CZECH TECHNICAL UNIVERSITY IN PRAGUE

FACULTY OF CIVIL ENGINEERING

BACHELOR'S THESIS

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BACHELOR´S THESIS ASSIGNMENT FORM

I. PERSONAL AND STUDY DATA

Surname: Maidanova Name: Assel Personal number: 463716

Assigning Department: Department of materials engineering and chemistry

Study programme: Civil engineering

Study branch/spec.: Building structure

II. BACHELOR THESIS DATA

Bachelor Thesis (BT) title: Charakterizace vybraných vlastností desek se zvýšenou protipožární odolností

Bachelor Thesis title in English: Evaluation of selected properties of boards with increased fire resistance

Instructions for writing the thesis:
The aim of the work:
The main goal of the bachelor's thesis is to evaluate the effect of the fire protection layer on the surface of building boards. The sub-goals primarily include the analysis of individual parameters affecting the properties of the surface layer.
Methodology:
Based on literature research and evaluation of the most suitable types of board materials for experimental measurements, test samples will be prepared. The testing will take place in laboratory conditions and under increased humidity. The evaluation will be made on the basis of the experiments carried out.

List of recommended literature:
1. Just, A., Schmid, J. and König, J., 2010. Gypsum plasterboards used as fire protection-Analysis of a database.
2. Alfawakhiri, F., Sultan, M.A. and MacKinnon, D.H., 1999. Fire resistance of loadbearing steel-stud wall protected with gypsum board: a review. Fire technology, 35(4), pp.308-335.
3. Rahmanian, I., 2011. Thermal and mechanical properties of gypsum boards and their influences on fire resistance of gypsum board based systems. The University of Manchester (United Kingdom).
4. Tsantaridis, L.D., Östman, B.A.L. and König, J., 1999. Fire protection of wood by different gypsum plasterboards. Fire and materials, 23(1), pp.45-48.

Name of Bachelor Thesis Supervisor: Assoc. Prof. Martin Böhm

BT assignment date: October 31, 2022 BT submission date in IS KOS: January 31, 2023

see the schedule of the current acad. year

BT Supervisor's signature Head of Department's signature

III. ASSIGNMENT RECEIPT

I declare that I am obliged to write the Bachelor Thesis on my own, without anyone's assistance, except for provided consultations. The list of references, other sources and consultants' names must be stated in the Bachelor Thesis and in referencing I must abide by the CTU methodological manual "How to Write University Final Theses" and the CTU methodological instruction "On the Observation of Ethical Principles in the Preparation of University Final Theses".

Assignment receipt date Student's name

Abstract

This bachelor thesis is focused on the evaluation of the properties of the OSB (Oriented Strand Board) board. The evaluation and classification of OSB are based on the determination of sorption isotherms depending on moisture content and relative humidity.

In the practical part, the changes in the properties of two different OSB boards were defined by the sorption isotherm method at a constant temperature, which was carried out by storing them in conditioned boxes with a specified relative humidity. As a result, we recognized which type of Isotherm it was and that at the highest relative humidity (RH) we obtained the highest moisture content.

Another chapter that was considered in this study was the fire resistance of OSB. In the practical part, a single flame source test method was considered, which was carried out according to the requirements of ISO 834 (ISO 11925-2:2020). Results showed the different spread of flame for OSB itself and coated OSB.

It has also considered the impact of a very humid area on OSB, where after being the material in a damp area, there appeared mould. The last objective was an abrasion test which was done by The Taber® Rotary machine to see the abrasion impact on coated and uncoated OSB.

Keywords: Sorption Isotherms, Relative humidity, Gypsum board, OSB, Fire resistance, Abrasion.

Table of content

Declaration

I hereby declare that this thesis represents my own work which has been done after registration for the degree Bc (bachelor) at Czech Technical University in Prague and has not been previously included in a thesis or dissertation submitted to this or any other institution for a degree, diploma, or other qualifications.

I have read the University's current research guidelines and accept responsibility for the conduct of the procedures in accordance with the University's Committee. I have attempted to identify all the risks related to this research that may arise in conducting this research, obtained the relevant ethical and/or safety approval, and acknowledged my obligations and the rights of the participants.

Signature: Assel Maidanova

Date: 09.01.2023

Special thanks…

I would like to express my gratitude to for his lasting support and guidance doc. Ing. Martin Böhm, Ph.D. and my friends for big support.

1. Introduction

The manufacturing of materials has seen a significant transformation in the building industry over time. Materials can now be gained anywhere in the globe through time-consuming and complex extraction and transformation procedures, whereas before something could only acquire locally and with limited extraction and transformation processes. Traditional materials like stone, gypsum, wood, and concrete are still employed, but in recent years, alternative systems embracing materials with lesser environmental impacts have become more common.

2. Aims of the work

In this research, experimental work to measure the moisture storage via the sorption isotherm is combined with hygrothermal modelling and post-processing to determine the effects of relative humidity (RH). It is able to evaluate several properties of the mentioned properties.

- To define the Sorption Isotherm. To see the behaviour of isotherms at a constant temperature with specified relative humidity and moisture content.
- The usage of gypsum board as a fire-resistant material and its methodology.
- Practical work for reducing the abrasion.
- Testing the OSB board in specified humidity to see the result.

3. Literature review

3.1 Plaster

Plaster is a building material that hardens upon drying and is used to coat walls and ceilings for protection or decoration as well as to mould and cast decorative features. In English, "plaster" often refers to a substance used for building interiors, whereas "render" typically refers to a substance used for building exteriors. Another word for this substance is stucco, which is also frequently used to refer to plasterwork that has undergone some kind of process to provide relief embellishment as compared to flat surfaces.

One of the oldest building methods is plastering. Evidence suggests that ancient peoples coated their reed or sapling shelters with mud, creating stronger buildings and better screens against pests and bad weather. Some of the earliest plastering that are still in existence are on par with modern plastering in terms of quality. (Weyer, et all., 2015)

Gypsum, lime, or cement are the key ingredients of the most popular varieties of plaster; nonetheless, they all function similarly. The plaster is produced as a dry powder that is combined with water right before being applied to the surface to create a stiff yet workable paste. The crystallization that results from the interaction with water releases heat, and the hydrated plaster then hardens.

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3.2 Chemistry

Gypsum plaster is calcium sulphate dehydrate ($CaSO_4 2H_2O$) that is researched in several nations and has many uses around the world. Both the natural and burned forms of gypsum have been used. Agriculture and the manufacture of Portland cement both use natural gypsum. Hemihydrates are made from calcined gypsum and are widely used in the construction, ceramics, and medicinal industries. (Singh, et al., 2019).

Compared to supply chains for lime and Portland cement, the gypsum plaster supply chain uses less energy and emits less CO2. Products made of gypsum plaster are inexpensive, have good thermal qualities, and are simple to assemble. Composites made from gypsum plaster have brittle matrixes, though this feature can be improved by adding fibres. The amount of waste produced by the quick setting times of gypsum plaster adds another challenge to its use.

Plaster of Paris is kept in water-proof containers since exposure to moisture can cause the material to hydrate, slow down the setting process, and eventually render it worthless. (Encyclopaedia Britannica, 2020).

Gypsum is created over time when dry plaster powder and water are combined. After mixing, the plaster slurry begins to set approximately 10 minutes later and finishes setting in 45 minutes. Plaster of Paris expands somewhat when it sets, adding a little bit of volume. It is employed in the production of statues, toys, and other casts. Orthorhombic crystals dominate the original matrix, which is the kinetic product. Rhombic crystals gradually disappear during the following 72 hours, and the plaster becomes stronger and harder as a result. Gypsum or plaster that has been heated to a temperature between 266°F and 350°F forms hemihydrate, which can then be combined with water to make new gypsum.

The almost water-free form, known as -anhydrite ($CaSO_4 2H_2O$ where n = 0 to 0.05), is generated when heating to 180 °C (350 °F). Some commercial desiccants take advantage of the fact that anhydrite slowly reacts with water to revert to the dihydrate form. Dead burned plaster, also known as -anhydrite, is created when materials are heated to temperatures above 250 °C (480 °F) (Szostakowski, et al., 2017).

3.3 Gypsum

Gypsum board is one of the most widely used building materials in the world, mostly because of how simple and quick it is to assemble and how versatile and clean it is. It is frequently used in homes, workplaces, hotels, hospitals, and other structures. Additionally, it is employed in the creation of internal partitions, wall linings, and fake ceilings. The gypsum manufacturing enterprises make and prefabricate the boards. Then, they are put together on the spot into a thin, metallic structure. This type of construction, also known as drywall, puts less strain on the existing structures during renovations and offers a higher level of comfort and greater ease of repair and/or modification. (Encyclopaedia Britannica, 2020).

3.4 Gypsum as a fire-resistant component

Gypsum plaster can emit water vapor when it comes into contact with flames, which can operate to stop the spread of the fire for up to two hours, depending on the thickness. Fireproof plasters are currently made with gypsum or cement as the binding agent, with mineral wool or glass fibre added for mechanical strength.

Due to its exceptional fire resistance, gypsum board (GB) is used in light wood frame (LWF) walls as a fire-resistant component; nonetheless, cracking and separation lead to LWF failure because water releases at high temperatures. (Nassif, Yoshitaka, 2014).

Because they significantly lower the structural performance of building components, building fires are a regular occurrence that endangers public safety. Building fire resistance has always been a significant consideration in structural design. One of the most popular building materials in use today is the gypsum board, largely due to how easy and quick it is to assemble, as well as how adaptable and hygienic it is. It is frequently used in hotels, hospitals, businesses, residences, and other buildings. It is also used to construct internal partitions, wall linings, and ceilings. The boards are created and prefabricated by gypsum manufacturing companies. They are then immediately assembled into a thin, metallic framework. Plasters have been used as fireproofing materials for passive fire protection for many decades (Encyclopaedia Britannica, 2020).

Typically, hydrated-calcium sulphate, gypsum, or hydrated-calcium silicate, panels are utilized as the fireproofing components in firebreak systems. Due to its dehydration into hemihydrate and anhydrite, gypsum has high latent heat. Due to the latent heat effect, the gypsum panels exhibit an isothermal stage on the exposed side during fire exposure. Dehydration causes fissures to form inside the panels, and when heat flows through these cracks, the temperature of the exposed side rises. As a result of the loss of bonded water molecules, dehydration causes a significant amount of thermal shrinkage. A silica filler was added to the plaster in this study. The gypsum panels' thermal, physical, and mechanical qualities are altered by this filler, which also lessens the production of fissures. (Cuerrier, 1994).

Gypsum plaster can emit water vapor when it comes into contact with flames, which can operate to stop the spread of the fire for up to two hours, depending on the thickness. Plaster also functions as a heat barrier, preventing steel structural elements from becoming weakened and collapsing during a fire by allowing heat to enter slowly. Early versions of protective plasters often included asbestos fibres, which have since been outlawed in many industrialized nations.

Currently, gypsum or cement are used as the binding agent in fireproof plasters, and mineral wool or glass fibre is added for mechanical strength. To reduce the density of the completed product and improve thermal insulation, vermiculite, polystyrene pellets, or chemical expansion agents are frequently used.

One distinguishes between fireproofing on the inside and the outside. Interior items are often less robust, less expensive, and have lower densities. Products for the exterior must resist more difficult environmental conditions. Inside structures, rough surfaces are usually overlooked since dropped ceilings cover them up. Based on technical merit alone, fireproofing plasters are losing market share to more expensive intumescent and endothermic solutions. Whether the plaster is aesthetic in character or is used for passive fire protection and has trade authority on unionized construction sites in North America remains with the plasterers. Plasters made of cement and gypsum are frequently endothermic. Firestop mortars and fireproofing plasters share many similarities. Because fire-stopping requires such fine detail work, most firestop mortars may be coated and roughed quite well.

Gypsum plasterboards are often utilized because of their non-combustible core and fire resistance. Plasterboards are mostly made of gypsum, which is a naturally occurring non-combustible mineral with the chemical formula CaSO4.2H2O. The core is encased between two layers of paper that are mechanically and chemically connected to form flat sheets. The board has sufficient handling and transit tensile strength thanks to the papers. According to Gonclaves T. and Clancy P. (1996), gypsum is made up of about 21% by weight of chemically bonded water of crystallization and about 79% by weight of calcium sulphate, which is inactive below 1200 C. Depending on the temperature and relative humidity of the environment, gypsum can include up to 4% free water in addition to the water of crystallization. (Thomas G., 2002) This water content -free water and crystallized water are primarily responsible for the gypsum board's fire-retarding properties.

The water content and the water of crystallization is released and evaporated. when the gypsum board is exposed to fire. Dehydration, often known as the loss of water, happens in two stages. Gypsum dihydrate loses some water during the first stage, calcination, to produce gypsum hemihydrate ($CaSO_4\ 1/2H_2O$). (Encyclopaedia Britannica, 2020).

3.4.1 Common Gypsum fire resistance test method

Light gauge steel framed (LSF) wall and floor systems have become more popular over the past 10 years because of the numerous benefits they offer. By preventing the temperature build-up of the load-bearing cold-formed steel (CFS) studs, the gypsum plasterboard frequently acts as the primary fire protection for these light steel frames. Additionally, working with gypsum plasterboard is simpler, it speeds up construction, and enhances thermal comfort. A calcium sulphate dihydrate core of the gypsum plasterboard is wrapped on both sides by two layers of paper. Small quantities of glass fibre and vermiculite are added to the gypsum core to improve its resilience and fire performance.

Heat can be transmitted through conduction, convection, or radiation. Radiation is the transfer of energy through electromagnetic waves, whereas convection is the transfer of heat through the movement of matter, such as a gas or liquid. Heat is transferred through direct contact in conduction. After being subjected to fire, gypsum plasterboard experiences change in its thermal and mechanical properties because of a series of chemical reactions that release both free and chemically bound water. It is essential to employ exact thermo-physical parameters for gypsum plasterboard to produce accurate and reliable heat transfer finite element (FE) models. Then, parametric analyses of novel LSF wall systems can be performed utilizing these models. (Rusthi, et al., 2017; Thomas, 2002)

The thermal properties of gypsum plasterboards have been the subject of numerous investigations (Mehaffey, 1994). Others have improved them by utilizing the findings of both small- and large-scale experiments. (Dodangoda, et al., 2016) conducted an extensive study on the physical and mechanical properties of fire-rated gypsum plasterboards at ambient and elevated temperatures. Additionally, they recommended a group of material parameters suitable for both small- and large-scale heat transfer modelling.

As demonstrated in earlier research studies (Sultan, 2008), when LSF walls are subjected to fire, plasterboard joints become loose and plasterboard pieces fall off. This phenomenon is statistically approximated by increasing the thermal properties of gypsum plasterboards or eliminating plasterboard components. However, the spread of joint opening-up and piece fall-off is still not fully understood since it can be challenging to observe the plasterboard on the fireside during a fire test.

The results of three full-scale fire tests that were conducted as part of this study following the guidelines of ISO 834 (ISO 834-1 1999) are first discussed. The heat-transfer FE modelling was improved by using the visual observations of the plasterboard joint opening and plasterboard fall-off phenomena made during the full-scale fire testing.

The physical and mechanical properties of gypsum plasterboards at ambient and elevated temperatures were evaluated by Dodangoda et al. (Dodangoda, et al., 2016) to determine a suitable set of material parameters for small- and large-scale heat transfer research. They suggested idealized gypsum plasterboard density estimates for numerical simulations of full-scale testing conducted at extreme temperatures. Gypsum plasterboards' specific heat values were evaluated in accordance with ASTM E1269 using a differential scanning calorimeter at temperatures as high as 1200.

3.5 OSB

A wood-based engineered material known as Oriented Strand Board (OSB) is made by sandwiching layers of wood strands with glue and compressing the layers at various pressures and temperatures. Due to its robust mechanical properties, this type of OSB is widely used in a variety of load-bearing building applications, particularly in wooden homes. The four OSB grades' respective moisture resistance and mechanical performance are described as follows: As opposed to load-bearing boards for use in humid circumstances, which are classed as OSB3, and boards with a high load capacity for usage in damp environments, which are classified as OSB4, general purpose boards and interior fittings, such as furniture, are categorized as OSB1 (EN 300:2006).

First off, Oriented Strand Board, often known as OSB, is created by compressing layers of wood strands and joining them with adhesives (wax and synthetic resin). Unlike similar products, OSB has been around since 1963 and can have up to 50 layers of wood altogether! To provide strength, the wood strips in each layer are placed strategically rather than at random. Because it comes from small, quickly growing, sustainable trees like southern yellow pine and aspen poplar, the wood is incredibly strong.

The thin, rectangular wooden flakes or strands that form the core of OSB are cross-oriented layers that are joined with synthetic resin adhesives. Now, OSB mostly replaced plywood in construction as a load-bearing material for uses like roof decking, flooring, wall sheathing, and roof sheathing. Even yet, it still performs worse than plywood in scenarios classified as class 3. One important factor is that, in water dynamic situations, the mechanical qualities of OSB deteriorate more quickly than those of plywood. (Zhan, 2018). As a wood-based panel, OSB's mechanical qualities are further influenced by several elements, such as the wood species contained in the strands, their shape, the type of resin used, pressing conditions, and the density profile of the panel. (Dias, et al., 2016)

The water resistance of OSB is now assessed using water sorption/desorption in conjunction with low (12–20 °C) and high (70 °C) temperature conditioning. Four different varieties of OSB can be identified based on internal bond strength or residual modulus of elasticity. Although it is well recognized that water sorption and desorption have a significant impact on OSB's mechanical performance, the underlying mechanisms remain poorly understood. Evaluation and enhancement of OSB's mechanical performance can be done more successfully by researching the impact of water sorption/desorption on fatigue deflection.

OSB is great for a lot to do applications, and because it's weather resistant, you can use it both inside and outside. Because of its durability, it is frequently used as flooring and is perfect for a workshop or shed. It can also be used as wall sheathing or as roof sheathing to put underneath your roofing system.

However, a skilled carpenter or creative person can use OSB to build a wide range of unique pieces of furniture or cabinetry. With countless alternatives, including headboards, noticeboards, drawers, and wardrobes, the sky is the limit with a little ingenuity.

Since the weather-resistant sealant was only applied to the OSB's surface, you will need to add extra sealant as soon as you make a cut into it to prevent water absorption through the exposed material. (Rose, Garay, 2009).

Any cuts must be sealed for them to remain water-resistant; otherwise, they may swell and absorb water. Compared to plywood, it may take longer to dry out.

The prepared OSBs had a density of 0.62 to 0.8 g/cm^3 and an average thickness of 12.1 to 13.4 cm, according to the findings. Increasing the pre-treatment's temperature causes the panels' density to rise while simultaneously decreasing their thickness. The outcomes are consistent with earlier research findings outlined by Pelaez and associates (Pelaez-Samaniego et al., 2013), who offered a concise yet thorough assessment of the advantages of thermal pre-treatment in the manufacture of wood composites from various sources. (Donohoe, et al., 2008; Hosseinaei, et al., 2011)

For wooden construction structures including walls, floors, ceilings, and furniture, oriented strand board (OSB) panels are frequently used. Small wooden strands linked together in certain orientations by adhesives are used to create these wood composites. Wax and other chemicals may be used to lessen water absorption.

As a less expensive alternative to plywood, OSB panels are being used more and more frequently. One of the primary drawbacks of the OSB produced today is moisture absorption, which can negatively impact their mechanical characteristics and reduce their resistance to microbial degradation. (Wooden Handbook 2006)

3.6 Sorption Isotherms and their types

An effective technique for forecasting and increasing product shelf life is the moisture sorption isotherm. You can use it to: Locate crucial water activity values where alterations like caking, clumping, and texture loss take place. Calculate the impact of component and formulation changes on the product.

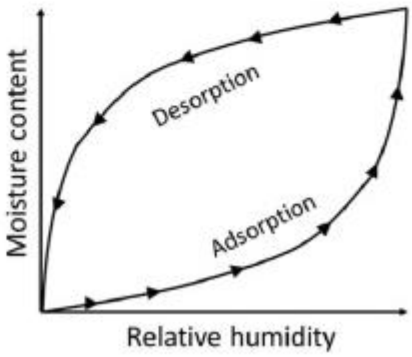

Figure 1: Humidity sorption isotherm as a function of relative humidity.

The water sorption isotherm shows, for constant ambient conditions, apart from humidity, the thermodynamic relationship between water flow and the equilibrium moisture content of a hygroscopic substance. Adsorption and desorption are two quite different processes that describe the equilibrium water content as a function of atmospheric relative humidity at a specific temperature. (Fig. 6). Isotherms are therefore among the most crucial characteristics of porous building materials for moisture distribution. Then, either an adsorption process or a desorption process can result in the generation of sorption isotherms.

For this relation to be regarded as unique, the retention/release equilibria of the individual processes must have been achieved, and all other physicochemical parameters must be constant. The name "isotherm" was specifically chosen since temperature affects sorption reactions; temperature needs to be maintained and defined. Typically, the difference between the initial solute concentration Ca0 and the final solute concentration C is used to estimate the concentration of the component retained on the solid.

Two typical units used to express the moisture content of concrete are we (kg/m^3) and u (kg/kg). Since there are strong correlations between relative humidity (RH) and the "adsorbed water" in the gel and the "capillary condensed water" in the larger pores, relative humidity can be used to describe the amount of moisture in concrete (RH). The relationship between the total amount of physically bound water and RH will therefore be provided by the concrete's specific surface area and pore size distribution. The "moisture sorption isotherm" refers to this relationship. In the graphic, OPC concrete examples are shown.

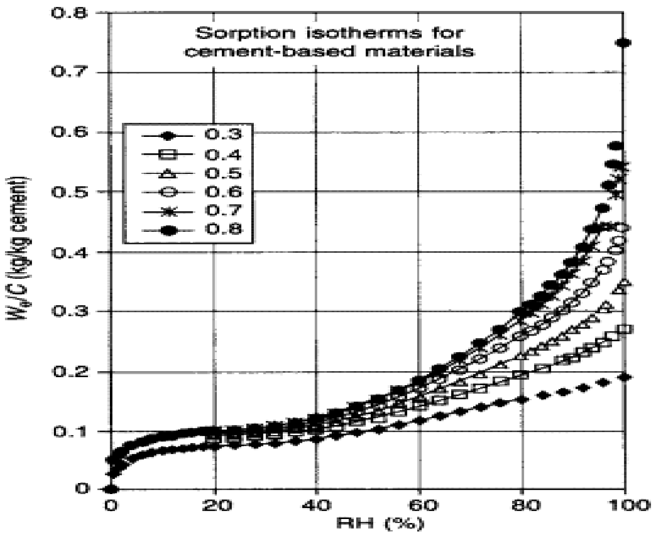

Figure 2: Graph of common relation of moisture content to relative humidity. (Skaar 1988)

Van Bemmelen created this method of showing solute retention on solids in 1888. Often, this isotherm cannot tell us what kind of reaction is occurring by itself (Sposito, 1984; Veith and Sposito, 1977; Scheidegger and Sparks, 1996). For instance, the precipitation of a new solid phase could be the reason for the retention or surface retention without the formation of a three-dimensional structure (McBride, 1994). Sposito suggested using the term "sorption" to discuss any form of retention (Sposito, 1984). Surface adsorption frequently serves as a "template" for the precipitation, which is why it is also referred to as "surface-enhanced precipitation" (Wersin, et al., 1994; Ford, et al., 2002). This process, which was demonstrated by James and Healy in 1972, is crucial for the development of new solid phases in soils and other geologic media (Ford, et al., 2002).

Hygrothermal modelling can be more effective than actual research in examining the endurance of building parts and assemblies, but these models need precise inputs for material properties. Hygrothermal model outcomes can be used to estimate the danger of mould growth, which is a sign of how long a building will last. Importance is given to mould growth in organic building materials like wood. One of the most popular kinds of sheathing board is OSB. However, several well methods for hygrothermal modelling do not take changing sorption isotherms into account. Moisture storage is one of the OSB sheathing's material characteristics, as shown by the sorption isotherm.

This research investigates the variation of sorption isotherms in following accelerated aging, OSB sheathing and at various temperatures. After integrating the measured data into hygrothermal models, the output was analysed to determine the mould index, a scale for mould growth, to estimate the danger of mould growth. Building materials and goods' hygrothermal performance and hygroscopic sorption capabilities were determined in 2000.

Hygrothermal modelling can be used to estimate long-term performance and durability (Straube, Burnett, 2001) An effective approach for predicting the longevity of buildings is hygrothermal modelling, but it can suffer from bad inputs like material qualities, which can have a negative impact on model outcomes. A crucial material feature that can impact durability and occupant comfort is moisture absorption. Variations in moisture storage input data can particularly affect model outputs used to determine subsequently applied Since the models do not accurately capture moisture movement through the materials, durability indications like mould growth cannot be predicted. Building material mass transfer under hysteresis was modelled in 2001.

The transition of chemicals from a mobile phase (liquid or gaseous) to a solid phase determines the mobility of compounds in aqueous porous media and aquatic eco systems. Since of this, an important thing for describing and predicting a substance's mobility in the environment is the "isotherm," a curve that shows a substance's retention at varying concentrations on a solid. It is crucial to describe how the sorption isotherm evolves over time since these retention/release events might occasionally be tightly kinetically regulated.

A graph known as a sorption isotherm shows the equilibrium moisture content as a function of relative vapor pressure (h) or percent relative humidity (H=100h) at a constant temperature. The wood moisture isotherm, one of six sorption isotherms, is classified as Type 2. The wood moisture sorption isotherm for desorption and adsorption is shown in Figure 3.

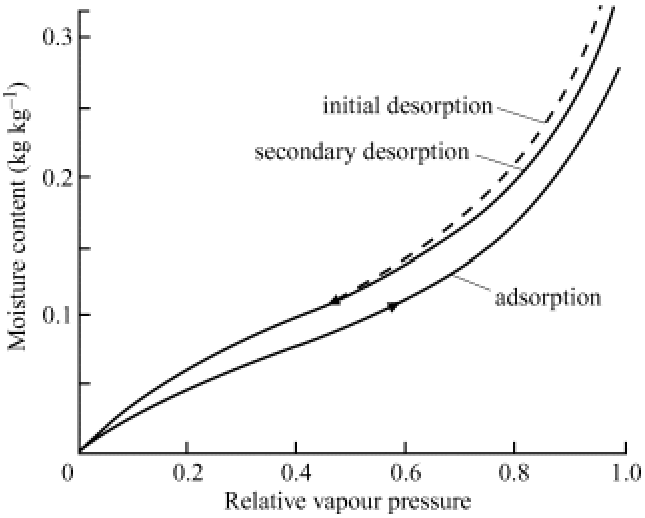

Figure 3: Typical moisture isotherm for wood at 25 °C for initial desorption, adsorption, and secondary desorption. (Skaar, 1988).

The desorption isotherm of green, or never-dried, wood is higher when compared to the adsorption and desorption isotherms of oven-dried wood. Additionally, for materials that have been dried in an oven, the desorption isotherm is always greater than the adsorption isotherm. When the relative humidity is less than 50%, the two desorption isotherms overlap. Many hygroscopic materials exhibit sorption hysteresis, which is the difference between the adsorption and desorption curves (Skaar, 1988). For a specific relative humidity, it is quantified as a moisture content to desorption (A/D) ratio (D). The A/D ratio varies for softwoods between 0.785 and 0.84 (mean A/D = 0.8120.02) and for hardwoods between 0.79 and 0.849 (mean A/D = 0.8280.02). (Skaar, 1988).

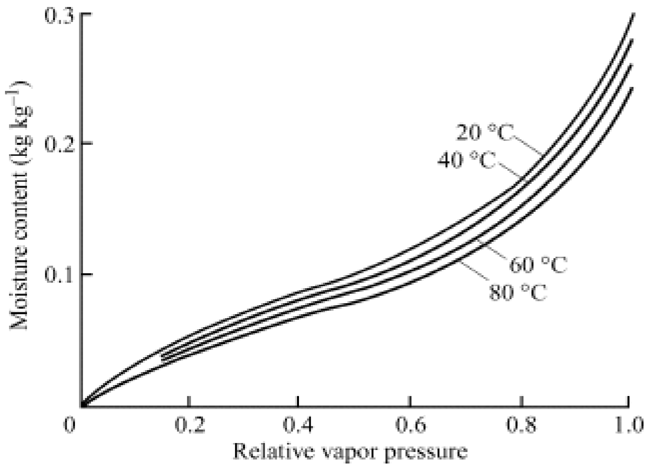

Figure 4: Impact of temperature on typical moisture isotherms for wood. (Wangaard and Granados, 1967)

3.6.1 The four main types of isotherms

Four specific types are now shown as the four main shapes of isotherms usually observed in Giles et al (1974).'s generic model of sorption isotherms (Fig. 5).

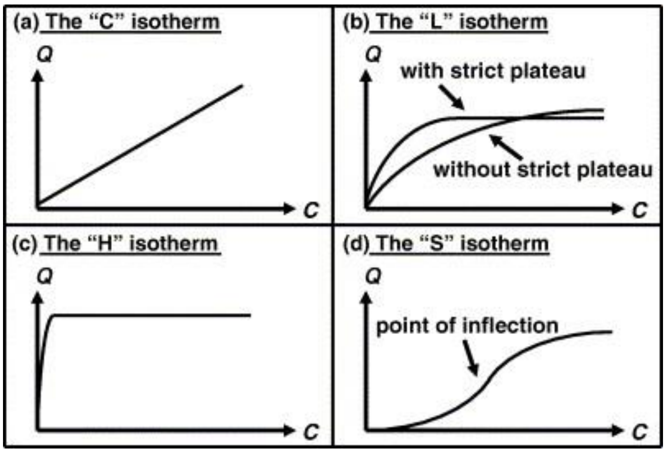

Figure 5: Main types of isotherms (after Giles et al., 1974).

The "C" isotherm

A curve is a straight line with zero origin. This indicates that at each concentration the ratio of the concentration of the compound in solution to the compound adsorbed on the solid is the same. The "partition coefficient" or "partition coefficient" for this ratio is Kd or Kp (L kg 1). The 'C' isotherm is sometimes used as a convenient approximation (for narrow ranges of values or very low concentrations reported for trace impurities) rather than as an exact description. However, the ease of use of this isotherm should not justify its indefinite use, as it may lead to wrong conclusions. For example, if the solid has a finite number of adsorption sites due to potential saturation plateaus, the isotherms can be nonlinear.

The “L” isotherm

The concave curve results from the fact that as the concentration of the solute increases, the ratio of the compound remaining in solution to the amount adsorbed on the solid decreases. This means that the solid gradually becomes saturated. The curve either approaches a strict asymptotic plateau (solids have finite sorption capacity) or does not plateau, usually dividing the data into two subsets (solids have finite sorption capacity is not explicitly shown). However, it often seems very difficult to determine whether an isotherm belongs to the first subgroup or the second.

The isotherm "H"

The 'L' isotherm only occurs in this special case where a steep initial slope occurs. Compounds have such a strong affinity for solids that the first gradient cannot be decoupled from infinity, but this situation is distinguished from other situations because it goes against thermodynamic logic. (Toth, 1995).

The isotherm "S"

The curve has a point of inflection since it is sigmoidal. There are usually at least two opposing mechanisms at work when this type of isotherm occurs. The classic example is non-polar organic molecules, which have a weak affinity for clays. However, once these chemicals have coated a clay surface, other organic molecules are more readily adsorbed (Karimi-Lotfabad et al., 1996; Pignatello, 2000). Cooperative adsorption is the term for this phenomenon, which is also seen with lubricants (Hinz, 2001). (Smith et al., 1990; Smith and Galan, 1995; Groisman et al., 2004). For metallic species, a sigmoidal isotherm can also be produced by the presence of a soluble binder. The presence of the ligand restricts the adsorption at low metal concentrations. Adsorption must first occur when the agent is saturated (Sposito, 1984). The inflection point indicates the concentration at which complex formation is abolished by adsorption.

Moisture sorption isotherms can be defined by semi-empirical formulas using two or three measurements. The GAB and BET equations have been used more than any other to describe the sorption isotherms of building materials, but Langmuir, Van Genuchten, and others have also been used. The Clausius-Clapeyron equation is used in several research papers to describe sorption curves as a function of temperature. A model proposed by Brunauer, Emmett, and Teller (BET).

The BET model was offered by Brunauer, Emmett, and Teller and has since been the model most frequently employed to explain sorption curves in hygroscopic environments S.

(Brunauer, et al., 1938). This idea is crucial to comprehending multilayer sorption isotherms, and its model is as follows:

$$w = \frac{X_0 c\varphi}{(1-\varphi)(1-\varphi+c\varphi)}$$

where c is the energy constant for the specific heat of adsorption, representing the difference in energy adsorption by the molecules of the first and subsequent layers, and ϕ is the relative humidity. X0 is the water content of the monolayer, the point where water binds to each ionic group.

The explicit consideration of thermodynamic state functions makes the GAB model a common choice for modelling isothermal sorption curves. This explains the sorption activity over a wide range of reasonable values between 0% and 90%. The GAB model underestimates moisture content values for relative humidity values above 93%. Especially when water activity is present in liquid form. Numerous research (Zhang, Ahmad, 2020) have approximated sorption isotherms using this approach.

3.6.2 Equilibrium Moisture Content

Wood eventually reaches the equilibrium moisture content (EMC) of unsaturated water vapor at a given relative humidity (RH). It is the amount or percentage of ambient water vapor saturation (Skaar, 1988). A constant RH atmosphere is easily achieved by placing a closed vessel over a saturated salt solution, and the correct salt can be used to achieve the desired RH level between 0% and 100%. Other alternatives are climate chambers with continuous electronic (RH, T) control or automated dynamic vapor sorption (DVS) devices. (Engelund et al., 2010).

To thoroughly analyse the matrix-capillary moisture transition near FSP, researchers need to carefully control the moisture value around saturated humidity conditions (RH > 98%). To measure the EMC of saturated water vapor, the compression plate approach (Fredriksson and Johansson, 2016) uses samples exposed to high hydrostatic pressure. Willems (2014b) found that at high relative humidity, hydrostatic pressure is associated with a well-defined humidity equivalent to atmospheric pressure, making his EMC measurements near the FSP slightly faster, but more accurate claims to be

EMC is calculated as MC after a "reasonable" conditioning time at given RH and temperature values. This can be verified experimentally by having a constant sample mass.

However, the MC might vary for a very long time under conditions of constant RH and temperature, making the experiment's duration impractical. The appropriate observation duration must be determined by the investigator based on his or her research objectives. For good EMC measurements, there must be no residual MC gradients in the sample, which favours the use of thin samples. It is crucial to understand the progressively slower transient MC dynamics at increasing RH. (Christensen and Kelsey, 1959; Kelly and Hart, 1970; Engelund et al., 2013).

For good EMC measurements, the sample should not have residual MC gradients. This favours the use of thin samples. It is important to understand the progressively slower transient MC dynamics with increasing relative humidity. (Christensen and Kelsey, 1959; Kelly and Hart, 1970; Engelund et al., 2013). A unique plot, known as a sorption isotherm, relates his EMC to various values of relative humidity (RH) at constant temperature (T). Wood sorption isotherms typically take the form of a sigmoid that is concave at low relative humidity and convex at high relative humidity. The specific variables that cause the formation of this curve are still being investigated by research (Engelund, et al., 2013). An increase in EMC vs. RH (adsorption) differs from a decrease in EMC vs. RH (desorption) due to the dynamic structural response of the wood matrix to moisture changes. Since the desorption isotherm is always above the adsorption isotherm, EMC can be observed at lower RH for desorption than for adsorption. When this happens, it is called "sorption hysteresis". (Engelund et al., 2013).

To calculate the moisture content, subtract the dry weight from the wet weight, divide the result by the wet weight, and multiply by 100

$$X = \frac{m - m_{\mathrm{d}}}{m_{\mathrm{d}}}$$

Where MC is the moisture content (%)

- m is the weight of wet sample
- m_{d} is the weight of dry sample

3.7 Classification of sorption isotherms

The shape of the vapor sorption isotherm, which depends on the interaction between vapor molecules and the solid, can often be used to determine information about the sorption mechanism of water on powder surfaces (Roos, 1995). According to the IUPAC classification by (Sing, et al., 1985), physisorption isotherms can be divided into six main classes (I to VI), as shown in Figure 5. It is unusual to see type V and type VI isotherms (Sing et al., 1985; Rouquerol et al., 1999). The Langmuir type, or type I, is characterized by a monotonic approach to limiting adsorption and is thought to cover the entire monolayer (Langmuir, 1917). Type I isotherms are provided by predominantly microporous adsorbents with relatively small external surface areas (Sing et al., 1985; Rouquerol et al., 1985). 1999), which holds large amounts of water at low RH. This type of isotherm is typical of anti-caking agents (Bell and Labuza, 2000). Uptake limitations may be determined by accessible pore volume rather than internal surface area (Sing, et al., 1985; Rouquerol, et al., 1999). Type II or sigmoidal sigmoid isotherms are usually associated with monolayer–multilayer sorption on nonporous or microporous surfaces of powders. Water absorption isotherms for biological materials often follow the shape of a sigmoid type II isotherm. This isotherm with hysteresis is obtained for plate-like particles with slit-like pores without stiffness (Rouquerol, et al., 1999). The physical properties of the solution, capillary action, and the interaction of the surface with water combine to produce the resulting curve (Bell and Labuza, 2000). A well-defined 'knee' usually indicates a monolayer formation. Type II and IV isotherm uptake is large at low partial pressures, followed by low concentrations of adsorbed vapor, followed by another significant uptake at high partial pressures (Singetal, 1985; Rouquerol, et al., 1999). Meso porosity is typically characterized by a hysteresis loop characteristic of both type II and type IV isotherms. Unlike the type IV isotherm, the type II hysteresis does not level off at high aw. The surface area of the mesopore walls followed by capillary condensation or pore filling gives the type IV isotherm its characteristic shape (Sing, 1998). The Type III and Type V isotherms show relatively low absorption at low concentrations and a large increase in adsorption at higher vapor concentrations, indicating weaker adsorbent-adsorbent interactions (Sing, et al. al., 1985; Rouquerol, et al., 1999). A type III isotherm appears when the multi-layer process causes all sorption over the entire pressure range. Water absorption of some crystalline substances. For example, sugar content may be low, but it is increasing at this point, following the Type III isotherm. Type VI isotherms, graded isotherms, are primarily introduced as hypothetical isotherms and are associated with layered sorption onto, non-porous surfaces (Rouquerol, et al., 1999).

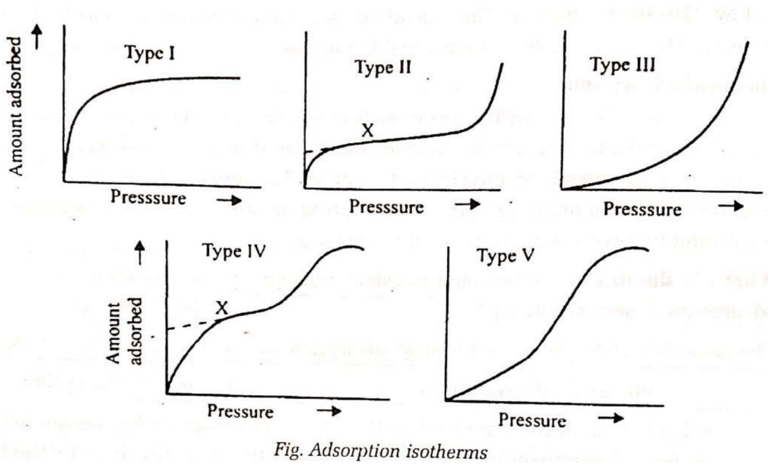

Figure 6: Types of sorption isotherms and how they act. Types of isotherms described by Brunauer.

Higher temperatures have a direct impact on the sorption isotherm by causing ME to decrease for a given relative humidity level (Fig.6). As the temperature rises, MF likewise decreases (Siau, 1984). This result can be reversed. Higher temperatures have the long-term impact of permanently reducing hygroscopicity in wood, especially at temperatures exceeding 100 °C. When wood is cooled to room temperature, this effect is permanent. Exposure to high temperatures over an extended period also reduces mechanical qualities (Stamm, 1964).

Before usage, not every wood is completely dry to remove all moisture. The new ME follows the general pattern of adsorption curves when fresh wood is dried to a moisture content of 12% (approximately 50% moisture) and then exposed to a higher moisture content of 85%. The desorption and adsorption isotherms will form a closed (or “hysteresis") loop when the wood is cycled through two humidities at the same temperature (Skaar, 1988).

time, research has shown that this is not always the case, but that does not mean that the procedure has somehow limited in importance. This is supported by the advancement of measuring methodologies over time, which were designed to produce more accurate and realistic results. Eventually, it became evident that building a machine to measure fabric wear in general is not even theoretically feasible, and there is also a need for improved techniques for measuring the wear of fibres, yarns, and fabrics for different types of fibres under specific loading conditions. (Cunko, 1989).

While medical scrapes and abrasions are common news stories, the aviation, energy, and general manufacturing industries are also susceptible to these very severe wounds. The usage of abrasion-resistant materials is frequently essential for manufacturers and organizations to achieve cost savings, consistent production, and quality control.

The capacity to withstand abrasive friction caused by mechanical parts and instances of frequent scraping or rubbing is known as abrasion resistance. Some materials, like chromium, are naturally resistant to abrasion, while other materials can be helped to achieve those qualities using lubricants, coatings, and process optimization (Praxair S.T. Technology).

The inclusion of hard particles between two sliding or rolling surfaces results in abrasion, a wear mechanism. Material is removed by abrasion or abrasive wear using either a two-body abrasion mechanism or a three-body abrasion mechanism. The hard substance gets trapped in the softer surface and eats through the other in two-body abrasion. The use of "sand" paper, in which silica particles are plastered to soft paper and used to remove material from another surface, is a typical example. The three-body abrasion mechanism entails the free movement of the abrasive particles, and as the hard particles are pushed into the surfaces, many indents are created. In this case, the material removal mechanism is more of a fatigue-type process, where the indentation process results in work hardening and subsequent crack initiation and propagation.

Many industries handle particles, like oil and gas, depending on abrasion.

Solids commonly occur in the fluid stream of a pipe system during the processing of minerals. However, the material loss can happen when rocks, sand, minerals, or other inorganic components in a slurry scrape against the inside of a pipe. The risk is most where the pipe joints vary in velocity.

The pressure rating and general mechanical integrity of a piping system might decline when the wall thickness is weathered down, which could result in pipe leaks or failure.

A piping material's rate of wear is dependent on two factors: the fluid passing through it and how resistant it is to abrasion. A substance's ability to withstand material loss when another material rubs up against it is known as abrasion resistance.

3.8.1 Requirements to Reduce Abrasion

Over time, all pipe systems experience some degree of wear. However, certain combinations of particle size, shape, hardness, concentration, density, and velocity might accelerate this erosion.

To reduce abrasion, the ideal system circumstances ought to be:

- slower speeds. Aim for a fluid velocity of no more than 5 ft/sec.
- spherical, substantial particles. Smaller, sharper particles are more likely to gouge the pipe due to their concentrated impact. If you scrape sandpaper or pebbles against a piece of wood, the sandpaper will do more harm.
- uniform distribution of the particles. Instead of a mix of large and small particles, fluid particles should ideally be about the same size.
- minimal direction changes Your pipe's bend radius can be increased to produce more gradual changes in velocity and direction. This decreases the force's concentration on one area of the elbow of a pipe. The optimum bends for easing into direction changes are large-radius elbow and capped tee bends (Solorio, 2017).

Environmental factors, aggregate prescription, concrete strength, mix ratio, usage of specific cement, and the addition of extra components like fibre and fly ash are the key determinants of concrete's resistance to abrasion. Surface finish, curing conditions, and abrasion resistance are all significantly impacted by the other two variables (Horszczaruk, 2005).

One of the most significant variables that relate to concrete's abrasion resistance is its compressive strength, which has been established. There is no association between compressive strength and abrasion resistance, although it has been shown that if one is high, the other usually follows.

Within 72 hours, Holland et al. (1987) showed a correlation between compressive strength and wear resistance of concrete. Tests have shown that compressive strength increases wear resistance. For repairs at Kins Adam, Pennsylvania, Holland studied the wear resistance of concrete containing 11-15% silica his fume and a water/cement ratio (w/c) of 0.24-0. 34.. After 28 days, the compressive strength of concrete he reached 79 MPa. By applying silica fume, wear resistance has improved compared to ordinary concrete. A study by Horszczaruk (2005) used nine high-strength concrete mixes modified with steel fibres, PVC fibres, and latex. Concrete is made up of different types of cement. He has three types of cement:

In Portland it is CEM I 42.5R, CEM I 52.5R, and CEM III 42.5. Fly ash (SiO_2, 93%) and silica fume (10% of cement mass) were also present in all mixtures. The mixture contained basalt aggregates with maximum grain sizes of 8 mm and 16 mm and a density of 3.03 kg/m3. The main conclusions of this study are:

The ASTM C1138 method is suitable for evaluating the wear resistance of high strength concrete (HSC) at compressive strengths of 80-120 MPa for 28 days. A routine analysis method in water (HSC) should be at least 72 hours. The linear dependence of the wear assumption (HSC) is correct and omits the first wear phase (12-24 hours). Wear rate is considered when HSC exceeds 80MPa (Horszczaruk's, 2005).

The abrasion test results for SHCC were initially published by Li and Lepech in 2004. They tested static wear and friction in accordance with Michigan Test Method 111. (Khattak M, 2001). For calculating the abrasion resistance of cementitious materials, an entirely separate method is used particularly in European nations. The Böhme grinding wheel, which is standardized in DIN 52108:2010-05, is used in this process (2010). The specimen surface is pressed onto the rotating disc of the test device. The use of a defined grinding media ensures repeatable abrasion conditions. In 2012, the Institute for Building Materials at the Technical University of Dresden focused a comparable test with a Boehme grinding wheel. (Wellner, et al., 2016)

4. Experimental

The subject of this study is the determination of the moisture-dependent diffusion resistance coefficient of OSB. Since the equilibrium water content of the samples was on either the adsorption limit curve or the desorption limit curve, we planned a series of measurements to estimate the value of the diffusional resistance coefficient of OSB at various average relative humidity points. The dependence of the diffusion resistance coefficient on water content is calculated using a functional description of the sorption curve.

Because of the risks associated with mould growth and the frequent use of wood in single-family home construction, wet heat modelling helps predict long-term performance and durability. Thermal models can be powerful tools for predicting the useful life of buildings but can be hampered by poor inputs such as material quality that adversely affect model results. Moisture absorption is an important material property that affects durability and occupant comfort. Since the model does not accurately represent the movement of moisture through the material, variations in the moisture storage input data have a large impact on the model output. The output of this model is used to predict durability indices for later use, such as mould growth. Uncertainties related to aging, stochastic inputs, and material data can also have a significant impact. A humid heat model describing the effects of temperature and hysteresis on moisture storage has been shown to be more like field data. Hysteresis has been shown to have a significant impact on the hygrothermal properties of OSBs for changes in equilibrium water content of 10% or more. The moisture uptake of OSB was determined by Hartley et al. (Straube, Burnett, 2001).

In this study the sorption of isotherms of the samples will be seen. The samples were kept for 1 week in climate chamber at same temperature for all samples to be dried out. In the table it will be seen the setpoints and temperatures of the samples.

Modern wood-frame structures commonly incorporate OSB as a vapor barrier layer when constructing their outside walls. Its purpose is to control the movement of water vapor from the inside to the outside.

4.1 Preparation of samples.

OSB board with coated by plaster and OSB itself without coating was chosen for experiments. Two types of OSB are available for testing, they were divided OSB boards into six pieces (Figure 7) with the measurements approximately 5x5 cm. Six samples of material and another six samples with plaster layer were prepared.

This is the OSB itself. As it is shown below dimension are almost around 5 cm each side. The thickness is 1 cm.

Table 1: Width and length of samples in cm.

Sample	WxL (cm)
S1	4.6x4,9
S2	4,7x4.9
S3	4.7x4.9
S4	4.8x4.7
S5	5.2x4.8
S6	4.8x5

Table 2: Width and length of samples in cm. The table is about OSB with plaster after drying out and being conditioned.

Sample	WxL (cm)
S1	4,5x4,8
S2	5x5
S3	4.8x4.7
S4	5.5x4.8
S5	4.4x5
S6	4.8x5.1

Figure 7. These are 12 samples after drying out

They were inside of the chamber to be dried after cutting for 4 days with temperature 105°C (Figure 8). In 3 days, all samples were checked and measured. They were kept inside the heated chamber for one week.

Dehydrating the OSB samples for 4 days at 105°C in an oven yielded the moisture content (AOAC, 1997). An analytical balance with a precision of 0.001 g was used to measure the sample weight. The measurement of moisture content was done on a dry basis (kg water/kg dB). The moisture content of the product can be determined by comparing the mass before (m) and after (md) drying in the oven.

$$X = \frac{m - m_{\mathrm{d}}}{m_{\mathrm{d}}}$$

Where MC is the moisture content (%)

- m is the weight of wet
- $m_{\mathrm{d}}$is the weight of dry

Figure 8: Drying chamber at the degree 105°C

Sorption measurements for oriented strand board (OSB) were carried out under cyclic relative humidity (RH) conditions. The measurements were made by placing test materials in a climate-controlled conditioning chamber until the specimens reached their steady-state equilibrium moisture content (EMC) at each given RH.

Relative humidity (RH) is a measure of how much water vapor is in a water-air mixture compared to the maximum amount possible. RH is a ratio of the humidity ratio of a particular water-air mixture compared to the saturation humidity ratio at a given temperature (dry-bulb). It is important to note that the relevance of relative humidity to a particular application depends on knowing both the dry-bulb temperature as well as the RH. For example, the amount of moisture in a water-air mixture at 80% RH at 40°C is different from the amount of water vapor in a water-air mixture at 80% RH at 10°C.

The measurements of each sample are in the following tables:

Table 3: There can be seen Relative humidity and weight of the samples for the whole period.

OSB board without coating								
Sample	RH (%)	Weight 1(dry)	Weight 2	Weight 3	Weight 4	Weight 5	Weight 6	MC (%)
S1	11	29,792	29.707	30,505	30.539	30,576	30,579	2.6
S2	44	32,102	32,036	33,172	33.238	33,297	33,300	3.7
S4	75	32,708	32,644	35,063	35.331	35,566	35,585	8.7
S3	84	31,257	31,194	33,841	34.222	34,416	34,416	10
S5	97	30,302	30,236	33,267	33,322	33,373	33,439	10
S6	98	31,182	33,181	34,017	34.183	34,395	34,418	10.37

Table 4: Relative humidity and weight of the samples for the whole period.

OSB board with plaster								
Sample	RH	Weight1 (g)(dry)	Weight 2 (g)	Weight 3(g)	Weight 4(g)	Weight 5(g)	Weight 6(g)	MC (%)
S1	11	23,871	23,814	24,776	24.812	24,842	24,847	4.1
S2	44	22,595	22,559	23,900	23.946	24,010	24,008	6.25
S3	75	17,123	17,083	19,054	19.235	19,304	19,295	12.68
S4	84	20,553	20,494	23,395	23.827	23,569	23,527	14.5
S5	97	20	19,797	23,497	23.8	24,263	24,264	22
S6	98	19,36	22,298	23,281	23.401	23,648	23,674	22.36

Those samples were inside six different boxes with different conditions. Those conditions are the first one is with 97 percent of salt, the second box is with Potassium carbonate (K_2CO_3), Potassium Chloride, Lithium Chloride (LiCl), the fifth condition is with Natrium chloride (NaCl), the last one is potassium sulphate (K_2SO_4).

Figure 10: Samples were conditioned inside 97% of salts and Potassium Carbonate.

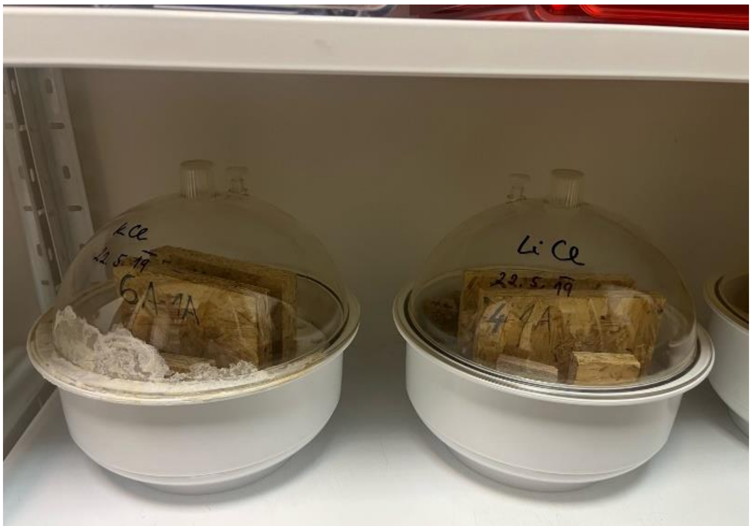

Figure 11: Samples were conditioned inside of Potassium Carbonate and Lithium Chloride.

Figure 12: Samples are inside of the box of Sodium Chloride

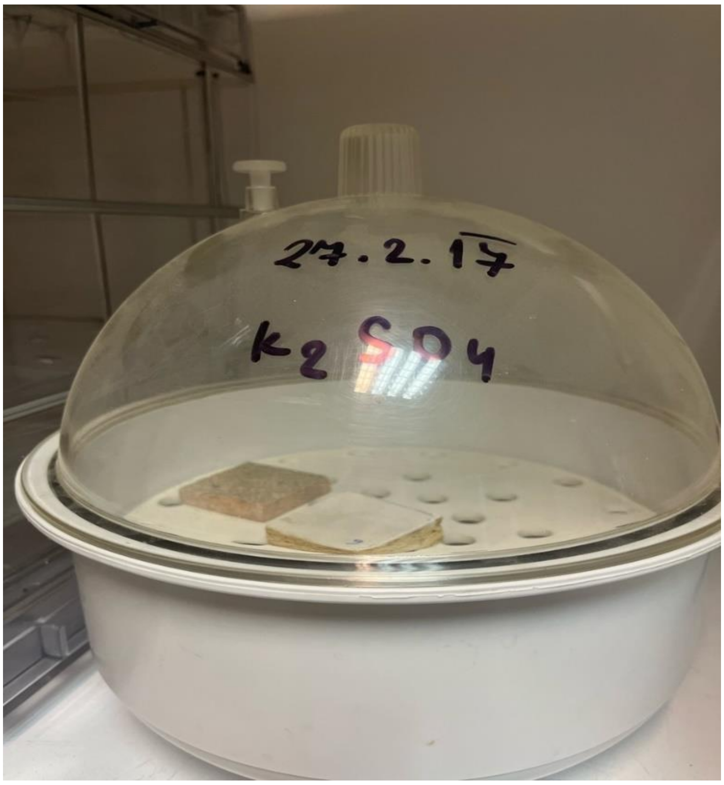

Figure 13: Samples were conditioning inside Potassium Sulphate.

As it can be seen in Figures 10-13 all the twelve samples were inside the conditioned boxes for more than month.

According to literature (Jowitt and Wagstaffe, 1989), Lithium Chloride has relative humidity RH 11% at 20C, Sodium Chloride 75% (20C), Pottasium Chloride 84% (20C), Potassium Carbonate 44% (20C),), Potassium Sulphate 97% (20C).

All the sample weight was measured by an electronic analytical precision balance (Adventurer Pro Ohaus) having a precision of 0.001 g. With a set of the most common features and a wide range of optional equipment, Adventurer Pro can adapt to the specific needs of the enterprise. They can count, add, store and transfer results for further analysis. All the measurement above is in grams. As it is seen on table all the measurements were checked every week and last row is results after one month.

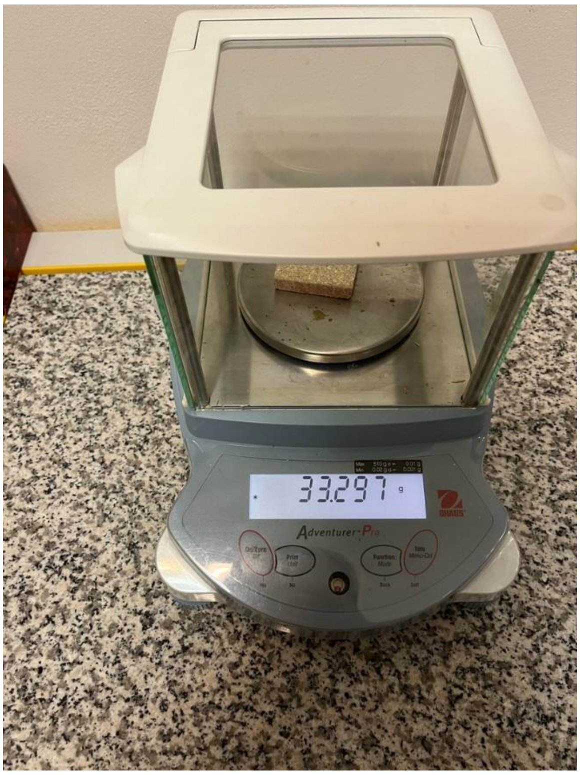

Figure 14: Adventurer Pro can adapt to the specific needs of the enterprise

4.2 Moisture Isotherms of OSB samples.

Dependence of the equilibrium water content of OSB on relative humidity during adsorption (solid line, based on measurements at 23 °C) and desorption (dashed line, estimated). The moisture content of wood and wood-based materials is usually expressed as moisture content per dry matter. H. Kilograms of water per kilogram of dry matter. The dependence of the equilibrium water content of OSB on the relative humidity at constant temperature, the so-called sorption curve (isothermal line) is shown.

Oriented strand board (OSB) sorption measurements were performed under cyclic relative humidity (RH) conditions. Measurements were made by placing the test material in a conditioned environmental chamber until the sample reached a steady-state equilibrium moisture content (EMC) at a given relative humidity. EMC-RH data were fitted to the Nelson sorption model by nonlinear regression analysis. We then used this model to predict the EMC distribution of substrates with vertical density gradients and developed a method to predict the average EMC change of OSBs under RH cyclic exposure conditions. It has been shown that the Nelson model can be used to describe the sorption data for OSB boards manufactured under different processing conditions. The parameters that define the adsorption isotherm depend on the adsorption mode (adsorption or desorption) and process variables.

Once equilibrium is reached, the water content is called the adsorbed or desorbed emf, depending on whether the equilibrium was achieved by an adsorption or desorption process. In isothermal plots, the EMC obtained by desorption processes is usually higher than that obtained by adsorption processes, leading to the formation of hysteresis loops (MSI) when represented graphically. classifies hygroscopic isotherms into five general types. Type I is Langmuir and Type II is a sigmoid or sigmoid isotherm. Type III is known as the Flory-Huggins isotherm and is usually affected by the presence of solvents or plasticizers such as glycerol above the glass transition temperature. Type V is the BET multilayer adsorption isotherm. The water intake isotherms for most foods are non-linear, generally sigmoidal, and classified as type II.

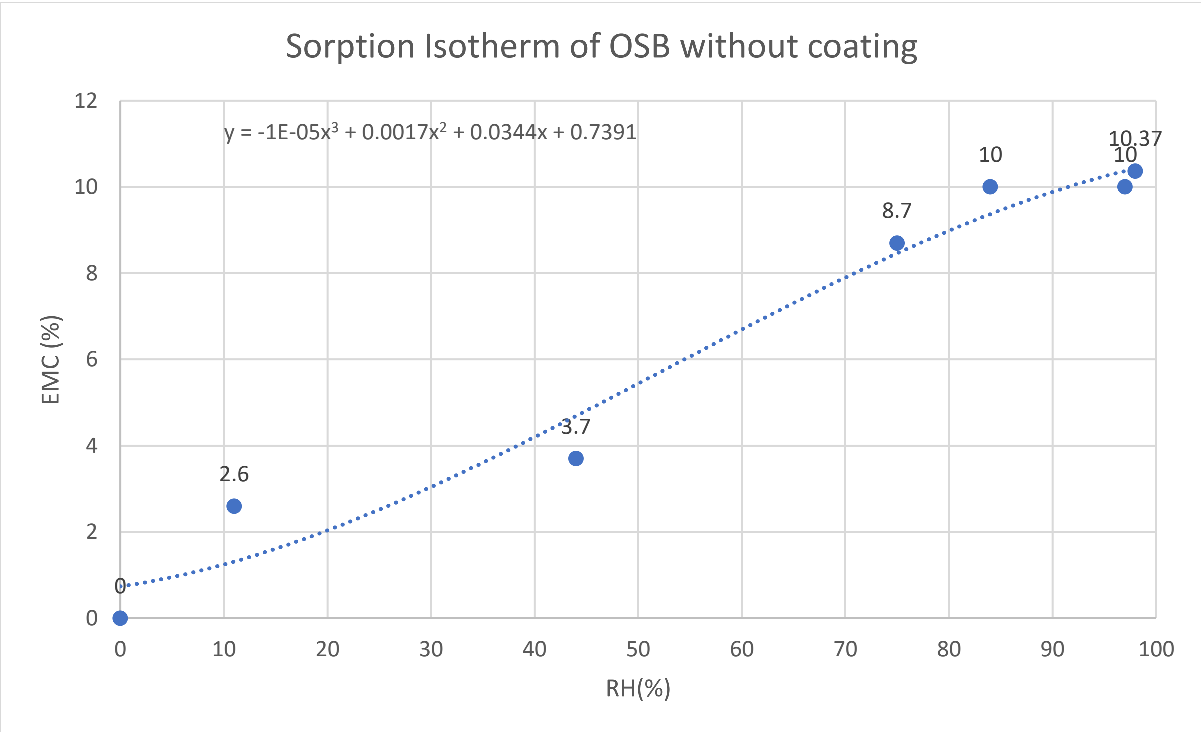

Figure 15: Sorption Isotherm curve of OSB without coating

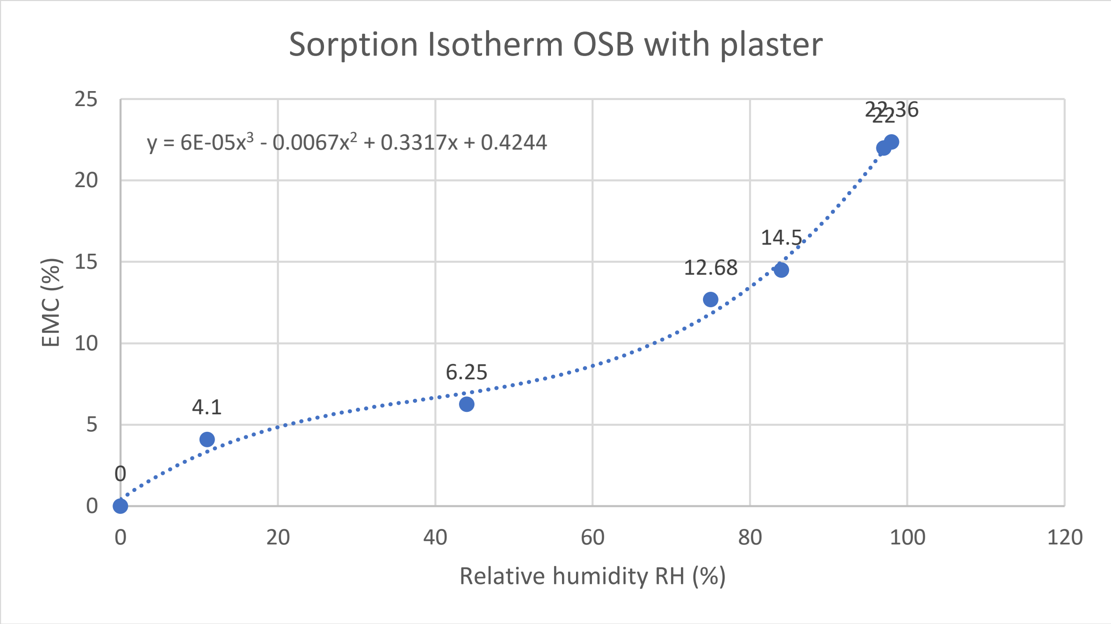

Figure 16: Sorption Isotherm curve of OSB**.**

As it is shown in the graph samples are reached the equilibrium moisture content and able to see the curve of the type S as it was mentioned above.

$$X = \frac{m - m_d}{m_d} * 100$$

The results were received by this formula. By subtracting the dry weight from the wet weight, divide the result by the wet weight, then multiply by 100.

4.3 Abrasion Testing

Figure 17. Abrasion test machine.

The Taber® Rotary Abraser is the industry standard used in wear and durability testing and is available with either a single or dual test head, allowing users to test two different or identical materials simultaneously.

Two samples of OSB coated and uncoated were put into machine. One cycle is 500 rounds, and each sample were put five times and weighted every time after each abrasion cycle.

Figure 18: OSB board with coating before abrasion test.

Figure 19: OSB board without coating before abrasion test.

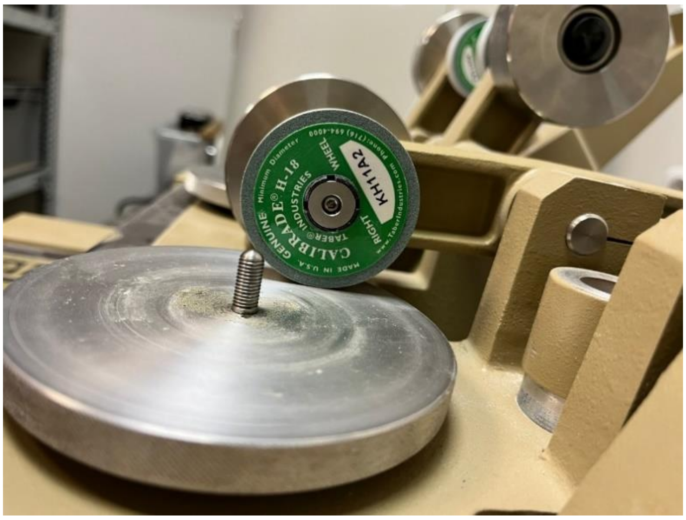

Figure 20: Picture shows calibrating wheels. Test was done by calibration method. Medium grain, medium abrasion, grey, vitrified, sintered serves as a medium-coarse abrasive. It is most frequently used to assess durable materials like flexible plastic sheets, woven textile fabrics, coated fabrics, and rubber that isn't sticky.

Samples were abrased 6 cycle, each cycle is 500 rounds. So, in general, they were affected by 3000 cycles. In the following figure, it can be seen the change in weight. The weight loss of the specimen is measured.

Table 5: All the measurements are in grams. The abrasion resistance is given in weight loss per cycles.

	original weight	500 cycles	1000 cycle	1500 cycle	2000 cycle	2500 cycle	3000 cycle
OSB	68.85	68.26	67.87	67.51	67.24	67.03	66.78
OSB with coating	84.89	83.01	82.38	81.82	81.48	81.31	81.23

Figure 21: Two samples are being abrased in the machine.

Figure 22: Samples after the abrasion with 3000 rotations.

4.4 Fire resistance test:

Flammability testing was performed according to the single flammability test method according to ISO 11925-2.2020. Underlying EN ISO 119252 is the small burner method for testing the ignitability of building materials vertically by direct exposure to a small flame without applied radiation.

The test apparatus is placed in a room with a temperature of approximately 20°C and a relative humidity of 50%. It has a combustion chamber constructed of stainless-steel sheet metal, with heat-resistant glass doors on the front and sides for access and observation. The chamber is ventilated with a required air velocity of 0.7 to 1 m/s. A burner was mounted and adjusted to control the height of the flame, which could move back and forth along the centreline. There is a sample holder consisting of two U-shaped stainless-steel frames. The frame was suspended vertically so that the samples were directly exposed to the flame. A highly adjustable burner assembly mounted on the runner allows a small pre-mixed flame to be tilted at a 45° angle to the sample.

The samples were cut and had a dimension of 250 mm length and 90 mm width, with the thickness 60 mm.

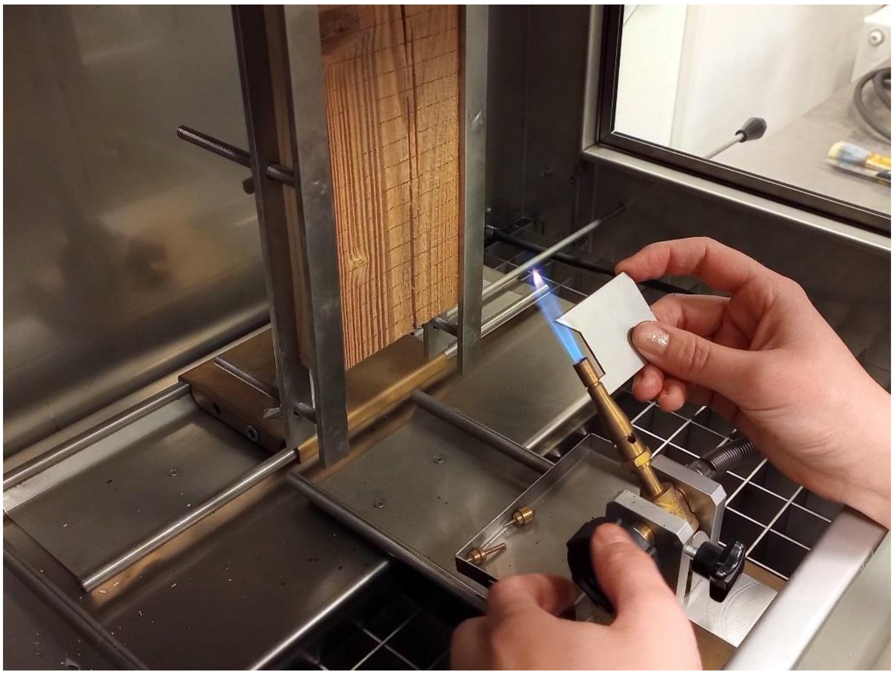

Figure 23: The arrangement of how the sample was set up.

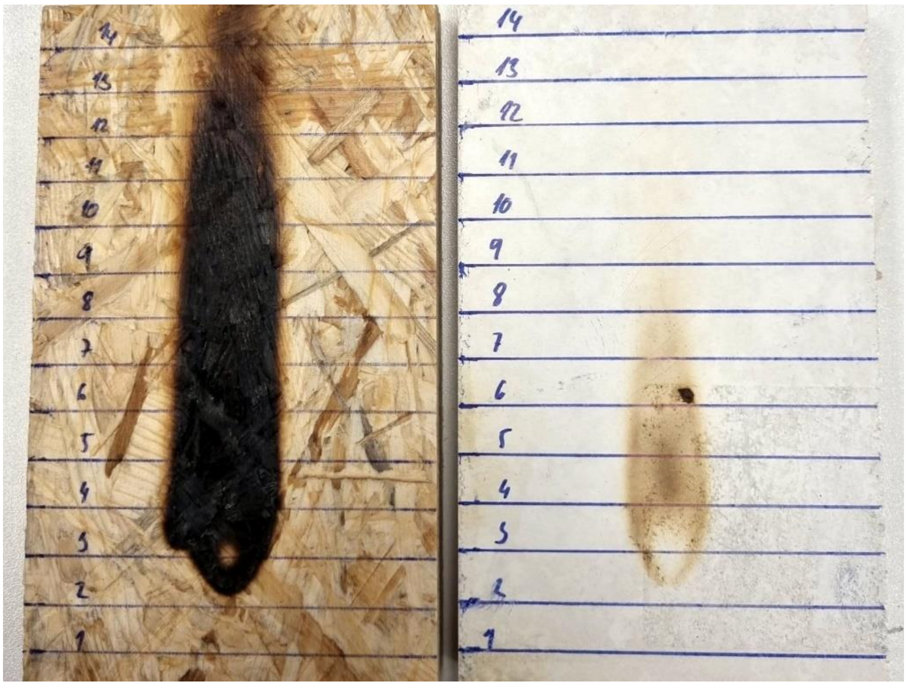

Figure 24: The difference between uncoated OSB and OSB with coating affected by fire.

OSB in a very humid area

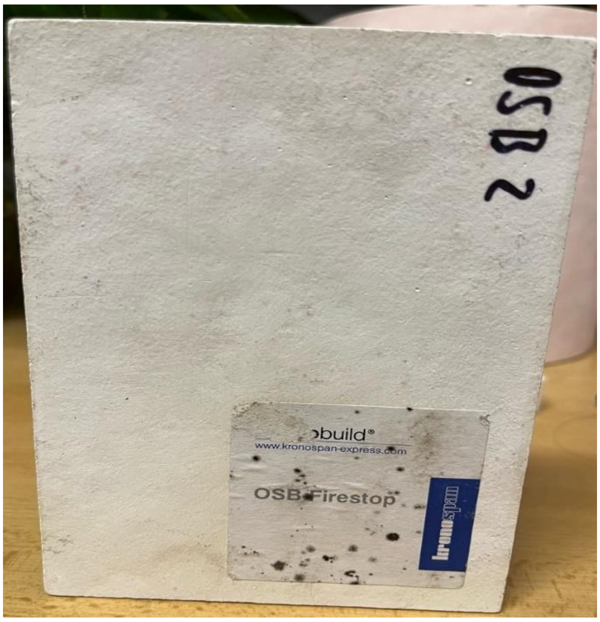

Figure 25: OSB with plaster surface with mould.

Figure 26: OSB with plaster coating with visible delamination.

This OSB board as it is shown in the picture was left in a very humid damp area with 89% humidity for 3 weeks. As it can be seen there are moulds on the surface that grew up and delamination on the sides. For those coming into contact with mould and its spores, this is not only unpleasant, but can stand a serious health hazard. Predict temperature and relative humidity (RH).

5. Results and discussion

The higher the water content, the higher the permeability or the lower the diffusion resistance coefficient. The diffusion resistance coefficient of OSB is close to the fibre saturation point ($\mu \approx 20$) and is ten times higher ($\mu \approx 200$) when dry than when wet. This number reveals that the water vapor permeability of OSBs is determined by moisture content rather than relative humidity.

Below the fibre saturation point, the moisture content of wood depends on the relative humidity (RH) and temperature of the surrounding air. Equilibrium moisture content (EMC) at a given temperature and RH is defined as that moisture content at which wood is neither gaining nor losing moisture. The relationship between EMC and relative humidity at constant temperature is referred to as a sorption isotherm. Samples were checked for the third time on their 10th day being in the boxes, and then in 2 weeks and lastly on their 3rd week. In those results, we can see that there are some differences. The weight of the samples is changing. So, it means they did not reach the equilibrium moisture content. The weight of each sample must have the difference not greater than 0.01%. For example, in the first sample of OSB itself, there is the difference in of 0.217% which we received in 10 days, after another week the difference increased by almost 10%. In 3 weeks since the start of the testing, we got a difference of 1.66%. Still not satisfied. The same situation for other samples, there are differences of 0.2%, 0.5%, and 0.7 %. So, there is seen that it did not reach equilibrium moisture content.

Among the samples with plaster the least difference that it reached by now is 0.14% which regards the condition of Lithium Chloride. This means still need to be kept inside boxes for more time.

Generally, after one month the difference in weights of the samples are got less than it was before. Almost all the samples were about 0.12% between 0.15%. It is getting less and less, so it can reach equilibrium moisture content.

On the other hand, after being conditioned over a month, 12 samples reached steady state condition. The moisture content of the samples was not fluctuating a lot anymore. For example, last time when samples were measured, one of the samples had measurements as 33.300 grams, and a week before it was 33.297 grams, the difference in percentage is 0.009% which is excellent, because it is under 0.001%. This investigation demonstrated that there was no difference in the sorption behaviour of the two species groups at 20 °C. However, both samples' adsorption isotherms are type III (J-shaped), which is typical of materials storing both large amounts of water at high relative humidity and tiny amounts at low water activity (aw) levels (see Figure 5). Additionally, with increasing water activity at a constant temperature, the equilibrium moisture content rises. In general, an experimental equilibrium moisture content is significantly influenced by both temperature and water activity.

OSB (Oriented Strand Board) Structural Panels protect against heat loss and condensation as they are made from real wood which is a natural insulator. Larger panel sizes also reduce the number of joints through which heat, airborne noise, or flames can "penetrate." On the other hand, as it can be seen in Figure 24, that fire had an impact differently on samples of OSB at the same time duration. In the picture can be seen, that fire is exposed more to material without coating than to plaster. The flame spread for 14 cm in length for OSB without coating and 5 cm for plastered OSB after 2.5 min duration.

The abrasion resistance method of wooden surfaces can provide very useful information on their performance and durability over time. It consists of weighing the amount of weight lost when rotational abrasive wheels with a specific load are applied to a coated (wooden) substrate. It can be seen a significant weight loss in the abrasion test. As it can be seen, the difference between the weight loss of OSB itself and OSB with the coating is small. For example, after the first cycles, the difference in weight loss for OSB was 0.6%, but for coated OSB it was 0.7%. As a result, not much difference. But the width of abraded part, can be seen that for uncoated material is 1.6 cm and for coated one is 1.45 cm. There is a significant difference for abraded parts.

6. Conclusions

Isotherm studies have shown that wood-based products are hygroscopic due to the high moisture content obtained at high relative humidity. Sorption/desorption of water can reduce the load-bearing capacity of OSBs. OSB has several advantages.

First, OSB is stronger than other composites. The uniform density of OSB is one of its advantages. Using a stronger, denser material will improve the functionality of the sheath. Secondly, applying an OSB sheath has less impact on the environment, which is an added benefit. Wood is the only building material that is completely renewable. This makes OSB a better environmental option that offers superior quality and durability.

- As a result of practical work, I was able to identify the type of isotherm and learn that the largest moisture content was obtained at the highest relative humidity (RH). In this instance, I can say that the sorption isotherms are of type II and III. According to, studies by Singetal (1985) and Rouquerol, et al., (1999), type III isotherms represent weak adsorbent-adsorbate interactions and exhibit limited uptake at low concentrations as well as a significant rise in sorption at higher vapor concentrations. On the other hand, the sigmoid type II isotherms, which is S-shape, are frequently related to monolayer-multilayer sorption on a powder's nonporous or moderately porous surface.
- Of course, when the protective layer wears off completely, the wood is no longer protected and gets dirty, stained and scratched very easily. As a result, both samples had approximately the same wear differential. Therefore, we can say that the higher the wear resistance, the longer the structure will last before it needs to be repainted.
- According to the picture of OSB in humid conditions, we can tell the big impact of very humid area on the material, that there appeared much delamination. As it can be seen before, OSB can have mould growth on the surface only when there will be in a very damp area with RH between 80-100%. These findings provide strong support to the existing recommendations to avoid high moisture or any water damage while a structure is being constructed and to ensure that the relative humidity (RH) on interior surfaces never exceeds 75% RH.
- It was concluded that OSB with a coating layer has better fire resistance performance than OSB material itself.

7. References

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