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PRODUCT SAFETY OF A CERAMIC COMPOSITE FILLED WITH RECYCLED WOOD WASTE MATERIAL

Examiner(s): Professor Timo Karki
D. Sc. (Tech.) Marko Hyvärinen

ABSTRACT

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Product safety of a ceramic composite filled with recycled wood waste material.

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Keywords:- Wood-cement composite, wood waste, EU standardization, salt frost test, VOCs emissions, leachate.

This report reveals the safety values of the product made up of a wood-cement composite by performing three tests, namely the salt-frost test, VOCs emissions chamber test and leaching test, which are very important tests for this type of sample in Europe. Five cube-shaped samples were prepared by combining wood, cement, and some additives and labeled MAS1, SUR2, ALU2, ECO2, and S 5% D for salt frost testing in accordance with EU standards and regulations. For emissions such as VOCs, ammonia, and formaldehyde from the products, an emission test chamber was carried out. Lastly, a leaching test was performed to calculate the leachate concentration of the elements present in the product. Also, it comprises a study of the product's legal and regulatory framework, as well as the present state of standardization in Europe. In addition, several analytic methods were used to investigate the measurement of solubility/emissions of produced products.

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LIST OF ABBREVIATIONS

CFBC - Circulating fluidized bed combustion.

CCAs - Chromated copper arsenate.

EU- European union.

EWC – European waste catalogue.

EC – European commission.

MDF - medium density fiberboard.

MOC- Magnesium oxychloride.

OPC- Ordinary Portland cement.

PEG – polyethylene-glycol.

RH – Relative humidity.

SER – Specific emission rate.

TVOC- Total volatile organic compound.

VOCs- Volatile organic compounds

WFC – Wood fiber composite.

WID - Waste Incineration Directive.

1 INTRODUCTION

1.1 Research question and problems.

The problem related with the environment, such as wood waste disposal are increasing day by day. In Europe you will find that there are different types of wood waste which amounts in tons. The main idea behind this research is to use the wood waste as a reinforced material to make composite and the low-density product manufactured from cement or ceramic filled with wood waste has gained popularity in recent years. In the 19th century, it was used for manufacturing interior walls and ceiling panels because of the resultant properties of the composite, such as fire resistance and the sound barrier. Further, the cement matrix also provides good dimensional strength as related to solid wood and it is easily available worldwide at a low processing cost.

The research question is that how wood-cement composite will react to different conditions of three different tests. The salt frost test will be carried out to investigate, the percent of mass loss in the product after tolerating the thaw-freeze cycles. The information related to the concentration release from the product will be checked with the help of leaching test. Finally, a volatile emission chamber test will be performed for getting information concerning the emissions form the product like ammonia, formaldehyde, TVOC and what are the legislation and regulation for the wood waste in Europe. Overall, investigating will be carried out to find either our samples is suitable for use while keeping all these tests in mind.

1.2 Wood waste

Europe generates up to 16 tons of waste materials per person in a year, and 6 tons of this waste becomes landfills. The overall rate of waste generated in European union estimated about 2.5 billion tons in 2010. The sum of the seven billion tons of non-chemical generated in 2002, a small share of 36 percent was recycled, the leftover was landfilled or burnt (European Commission, 2020). The European Union finds the liquid waste produced to be dangerous and illegal to dispose of. As per the rules of EU, material which can be discarded or the owner of it wants to throw is commonly named as waste (Jansen, 2013).

Wood is one of the most flexible raw materials which is used in different forms such as paper, packaging, decor, housing, paper, and other industries. As stated in a Parliament briefing, in 2012 the wood waste made in the EU was about 52.9 million tons. Depending on the location and the building, construction and demolition waste make up approximately 46% to 50% of all the waste produced in the EU. Perhaps like a lottery, the nature of wood waste decides which of its components may be processed, used for electricity, or discarded in a landfill. The manufacturer of panel boards in Europe uses around 13.3 million tons of wood at the present, and 7.7 million tons of old boards are discarded annually (Samuele Nannoni, 2019). Wood is an incredibly flexible material. This is because wood differs in its hardness. The material comes from various sources and can vary. For instance, it can come from real wood from a forest, off-cuts and sanding dust from different buildings and furniture, and wood from packing products. All these are surplus wood that has been processed with wood treatment agents (Foen, 2019). Different origins (municipal, commercial, and industrial), as well as different kinds of wood waste (preservatives, etc.) may come from different sites (construction and renovation, municipal, etc.) (Defra, 2012). Several sectors manufacture products that must be disposed of, which include plastic, concrete, glass, and wood. Wood waste is broken down into various fractions—treated wood that contains preservatives, as well as non-and post-consumer waste—all of which may be found in a wood waste landfill Figure 1 depicts the approximate percentage of wood waste produced in Europe (Jansen, 2013).

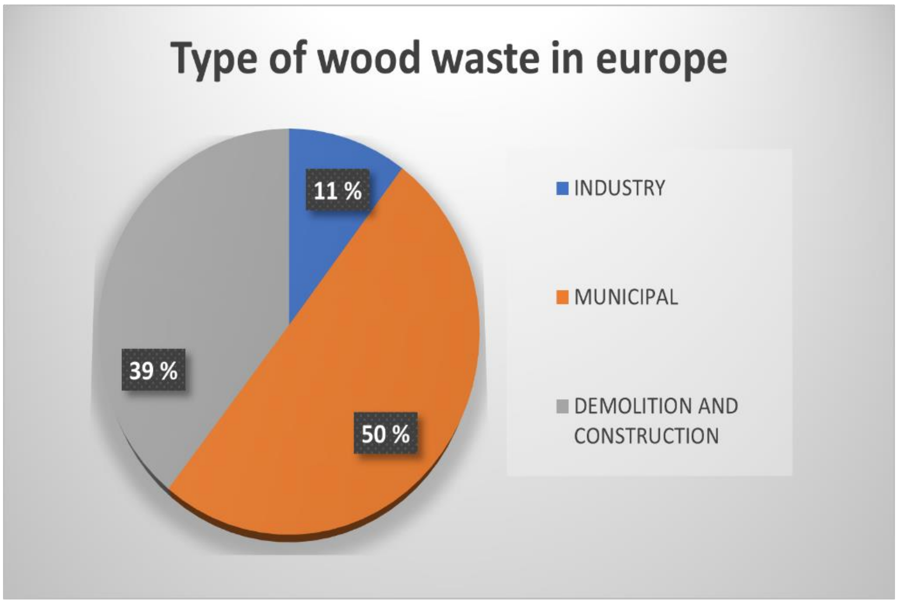


Figure 1. Types of wood waste in Europe (Jansen, 2013).

1.2.1 EU wood waste legislation

In one study it was stated that wood refining, gathering of wood, at the end of its planned usage, and even at the end of its utilized lifespan are the types of processes used to generate wood waste. Wood waste that comes from logging is deemed comparatively safe and it comes below rules of the timber made by European union. He defines this waste wood as having more than 50% of wood and often, as being a wood-specific waste. Everything that is processed by one company is usually recycled by another company, such as timber. About 22% is treated as post-consumer wood, which is 9% used for commercial uses, and over 12% is treated as energy waste (Mantua, 2012).

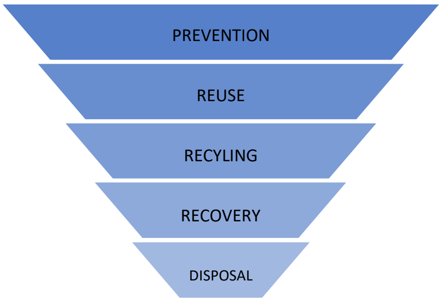
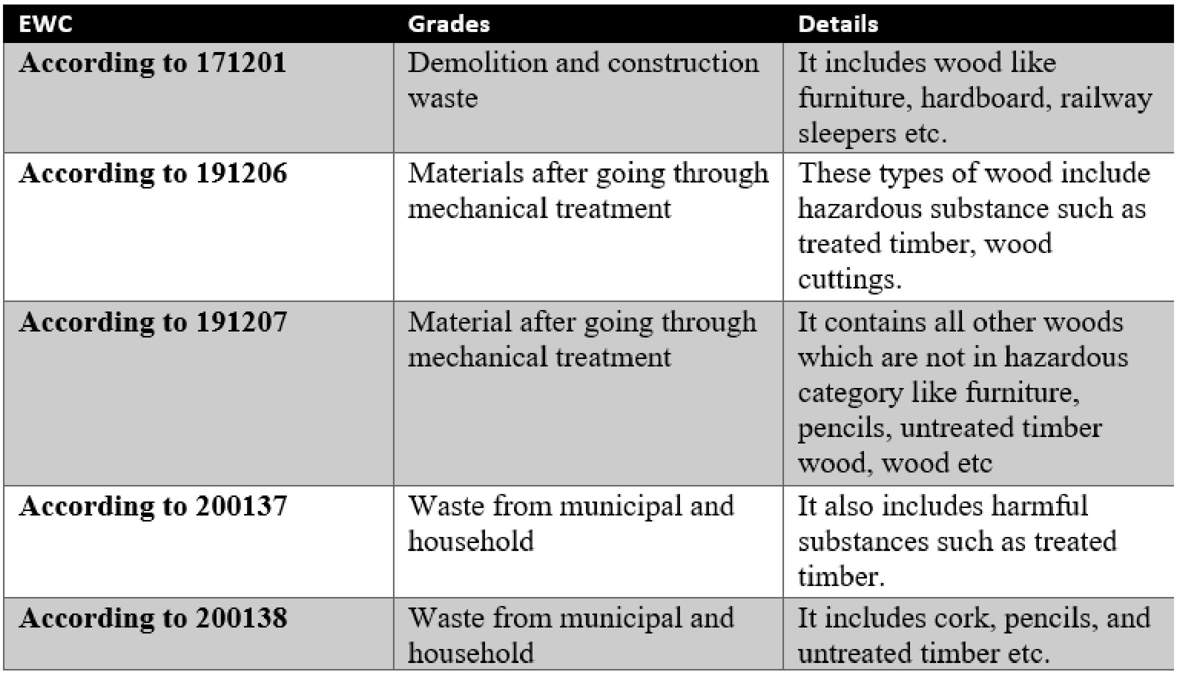


Figure 2. Waste Hierarchy (Mantua, 2012).

In the European Union, officials produce rules and guidelines that in turn set the criteria for each nation concerned. A guideline is not explicitly available as a law, but it should be implemented for national regulation (i.e. the European union Directive) within a certain period (one to three years). The guidelines are aimed at establishing a similar baseline expectation from each nation. The idea is that each member of the EU can enforce tougher sanctions on their residents. It states that the Waste Hierarchy is a visualization of when and how various end uses are integrated into waste. There is a law stating the regulations acts for importing and exporting of waste (166/2008). The Lisbon treaty has overall optimistic consequences for fostering environmental growth in Europe. It is based primarily on its polluter pays price concept. Below you will see the waste catalogue for Europe (EWC) concerning about the grades of wood waste. (Junginger et al, 2018). Table 1 shows the details of wood waste concerning the grades.

Table 1. Grades and details of wood waste according to EWC (Junginger et al, 2018).



EWC	Grades	Details
According to 171201	Demolition and construction waste	It includes wood like furniture, hardboard, railway sleepers etc.
According to 191206	Materials after going through mechanical treatment	These types of wood include hazardous substance such as treated timber, wood cuttings.
According to 191207	Material after going through mechanical treatment	It contains all other woods which are not in hazardous category like furniture, pencils, untreated timber wood, wood etc
According to 200137	Waste from municipal and household	It also includes harmful substances such as treated timber.
According to 200138	Waste from municipal and household	It includes cork, pencils, and untreated timber etc.

1.2.2 EU Laws and regulation

Directive 1999/31/EC of the Council of 26 April 1999 concerning waste landfills (European commission 1999).

This directive was adopted because it is considered that landfill pollution poses a concern for the ecosystem. Its main objective is to minimize or avoid the landfilling generated in all of Europe, and to eliminate the bad impacts related to it. The other initiative which controlled the market was the "Waste Directive of the European Union", which specified various types of waste, such as municipal, dangerous, non-hazardous, and inert waste. This latest policy requires that member states reduce their dumping waste by at least 75% by the point of the law, or they will be evaluated for a landfill exemption. Finally, the delegates want the majority of Europe to get on the program too. The directive specifies the forms of waste that should be properly disposed of in landfills. We will have, in effect, a Circular Economy

Directive as we drive towards a Circular Economy as a means of reducing waste. The latest legislation on the regulatory directive came into practice in August 2009 (European Commission, 1999).

Industrialized pollutants Regulation 2010/75/EU (European commission 2010).

This new directive changed the old Directive 2000/76/EC and is a newer revision of Directive 2000/76, that emphasizes environmental preservation by requiring a more sustainable way of incinerating waste (WID). The directive dealing with waste management in the European Union, incineration, and co-incineration, works within the European Union. It establishes specific standards for the polluting amounts of contaminants being emitted into the water from an incinerator and into the environment from a waste incinerator. It further specifies the operational conditions of an incinerator and the technical specifications of an incineration facility. The main goal of these two directives, ETS Directive 2001/81/EC on polluting gas regulation and EEDP Directive 98/70/EC (which is also identical to the US SO2 Directive from the 1970s), for removing air emissions from waste plants and promotes the waste renewable energy recovery (European Commission, 2000).

Rule (EC) No 2150/2002 of 25 November 2002 was made to get proper waste statistics in the European Parliament and the Council (European commission, 2002).

This legislation is the one that governs the production and preservation of waste management statistics at the EU level. Standards like those featured in the Average Number of Children Supported per Member State Listed from the ELMO program are a valuable instrument for the EU legislators. The European Commission released a research report on electronic cigarettes (European commission, 2002).

According to the law (EC) No 1013/2006 of 14 June 2006 was made for importing and exporting of waste in the European Parliament and the Council (European commission, 2006).

The legislation allows shipping waste to be more efficiently processed by member states. The ministry laid down unique procedures that allow people to learn about their world more frequently. It keeps track of the flow of waste within each member region. The law defines the paperwork that needs to be sent to the government and the basic protection procedures that ought to be taken before transporting electronics. The legislation is made up of waste that will not be permissible as hazardous waste and is based on the International Basel Convention. And it has a very big anti-smoking advertisement program (European commission, 2006).

Directive 2008/98/EC of 19 November 2008 was made for removing excess regulation on wood waste which are not efficient in the European Parliament and the Council (European commission, 2008).

The directive sets out a legislative system that requires waste to be handled more efficiently in the European Union. Law 141/2000/EC also describes a range of words relevant to waste management, including ‘waste', ‘hazardous waste', ‘waste management', ‘recycling', ‘disposal', ‘treatment', and ‘prevention and control'. The order is indeed within the purview of the government. Introducing the principle of the waste hierarchy and polluters pay a fee. It is the initial directive that lays the foundation for all future directives on waste in the remaining years of the EU. This Directive came into enforced form on 12th December 2010. A modern medicinal application of nicotine will be possible beginning in 2010 (European commission, 2008).

1.2.3 Forms of wood waste

Because of the possible environmental dangers associated with various forms of wood waste, it generally gets categorized under one of the four categories such as untreated, scrap, used and issued wood waste, respectively. Unburned timber prepared from manufacturing, logging, and sawmills are both called "Natural Wood." Used wood waste is considered natural wood as well. Hardwood is excellent content that we can manufacture for free from sawmills, carpenters' workshops, and furniture factories with no damage or waste when we are finished (scaffolding planks, struts). Wood is used in various styles of items in our lives, including, though not limited to wood construction components, wooden wrapping, and wooden furniture. Issue wood waste involves mangled timber waste, scored wood waste, glue waste, and wood treated with wood protector agents and gluing tiny wood shavings into waste (Foen, 2019).

1.2.4 Grades of wood waste

For the practice of wood processing, the wood is divided into four divisions (i.e. class-A, class-B, class-C, and class-D). Before wood can be sorted and used for other uses, it must be efficiently divided into these sub-grades. It is stated that in the processing of wood, there is no segregation of the different grades of wood, especially grade A wood and grades B and C wood. There is no explicit segregation; nevertheless, there are several minute variations in the classification between grades A and B, and between grades B and C. The safety of goods from harm must be affected by efficient and adequate containment. Throughout this entire session, we have been talking about the need to have proof of the efficacy of segregation into these grades and assurance of whether there are management controls in place to maintain such segregation, to provide legal clarity for the potential end uses. Delivery practitioners can contact them to ensure they follow all importation & export regulations (Budioni).

Grade A timber, which is primarily reclaimed wood from wood component, which is untreated, process off-cuts, wood waste produced from manufacturing, scrap pallets, packing cases, and cable drums was used for this plant. To guarantee that the highest quality of criminal proof is being presented in court, stringent segregation must take effect, and, in a manner, which is as like the initial crime scene as practicable. In my view, there are quality procedures that should fulfill those products. The wood can include Grade A wood (as if from reputable wood sources), along with other wood from building and destruction. (Budioni).

In certain instances, grade B waste wood can be considered as the wood used as a chemical pollutant and should be often used in panelboard manufacture. Grade C can include grades C that are wood products that are from similar origins, or that are the products made from panel such as MDF, panel board, plywood, etc. That is, the products that are not completed, or those in the treatment process after being subjected to heat treatment. Under EU Decisive Regulations (Directive 2009/100/EC), classified C chemicals, which typically contain waste wood such as scrap wood, are regarded as biomass fuel, although these products cannot be burned as fuel in a small appliance since they have a rather low BTU value, but they would be retained as raw materials or burned as fuel in the WID-compliant plant. Grade D is a waste wood that has been processed with CCAs or chromates. It is typically a faded brown color and has a pungent odor. It can only be disposed of by the proper form of incineration or toxic waste landfill (Budioni).

1.2.5 Demolition and construction waste in Finland

For the author Dahlbo, demolition and construction activity have increased in the present and are expected to continue because of demographic and socioeconomic developments and ageing buildings, as well as advances in construction technology in the next two decades. Construction and demolition waste are equal to around a third of the overall produced waste in Europe, although there is a significant variance between the various countries. In Finland the waste related to construction and demolition amounts to 41% of the total waste generated (Bachér et al. 2015).

The average of these amounts is larger in the central and southern European countries than in comparison to Europe as a whole. Wood waste accounts for about 41% of the building and renovation waste in Finland. This figure is considerably higher than the sum of wood waste produced in Europe's central and southern regions. Furthermore, according to a survey of demolished buildings in Finland, timber buildings accounted for 41% of demolished buildings (by gross floor area) between 2000 and 2012 (Huuhka and Lahdensivu 2016).

1.2.6 Classification of Grade-D wood waste in Finland

The general framework developed by Alakangas and Koponen is used to sort wood waste. This system divides construction and demolition waste into four categories:-

A-chemically processed by-products and residues.
B-chemically handled by-products and residues.
C-recovered fuel
D-hazardous waste (Alakangas et al. 2015).

1.3 Ceramics

Ceramic materials can be characterized as the combination of metals and non-metals and they have different flexible shapes of Ceramic materials are the most flexible of all forms of materials. The key chemical properties of these forms of molecules are the strength of their chemical bonds, because, while they have powerful ionic and covalent bonds, they still have weaker van der Waals bonds. Several characteristics of ceramics are specified (and are incorporated) in the bonds, including relatively high fusion temperatures, high modulus, high wear resistance, weak thermal properties, high toughness, fragility combined with tenacity, and poor ductility. Electrons, which are the conductors of energy, are dispersed from the vast numbers of electrons that are NO's and bind into form chemical bonds. The synthesis of the powders, mixing, shaping, and heat treatment are all methods of processing ceramic components, with sintering occurring either via diffusion in a solid state or the formation of an intergranular-liquid phase (Quesada et al. 2019).

Besides, the ceramic and cement industries use manufacturing techniques that allow the lessening of their waste very possible, either by taking advantage of the heat that is produced by the combustion process, or by integrating the waste into the framework of the products, becoming part of their matrix and being an inert product. Because ceramic materials have several properties that render them usable that cannot be derived from any other material, it can be inferred that ceramic materials would be very useful in all kinds of applications (Quesada et al. 2019). Glass is formed by elemental particle fusion and shape and is made up of atomic weight silica, calcium, and iron. Cement is a fine powder produced by combining, firing, and grinding minerals including granite, silica, and limestone, which tie stone and sand together by hydration because it becomes solid. Refractories (also classified as refractories) can endure high temperatures and are used in the building of kilns used in the making iron, steel, and glass (Balasubramanian et al. 2014).

1.3.1 Classification

Ceramic products are categorized into two categories depending on whether they are listed as "traditional ceramics" or as "technical or advanced ceramics". A ceramic (traditional) is a substance that can be divided into components of silica and ceramic that are uniform in scale, form, and composition and that are strong in thickness. Traditional ceramics are manufactured in very large quantities and are a very valuable sector. Many typical ceramic products are manufactured from raw materials that are mined in the natural world. Academic or specialized ceramics, on the other hand, are made from synthetic raw materials that have undergone chemical processing to improve the purity of the material. (Quesada et al. 2019).

This is since they are getting more modern and sophisticated. Prospective ceramic goods include carbides, nitrides, borides, pure oxides, and a broad range of ceramics with magnetic, ferroelectric, piezoelectric, and superconducting properties. These ceramics offer remarkable mechanical properties under high stress, high wear intensity, or excellent electrical, magnetic, or optical capabilities, as well as incredible strength at high temperatures and corrosive conditions, as well as excellent chemical resistance. (Quesada et al. 2019).

A third group of glasses is classed as glass-ceramics, although it is not considered a real ceramic since it has not gone through the glass-ceramic phase. It is, nevertheless, studied individually since it goes through a unique and distinct stage of development (Quesada et al. 2019).

1.3.2 Properties

Ceramics weigh a little lighter than metal and a bit heavier than plastics. The melting point for platinum is significantly greater than other metals. One form of pottery cannot fully decompose. The electrical and thermal conductivities of these materials are smaller than those of metals; nevertheless, the spectrum of values is larger, because some of these materials are insulators while others are conductors. The expansion of metals when heated is marginally smaller, however, enough to produce a more harmful volume of harm because of brittleness. Diamond is of high hardness, has electrical and thermal insulating properties, and is a chemical solid. When used incorrectly or improperly combined with other materials, brittle products may trigger problems in both the processing and performance of ceramic products. All ceramics (typically, glass) are transparent, where sulfate-based window glass is the clearest example (Balasubramanian, 2014).

1.4 Composite

When two or more components are macroscopically combined, a material known as composite is formed. However, one component represents filler\reinforcement and the other as a continuous matrix (Setter et al. 2020).

1.4.1 Wood-cement composite

Small pieces of wood when went under pressure with the cement, wood-cement composites (also described as fiber-cement) are made. Wood-cement composites could be produced with various wooden components of various sizes and shapes. These composites use significantly less wood as compared to other wood panels and, in some situations, a wood part is used as product filler to minimize the amount of cement used (canada et al. 2020). They have improved insulation, fire efficiency, water resistance, stiffness, and bactericidal properties to prevent the growth of mycelium and micro-organism (Fan et al. 2012.) Wood cement composites have excellent strength properties for construction materials and have good acoustic properties that include road sound barriers which are used extensively in many countries for interior as well as exterior applications (Na et al. 2014.) With closed edges, these composites have a higher tolerance to humidity and dimensional stability, but they cannot be cut as easily as typical wooden composites, and we must be careful when selecting the species because the cure of cement is inhibited by the sugar and other chemicals present in the wood (canada.ca, 2020). There is a loss in the strength of cellulose fiber due to the alkaline degradation and mineralization in cement composites has been concluded by many studies and the various issues with the contact of cellulose and cement can be reduced by selecting good quality of the wood particle (Wolfe and Gjinolli, 1997). The wood-cement composite will have good mechanical strength, better protection against moisture and it is in-combustible. Moreover, it consists of a biodegradable wood particle that can be considered better in terms of environmental aspects (Setter et al. 2020).

In contrast with concrete, wood cement composite can minimize the overall production costs, it can reuse the waste wood and it increases the thermal stability of traditional concrete panels while retaining the mechanical properties (Fan et al. 2012.) However, when wood (as wood) is used in clay concrete to reduce stiffness, the improved insulating capabilities are accompanied with a drop in mechanical strength and an increase in deformability (Jorge et al. 2004.) The binder which holds the cement maintains a tough surface that may also be embossed and polished for a beautiful, low-maintenance product. Over the last 60 years, cement-bonded wood-excelsior panels have been employed, but instead of strength and rigidity, the focus has been on acoustics, fire tolerance, and aesthetics. In recent years, the industry has concentrated on producing fiber-reinforced cement covering products. These goods usually use 8-10% of wood by weight, compared with 20-40% of wood particle composites. For these products, appearance is the key factor for their recognition rather than strength and resilience (Na et al. 2014).

1.4.2 Engineering Properties of wood-cement composite

- Bending strength and stiffness

There was a big emphasis on producing high strength fiber-reinforced cement products, but ultimately 50% of the study was on bending strength of wood-cement composites. It is used as the primary material in the manufacture of concrete with strengths ranging from 20 to 35 MPa, as well as a secondary material in the inclusion of solid fibers. There are several different bending capabilities for steel are in the range between 7 and 20 Mpa. Whenever there will be addition of particles of the wood to a composite will boosts its resiliency by inhibiting fracture growth. This feature allows the composite to carry a heavier weight and have a greater capacity limit. Figure 1 depicts the normal deformation of a load of a wood-cement hybrid. The first section of the diagram (AR Zone) is linear and represents the overall intensity of the cement matrix. The nominal composition of the figure decreases (phase separation) as it approaches full load. Under the pressure of the technology, the impression of order often bursts. The fiber or particle material continues to inhibit fracture propagation if we continue to focus about this source. When this technique is performed, the composite may be preferable to an ordinary fiber in terms of absorbing a little greater load or it may display a highly ductile breakdown, deflecting till the fiber-reinforced reaches a strain-limit (Campbell and Coutts, 1980).

Wood fiber reinforced cement products, according to a researcher's theory, have bending capabilities ranging from 7 to 30 MPa, depending on the fiber types, moisture content, and fiber diameters. Figure 2 depicts the impact of friction and temperature on the increase in bending power. Coutts ascribed the strength loss of more than 8% to the fibers' propensity to stack less efficiently after the fiber mass exceeds this threshold. The water helps to reduce the stretching power of the wires. Therefore, it has become more stable and less prone to breaking in the cement matrix. Producing an electronic cigarette from a high-yield, thermomechanical pulp takes longer than making one from chemical pulp, according to the research. The "poisoning" of the cement by the extraction of polysaccharides and wood acids, as well as the damage to the fiber, seemed to be the reasons for his experiment's findings. Unwanted compounds that were not eliminated during the chemical pulp phase are collected during the mechanical pulp process (Campbell and Coutts, 1980).

The wood particle-cement composites may be stacked in a variety of configurations, each with a different level of strength. Dr. Dinwoodie and Dr. Paxton of the University of Wisconsin offered various sample boards composed of wood-related material in the form of extremely small pellets, ranging in length from 10 to 30 mm and width from 0.2 to 0.3 mm. Drdlová et al. (2018) found densities ranging from 1.2 to 1.3 grams per cubic centimeter and intensities ranging from 10.1 to 12.9 megapascals (Drdlová et al. 2018).

The authors provided data on a range of commonly used composites (Fig. 3) in their research on particleboard strength, including fiber-reinforced cement particleboard and wood particle-cement composites containing 20% wood flakes by weight (Wolfe and Gjinolli, 1997). The quantity of wood had no impact on the bending strength of raw cement-bonded particleboard at a ratio of 1.3 to 2.3. With 90 percent confidence, there was no significant difference in the mean average strength of tabs made of lodgepole pine flakes with an average thickness of 0.6 mm and a Portland form I binder (Karam and Gibson, 1994).

- Compressive strength

When the timber-cement composite is compressed, the strength of different assemblies can distinguish depend on the quality and quantity of cement, and the type of particles used. An essay, which comes from a respectable scholarly journal, mentions that clay bricks could withstand the compression force applied by building materials. In this structure, the bricks were manufactured using shavings from pine planer and had a bulk density of 5 grams per cubic centimeter to 20 grams per cubic centimeter and some wood: cement ratio up to 1 to 10. A rise continues to arise in the tension at a certain stage in the deformation because of the limitation of the substance to break (Fig. 5). The slope of the initial rise in the slope rose as the wood: cement ratio declined. Here, the load was increased as the number of layers was changed, and the compressive intensity of the blend did not adjust at the same pace with both packages. A tipping point was never met in a 15-mm displacement, and so about half of the research specimens received a compression pressure that was less than their initial compression strength (Zziwa et al. 2006).

The FPL's concrete tests on wood-cement particle composites were like the author's in that the test samples' height was higher than their breadth, and failure was more akin to buckling than pure compression failure. The loads were contrasted in this case, resulting in a deformation pattern. The usual trend was beginning to see a kind of shift in stiffness that was fully due to the compaction of the particulate content. When the matrix went out, the samples started to break. As the convection proceeded, the load decreased at first by 30 percent, then decreased steadily or before the convection phase stopped. As a part of this research, a factoring of 1:2 was implemented point by point to tailor what was being said to the science and technology world (Zziwa et al. 2006).

- Toughness

Toughness is a calculation of how much energy a test uses for each subject in the experiment. The area beneath the load-deformation curve determines the results of a computation. When characterizing a material or piece of equipment, keep its hardness in mind. One unit is typically used to define a notch starting at a fracture surface to measure fracture durability. The fracture area versus energy is used to calculate/measure toughness (length times width). The paper is also tested under severe stress, and this term is often used to describe the long-term durability of the fracture that results. The ASTM C 1018 standard for fiber-reinforced cement defines a set of hardness indices in the concrete industry. These indices are less than, but very similar to, the region under the load-deformation curve, up to deformations of 3, 5.5, and 10.5 times the deformation at the first crack as a multiple of the first crack's area, up to deformations of 3, 5.5, and 10.5 times the deformation at the first crack as a multiple of the first crack's area (at least three times the intact surface area). Because concrete has a hardness index of one, the initial crack is critical for it to collapse (Wolfe and Gjinolli, 1997).

1.4.3 Factors affecting the quality of wood-cement composite.

The characteristics of the original components (i.e., organic filler, mineralizer shape, nature, and application of cement); the composition of the original components; technological factors (conditions for the manufacturing of wood-cement mixtures, manufacturing process, and densification and hardening method) are key factors that determine the quality of wood-cement composites (Frybort et al. 2008).

- Properties of original components

Wood and cement are also evil since they are antagonistic in design. Most of the wood is made up of different organic compounds (cellulose, hemicellulose, and lignin, among others) which account for at least 99% of the wood content. The elemental chemical composition (carbon, hydrogen, oxygen, and nitrogen) of wood is almost indistinguishable from all other organisms. In the arrangement of wood-cement blends, there are the quantities of hemicelluloses and extractives entering a chemical relationship when combined with wood filler and cement and which decide the consistency of the general wood cement composite.

Scientists in many disciplines take for granted the physical, structural, and chemical properties of wood when determining the suitability of the wood but are ignorant of the chemical and molecular structure of water-soluble substances that affect the quality of the wood used in the composite material. To get the highest quality wood-cement composite products, to get the lowest volume of water-soluble substances, it is suggested that the usage of branches of fir trees, or even oak trees is preferred. Species such as aspen, birch, poplar, beech, and other hardwoods typically have higher amounts of water-soluble compounds. The usage of various water-soluble contents, such as PEG and PLIB, may lead to major differences in the set period of the clay-cement mixture and affect the strength of the adhesive joints. As a result, wood-cement composites, made from various wood forms, have intermediate properties, both physical and mechanical. To decide whether chipped wood may be used for the manufacture of wood-cement composites, a GOST 54854-2011 defined suitability test is performed (Frybort et al. 2008).

The fractional concentration of organic filler composed of a chosen wood has a major effect on the properties unique to the wood-cement composite product. The average value of the form factor of particles (the ratio between the largest and smallest dimension) should not be higher than 8 (Frybort et al. 2008). The reliability of the connection between the structural elements as well as the strengths o all the respective bonding structures demands that the consistency of the wood-fiber-cement composite make up the strength of the construction and must be considered. The analysis of the adhesion of the cement to the wood provides good solid proof of the poor adhesion of the cement compared to the material. This consistency (low strength) of the wood-cement composite does not follow it being a non-deformable composite as it cannot survive as much environmental loading as stronger composites would. Also, a careful look at cohesive and sticky bodies is in order because these processes are intricately related (Frybort et al. 2008).

In the manufacture of wood-cement composites, liquid silica, calcium chloride, calcium nitrate, sodium sulphate, among others, are commonly used. These chemicals that we are applying to the mixture, are inserted into the mixture, such that they render the mixture heavier, and that they make the mixture tougher, and then they even make the mixture of the wood and the cement work in a certain manner. The types of food additives, which slow down the impact of harmless substances with a water-soluble are added, or they coat filler particles with a waterproof film which prevents the interaction of harmful substances inside the filler, with the cement paste. The option of chemical additives to the flavored solvent chocolate depends on the form and consistency of the filler, as well as the sugar content in savory water-soluble substances of the wood filler (Frybort et al. 2008).

- Composition of the primary component

In the development of a wood-cement hybrid, the composition of the wood and the cement has a major impact on the composite's different properties. We found that the elasticity modulus, rupture modulus, tensile power, and creep of the wood-cement composite decrease as the class (grade) of the wood increases. The greatest qualities of all forms of concrete—as in the optimal state—are where the ingredients are used together. As a result, in the optimal state, the wood-cement structure is one of the best products. A scheme of the best arrangement of the commodity is described by the uniform distribution of the solid phase in the dispersed phase, numerous types of processes, an optimum particle packing density, inclusion of the continuous layer of binder, a good structure of the conglomerate, a good solid phase system, and efficient support of the conglomerate are required, respectively. In the factory laboratory, the essential criteria when selecting the composition of the wood-cement composite is to achieve a certain average density and a specific amount of compressive strength with the least possible amount of cement accumulation. The combination of the water-cement ratio W/C and the wood-cement ratio D/C has a considerable influence on the consistency of the wood-cement composite. The strength of the wood-type composite may be improved by decreasing the amount of water of the wood of the mixture or increasing the amount of the concrete of the mixture (Sanaev et al. 2016).

- Technological factors

Experiences have shown that technical influences have a significant impact on improving the consistency of wood-cement composites and on altering their characteristics. This is the explanation that, when these components are molded, the various properties of wood-cement composites material are influenced by the crushing phase of the wood-cement mixture. The characteristics of wood-cement composites depend to a very significant (or very distinct) degree on the molding method and the degree of compaction of the wood-cement blend in the manufacturing of the goods. (the degree of compaction... all firms do not do this) If the pressure on the wood-cement composite has improved considerably, the efficiency of the wood/cement composite would improve dramatically. The added content could raise the molding pressure from 3.5 to 4.4 megapascals (MPa) to a value of 10.0 to 16.0 MPa with an indicated increase of cement use from 200 kg/m3 to 450 kg/m3 (Na et al. 2014).

1.4.4 Compatibility of wood-cement composite

Wood-cement composites are practically incompatible with species such as oak, particularly when the wood cement is produced with acidic phenols. It has been seen that different wood-cement adhesives will perform better on different types of trees. It is critical to verify that the wood is consistent with the concrete while evaluating its effectiveness for use in the manufacture of wood-cement composites. Currently, several various measuring and research techniques are being used to differentiate wood from different varieties such as oak, cypress, and hickory based on wood's hydration heat, temperature, electrical conductivity, and form as to its consistency with cement. Using inorganic chemicals speeds up the process of making cement or improving the compatibility of certain wood types for making wood-cement composite boards by pretreating them with aqueous extraction. This paper examined the kinds of new studies on wood-cement compatibility and its significance, as well as the explanations for the strength of the wood-cement incompatibility issue, and the results of the causes and measures of wood-cement compatibility to get a better understanding of the situation (Na et al. 2014).

In the area of wood-cement composites research, the word "consistency" refers to the degree of cement setting after being combined in a split form with water and a certain wood. As a rule, when cement is used as the main or single substrate of structural integrity, wood-cement consistency is a measure of the relative proportions of these materials in wood and cement. When any one of the essential building blocks of timber, as well as water, sand, and/or air, are present in the mortar or concrete, compatibility is a measure of the relative proportions of these in the wood and cement. Compatibility is not, however, a measure of the relative proportions of wood and cement in wood. Significant findings of the paper are that touch phenomena could occur in the bridge joints and that the samples studied for physical properties got less solid, thereby losing their integrity (Jorge et al. 2004).

1.4.5 Cause of incompatibility in a wood-cement composite.

The thinking process goes like this: Wood removes everything from cement (edges, holes, oaks). This other item influences the hydration of the cement (e.g., making the mortar a nice look, structure consistency, etc.). The real suppressant thought process is: The hydration of cement relies on the substance in the cement and the water-binding capability of the cement. There was a reading where it was discovered that nuclear pine (pine bark) hydrates at a pace five times slower than the heartwood, and any boards from it were unsuccessful at causing the concrete to harden (Jorge et al. 2004).

As there are sugars and starches present in wood, particularly in softwood, wood extract enzymes have varying degrees of optimum or retarding hydration, resulting in a different portion of an interesting or matrix activity; it has previously been known that these are the most significant inter-variables that allow wood and cement to be mutually incompatible. Not all sugar molecules have the same inhibitory impact on the body. According to the research, the main cement-hardening inhibitory components are glucose and sucrose. Concentrated sucrose has a stronger retarding impact at the same dose than glucose since its circular shape produces more steric hindrance than glucose's chain structure (Na et al. 2014).

However, Sandermann and Brendel's (1956) research revealed that certain sugars, including fructose, did not have significant effects on concrete hydration, even at about 0.5%, while other sugars inhibited it at about 0.25%, and gluconic acid, along with polysaccharides that were not sugars, completely inhibited cement hydration at a concentration of about 0.2%. Sugar and asphalt can emit various types of ultrafine particles. The cement will have fewer releases but would still have ultrafine particles with super-heating and super-cooling properties. A small volume of hemicellulose (0.1 percent) has been shown to significantly decrease the curing strength of cement and to have a great impact on the hydration properties of cement paste.

On the impact of various extracts on the period to seal hydration, they tested the influence of different extracts on calcite hydration in different types of plants. In contrast, the analysis did not find any of these to be the main retardants for hydration. The reason may be the existence of trace elemental tannins. In forest oak, acetic acid and phenolic compounds are shown to be the key retardants of hydration. In addition to inhibiting cement hydration, organic acids such as acetic tannic acid and other phenolics may also slowly strike and sever the cement bond, resulting in a decrease in panel strength values and impacting the other properties of the panel (Jorge et al. 2004).

1.4.6 The influence factors of wood cement-compatibility

- Wood species

Every form of wood has drastically different alkali compounds which are found in the wood extractives because they have different effects on the chemical reaction of the wood as it is placed on cement. Softwoods are usually less compliant than hardwoods. In the softwood insertion period, erythrosisxanthus inserts softwoods, after they have been water-logged for the prescribed time. Scientists investigated the compatibility of wood species by examining the growth of several wood species in diverse locations and calculating inhibitory indices for softwood and hardwood species. According to the findings, lodgepole pine has a high degree of harvestability (Na et al. 2014).

- Part of wood

Another aspect is that the wood can be different from the other bits of wood. The heartwood from the tree was found to require significant inhibiting of the concrete hydrating capacity, and the wood-cement boards produced with the heartwood have very little structural integrity, while boards made from the sapwood have been made industrially and commercialized. The heartwood had better solubility than the sapwood, showing a larger number of compounds that would keep cement from settling (Evans et al. 2000).

- Storage condition of the wood

The wood-cement mixture can be influenced by the conditions of wood storage. A lot of research has shown that the preservation of logs outdoors for forty or fifty days by itself does not affect the final structural strength of the wood in the logs, but it does decrease the wood sugar content, rendering it more beneficial to the manufacture of wood–cement composites (Na et al. 2014).

- Type of cement

Besides the OPC, in recent years, magnesium oxychloride cement has been the most used material to make wood-cement composite products, such as MOC-wood fiberboard, straw-MOC thermal insulation wall fabrics, bamboo-MOC particleboard, and so on (Li et al. 2018). Micro-elements (such as Carbon Nano-element, Ceramic Nano-element) have been integrated into structural concrete to create a safer composite that is fire-proof and can withstand heat, more solid and can be compacted, stronger and can eliminate shrinkage and creep. (Na et al. 2014).

Compared to the ordinary Portland cement, the MOC cement that matures relatively slowly takes a period longer than the traditional one to completely set, and there is reasonably strong compatibility with wood species, so this MOC cement may be a good replacement for Portland cement to produce particleboard primarily for the wood species that have little compatibility with Portland cement. It is observed that incorporating the external bamboo will powder into a cement mixture improved the internal MOC heating power, and the inclusion of different bamboo powders increased the flexural and compressive strengths of the cement mixture (Na et al. 2014).

1.5 Wood-Cement composite manufacturing process.

The manufacturing of wood-cement composite follows a general layout as you can see in figure 3.

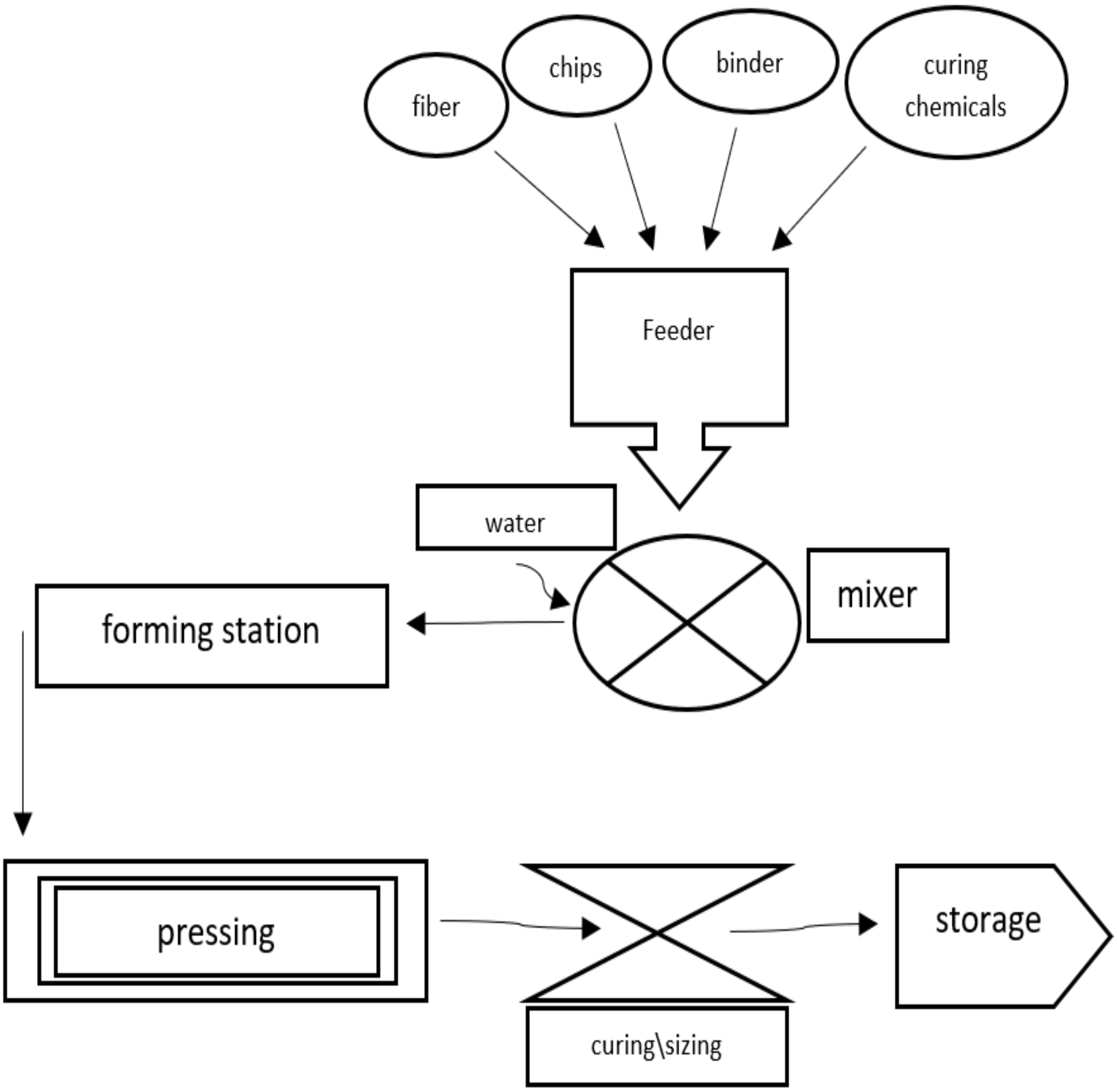


Figure 3. General layout of wood-cement composite manufacturing process (Sahini et al. 2019).

The method which is used for fabricating the product with thermosetting resin can be separated into several categories, including

-Preparation of fiber

-Mat formation

-Pressing process

-Curing and drying.

Despite this, the process of pressing and rubber band formations may be on a continuous or segmented timeline. The dry or wet blending and forming operation is used to determine the moisture content of wood threads or particles. Since the process necessitates the use of water, particularly when using dry methods, it is normally higher than by using thermo-setting resins to make sheets or panels (Sahini et al. 2019).

In addition, for thermo-setting tables, the expanding process involves an "extremely hardening cycle," which takes a very long (up to 4 weeks) time. On the other hand, the rate of strength development in thermo-setting materials allows for the discharge of rapid compression force in a very short period of time., concrete-filled panel products need a curing cycle before they can be used, as well as an 8-hour press time. The content might have solidified by the time this is done, so the boards are returned to their original position and reused as expandable material. Many binders need additional time to reach their full strength. Nonetheless, processes of manufacturing may be classified into three basic categories depending on the quantity of water in the furnish (Sahini et al. 2019).

-The wet process
-The semi-dry process
-The dry process

The paper products, such as corrugated boxes and extended paper, are manufactured using a water-based manufacturing technique basically called wet process. As per this process, fine-distilled wood slurry (fiber-free) aggregate mixture (aggregate combined with water), as well as additives, is formed into a mat, which is then de-watered in a vacuum-sealed chamber. Consequently, since water is found in the chemical solution, it can melt a portion of the cement, resulting in a saturated solution. Tricalcium silicate hydrate crystals formed, which then expand and segregate to give way to tricalcium hydroxide. The sections of tricalcium aluminate and trisodium sulfate mixed into the solution formed before and trisulfide would be formed (Sahini et al. 2019).

Hatschek is the global standard for making wood-based boards. Although the Hatschek process starts by soaking wood shavings in water and combining them with cement, the first step includes mixing them in a certain proportion. The chemicals are used to create a pulp that is light and textured. This super slurry is conveyed via a sieve cylinder that is part of a sieve decking unit. After the cylindrical slurry flow is delivered to it, the forming cylinder rotates the skimmed off to a thin layer to create a smooth layer on the forming roller. Water can be squeezed through the layers of the mat until it reaches the desired thickness, at which point it is reduced in size and sent to a pressing chamber where pressure is applied to remove any remaining moisture. The panels are submerged in an 80-100 percent liquid environment for 8 hours after the cement has been taken to a final total of about 60% and held at around 90-95 percent humidity for the remainder of the hydration process. Depending on the preferences, these panels must be stapled or stapled and hand-autoclaved once they have been extended. When one sheet is stacked on top of another and left at room temperature for three to four weeks, it is said to be air-cured. In figure 4, you will see a general Hatschek process chart (Bodnarova et al, 2005).

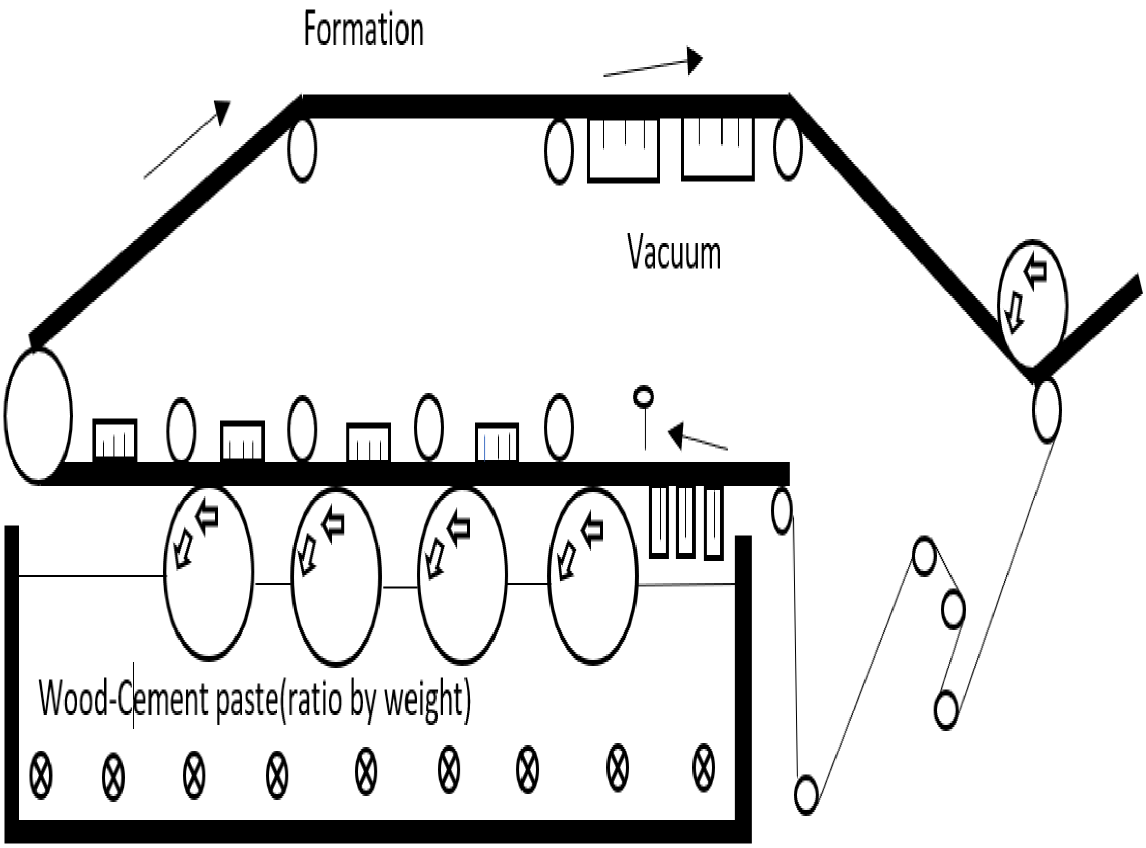


Figure 4. A general Hatschek process chart (Şahini, 2019).

The water to cement ratio in the semi-dry phase is about 0.5 to 0.8. The extremely viscous mixture is compacted by vibration or light pressure after mat forming in molds by mechanical machines. However, after compaction, wood wool boards (Excelsior) produced with the semi-dry technique (casting process) need continuous strain. The moisture emitted from the wood particles during pressing makes up a portion of the necessary water for hydration in the dry phase. Wood cement boards made of shavings, however, do not need sustained compaction pressure. The spring back forces in boards built of refined wood fibers are negligible after pressing as compared to particles or flakes. Consequently, fiberboards may be reinforced without being compressed for an extended period. (Şahini, 2019).

2 PREVIOUS EXPERIENCES WITH WOOD-BASED COMPOSITES

2.1 Coupling agent for wood-based composite

The strength and durability of cement-based materials and components are defined by the role of the structural bonds formed. Many such bonds, which develop between the concrete constituents' particles or aggregates, and, in our case, for both cement materials and fibers, are highly resistant to mechanical, physical, and chemical action. Coupling agents were applied to the surface of the fibers in the hopes of marrying the chemically incompatible fiber cement components of the composite structure together, resulting in a long-lasting interfacial bond. To determine flexural strength and energy, Robert S. P. Coutts performed tests on the use of common binding or coupling agents on wood-fiber reinforced composites. He looked at how binding agents affected the interfacial relationship between reinforcing fibers and the matrix. The 'Chemical Bonding Hypothesis,' which proposes that the coupling agent works as a connection between fiber and matrix by forming a chain of covalent chemical bonds, is the most widely accepted explanation to produce coupling agents. Silanes, which offer the largest variety of uses in composite materials, were three of the coupling agents employed in the research. In this analysis, commercially available silanes such as (Z-1225, Z-6031, and Z-6040) were used (Coutts, 1980).

The weighing matrix was ordinary Portland cement. The composites were made with a 40:6:1 blend of ordinary Portland cement and water by weight. The experiment was conducted using a General Electric puncture tester. Chemical functional groups on the surfaces of the additives used in this analysis may theoretically react with groups on the surface of lignified wood fibers and the cement matrix, serving as a binding agent. The coupling agents were designed to be water miscible in their final state, but before applying the matrix, the fiber would be slurries with the coupling agent solution. One such illustration (RSC-1) shows improved modulus of rupture values after a 28-day cure. The modulus of rigidity was strengthened because of the wood pulp's contribution, which improved hardness and tensile strength. Due to the duration and direction of the fibers that hit a high point in their development and pullout, it is a more efficient elastic resistance during a strain that causes failure. It was discovered that the modulus of dissolution could be increased or decreased over time, as well as by growing or decreasing the usage of fracturing materials, but that fractural intensity and composites could not be modified (Coutts, 1980).

2.2 Chemical additives in WFC

The researchers used various test methods to investigate the behavior and characteristics of fiber in concrete materials, as well as to estimate the different properties of flexural strength, compressive and density, and chemical modifications of water-based matrices. Since, normal Portland cement was used with chemical additives, water soluble fluxes, and without fluxes. Three common wood mixtures were used with the three different WFC mixtures, which had ratios of 50/40 percent, 30/70 percent, and 40/60 percent. Three different chemicals like magnesium chloride CH_3CO_3, calcium formate Ca$(CO_3)_2$, and calcium hydroxide $\mathrm{Ca(OH)}_2$ are needed to produce WF. The wood accelerant chemicals were used to speed up the overall setting of the mixture setting phase. The cement was sprinkled over the moist wood fibers after the mixture was worked and left to rest for 5 minutes. Expanders were mixed with the three wood/fiber ratios to see if wood/compare the variations in mass. Twenty-four cubes were constructed from chemically cured wood or raw wood, and another twenty-four cubes were made in the same manner, with no additional wood included. The sample was diluted 50 times after the water absorption and density tests were completed. The samples were held at room temperature (23°C) for 24 hours before being submerged in 25 mm of water. The samples had to be weighed to calculate their mass before compression, which included pouring molten steel into a beaker and calculating its weight, then straightening using a stretching system to maintain dimension uniformity. The tests, which used a 5000 N compressive force and a tiny test specimen to determine the modulus of rupture. The compressive strength of the WFC matrix rises as the wood/cement ratio decreases from 50:50 to 40:60 as shown in figure8. In figure9, the density was observed the same as measured according to the standard. At the ultimate loading, the strength of 30:70 wood/cement ratio matrixes decline and indicates brittle failure. The wood/cement ratio has little effect on water absorption as shown in figure10, but the existence of chemical additives has a substantial impact. The processed wood fiber matrix absorbs water in the same range as most wood cement composite products. In contrast to other moisture conditions and ratios, the authors suggested the accelerated aged boards with 40:60 wood/cement ratios as the combination configuration that achieves the best range of mechanical properties (Mst. sadia mahzabin, 2013).

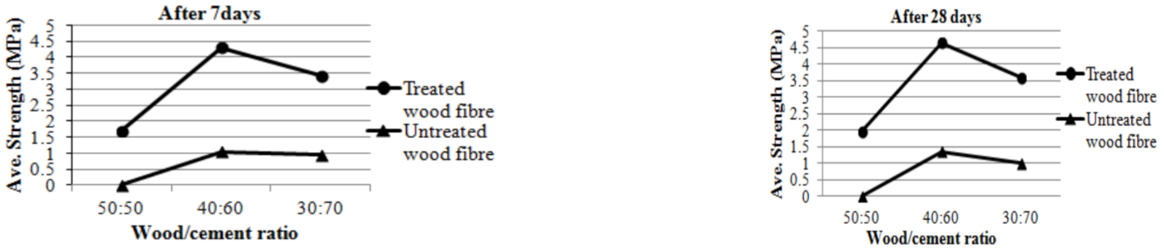


Figure 5. The compressive strength after 7 and 28 days with and without chemical additives at different wood\cement ratio respectively (Mahzabin, 2013).

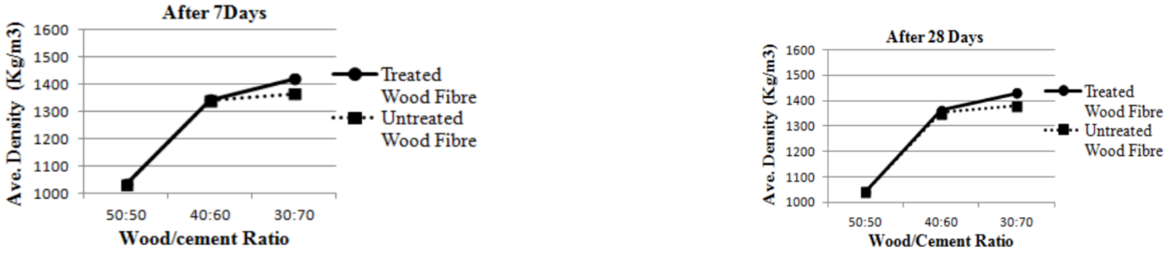


Figure 6. The density after 7 and 28 days with or without chemical additives at different wood\cement ratio respectively (Mahzabin, 2013).

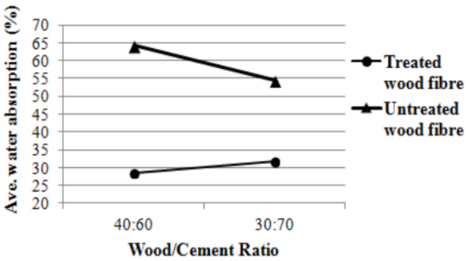


Figure 7. The water absorption with or without chemical additives at two wood\cement ratios (Mahzabin, 2013).

3 OBJECTIVE

The specific objective of this experimental research is to check the product safety of ceramic composites filled with recycled wood waste. It entails researching legislation, product regulations, and the current state of standardization. In addition, the measurements of solubility and emissions of manufactured products will be investigated using various analysis methods.

4 MATERIALS AND METHOD

In this section, we will discuss the materials and the manufacturing process of the product. For proper and accurate testing, we manufactured samples with different compositions such as ECO2, MASI, ALU2, SUR2, and S5. The ECO2 sample had a composition of three different materials. First, 5 percent of impregnated wood is over 100 percent. 90 percent of cement mortar and the remaining 5 percent of additives, namely Ecofax. The MASI sample also had the composition of three different materials, with 5 percent of impregnated wood, 80 percent of cement mortar and the remaining 15 percent of additives, namely Masuunikuona. The ALU2 sample was made up of impregnated wood, cement mortar, and alumina acetylation as an additive in proportions of 5, 90, and 5, respectively. The SUR2 sample had a composition of three different materials. To begin, 5% of the impregnated wood is empty.93 percent of cement mortar and the remaining 2 percent of additives, namely surfactants, and, lastly, the reference sample had the composition of 5 percent of impregnated wood, and 95 percent of cement mortar. In the manufacturing process, the raw material of individual samples is mixed individually with the help of an electric mixer. Figure 8 depicts the mixing of the materials.

Figure 8. Mixing of materials in an electric mixer.

Before creating the first core, an infill is applied to the inside surface of the mould. This layer prevents the concrete from sticking to the mould when the mould is used again and the thickness of this layer must be 10% to 20% of the height of the original sample. When it is placed in the mould, the concrete is to be at a consistency neither expanded too much nor compacted thoroughly, resulting in excessive segregation. Molds with the filled sample are shown below in Figure 9.

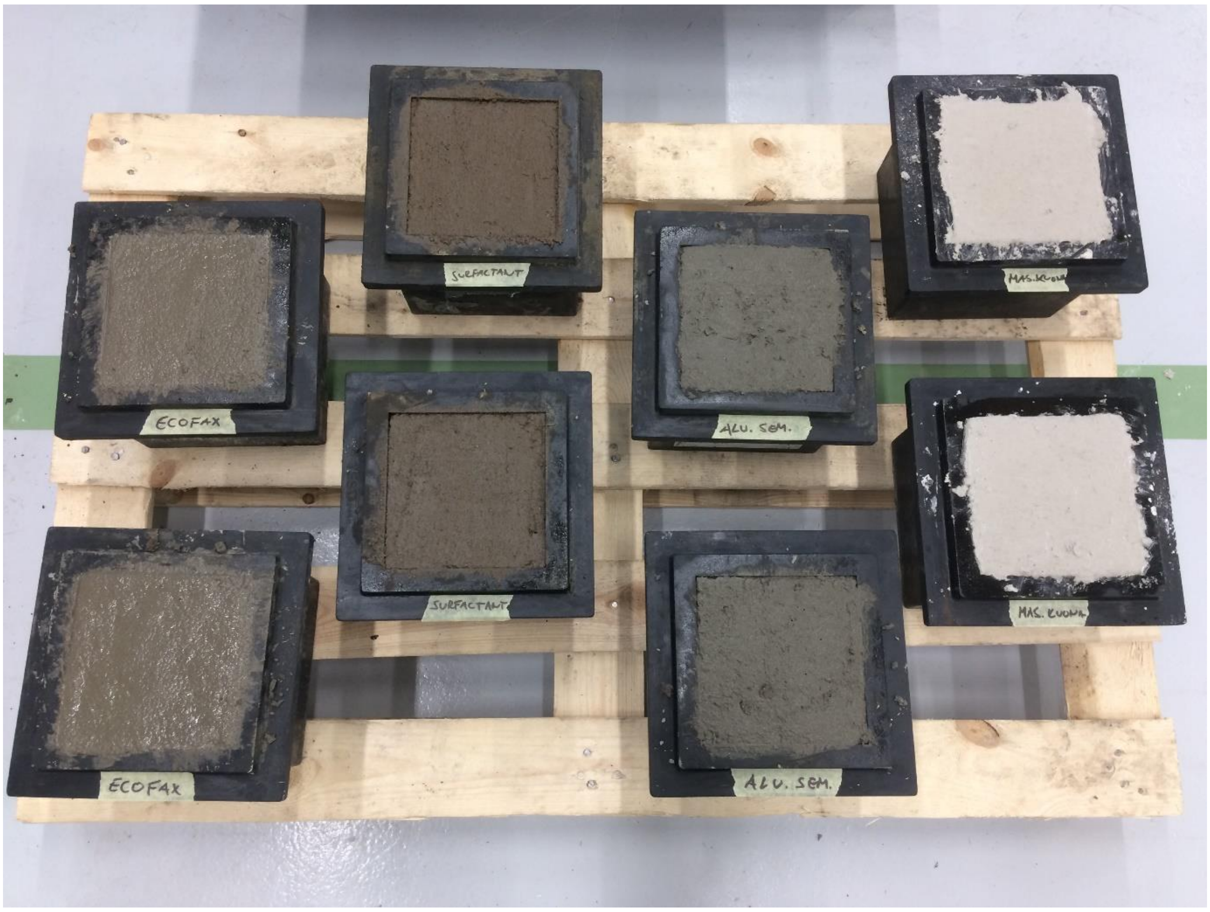


Figure 9. Samples inside the molds.

Then, the samples were removed from the mold. Before removing them, the samples should be in the mould for at least 16 hours, but not more than 3 days. For this condition, the temperature should be (20 ± 5) °C (or (25 ± 5) °C). When the samples are removed from the mould, the samples undergo curing as per the guidelines of the standard SFS-EN 12390-2.

4.1 Salt frost test

The salt frost test was done according to the instructions of SFS (EN 1338) standards, to determine the stability of the formulation in low temperature conditions. A square-shaped sample was manufactured for this test with the measurements of 00mm x 00mm x 00mm thickness. The sample was placed in the freezing chamber and exposed to repeated 28 freezing and thawing cycles. The temperature was maintained above 0 °C for each cycle for 7 hours. 3% of NACL was added in the thaw cycles to maintain a (5 ± 2) mm layer on the test surface of the sample. Scaled materials were collected and cleaned. The formula (1) is used to express the result.

$$L = \frac{M}{A} \tag{1}$$

where L in kilograms square per meter refers to the loss of mass per unit area of the sample, M in kilograms refers to the loss of mass after 28 cycles, and A refers to the surface area of the test surface in square meters.

Samples were coated with an epoxy layer and when they had dried, we used tapes to cover all the surfaces except the testing surface. To check for leaks, water is poured onto the testing surface. Below, in figure 10, you will see the samples before and after the tapes.

Figure 10. Samples for testing.

4.2 VOC emission method

The emission test chamber technique is used to evaluate the impact of environmental factors on the rate of VOC emission from building goods, according to the recommendations of the Finnish standard organization SFS (SFS-EN ISO 16000-9). The specimen was put in the center of the cleaned chamber, and the test was conducted at a temperature of 50 degrees Fahrenheit and a relative humidity of 50 percent (relative humidity). The relationship between the area specific emission rate, the area specific air flow rate, and mass concentration is shown in Formula (1). The sample's emission component was expressed using the equation (2).

$$\rho_X = q_A.(L/n) = {}^{q_A}\!/_{q} \tag{1}$$

where q_A refers the area specific emission rate, the area specific air flow rate is denoted by q. ρ_x mass concentration of a VOC_x in the emission test chamber. n and L refer to air change rate, product loading factor respectively.

$$q_A = \ \rho_x \ . q \tag{2}$$

4.3 Leaching test

There is one committee named "construction products: assessment of release of dangerous substances" under CEN TC 351. Under this committee, two types of leaching test are described. One test is called the horizontal leaching test, which is usually applied to construction products. Materials with a few deviations are normally subjected to horizontal leach checks. When no other information about the environment is provided, it is assumed that all standardization can be accomplished with demineralized water. CEN/TS 16637-2:2014 is one of many tests developed to determine the solubility of monolithic materials in construction products. It is used to measure leaching area [air-generated per fluorocarbon concentration inside buildings. This procedure is also known as dynamic or diffusion-leaching testing, and it is used in systems where diffusion is used to regulate the diffusion of potential substance leaching. In a monitored laboratory environment, test samples are exposed to water. Once the water has been restricted to a specific amount and time span, it is constantly recirculated to screen for target compounds. For the first 21 days of the test cycle, the contact duration ranges from 6 hours to 28 days, followed by a six-day period over the remaining 49 days. The obtained sample concentrations are used to calculate emission per surface area, which is proportional to the exposure period. It is possible to determine whether leaching happens through diffusion or other considerations such as washout effects at the start of the process based on the resulting emissions curves. (Nicole Bandow, 2018.)

The second test, CEN/TS 16637-3:2016, is related to the mass release of granular building products, called the percolation test. The granulated construction materials are infiltrated into the columns, and the percolation process is performed from the tip. Water is removed in stages until a specific liquid-to-solid ratio is reached. The results are shown as a ratio of liquid to solid so that it will be easy to differentiate between various leaching tests. (Nicole Bandow 1, 2018.) The experiment is performed with the help of European standard SFS-EN 12457-3. The testing follows close contact of the sample material (whose grain size should be less than 4mm) with water in various conditions. The test was achieved on the presumption that equilibrium should be accomplished between liquid and solid phases. Then, the filtration process was used to split the solid residue. The testing was done at room temperature. The blank test was carried out for the verification of the leaching procedure, so that if it did not fulfill the requirements, we could reduce the contamination before the test started. The procedure of leaching is divided into two steps. In the first step, we put the testing surface with the total mass M_W related to 0,175 $\pm$ 0,005 kg of dry mass into a 500 ml bottle, then to make a good ratio between a liquid and solid such as (L/S) = 2 l/kg $\pm$ 2 % add an amount of leachant (L_2) and mixing should be done properly.

$$L_2 = (2 - \text{MC}/100) \times M_D \tag{1}$$

L_2 , M_D , MC refers to the leachant volume (L), dry mass of testing surface (Kg), and ratio of moisture content (%) respectively. Give 15 min $\pm$ 5 min for the solid to settle down and then filter it.

For the second leaching test, put the filter and centrifugal part in 2-liter bottle, again add a leachant (L_8) with same condition as for the first test.

$$L_8 = 8 \times M_D \tag{2}$$

In which, L_8 is also refers to the volume of second batch. The equation (3) represents the calculation of the release quantity of first leaching batch at L/S = 2,

$$A_2 = C_2 \times [\left(\frac{L_2}{M_D}\right) + (MC/100)] \tag{3}$$

where, A_2 represents constituent release at L/S = 2.

For the second leaching batch test at L/S = 8, the expression is shown by equation (4).

$$A_{2-10} = C_2 \times \left(\frac{VE_1}{M_D}\right) + C_8 \times [(L_2 + L_8 - VE_1)\frac{(L_2 + L_8 - VE_1)}{M_D + (MC/100)}] \tag{4}$$

where, A_{2-10} refers to cumulative release at L/S of 10. VE_1 , C_8 is eluate volume recovered from the first batch and volume of second batch of leachant respectively.

5 RESULT AND DISCUSSION

Due to its many advantages and increasing use in different studies, wood-cement composite research has gotten a lot of attention in recent years. It is understandable that the WCC form may break or crack or loss of material because of environmental influences such as instant impact, production defects, form defects, poor maintenance, overload etc. The aim of the completed tests on these composites was to get information about the safety and stability of the product, a ceramic composite filled with wood waste. The results of these experiments on composites are presented in this section.

5.1 Salt frost test

The salt frost test started on the 15th of February and ended on 31st March, so basically, the test took one and a half months to finish. We used five different types of samples to complete this test. In all the samples, the wood material used was impregnated wood of class D with less than 4mm of its particle size.

The ECO2 sample was made up of three different materials. First, 5 percent of impregnated wood is over 100 percent. 90 percent of cement mortar and the remaining 5 percent of additives, namely Ecofax.

The MASI sample also had a composition of three different materials, with 5 percent of impregnated wood, 80 percent of cement mortar and the remaining 15 percent of additives, namely Masuunikuona.

The ALU2 sample had the composition of impregnated wood, cement mortar, and alumina acetylation as an additive of 5, 90, and 5, respectively.

The SUR2 sample was made up of three different materials. To begin, 5% of the impregnated wood is empty. 93 percent of cement mortar and the remaining 2 percent of additives, namely surfactants and, lastly, the reference sample, had the composition of 5 percent of impregnated wood, and 95 percent of cement mortar. These samples were taken out and dried for 24 hours at 105 temperature. As in the figure, 11, you can see five different specimens after testing for 28 cycles.

Figure 11. ECO2, MASI, ALU2, SUR2 and the reference samples after testing.

Table 2 shows the features of five specimens with various compositions, as well as differences in mass, length, breadth, and mass loss. The table and bar chart clearly showed the findings of the salt frost test.

Table 2. Length, width, area, mass, and loss of mass of five different specimen.

Samples	**Length [mm]**	**Width [mm]**	**Area, A [mm2]**	**Mass, M [g]**
S 5% D	125	65	8125	2,08
SUR2	125	65	8125	2,27
MAS1	124	65	8060	42,52
ALU2	122	66	8052	6,42
ECO2	122	65	7930	12,04

The greatest mass loss was recorded at 5.2 kg/m2, 1.5 kg/m2 in the compositions of MASI and ECO2 specimens, respectively, according to the mass loss plot (Fig. 12). After 28 freeze-thaw cycles, the total mass loss in the composition SUR2 specimen was 0.27 kg/m2, whereas the total mass loss in the composition ALU2 specimen was 0.79 kg/m2. The composition of the S 5 percent D specimen had the least amount of mass loss. After 28 freeze-thaw cycles, the mass loss in this specimen was 0.25 kg/m2.

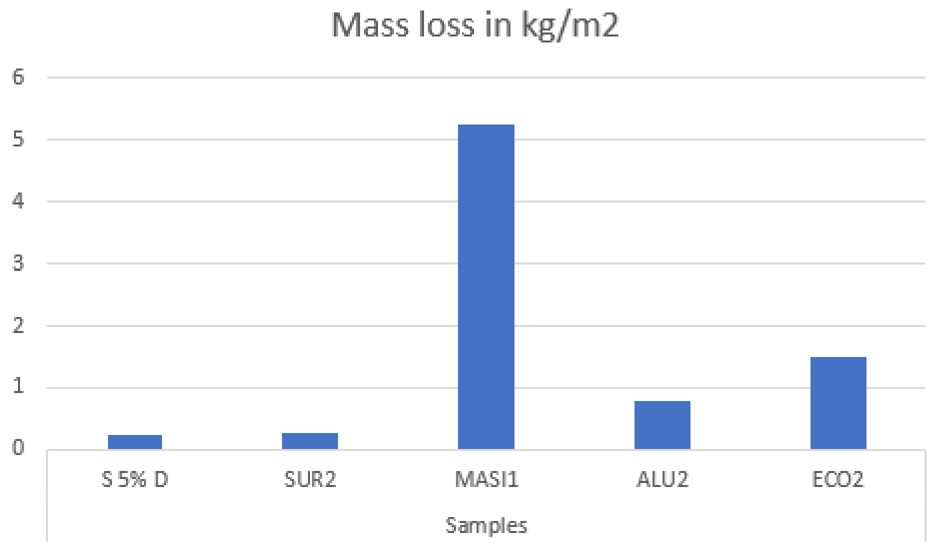


Figure 12. For five different specimens, the bar chart distinguishes between the original mass and the loss of mass.

5.1.1 Comparison of scaling of salt frost test

In one study for the salt frost examination, two ECC mixtures and two mortars were used, one without fly ash Portland cement and the other with fly ash. ECC mixes with fly ash that has cement ratios of 1.2 and 2.2 by mass. The inclusion of fly ash increases the amount of scaling residue in these concretes to the same W/CM ratio, generated with the same volume of cementitious material, and with the same air content. Figure 13 depicts the mass loss in kg/m2 of several specimens following 28 frost episodes (Şahmarana, 2007).

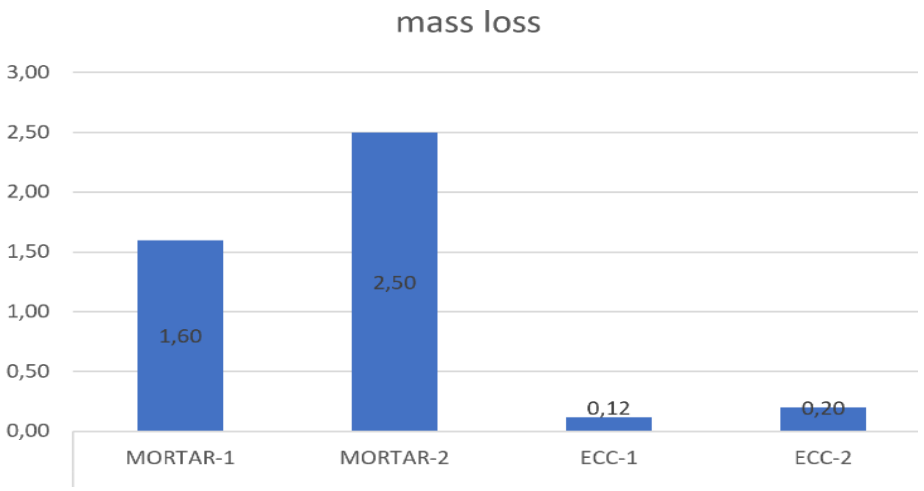


Figure 13. Mass loss of EEC-1, EEC-2, Mortar-1, Mortar2.

As it is very clear from the chart, the loss of mass in the samples, mortar 2 and mortar 1 is very high and near to each other, equal to 2,50 kg/m^2 and 1,60 kg/m^2 respectively. But the samples, such as ECC-1 and EEC-2, had a small mass loss equal to 0,12 kg/m^2 and 0,20 kg/m^2 respectively.

Regular concrete also requires an appropriate air-void structure to avoid internal cracking from freezing and thawing phases, as well as scaling from freezing in the presence of de-icing solutions. The presence of a natural air-void device with a low average spacing factor and micro PVA fiber in the case of ECC seems to be responsible for increasing frost and de-icing salt scaling tolerance, as demonstrated in this set of tests. The virgin ECC prisms behaved excellently when exposed to freezing and thawing processes in the presence of de-icing salts, with a scaled-off particle limit of just 0.20 kg/m2 observed after cycles. (Şahmarana, 2007).

One investigation concluded that with the growing number of freezing and thawing periods, the mass of scaled content on the surface of concrete specimens was observed to rise gradually and increasing the cement substitution ratio also resulted in a substantial increase in the mass of scaled content. You will see in table 3, concrete CEM with zero percent CFBC (circulating fluidized bed combustion) content and almost negligible mass loss, so from this investigation we can conclude that our product also has the same value and the product is good (Zielinski, 2008).

Table 3. Mass scaled-off of CEM without CFBC content and other specimen are CFBC content (Zielinski, 2008).

Specimen	**CFBC(%) content**	**Mass scaled-off after 28 cycles(kg/m2)**
CEM	0	0.03
FLK20	20	0.47
FLK30	30	0.56
FLK40	40	1.24
FLK20	20	0.25
FLK30	30	0.38

FLK40	40	0.87

The mass loss of concrete cylinders during a salt scaling test provides a clear indication of the salt scaling tolerance of surface-treated concrete vs. untreated concrete during freeze-thaw cycles, according to the findings of research. It's worth noting that adsorption of salt solutions and reactions with cement hydration products may result in some mass advantage. However, any mass increase is dwarfed in the dilute NaCl solution by mass loss owing to freeze/thaw degradation and concrete spalling. Both types of surface treatment substantially enhanced the concrete's salt scaling tolerance, according to the results. After 15 cycles, all surface-treated concrete lost less than 3% of its mass, while concrete without any surface treatment lost 30% of its bulk (Zielinski, 2008). After comparing the results of previous studies to our salt frost test, I concluded that our samples had less mass loss and were in excellent condition after 28 cycles. The findings of the second research, which looked at concrete products, were identical.

5.2 Emission test result

It is now well acknowledged that building materials may have an impact on indoor air quality. Indeed, building materials are a regular good source of VOCs (Volatile Organic Compounds) produced in inside air, which have the potential to harm human health and well-being. It is often recommended to enhance indoor air quality by optimizing ventilation and controlling sources by minimizing pollutant emissions, and with the help of low-emission building goods or products.

In this section, discussion was about the results of the VOC testing on the concrete composite for the specific emission rates, which were performed according to (SFS-EN ISO 16000-9). The product, shown in figure 14, S5% (concrete composite), was tested in a laboratory. The emission samples of volatile organic compounds (VOCs) have been collected at the pump of a Tenax TA adsorption collector and analyzed by thermo desorption-gas chromatography-mass spectrometry.

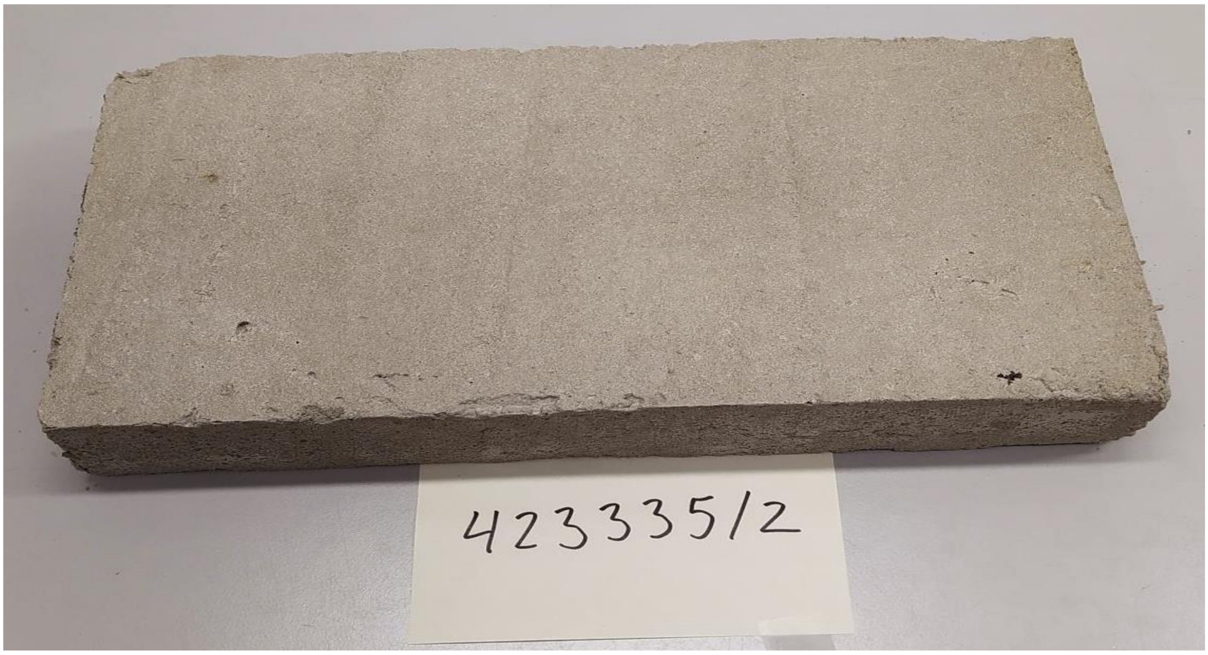


Figure 14. Testing sample.

Tables 4 and 5 show the various test conditions for the product as well as the method used for sampling and analysis of the product for VOC and ammonia.

Table 4. Experimental condition for chemical measurements.

Chemical Measurements	Chamber volume (m^3)	Ventilation factor $(1/h)$	Temp (℃ ± ℃)	Relative moisture (% ± %)	Sample area $(m)^2$	Load (m^2/m^3)
	0.25	0.5	23±1	50±5	0.14	0.5

Table 5. Results of chemical analysis.

Analysis	Analysis result	
	SER [mg/(m^2h)]	Model room content $[\mu g/m^3]$
TVOC	0.037	30
Ammonia (CAS 7664-41-7)	0.020	16
CMR compounds ((EC) no 1272/2008)	0.002	< 1
Individuals VOC	-	< EU-LCI

Table 6. Toluene response of VOC.

Compound	CAS number	SER [mg/(m^2h)]	Model room content[$\mu g/m^3$]
1-methoxy-2-propanol	107-98-2	<0.007	<5
Heptanone	110-43-8	<0.007	<5
α- pinene	80-56-8	<0.007	<5
Benzaldehyde	100-52-7	0.013	10
Mixtures of terpenes and aliphatic and aromatic hydrocarbons	-	0.024	19
TVOC The sum of the concentration of the identified compound. VOC- identification percentage.		0.037 0.037 100%	

The table above specifies the results of the VOC test. As you can see in the table 6, there are different criteria for the analysis such as model room concentration and specific emission rate so if the model room concentration of the elements emitted are between 1 $\mu g/m^3$ and 5 $\mu g/m^3$ or less than 5 $\mu g/m^3$, it is always excluded from the TVOC and if the results are greater than > 5 $\mu g/m^3$, it is always included in the TVOC. Table 7 shows the criteria for the EU-LCI list. The table has the LCI limit value for the compounds that belong to this list. The EU-LCI values in this table (typically stated in g/m3) are health-based values that are used to assess emissions after 28 days from a single product in a laboratory test chamber method. It is basically helping to simulate long-term indoor VOC emission scenarios.

Table 7. Compound-specific response of VOC.

Compound	CAS	SER	Model room content [mg/(m^2h)]	EU-LCI List [µg/m^3]
1-butanol	71-36-3	<0.007	<5	3000
1-methoxy-2propanol	107-98-2	0.009	7	7900
pentanol	110-62-3	<0.007	<5	800
hexanol	66-25-1	<0.007	<5	900
2-heptanone	110-43-0	<0.007	<5	-
α- pinene	80-56-8	<0.007	<5	2500
Benzaldehyde	100-52-7			-
Benzyl alcohol	100-51-6	<0.007	<5	440
Dodecane	112-40-3	<0.007	<5	6000

5.2.1 Comparison of emission test results with other studies

Comparison of VOC emissions results with other studies on concrete was difficult to find because there is only little research available on this topic, so for the comparison, I chose the minimum value or basic value of VOC, required to maintain the emissions inside the residential building and to maintain indoor air quality (Järnström, 2007).

Indoor air concentrations and emissions from structures and interior materials were investigated in eight residential buildings throughout the construction phase and the first year of occupancy. Temperature, humidity, and ventilation were all measured, as were the concentrations and emissions of volatile organic compounds (VOCs), formaldehyde, and ammonia. The total VOC (TVOC) concentration in newly built buildings was usually over the S3-class limit of 600000, but it normally fell below the S3-level after six months, and in certain flats, below the S1-level of 200000. During the first six months of occupation, the concentrations of the main VOCs dropped the most, reaching mean levels of 515000. The ventilation system, floor covering material, ceiling surface product, wall surface product, season, relative humidity and temperature of the interior air, and occupancy all influenced gaseous pollution concentrations in the buildings. The relative humidity had the greatest effect on the quantities of ammonia and formaldehyde (RH). When the RH was more than 50%, higher concentrations were observed during the follow-up. The formaldehyde level in any of the units did not significantly surpass the S2-class limit of 50,000 throughout the first year. In many newly constructed buildings and throughout the follow-up, indoor ammonia concentrations were over the S3-level of 40000. The emissions from the whole floor construction were measured, and it was discovered that all the components, including the structure, leveling agent, adhesive, and floor covering material, influenced the emissions. These were the overall figures for the building's fundamental emissions, which included the concrete floor (Järnström, 2007).

5.3 Leaching test

A leaching test is a method of determining the amount of trace elements leached from an untreated sample (such as a mortar specimen, concrete specimen, or core sample) after it has been immersed in a leaching solution. The material is maintained at room temperature in an undisturbed leachant throughout the test. A leachant is a solution produced by leaching with particles removed via solid-liquid separation, such as filtration. The CEN/TS 16637-2:2014 standards were followed throughout our testing. The values of the leaching concentration of heavy metals after 6 hours and 18 hours are shown in tables 8 and 9, respectively, with a blank as a reference. The values for the items in green are standard, while the values for the elements in yellow seem to be below standard, and the values for the elements in red seem to be above standard.

Table 8. The value of the leaching concentration of heavy metals.

	Na	Mg	Al	K	Ca	V	Cr	Mn	Fe	Co
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blank 6h	23,7	2,5	2,8	20,1	17,8	<0.2	1,1	3.4	63,7	0.4
S 6h	10328,3	33,7	143,3	11361,8	51392,2	1,5	32,2	1,1	15,2	0,3
Blank 18h	24,7	1,2	5,7	14,5	37,6	0,0	2,6	6,0	78,9	1,0

S 18h	5797,3	42,8	395,2	6412,9	54458,4	2,8	20,6	1,2	314,6	0,2

Table 9. The value of the leaching concentration of heavy metals.

	Ni	Cu	Zn	As	Se	Mo	Sn	Sb	Pb
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blank 6h	24,6	1,0	0,8	ND	ND	ND	ND	ND	0.09
S 6h	2,1	3,7	3,2	0,57	<0.17	2,19	ND	ND	ND
Blank 18h	56,1	1,4	0,8	ND	ND	<0.14	ND	ND	ND
S 18h	2,1	2,5	0,9	0,48	<0.17	0,93	ND	ND	ND

The table, 10 and 11, shows the area related to the release of the substances after 6 hours and 18 hours with blank as reference. The values of the elements in the color green are those that are within the standard, but the values of the elements in the color yellow appear to be below the standard, and the values of the elements in the color pink appear to be above the standard. These values are calculated by using the formula, according to the standards of this test.

Table 10. Area related release of the substances (r).

	Na	Mg	Al	K	Ca	V	Cr	Mn	Fe	Co
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blank 6h	1,90	0,2	0,22	1,61	1,42	1,62	0,09	0,27	5,01	0,03
S 6h	826,27	2,78	11,46	908,94	411171	0,12	2,58	0,09	1,25	0,02
Blank 18h	1,976	0,096	0,456	1,16	3,01	0,0	0,21	0,48	6,31	0,08
S 18h	463,78	3,42	31,65	513,03	4356,67	0,22	1,65	0,10	25,15	0,02

Table 11. Area related release of the substances (r).

	Ni	Cu	Zn	As	Se	Mo	Sn	Sb	Pb
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blank 6h	1,97	0,08	0,06	ND	ND	ND	ND	ND	0,01
S 6h	0.17	0,296	0,26	0,046	0,01	0,18	ND	ND	ND
Blank 18h	4.49	0,11	0,064	ND	ND	0.0112	ND	ND	ND
S 18h	0,15	0,2	0.07	0,04	0,01	0,07	ND	ND	ND

In tables 12 and 13, you can see the values of cumulative area related release of the substances which are obtained after adding the values of blank and sample for 6 hours and 18 hours respectively. These values are calculated by using the formula, according to the standards of this test.

Table 12. Cumulative area related release of the substances (Rn).

	Na	Mg	Al	K	Ca	V	Cr	Mn	Fe	Co
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blank	3,87	0,30	0,68	2,75	4,43	1,65	0,30	0,75	11,40	0,11
S	1290,0	6,12	43,07	43,07	1421,97	8468,36	0,34	4,22	0,18	26,38

Table 13. Cumulative area related release of the substances (Rn).

	Ni	Cu	Zn	As	Se	Mo	Sn	Sb	Pb
	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb	ppb
Blank 6h	73,78	0,19	0,13	ND	ND	ND	ND	ND	0,01
S 6h	0,04	1,85	0,50	1,41	0,08	0,15	0,25	ND	ND

5.3.1 Comparison of leaching test with another research

The author of a study on concrete concluded that the column leaching test method was utilized to determine the leaching concentration values while interacting with water. A high-range water-reducing additive such as sulfonated, naphthalene, formaldehyde are mixed together in some of the concrete and finally six concrete mixtures were created along with a reference for regulating Portland cement concrete with a water to cement ratio of 0.50. The fly ash source of two fly ashes was determined to be between 30% and 60% of the total cementitious materials by mass. By keeping the water content constant, the water to cement ratio was increased from 0.40 to 0.70. From the original length of the concrete cylinder, a concrete shape with a prism size of 32 x 32 x 203 mm was seen for the column test (Zhang et al. 2001).

Tables 14 and 15 indicate the metal concentrations when concrete is subjected to a column test. The Se levels were found to be below detection limits because many of the Pb values were near to the detection limit, so the comparisons were difficult between our leachates and heavy metals. The metal levels in the fly ash concrete samples were equal or higher than the values in the samples of Portland cement, except for Cr. While other metals tested in leachates, as shown in tables 14 and 15, showed an increase in leachability due to an increase in the amount of fly ash in the concrete, Ni showed a decrease in leachability (Zhang et al. 2001).

Most of the Ni metal were leach out from the sample of Portland cement (Zhang, Blanchette, Malhotra, 2001). When the concentration of fly ash in concrete is reduced with an increment in water to cement ratio, the leachability of Cd, Cr, Ni, and Pb seems to be unaffected. Because of the increased porosity of the concrete, the leachability of Cd and Cr rises with increasing water to cement ratio and the metals such as Cu, Fe, and Zn have an increased concentration along with the increment in the content of fly ash. Arsenic, on the other hand, exhibited a declining tendency with an increment in the water to cement ratio. According to the amount of As leached per kilogram of fly ash in the concrete, the water in the cement had no impact on the leaching. Rather, the fly ash concentration was shown to be a regulating element in As (Zhang et al. 2001). Finally, our values were obtained without any mixing of the fly ash source with the concrete, so it's not a perfect comparison due to different samples, but from this comparison with other studies, we know about the factors influencing the leaching test. Tables 14 and 15 show the results of the test in ppb.

Table 14. Leaching concentration results with TCLP test of leached elements (Zhang et al. 2001).

mixture	Fly ash, source	Fly ash	W (C+FA)	As	Cd	Cr	Fe	Ni
				ppb	ppb	ppb	ppb	ppb
T0	--	0	0.5	<2	<1	42	20	61
T2	Lingan	30	0.5	100	2	24	100	145
T5	Forest burg	30	0.5	<1	4	25	140	143
T14	Lingan	60	0.5	17	6	40	1730	113

Table 15. Leaching concentration results with TCLP test of leached elements (Zhang et al. 2001).

mixture	Fly ash, source	Fly ash	W (C+FA)	pb	Se	CU	Zn
				ppb	ppb	ppb	ppb
T0	--	0	0.5	<1	<23	14	280
T2	Lingan	30	0.5	13	16	30	410
T5	Forest burg	30	0.5	1000	11	27	410
T14	Lingan	60	0.5	10	7	158	580

After six weeks of column leaching testing, the leached components are shown in Table 16 and 17. This experiment was done by making samples which were mixed with fly ash. The concentration of metals such as Cd, Cr, Pb, Se, Zn, and Fe concentrations did not vary with time and the values were below detection limits throughout the whole test. There were noticeable amounts of copper and nickel leached out. The results, on the other hand, did not contradict the concentrations of leached Cu and Ni in the control Portland cement concrete (Zhang et al. 2001).

When compared to other concrete mixes, the Cu content of the concrete containing 30% Lignan fly ash and a w/cm of 0.7 (Mixture T17) is high at 0.075 ppm, although it is much lower than the water quality standards. Based on the results of the other tests, as well as the composition and leachability of the fly ash itself, the previously stated test result may be an outlier (Zhang et al. 2001).

Table 16. Leaching concentration of column leaching test after six weeks (ppb) (Zhang et al. 2001).

Mixture	Fly ash, source	Fly ash (%)	W (C+FA)	As	Cd	Cr	Fe
			ppb	ppb	ppb	ppb	ppb
T0	--	0	0.5	<4	<1	11	<200
T2	Lingan	30	0.5	51	<1	11	<200
T5	Forest burg	30	0.5	<4	<1	11	<200
T14	Lingan	60	0.5	64	<1	12	<200

Table 17. Leaching concentration of column leaching test after six weeks (Zhang et al. 2001).

Mixture	Fly ash, source	Fly ash (%)	W (C+FA)	Ni	Pb	Se	Cu	Zn
				ppb	ppb	ppb	ppb	ppb
T0	--	0	0.5	17	<1	17	7	280
T2	Lingan	30	0.5	14	<1	11	6	410
T5	Forest burg	30	0.5	19	<1	11	3	410
T14	Lingan	60	0.5	12	<1	11	7	580

In one research, the author utilized a tank test to assess the leaching actions of different made up of cement pastes with the addition of fly ash. For the completion of the test, the standard curing conditions were used. According to the findings of this research, leached heavy metals are usually created when the number of days grows, and drastically decline and go unnoticed. The long-term exposure to the aqueous environment of cement concrete containing MSWI and FA results in Cr and CD contamination, respectively. The results of this research are shown in tables 18 and 19 for 7 and 28 days respectively. Samples A and sample B had different values after having the same elements leached out because of the addition of fly ash. From the values, it is concluded that values for PB and CD were high as compared to our values or we can say most of the values were high because of the mixing of additives in cement, so, again, it is proved that content always diverts the values of the metals.

Table 18. Leaching concentration results of cement paste mixed with additives after 7 days under standard conditions (Zhang et al. 2001).

Sample	Cr	Pb	Cd	Zn	Cu
A	8.3	11	5.1	117	6
B	43.5	12.2	0.6	359.5	16.2

Table 19. Leaching concentration results of cement paste mixed with additives after 21 days under standard conditions (Zhang et al. 2001).

Sample	Cr	Pb	Cd	Zn	Cu
A	0.7	0.5	0.6	12	0.5
B	1	0.8	-	49.5	--

6 CONCLUSION

Combining wood with cement has a lot of benefits which enhance the usage of such composites in buildings. After doing the preliminary research for this report, I came to know that certain wood-cement composites also possess properties which qualify them as structural materials. According to current literature findings, the most common trait of this type appears to be toughness, but in this experimental research, we focused on some other important tests that are appropriate for products in cold areas. However, as you read this report, you will understand the conditions, operations, and results of various types of tests performed on wood-cement composite to demonstrate that it inhibits good qualities, i.e., ice-deicing resistance, volatile emissions in buildings (emission test chamber), and the effect of water (for example, leaching concentration) on the samples, commonly known as the leaching process.

Before proceeding into the deeper literature, research into common composites containing wood waste as a reinforced material was done. I studied the common legislation and regulations in Europe concerning wood waste. These types of legislation give us information related to the tons of wood waste in different countries in Europe. They also specify various types of acts under which you must reuse, recycle, or prevent waste, and these acts are overseen by the EU Commission.

Composites, on the other hand, are far more preferred over other traditional materials because they improve the properties of their basic materials and can be used for a wide range of applications. Generally, a composite material is made up of two materials which have distinct physical and chemical properties. When this type of element is combined, it creates a material that is specialized to perform a specific task, such as being stronger, lighter, or more electrically resistant. They may also aid in the reduction of stiffness and the development of strength. Moreover, wood is also one of the most adaptable raw materials, with use in paper, packaging, decor, housing, and a variety of other sectors. The wood used in all the samples was impregnated wood of class D, with particles measuring 4mm in size. According to the findings in the literature, Europe generated 52.9 million tons (mt) of wood waste in 2012.

Depending on the region as well as the type of building, construction, and demolition waste accounts for 46 percent to 50 percent of all garbage created in the EU. Whether wood waste can be processed, used for energy, or disposed of in a landfill depends on the type of wood waste. Furthermore, wood waste accounts for about 41% of the building and renovation waste in Finland. This figure is considerably higher than the sum of wood waste produced in Europe's central and southern regions and, according to a survey of demolished buildings in Finland, timber buildings accounted for 41% of demolished buildings.

For experimental results, we tested a product which was made up of wood and cement mixture (concrete), through three different tests. In the mixtures, we also incorporated certain types of ingredients to get more appropriate results. Tests such as salt frost, volatile emissions, and leaching were performed. There are many tables, bar charts and figures in this report that clearly show the findings of the salt frost test, emissions/solubility, and leaching concentration statistics and all the tests were performed according to the standardization acceptable for Europe. For the salt frost test, the maximum mass loss was found in the compositions of MAS1 and ECO2 specimens, which was 5.2 kg/m2 and 1.5 kg/m2, respectively, and the mass loss in one of the compositions of specimen SUR2 after successfully completing 28 cycles of the test was 0.27 kg/m2, and the same for the sample ALU2 was recorded at 0.79 kg/m2. The composition S 5% D specimen showed the least amount of mass loss. The results of the salt frost test were related to other studies by other researchers that performed the same test, but mostly with the same type of samples. Following this discussion, we concluded that our sample was in good condition, with less than a percent mass loss. Moreover, only one sample showed the maximum mass loss.

The emission test was also performed under standard conditions. There were different emissions, such as ammonia, formaldehyde, and TVOCs, from the sample. Few tables were presented with the values concerning the model room content and specific emissions rate. There had been no prior research about the results of this test and so it was compared with the basic emission values of the concrete/ceramic used in buildings, but the emissions were quite good. I also learned that if the results of the model room concentration are between 1 and 5 or less than 5, it is excluded from the TVOC, and if the results are greater than > 5 5, it is included in the TVOC and the specific emission rate of each compound is mentioned.

For the leaching test, I compared my work with other research papers. Hopefully, I found leaching concentration values for the elements which were leached out in an experimental result in some research papers, but the manufacturing process used for the preparation of the samples was different and the results were surprisingly good. After reading the concluding part of the results and discussions of this test, I clearly understood that after adding different types of additives or fly ash, it helps the elements present in the product to not leach out. Also, it depends on the percentage of fly ash or other additives used in the product.

This experimental research cannot define the future potential of the wood-cement composite. We just investigated a few tests which are very important, but not all. There are only a few research papers that performed the same test but with different conditions and processes, so more research must be done on this topic to define its future possibilities.

Overall, wood cement composites offer great strength qualities for building materials and good acoustic qualities, which are utilized widely in various countries for inside and outside applications, including road sound barriers. These composites have good resistance to salt ice and de-icing, minimum VOC emissions, and resistance to resisting the leaching process. Also, these composites have a higher humidity tolerance and dimensional stability.

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