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An Investigation into the Red Listed Material: Pressure Treated Wood (Preservative Infused) and Possible Alternatives

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ABSTRACT

The new Student Union Building (SUB) project is set to be completed within the next few years and it will be a central UBC landmark that serves over forty thousand students. As such, the building will have to withstand consistently heavy use for many years, so a durable and attractive building is a must in this scenario. Pressure treated wood, a commonly used building material in British Columbia, is a red-listed material that contains hazardous chemicals and pollutants and it must be avoided if the new SUB project intends to qualify for LEED platinum status. This research paper presents and evaluates several alternatives including brick, concrete and stone. The evaluation is carried out through a series of comparisons of the materials' feasibility when used as the main construction element in the walls and flooring. Some key parameters that were assessed included durability, thermal properties of the material and the impact on the environment all the way from extraction of the raw material to the end of its lifetime.

The lengthy analysis provided us with enough information to be able to suggest any of our three alternatives, brick, concrete and stone, over pressure treated wood as the primary building material. All three alternatives surpassed pressure treated wood based on the evaluation criteria and were thus proven to be far better alternatives. This suggestion is widely applicable in most construction projects and can be taken as a rough guideline for choosing a cleaner alternative to pressure treated wood.

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GLOSSARY

Corrode: To wear away by chemical reaction

Facade: The face of a building

Preservative: A naturally occurring or synthetic substance added to products to prevent decomposition

Sustainability: Preserving resources for future generations

Thermal mass: A thermal property of a material that dictates its ability to control temperature changes by absorbing and releasing heat

Veneer: Any facing material that is applied to a different backing material

1.0 INTRODUCTION

Sustainability has become a large issue and focus globally due to the limited amount of resources that we have and the shortages of such resources occurring. Following this, the protection of our environment has also become a main focus among many countries as a result of the exposure of many issues. One of such issues is the concern of recycling, reusing, and disposal of waste. Many measures have been taken to promote sustainability and to protect our environment, one of these measures being the red listing of certain materials which are harmful to our environment and its inhabitants. The focus of our research is the red listed material pressure treated wood and the possible alternatives that could replace it under specific situations. Since the main use of pressure treated wood is in the structures of buildings, we have decided to evaluate the advantages and disadvantages of pressure treated wood and three other alternatives, brick, concrete, and stone, for use on the main wall structuring and flooring of the new SUB.

2.0 PRESSURE TREATED WOOD

2.1 Background

Pressure treated wood is wood that has been treated with chemicals by means of a particular process which lengthens its lifespan. This process is usually done by placing the wood to be treated into a large, depressurized tank which is then filled, under pressure, with the preservatives to be infused into the wood. By using this process, the chemicals penetrate deeply into the wood. As a result, the lifespan of this processed wood is much longer than that of unprocessed wood due to the chemicals repelling termites, insects and fungal decay. This process can be done on the sapwood and heartwood layers of trees used for commercial wood, but the process involved for treating the heartwood is more expensive and time consuming as it is harder to penetrate.

The use of chemicals with wood dates back to almost as old as the use of wood itself, but the treatment of wood using pressure dates back to the 1800s. Pressure treated wood is commonly used nowadays for commercial and residential buildings, especially in North America where there is an abundance of forests.

2.2 Floors

Use of pressure treated wood for flooring is uncommon, as there are not many insects and termites indoors. However, the use of untreated wood for flooring is quite common in North America. Wood floors are aesthetically pleasing (for more expensive wood) and can look quite timeless if properly maintained. However, crackling sounds are generally commonplace for wood flooring, and it would especially be bad for the new SUB due to the amount of daily traffic flow.

Wood flooring has a large range when it comes to cost depending on the quality of the wood. However, for an important building meant to last a few decades such as the new SUB, the use of cheap wood for flooring would not be ideal nor economically smart due to frequent future maintenance and replacement, and more expensive wood flooring can cost upwards of $10 per square foot. Wood does not conduct heat very well, so the energy spent in heating during the wintertime can be quite costly. Basically, for a building that has a high population density, wood floors would not be ideal as dirt accumulates easily on wood and the chipping of wood would likely occur frequently because wood is not very strong.

2.3 Walls

The cost of erecting the structures of buildings using pressure treated wood is relatively low in B.C due to the abundance of local forests. Also, the skill involved in handling wood is not very high and also commonplace in B.C, so the cost of hiring workers would also be quite low compared to other materials. Wood is relatively light, so the transportation costs would not be an issue, especially since wood can be obtained locally. Recycling pressure treated wood is a possibility, but is not commonplace due to wood being a renewable resource, as well as the chemicals in pressure treated wood being released in the form of dust.

Furthermore, the tipping fee for disposing of solid waste at Metro Vancouver is calculated by weight, and since wood is relatively light, the cost would not be significant for future replacements and restructuring [13]. If arsenic based preservatives are used for the wood, it would not be a sound decision from an environmental standpoint. Arsenic based preservatives are toxic to humans, and the chemicals from the wood will leak into the soil and groundwater over time [6]. However, presently, most pressure treated wood uses copper-based preservatives, which has been proven to be non-toxic to humans [17]. However, the copper in the wood could cause other metal parts (such as nails, bolts, screws) to corrode over time due to rain coming in contact with the wood.

The lifespan of pressure treated wood (before obvious degradation starts) is usually around 40 years. Wood is also not very strong compared to most other materials, so in the event of a natural disaster such as a big earthquake or fire, the likelihood that it will survive it perfectly is not very high. Wood is also ineffective at keeping out noise, so for a five story building the noise would be quite high which would result in a low quality environment.

3.0 BRICK

3.1 Background

Brick is a building material that is composed of ceramic blocks that are bound together with mortar, a lime or concrete based paste. Brick has been used for thousands of years due to the many advantages that it has over other building materials. It is made of widely available natural resources like clays and shales which are mined in open pits using extremely environmentally friendly extraction practices [3]. There is virtually no wasted raw material that is extracted for brick production. Throughout the entire process, thermal energy and water are constantly reused. The post-extraction manufacturing process is also very sustainable and much like the extraction process, it reuses thermal energy during the kiln firing and water during other parts of the process. When used as the primary building material for the construction of walls and flooring, brick provides a wide variety of advantages over other materials.

3.2 Floors

Brick is a great option for both indoor and outdoor flooring, and a large-scale project such as the new SUB could benefit strongly from its use due to the high level of traffic that the building will eventually attain. First and foremost, brick is a very durable material which is a crucially important aspect for the choice of flooring. Heavy traffic in the new SUB would require a material that can withstand large amounts of use and brick would fit the bill perfectly. An unsealed brick floor would be prone to chipping and would be harder to clean, but when properly installed with a sealant, it would be resistant to wear, tear and chipping. The only downside of sealing brick flooring is the heavy use of chemicals [2]. Regardless, a sealed brick floor has many other valuable advantages that make it a wonderful choice. Brick floors provide an anti-slip surface which would be a great advantage in the new SUB due to Vancouver's heavy rain that creates a slippery environment on most other floor types. Fire resistance is another key quality that makes brick a wonderful flooring choice. Brick does not ignite, burn or emit toxic fumes when subjected to extreme heat. As a timeless material, brick does not lose its color when exposed to light and it provides a very natural and aesthetically pleasing texture and look that is very familiar to most people [5].

Brick flooring is not without its downsides however, there are several minor disadvantages that are present alongside the many benefits. Brick flooring is slightly more difficult to install than some other flooring materials such as wood. Brick floors can also have a slightly uneven surface and this can increase the difficulty of cleaning the floor. However, all of these downsides are very minor and they do not significantly detract from its highly valuable advantages.

3.3 Walls

Brick is a highly effective material when incorporated into the construction of walls. It provides a wide variety of benefits that cannot all be encompassed by other building materials. Brick walls have a high durability and this allows brick buildings to have lifetimes spanning hundreds of years. Brick walls provide great protection from extreme weather conditions, especially airborne debris caused by heavy wind. Heavy impact from flying objects is usually unable to penetrate brick walls with them bouncing off, whereas other exterior wall materials suffer because they can be penetrated more easily [2]. As previously discussed, brick's high fire resistance is another major benefit which contributes to such high potential lifetimes.

Brick also has many non-structural advantages, most of them affecting the interior, that make it an excellent choice for use in a building with high traffic such as the new SUB. Brick has excellent thermal energy properties, especially when using a combination of interior veneer and exterior facade made of brick. Brick's thermal mass gives buildings many benefits such as decreasing indoor temperature swings and reducing temperature extremes. Acoustic comfort is another relevant bonus of using brick, as brick provides superior acoustic penetration compared to other building materials. Brick walls are very low maintenance when left untreated. Brick is an inorganic building material and thus it does not provide a food source for mold which means that walls stay naturally mold-free [2]. However, in the event of a need for cleaning, untreated walls make it very easy to do so. Brick walls can be left untreated, without paint or coatings, and thus are eliminated of the use of volatile organic compounds that are commonly found in paint and other coating. This means that brick walls provide air quality that is superior to that of buildings with treated walls which is a major benefit when considering the fact that so many people will be spending many hours in the new SUB building.

4.0 CONCRETE

4.1 Background

Concrete has been in used for construction since the ancient civilizations. The first major concrete users were the Egyptians, in around 2500 BC, when it was made from sand, gravel and cement [7]. Over the years, the second major user – the Romans from 300 BC had made improvements to concrete by applying siliceous and aluminous materials, and upon mixing with water, they would chemically react to form a far stronger cementious material available for construction. Today, Portland cement is the most common type of cement used to make concrete shapes. Portland cement was made from a mixture of clay and limestone, which had been crushed and fired in a kiln [8]. This composite cement is widely used in buildings and roads today, because of its high tolerance to compressive load and its excellent durability and longevity compared to other building materials such as wood.

4.2 Floors

One of the advantages of concrete for flooring is that it is economical and durable. It costs approximately $5 CAD per square foot for basic types of concrete floors. For specific patterns or styles of concrete floors, such as stamped or polished floors, the price could vary from $7-15 per square foot [16]. Even with the extra cost on the decorative concrete installation, in the long run there is virtually no maintenance needed for concrete floors, which reduces repair and maintenance costs. In summer, concrete floors can help reduce the costs for air-conditioning because concrete has a low thermal conductivity and does not deliver radiated heat from outside the buildings [10]. Furthermore, concrete floors can also absorb the heat from the sunlight, making the floors relatively warmer during wintertime. By applying rugs and fabrics, concrete floors can also help reduce sounds and echoes, as well as keep the floor warm. Concrete floors are generally not slippery, and with proper installation, they can be blocked from moisture contents and avoid corrosion as well. Concrete floors are also a good option for those who suffer from allergies because there is few dust mites on concrete and simple sweeping can generally remove any dirt accumulation on the floors. Lastly, depending on the scale of the project, the production of concrete flooring generally uses less energy compared to other floor types and does not take precious environmental resources like the hardwood of trees.

4.3 Walls

The construction cost of a building with concrete walls is generally slightly higher (around 5%) than for a comparable wood-frame building [16]. Nevertheless, the cost of concrete buildings can quickly be paid back through the savings in monthly heat and cooling costs for the same reasons mentioned in the floor sections. With a large building meant to operate for fifty years, this can greatly reduce the maintenance costs and energy expenses of the building [16]. Furthermore, concrete buildings have higher resistance to fire, tornadoes, storms, and earthquakes, reducing the risk of structural collapse, hence reducing insurance costs. Also, concrete walls are effective at keeping out loud noises. The mass of the walls can reduce sound penetration through the walls by more than 80% when compared to stick-built construction [10].

Recycling of concrete disposal is a relatively simple and environmentally friendly process. A common way to dispose of concrete is to transport it to landfills. It costs approximately $0.25 per ton/mile for transportation, and costs about $100 per ton to dispose of [8]. However, prior to concrete disposal in landfills, the crushed concrete may be reused as an aggregate in new Portland cement. It can be combined with new aggregate as a sub-base layer, and generally forty percent of the crushed concrete is delivered back for recycling, hence reducing the amount of concrete to be disposed of in landfills.

5.0 STONE

5.1 Background

Humans have been constructing stone structures since the beginning of civilization, as evident by the existence of the Egyptian pyramids, the Great Wall of China and the countless Greek and Roman temples dotted all over Europe. Stone buildings can easily last for thousands of years and stone is readily available almost anywhere across the globe. It is a very dense material so it is extremely durable, however that also means the material is extremely heavy. Due to its high density, once heated to the correct temperature, stone will remain at that temperature for a long time, therefore stone houses are cooler in the summer and warmer in the winter [12]. Stone is naturally fire retardant, water resistant, mold resistant, and unable to rot and is aesthetically pleasing due to its wide range of colors, patterns and textures. Originally stone walls were made via the method of dry-stone walls, without the use of mortar [1]. It is known that Egyptians had some sort of mortar plastered on the pyramids, but the use of mortars was only fully documented during the times of the Romans, and currently the most commonly used adhesion is cement [7].

5.2 Floor

Wood flooring has to be placed on top of concrete to protect it from insects and moisture. In order to reduce noise and increase floor insulation, an additional layer of carpet is often placed between the concrete and the wood [14]. Stone floors can be assembled directly on the ground without any additional supports. The lifetime of wood floors depends on the type of wood used and the amount of traffic it endures, but the average lifetime is around 45 years, while stone floors can last indefinitely to the end of the building's useful lifetime. Wood floors have to be occasionally treated with oil, and the air moisture of the room must be kept consistent. Stone floors only need occasional cleaning and possible repairs for broken stones, while wood wastes are some of the most common forms of demolition waste and are usually land filled or incinerated. Due to stone's large mass and the fact that landfills charge by the weight, stone is more commonly recycled or reused [13]. The stone and mortar can be broken down to form filling materials for roads or concrete [12]. The cost of the flooring will depend on the type of wood and stone chosen. Common wood floors can range from $5-20 per square foot, and up to more than $60 per square foot for more exotic wood or cuts. Stone floors ranges from $10-25 per square foot for cheap tiles, and up to over hundreds dollars for natural marble flooring. If we assume that the new SUB will be in use for more than 200 years, wood floors would have to be changed at least 5 times. Not including the insulation fees, the lifetime cost for wood floors would be much more than that of stone floors. Wood floors takes around 48kWh/m^2 of energy to manufacture, while stone takes 79kwh/m^2 of energy, so again taking into the consideration of the lifetime of a building, the price of the stone is much lower [14]. The manufacturing process for 1m^2 of wood floor produces 6kg of CO_2 emissions, while the stone floor produces 16kg/m^2 of CO_2 [14]. By taking into account the amount of traffic that the SUB takes in everyday and the humid of the Vancouver weather and the heating cost of the building, the environmental and economic cost of having wood floors is much higher than of stone flooring due to the long lifetime of the SUB building.

5.3 Walls

Currently there exists a composite board made from wood pruning and waste porcelain stone [9]. The material is waterproof and the fire retardant properties are better than commercial pressure treated wood. Although some woodchips are used as compost, animal beddings and mulching materials, most are incinerated or put into landfills. In Japan, they managed to recycle 68% of scrap wood and demolition wood [9]. In porcelain stoneware manufacturing, 30% of daily production is porcelain stone scraps with no commercial use [9]. Average density is 0.78g/cm^3 with a Young's modulus of 95GPa, these values can be easily changed depending on the ratio of wood pruning to waste porcelain stone. The composite board is made from fine grained recycled material, so it can easily be meshed and recycled into new boards. This material is a perfect wood wall panel replacement.

Alternatively, the walls can be built directly from natural stone. For space segregation, the dry-stone wall method can be implemented, hence in this way there will be less mortar waste at the end of the building's useful lifetime [1]. Stone walls do not need to be insulated with padding or foams, covered with drywalls or painted; all of these will decrease the amount of the waste sent to the landfills.

6.0 COMPARISONS

Based on our research, the following chart shows a concise overview of our findings for comparison between pressure treated wood and its' three possible alternatives.

	Pressure Treated Wood	Brick	Concrete	Stone
Fire retardant		X	X	X
Water resistant		X	X	X
Earthquake resistant		X	X	X
Efficient at noise reduction		X	X	X
Possibility of being recycled	Lowest	High	High	High
Possibility of being reused	Lowest	High	High	Highest
Possibility of disposal	Highest	Low	Low	Low
Renewable Resource	X	X		
Good Insulator	X	X	X	X
Abundant locally	X			X
Mold resistant	X (limited)	X	X	X
Contains toxic chemicals	X			
Amount of Maintenance	Highest	Low	High	Lowest
Cost of material and construction (in B.C.)	Lowest	High	High	Highest
Life Span (before exponential decrease in quality)	Lowest	High	High	Highest

Table 1: Red Listed Materials

Overall, the use of wood for flooring in a building such as the new SUB would not be a great choice. Although pressure treated wood is cheap compared to other materials, it is a substandard material for a building that is meant to last a few decades and be environmentally friendly. Wood is a renewable resource, but the environmental implications that come with using pressure treated wood would likely overshadow that advantage. Alternatively, brick is a material that has many benefits and would serve well in place of pressure treated wood. Due to its high durability and low maintenance as well as the other plethora of positive factors, it would be a great choice for the interior and exterior walls. Its high lifetime suggests that it would stand for many years without much trouble. Similarly, brick would make a great choice for the flooring due to its slip-resistance and high durability, which suggests that it would last a long time under heavy traffic.

Furthermore, concrete, another highly viable building material, is another great alternative material. In general, using concrete for walls and floors of a building can optimize energy performance for air conditioning, conserve natural resources and minimize waste, improve indoor environmental quality by minimizing exposure to mold and other indoor toxins, and save maintenance and repair costs due to its high durability. Concrete structures can also easily be disposed of and recycled, saving disposal costs and resource consumption. Natural stone also presents a similar scenario, although it is one of the most expensive building materials. It is extremely heavy to transport, however we have several stone quarries around Vancouver so transportation cost of the material will be kept to a minimum. There are not many stone masons in Vancouver, since we build most of our buildings with wood, so the cost of construction will be higher. Also the time it takes to construct stone buildings is much longer than that for wood buildings since it takes time for the mortar to set. However, considering the decrease in environmental impact and the decrease in cost for the overall lifetime of the SUB, it is a good alternative to pressure treated wood. One suggestion is that stone be used for the outer walls of the new SUB building and the first floor where traffic is the greatest. Lighter materials should be used for the upper floors.

7.0 CONCLUSION

Pressure treated wood involves the use of toxic chemicals during its production stage and the chemicals are released into the environment during and after its useful lifetime. Due to the geographical location of Vancouver, wood is cheap and abundant, so it is a common building material. However, due to its short lifetime and low tipping fees, large amounts of wood used in construction are dumped in landfills where they wreak great negative impacts on the environment. Brick, concrete and stone have all the positive benefit of pressure treated wood such as fire retardant, mold resistance, water resistant, use less energy for heating and reduces noise. Although these three alternatives are more expensive, require more skilled tradesmen and time for the proper installation of flooring or walls, their durability and low maintenance stature will ensure an overall lifetime cost that would be several times cheaper than that of the wood counterpart. At the end of the useful lifetime, these three materials are more likely to be recycled or reused, as the tipping fee for these dense materials is very expensive. Even if these materials are being disposed to the landfill, there will be minimal environmental impact since most of these materials are solid materials that do not release any harmful chemicals. Economically, brick or concrete will be better choices due to natural stone being expensive. Overall, any of these three materials would be great alternatives to pressure treated wood and wood building materials in general.

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