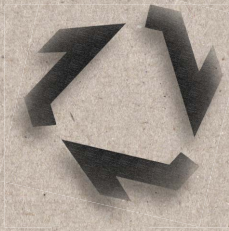

Circular Economy in Architecture
- sustainable principles for future design

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"We can't solve problems by using the same kind of thinking we used when we created them."

- Albert Einstein

Abstract

At present, construction is one of the most destructive, energy consuming and material wasting industries. The current linear system cannot last, and to change anything, we need to redesign the system and our way of thinking. In my thesis, I will explain the theory behind a circular economy and how it could be applied to building, as well as discuss waste issues and material sources. Deconstruction is also a big polluter, and one solution to combat that problem would be to design buildings to be readily disassembled.

The aim of this project is to bring awareness about the subject of sustainable design in a modern context and gather this information into one place. Many ideas presented are ones that have been around for as long as people have built buildings, such as material scarcity, resource efficiency and reusing existing materials while reducing waste. Some ecobuilding projects that have successfully implemented these ideas will be presented.

In the conclusion, I will present certain concrete ideas and methods for bringing about circular thinking into the built environment. A good starting point would be to decide whether a building needs to be demolished, if so, can the elements be reused or recycled, or if designing a new build with renewable raw materials is the best option.

Tiivistelmä

Yhteiskunnassamme rakennusalla kulutetaan nykyään eniten energiaa ja haaskataan materiaaleja. Lineaarinen talous ei kestä nykyistä toimintatapaamme ja muutoksia saamme aikaan vain muuttamalla järjestelmää ja ajattelutapojamme. Diplomityössäni käsittelen kiertotalouden teoriaa ja sen hyödyntämistä rakentamisessa, sekä pohdin jäteongelmia sekä materiaalilähteitä. Myös purkutyö on rakentamisessa suuri saastuttaja ja siihen esitän ratkaisuksi rakennusten suunnittelemista purettaviksi.

Diplomityöni tavoitteena on lisästä tietoisuutta kestävän suunnittelun aiheesta (nykyhetken viitekehyksessä) ja koota nämä tiedot yhteen. Monissa esittämistäni konsepteissa hyödynnetään olemassa olevia ideoita, kuten materiaalien saatavuutta ja uudelleenkäyttöä sekä jätteenhallintaa, mutta oleellista on kuinka kokonaisvaltaisesti niitä käytämme. Esimerkkiprojektien avulla havainnollistan konseptien sovellutuksia käytännössä.

Lopuksi ehdotan käytännön esimerkein miten kestäviä suunnitteluideoita voi käyttää rakennetussa ympäristössä. Rakentamisessa hyvänä lähtökohtana voi pitää, että rakennusten tulisi olla purettavia, kierrätettäviä ja että uusissa rakennuksissa käytettäisiin uusiutuvia raaka-aineita.

No more styrofoam!

Table of contents

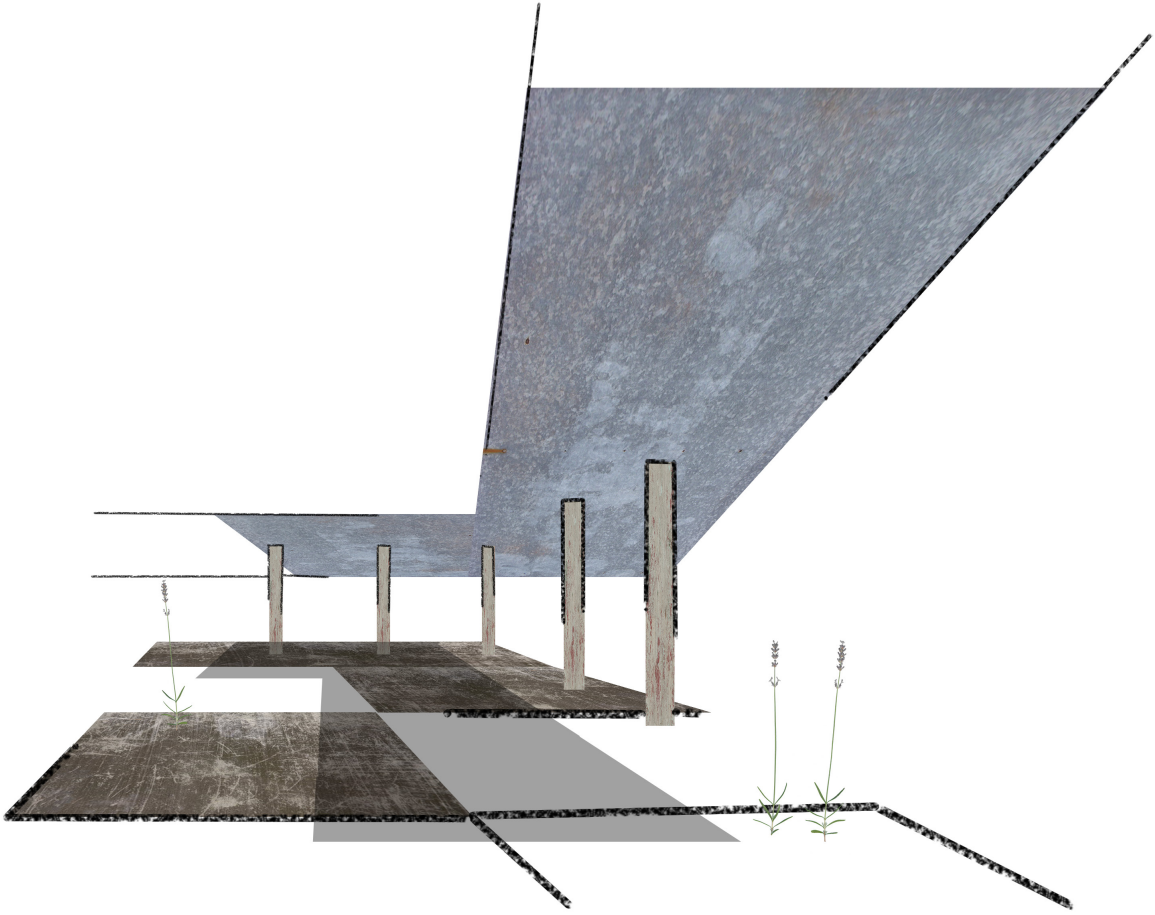
Foreword

Trash.
Garbage.
Spam.
WASTE.

Our daily lives, in mind and body, are surrounded by it. Emails and beaches are overflowing with it. Even though I may work better amidst a bit of clutter, I often need to clear my head in clean and pristine nature. But if I see something that doesn't belong in nature every time I try to relax, it slowly builds up my annoyance at others for not doing their part in giving back.

How could I make a difference in a world full of litter?

I'll use my words and examples as much as possible, that's how.



Introduction

I took on this subject with little introduction into the world of actual construction on site but with a keen interest in finding out more. My initial idea for this investigation started in the summer of 2016 when I visited the 15th International Architecture Exhibition Biennale in Venice, Italy, titled REPORTING FROM THE FRONT, curated by Alejandro Araveña. This exhibition took a sectional look at where the current situation was in the building industry. There, I found many sources of inspiration but what stood out most to me was an exhibition showcasing the world's waste on one side, and on the other, how about two dozen example companies were attempting to use that waste as building material. Suddenly, I was taken by the idea that what we are using for building is unsustainable and new methods need to be implemented.

Fast forward to the spring of 2018 and beginning my thesis. I had not pursued any research into waste management or material regeneration, yet it kept nagging at me in the back of my mind. I wanted to learn more. When I tried to come up with a subject to take on, I realized I was disinterested in much else and so I decided to investigate the world of circular economy as well as using recycled materials for future buildings and anything else that this realm of sustainable design had to offer.

This undertaking was staggering from the start as I wanted to touch on anything relating to the topic and the deeper I dug, the more I was flooded with many research projects into sustainability. But I did not want the reader to have to feel overwhelmed by information. Thus, I decided to gather the main

points together into a concise and easily digestible booklet of knowledge for a comprehensive overview for all to enjoy.

As this subject was of great inspiration for me, I wanted to illustrate my thoughts and feelings about it visually. Throughout these pages, there are abstract compositions which I have created to showcase each subject loosely and somewhat thematically. They can be seen as material moodboards during the first steps of a design process where material consideration is incorporated into that critical phase.

This booklet is designed to be used as an introduction to alternative ways of thinking about building and architecture. The chapters are organized to start with larger, theoretical ideas and facts and as they progress, explain more hands-on approaches for the actual design process. By the end, the reader should have a solid synopsis of what is needed for future design to thrive.

For me, this thesis was the perfect opportunity to educate myself about how to line up my environmental ethics with my work in practice. I wanted to gain knowledge of where the building industry currently is and how to bring about some sort of change for the future of construction methodology. My curiosity led me down different paths, all with the same outcomes: things need to change fast, and the only way for that to happen is to start. Changing the whole industry overnight will not happen. As people, we like to control our surroundings, but I now believe that by giving up this control,

good things will come.

1 The big picture

* Facts and figures
* How the world is being depleted of resources

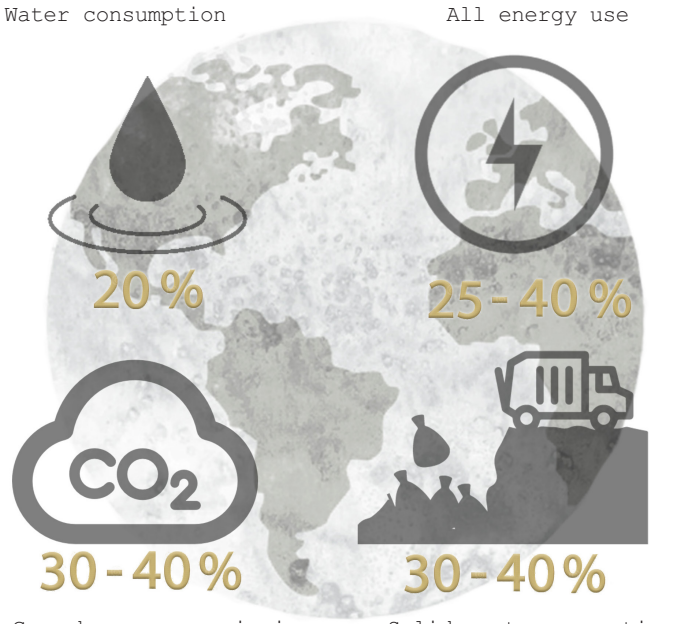
From excessive consumption of global resources to the pollution of the environment [Ding, 2008], construction causes more destruction than what humans can give back. This is devastating, and the figures are staggering to behold. I consider myself a blooming environmentalist and I believe that naming the problem and confronting the facts will help in making better decisions as construction is an inevitable part of living in a society. As the human population grows, the planet is affected in ever-increasing ways. Climate change is one such issue, but the depletion of resources - such as fresh water and minerals, different forms of pollution, and ecosystem destruction are all urgent matters as well.

The leading cause of waste, and a large culprit for emissions, is the construction and demolition industry. It is also the world's largest consumer of raw materials, with about 3 billion tons annually. [Arup, 2016] To reduce greenhouse gas emissions, a sustainable construction sector is vital to reaching the 80-95% long term reduction goal set by the EU [European Commission, 2012]. The construction sector is of great economic importance and provides 20 million jobs in the European economy [European Commission Brussels, 2012]. Out of those, 11 million people work in construction, and they can be exposed to a lot of harsh chemicals. 45 000 chemical substances are used in building products across Europe, and 35% of them are regarded as hazardous to human health and the environment. Such elements may be carcinogenic, bio-accumulative, mutagenic, allergenic, and more. [Sheidaei, 2006] Globally, the environmental impact of building amounts to 20% of all water consumption, 25-40% of all energy use, 30-40% of greenhouse gas emissions and 30-40% of solid waste generation [European Commission, 2012].

This problem is universal and Finland is not excluded. 16 million tons of Construction and Demolition Waste (CDW) was generated in Finland in 2012, according to a CDW waste publication issued by the EU, a large part of which is wood waste. Resources are being consumed at an exponential rate. Around 90% of CDW is kept from landfill since a sizeable portion is recycled. This is thought of as a neat solution, tied up in a bow of beautiful closed loop recycling. The truth is that the materials get downgraded, as they are of lesser quality, and the industry has not capitalized on the full potential CDW has to offer.

8%, or 2,8 billion tons, of total global emissions of carbon dioxide were generated by the concrete and cement industry in 2015 [Timperley, 2018], cement being the substance that binds other materials together. This figure is horrifying, seeing as urbanization is set to increase to around 25% more than today, to about 5 billion tons by 2030 [European Commission, 2018]. The need for products

The global environmental impact of building



with concrete will continue to rise equally. Half the emissions are due to clinker, so improvements could be made by creating clinker-free cements, or simply reducing the amount of concrete in the built environment [Timperley, 2018]. Approximately one million tons of concrete accumulates in Finland annually, about 80% of which is used for the production of recycled aggregate. Each year, around 350 000 tons of recycle-based mixtures are used. Fly ash makes up a third of this, and blast-furnace cinder accounts for the remaining two thirds. [Saarinen, 2018]

Green Building Council Finland (GBCF), with funding from Sitra, has developed a Life Cycle for Buildings -system with a goal of influencing the Finnish building laws and directives towards a more sustainable future. The life cycle measurement system by GBCF measures the load of a building already in the pre-planning phase, as well as the use-phase, so that the potential environmental impact of the whole building cycle is considered. The measuring system is based on international measurement standards, and it is applicable to the Finnish regulations. It contains six different variables, from the carbon footprint of the life cycle to indoor air environment quality. But at this point, giving out scores for using better materials is a waste of time. Building practices need to be drastically changed for anything of impact to happen.

Factors involved in the current building chain:

Design and regulation: design is highly regulated with lots of menial phases and poor communication

Construction: methods that are outdate and unsustainable are used

Affordability: resulting buildings are priced high

Demolition: lacking a circular approach and generates massive amounts of waste material

The depletion of sand

Globally, the demand for sand and gravel has multiplied exponentially since the invention of modern-day concrete, making them the world's most extracted materials [The Economist, 2017]. Sand is essential to the production of cement, glass and concrete, and increasing urbanization means their demand will rise as well. Between 2011 and 2013, China used more cement than the United States did during the entire 20th century. Around 11 billion tons of sand was mined in 2010 for construction alone. [The Economist, 2017]

Naturally formed sand from the weathering of rocks and corals takes millions of years, and these reserves are being used up more quickly than they can be replenished. Desert sand is too fine to use in construction, so most often sand must be imported. Sand extraction damages the environment by destroying natural habitats and polluting waterways, and extraction is becoming ever more difficult and expensive [The Economist, 2017]. Construction rates grow nearly 4% annually. Over-exploitation of sand resources has even caused illegal trade in the business. [Smithsonian, 2017].

New ways of building and renewable resources need to be created just to keep up with the ever-growing population.

Building law and its primary goals on sustainability and eco-friendliness are conflicted with the building industry. The term "life cycle" is not a very good measure, since it is not a means to pursue a genuinely sustainable building method. For a sustainable building to be designed for 100 years is too short-sighted, and the building industry should instead be striving for solutions that are permanent, or as durable and long-standing as possible. The current issues in building are strongly associated with materials and substances that lead to waste that pollutes. Wood, rock, clay, sand, brick, glass and steel are recyclable, and are not polluting in themselves. If a building built out of sandwich elements, versus a wood-structured building, burns, which one retains arable land? The problems therefore relate to other substances that are not regulated: the building industry has kept their products hidden, and these products can contain harmful substances.

Combating this issue means looking into alternative solutions to the current ways of building. More sustainable and greener ways are continuously being researched, and some are even being used, but the rate of change is still small in comparison. It will not take long for the detrimental effects to start being noticeable. So far, mostly efforts into reducing the energy expenditure of buildings have been made through regulations. This is just a tiny slice of the building picture. There is much more that can be done. Beginning from the design up until demolishment, all aspects of construction need to be considered to accommodate better ways to handle construction.

Why is the building or area being built in the first place? Could it be located somewhere already existing? Can the new building accommodate a variety of uses throughout its lifespan? What materials are being used? Are they safe, renewable and local? Have they been put together in a way that they can be taken apart? Can the elements be useful beyond their initial use? Where will the parts go after disassembly?

These questions should be answered when a project is being started, for they have as much impact as the energy use during the building's lifetime.

Construction is disruption, there is no way around it. The hot topic of discussion is curbing the effects it has on climate change. But construction is also necessary with a growing human population and increased urbanization, which in turn leads to more resources being consumed, and the planet being violated. Resources such as fresh water and minerals, pollution in various forms, and the destruction of ecosystems all have long-lasting effects with results that are yet to be fully felt. Implementing environmental life-cycle assessments (LCA) that try to quantify all these vectors of concern seek to present more informed decisions when it comes to building. [Green Design, 2011 - Nadav Malin "Materials for green building"] The building sector could solve many issues by simply returning to the old ways of building, pre- 1960s and before plastic, when resources were scarcer.

Replacing concrete

Two facts that need to be kept in mind regarding concrete: firstly, it is the most used construction material that shapes an enormous amount of the physical environment, second is the relatively high embodied energy due to the use of clinker in its component [Salama, 2017]. To make cement from calcium carbonate, the carbon is driven out of the mineral and released into the atmosphere [Green design, 2011 - Nadav Malin "Materials for green building"]. Reuse of concrete construction products as products for the same or equivalent use can be made when the products can easily be removed intact. [Saarinen, 2018]

As the demand for concrete rises, alternative materials are being researched.

Ferrock:
By using waste steel dust from the steel industry, a building material that is five times stronger than concrete can be made. [Build Abroad, 2016] It absorbs carbon dioxide as part of its drying and hardening process. [Inhabitat, Peckenham, 2018] It becomes stronger in salt water environments and can withstand compression before breaking and is more flexible than traditional concrete. [Build Abroad, 2016]

Hempcrete:
Combining the woody inner fibres of the hemp plant with lime, light and strong concrete-like blocks can be created. Hemp is fast-growing and renewable, and it lasts longer while having a lower carbon dioxide footprint than concrete. [Inhabitat, Peckenham, 2018] This material is non-toxic, waterproof, fireproof and resistant to mold above ground. It can be used for insulation, flooring, walls and roofing.

Mycelium:
Mycelium is a fungi root that can be encouraged to grow around a composite of natural materials, such as straw, into premoulded shapes. It is then air-dried to form a lightweight and strong brick. [Inhabitat, Peckenham, 2018] This eco-friendly biomass has grown in popularity recently due to its sustainable nature.

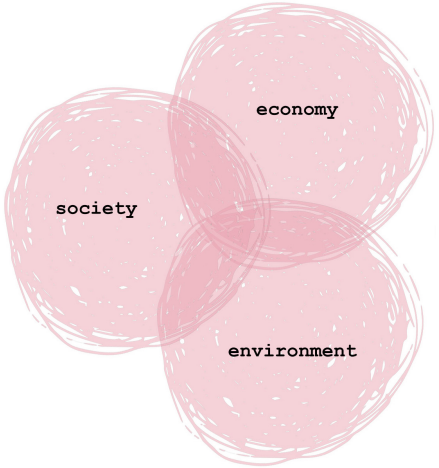
Aircrete:
Fire resistant, moisture resistant, frost resistant with structural and thermal insulation capabilities, aircrete (officially autoclaved aerated concrete) is light and cost-effective. It can be used for blocks, wall panels and cladding and uses 30% less energy to be produced. Unfortunately, it is brittle, which limits its overall use. [Inhabitat, Peckenham, 2018]

Timbercrete:
Replacing some of the energy-intensive components of traditional concrete, timbercrete is made up of sawdust, a by-product of timber mills, and concrete mixed together. As it is lighter in comparison to concrete, transportation emissions are reduced. [Inhabitat, Peckenham, 2018]

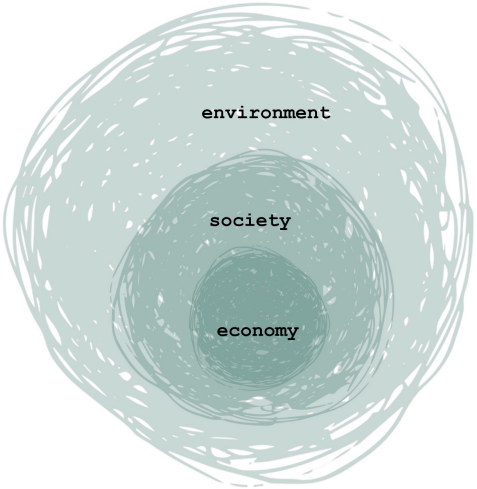
Greencrete:
Composed of waste and naturally occurring materials, greencrete is a low-carbon alternative to cement. Its main use is for covering the ground, as it allows vegetation to push through it. [Inhabitat, Peckenham, 2018]

Values applied by the architect to the properties of the materials

How current values stand



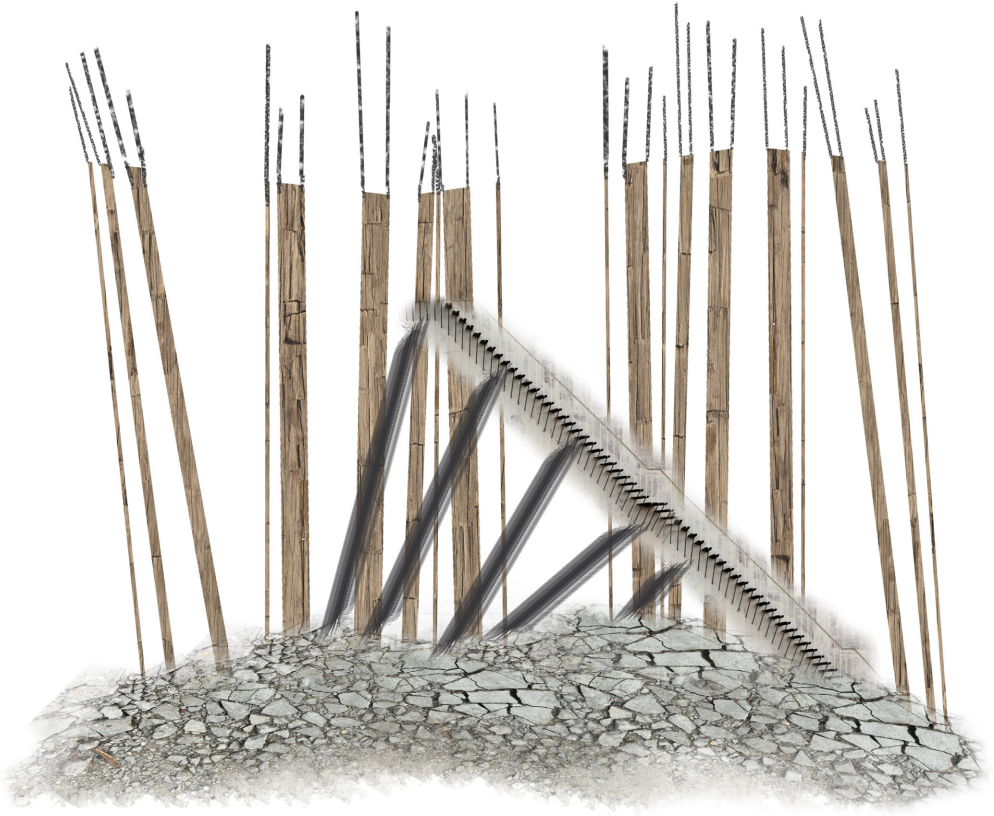
How values should be addressed



[Mattila, 2014]

The figure above illustrates the prevailing system of values, and what it should move towards. The left figure is often presented to show that these core values of economy, society and environment should be treated equally, creating a balance between them. In reality, economy, and ultimately money, is the one coming out on top. As a consequence, the environment suffers, and societal issues are superficially undertaken.

On the right-hand diagram, the environmental value is the most significant tool of decision-making. Choosing methods and materials that cause the least amount of harm to the environment eventually serves the needs of us all. Societal needs come second in order to keep communities healthy and happy. As these two fall into place, the economy will bloom as a result.



"Every building is interference, a change, and starts with destroying something but at the same time has the chance of creating something new and better."
- Thomas Herzog

2 Sustainable architecture

"Green building, also commonly known as sustainable or high-performance building, is the practice of creating structures and using processes that are environmentally responsible and resource-efficient throughout a building's life-cycle, from siting to design, constructions, operation, maintenance, renovation and demolition." [Green Design, 2011 - Khee Poh Lam, p. 80]

* Defining sustainable architecture
* What methods are used in real life

Rule number one: Don't build.
Rule number two: Repair old.
Rule number three: If it must be built, make it SUSTAINABLE.

"Sustainability" in design can be defined and approached in many ways. Considering all the energy and resources going into building, it should be the number one concern and always the starting point of design. Awareness of the environmental impact of construction has dramatically increased due to heightened concerns over pollution, resource depletion, environmental degradation and climate change [Green Design, 2011, p. 96]. Hopefully, future buildings will be able to marry the juxtapose of quality aesthetics with being environmentally responsible all around.

How does building impact the environment? How to build it to last as long as possible with maintainability in mind? Which non-toxic materials should be used? How to achieve an overall beauty of functional aesthetics in theory and practice? These questions should be answered during all stages of building from design to manifestation.

The most unimposing way to support the sustainable architecture ideology is to conserve existing structures. According to Sitra, it would be highly advantageous to increase the usage percentage of existing buildings to curb the effects of the sustainability crisis [Arponen et al, 2014]. For example, the utilization rate of offices in Finland is only about 40% [Herlevi, 2015]. This means that a significant part of the built environment is lying in a partially or even fully unused state, while new space is simultaneously being created ever more rapidly. In a hyper connected society, sharing could become more important if the information about unused and shared spaces would be available comprehensively and in real time The Platform economy is a favored term in city development strategies, and it refers exactly to these sorts of easy-to-use applications in a sharing economy [Raunio et al, 2016]. With the help of networked applications and sensors, the use of the built environment could be diversified and improved

significantly. From the perspective of the designer, the circular economy and enhanced utilization of buildings would mean a continuous workflow from renovations and refittings as well as designing more multifunctional and adaptable spaces. As experts in the built environment, architects are responsible for sustainable as well as functional buildings.

Construction is led by government regulations. The Minister of the Environment, Energy and Housing, Kimmo Tiilikainen, believes that good policies with achievable targets can be profitable for businesses, which leads them to drive actual change. In turn, this will result in quality growth, healthy cities and clean air. Striking a balance between environmental, social and economic aspects tests the ability of creating sustainable architecture. Sustainability and controlled growth go hand in hand. This can be brought to fruition when the current situation is known, the ideas of where we want to be, and the steps to get there are mapped out clearly and concisely for the benefit of the people, businesses and the environment. [Tiilikainen et al, 2018]

Wolfgang Teubner, the ICLEI regional director for Europe, argues that we must change our mindset to being satisfied with sufficiency and forget the notion of continual growth through overconsumption. [Tiilikainen et al, 2018] To be sustainable is to distribute everything that is produced, meaning there is no waste, with more efficiency. This begs the question of how to produce more with less in a constantly growing environment? The present day is always beating out the future, meaning that resources are consumed with little thought to repercussions.

Much attention is given to the energy use of a building during its use, and often the emphasis of a building is to make it as energy-efficient as possible. Buildings are then designed with thick walls and roofs to keep heat in, and mechanical ventilation systems to recover the heat that would otherwise escape. Using renewable energy sources while designing would seem logical. Geothermal, solar and wind energy are considered to be environmentally friendly, and I do agree to an extent. However, producing the apparatus that gather energy also requires resources. For example, solar collectors. The production of solar collectors for energy has a larger carbon footprint compared to emissions from other building parts. Solar collectors also have a relatively short lifespan. The net effect on the carbon footprint depends on what energy forms the collectors can replace. Therefore, keeping things simple and unmechanical as far as possible would be ideal.

A basic checklist at the beginning of design:

1) low construction impact (using minimally destructive methods to place the building through careful and conscious design by using replenishable materials)

2) resource efficiency through the life of the building (conserving resources during use)

3) long lasting (the longer used/lasts, the more efficient the material use)

4) nontoxic

5) beautiful (something to cherish and uphold)

2.1 Sustainable building practices

Part of my research was acquainting myself with how to build in practice in a sustainable way. Each building is unique and site specific and should be treated as special. A building should be easy to understand and maintain. Old buildings are a source of knowledge.

At the very basic level, a building needs a supporting structure, temperature control, separation from the elements and connection to those elements [Snell, 2009, p. 15]. A great emphasis should be placed on good quality and durable structures and materials. The structure of each building needs to be designed specifically for that building [Snell, 2009, p. 47]. Also, the context of the building must be considered: is it in a city environment or in nature?

At its core, a building itself protects the user while also protecting itself from the elements. It has to have a skin to keep from decaying from wind,

sun, rain, snow and moisture, while at the same time allowing these features to work for it, like utilizing the sun for heat sources and redirecting water with overhangs. [Lacroix, 2007]

Minimizing excess use of materials is also an important factor in sustainability. Mass-scale production of modular materials, which are customized on site, is a waste of materials [Snell, 2009, p. 403]. It's not the materials but the builder that makes the building green. Building is a process of assembling materials that can be self-produced, salvaged, locally produced or mass produced [Snell, 2009, p. 144]. It is good to keep in mind that nothing is ageless, and decay will eventually win, thus giving the elements something to damage that can be repaired. This offers one solution for making the building last longer.

As I am on the verge of becoming a more independent designer, I want to be as aware as possible which product and material choices have the least potential to have a negative impact on everything.

There are the conventional factors, which we are taught to use, to consider. How a product or material functions to serve its purpose and its aesthetics are at the top of the list. Availability in sufficient quantities in relation to location as well as cost are not so much the designer's concern, but still important factors. Durability and maintainability help increase the longevity of a building, and this ties in with the quality of the products. When it comes to environmental and human health concerns, things like embodied energy, design for disassembly, toxicity and transportation impacts become more important to consider. [Green Design, 2011 - Nadav Malin "Materials for green building]

The overall carbon footprint of a whole structure could become smaller with some slight improvements in the frame material, [GBC, 2016, p. 10] meaning optimizing the material either by reuse or using less, for example, vault structures. It must be noted that when recycled materials are used as load carrying structures, the validity of that material must be tested.

2.2 Aesthetical yet functional

"Architecture as the crystallization of the thoughts and feelings of a civilisation."
-Louis Sullivan

In a perfect world, all buildings would be objectively beautiful, functional and environmentally responsible. A building is always inseparable from its building site, and choosing the right way to build for a certain project can enhance the immediate surroundings ecologically as well as visually. The trinity of design, functionality, durability and beauty, can be fulfilled with an ideal of reinstatement, meaning bringing back, returning. [Architects' Council, 1999]

There is sustainability in beauty, as it is able to fulfill while not attracting attention. A building becomes independent of time, exudes the sense of use, has pleasant smells and alluring sounds when it is beautiful. Building as an art form serves the soul and simultaneously our physical bodies of all sizes, ages and abilities. It becomes a place where people want to stay and spend time. [Löfroos et al, 2018]

We can look to nature to find the most efficient and pleasing structures and use that knowledge in designing. Finding a balance between using technology in a way that optimizes the use of materials while also sticking to the basics in building rules has the greatest potential to succeed in the long run. The architect is the one responsible for keeping that balance in check from managing the whole system to the smaller details. The future of sustainability depends on how much we work together with nature and still maintain the standards of living we are used to. [Riuttamäki, 2003] "Development that meets the needs of the present without compromising the ability of future generations to meet their own needs." [Green Design, 2011, p. 58]

A case can be made for using certain guidelines in creating peaceful, comfortable and beautiful surroundings. Architecture is only partially a visual art since it has to simultaneously meet the needs of the users in a practical way and also give the space deeper meaning and value. When designing for a certain place or space, the character and feeling of the surroundings should be considered and, in this way, try to complete and complement the area with the design [Rihlama, 1978]. Employing techniques that create movement and tension working together can form a pleasant result. Motion can be generated by swerves and undulating forms [Rihlama, 1978, p. 31].

Taking inspiration from nature and emphasizing it in a building is a sensible way to approach graceful design. Human existence is always fleeting compared to the eternity of nature. Architecture at its best dissolves the boundary between nature and building, supporting and linking into each other with the use of light, texture or transparency. Villa Långbo (2000) by Olavi Koponen in Kemiö takes this idea to a whole new level of integrating a structure with its environment and clearly shows that it is possible to have a harmonious meld. [Museum of Finnish Architecture, 2005, p. 85]

Beyond the physical, architecture is a philosophical form of art. Architectural space is used to symbolize man's existence in space, symbolically leading to the world beyond death. Man and nature are as one, forever immobile and eternally moving, neither finite nor infinite. [Norberg-Schulz, 1975] Sustainable architecture, therefore, is the embodiment of what it feels like to be human, creating a place of belonging for the body.

"Man is surrounded not only by the dimension of space but also that of time". -Karl Schefold

Applied practices to further the sustainability of construction to save natural resources and use less energy

Building less

Better durability for long-lasting structures

Choosing to use recycled and renewable materials and products over new, synthetic, multi-layered ones

--

We have gone from working with nature to working against it, trying to control it or even, egotistically, trying to prevent it from happening. Nature will always win, and once we accept that and allow nature to become a part of architecture, true sustainability can flourish. Architecture is bigger than the architect, and so, too, nature is bigger than architecture. Space cannot be controlled, but it can be created and have meaning. [Löfroos et al, 2018]

The current construction industry is a wild swamp of demanding voices. The sustainable voice can easily be lost in the cacophony, but it is an important one that will start gaining traction once the tipping point is reached (although hopefully before it is too late). Imagine the industry as a large ship on course. Turning that ship is hard and slow but with small shifts, the whole direction can be changed.

Ecobuilding case 1

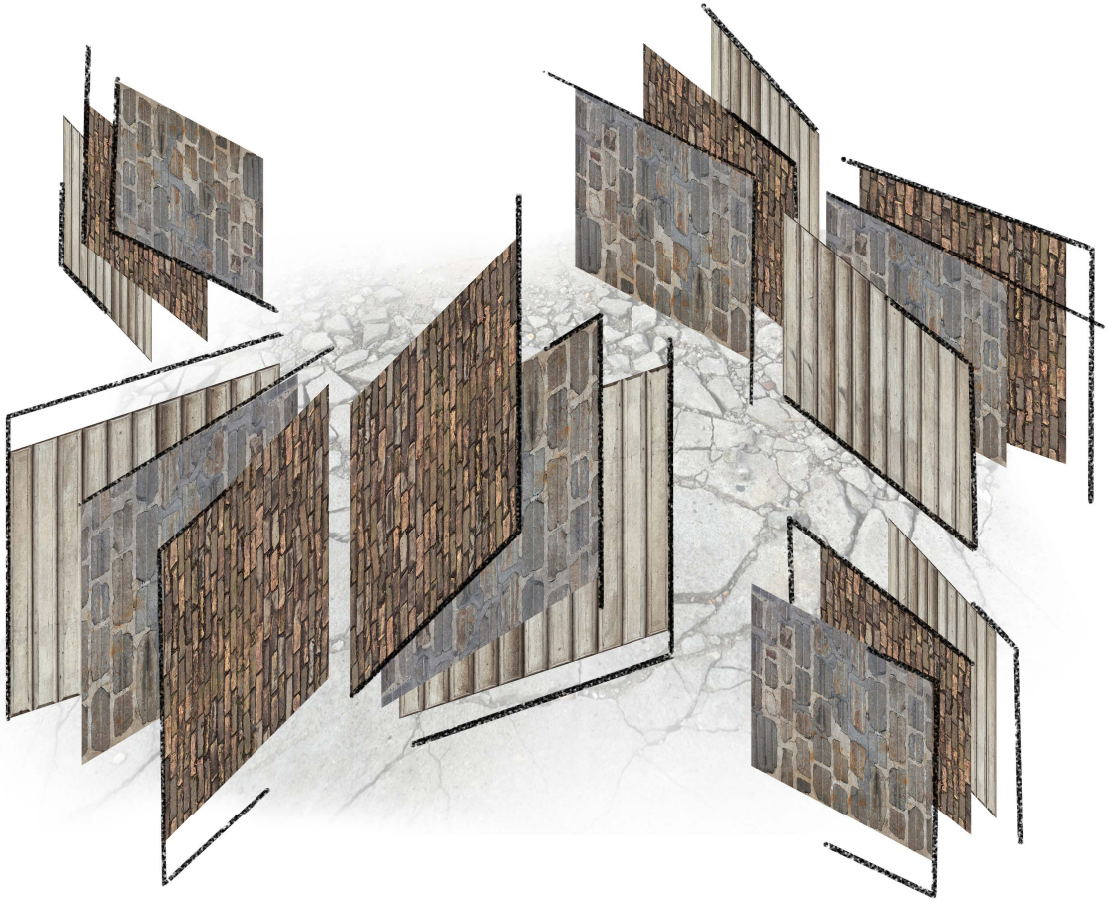
Area of Svartlamon
/ Haakon Haanes, Trygve Ohren
/ Trondheim, Norway

A quirky street scene from the Svartlamon area [Haanes, 2015]

This area is an experimental building arena for city ecology. It showcases Norway's tallest wooden building while most of the other houses were built at the end of the 19th century or the beginning of the 20th century. In 2001, the city decided to rehabilitate the existing buildings.

The area is organized and run by residents and other tenants in common, according to principles of sustainable environmental solutions, flat structure, transparent economy, low standards and affordable rentals. [GBE, 2016]

"Svartlamon is the first experimental urban ecological area in Norway. The overarching goal is that Svartlamon becomes an alternative space in the city. A space which gives room for experimenting with housing, ways of living, social interaction, participation, ecology, energy, municipal services, art, culture and commercial development." [Haanes, 2015]



“Circular economy works like nature.
No waste,
just resources.”
- Jules Coignard, Circul’R

3 Circular economy

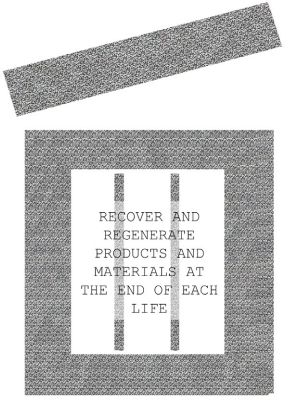
* What is circular economy
* How it relates to building and architecture
* Advantages of the circular economy

The circular economy is a way to be prepared for dwindling resources [Pantsar, 2018]. The theory behind it is to make use of what was once waste, which can be re-imagined into a resource by reusing materials for a longer time, regenerating new products from its previous life or discovering a way to make use of production by-waste. In a circular economy, the already once extracted natural resources stay in circulation and they are used for as long as possible. This can also be called the cradle-to-cradle approach as material will always circle back to the beginning. [Arup, 2016]

Some characteristics of the circular economy are designing of long-life spans for a product, utilizing digitalization, resource efficiency and the sharing economy [Arup, Schofield, 2016]. The end objective is to produce products that are designed to be recyclable. This can create new opportunities of enterprise, create new markets, and grant competitive advantages. In contrast, the prevailing system of a linear economy, with a mantra of make, use, dispose, has products end up as waste, placing a substantial strain on the planet's natural resources. [Provada, Circular Economy, 2018]

In a circular economy, resources are kept in use for as long as possible, extracting the maximum

A systemic shift that builds long-term resilience



value from them whilst in use, then recovering and regenerating products and materials at the end of each service life. As well as creating new opportunities for growth, a more circular economy will reduce waste, drive greater resource productivity, deliver a more competitive economy, address emerging resource scarcity issues in the future and help reduce the environmental impacts of our production and consumption. [Wrap, 2018] By creating products, and in this case buildings, with a cradle-to-cradle philosophy and using waste-to-product materials, circular economy can be achieved.

As with all things construction, bringing the circular closed loop idea into use is not simple task. One way to look at it would be to design for changing circumstances, i.e. evolving uses, thus extending the lifetime of a new building. Another is to make use of existing spaces via technology and re-imagining them to fit different needs, for example, using office space or schools during the evenings and night, otherwise known as the platform economy. [Circular Economy, 2017] The construction industry needs to be encouraged to incorporate cradle-to-cradle mentality into all areas of building. This means reshaping the way projects are procured, designed, constructed, operated and repurposed. [Arup, 2016]

The most interesting aspect of circular economy to me personally, and what some of this thesis will focus on, is the salvaging of used materials from deconstruction, as well as designing for disassembly. When deconstructing buildings, the building parts should firstly be attempted to be used again, secondly recycled into new materials, and only be burned for energy as a last resort. Thus, the circular economy encourages energy, material and resource efficiency. [Green Design, 2011]

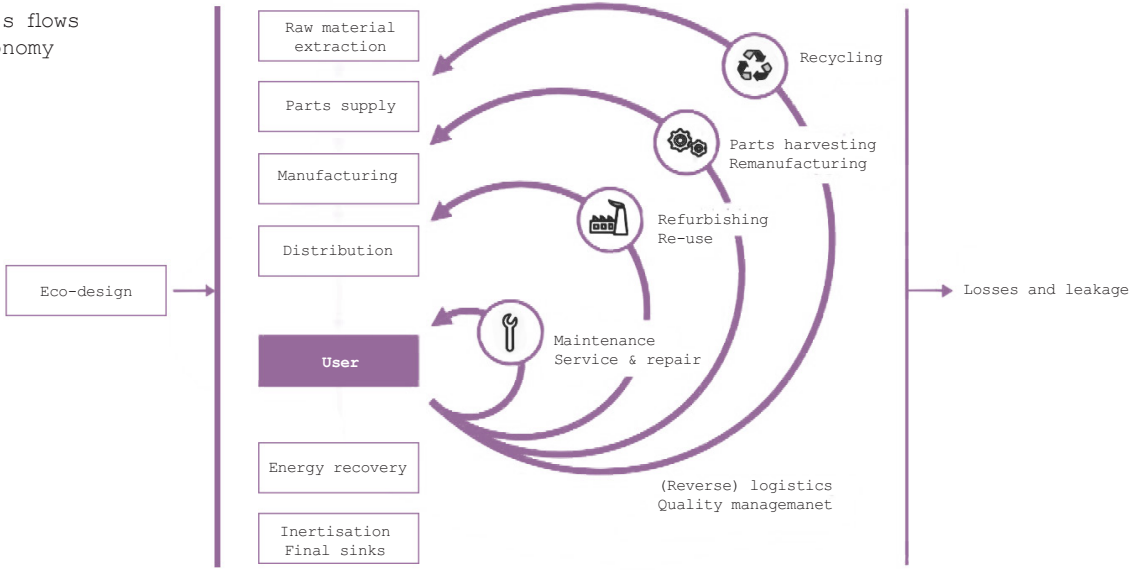
Technically speaking, there are two types of material flow. The first is biological cycles, which use renewable and plant-based resources that are designed to re-enter the biosphere safely. The second is technical cycles, which have artificially made, high quality products which are meant to circulate in the production system without entering the biosphere, creating a closed loop. For example, using untreated agricultural waste that can be returned to nature as is, or manmade products that are designed to withstand multiple uses that keep their quality regardless of age. By designing a system that realizes this theory, energy requirements are decreased, waste production is lowered, and pollution is reduced. Planning how to minimize waste and how materials can be reused and recycled at a product’s end of life should be done preemptively. [Arup, 2016]

It is hard to justify single use building anymore, as maintainability rises to become the most important criteria. Future infrastructure will need to share the values of the life cycle of older structures. It will have to be simple

technology, be indefinitely maintainable as well as natural, renewable and be able to utilize the flow of ample recyclable materials. Continuing to carry on with the status quo way of construction, without interfering with the too brief lifespans of buildings and building products, the future is on unsustainable grounds, despite the efforts of energy savings during use. It is vital to focus on the bigger picture when it comes to building, and look beyond the immediate effects at longer lasting and broader contexts. [Mattila, 2014]

Goals regarding moving to a circular economy [Herlevi, 2015]:
- economic growth becomes independent from resource consumption
- sustainable business
- optimizing the value of materials
- new jobs and increased wellness

Functions and mass flows in a circular economy



[Ellen McArthur Foundation, 2018]

Ecobuilding case 2

The Circular Building
/ Arup
/ London

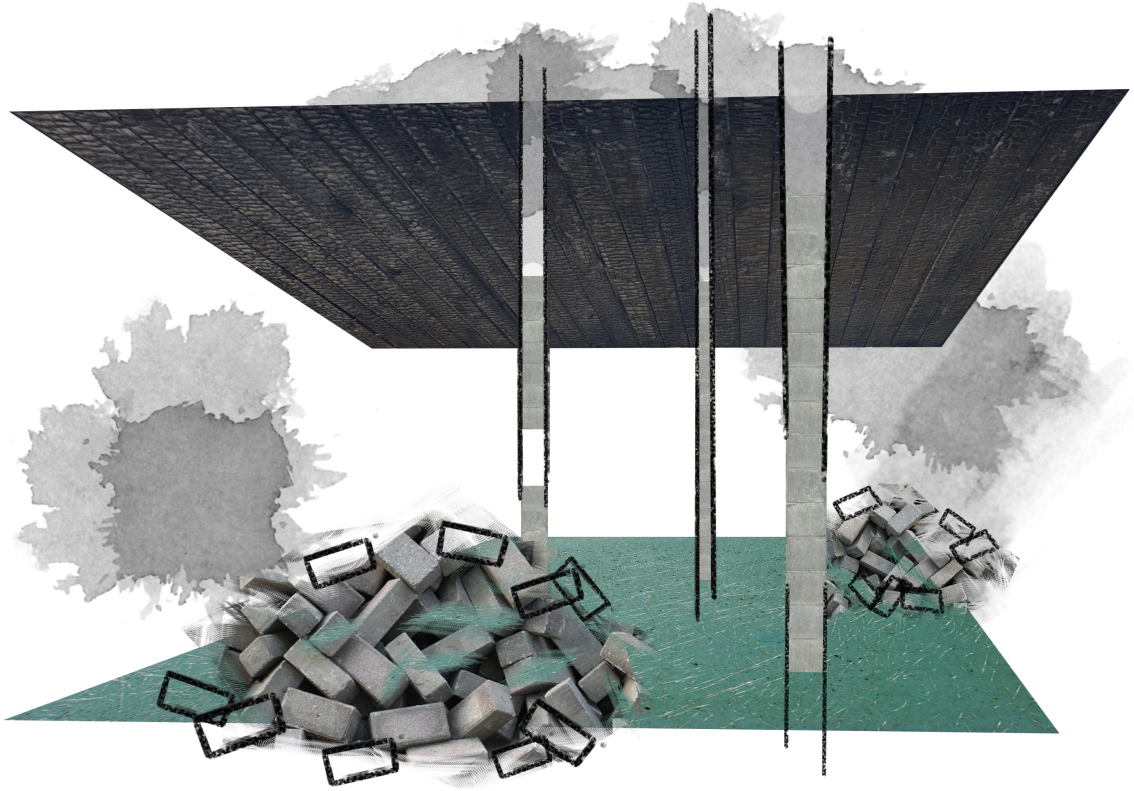
The pavilion on display in London, fall 2016.
[Architect's Journal, 2016]

"All components need to be implemented and utilized to their full potential and to the duration of their life cycle, while creating a comfortable and aesthetic environment for the user." [BAM, 2016]

The company Arup wanted to apply the principles of the circular economy to a building. By dissecting each component that goes into a building, they were able to design a prototype pavilion with fully circular materials and products. It is made from recycled and recyclable components and can be assembled and disassembled like building blocks. [E and T Magazine, 2016] The components are digitally tagged and retain all information about the product as well as real time viewing of data about the use. [Arup, 2016]

The steel frame structure has structurally integrated panels (made from agricultural by-product) which are removable as all buildings will eventually out-live their original function. [BAM, 2016] The design is modular and flexible as well as nontoxic and resourceful via materials used, such as the inside walls made from 80% PET bottles just pinned to the exterior. Some products can be sent back to the manufacturer at the end of its life cycle and remanufactured into new products. The envelope is made to preserve energy expenditure and temperature can be controlled with the help of sensors. [Circular Building, 2017]

This project illustrates that the industry's current one-off type way of building is outdated. It is 100% cradle-to-cradle, meaning everything down to the smallest part can be reused into something new. The result engages all fronts: designers, suppliers and users.



“Waste is material without identity.”
- Thomas Rau, Madaster

4 Getting rid of the concept of "waste"

Garbage has value. The world is full of waste yet the demand for raw materials is increasing globally.

* How the current waste management flow systems works
* Future waste management strategies
* Closing the production loop

The most substantial cause of dumping waste is made up of construction and demolition waste (CDW). By increasing the performance of construction site management, using more recycled materials and preserving and reusing existing buildings, a considerable portion of CDW could be diverted. So, to start, a mind shift is needed. There is no "away" or "gone" when it comes to the life of materials. The baseline should be that everything can be used, there is no such thing as waste. Once that concept is internalized, measures can be taken to prevent waste from happening.

Predictions show that the global demand for raw materials will increase during the next 20 years, for example steel by 57% and energy by 32%. Currently 10-15% of building materials goes to waste already during construction. [European Commission, 2012] In Finland in 2017 alone, 350 000 tons of concrete and brick waste was demolished. Together, all demolished material amounted to 1 000 000 tons. A small house weighs about 45 tons, whereas an entire apartment building is about 65 000 tons. [Palomäki, 2018] Waste among building is distributed unevenly. Compared to new construction (14%) and demolition (27%), renovation (57%) is the greatest source of waste with over half of everything going to landfill [Ministry of the Environment, Waste Plan, 2018].

Steps that can be taken are readily available, the greatest one being to RECLAIM vacant buildings. Mostly their structures are sound, but for some reason they are unused. Taking them back into use is the most obvious way to prevent waste from demolishment. This also REDUCES the amount of new buildings that need to be built, and in turn reduces the amount of material needed. RETHINK comes into play as the mind shift settles in. Waste is no longer designed into the process but is designed to become part of the process. Currently, buildings in Finland are demolished with one ultimate goal: make the building go away. Sometimes it is necessary. However, in the case of a building with quality parts, selective demolition could be applied to RECYCLE and RECOVER those parts. [Sheidaei, 2006]

New materials waste a lot of finite resources, especially energy, therefore reusing materials would be a great benefit for all. Less demand should be placed on the perfect condition of materials, for example, using wood with knots is quite acceptable. According to Demolition Services Business Manager Kimmo Palomäki from the demolition company DELETE, buildings that are currently being demolished are

generally in good condition and could be used again. The final material costs, consisting of the labor and transportation, would hypothetically be minimal. Almost all of the material that is demolished is in good shape and could be used again, including foundations, columns, beams, windows, doors, furnishings, façade cladding and so on, and only things that have been glued or melded together and are difficult to disengage from each other cannot, most likely, be reused. Bitumen roofing material cannot be reused as it is damaged in the demolition process. [Palomäki, 2018]

As stated, nearly everything that is demolished would be in good enough condition to be reused in construction. The only hindering factor towards the use of these materials in Finland is that they are classified as "waste" at this time, and do not have CE certificates that are required on the EU level in construction. From the Finnish Standards Association SFS:

> "CE marking is the manufacturer's declaration that the product meets the requirements of relevant directives. The marking is obligatory, and it shall be affixed to products if this is required by the relevant directive. Other products shall not be labelled with a CE marking. There are more than 20 directives requiring a CE marking. -- In addition to requirements concerning the product, the directives include requirements on the attestation of conformity. Certain products shall, for example, be tested before affixing the CE marking. -- For construction products, the CE marking does not necessarily guarantee that all regulations have been met. Users of construction products shall ensure that the CE marking details prove that the product meets the minimum requirements set by authorities for their intended use. -- There are several ways to apply for a CE marking to a product covered by a directive. In some instances the manufacturer's Declaration of Conformity is sufficient, whereas sometimes a third party (Notified Body) has to be involved." [SFS, 2018]

On one hand, this is understandable, seeing as there is likely no way to trace the origin or quality of an older material. On the other, a system could be set up where these demolished materials going to waste could be briefly examined and tested and put back into circulation. Countries like the UK, Sweden and the Netherlands are already allowing the use of demolished elements and have databases where designers can find the parts they want. For example, the Dutch site Madaster [Madaster, 2018] or the established companies in Sweden such as Kompanjonen and Kretsloppsparken, deal with the selling of second-hand construction materials for reuse. Kompanjonen is a construction store of used and second-hand building materials founded in 2005. All products are 100% reused, which means cheaper materials which are better for the environment. Inventory is updated in real time on their website and products delivered throughout the Nordic region. They also offer storage and knowledge about recycling. In 2002, the Netherlands were able to return up to 60% of their material waste to use [Architects' Council, 1999].

"The future city makes no distinction between waste and supply."
-Mitchell Joachim

In recent years, companies like DELETE, which take apart existing buildings have made strides to decrease their emissions by streamlining traffic routes and optimizing the material for transportation. Using circular economy principles is not part of their business yet, mostly because of regulations. Buildings that are to be demolished do not currently get documented beforehand. Only the contractor makes a price estimate of the work involved and the actual numeral facts of weighed material are available only after demolishment. In the case of hazardous materials, they do have to take measurements and get rid of these materials separately and safely. [Palomäki, 2018]

At present, demolishment means crushing the deconstructed, existing material which is then transported to either recycling facilities or the municipal waste management location. This demolition waste consists of materials that are sorted according to the following categories:
- stone-based (reinforced concrete and brick)
- wood
- metal (colored)
- black iron trash
- general building waste
- miscellaneous materials (plaster, tiles, cardboard)

[Ministry of the Environment, 2013]

On the other side of the spectrum, there is construction waste. This comprises from the leftovers of undesirable materials resulting from the completion of a constructed building, such as excess mortar, broken tiles, broken framework, wires and material packaging, to name a few. [Sheidaei, 2006].

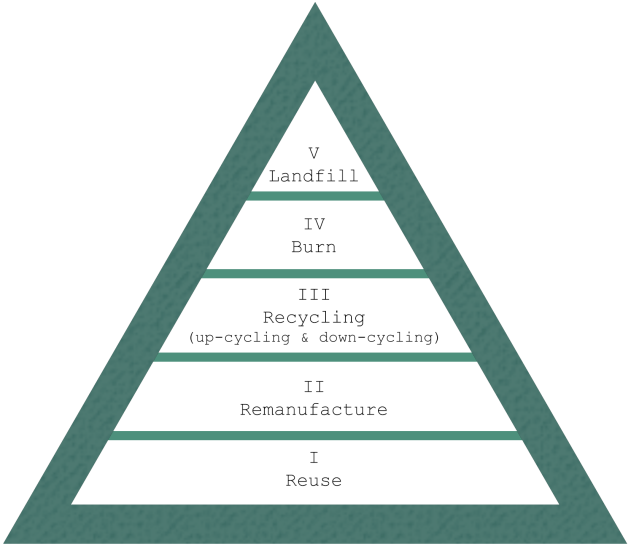
These two categories need different approaches in the way their waste can be reused, but it is clear that they both create unwanted materials at this time.

Palomäki assures that so much demolishment is happening continuously around Finland, as well as around Scandinavia where DELETE operates, that there would be no need for a demolished material storage. Only the logistics would need planning, such as when construction needs to take place, and have a nearby demolition going on, leading to just the transfer of chosen materials to the new site. [Palomäki, 2018] Since almost everything could be reused, according to Palomäki, new construction has great potential to become truly circular using existing resources. Overall, selective demolition is more environmentally friendly, although a more expensive option, since the building has to be dismantled instead of demolished. During the dismantling process, having a very clear material inventory helps to determine which materials are suitable for reuse or recycle [Sheidaei, 2006].

Waste is a DESIGN FLAW. It is a resource like any other and it should be implemented into the design process.

The production process regularly wastes material by simply discarding the unwanted parts. This way of thinking needs to be turned around and designers must be taught that waste is a resource, so that these discarded materials are used to their full potential. Already, by clearly managing material waste flow, the amount of CDW can be decreased [Architects' Council, 1999]. By using creative design and quality construction, waste can be minimized. Ultimately, this would all lead to creating a closed loop future where every bit of everything is made to be reusable, adaptable or biodegradable.

From a circular economy perspective, the most relevant factor is to design using as much renewable resources as possible, while preventing the creation of waste, and also in a manner in which the materials do not strain the environment. Attention must not become stuck in managing waste flows but in their absolute minimisation. [Arponen, 2014] The environmental impact varies for each material. For example, reusing plastic is much better than creating it from raw materials. Then there are concrete and steel, which require lots of energy and extreme heat to produce. Unsurprisingly, wood is the least environmentally harmful material. [Sheidaei, 2006]



Hierarchy of End of Life Cycle Scenarios

Long-term waste plan for waste management and waste prevention for the year 2030

1. A well maintained and quality waste management system as a part of sustainable circular economy.

2. Material efficient production and consumption save natural resources and moderate climate change.

3. The amount of waste have decreased from the present. Reusing and recycling have reached a new level.

4. Circulation of materials work well. New jobs are created from reusing and recycling.

5. It is possible to recover also small amounts of precious raw matter from recycled materials.

6. Material loops are harmless and less harmful substances are used in production.

7. The waste management sector has high quality research and experimentational action as well as a high level of knowledge and practice.

[Ministry of the Environment, 2013]

To combat waste and reduce the use of virgin materials, secondary materials should be increasingly used. They are materials that have been used before, whereas primary materials are extracted straight from nature, and are used in the production process for the first time. Replacing primary materials with secondary ones means less waste is created and more natural resources are saved. [Sheidaei, 2006] Existing buildings are significant reservoirs of materials and components ready to be mined to provide resources. Reusing old materials greatly reduces the environmental impact of a new building, while creating new jobs and business opportunities. This also reduces harmful emissions and results in a reduction of waste. [Green Design, 2011 - The Process of Designing with Reused Building Components, Mark Gorgolewski] Thus, the key to recycling is the separation of different waste types as early as possible. The most valuable parts of existing buildings waiting to be demolished are the parts that can be detached as wholes, such as trusses and fixtures. [Architects' Council, 1999]

With the growing need to circulate building materials, the design process is changed. Government regulation can aid in this transition to provide legislation that better incorporates the use of recycled products from derived CDW. This could result in new profits for the industry while improving the environmental impact coming from the extraction of valuable resources. The demand for recycled materials depends largely on the price and quality of these secondary materials. Price comprises of the work involved in demolishment, location, and quality control. The quality of the material is determined by authority standards which should be universal to determine or test. [Sheidaei, 2006]

Waste is an issue only if it is made out to be one. Landfills are overflowing, therefore designing waste into the building practices and products is a very viable solution. Already, there are numerous ideas that make use of excess materials, and new things are created with them, which is what the next chapter will touch upon.

Waste management

NOW

creating less waste
where it is sourced

waste separation

reuse or recycle

safely dispose of the waste

IN THE FUTURE

all matter has use

construction uses digital
means of logistics and marking

hazardous materials
are not used

no waste is created

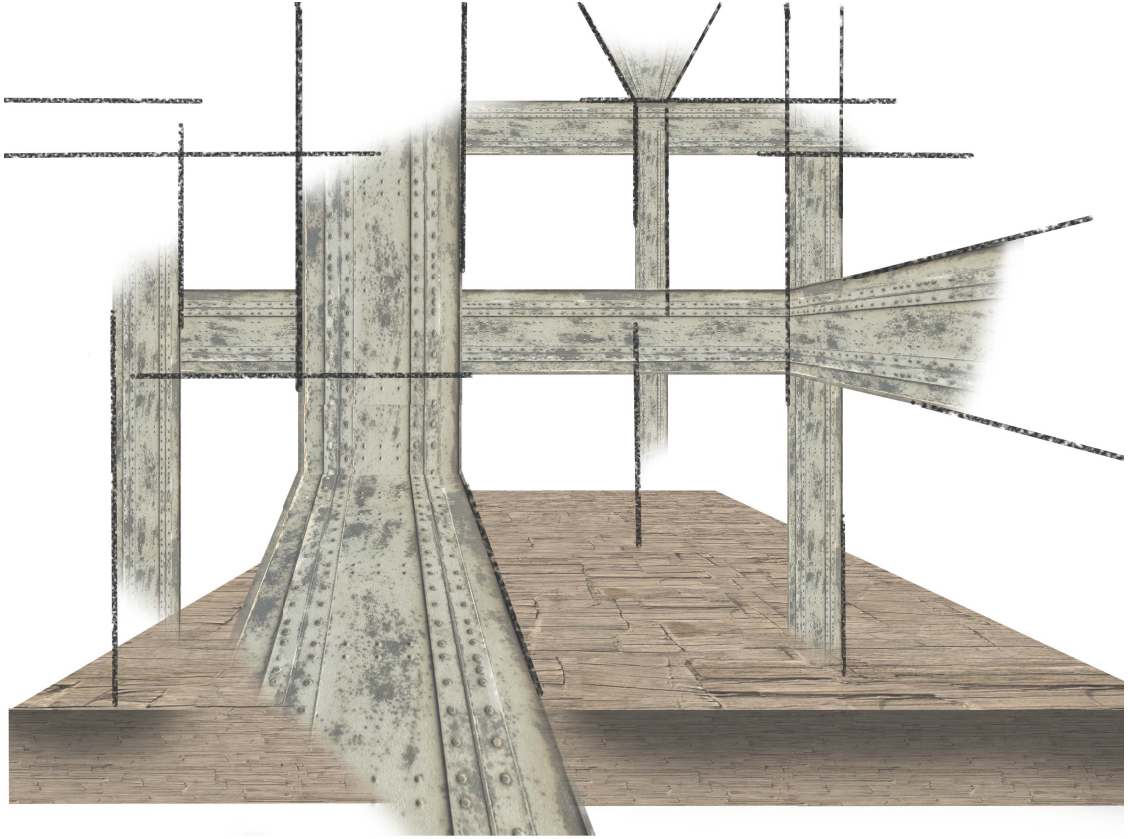
Ecobuilding case 3

The Resource Rows
/ Architects Lendager
/ Ørestad Syd, Copenhagen, Denmark

The reclaimed brick walls.
[Lendager, 2018]

The average new build can be easily identified by crisp white walls and contemporary roof shapes. The Resources Rows is a reclaimed wetland area in Copenhagen which uses its wall façade materials from abandoned rural dwellings, reducing carbon consumption by 70%. This creates weathered character that pulls out emotion from the onlooker. The existing façades were cut from abandoned buildings and by installing these pieces into steel frames, were able to give them new homes. These buildings are also a part of nature as they harvest rainwater for toilets and irrigation and encourage biodiversity with vertical gardens. The building has also recycled waste concrete and surplus wood from a recent metro expansion. [Auken, 2018]

The architects had the idea of using empty, rural buildings, as urbanization leaves them unwanted, but a treasure trove of materials. They wanted to promote the concepts of resource efficiency and optimization as part of curbing waste, while moving to a more circular building style. These “recycled” homes have a living history that can be shared with the new inhabitants in the community spaces. These sorts of projects are definitely forward thinking. [Lendager, 2018]



“If it can’t be reduced, reused, repaired, rebuilt, refurbished, refinished, resold, recycled or composted, then it should be restricted, redesigned or removed from production.”
- Pete Seeger

5 A world full of materials

Returning to the days when homes were built from natural, locally occurring materials.

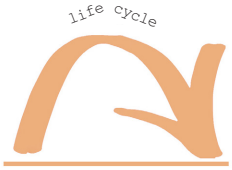
* The (im)permanence of materials
* Points of comparison (carbon emissions, energy expenditure, resource efficiency, water consumption, air quality, climate change)

As stated in the introduction, I learned about a whole new world of materials at the Venice Architecture biennale and that was where I heard the term from cradle-to-cradle for the first time. This concept made a lot of sense to me since it was very intuitive in the way it works. Take a material from nature, use the material for a while, and once it is no longer of use, return it to nature. Simple, effective, clean, sustainable. Unfortunately, construction is a bit more complicated than that, so it will, for the time being, be something to strive towards while remaining realistic of what can be built.

Everything will eventually break or break down, meaning nothing is permanent. Then again, in building, the goal is to have structures last as long as possible. Instead of fighting these two opposing ideas, there needs to be a happy medium while maintaining the beauty, health and accessibility of the materials and the whole. Naturally and locally occurring, yet minimally altered parts straight from nature are the most suitable for building. They create ageless surfaces and spaces while providing healthy places to dwell and work. Artificial, multi-layered and complex materials, on the other hand, have unappealing additives and appearances which cause problems sooner or later. They cannot be returned to the natural environment, as they would alter it and disintegrate too slowly, so, regrettably, they accumulate.

Quantifying how ecological a material is can be a complicated issue when comparing building materials. Many factors are involved and raising one over the other is quite arbitrary overall. Is the material local, is it efficient in resource use, how much energy is put into making it, what emissions are created, how much it pollutes and uses water, will it affect the air quality of the building poorly, are there added chemicals or hazardous toxins involved, and so on. These measures are negligible. There will always be energy used and emissions caused from modification and transportation. The real questions should be what the origin is, and can it be renewed. A simple answer is usually the best answer.

The constant obsession with new, maintenance free and extremely durable materials, to the point of being indestructible, has unsustainable built into it. While it is important to build long lasting buildings, the all-around environmental and health cost from materials is often dismissed. The responsibility should also be with the producer of the material and the contractor to not choose the



The present situation: materials are designed to have an end. Artificially made materials spread toxins into the environment causing ozone depletion, acidification, desertification, biodiversity loss and ground water contamination. Waste is created by accumulation. Complicated building methods, chemical treatments, plastic is forever.

How it could be:
a regenerating loop.
Nothing is wasted, using directly from the environment, can be returned to nature, is harmless and healthy, simple massive structures, easy to understand and maintain, ecosystems become a part of architecture.

Material circulation:
the present situation vs how it could be
[Mattila, 2014]

cheapest available, but the best quality product for the circumstances.

Choosing the right materials as well as technical solutions has a lot to do with how long a building lasts and how much energy it consumes as a whole, along with how locally it is available for use. Using materials which are cheap and easy at the moment, without considering the energy and resource consumption, upkeep durability as a whole, often fails the test of time. Energy efficiency is often over-emphasized with layered structures and thick insulation that predispose to moisture and mold [Länsiväylä 2018]. The longest and most important part of the life-cycle phase of a building is when it is in use. Materials affect indoor air quality both directly and indirectly, which is why choosing the best products for each situation is vital. [Green Design, 2011 - Nadav Malin “Materials for Green Building”]

Renja Rautiainen from Ämmässuo waste yard suggests that a certain percentage of recycled materials should be required to be used in building projects by law [Yle, Eskonen, 2018]. At the moment, reclassifying waste concrete debris as a useable material is only being planned. This is much less than should be made mandatory if we are ever to start reusing materials. Therefore, awareness of resource origins and scarcity should be highlighted in terms of sustainable architecture and construction.

A very important and serious matter is that materials are not always safe. According to the EU, "there are more than 45,000 chemical substances used in construction across Europe and about 35% of these chemicals are regarded as dangerous to both human health & the environment". [Sheidaei, 2006] These dangerous substances can have adverse effects, such as being allergenic or carcinogenic. This is a huge reason why a movement towards more natural and wholesome materials should take place, because living or working in an environment that causes illness is not good for anyone, when it can easily be avoided. Not to mention the construction workers that deal with the toxins themselves. It is also a risky investment for the state to have a large amount of national wealth tied into constructed infrastructure if it is just a ticking time bomb, waiting to explode in health care and reparation costs [Löfroos et al, 2018].

Still, construction will always be necessary. To build, a variety of materials are needed for different purposes: load-bearing, waterproofing and insulating, to name a few. Quite often in design, not much thought is given to how materials are sourced or how permanent they are. They just need to get the job done. This careless way of choosing whatever is cheapest and fastest to build is detrimental and carries long-lasting effects. The most important point of comparison should therefore be the environmental cost. It would incorporate all aspects necessary to make the most suitable choice for human and nature alike.

5.1 Renewable materials

"We should regard architecture as artefacts which eventually need to be integrated with nature." [Green Design, 2011, p. 12]

Renewable materials are ones that can be created again and again. This can be achieved by growing them. That is why only plants can be considered renewable and for construction, it means using materials already present in nature: WOOD and NATURAL FIBERS. These can be returned back to nature safely if they are not chemically treated or don't contain additives. All their parts can potentially be used, preventing waste creation. It is important to use vegetation native to the building location, since it would make little sense to transport, as the site-specific plants already work well with the local climate. [Löfroos et al, 2018] Even though wood and natural fibers, such as straw, are renewable, they should not be overused, and need to be allowed to grow sustainably to keep the base healthy and thriving.

Reading about the newest innovations in renewable building materials can be exhilarating. People are able to invent wonderful things seemingly from nothing. Examining these innovations somewhat critically, I found some potential materials that would suit sustainable building, while many others were a bit lackluster.

5.1.1 Wood

Forests are abundant and plentiful in Finland. Being a prevalent construction material here, it would make most sense to use it as much as possible. Trees trap carbon dioxide (CO2) to produce oxygen during photosynthesis, thus storing greenhouse gases. The timber created from trees retains the CO2 during use and when it is repurposed. Wood is meant to breathe, as it binds moisture and balances humidity differences, resulting in good air quality and energy consumption [Museum of Finnish Architecture, 2005, p. 29]. It is given many connotations since it is a versatile material: old-new, trendy, limitless and exposed, to name a few [Museum of Finnish Architecture, 2005, p. 16-21]. Even though wood is a more ecological structural material compared to concrete, steel and brick, it is still only a marginal product that cannot be used everywhere.

Wood by itself is great, but it needs protection, as it wears away 5-7 mm/100 years from sunlight, rain and dampness [Museum of Finnish Architecture, 2005, p. 31]. Choosing which substance to protect it with has an impact on the end users. Strong chemicals can make it last longer, which in turn make them less desirable in terms of healthy materials for indoor air quality, whereas using a more natural solution can be beneficial all around.

Wood is very versatile and pleasant to all senses. It can range from structural and load bearing to small interior details. Thick timber log outer walls are a traditional means of building in Finland, and are being examined more in a contemporary setting. Timber logs can be easily modified by cutting and attaching pieces to each other in a variety of ways (with nails, bolts and pegs for disassembly, and other natural methods like joints). Using wood as the main construction material would be the best solution since it can be part of a natural circulation.

Wood has many advantages as a construction material since it is a renewable and truly recyclable resource. Wood is often marketed as being environmentally friendly, which results in an accepted perception that all wood construction is ECO-construction, which is not the case. Wooden frames can also be poorly designed if weather and time conditions are not properly considered. When compared to concrete, the carbon footprint of wood is utilized to its greatest potential when it emits about half as much as concrete.

Historically, a felled tree was used in its entirety. The straight trunks were used as walls for a building, the branches acted as trusses, the bark kept water out as insulation, and the roots were utilized to support the eaves as hooks. The same concept of making full use of wood material is being used by the company Brikawood. They make interlocking wooden bricks which the builder can assemble without using glue, nails or screws. The walls are filled with leftover wood shavings from the manufacturing process, resulting in near zero waste and a cradle-

to-cradle product. [Simplemost, 2018] This concept could be expanded from single detached housing to a larger scale, allowing perhaps even industrial-scale buildings to become more sustainable.

5.1.2 Natural fibers

Compressed dry straw gathered into bale panels is extremely environmentally friendly, affordable and rapidly renewable. Straw and other plant fibers can also be made into panels by compressing them together in 200 °C without adhesives [Architects' Council, 1999]. They can be used to replace materials such as concrete, wood and gypsum [Inhabitat, Peckenham, 2018]. Straw is long-lasting when it is protected against moisture and well-constructed. It is fire resistant when packed tightly, and has a small environmental impact, since it is a by-product of agriculture [Architects' Council, 1999, p. 120]. For example, the Lithuanian company Ecocon manufactures straw bales using the least possible amount of straw and wood, and the energy required for production is very minimal [EcoCocon, 2018]. The company is also Cradle-to-Cradle certified.

The bales provide high levels of insulation (400mm thick straw wall has a U-value of 0,14 W/(m²K) in both heating and cooling during their lifetime. Some detached houses have been built using straw as the primary material in Finland. [Natural building, 2018] The walls can be plastered inside and outside. The interior can be a three-layered clay plaster that balances the air moisture, keeping the structure dry. The plastered interior straw wall is very fire safe (EI120) and has enjoyable acoustic properties. [EcoCocon, 2018]

Construction using a structural straw bale system is simple and can use only manpower if necessary. The bales can be firmly attached to each other with lag screws. Building erection time is fast and tidy. The bales protrude so that the straws overlap, making the structure uniform and preventing the formation of thermal bridges. [Natural building, 2018]

Besides dry straw, making durable walls, boards and panels from a variety of agricultural by-product and waste (wheat, rice and sugarcane straw), is low cost and energy efficient. They are 100% renewable, use significantly less energy to make, and save in building costs.

5.1.3 Other vegetation suitable for building

Hemp is easy to work with, healthy, durable and can be used in a variety of ways to replace synthetic, petroleum based and other high-bodied energy materials. [EPN, 2014] It is also stronger and lighter than conventional building materials. The parts used for construction are the inner woody core (for hempcrete, reinforced concrete), the fibrous outer skin (for fiber insulation) and hemp seed oil (for finishes and stains). [Thehia, 2015]

Bamboo has much of the same properties of hemp and is suited to its indigenous areas of Central and South America, Asia, and the South Pacific. Its tensile strength matches that of steel, and can be used to build structures that are earthquake-resistant. The cylindrical and hollow branches can be cut and laminated into sheets and planks. By applying heat and pressure, bamboo can be curved or flattened with no warping effect. Regrettably, bamboo is often susceptible to various plant and animal life, is prone to splitting, has poor fire-resistance and has to be harvested properly to be of constructional use. Special fastening techniques need to be used to join bamboo together, such as vegetal cord, steel or bolts with mortar filling. That being said, it is worth using when it is local and renewable. [Modlar, 2016]

A promising resource is a wood component called lignin, derived from lignocellulose, which gives plants shape and stability [Biooekonomie, 2017]. It can be obtained from wood, paper by-production or other renewable raw materials, making it climate neutral in contrast to fossil petroleum [Hiltunen, 2014]. Annually, around 50 million tons of lignin is produced worldwide. It can be used in 3D printing to make technical components for buildings, or it could replace chemical adhesives for a more environmentally friendly option. [Raunio et al, 2016]

Materials and surfaces often need finishing to protect them and make them last longer. The environmental aspect should be considered when choosing what to use. There is an assortment of environmentally friendly options available. An example is furfuryl alcohol which polymerizes wood, improving its stability and durability. It is a by-product of corn and sugarcane agriculture.

Construction materials derived from food-based waste have caught the eye of several companies. Organoids produce acoustic panels made from a mixture of leftover seeds, stalks and leaves, Enviroboard uses compressed wheat to make walls, and Materia creates acoustic and thermal insulation out of potato peels, producing a lightweight, fire-resistant and water-repellent substitute for cork. [Provada, Construction material from waste, 2018]

5.2 Non-renewable materials

Non-renewable materials can be placed in two categories. The first are materials already found in nature that are harmless when returned to the environment. This includes clay, natural stone, lime, glass and steel. The second are harmful in the environment, as they will not disappear, and can accumulate over time to disastrous proportions. All plastics, such as polystyrene, polyurethane, epoxy, PVC, as well as materials with chemical additives in them, cause problems. They cannot be properly destroyed, and they spread everywhere. [Löfroos et al, 2018] As a first measure, substances that are of

harm to the environment should be eliminated from use. This is relevant regardless of the fact that material efficiency would be attainable by creating a closed loop, since nothing of human creation can be completely closed. If and when these substances escape the loop, it should only be a lack of efficiency and not an environmental issue.

Easily shaped, harmless earth materials are soil, clay and dirt. These have been used since the beginning of building the first dwellings. A third of people live in some sort of earth substance house. Mixing earth materials together can make durable and natural small structures. Living conditions are pleasant because they are breathable, insulating and non-toxic. These materials are usually easily available, create minimal emissions, can be dug and are easy to return back to the earth. For larger construction though, the primitive nature of these is not as practical, since the conditions and workmanship require time, knowledge of how the material performs, and effort. Used alone, they are not very good insulators (0,33-2 W/mK). [Architects' Council, 1999]

Almost as strong as steel, Cross Laminated Timber (CLT) is a solid wood construction product made from spruce or pine wood, which has made large structures out of wood possible. It is a strong building material measuring up to 2.95 x 16 m and consisting of at least three bonded single-layer panels assembled at right angles, attached using adhesives across the surfaces. Panel thickness can vary, and depends on structural requirements. Glued finger joint details are the most used as they create the least amount of waste, they do not split, and can be dimensionally and angularly controlled. [Museum of Finnish Architecture, 2005, p. 18] The polyurethane adhesives make up 1% of the CLT panel, but it accumulates into large amounts the more it is used. [Stora Enso, 2018] CLT is an exciting structural material, however, the use of adhesives means it cannot be considered a cradle-to-cradle product. After contacting the Finnish company Elementti Sampo, I learned that the CLT prefabricated units are theoretically reusable. Services (pipes, electricity) can be demounted and the elements can endure transportation. In practice, nothing has yet been designed to be moved, and the materials on the inside have not been chosen to withstand multiple transports. However, this could be implemented in the design process.

Chemical paints and finishes are a considerable health and environmental hazard. Researching and choosing them to be as natural and healthy as possible is important. Internationally, the Italian-based company Romabio [Romabio, 2018] and domestically, Suomen Luonnonmaalit [Suomen Luonnonmaalit, 2018], create non-toxic and clean paints, plasters, stains and varnishes. These paints and such are comprised of natural and harmless substances, like potassium silicate and earth oxide pigments. When choosing environmentally friendly finishes, ingredients such

as solvents, acrylic resins and VOCs (Volatile Organic Compounds) and TVOCs (Total Volatile Organic Compounds) should be avoided at all costs. [Romabio, 2018]

5.3 Recycled materials

Using recycled materials decreases the need for mining, natural resources are saved, and carbon emissions are reduced. During my research, not a lot of recycled materials that have been given a new life as such are used in the structures of buildings, but quite a lot can be found for cladding and elements. It is also very possible and encouraged to start using dismantled building products in new projects to bring down the pollution and waste of a new build. Even just picking high-quality reused materials encourages the reclamations markets.

Recycling is not a long-term solution, though. The quality of the material goes down with each cycle, since the material gets weaker, such as metals. The whole process simply prolongs the situation and does not necessarily change anything in the long run. At the same time, we should keep in mind that an abundance of materials has been created once, and not using them in some further way would mean wasting more.

New products from “waste”

A true circular material flow can only be possible if the created excess can be utilized in some way, either by reusing it in its original form, making small alterations, or total reconfiguration.

There are a multitude of companies that have taken up the challenge of creating bricks from waste materials. Waste bricks are already being composed out of ground up things from construction, like wood scraps, flooring, insulation and tiles, and then recomposed as bricks. These use lower temperature, 25% less energy and raw materials. The company Redhouse Studio uses a dose of mycelium, a vegetative part of fungi, to create binding properties for the brick. [Inhabitat, Peckenham, 2018] Autex is an acoustic fabric which is made from recycled bottles. It is part of the wall structure but easily detached for maintenance, as well as insulating. [BAM, 2016] Roof shingles made out of old rubber tires and coated with sawdust are durable, high quality and easily molded into shape, and can be used like traditional roofing materials. [Inhabitat, Jeppsson, 2011] Making use of fiber waste from agriculture, ECOR creates alternatives to wood, cardboard, composites, metal and plastic, which can be applied to construction. These strong construction panels are produced with mixing water and fibers, then pressure and heat are applied to make a cardboard-like consistency with flexible shapes. It is clean and light and embodies the cradle-to-cradle principle. [Ecor, 2018]

Geopolymer is a new building material which uses industrial by-products and mineral wool. In Australia, geopolymers have already been used instead of concrete with good success, and production development in Finland is at a point where it could be on the market within three to five years. Emissions are about 40-80% less than that of concrete, so the potential as a construction material is significant. [Arponen, 2014]

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Although there seems to be and is an abundance of building materials in the modern world, it is how we choose to utilize them that matters. Building methods matter as well, such as using algorithmic design or vaulted structures, which are approaches that attempt to use as little as possible, while utilizing the maximum potential. [Kuismanen, 2000]. As awareness of sustainability grows, innovation in the construction material industry will too. Non-renewable resources are dwindling, so the only sustainable growth is degrowth.

Moving towards using more renewable materials is not a matter of choice, but a necessity. Not all materials are made equal, and it is time the construction industry faces that fact. Using old-fashioned ways to build with thick timber wood or bricks may seem like a costly alternative, but there is less work involved in construction, since it is just one layer of material, thus saving labor cost. Construction with nothing superfluous is healthier for both the material and the user.

Ecobuilding case 4

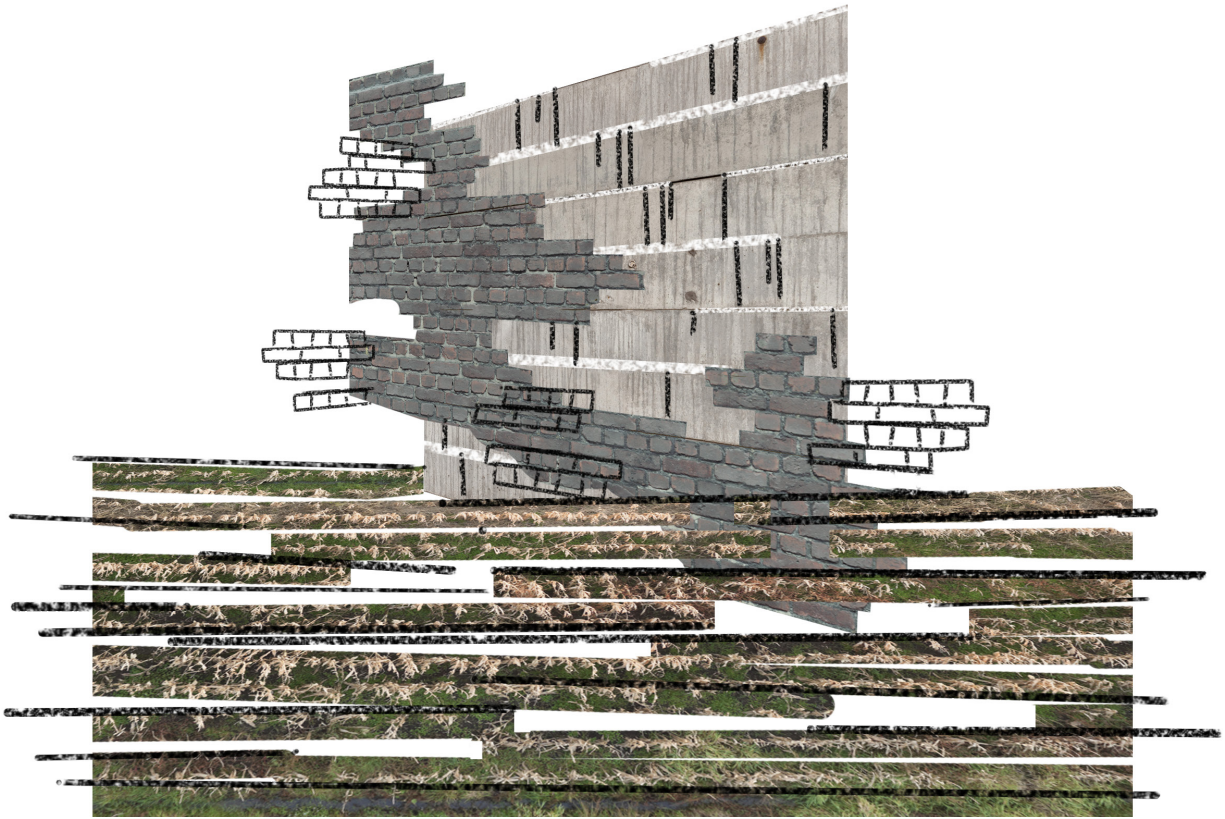
Talo Nöykkiö detached house
/ Espoo, Finland
/ Pekka Saatsi 2018

"It is important for the conservation of natural resources to build long-lasting and sustainable buildings."
- Pekka Saatsi, head architect

Concept of the house by Saatsi Arkkitehdit & Trä Kronor. [Länsiväylä, 2018]

Using old ideas and practices with modern methods and materials is the concept of this family house set to be built in Espoo. The two-storey structure is to be made from MHM-elements of massive wood that consist of untreated crossing board layers that are nailed together with aluminium nails instead of glued. The insulation solution for these 25 cm thick walls is based on inbuilt grooves in the boards. The roof is slanted, the eaves are long and protective, and the ventilation is natural. The insides of the load bearing walls, as the façades, are clad with wood panels, and a simple paper vapor barrier. Partition walls are also all wood, no gypsum boards. The roof is insulated with turf.

No plastic vapor barriers are used and neither is any wool insulation or urethane. The only plastic parts are in the sewers. Too often a building looks fine, but short eaves and flat roofs create a predisposition for mold and moisture issues. The life span of this house is set to be at least 100 years. The house concept can be easily duplicated and will become a townhouse complex. [Länsiväylä, 2018]



“Building art is a synthesis of life in materialised form. We should try to bring it under the same hat, not a splintered way of thinking, but all in harmony together”
- Alvar Aalto

6 Design for disassembly

* Demountable structures and elements
* Emphasis on non-permanent joints
* Embedding digital codes to track the element through time

For the circular ideology to work in the future, building practices have to be rethought. The building industry has all the tools at its disposal, yet the awareness of the finite nature of structures is often forgotten. Constructions simply will not stand forever, and it is time that our modern way of building takes that into consideration in the assembly phase. Still, demolishing buildings should always be considered on a case-by-case basis. It can be a viable option when the building is in a location that is no longer used, and which has become useless.

Designing for disassembly (DfD) is a concept of factoring in the deconstruction of a building at the end of its lifespan by design. With the help of technology, like branding each building element with a digital past, we could already be constructing buildings with materials that can be traced to their origins. The design of buildings prepares for future change and the eventual dismantlement (in part or whole) and for recovery of systems, components and materials. [Green Design, 2011 - DfD in the built environment] In practice, this means that products will be designed in a way that materials are separable and recyclable [GBC, 2016, p. 15]. Only recently the idea of reusing deconstructed constructions as building blocks for new buildings has been revived. In the age after industrialization, demolition simply resulted in landfill waste.

Construction should be done in a way where demounting the building in the future is as easy as possible. This requires a bit more planning and cooperation with the building contractor in order to come up with the right sort of joints and building sequences to make it possible. [Palomäki, 2018] It can already be agreed upon that good design takes future needs into account for easy components repair or changing uses. For decades, fast and effective constructability in installing of construction materials and products on site has been the main focus in building, as this shortens the overall construction time, saving costs. This idea can be carried into the use phase and building dismantlement. Down the line, designers will become more attuned to how building parts can be reasonably repaired or utilized in new applications [GBC, 2016, p. 29]. The dismantling principles can be integrated into the program development and schematic design phase and in turn, into the life cycle assessment.

This is not a novel idea. Traditional log houses were built in a time when materials were scarce, and laboring over these was an intense and long process. Thus, the natural solution was to use the old parts again either as whole or separate building blocks. Logs can be considered as one of the earliest

forms of prefabricated building systems along with brick. Log frames are easy to dismantle and move. Horizontal log structures are load bearing, heat retaining and insulating, forming inside and outside surfaces of the building, making it a monomateria. [Museum of Finnish Architecture, 2005, p. 8] Modular systems and standardization of building components have always been in architecture, making classical and modern building quite similar to each other, although replication is usually associated with the modern industrial age. [Museum of Finnish Architecture, 2005]

Indigenous structures regularly needed to be repaired, moved or changed, and thus they were designed and built to have a symbiotic relationship with their surroundings. Hence, Dfd was essential to some native cultures. The Native American tepee accommodated their migratory patterns. In Japan, the earthquake-prone geography combined with craft-intensive architecture based on wood joinery was remarkably disassemblable.

Dimensional coordination is one theory in how to increase the shelf-life of buildings. There is a great supply of reused building products available, but due to them being inaptly sized or not up to standards, they cannot be used. Reconfiguration strategies are often not considered in current design practices, limiting the extension of buildings' end-of-life. [Durmisevic, 2017].

DfD how to:

1: **Define strategy** for the reuse of elements

2: **Keep a material inventory** describing the maintenance and durability of the components as well as suggestions for how to reuse or recycle them

3: **Make accessible, detachable connections** and minimize chemical connections. Avoid punctures between different elements/components, keeping them separate from each other

4: **Keep the design simple** in structure and form (open-plan structural systems and standard dimensional grids)

5: Describe the **methods required to deconstruct** the elements with examples of equipment and sequences

6: Create **maximum awareness of the Deconstruction Plan** by distributing and storing in as many locations as possible.

DfD design principles

For disassembly designs to work, there are a plethora of things to consider beforehand. First is to keep things as simple as possible. Beginning with the concept of structural systems, using simple forms and open-spans means the construction itself inspires flexibility and interchangeability. Flexibility is achieved when different building types are given their own spatial and architectural qualities, allowing for present and future needs. The end goal is to have an easy way to reuse the space over the length of time and at its end, be as intuitive and safe as possible in deconstructing it. Connections play an important role and using standardized and minimally different methods of connections like bolts, screws and nails, ensure that the effort to take apart is not hindered. [Durmisevic, 2001]

Building services like electrical and plumbing should be separated from structures so as to be repaired and replaced easily. These, as well as joints, should be accessible visually, physically and ergonomically as they are places that need to be reached. Connectors should be uncovered by finishes. Documentation which details the construction method and materials is essential, and should be archived in a secure but accessible manner. [Thormark, 2007]

As for the materials, choosing non-toxic ones promotes the health of the building and the users in it. Composite and inseparable materials should be avoided, making the parts easier to recycle. Materials should also be durable, for they are likely to be reused in repeated assembly and disassembly to allow for adaptation and change. The same applies to connectors. A possible spare parts storage should be located somewhere in the building, in case of damage or adaptation. Disassembly should be simultaneously possible from many different points in the building, which should be identified in the disassembly plan. [Guy, 2008]

The architect’s role is to keep certain matters in mind when designing a DfD building. A dynamic and open structured building which allows for adaptation to changing needs is considered first. A building should be conceived as an ongoing process which does not stop when its usefulness has come to an end, but which extends beyond that time. Materials are long-term, valuable assets which can be reconfigured. Waste and demolition become flaws in design. Most importantly, cooperation between different designers and constructors is needed, and involving them in the design process is highly necessary. [Green Design, 2011 - Elma Durmisevic “Design for disassembly of buildings”]

Allowing buildings to be designed for disassembly makes buildings less static and permanent in nature. User demands are constantly changing, and this way, buildings are ready to meet changing demands. The life cycle extends as buildings transform from

inflexible to dynamic and flexible structures, whose parts could easily be disassembled and later on reused and recycled. [Durmisevic, 2017]

In a study comparing conventional demolition to deconstructive demolition, it was clear that the environmental impact was greater using the conventional method. [Sheidaei, 2006] Limited amounts of materials are recovered for reuse. The study thus suggests, in comparison, that selective demolishment with the intent of reuse and recycle is a more environmentally friendly scheme and the resale of the recovered items can help offset demolition costs, landfill costs and other related costs. A clear material inventory after demolition is suggested to keep track of the deconstructed items. Using more steel and wood as building materials would be more beneficial, since they can be more readily reused, in contrast to concrete and plastic. When embracing this idea in the design phase, resulting labor costs and energy requirements are lessened, and it is an overall better option for the environment and resource management. [Sheidaei, 2006]

Treating buildings as just a modular framework, like in technology, where the computer stays the same, but the software is updated, is the goal that DfD aims for. Then it is the user that customizes the building to suit their needs and the age, and who repairs it along the years. [Green Design, 2011 - The Process of Designing with Reused Building Components, Mark Gorgolewski]

Designing a TRANSFORMABLE building is fundamental in Dfd. Pinpointing helps in understanding what is actually important, and to find out what needs to be transformed during the building's lifespan. These points can be found by answering certain questions:
Defining what is to happen
What expires
What needs replacing
What possible functions could the space hold

Ideally, a building should always function well during use. For easier upkeep, the possibility of removing or exchanging building systems and components should be made possible. This, in turn, has a direct effect on energy consumption and waste production. The spatial adaptability and technical serviceability are improved as well. [Green Design, 2011 - Elma Durmisevic "Design for disassembly of buildings"]

In the future, sustainability for buildings may be measured by their disassembly potential. While the current linear model assumes the limitless quality and quantity of materials and energy, designing for disassembly renders it possible to reuse and reassemble components into new combinations or allow remanufacture of existing materials. [Durmisevic, 2006]

Another term for DfD is IFD, or Industrial Flexible Demountable. A project in the Netherlands was prototyped using this theory. The process was more difficult than anticipated, and some valuable lessons were learned, which are good to keep in mind, if this method is used for future construction.

- Specific instructions for how to assemble the building AS WELL AS how to disassemble should be planned, provided and kept accessible.

- As much assembly should be done in factories as possible.

- On-site storage crates in case of last-minute protection for the elements and materials.

- Materials should be pre-sorted and labelled to avoid confusion and damage.

- The logistics of construction should be mapped out, for example, using common cranes and scaffolding to their full potential. [van Gassel, 2011]

Ecobuilding case 5

K2 sustainable apartments
/ Windsor, Victoria, Australia
/ Hansen Yuncken, Design Inc, 2006

Aerial view of the K2 apartments in Australia
[Design Inc, 2007]

This project was a result of a competition for designing a sustainable apartment building complex with a life span of 200 years. [The AIA, 2013] The apartment block features passive solar design, recycled and sustainable materials, wastewater treatment (collecting grey water for toilets and watering and water efficient appliances), rainwater collection (this saves almost 50% of normal water usage), energy savings up to 30% and use of low VOC emission materials. In addition, up to 80% recycling of waste materials was achieved during the construction process. [Design Inc, 2007]

In this instance, sustainable building materials include recycled denim or blown-in fiberglass insulation, sustainably harvested wood, bamboo, and non-toxic low-VOC glues and paints. The reduction in use of new materials creates a corresponding reduction in embodied energy (energy used in the production of materials). [The AIA, 2013]

“It’s not about ideas.
It’s about making ideas
happen.”
- Scott Belsky

CIRCULAR ECONOMY BUILDING STRATEGIES

EXISTING BUILDINGS

1) As far as possible, existing buildings should not be torn down.

Finding optimized uses for them through virtual networking applications to provide the services required in the nearby area.

2) If demolition is the only answer for the building due to something like indoor air issues or the building simply being in the absolute wrong place to be of further use, dismantling it with the idea that all materials that can be reused are taken out with care.

This strategy works when existing buildings are being contracted to be demolished and the timelines match up, otherwise storage becomes an issue. The dismantled materials should be kept local and not transported too far. Also, before demolition an inventory should be made to see what the buliding contains.

NEW BUILDINGS

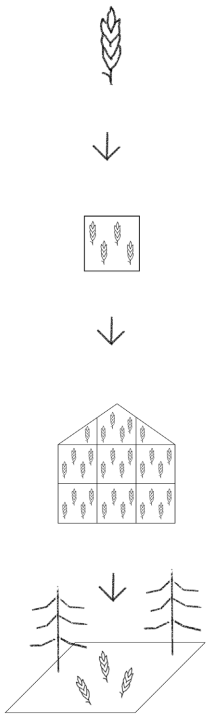
3a) Using new materials that are made from renewable resources.

3b) Using elements from dismantled buildings as much as possible.

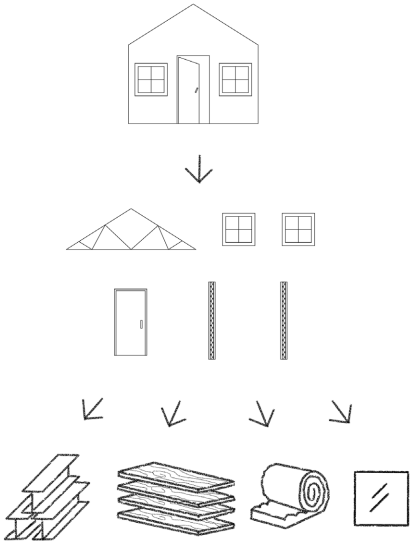
4) Designing for disassembly.

The building process is meticulously documented and disassembly strategies are applied to the building. In the future, all buiding products can be made with radio frequency identification (RFID) tags built into them, therefore information can be retrieved either directly or in the form of a code that references a separate database.

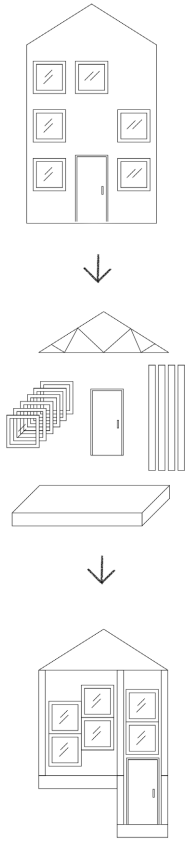
3a - Renewable method



3b - Recycle into new materials method



4 - Design for disassembly method



Once the decision to use reclaimed or salvaged materials and components in a new building has been made, they can be categorized accordingly:

Reuse component on site

ranging from using the whole structure to more individual components such as bricks from the old building to the new building

Refitted components

usually parts from demolished buildings like staircases and building services components (radiators, bathroom fixtures) that need a few improvements before relocation

Reclaimed from another site

most often taken from local demolition sites that require little reprocessing such as bricks, timber or steel

Recycled content building products (RCBP's)

readily available building products that have used material from demolition sources including, gypsum boards or insulation

[Green Design, 2011 - The Process of Designing with Reused Building Components, Mark Gorgolewski]

Designers should be aware and allow that the design process is quite different from traditional building when choosing to reuse construction components. It requires flexibility to develop a concept that works with the nature of possible limited availability, and these dimensions should already be worked with during the design phase, instead of deciding which materials to use at the end. Ideally, the reused components will be known at that time. Out of the categorizes outlined on the left, RCBPs have the least impact on the design process, whereas salvaged materials from other sites are the hardest to integrate, as they need to be identified and sourced at the appropriate time. As a result, the sources available during the pre-design phase of a project are fundamental to scheduling, resource planning and cost estimation. [Green Design, 2011 - The Process of Designing with Reused Building Components, Mark Gorgolewski]

Changes are already happening, even in Finland. At the end of 2017, the city of Rovaniemi, along with 9 other Finnish municipalities, are investing in circular economy with concrete actions. The Rovaniemi city municipality has decided that recycled materials should be used in public buildings whenever possible. "There is a common will to act in an environmentally sensitive and innovative way. Local products, innovations and expertise in Arctic conditions will be the basis for the success in implementing circular economy in processes, services and products," the city architect explains. [Daily Finland, 2017] This is encouraging and hopefully it will grow from 10 cities to the whole country, while increasing the amount of sustainable building methods currently available.

Designing a green, sustainable building is tricky in modern day society with a growing number of requirements and regulations being imposed on designers. With all the strategies I've presented, I do believe that it can become possible. Altogether, finding a balance between aspects such as architectural quality, transformability, resources, comfort, safety, constructability and cost from the beginning of the design process is called for. [Green Design, 2011 - Elma Durmisevic "Design for disassembly of buildings"]

“If you can make your structure last longer, you’ve actually made the material more sustainable.”
- Rishi Gupta, professor from the University of Victoria

8 Thoughts and ideas for the future

The ideas presented have been nothing new. This issue of waste and material use in the construction industry is becoming more important and pressing as time goes by. I wanted to bring it all to the forefront and educate myself and become a better future architect. This learning process has engaged and enraged me to all that is good and bad in this world, even if it is not quite as simple as that.

I have discussed concepts that could be implemented into the industry with a bit of effort and dedication. All of them relate to each other and have a same common ground of preserving our planet and increasing the lifespan of buildings.

Sustainability can have many definitions. For me and this thesis, it is about getting the maximum out of the minimum. Circular economy is a hip buzzword at the moment, but it is the direction our society is moving towards in all areas of human life. Not being wasteful and using resources to their full potential can only be a good thing. Waste management is influential in how the building industry will cope with excess or demolished materials. The goal is to reduce overall waste formation until no more waste is created.

Materials are to be sourced in ways that do not affect the environment detrimentally. Using renewable and recycled building elements will help reduce emissions and preserve resources. In designing new buildings, new technologies and strategies of disassembly should be applied to plans. This will aid in lengthening the life of materials.

In design for disassembly, the technology already has the capability and readiness to start digitally marking building components and elements so that they can be tracked in the future for easier reuse and recycling. Using joints and connections that come apart easily, yet are strong in their bond, will become increasingly important as materials start to run out. Also, sticking with natural monomaterials as far as possible allows the building blocks to be of further use than just the first time they are built, and they can be returned to nature.

Renovation has gained importance with increasing energy efficiency, maintenance of outdated parts, renewing for a new generation of users and new use as old practices end. It is usually viewed as a contingency market when new building slows down. This results in using much of the same practices in renovation projects as in new building, instead of developing new methods that are suitable just for old buildings. From an environmental perspective, renovation and upgrades are a better option to dismantling and rebuilding as it saves waste, materials, energy and emissions.

In the future, the environmental impacts of the building lifespan will be highlighted in the decision making process. Making the building as energy saving as possible during the renovation

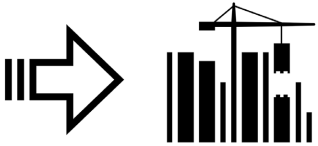
Key points in affecting change:

MASTER the principles of chapter 7

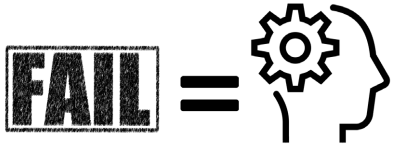
EDUCATE fellow designers, engineers, municipal workers with facts and figures

LEARN and continue to SEEK OUT new advances in building methods and materials

APPLY these principles to projects



FAILURE is LEARNING



CHANGE is achieved!

is vital when the upgrades are being planned. A more consciously planned approach will be the way to design in the future. The lifespan will be calculated, how the building is used will be thought out and what the transportation cost will be in relation to its location to other infrastructure.

Zoning plays a meaningful role in how long a building can endure in its place. When the city zone is marked as protected, the building is more likely to have a long lifespan. Also, defining the use of the building in a certain zone should be more lenient, and buildings should be marked as multipurpose so as to avoid overly complicated bureaucracy hassles. Incentives and concrete means of how to achieve these changes should be introduced by municipalities more often along with abiding with regulations. Making community participation easy as a part of the design process further helps to understand the environment and is a cost-effective way for involving inhabitants to care more about their surroundings. This aids with the upkeep and care of buildings, since the community is connected in some way to their living spaces.

Implementing a mandatory percentage of recyclable or renewable materials in new construction would be a first step. This could introduce untapped markets and new businesses, which is good for the economy, as well as the environment.

The key question to answer is how to utilize the full potential of materials. Recycling is good, but it requires transportation and processing. To directly use the components is a better choice, as existing buildings contain a wealth of useful materials. Collecting information about these materials and creating a system where the information is available and shared with the people who can use it. This step would involve the developer to gather a materials menu for each building being demolished and rating the materials and components according to quantity, quality (condition) and where and when they will be available, creating an interactive map of materials that can be searched for in real time. Material waste goes down and disposal costs are reduced. A whole new world of creativity is opened up, and a market for reuse could begin to evolve. This goes beyond just one building, into organizing the regeneration of cities into a post-waste era. With the aid of digitalization, applying the use of technology into making construction more resourceful, the resources of the world will be more effectively used than ever before!

Design should be driven by values, and by being aware of our choices. Choosing the right materials and building method for each purpose can either shorten or lengthen lifespans, determine how we end up valuing the final result, and also result in saving or spending resources. Efficiency should not be the end-all of the process, just another factor to consider. As with all new, untested and somewhat opposing viewpoints, so, too with circular economy come the doubters and critics. But as problems are bound to worsen, these suggestions will have legitimate use in how we build our future, both figuratively and literally.

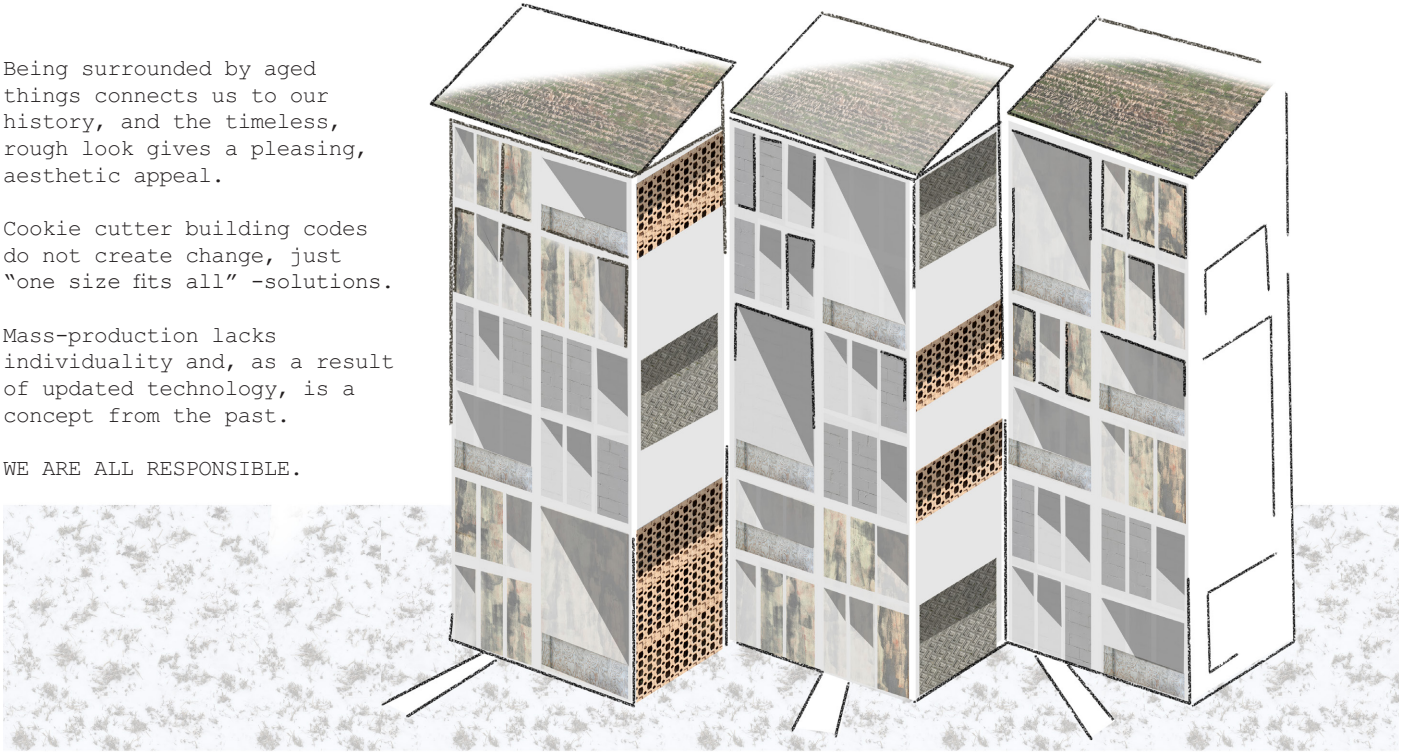
Closing thoughts:

Being surrounded by aged things connects us to our history, and the timeless, rough look gives a pleasing, aesthetic appeal.

Cookie cutter building codes do not create change, just “one size fits all” -solutions.

Mass-production lacks individuality and, as a result of updated technology, is a concept from the past.

WE ARE ALL RESPONSIBLE.



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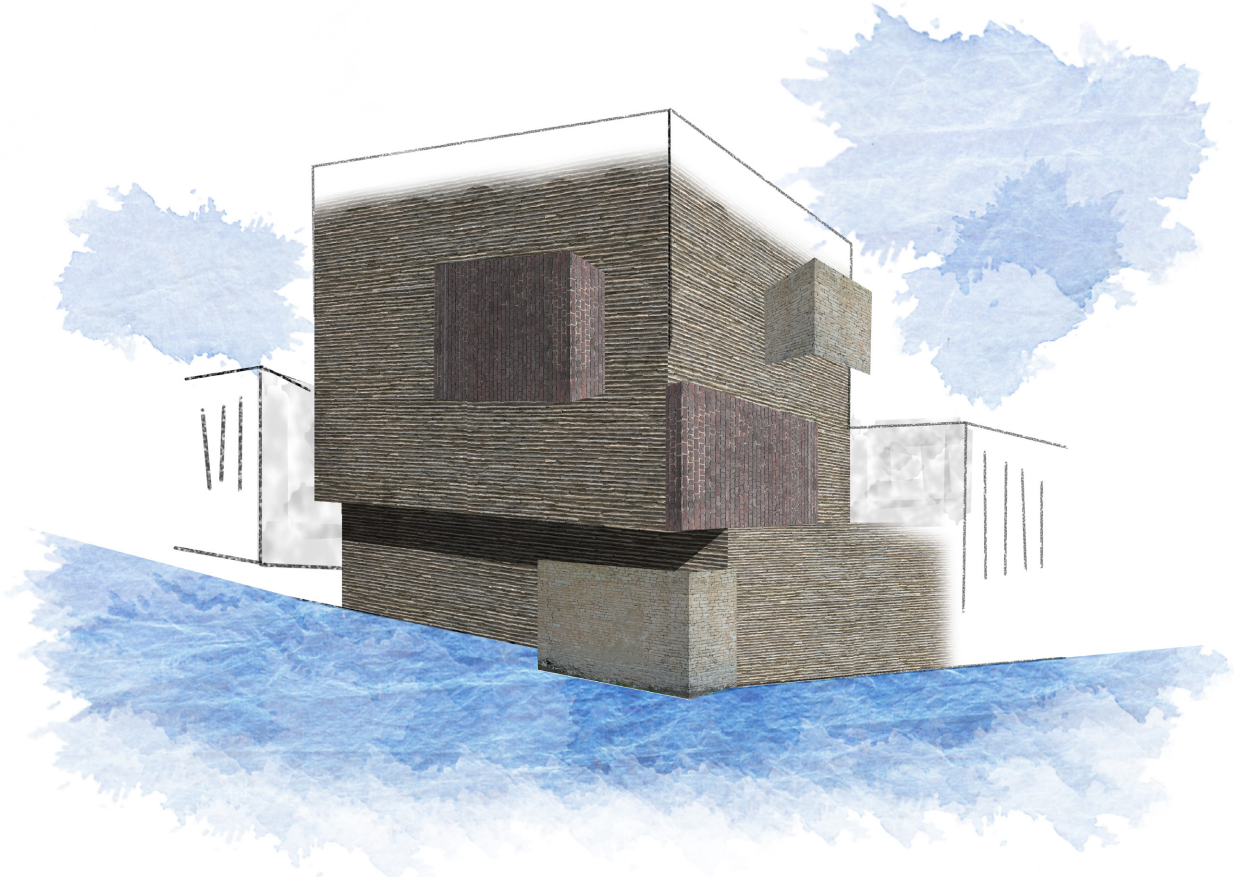

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