for mock ups”)

- Plucked look without mesh (FIBRE 1.3)

Yosima coloured clay putty, cut Japanese hemp, China Chalk, FIC 500P, recycled textiles

- External Render look (CHALK 2.2)

Yosima coloured clay putty, jap hemp, China & Baltic Chalk, Foamglass (0.04-0.125, 1200/180)

- Smooth look with lines on mesh (CHALK 1.2)

Yosima coloured clay putty, jap hemp, China & Baltic Chalk, (micro) cellulose fibre FIC 500P & CMC 300P, Seagrass

THE RECIPES:

The chosen samples were to be optimised to achieve highest integrity upon manipulation (rolling) and best sticking capacity with only water as an activating agent. A first round of tests was undertaken to come up with samples that could be experimented with by sticking to a clay plastered wall in the storage loft above the old kiln.

MAKING OF SAMPLES:

As before, the best results were achieved when using a cellophane spread, taped to the table top along its edges, on which to spread the clay mix and let the samples dry on.

The recipes were prepared in small quantities, using scales for the first time. Samples were prepared and left to dry, noting the time it took (as far as possible), then subjected to a series of tests.

DESCRIBING AND TESTING THE MATERIAL AND FINISHED SAMPLES:

As before, during the 1st work stint, the samples were described with respect to appearance, resistance to rubbing (vigorously with a finger), tearing (pinch between two fingers of each hand and pull apart while trying not to flex it), and bending (samples without mesh judged separately from samples on mesh). The samples without mesh were destroyed in the bending test, so the evaluation on “material loss in bending” refers to the samples on mesh only. The bending of samples with mesh was then continued to be able to judge the sample durability. Finally the samples without mesh were tested to see what happens if a drop of water is placed on the surface, does it stay intact on the surface or gets absorbed and does it leave a stain once dried up?

For more details please refer to tables, pictures and product data sheets in appendix.



Ssamples with variations of lime and other mineral additives

TEST RESULTS AND SUMMARY DEVELOPING PROTOTYPES

PLUCKED SURFACE DESIGN

- Translating the rough measures of quantities of materials used in previous experiments into units of measurable weight (e.g. a heaped lump of material on a tablespoon became x grams) the recipes were defined and elaborated on varying their quantity and mixture using scales and measure cups.

In the recipes based on FIRBE 1.3, the Japanese hemp was left uncut, then cut, replaced by a local product of untreated hemp (uncut and cut), mixed with and without addition of chalk and recycled textile fibre. Acknowledging that the most convincing results were 1.4 and 1.8 on sizoweb and 1.6 without mesh, 1.3, 1.5, 1.6 and 1.8 were tried out with and without mesh, varying quantities of ingredients, out of which samples 1.5.1 and 1.6.2 were used to test sticking capacities on a clay rendered wall.

The sample 1.5.1 (on sizoweb) stuck well to wall but needed a lot of wetting of both paper and wall, which was not a problem due to integrity of sizoweb even when wet, as well as it needed a lot of pressure to apply. After drying, peeling off is possible, even easy in parts. Sample 1.6.2 has no mesh, needed similar amounts of wetting and pressure, stuck well to clay plaster, but due to the perforated design was not easy to peel off, but possible.

For more details please refer to tables, pictures and product data sheets in appendix.

Plucked Design surface out from the 3D range of samples



MINERAL (GRAINY) PLASTER DESIGN

- In the recipes based on CHALK 2.2, a series of samples was produced in which Japanese hemp was substituted with local hemp product (black forest is relatively local to Claytec, Viersen, Germany, in comparison to that fantastic hemp imported from Japan) and/or cellulose fibre, a choice granulometry of fine quartz sands and a pinch of Baltic chalk.
- While samples 2.1, 2.2c, 2.3 and 3.3d turned out most convincing, the samples chosen to go forward with to test on the walls were 2.2c, 2.3 and 3.3d. After deliberation on quantities needed, sample 2.2c2' was qualified in theory, however, unfortunately, after testing, none of the samples turned out well enough to stick to a wall (where people would see it), and there was no time to produce more.

For more details please refer to tables, pictures and product data sheets in appendix.

Mineral mix with traces of glitter and herbs

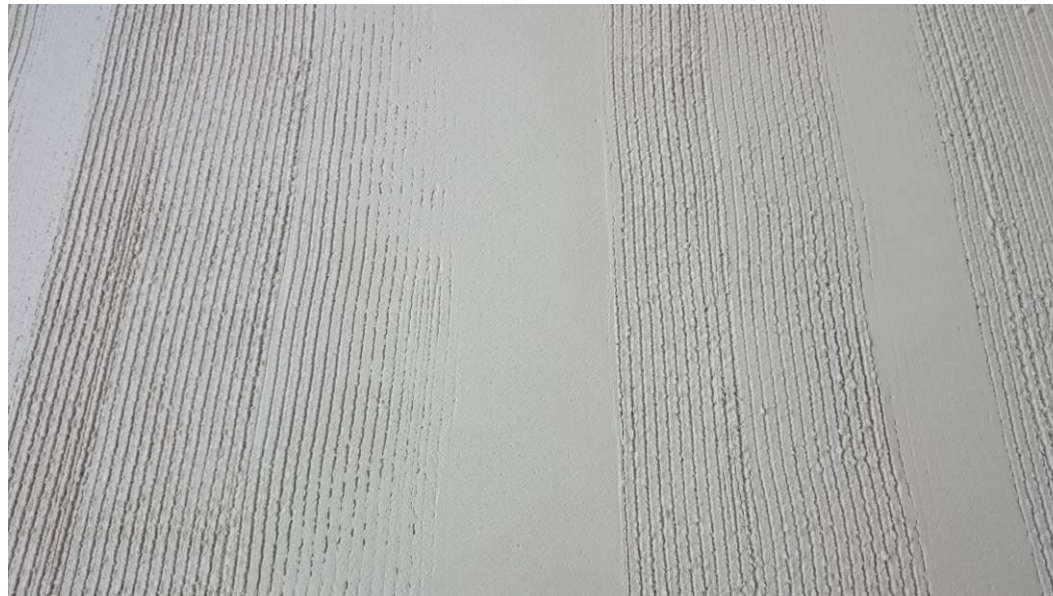


SMOOTH DESIGN

- In the recipes based on CHALK 1.2, a series of samples were produced from which seagrass had been eliminated from the start, but the fibre content was varied with recycled textile, local hemp or cellulose. Further testing came up with good results, and 3.1.2 (for some reason sample did not look like previous) and 3.2.3 were produced to hang on walls. Sample 3.2.3 unfortunately disintegrated, due to a handling error, in practicing the moves prior to actually hanging the paper on the wall. Accordingly, only 3.1.2 was hung on the wall. This paper became very heavy when wet, which was not a problem in this instance, because the sample was only relatively small. (If sample was longer, wetting in stages would be recommended). Sample 3.1.2 also stuck very well to the clay wall and needed quite a bit of work to peel off at the edges.

For more details please refer to tables, pictures and product data sheets in appendix.

Fibrous mix on jute mesh with combed optic



APPLICATION OF PROTOTYPES

THE PLAN:

The plan was to produce bigger samples of the ones that were used in the first sticking test. The bigger samples would be 3.5m long and 55cm wide to be cut to size (~3m) on the wall. These runs would then ideally be glued on with water or clay paint, allowing Iris, the painter-decorator at Claytec to advise on how she, being trained in both hanging normal wallpaper and in application of Claytec clays, would go about hanging these.

THE SAMPLES:

The small samples 1.5.1, 1.6.2 and 3.1.2. had performed well in the first sticking test on the clay wall in the storage loft. Although the sample used had performed convincingly, the recipe for 1.5.1 had to be amended to contain a mix of local and Japanese hemp, while the surface design was adapted to the site of its application, to pronounce the verticality of the long paper run to be stuck on the wall, i.e. less of 3D plucking, more pronounced gaps.

Sample 1.6.2 was prepared using various lengths of local hemp and reintroducing Baltic chalk to the mix, hoping to return to the original look, while sample 3.1.2 received a larger portion of CMC and FIC. The result for 3.1.2 looked good, however, upon wetting (as whole), became too heavy to handle like normal paper. The sample tore before it went on the wall.

STICKING PROCESS:

Iris, drawing on her painter-decorator past, advised on using methylcellulose to glue the “papers” to the wall, regardless of the fact that the papers were made of clay, as well as ignoring that the first round of sticking trials, based on using only water to activate the clay as glue had already worked a treat. A compromise was found in that we decided to use a clay paint instead of cellulose glue and the papers would be stuck to it, while it was still wet.

UN-STICKING PROCESS:

The un-sticking of the papers is a part of the test. Only sample 1.5.1 (on sizoweb) and 1.6.2 (without mesh) were hung, and whereas sample 1.6.2 proved impossible to remove without damaging the paper, sample 1.5.1 was possible to take off without much material being lost (or gained), see picture top right. The polypropylene mesh kept its form and stayed intact in the process, if taking parts of the light green paint base with it. After applying a darker (umbra) shade of clay paint as a backdrop on the wall, the paper was re-hung, using various methods of applying methyl-cellulose : applied only to paper, only to wall, and both, see picture on right.



Removing wallpaper from wall because base colour did not show though the holes in the design as desired

The very same piece of wallpaper stuck to a new umbra paint base



3RD WORK STINT – THE REAL THING

APPLYING PROTOTYPE 1.8.1 ON OFFICE WALL

As a final challenge, Claytec chose a sample that had not yet been produced to be tested on a wall, nor produced on a large scale, to be hung in an office space in Claytec's new workspace headquarters.

Sample 1.8.1 is a fibre based mix, applied to Sizoweb, in a random manner, thicker in places, with a fine plucked surface, giving it a 3D depth that would be improved by using a dark background colour. I had but one day to produce five strips of this untested paper, and on top of that, there were no tables available to work on.

The production of the papers was improvised by taping cellophane covered corrugated cardboard to the warped timber floorboards, and applying the mix, to the Sizoweb mesh, kneeling, with one site lamp to assist.

These circumstances resulted in three major differences to the original working method. For one, my movements in application were not as easy to control as at table height. Two, as might have been expected, the lines of the corrugated cardboard showed through in the sample already while still wet, and three, both my kneeling perspective and the 'lighting' situation (single light source) made some otherwise unnecessary flaws inevitable. Having had no time to check back with Claytec to discuss the change of design, I chose to omit the plucked detail to allow the unwanted lines to step into the limelight and hope for the best.

The paper was left out to dry on the floor for a day and a half, then, still not entirely dry, removed from the cardboard, however keeping the cellophane as a protective guard. The paper was very nice and flexible already and bendable to a diameter of about 15cm after manipulation by passing the steel roll (8kg, 10cm diameter) over it (only 2 layers of padding were available).



Rolled sample of 3.2m long and 50cm wide sample of clay wallpaper

In order to 1. apply the paper to the wall skilfully and 2. get the maximum benefit from seeing how a trained painter decorator would work with the clay prototype without my (untested) instructions, the decision on approach and method were to simply leave the decisions on these aspects to colleague Iris. Claytec Architect Mr. Ballis, decided the background colour was to remain the colour of the Claytec basic building clay.

Iris chose to apply the first length of paper using a moderate amount of relatively thick methylcellulose paste on the back of the paper, and wetting the wall with a water spraying pump. The paper had dried up on the floor, contracting to produce a crease running up in its middle. Iris applied the sheet pushing it on to the wall, working herself outward from the centre, top to bottom, and the creases disappeared. On the second, third and fourth paper, more methylcellulose paste was applied, the wall was humidified twice and finally pencil marks were drawn into the clay of the already hung paper, to mark where the next length needed to be hung. The edges were overlaid and cut with a cutter knife, along and thin metal sheet. Wet clay and wet fibres on slippery plastic mesh don't cut well, even with a sharp edge, and this left the joints looking slightly more frayed than may have been necessary.

The pencil marks did not rub off as they normally would on paper either, so, all in all, very regretfully, the product on the wall, once it was done, hung and dried out completely, was quite terrible. But nevertheless, regardless of how the spontaneous design had turned out, the paper was produced, rolled, and stuck to a clay wall, all of which worked brilliantly, even using methylcellulose glue. Except for good looks, all boxes of quality and single handed application were ticked!



Above (left to right): series of pictures showing the mounting of the paper by the professional painter and decorator of Claytec using edge rolls, metal edge and carpet knife.



*Far left: The wet paper hung to the wall
Left: The finished dry wallpaper*

6.3.4 INSPIRATION FOR PRODUCTION TECHNIQUES AND TOOLS

DESIGN IDEAS FROM CLAYTEC SURFACE DESIGN COMPETITION

Out of maybe thirty samples that were sent in from all over the German speaking countries the Claytec team chose ten that they thought most pleasing. The producers of the ten best samples were invited to reproduce the plaster on areas of wall in the new office quarters. These were then appraised and judged by a team of experts including clay surface design experts like Irmela Fromme, of Wangelin.

For a range of the design scope that was displayed please refer to the annexe “picture reference Claytec surface design competition”.

MANIPULATION CONTRAPTIONS

In order to apply a force resembling the timber edge of a table and a soft pressure of a hand from the other side, I set up a kind of rolling press. Making use of a few painter’s carpets I found, I produced a padded surface. The paper to be manipulated was spread out on this and covered with a sheet of plastic. A roll of 8kg and a diameter of 10cm was then slowly rolled backwards and forwards, to have worked on the entire paper at least twice.

A version that was to simulate a mechanical set up, saw the roll fixed towards the end of the table, and a cardboard roll was fixed to the end of the table as well using tape, creating a soft bend from the table surface to the round of the cardboard roll. The length of clay paper, covered top and bottom with plastic sheets, is pulled through this contraption to the same effect.

RESEARCH RESIDUE FACTS TO RETAIN

The research on bending the clay paper is encouraging but needs to be looked into further. Different papers are likely to need different methods.



Top left: 8kg steel roll tied down with twine, used to roll dry paper

Far left: Experimenting with a protective plastic to ensure smooth gliding of the sample

Left: Inversed set-up, with the friction of the painters carpet used as a means to pull sample through device

PHASE 2 – EVALUATION AND OUTLOOK

EVALUATION

Based on the experiences made at Claytec, a few valuable lessons were learned and inspiration for continuation of research gained. For one, some of the insights gained from the first internship in Estonia were viewed in a different light, and could be refined, e.g. the role of sand or savon noir in the mix.

While most of these refer to the physics and chemistry of the material mixes, some touched areas beyond making the sample work. Manipulating the papers to gain flexibility, getting the edges right and how to make storage possible, for example, are important questions that I have already done some research on, and imagined solutions for, but I have to admit I remain in search of a tried and tested answer.

With the various mixes having more or less thicker or finer fibre to wield, a variety of mixing and application methods were tried out. From hacking down the knotty bits with the edge of a trowel, through smoothing out a sticky mix with a rolling pin in a plastic bag or placing the sticky grainy pastes in evenly distributed smaller portions, many options were tested to suit the sample at hand.

And this is where the problem becomes apparent: every mix requires a different kind of treatment.

Finally, it has to be said that the entire subject area of how to industrialise the production of the wallpaper may only be necessary to be resolved for very few samples.

Joints between work surfaces covered with cardboard but still showed through



OUTLOOK

The hand-made wallpaper serves well to get the word out, but from thereon, clay wallpaper will remain a handcrafted pricey accessory. In order to take the product one step further, the process will need to be industrialised for at least a couple of versions of it. However, due to the wide variety of possibilities as well as requirements to meet, it is hard to define which samples to choose and where to start. It could be an idea to involve interior design schools in the imagining of suitable designs, monitor the interest in these in an online questionnaire and then start off with developing a way to produce that one using machines.

The type of machines required to be invented depend entirely on the type of wallpaper to be produced. But, breaking down the problem into bite size units, it seems likely that there will be a need for a mixing tool and storage container for the wet mass to sit, a pump, a static or mobile duct and nozzle to distribute the mass onto a static or moving conveyor belt-like surface of the required length and equipped with a defined edge, with or without heating or aspiration facilities connected. And as far as I know all of these already exist and can maybe quite easily be adapted?

Collection of samples deemed ready to be used on walls, based on Capsil® clay, various fibre and mineral components



6.4 PHASE 3 – OTHER RESEARCH

6.4.1 APPLYING CLAY WALLPAPER TO VARIOUS SUBSTRATES USING VARIOUS AGENTS

Having produced various samples of a range of ingredients, with a mesh or loose fibre as an integrated skeleton, the samples have undergone various tests, from rubbing and tearing at the edges, to bending and spraying with water. However, all of these examinations seem like checking the hull of a boat for holes with a microscope and calculating the floating capacity. Just like the boat needs to be tested on all waters, the wallpaper samples need to be tested on a variety of substrate.

THE PLAN:

At least one of each of the three prototypes was chosen to be stuck to and once dried, removed from various surfaces, employing various agents to facilitate sticking.

THE SITE:

In a (relatively) fair-faced concrete room in the basement at a friend's house, which is to be turned into a natural cellar with an earth floor and a thick clay plaster to the walls and ceiling, I was given permission to glue and remove whatever I want.

THE PROCESS:

A variety of samples were chosen to be stuck to the concrete surface and more of the same samples were chosen to be stuck to random pieces of Fermacell (gypsum/recycled cellulose) plasterboard.

The agents used were (see picture to right):

- A. Water (no visible patch)
- B. clay paint (clay, talcum, chalk, gum arabicum, saponin _ yellow)
- C. clay putty (clay, talcum and fibre _ umbra)
- D. Clay finish plaster (clay, <0.5mm fine sand and cellulose fibre _ beige, top & bottom right)
- E. fibre reinforced clay mortar (clay with fibre and sand <1mm _ beige)

THE RESULTS APPLICATION AND REMOVAL OF WALLPAPERS

THE EXAMINATION OF SAMPLES GLUED TO CONCRETE AND FERMACELL PLASTERBOARD BROUGHT RESULTS FOR:

- Quality of adhesion (apparent quality of bonding with substrate, tested by listening for hollow sounding areas, running hands around edges)
- Ease of removal (taking paper off wall, whatever means and tools it might take) and
- Resistance to shearing (pulling on the sample parallel to wall).





THE RESULTS WERE IN GENERAL:

- All samples were possible to stick to the different substrates with all agents
- The samples with mesh can be removed without damaging
- The grainy samples especially those without mesh, need to be scraped off
- The fibrous samples can come off in larger patches or flakes
- Grainy glues work best with grainy sample
- Water works best with clay substrate but works on concrete and Fermacell too



INSIGHTS TO RETAIN FOR APPLICATION ON CONCRETE WALL:

- All samples were possible to stick to the concrete wall with all agents
- A lot of pressure needs to be applied for some time to achieve bonding to concrete surface
- The quality of adhesion varied due to the following deductible reasons
 - substrate was not humidified evenly (dry patches with no adhesion)
 - pressure was not applied evenly (dry patches with no adhesion)
 - clay glue was not applied evenly (dry or thinner patches)
- Fibre-reinforced clay putty worked best for most samples on concrete

INSIGHTS TO RETAIN FOR APPLICATION ON FERMACELL PLASTERBOARD:

NB.: Plasterboard was NOT wet-wiped and brushed before application of papers

- All samples were possible to stick to the plasterboard with all agents
- The quality of adhesion varied due to the following deductible reasons
 - drying time for humidified plasterboard is a lot longer than with concrete wall. Samples were still humid when removal began (bad results because still wet or good results because water was still acting as a glue?) further testing needed.
 - substrate was not humidified evenly (due to remaining surface contamination dry patches with no adhesion)
- The grainy glues did not perform as well as the smoother glues or water (grains create gap?)
- water worked but did not give great results, possibly due to drying time (see above)

FACTS TO BEAR IN MIND:

- Tests were only let dry for a couple of days in a non-ventilated cold space before removal
- Samples were small and easy to handle in application
- No tools were used except for hands and a trowel (need to invent a device that will allow to put an even pressure over larger area of wall paper to get more even effects and to limit damage to product)
- There is a wide range of other clay mixes that could be tested for other qualities in application, like drying speed, or adhesion strength etc (Claytec primers are very promising)
- Substrates not tested yet: (variety of) natural stone, lime or gypsum plaster, straw boards, solid timber or wood fibre boards, etc



Top: Lifting a ca. 0.5m² of a 12.5mm gypsum fibre plasterboard (ca. 10kg) by pulling on the jute mesh wall paper sample of 0.01 m² area of connection.

Top right: Same with sample on PP mesh at are of 0.03 m².

Right: Pulling off PP mesh sample shows minimal damage to sample.



See appendix for video footage of the removals above.



Various samples being removed from concrete substrate

6.4.2 MANIPULATION OF SAMPLES IN STEAM LAUNDRY MANGLE

Another experience worth sharing is the attempt of running a sheet of clay wallpaper through an old steam press.

THE PLAN:

If the wallpaper is left to dry completely, lying flat, then manipulation in order to persuade the clay to allow rolling at a radius of down to 5cm diameter, has to be done extremely carefully so as to not damage the sample. In order to avoid this problem the idea was to use a steam laundry mangle, to force-facilitate the bending while issuing steam to instantly “heal” any damage incurred.

THE PROCESS:

After introducing the idea to the only steam press owner that I know, my then ninety-three year old great aunt Hidda, she agreed to let me hijack her device for the experiment. She did however impose one condition: she’s doing the driving! That settled, I prepared the samples, handed over and she passed the samples through the machine in various manners: humidified, and dry, applying heat or not, etc.

THE RESULT

Very promising indeed. The best results were achieved spraying the sample with water before running through the press, and applying moderate heat.

Set up for experimenting with a steam laundry mangle. Best results were obtained when pre-spraying the samples and using a soft heat while rolling



6.4.3 MAKING WALLPAPER SAMPLES USING A PASTA-MAKER

Hoping to be able to effectively eliminate an entire production phase should using a pasta maker work in preparing the sheets, as it might have shown to require or allow using a drier mix and thus cutting the drying time as well as the space required for production, a few mixes were prepared and run through a (lasagne) pasta-maker.

THE PLAN:

The paste would be fed to fall into the gap between the rolls from above, and, making use of gravity and friction the mass would be squeezed into a flat sheet that, should the mix be right, and the product stable, could be fed straight into a drying and rolling press.

THE PROCESS:

It has to be mentioned that one of the clays used to produce the mix was a new clay (from Læsø, a Danish island in the Baltic) that I was doing some identification experiments on at the time, and had no information on how it would behave as a base for a wallpaper. That noted, the mixes that were conjured up were fed through the press, and the sheets that emerged left to dry.

THE RESULT

Although it has to be said that getting the mix just right is essential for this method to work, which the mixes were not, the results here were also very promising indeed. It was a real hassle to force the drier mix through the press, but in the end, even the samples containing the bulky fibre went through and came out in 2mm sheets which is all that was required.

The process of squeezing unwieldy fibre through the pasta maker is no easier than spreading with the trowel



Some of the results of using the pasta maker however do inspire further investigation



6.4.4 EXAMINING CELLULOSE FIBRE CHARACTERISTICS AT CTP / CNRS

RESEARCH INTO FIBRE IN VARIOUS STATES

In the course of an internship at the Centre for Paper Technologies, in corporation with the 3SR laboratory of the National Centre for Scientific Research in Grenoble, I had an opportunity to use a microscope on a variety of fibres exposed to a variety of conditions.

THE PLAN:

The intention was to subject a choice of fibres to conditions that they may encounter in the process of wallpaper production. By monitoring the changes in the fibre and its behaviour in various conditions, information is hoped can be deduced, enabling to predict pitfalls or identify potentially beneficial characteristics that may be exploited.

THE PROCESS:

To imitate the various types of tap water one may be using to produce wallpaper, the fibres were soaked in solutions with a lower ph (here: tap water is slightly acidic at ph6) and also in liquids of raised ph (slightly alkaline at ph8) levels.

Then, an amount of the same choice of fibre samples was soaked in a liquid (cabbage juice), that contains lacto-acidic bacteria, likely to encourage fermentation of the fibre, if kept at a constant warm spot, however not exceeding 40°C for longer than 30 days.

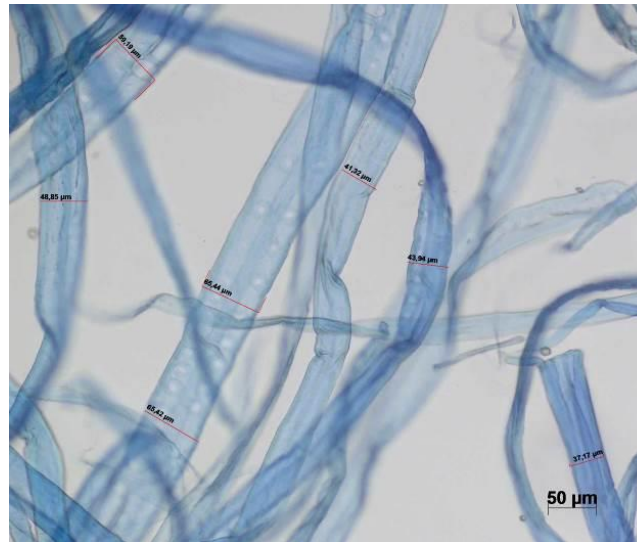
The three samples were then inspected under the microscope, using blue methylene as a dye to enhance visibility of the fibres, inside and out, and any change in size, shape, constitution and visible flexibility noted. To measure the flexibility another "Morphology" device was used.

From left to right:

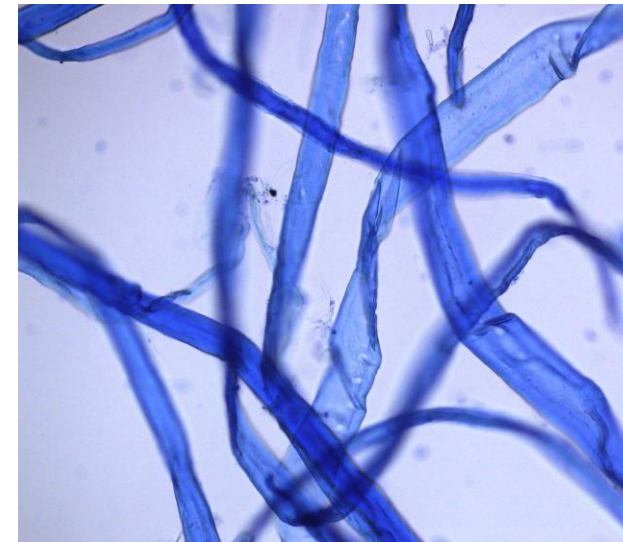
Fibre 1A in tap water ph6 (x20)



Fibre 1A in alkali (soda) ph8 (x20)



Fibre 1A part fermented (x20)



THE RESULT:

As stated in literature on the matter²³, cellulose fibres (which is a term that refers to all plant fibre material²⁴) will inflate when exposed to an alkaline environment.

Comparing the fibres under the microscope did not show this effect in all fibres, but in some (see pictures on p.82). It needs to be said that raising the pH level to only pH8 is not a lot and unlikely to show big changes, so having been able to witness a swelling in at least a couple of samples is already an indicator. The pictures below right show the fibre sample 1A (long softwood fibre, chemically sourced) with an average width of 38µm, whereas at the same resolution (x20) the fibre in an alkaline (pH8) environment measure an average of 43 µm.

Most natural cellulose fibre differs from synthetic fibre in that it has an internal void, i.e. like a pipe or tube. If, as the results suggest, an exposure to an alkaline environment causes (some of) the fibre to expand, one might be inclined to assume that it could be possible that fermentation may have a similar effect by relaxing the fibre structure and if the fibre is left in the wet clay paste for long enough, the clay may wander inside the fibre too. This may then result in greater stiffness of the sample but also in better connection of fibre to clay, and, with respect to use in clay wallpaper, reduce damage in manipulation. Should this void be inflatable to a size that the clay particles can easily enter this space, the surface available to link the fibre with the clay would almost double

As a second possibility, it should be investigated further if fermentation, as suggested in the experiments, makes fibre more flexible, this could also encourage greater flexibility of the product after drying, if this flexibility could be maintained.

As far as the fermented version of a fibre however is concerned, I was informed by the paper technologist I was working with, that in general fermentation does not change the fibre structure it just makes it less resistant in further manipulation. Which in most cases is a considerable change, since the fibres are seldom used the way they are, but manipulated further to become a product. A second fact to bear in mind is that lacto-bacterial fermentation is a process that takes place in a slightly acidic environment, albeit, forming some polysaccharides, which is only possible in alkaline conditions.²⁵

Looking at the pictures on p.82, the third picture indeed does not show a change in surface structure, bending or breaking radii, torn or inflated parts. More interestingly though, testing the humidity intake of natural fibre and then comparing it to the humidity intake capacity of a sample of the same set of 10 different fibres that have been left to ferment for a 5 weeks in cabbage juice containing lactose bacteria, shows that the intake generally decreases for most fibres. The theory of the increased clay intake has to be tested again, since the above suggests the opposite is the case.

These above insights give rise to yet more incentives to conduct further tests, in that the fibre could be added into the clay using an alkaline mixing water, and then left to stand for an extended time, in order to better distribute the clay around and inside the fibres as well as encouraging the beginning fermentation of the fibre, to hopefully result in a more flexible product.

²³ Constituants Fibreux des Pâtes Papiers et Cartons – Pratique de Analyse, Y.Aitken & E Cadel & C. Voillot, 1988 – 1^{ère} edition

²⁴ www.Biologie-lexikon.de/lexikon/cellulose.php

²⁵ <http://www.jbc.org/content/145/1/131.full.pdf> “ The Effect of pH on the Lactic acid Fermentation by I. C. Gunsalus and Charles F. Niven, Jr”, 1942

7 CONCLUSION

THE JOURNEY HAS BEGUN

A lot of practical and theoretical research and experimentation has already been undertaken and all signs seem set to 'go'. But where to? The horizon seems lit up and beckoning, like a landing strip for UFOs. However, this first phase of investigation, as promising as it looks, will need more thought, effort, heart, soul as well as lots of time and also a material commitment to take it that crucial one step further. Before we allow the product to enter onto the market, we should make sure it really works.

In all of the above, I have presented the idea and the ins and outs of the possibilities and options for its production, as well as I have offered an honest take of the current market, and made my case for and against the product in detail, in order for this product to get picked up and developed and finally be put into use.

History seems to suggest that a more liberal interpretation of the product as to its physical attributes, like size and method of application, and its use as well as optics is indeed legitimate.

Physics also speaks in favour of applying even the thinnest coat of clay to any surface of habitable or inhabitable space, in order to enhance both, the well-being of the habitant and the structure.

The results of the **market research** conducted emphasized that there is not just a space for an alternative to the common wallpaper, but moreover that it is actually about time it got an innovative make-over and the idea of wallpaper, opening the doors into activating the walls to perform in a way that answers to the use of the space, was infused with new life. Very encouraging feedback was obtained from trade and labour professionals and potential private users, albeit pointing out demands for high standards regarding the dust-free, reliable quality and ease of application of the product are to be heeded, if it is to be a successful launch.

Existing rules and regulations, do not strictly apply to the product, since it is neither synthetic, toxic nor flammable, nor does it pose problems with health and safety aspects in handling or applying, which suggests a route of pretty plain sailing. New rules and regulations are currently in the pipeline to be released, one for instance, set to certify clay as a fire-proofing material. All of these guides, rules, regulations and certifications seem set to strengthen the argument for applying clay to all walls, in whatever form, also as wallpaper.

The wide but intensive look into how **related trades** historically used to, and currently handle the manufacture, storage and sale of wallpaper or paper based products, has emerged with a picture of what a production line of a clay wallpaper prototype could be comprised of.

With another quick reference to the **history of wallpaper**, the future for a clay based wallpaper seems up for grabs and I am confident that I am not in fact reinventing the wheel, but liberating one that's got stuck in the conceited hyper-design-charged mud of today, with colours blazing and all lights flashing, stripping it of the unnecessary fluff and returning it to roll on into the world as a more useful, maybe even more appealing and definitely more healthy, but all in all, more appropriate to the times version of itself. History holds inspiration not only as far as the format and size of the sheets is concerned and maybe a future product does not have to be 53cm wide and 10m long, just because all the others are. It may just go back to being picture sized pieces, or even random decorative accessories, much like an ecologically safe wall graffiti.

The **results of the first attempts** to produce clay wallpaper at Grains d'Iserre 2017 were extremely good, but the samples were not submitted to the manipulation necessary to roll the material. The matts produced were smooth and not too delicate, which was probably due to the fact that they comprised of multiple layers of mesh.

The **experiences in Estonia** came up with very encouraging if not already sellable samples. The very liberal experiments opened up a new playground for thought on the wide range of jobs that can or should be performed by a clay wallpaper. Just as a reminder, I would like to list again a few ideas, inspired by samples produced in the research phase: a **cushioned wallpaper** that could be interesting with respect to both thermal and acoustic properties, a **leather wallpaper** and one that has a **sheep wool finish** which could give comfort or protection for the wall or the user at a given spot or height, one that was **smoked in beech wood fumes** at 80°C in an Estonian "smoke sauna", which even today (2 years on) dissipates a smell of smoked beech wood, which is a quality that could be useful not just in the world of aroma therapy, but to mask other smells or, and daringly be experimented to trigger bodily reactions to the smell it exudes (anything from soothing lavender to salivating delicious barbeque flavours...) as well as I happened to make a wallpaper that carried a **layer of moss**, which lives off the moisture in the air around it and could well be used to buffer excessive humidity in rooms with special requirements. This list is not exhaustive. This list already helps to realise that there is a much wider field of studies to follow on from this initial research, waiting to be taken on.

The **samples produced at Claytec** may seem limited in relevance because the main focus was put on achieving specific designs that was neither fetching nor representative for the initial idea of an eco-wall finish, as it used a polypropylene mesh. However, a great many viable recipes have been found that would or will work and the results obtained overall made it another very encouraging series of experiments. Being able to hang and remove 1:1 samples from real walls is the kind of test that the product needed to reason for further investigation.

The **private research** into possibilities to streamline production were also promising, if to date not easy to implement. A production line of pasta-makers and steam-mangles does not sound like a viable option.



Finally, a handful of as yet **open doors and loose ends** from the research undertaken to-date, leaves a string of questions yet to answer, incentives to investigate further, with a promise to open yet more doors and maybe eventually facilitate production.

Linnen felt smothered in a fibrous finish on one side, and a more grainy fibrous finish on the back side stuck to a bit of plasterboard, a set-up I would like to test for insulation values, both thermal and acoustic.

MISSING STEPPING STONES

LOOSE ENDS AND OPEN DOORS

As an incentive to continue research on the subject of clay wallpaper, or just as well to encourage to venture into finding derivate alternatives, whichever, I would like to list a few of the various routes that branched out from my path of experimentation but I had no time to look into, as well as those that I simply assumed or didn't get round to verify.

SOME OF THE QUESTIONS THAT AROSE, DIVERSIONS NOT YET EXPLORED MAY BE APPROACHED VARYING INGREDIENTS:

- the only non-fibre ingredients showing slightly promising results with regard to an increased flexibility in the clay, were latex and possibly cottage cheese (0.1% fat). It needs to be said, that the experiments were done using a somewhat un-typical clay, in that it was acidic but had lime content. A range of experiments with more selective additives aimed to increase flexibility in the clay should be repeated with a common clay of good availability and high consistency of ingredients.
- an alternative to latex is the sap of dandelions and other plants with sticky milky sap. Bearing in mind the probably considerably adverse effect on breathability, as well as a potential waterproofing coat of the wall for this kind of mix, this could be looked into further.
- the range of the additives tested was wide but limited. There other additives to influence flexibility and material integrity. I have for instance not fully explored the field of mucilage and fungi, which is experimented with giving promising results at Amsterdam university.
- it may be worth to go back to square one, and monitor with proper tools and testing equipment, the effect of choosing one type of fibre and varying the kinds of clay instead. In the course of this series of experiments it may be worth validating statements by Minke and other experts on the importance of letting a wet mix sit for a short or long while, and at varying temperatures, also varying the agitation routines and times.
- sheep wool has brought up contradictory results, hinting at a whole science to the fibre yet to be explored. Different sheep produce different wool, some have a double some a triple layered coat. One layer may be more suited to the cause than the other? Since most sheep wool is burnt as a waste by-product of the sheep farming industry (because it is too expensive to sanitise to be fit for most uses) this is maybe worth looking into.

OTHER QUESTIONS MAY BE SOLVED BY VARYING METHODS AND TOOLS FOR PRODUCTION:

Apart from the obvious questions of how to set up a production line for at least the most simple of products, including all stages from mixing to packaging and storage, the following may be worth looking at.

- having also tried a variety of chemical agents, like hair conditioner, de-tangler and shoe-cream, to some notable albeit no useful effect. It may be, that the way to deal with or avoid or reverse knotting of fibres can be found in the manner of processing, rather than in the mix?
- how to avoid or stabilise crumbling and friable edges when not using a mesh?
- how to avoid or reverse warped edges in otherwise beautiful finishes?
- samples have not undergone any testing as to their actual humidity absorption capacity, thermal or acoustic insulation, anti-seismic qualities, fire retarding/prooofing nor any other suspected use. So, putting my head on the block, it maybe my recipes could be re-enacted, tested and validated for the use it claims to have.

Other questions may be solved by continuing the series of experiments already started:

- application of samples to other common substrates, like straw or wood fibre boards, lime or gypsum plaster, brick and stone, etc.
- application of samples to particular surfaces with special requirements, for instance as a seismic paper on adobe walls which can then be tested for improved stability on the shaking table at 3SR

Yet other questions may only be solved by waiting for time to pass, unless a scenario can be thought up for speeding up the process:

- will it be necessary to have a best-before-date, or alternatively maintain a certain humidity to avoid breakage or crumbling of wallpaper when unravelled after a certain period of time?
- will wallpaper with a certain fibre content be prone to grow mould if frequently exposed to extreme levels of airborne humidity?
- how durable over time are the bonds that are effected by wetting clay wallpaper in order to stick to a substrate?

If further research is undertaken, do feel free to keep me in the loop!



A clay wallpaper piece was painted with Kefir, and moss and lichen left for a few days sitting on the sample to grow into it. The sample was hung on the wall sprayed for a few days with water, then forgotten about and removed in the course of a general refurbishment two years later, with the moss doing fine whereas the lichen had fallen off.

THE FUTURE IS BRIGHT

“MUNLAB” ITLAY, FRICK HAUS GERMANY

Leaving aside the questions of whether “Clay Wallpaper” is necessary or even possible, as well as the question if the world is ready for it, time is passing and a bright future of whatever we will make it be, is cowering on the horizon, lurking with great intent to launch itself upon us, ready when we are.

Not meaning to be pathetic, but while some might be afraid that the future will be too short-lived to go far with this particular research and all time invested would be lost, I think that for as long as the clock is ticking and there is hope, it is up to us to provide solutions and answers for a future generation to benefit from. So let's get active!

I do want to stress one last time the potential qualities Clay Wallpaper bears. It is more than a product that happens to be made of natural materials only, it :

- is an alternative that will facilitate introducing clay as a conveniently flexible and thin wall covering into households that may otherwise not have the incentive or possibility to turn to a more ecological life-style and enjoy the benefits from it.
- can be stuck to a large variety of surfaces (to be confirmed) using no more than water
- can be tweaked to suit any cultural (design)
- can be tweaked to suit any functional use
- can be home-made to own design
- dries quicker than any other wall finish
- can be applied by non-professionals
- can be applied using only water (cellulose glue inhibits breathability of walls)
- (some) can be removed and re-applied elsewhere
- can be removed and disposed of as organic waste

and with that, this product warrants further research than development of yet another wallpaper-as-we-know-it would warrant.

Going back to those ominous questions at the outset however, I have to admit that it looks like there may be no perceived “need” for the product in the Western World, but there is evidence that there is a “want”, and following the experts' advice and predictions on the climate change ahead, we should be trying all options.

The “want” is also detectable from the enquiries as to when the product would be available and how much it would cost, by private persons, as well as companies that produce prefab eco-houses. Is it therefore a moral imperative to continue to develop the product, if not for them, then for people to be able to benefit from earth finishes on their walls, while sticking it out, living in the concrete construction sins of the past?

In order to get the interest and maybe even funding for further research sorted, a little bit of publicity may be of help and I am very pleased to be able to say that Clay Wallpaper (ClayPer) will be hung in a show-house that is currently being built in southern Germany, in which only purist ecological material and detailing is applied. It will be a platform to shout from, monitored by no less than three universities who will be doing tests on air quality and other aspects of the internal environment in this house. With at least three rooms (basement, ground floor and attic) looking to be finished in three types of wallpaper, I am confident the word will get out and about.

Before this happens, there is yet another possibility for development in the pipeline. I have had an invitation by MUNLAB, Italy, to join them in experimenting with a choice of Italian clays, as a part of one of their projects, working alongside and with Architect Antonio Salvatore, in Turin. The dates and details are yet to be discussed, but the session is proposed for this autumn.

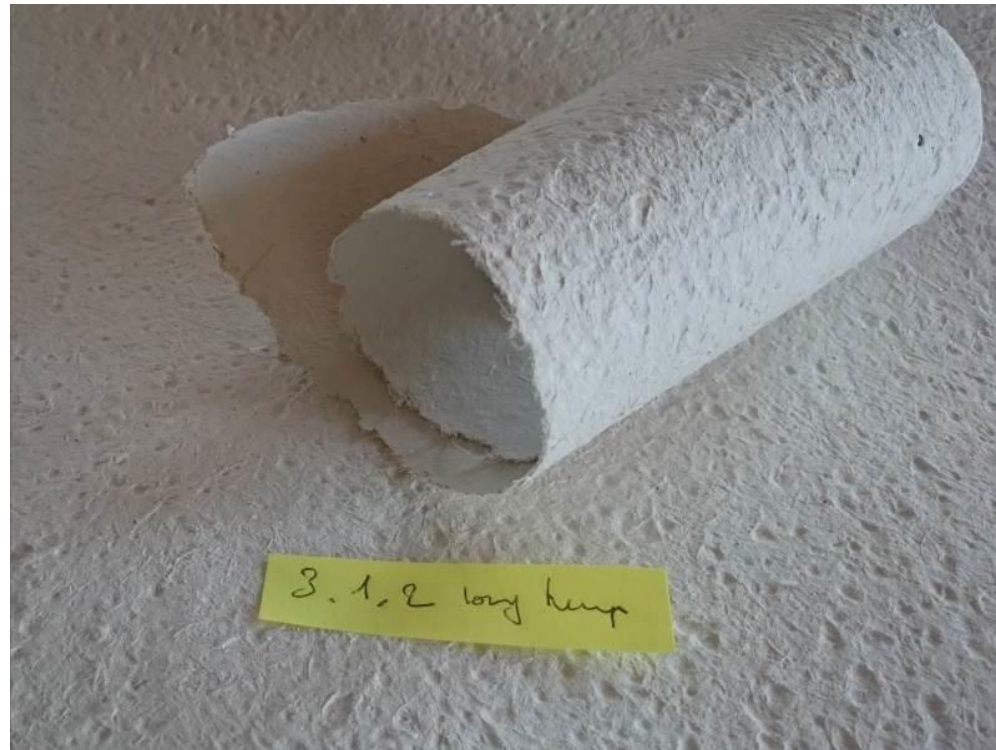
Having had experience with material and market in Estonia, Germany and soon also Italy, I am confident that others will pick up the lead. As one last thought I might ask anyone inclined to pick up the baton from here, to restrain from putting a stop to the development of ecologically sane and safe products by putting a patent of one sort or another on it.

Please feel free to hop on the band wagon and do the research, but let's keep it open-source, free to share and benefit from for all.



Sample prepared in September 2017 at Saviukumaja

...there is still lots to do, and I can't wait to get going...



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- "Paperclay" The new Ceramics, Rosette Gault, ISBN 978-1-4081-3120-6
Checking how, by using the same ingredients the exact opposite is achieved. A sturdy unbreakable, solid piece of art.
- "Ogres & Terres" Recettes et Applications, ISBN 978-2-7449-1023-4
Inspiration for what agents to use to achieve what effect in clay, however most agents recommended, render the clay less breathable.
- "Lehm- und Kalkputze" von Irmela Fromme und Uta Herz
- (ökobuch Verlag)
General and specific information about mixing and application methods, but no information about e.g. how flexibility in thin coats can be achieved.

USB (see attached to front cover of mémoire)

- Full test results of all work stints
- Pictures giving an overview of how the work was done and what the samples looked like for Saviukumaja and Claytec based internships
- Videos showing the removals of the samples stuck to plasterboard and concrete
- Technical Data Sheets for Claytec Products used (German version only)
- The article „Auswirkung von Lehmbaustoffen auf die Raumluftfeuchte“ by Wulf Eckermann and Christof Ziegert (German version only)

ANNEXE

A choice of pictures (on the following pages)

Phase 1 - saviukumaja

- 01_saviukumaja_Grains d'Iserre 2017
- 02_saviukumaja_Testing Clays a
- 03_saviukumaja_Testing Clays b
- 04_saviukumaja_Samples with and without mesh
- 05_saviukumaja_testing additives and application methods
- 06_saviukumaja_Testing additives and initial water resistance
- 07_saviukumaja_Testing various fibres
- 08_saviukumaja_Testing various Clays
- 09_saviukumaja_Testing flexibility of samples
- 10_saviukumaja_fun painting with clay
- 11_saviukumaja_finals
- 12_saviukumaja_ECO MESS, Tallinn Estonia, 2017

Phase 2 - Claytec

- 01_Claytec_pure clays
- 02_Claytec_pre-mixed clays
- 03_Claytec_long fibre no mesh
- 04_Claytec_first small samples on wall
- 05_Claytec_pre selection finals 1st work stint
- 06_Claytec_finals 1st work stint
- 07_Claytec_straight and narrow on mesh
- 08_Claytec_straight and narrow rolled
- 09_Claytec_plucked and with holes
- 10_Claytec_plucked and hole samples rolled to 5cm dia
- 11_Claytec_runners up to finals 2nd work stint
- 12_Claytec_finding finals work 2nd stint
- 13_Claytec_semi final 1 on clay paint
- 14_Claytec_semi final 2 on clay paint
- 15_Claytec_semi final 2 off and on new clay paint
- 16_Claytec_final on wall

Positions in grey to be found on USB in front cover of mémoire.

A choice of tables of results (in the attached pouch)

Phase 1 - Saviukumaja

- A - List of Materials
- B - Tests 1 to 4, testing fibre, sand and mesh
- b - Tests with other Estonian clay
- C - Test 5 lipid and glue agents
- D - Test 6 manipulated fibres
- E - Test 7 agents
- F - Test 8 Fibres
- f - Test 8 Fibres comments

Phase 2 – Claytec

- a- 1_Material glossary_Additives description
- b- 1_Material glossary_Clay description
- c- 1_Material glossary_Fibre description
- d- 1_Material glossary_Mesh description
- e- 2_Claytec Wallpaper_Additives tests
- f- 2_Claytec Wallpaper_Clay tests
- g- 2_Claytec Wallpaper_Fibre tests
- h- 3_Tests YOSIMA CAPSIL®_1.1 no mesh
- i- 3_Tests YOSIMA CAPSIL®_1.2 no mesh
- j- 3_Tests YOSIMA CAPSIL®_2 chalk
- k- 3_Tests YOSIMA CAPSIL®_2 fibre
- l- 3_Tests YOSIMA CAPSIL®_2 lime
- m- 3_Tests YOSIMA CAPSIL®_2 mineral grain
- n- 3_Tests YOSIMA CAPSIL®_ glossary
- o- 3_Tests YOSIMA CAPSIL®_ list of best results for finals
- p- 4_Finals _ Recipe choices_Wallpaper Design 1_plucked
- q- 4_Finals _ Recipe choices_Wallpaper Design 2_mineral
- r- 4_Finals _ Recipe choices_Wallpaper Design 3_mesh
- s- 4_Finals _ Wallpaper Design 1
- t- 4_Finals _ Wallpaper Design 2
- u- 4_Finals _ Wallpaper Design 3