

ECO CLAY THERMAL BUILDING BOARD

ROOM CLIMATE

Introduction into the relevance for comfort

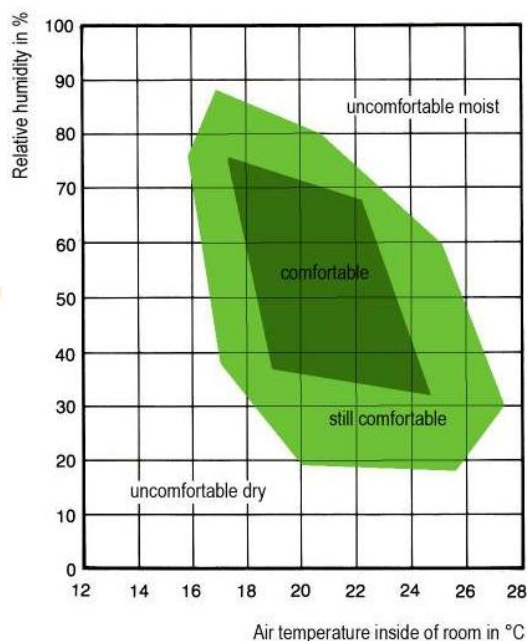
Fundamental studies of thermal comfort, such as acceptable ranges of dry-bulb temperatures, relative humidity, and activity levels were completed in Germany in the 1970s. Some key findings were that not everyone will be satisfied by a particular set of indoor environmental conditions, but in ranges of conditions about 80% express satisfaction. If very good conditions are in place, a maximum of 95% of all persons might be satisfied. Statistical methods were used to evaluate the thermal comfort opinions of the many test persons to yield what are known as the *comfort conditions*; the *predicted mean vote* (PMV) was one of the measures used.

The reason for the diversity of the experience of comfort is the diversity of the influences. They were found to consist of physical influences (relative humidity, air temperature, surface temperature/ radiation, draft/ air movement, clothing, activity), additional influences (adaptive state towards climate, season of year, gender, age, ethnical influences, constitution, alimentation), secondary and guessed influences (air pressure, composition of air, ionization of air, acoustical influences, optical influences, psychological influences).

Of these influences the physical ones were found to be dominating. That is the conditions inside of a room can be described by:

- Air temperature
- Surface temperature
- Air movement
- Humidity

Humidity therefore is an important factor for the human experience of comfort. That is materials that influence the humidity of the air inside a room by sorption processes influence comfort as well. Graph 1 shows, that under the conditions of 20°C the area of comfort (concerning relative humidity) is relatively large. From 37% (860 Pa) to 71% (1600 Pa) 95% of the people questioned stated that they feel comfortable. From 20% (470 Pa) to



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37% (860 Pa) and from 71% (1600 Pa) to 82% (1920 Pa) anyhow 80% of the people questioned stated feeling comfortable.

The more extreme the temperature, the more narrow the comfortable realm becomes. At 26°C no conditions can be found that satisfies 95% of the people questioned. The field under which 80% of the people questioned express comfort narrows down to 20% (680 Pa) to 40% (1350 Pa). It can be argued that the influence of humidity becomes increasingly more important the more extreme the temperature gets. It has to be noted that there is no direct relation of absolute humidity and comfort – the relevant factors are a complex interchange of relative humidity, temperature, radiation and draft.

In regard to designing a comfortable indoor climate the usage of sorption active materials becomes increasingly more important. They are needed to buffer the humidity the inhabitants produce in summer (as this would create an uncomfortably moist climate very fast) and give off stored humidity when it is cold. Being able to choose the best material for certain climate conditions demands solid data on the sorption characteristics of the available materials. As this data is not available, especially not for climate conditions like very hot or cold temperatures, a test was set up designed to measure several promising materials by the University Hannover Germany in 2005.

Another important aspect is the interchange of comfort and building physics, as condensation has to be prevented in order to prevent the development of mould. Recent experiences with tight building solutions speak in favour of the more traditional materials as well. The sorption capacity of these materials seems to counter most of the problems that come with these concepts.



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CLAY CONSTRUCTION BOARD

Short Description

Interior (dry wall) construction board made of clay and coconut fibres reinforcement. The clay board has a positive effect on the room climate such as moisture absorption, vapour diffusion, odour-binding, heat storage capacity, and shielding of high-frequency electromagnetic radiation. Clay construction boards are the professional and healthy alternative to the standard gypsum plaster board. 22 mm boards can be used instead of conventional gypsum boards as interior wall mounting on timber constructions or dry un-rendered walls, as partition walls and wall boarding. They are also suitable for droops and ceilings with strengthened substructures and for attic constructions. 14 mm boards can be used as additional interior wall cover on top of OSB boards or gypsum boards, e.g. for building renovation.



Application

The clay boards can be easily cut to size with a compass saw or circular saw and broken. The clay boards should be installed by two people. Wearing a protection against dust is recommended.



22 mm board

On vertical construction, the 22 mm clay board should be fixed with screws only. Each board with up to 9 anodized screws or stainless steel screws, 3.5 mm x 45 mm onto the supporting construction. On ceilings and underroof construction, up to 15 screws are applied using an additional under-laid metal washer. The screws should be fixed until they are even with the clay board surface (sinking of the screw into the clay board of 1 to 2 mm is acceptable). For installation of clay boards in bath rooms and laundries, the screws should be corrosion-free (galvanized screws are not sufficient in this case).



14 mm board

On massive construction (brick or concrete walls), 14 mm clay boards can be applied directly to the wall with clay surface plaster or mortar used as adhesive. On OSB boards or gypsum boards, the 14 mm clay board is fixed with screws. The 14 mm board is flexible within a radius of 1.50 metres or more. Even when flexed the clay board does not need any fixing other than screw.

Surface finishing



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The boards need to be lightly watered. Afterwards an armouring soaked in thinned fine clay plaster is applied on the whole surface. On top of the armouring another layer (3-5mm) of fine clay plaster is applied to equalize the surface after 2-3 days drying time the surface is ready for painting. Recommended is VOLVOX Clay Décor as it has the same physical qualities of clay itself. If other paints are used they must be permeable to vapour more than 95%.



Technical data

- Weight: 29 kg/m² (22 mm board), 17 kg/m² (14 mm board)
- Specific weight: 1200 kg/m³
- Compression strength: > 2.5 N/mm²
- Thermal conductivity: 0.47 lambda W/mK
- Tolerated deviation in length and width: 2-3 mm
- Building Material Category: A1

Storage

On a dry place, the clay boards can be stored without time limit. Always store horizontal, not upright or leaned against a wall.



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Clay Construction Board Test

Introduction

The following description is a summary of the research at Hannover University as part of the development of climate tailored building design. Goal of the research is to enable energy saving and healthy living by specifically designing construction systems and shapes for a specific climate. The research aims for a synergy of traditional knowledge, local materials, up to date building physics and design. One of the key focuses of the research is central Japan as an example for a very hot humid summer climate. The measuring of sorption performance was conducted in cooperation with the company Made in Clay. The company produces, among other ecological products, several types of innovative soil panels and already has experience values with several projects in Asia.

Basic terms of sorption processes

Sorption refers to the action of either absorption or adsorption. As such it is the effect of gases or liquids being incorporated into a material of a different state and adhering to the surface of another molecule. Absorption is the incorporation of a substance in one state into another of a different state (e.g., liquids being absorbed by a solid or gases being absorbed by water). Adsorption is the physical adherence or bonding of ions and molecules onto the surface of another molecule. Simplified absorption is a chemical process, while adsorption is a physical one.

Absorption, in chemistry, is a physical or chemical phenomenon or a process in which atoms, molecules, or ions enter some bulk phase - gas, liquid or solid material. This is a different process from adsorption, since the molecules are taken up by the volume, not by surface.

Adsorption is a process that occurs when a gas or liquid solute accumulates on the surface of a solid or, more rarely, a liquid (adsorbent), forming a molecular or atomic film (the adsorbent). It is different from absorption, in which a substance diffuses into a liquid or solid to form a solution. The term sorption encompasses both processes, while desorption is the reverse process. Adsorption is operative in most natural physical, biological, and chemical systems, and is widely used in industrial applications such as activated charcoal, synthetic resins and water purification. Adsorption, ion exchange and chromatography are sorption processes in which certain adsorptive are selectively transferred from the fluid phase to the surface of insoluble, rigid particles suspended in a vessel or packed in a column. Similar to surface tension, adsorption is a consequence of surface energy. In a bulk material, all the bonding requirements (be they ionic, covalent or metallic) of the constituent atoms of the material are filled. But atoms on the (clean) surface experience a bond deficiency, because they are not wholly surrounded by other atoms. Thus it is energetically favourable for them to bond with whatever happens to be available. The exact nature of the bonding depends



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on the details of the species involved, but the adsorbed material is generally classified as exhibiting physisorption or chemisorptions.

The test procedure

The tests measured the sorption characteristics of several materials. Every test consists of several sharp changes between 45% of relative humidity and 80% of relative humidity under a defined temperature (20°C, 30°C and 35°C). Every change of humidity lasted 8 hours. Small probes of all materials (20cm x 20cm x height) were created. All of them were sealed on five sides, as to measure the sorption process in relation to the surface (20cm x 20cm). Polysiloxane was used to seal the templates on a plexiglass panel. A raw probe of plexiglass was evaluated under the same conditions in order to eliminate influences by sorption of the sealing materials. The influence was found to be less than 1% in all cases. Before the test all probes were put in the climate chamber under the starting conditions (45% of relative humidity) in order to reach their basic level of humidity. The testing started after no further change in weight was



Picture 1: Probes in Container



Picture 2: the different soil panels

As the climate chamber takes about 10 minutes to change the conditions, the probes were stored in a container with a saturated salt-water mixture that created the matching conditions inside during these 1---0 minutes. Two containers were used – one for 45% of humidity and one for 80%, both were inside the climate chamber. The only difference between the time in the container and the time outside of the container was the amount of air stream (near zero within and high outside). The humidity inside and outside of the container was measured – no change greater than 2% occurred during the 20°C tests and no change greater than 3% occurred during the 30°C tests at any time. After the climate chamber changed the conditions the containers were opened, so to create a sharp change of conditions from one second to the other.



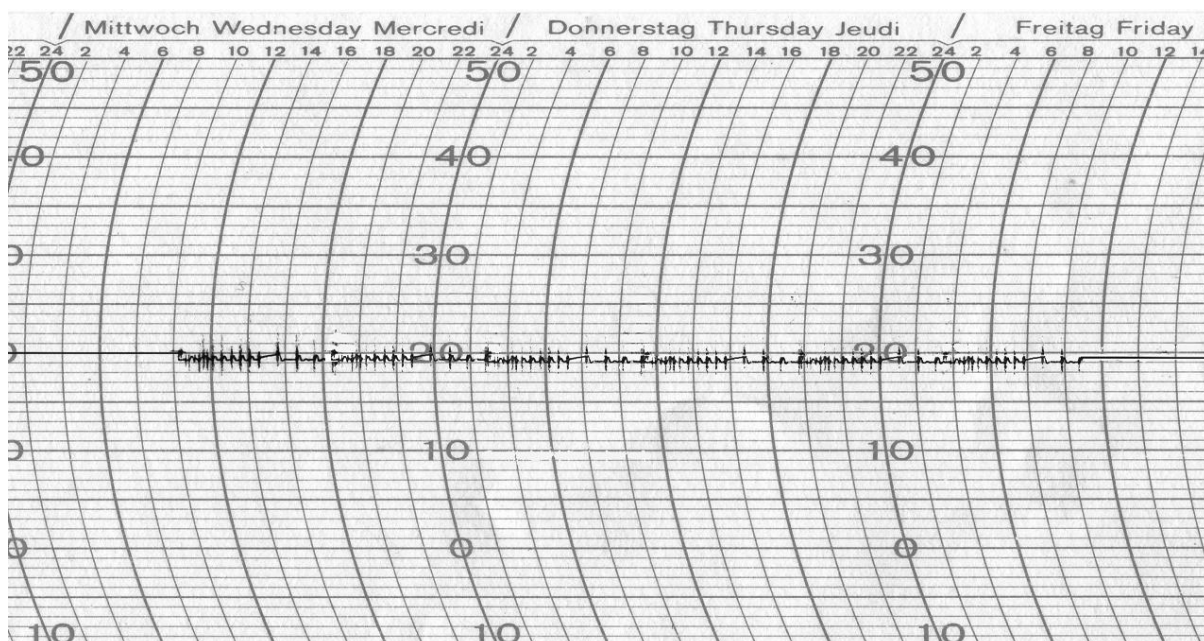
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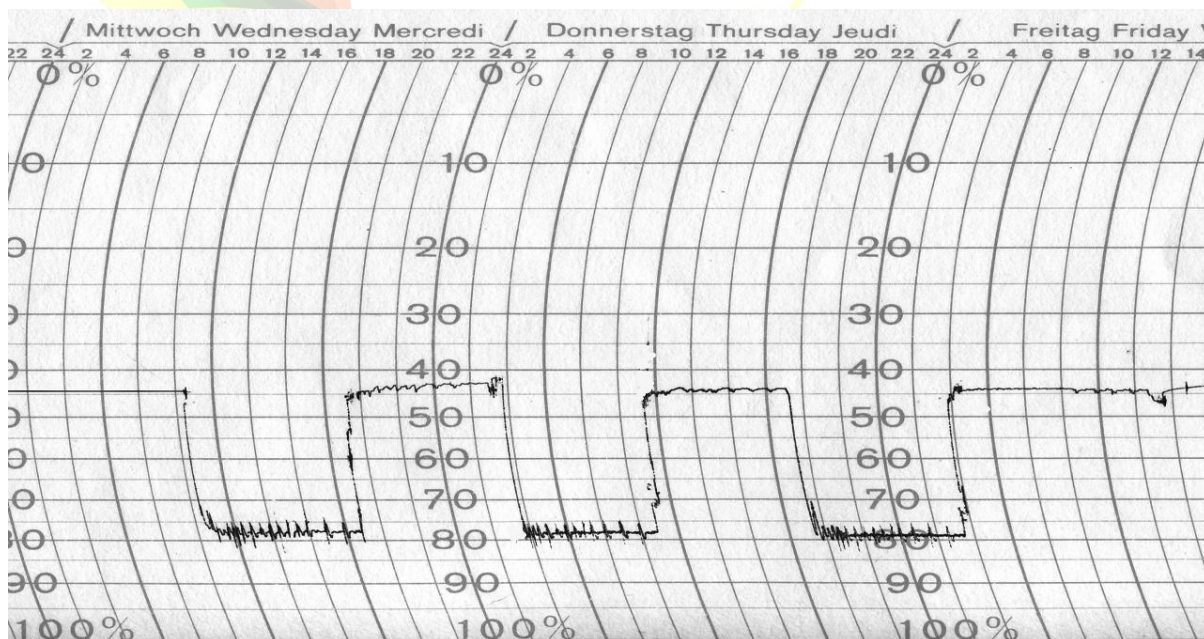
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The graphs 2 and 3 show the temperature and the humidity inside the chamber as supervised during the tests. The precision of the test is within the guidelines of the respective laws.



Graph 2: temperature during 20° test of soil panels



Graph 3: humidity during 20°C test of soil panels



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To qualify the sorption of the materials they were weighted. Gathering of data was conducted after 15, 30, 45, 60, 75, 90, 120, 150, 180, 210, 240, 300, 360, 420 and 480 minutes of each change. As the air stream inside the chamber would have influenced the data/ weight, the chamber was turned off for about one minute for weighting – again the condition did not change more than 2%.

To guaranty the proper working/ adjustment of the sensors, an unrelated probe was measured before and after the test – both times the weight was within 0,02 %. The probes of the first series of tests consisted of 4 soil probes (with different compositions and finishes), 2 OSB probes (one painted the other raw) and 2 plasterboard probes (one painted the other raw). (Photos are attached as well).

Results

The graphs show the sorption of water per m² over time in gram over three intervals of a total of 2880 minutes.



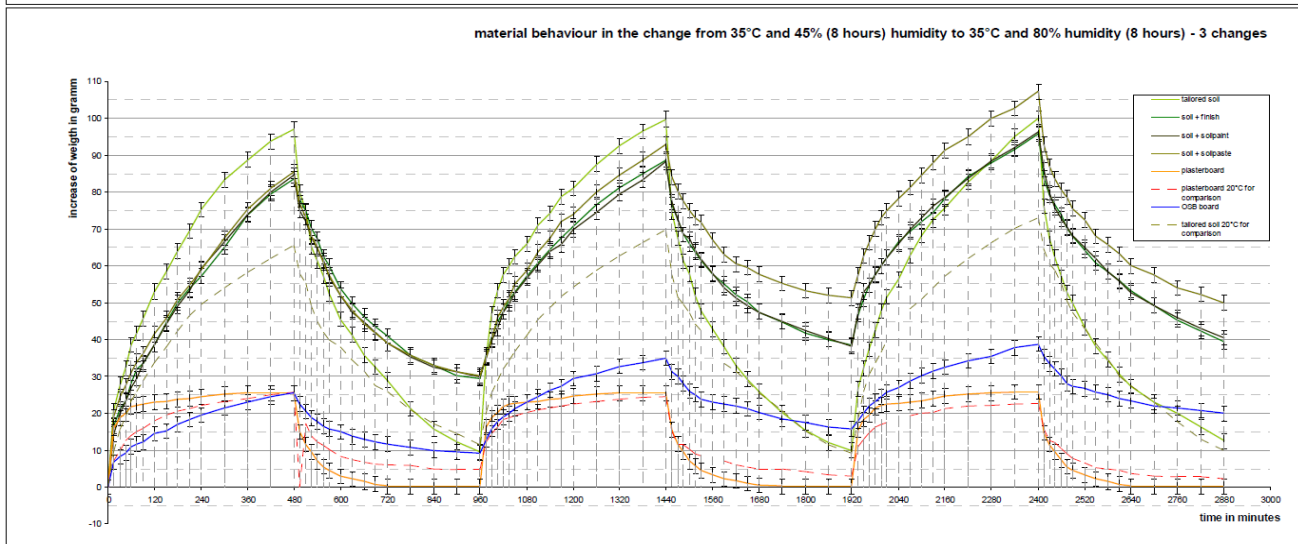
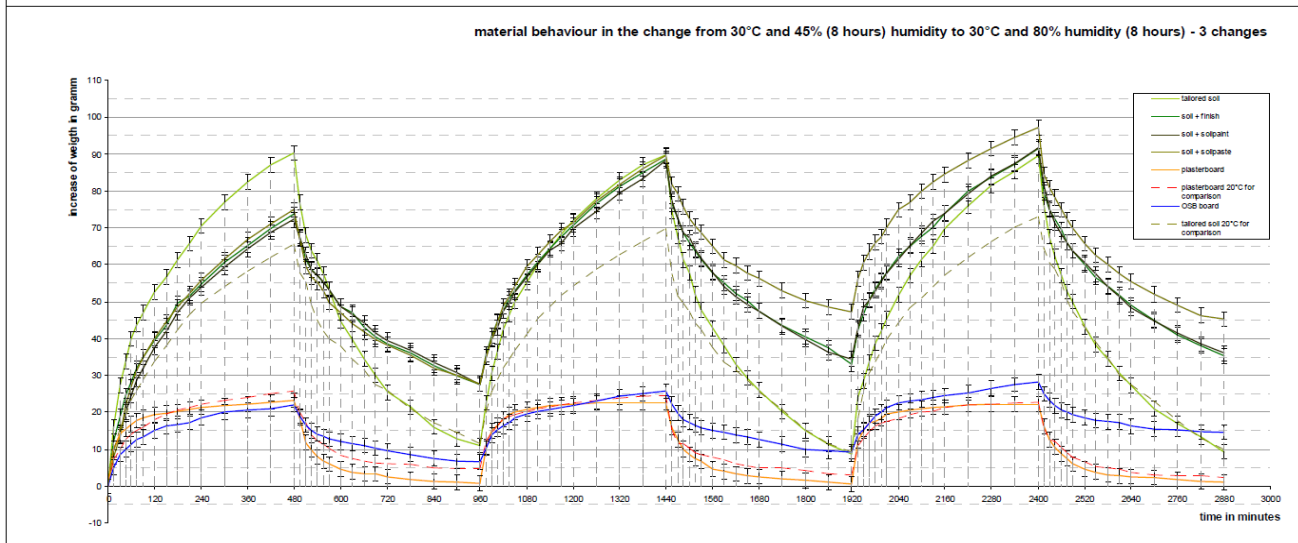
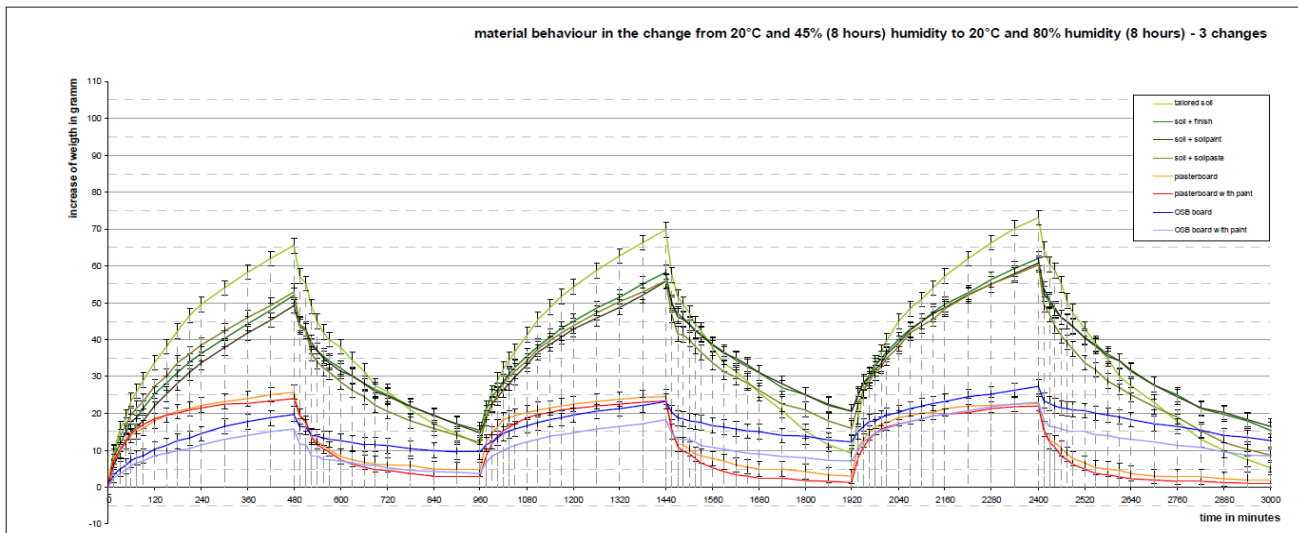
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Water vapour pressure is seen to be an important factor for the speed of sorption processes in the materials tested. The following lists the data for the materials tested for 30 minutes, 120 minutes, 240 minutes and 480 minutes (weight gain n gram per m²) - (WVPPD = water vapour partial pressure difference) – for the first period of the sorption process.

Material	20°C (WVPPD =820pa)				30°C (WVPPD = 1390pa)				35°C (WVPPD =			
	30	120	240	480	30	120	240	480	30	120	240	480
Soil					27,25	52,5	70,5	90,25				
tailored	15,75	33,75	49,5	65,5					27,75	53	75,25	97
Soil					13,75	37,5	53,75	72,25				
+ soilpaint	9,75	22	33,75	49,25					20	38,5	59,25	84,5
Soil					18,75	39,5	54,75	73,75				
+ soilfinish	11,75	25,25	36,25	52					21,25	38,5	57,25	83,5
Soil					13,5	40	55,75	75				
+ soilpaste	13,75	27,25	38,5	53					24,5	41,5	59	85,5
OSB					15,75	33,75	49,5	65,5				
+ paint	3,75	8,5	11,5	15,75					15,75	33,75	49,5	65,5
OSB					8,5	15	18,5	22				
raw	5	10,25	14,5	19,75					8,25	14,5	19,5	25,5
Plasterboard					10	18	22,25	25,75				
	10,25	18,5	21,5	24					10	18	22,25	25,75
Plasterboard + paint	10	18	22,25	25,75	14,25	19,25	21,25	23,25	18,75	23	24,5	25,5

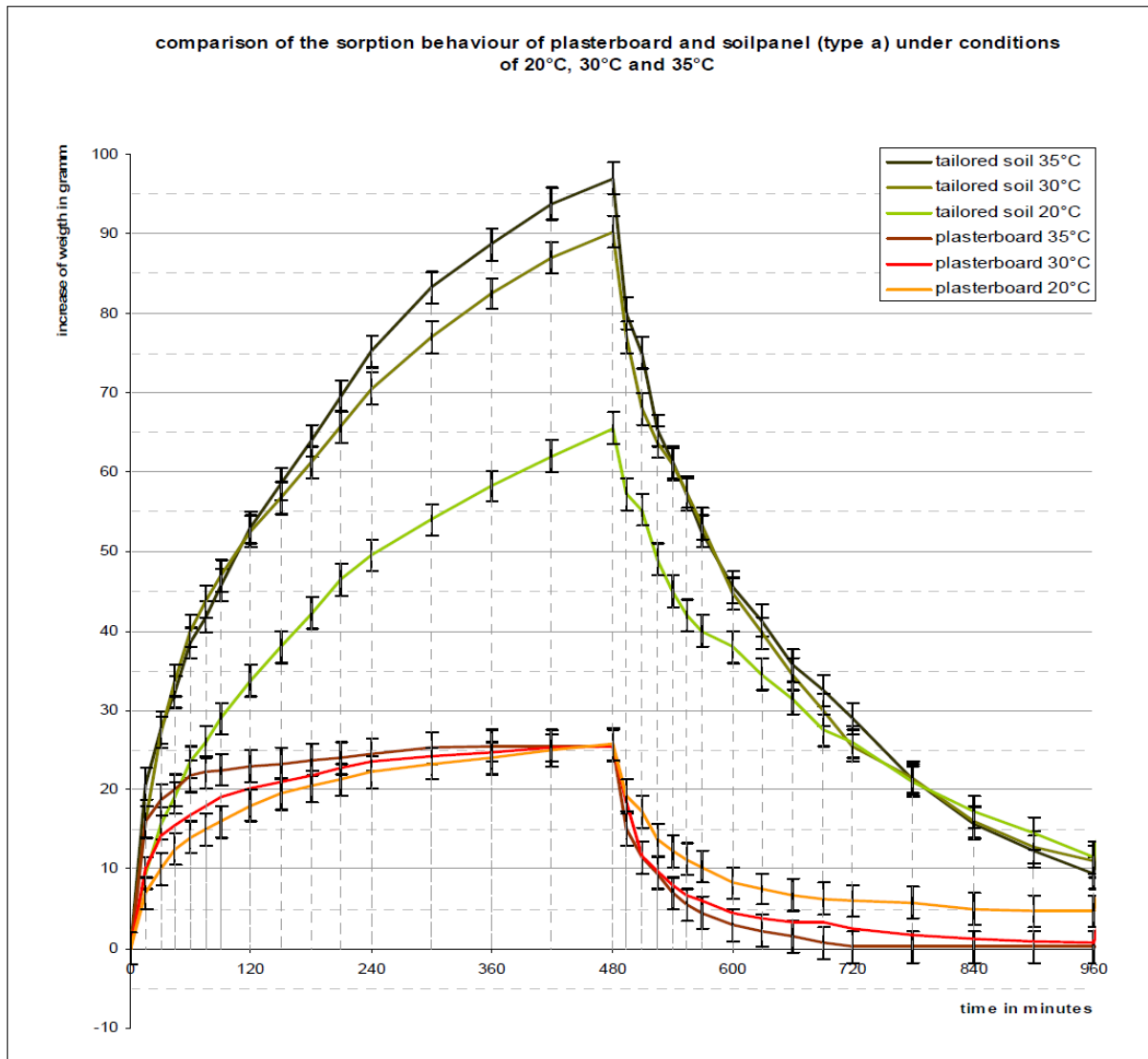


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- No linear relationship between absolute humidity and the absolute sorption capacity can be seen as the sorption capacity is capped. The capacity is limited mainly by the relative humidity. Although pressure and temperature are relevant factors, their influence is nearly negligible at 45% and still small at 80%. In regard to the comfort conditions aimed for in buildings this further strengthens the demand for larger sorption capacities in hot humid climates.
- Analysis of the sorption speed strengthens the assumption that plasterboards exhibit mainly physical sorption while soil exhibits both chemisorptions and physisorption. This is seen as one of the key reasons for the high sorption activity of soil. Chemisorptions activity of soil however depends to a great extent on the composition of the soil. Accurate prediction of Chemisorptions therefore relies on an exact knowledge of the individual components of the soil used.



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- As the materials tested give off humidity slower than they absorb and adsorb it, the material gains weight with every full interval. Over time this reduces the sorption capacity of each material down to what they can give off during the low relative humidity interval. This clearly shows the need of all materials for desorption phases in order to prevent mould due to high humidity.
- The capacity of water sorption is far higher with the soil probes than with the other tested material. In the used intervals of 8 hours of sorption and desorption soil is 3 to 4 times more active than plasterboards or OSB panels.
- . The speed of the sorption process is far higher with soil than with the other tested materials. This is especially true after the first hour of the sorption process. The reason for this is partly the physisorption on the surface that does not seem to differ as much as other factors, as well as the bigger sorption capacity of soil. While plasterboards reach their maximum capacity after about 2 to 3 hours soil has not reached the maximum capacity after 8 hours under any temperature
- The speed of the sorption is greatly affected by the temperature. All materials reach their respective levels of humidity balance faster the greater the water vapour partial pressure difference is. Again this can be seen as a clear demand for more sorption active materials in hot climates, as the materials such as OSB panels or plasterboards can not provide solid sorption values after the first hours.
- The different soil panels, though all tailored to the Japanese climate, exhibit a range of sorption speed and capacity. The composition of the soil as well as surface structure and production process can be seen to be clearly relevant to the sorption behaviour. By combining the evaluated sorption data of the tested materials with their basic level of humidity the change in the absolute humidity levels was calculated. The graph 5 shows the absolute values of the 35°C test (see above).

By combining the evaluated sorption data of the tested materials with their basic level of humidity the change in the absolute humidity levels was calculated. The graph 5 shows the absolute values of the 35°C test (see above).

The graph shows clearly that plasterboards have a high level of inert humidity under normal room conditions. However this humidity cannot be activated by desorption under normal conditions. In regard to their absolute humidity the change caused by a change of the room conditions is minimal.

Second are the OSB- boards that, on a far lower level show the same characteristics. By far the lowest absolute humidity is measured in the soil panels, in combination with the greatest activity in regard to sorption and desorption. The low level of absolute humidity can even be felt as a surface characteristic in the course of the testing procedure. While the soil probes remain dry to the touch under all conditions, a wet, damp impression can be experienced especially on the surface of the plasterboard probes.

The high level of absolute humidity in some of the probes is deemed to be one of the reasons for the development of mould especially in connection to these materials. The limited capacity of sorption in connection with the high inert level of humidity presents a problem especially under hot humid conditions in combination with sharp temperature changes.

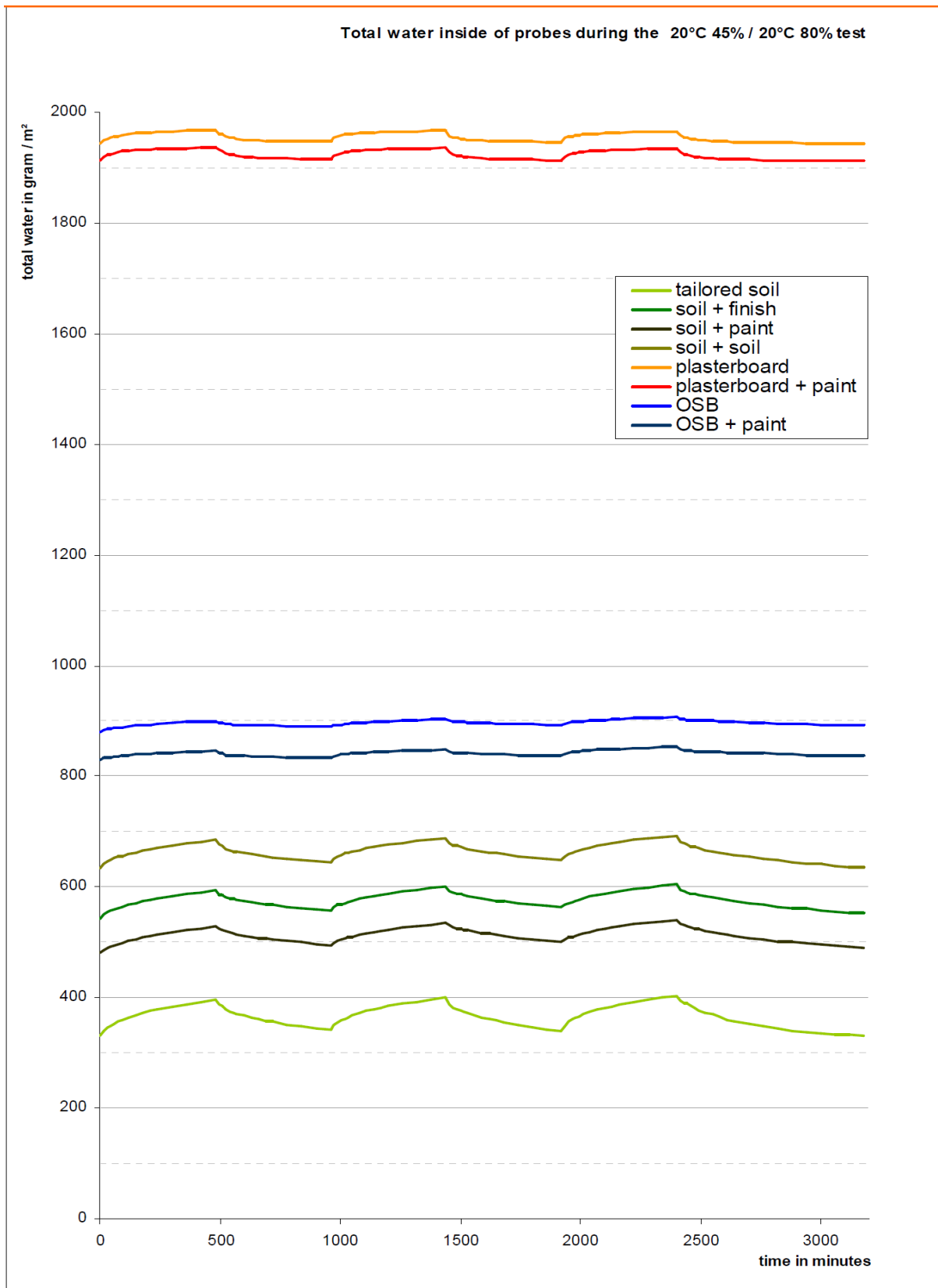


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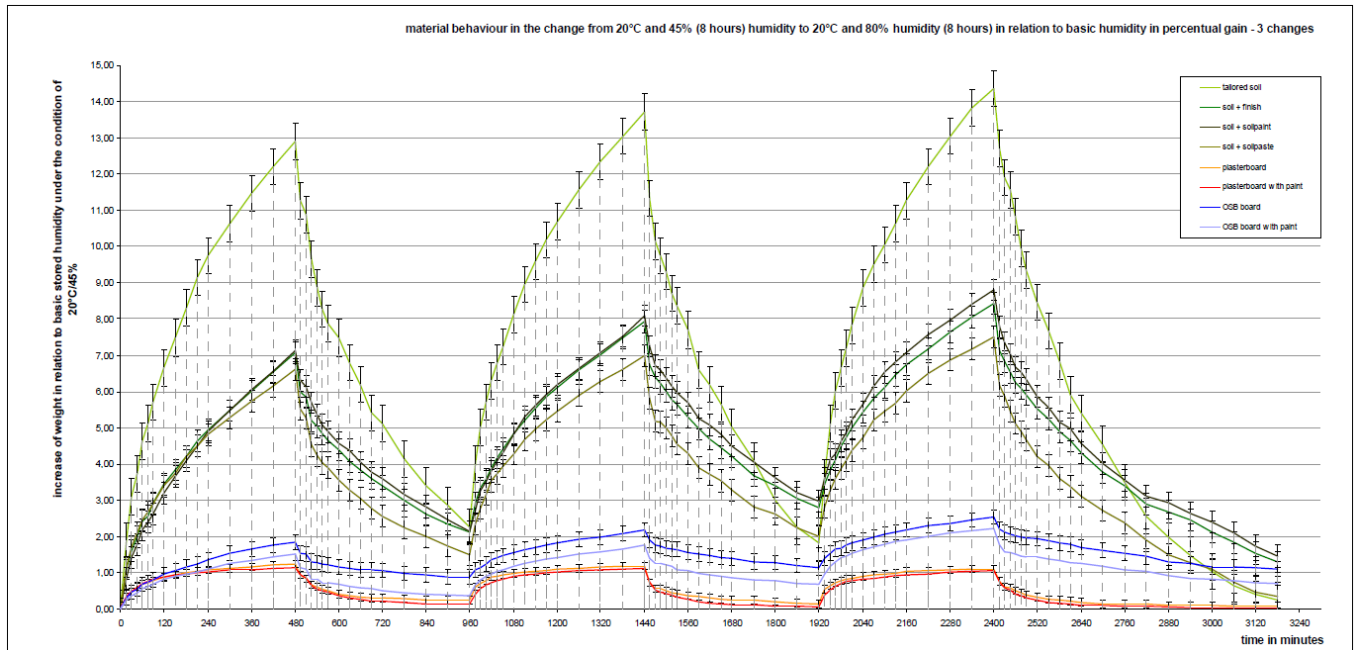


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Graph 9: percentage change of water inside of probes during the 20°C test

Relevance of the results

Obviously some materials are more suited to certain defined climate conditions than others. In case of a hot humid summer climate the usage of soil as a sorption active material can be seen as a good choice. A strong point for this is the traditional usage of soil in these areas despite the abundance of other available materials. The research strengthens the assumption that the experience values of traditional craftsmen created a rather efficient building within the available possibilities.

As soil is seen to provide a range of sorption characteristics based on the composition and the surface structure solid knowledge on the working of the involved mechanisms is needed to put the material to optimal performance though.

The sorption activity of the plates tested is well within the range to prevent the development of mould even under problematic circumstances. However, wrong constructive systems cannot be made working just using soil. This is especially true concerning the water vapour diffusion streams inside of the walls.

The exact tailoring, also taking into account condensation and water storage inside of the pores will be the topic of further research.



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