CAN WE MAKE A BUILDING FROM WASTE?

A Thesis

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FROM WASTE TO ARCHITECTURE

CULTIVATING SUSTAINABILITY

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REINVENTING MATERIALS

As a way to reduce carbon emissions and the carbon footprint of architectural building materials to develop a more sustainable future.

ABSTRACT

One of the biggest challenges facing today's architecture is the waste that comes from building materials. It is estimated that the construction process currently results in as much as 40% of wasted materials[1]. This research explores building materials in ways in which they are successful as well as their limitations. The proposed questions are in terms of a material's carbon footprint and how waste comes about when buildings are first constructed and when left to nature's disposal. This study will be a compilation of research and active practices starting with everyday building products with an emphasis on concrete. The environmental impact of these materials as well as initiatives in place that prompt the need to reconsider what we are using to build will then be discussed. The leading products used in today's typical construction practices, innovative solutions towards greener practices, and cutting-edge products currently in their development or early application phase will be compared. Through analysis, a discovery will be made on whether or not green technology trump's everyday materials or if their application poses more wasteful techniques than the former. As a conclusion, ways in which we can develop or deploy these materials to a point of minimal if not zero waste will be analyzed, or if more innovative materials can be created through the applications of waste. *If current processes and standards of building construction are not sustainable in their entirety, is there an alternative solution that can be further developed from a more experimental approach?*

Keywords: Recycled, Materials, Sustainability, Cultivated, Carbon Neural, Waste, Limitations

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[1] Mike Hower, *PlanetReuse* (Sustainable Brands)

Can We Make A Building from Waste?

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INTRODUCTION

Growing up I reused, recycled, or repurposed absolutely everything. I made bowls out of soda cans, bracelets out of candy wrappers, and I have a tote bag made up of over 3,000 pop tabs. As a child I didn't understand the concept of throwing something away unless that was the only thing that could be done with it. One of the biggest problems in today's architecture is the routine of wasting materials. Society is so focused on building new things that they often forget about the old. We produce waste not only during the neglect and decomposition of old buildings, but also in the way in which we are constructing the material that goes into new structures. The built environment is becoming a platform for zero energy, LEED, Living Buildings, and any and all sustainable practices that society can develop. These active attempts are crucial towards redirecting climate change. As a result, the nation is pursuing practices for more sustainable buildings in terms of energy consumption but lacks emphasis into what makes up these highly efficient products and structures. Our carbon focus needs to shift, as well as our tendency to just throw unwanted things away. Our construction industry currently results in 40% of material waste[2]. As an industry, architecture must move towards carbon neutral and Living Building design in order to bring this percentage of wasted material down. An emphasis must be made on looking into new practices for everyday reliant materials such as concrete and how we can make these products better. This is a focus on finding alternatives to improve our once loved products instead of just doing away with them completely. We will alter, we will cultivate, and in the end, we will need to simply rescue. *In order to fully achieve a sustainable future, we must first change the way we build buildings and what we are using to build them.*

METHODS

Collectively, both buildings and construction account for about 40 percent waste, 36 percent of global energy use, and 39 percent of energy-related carbon dioxide emissions annually[3]. How can the material waste generated by buildings and construction offer opportunities to recycle the waste to construct new building projects? How can architectural design take into account the

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[2] Hower, *PlanetReuse*

[3] Thibaut Abergel, and Brian Dean and John Dulac, "Global Status Report," United Nations Environment Programme, 2017

waste of the construction sites in the beginning of the design process? The following discussion analyzes the environmental impact of building materials in order for society to fully achieve a sustainable future. It is estimated that the world is expected to build 230 billion square meters in new construction in the next 40 years, which would be comparable to adding the equivalent of Paris to the planet every single week [4]. To account for this substantial growth and environmental impact one must start at the foundations of a building's source in terms of materials that are being used and materials that one could develop.

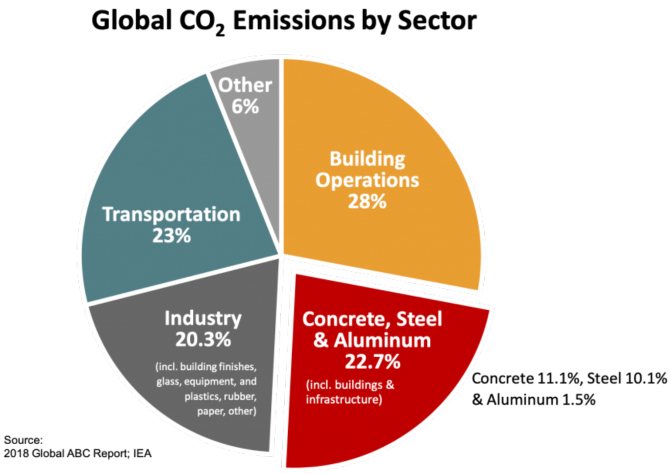

Figure 1: Concrete as #1 in highest emissions, Architecture2030

By first analyzing the leading materials in building design, one can discuss the transformation of these materials into more truly sustainable products. To consider materials and waste in the beginning of a design process, multiple pieces of literature will be discussed to better understand construction products and the problems they pose. To reach the goal of reducing our carbon emissions by 50 percent in 2050, we must reduce the amount of materials we produce and re-examine how these materials are made. It is important to analyze methods in place currently to lower CO2 and make rid of fossil fuel usage. Programs like LEED and The Living Building Challenge will be discussed in short detail. Emphasis on types of carbon output will also be evaluated with a strong stance towards embodied carbon and the importance of bringing its attention to the built world.

Multiple case studies will be analyzed capturing the reasons why we are using the materials that we are using, recyclable building materials, the embodied energy, and the impact on the community and environment. With concrete being one of the most energy intensive products, it will be discussed in detail as well as applications to lower its CO2 output. With the previous criteria's in mind, the following case study is discussed: *725 Ponce de Leon Ave.* The *725 Ponce de Leon Ave* project in Atlanta is analyzed because of its extensive use of CarbonCure, a process of using collected carbon as a substitute to cement in concrete production. Not only does the developed system reduce factory carbon that would otherwise be waste, but it reduces the need for cement, a CO2 intensive product.

As an additional leap towards sustainability, cultivated and natural materials can be studied to consider if growing products is

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[4] Abergel, "Global Status Report," 2017

more environmentally friendly and result in materials that offer themselves as a strong alternative. Cultivated materials are extremely promising for they are typically recyclable, renewable, CO2 neutral or negative, and can be produced and accessed easily. With this in mind, the following study will be analyzed for better understanding: *Hy-Fi at MoMa in New York City. Hy-Fi* puts attention on mushroom mycelium as a new building material and how it has potential to be not only an alternative to Styrofoam in packaging products but also as a concrete substitute in building design.

Methods of case studies are extremely valuable when conducting material studies and possible alternatives in construction design. Sustainable and cultivated substitutes are just a fraction of the alternatives that can be examined. Applications of recycled materials/ buildings made of waste may also be discussed in short detail, as well as the opposite spectrum, suggesting we leave common materials as is and conduct more research on how we can lower CO2 processing costs or create a longer lifespan for these materials. A study on methods to recycle and reuse materials will be looked at which includes: *The Lavezzorio Community Center. The Lavezzorio Community Center* is a great use of donated materials seen in unordinary applications.

DISCUSSION

Carbon Emissions: The Problem

The rate at which we are destroying the earth is unforgivable. To give statistics, our earth has warmed about 1ºC and it is estimated that once we reach 2ºC, the effects of climate change will no longer be reversible. According to the ICPP, crossing 2°C of warming could lead to a domino-like series of events, leading to a "hothouse earth[5]". We need to redirect this curve, but how? As a start, the focus should be on the number one leader in climate change: carbon emissions.

Operational Carbon

It is estimated that within the next forty years, we will be adding 230 billion M2 of new construction to the earth. That's equivalent to doubling the current number of buildings we have on the planet by 2060. As a better perspective, that's comparable to building an entire New York City every month for the next 40 years[6], or like mentioned previously, adding the equivalent of Paris to the planet every single week[7]. Building sustainably is no longer optional but rather a necessity in the race to zero emissions. Many initiatives focus on the operational carbon output of a building, seen largely in Passive House design and Net Zero buildings.

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[5] Anthony Pak, "Embodied Carbon: The Blindspot of the Buildings Industry." LinkedIn Corporation, March 11, 2019. https://www.linkedin.com/pulse/embodied-carbon-blindspot-buildings-industry-anthony-pak/.

[6] Pak, "Embodied Carbon," March 11, 2019

[7] Abergel, "Global Status Report," 2017

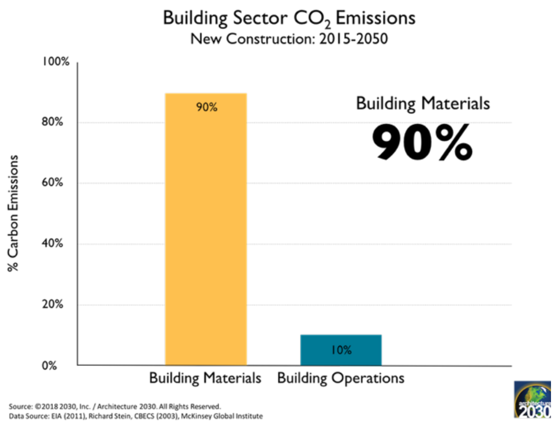

Figure 2: Materials as the biggest blind spot in emissions, how can we bring this percentage down? Source: Architecture2030

Operational or whole life carbon of a building is seen in the heating, cooling, powering, water, and other active building systems and make up about 51% of a building's carbon emissions. On a global scale, these emissions account for about 28% of carbon emissions that come from buildings. Although operational carbon is a huge contender to emissions and should not be unnoticed, embodied energy is, as the saying goes, the "blind spot of the buildings industry." The issue arises that once a building is built, nothing can be done to reduce the embodied carbon whereas operational carbon can be reduced and reduced again based on its renewable energy generation and retrofitting of the building[8]. We must also keep in mind that once a building's operational efficiency goes up, the embodied impact of the materials used increases as well[9]. For this reason, a focus on embodied carbon and how we can work towards lowering this percentage will be the overall goal of this thesis.

Embodied Carbon

Embodied carbon refers to the carbon footprint associated with building materials during manufacturing, assembly, deconstruction and ultimate disposal of the materials which make up a building[10]. While the majority of emissions come from operational means, the remaining 11% come directly from embodied carbon of newly constructed buildings[11]. And in the everyday building industry, that 11% is largely ignored.

"Embodied carbon will be responsible for almost half of total new construction emissions between now and 2050."
- Architecture 2030

A zero emissions building simply cannot produce zero emissions if half of the equation is ignored[12]. We need to make reducing embodied carbon a priority, not a second thought. To do this we first need to analyze what type of building produces the most emissions. We then must follow challenges, goals, and protocols set in place to reduce emissions in their entirety. We cannot wait until 2030 to start building the way we should have ten years ago. The building industry produces almost 40% of our annual emissions, consumes almost half of the world's material resources every year, and near 40% of those resources in construction

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[8] Pak, "Embodied Carbon," March 11, 2019
[9] Ibid.
[10] Architecture2030.
[11] Pak, "Embodied Carbon," March 11, 2019
[12] Ibid.

are wasted. The problem doesn't just lie in what we are building. The issue is how we are building and what we are building with.

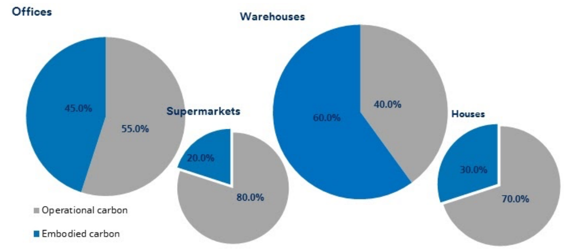

Figure 3: Carbon Emissions Based on Building Type

Challenges in Place

In the midst of climate change multiple organizations have taken a global approach in reducing carbon emissions. One of the most commonly known initiatives, the 2030 Challenge, was brought about from the Architecture 2030 group with an independent non-profit organization established in response to the ongoing climate emergency[13]. The 2030 Challenge was developed with two goals in mind: First, to reduce not only energy consumption but also greenhouse gas emissions of the built environment. Their secondary goals are to give headway to the development of sustainable, resilient, honest, and carbon-neutral buildings and communities[14]. The initiation of this carbon challenge was started in 2006 and has since led to a global movement for reducing carbon emission by 50% by 2030, with an end goal of phasing out fossil fuel emissions entirely by 2050. Even at a young age we're told that fossil fuels are bad, so why are we using them if we are teaching our children that we shouldn't be? If we lower the extent in which we are utilizing them, maybe we can step away from nonrenewable resources in their entirety.

Organizations in Place

Energy saving initiatives are actively pursued in everyday building design. LEED, one of the most prominent programs in the race to NetZero, is favorable for its checklist of design strategies reaching a goal of set sustainability. Although a great standard of efficiency, the goals of LEED could be seen as doing less harm, where the Living Building Challenge (LBC) has a stronger focus in fixing the damage[15]. LBC has a much higher standard of excellence, even surpassing the highest LEED rating, giving the challenge priority in pursuit for zero emissions. One of the few main differences is that LEED is based on theoretical points in order to improve the standard of energy in building codes, where LBC requires data taken from an entire year of operation in order to accurately validate that the project is net zero at the very least[16]. There is no question of energy use or intensity, so when a building is LBC certified, it will truly operate exceptionally[17]. The problem with this system is that designers, architects, developers, and ultimately clients are fixated

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[13] "Meeting the 2030 Challenge." Architecture 2030. Accessed April 21, 2020.

[14] "Meeting the 2030 Challenge." Architecture 2030. Accessed April 21, 2020.

[15] "Williams College." LEED vs. Living Building Challenge | Kellogg Building Project. Accessed April 22, 2020. https://sites.williams.edu/kellogg/articles/leed-vs-lbc/.

[16] "Williams College." LEED vs. Living Building. Accessed April 22, 2020.

[17] Ibid.

on the idea that LEED is the best. Although LEED has potential to focus on material carbon, to really reduce emissions we need to prioritize Living Buildings.

The Living Building Challenge was first developed in 2006 by the non-profit organization International Living Future Institute. LBC is seen as an international sustainable building certification program that defines the most advanced measure of sustainability. It provides the foundation in creating a synergy between all aspects of the built environment and those encompassing it[18].

> *"People from around the world use our regenerative design framework to create spaces that, like a flower, give more than they take."*
> International Living Future Institute

As a summary, living buildings are those that are seen as regenerative, connecting occupants to light, air, food, nature, and the community[19]. They are qualified to be self-sufficient and must not extend their site's own resources. Lastly, they are designed to create only a positive impact on both the environment they interact with as well as the humans occupying them[20]. Like anything seen in the natural world, a Living Building must be able to thrive on its own as well, benefiting the environment rather than creating harm.

Learning from Example

Thinking in terms of a living building is to think of every single aspect that goes into something that is or has once lived. That brings up the idea that if we want to build a structure that lives, can we build it from things that are also living? Cultivated materials are making headway in the building industry as great alternatives to everyday products like bricks and insulation. The idea of using these materials appears promising in the fight to embodied carbon emissions. But to first tackle the issue of greenhouse gasses, we need to look into the materials we are currently using and why we should reconsider such use.

COMMON MATERIALS

The industrial revolution brought remarkable production quality and quantity to metal manufacturing and building construction. Without the introduction of steel, we would not have the high-rises we see today. However, this exciting fabricated life cannot exist without consequence. In today's society we produce more than 10 times our body weight every year for each person alive in steel, aluminum, cement, paper, and plastic[21]. The demand for materials not only depletes resources but also accounts for our rising levels of CO2 emissions. The focus on CO2 output is especially important when considering the rise of cities and the population that occupy those cities. It is

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[18] "Living Building Challenge." International Living Future Institute, February 20, 2020. https://living-future.org/lbc/.

[19] "Living Building Challenge." International Living Future Institute, February 20, 2020.

[20] Ibid.

[21] Julian M Allwood and Johnathan M Cullen, *Sustainable Materials with Both Eyes Open*, (Cambridge, England: UIT, 2012), 4.

estimated that buildings produce nearly 40% of all emissions, in which building construction accounts for 11%[22]. In 2009 50% of the world population lived in cities and as long as that number increases CO2 production will increase with it[5]. Goals and challenges have been initiated to combat the rise in emissions, but reaching these goals is especially difficult in architecture for we tend to collect more scrap from production processes than from products that have reached their end of life[23]. To fully understand the emissions that come from construction processes in terms of production and operation, we must first understand the materials we are using and why they pose a threat to our environment.

A Focus on Concrete

Concrete, being the largest CO2 producer, will be emphasized for the remainder of this research.

> *"After water, concrete is the most widely used material on the planet."*
> CarbonCure

Concrete has been a frontrunning product since it's very beginning, seen for its strength, durability, and long life. It's no wonder world renowned architects like Scarpa and Tadao Ando implement it in their designs like it's the only material they have ever heard of. It's easily available, can be manufactured to a custom strength, is super low maintenance, and clearly fire resistant. It's a product made to last in both physical structure and popularity. So, what exactly is concrete? In simple terms, concrete is a mixture of paste and aggregates, or rocks[24]. The paste consists of Portland cement and water which then coats the surface of the fine and coarse aggregates. After hydration occurs through a chemical reaction, the paste hardens and gains strength to form concrete. The quality of the paste determines the properties of the concrete and the strength of the paste depends on the ratio of water to cement. With that being said, the best concrete is that with the lowest water content that still has enough workability to be placed. As a makeup, concrete consists of around 10 to 15 percent cement, 60 to 75 percent aggregate and 15 to 20 percent water with an additional chance of trapped air in which would take up another 5 to 8 percent[25]. In terms of type, the most common types of concrete include: Precast, cast in place, and reinforced. Various types depend on the way the material is produced and where.

Concrete's nearly age defying, with an average life of 30-50 years. Not to mention its low lifecycle cost due to the three necessary ingredients and very low maintenance[26]. Concrete is also considered safe and reliable for it will not rust, rot or burn. As a real-world example, pavements are also less susceptible to damage from heavy vehicles, easier to see at night, gives ground for short stopping in bad weather, and requires less work zones and construction

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[22] Allwood, *Sustainable Materials with Both Eyes Open*, 14.

[23] Allwood, *Sustainable Materials with Both Eyes Open*, 53.

[24] "How Concrete Is Made," Portland Cement Association, accessed March 30, 2020.

[25] Ibid.

[26] "How Concrete Is Made," Portland Cement Association, accessed March 30, 2020.

through its lifetime[27]. Concrete is also seen as resilient for it is resistant to natural and man-made disasters and will not need to produce more carbon in repairing processes[28]. The material is great for both interior and exterior applications as seen in interior foundation and exterior walls, pathways, and common structures. It's water-resistant, strong, and not easily destroyed. Although, with such rewarding benefits there are always downfalls especially in the sustainability category. Not only does cement result in high levels of CO2 but unbelievably so, production happens to be the third largest contributor of man-made CO2 after transportation and energy[29]. In total, it's actually 6 - 7% of the worldwide percentage of CO2 emissions[30]. As if the CO2 percentage is large enough already, cement is expected to rise in 2020, and it's already the most expensive material portion seen in concrete production[31]. With the industry alone being worth over $37 billion and producing about 10 billion tons of concrete each year, this percentage is of the utmost concern.

Although concrete is nothing shy from perfect, for it decreases its value due to its brittle nature and need for reinforcement. It's low in tensile strength, toughness, specific strength, and the framework needed to build up and enhance the material can get pricey and difficult to install due to the need of framework and steel reinforcing[32]. The product can take days to get to its full-strength ability and the process not only needs to be monitored greatly but can result in failure or cracking early on. Although a versatile material, the quality control needed to successfully employ the product to perfection can be a lot for manufacturers[33]. The argument isn't to disregard concrete as a substantial material for building and construction. The substance is on the less expensive end, fairly easy to manipulate, and can be sustainable in the right context. But given the limitations and CO2 impact, it may be wise to explore more sustainable and efficient products not only for economic and environmental advantages but also for a pleasant transition into more building diversity. After all, before steel concrete was the love of all building design. Figuratively speaking, if we can improve both the quality and sustainability of the material, can we learn to love it again?

CEMENT ALTERNATIVES

With cement being a notable downfall to concrete production it's no surprise that alternatives to the product are being implemented to either lower the cement content or get rid of it completely. Supplementary Cementitious Materials, SCMs for short, are cement alternatives with the intent to lower the cement amount as well

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[27] Ibid.

[28] Ibid.

[29] "The Environmental Impacts of Concrete," Greenspec, accessed March 30, 2020.

[30] CarbonCure. *Secrets to Boosting Your Concrete's Profitability*. CarbonCure, n.d.

[31] CarbonCure. *Secrets to Boosting Your Concrete's Profitability*. n.d.

[32] "Limitations of Concrete or Disadvantages of Concrete," EngineeringCivil.Org, October 22, 2016.

[33] "Limitations of Concrete or Disadvantages of Concrete," EngineeringCivil.Org, October 22, 2016.

as provide various performance qualities to the concrete itself. Most commonly seen as a SCM is fly ash, a by-product of the coal industry. Slag, a by-product of steel production is also commonly used as well as silica fume, a by-product of the ferrosilicon metal industry[34]. An additional benefit to using these replacements is a decrease in production costs for these by products are usually significantly lower in price due to them being seen as waste material. Not only do SCMs reduce CO2 output from the removal of cement but they also give new life to these byproducts that would otherwise lay to rest in a landfill. After all, why create new waste when we can just use what we already have made? As a materiality benefit, studies have proven that SCMs can actually increase the strength of concrete over time to levels even greater than traditional cement[35]. With all this in mind the million-dollar question arises: Why are we not adopting these products as permanent solutions? Nothing can ever be absolutely perfect, and for that SCMs have their disadvantages. Fly ash for example has both its successes and limitations. Shortly noted it can have different properties depending on where and how it was obtained[36]. Fly ash also has the tendency to effloresce which raises concerns with its freezing and thawing capabilities. Fly ash may also be seen to have a seasonal limitation, require salt scaling when in higher concentrations, may need air-entraining mixtures, and the possibility of slower strength gain[37]. Supplementary Cementitious Materials are great alternatives, but far from perfect solutions. And thus, the search continues.

An additional innovative approach to a cement alternative is the use of Portland-Limestone Cement (PLC) as a type of cement that's more sustainable without a lesser performance of that in typical cement. PLC uses underground limestone to replace up to 85% of the stone residue used in regular concrete, resulting in up to 10 percent less carbon emissions during concrete production[38]. PLC is being heavily implemented on the west coast in all concrete applications for when it's mixed with SCMs it's seen to acquire similar to regular cement[39].

CarbonCure as an Alternative to Cement:

A Case Study

One particular product making headway as an alternative to cement is CarbonCure, a company based in Nova Scotia. CarbonCure was founded in 2007 by Rob Niven, who received his master's in engineering from McGill University. While at McGill Niven studied the benefits of implementing CO2

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[34] CarbonCure. Secrets to Boosting Your Concrete's Profitability. CarbonCure, n.d.

[35] CarbonCure. Secrets to Boosting Your Concrete's Profitability. n.d.

[36] Juan, Rodriguez. "Uses, Benefits, and Drawbacks of Fly Ash in Construction." The Balance Small Business. The Balance Small Business, February 17, 2019. https://www.thebalancesmb.com/fly-ash-applications-844761.

[37] Rodriguez. "Uses, Benefits, and Drawbacks." February 17, 2019.

[38] CarbonCure. Secrets to Boosting Your Concrete's Profitability. n.d.

[39] Ibid.

into fresh concrete[40]. After attending a United Nations summit on Climate Change Niven was drawn to the movement of reducing carbon emissions. Inspired by this, Niven started his journey with CarbonCure as a means to turn concrete into a green material. Since then, CarbonCure began its development in producing a scalable technology that not only provides economic benefits but lowers carbon emissions as well.

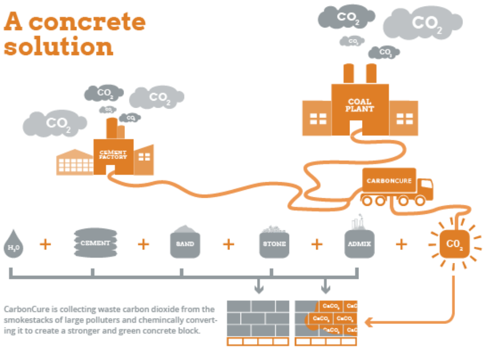

Figure 4: "An Economically-friendly Way of Incentivizing Companies to Capture Their Emissions," CarbonCure

CarbonCure is known for its development of a system that uses liquefied carbon dioxide that is then pumped into wet concrete during the mixing process. One the concrete hardens the carbon reacts with the concrete in a mineralization process[41]. The benefit of CO2 in the mineral state is that it can act as a replacement to the cement without lowering the concrete's strength or affordability. The company concluded a study between a reference batch, reduced binder batch and reduced binder batch with CO2 added to test the strength properties and limitations of CarbonCure's technology. After experimentation the company concluded that the carbon dioxide could allow for a 5-8% reduction in binder loading without compromising strength[42]. Within the model they were able to show that using CO2 in common concrete can indeed reduce the carbon footprint of the concrete by 4.6%. With this being said, the improvement of the concrete is then estimated to be more than 35 times larger than the amount of carbon dioxide required to produce the CO2 enhanced product. In comparison, an average size concrete plant would need to use about 24 tonnes of carbon dioxide to achieve nearly 897 tonnes of CO2 absorbed and avoided[43]. As an additional green benefit, when CO2 becomes a mineral it is then permanently embedded within the concrete due to the chemical reaction between the CO2 and the concrete mix[44]. Once this reaction happens the CO2 is never to be re- released into the atmosphere. According to Christie Gamble, CarbonCure's director of sustainability, the process of converting CO2 into a mineral can reduce the equivalent carbon that a thousand trees would absorb in a year[45]. Gamble believes that if CarbonCure was activated worldwide, the amount of carbon dioxide reduction would be like taking 150 million cars off the road[46]. CarbonCure has a very simple operating system, for it only requires a computer, CO2 storage tank, and a tube to pump the concrete mix for the liquefaction

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[40] Ibid.

[41] Marcello Rossi, "Scientists Are Taking Concrete Steps towards Reducing Cement's Massive Carbon Footprint," Quartz November 15, 2019.

[42] CarbonCure. Secrets to Boosting Your Concrete's Profitability. n.d.

[43] Ibid.

[44] Ibid.

[45] Rossi, "Scientists Are Taking Concrete Steps," November 15, 2019.

[46] Ibid.

process[47]. Right now, the company is primarily based in North America with 150 plants but has intentions of spreading across seas[48]. The company works closely with Thomas Concrete, a concrete producer, who pays to use CarbonCure along with captured CO2 purchased from an outsourced plant[49]. The company proclaims that those costs even out with what they save by using less cement[50]. The benefit of CarbonCure's system is that CO2 that would otherwise be disposed of as waste is collected and reused. CarbonCure believes that developing new uses for CO2 waste is "an economically-friendly way of incentivizing companies to capture their emissions[51]." The company predicts this development of capturing CO2 will rise exponentially in the next ten years and will become a 1 trillion-dollar market by 2030. Carbicrete and Carbon Upcycling are an additional two companies that are working towards the goal of capturing and reusing CO2 for a more sustainable solution to concrete[52].

725 Ponce de Leon Ave - Atlanta, GA

Project Size: 360,000 square feet

Architect: S9 Architecture

Developer: New City Properties

Engineer: Uzun+Case

Completion: 2019

Concrete Supplier: Thomas Concrete - Buckhead

Total CO_2 Saved: 1.5 million pounds

> *"To make 725 Ponce de Leon Avenue, Thomas Concrete poured 48,000 cubic yards of concrete made with the CarbonCure Technology, diverting 1.5 million lbs (680 tonnes) of CO_2 from the atmosphere. That's equivalent to 800 acres of forest absorbing CO_2 for a year!"*

725 Ponce is a multi-story commercial office building in one of Atlanta's most popular neighborhoods[53]. The surrounding neighborhood first developed in 1860 and has since gone through a slew of transformations, with the most recent being a $140 Million dollar mixed-use office building renovation that includes a 60,000 square foot Kroger on

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[47] Ibid.

[48] Ibid.

[49] Bronte Lord, "This Concrete (Yes, Concrete) Is Going High-Tech," *CNNMoney*, Cable News Network, July 6, 2018.

[50] Lord, "This Concrete," July 6, 2018.

[51] Ibid.

[52] Ibid.

[53] Rossi, "Scientists Are Taking Concrete Steps," Quartz November 15, 2019.

the ground floor, below a lifted office space that connects to the BeltLine Eastside Trail, which revitalizes the surrounding neighborhood[54]. The structure is lifted on 60' tall columns and contains a terraced landscaped entry to the trail in which the gardens extend the greenspace[55]. The project is now one of the first large-scale buildings to use CarbonCure concrete throughout the entire structure[56]. Cast-in-place concrete is used as both the structure and the facade of the building[57]. The building is also equipped with large factory style windows as well as carved out outdoor spaces to optimize views of the Beltline trail and surrounding neighborhood[58]. The premise of the project was to create a new urban space on the Beltline, with opportunities for retail and terrace spaces, as well as a direct view of the Ponce City Market across the way[59].

Mycelium as an Alternative to Cement: *A Case Study*

With replenishable materials in mind there is one particular area of research fairly new to the world of construction yet could send a ripple through the building industry; And that cutting-edge strategy is none other than the cultivation of mushroom mycelium. Mycelium is favorable for its comparison to some plastics and other petroleum-based resins with glue like properties[60]. In the growth process mycelium forms a net-like structure that gets denser and denser making it a lightweight and strong material once dried. It can even be tested to bounce back when smashed against a cement wall due to its flexibility and durability. Like plastic, mycelium can be grown to express many different qualities within a single component. It can be produced to be soft or hard, light or heavy, strong and durable, weak and fracturing, or any combination of the former or others too. In terms of building design, the mycelium is frangible and corklike, yet the outer layer contains a harder shell making it great at fire-resistance, a good insulator, and free of toxic volatile compounds. It can achieve compression, thermal and acoustic insulation, and flexural characteristics similar to petrochemical composites and engineered wood making it an easily comparable product to things such as wood, stone, plastic, and other common elements[61]. Mycelium can also be altered to grow around other materials (such as ground up straw) and then air-dried to create lightweight and strong bricks and other shapes, making it potentially reinforceable in building design[62]. Although it would be ideal to implement in exterior and structural design, mycelium is best made light and strong for architectural and design applications for interior purposes[63]. Given the newness of the material there's not much research done on its ability to be used as a construction base. The flexible properties

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[54] "A Timeless Community," 725 Ponce, accessed March 23, 2020.

[55] "725 Ponce: BUILT," S9 Architecture and Engineering, accessed March 23, 2020.

[56] Rossi, "Scientists Are Taking Concrete Steps," Quartz November 15, 2019.

[57] "725 Ponce: BUILT," S9 Architecture and Engineering, accessed March 23, 2020.

[58] Ibid.

[59] Ibid.

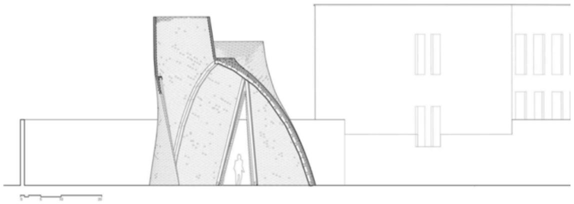
[60] Dirk E Hebel and Felix Heisel, Cultivated Building Materials, Basel Switzerland: Birkhäuser, 2017.

[61] Dirk E Hebel and Felix Heisel, Cultivated Building Materials, Basel Switzerland: Birkhäuser, 2017.

[62] Peckenham, "11 Green Building Materials That Are Way Better than Concrete," 2016.

[63] Hebel, Cultivated Building Materials, 2017.

may come as a positive but even if produced to be strong and light, it is unknown just how strong they actually are or how to describe their qualities other than through descriptions like tough, brittle, rubbery, and so forth[64]. Regardless, the material is worth the research with a great example being Hy-Fi, a pavilion at MoMa in New York City.



Hy-Fi, Kris Graves

The main architect, David Benjamin, as a member of the firm The Living, used over 10,000 mushroom bricks to create a captivating experience. Hy-Fi consists of corn stalks and mushroom mycelium as a natural digestive glue. The materials offer a combination of agricultural byproducts and are entirely from biodegradable matter[65]. To create the material, specially designed molds were used to cultivate the biobricks in which some were then coated in a light-refracting film that had been developed by the materials firm 3M. The mirror-like coated bricks were then used around the top of the structure to help bounce light down inside. The reflective bricks are produced through the custom-forming of a new daylighting mirror film[66]. As far as the structure goes, the framework is built from Hemp-crete foundation bricks along with a steel and reclaimed wood diaphragm[67]. The form allows for gaps in the brickwork to help with natural ventilation of the interior utilizing a stack effect which allows for cool air to be drawn from the bottom therefore releasing hot air from the top[68]. As a result of the ventilation the structure allows for a "pleasant microclimate." It’s also stated in the article’s release that “Hy-Fi offers shade, color, light, views, and a futuristic experience that is refreshing, thought-provoking, and full of wonder and optimism[69]." As if the structure’s material composition isn’t impressive enough, it’s also the first sizeable structure to claim near-zero carbon emissions in its construction process and, beyond recycling, it presents itself as being 100 percent compostable[70]. The structure is beyond impressive for its seen as a building that grows out of nothing but earth and returns to nothing but earth. It contains almost no waste, no energy needs, and no carbon

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[64] Ibid, 2017.

[65] Amy Frearson, “Tower of ‘Grown’ Bio-Bricks by The Living Opens at MoMA PS1,” Dezeen, July 11, 2014.

[66] Frearson, “Tower of ‘Grown’ Bio-Bricks,” 2014.

[67] “YAP 2014 Winner: Hy-Fi by The Living,” MoMA, accessed March 30, 2020.

[68] “YAP,” 2020.

[69] Frearson, “Tower of ‘Grown’ Bio-Bricks,” 2014.

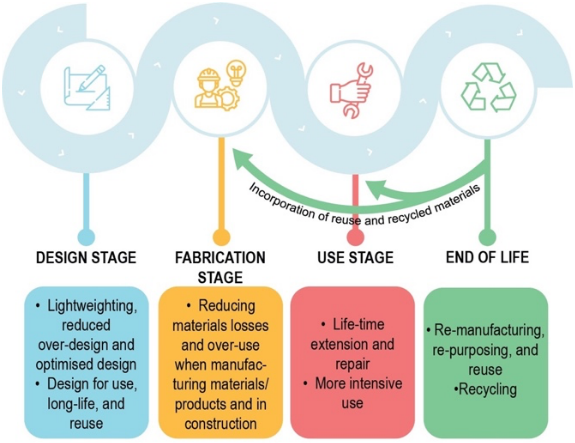
[70] Ibid., 2014.

emissions[71]." It's seemingly defying gravity for its light and thin bottom and is additionally fantastical for its captivating light effects on its interior walls through reflected patterns[72].

"How marvelous to build in collaboration with nature—to allow the strength of a living thing to forge the walls and floors of a place meant for living."
MycoWorks Founder

MOVING TOWARDS RECYCLING & REUSE

Ultimately it is understood that moving away from materials that cloud our atmosphere with carbon dioxide is a necessary step towards sustaining our earth. It's hard to say if there will ever be a material that could be as strong as steel, as malleable as aluminum, or as solid as concrete. These materials have a detrimental impact on the environment, and if we are to continue to use these materials, we need to consider how to mitigate their negative effect on our environment as we use them and then we need to consider using them differently. We cannot so much change the way these materials are produced, but we do have some control over how we choose to dispose of them. Although recycling isn't a completely bulletproof system since melting down an empty soup can require a heavy sum of energy. That leaves the second option: reusing. We should be thinking of a circular economy, which emphasizes that once something is produced it should be reused at the end of its intended use, not disposed of. But let's say your can of soup has a dent in it or becomes rusted over time. Reusing something isn't as simple as it sounds when the product starts to damage, or that a new product is better at taking on what you had wanted the old can for. So, we are left with the idea that maybe if we design materials specifically for recycling and reusing then we are much better off down the road.



Standardizing building products are extremely durable not only for their current use but also the lifespan of the product. However, if the product is to be reused for another site, the challenge is in how the building is disassembled and materials are transported[73]. Take masonry for example, a solid material that is fused together with mortar and nearly impossible to separate without damaging the brick[74]. This leads to the concept of alternative solutions to everyday materials. There are mortar-less

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[71] Ibid., 2014.

[72] "YAP," 2020.

[73] Tom Wood. "Blank Canvas: Can We Make A Totally Recyclable Building?" The Possible, Aug. 2017, www.the-possible.com/how-to-design-completely-recyclable-building/.

[74] Wood, "Blank Canvas: Can We Make A Totally Recyclable Building?" 2017.

approaches that allow for blocks to join together through a slotted fashion, but this questions the water tightness and air leakage of the joints[75]. The results in a final everlasting approach: designing with the intent of things being easily deconstructed. Like seen in the analysis of steel and aluminum, the problem is not recycling for a lot of what we are currently using to build with is already being recycled. The issue is making this cost-effective enough to recycle, preventing additional energy use and CO2 emissions, and finding a way to deconstruct these materials to make the process more efficient. We could shoot for entirely modular buildings, but the concern of air and water tightness still arises, and sealants are not yet developed enough in ways that make them recyclable[76]. We could design to combat these moisture aspects, but that would require a whole slew of limitations. The way a building is maintained would also contribute to whether or not it's materials can be reused down the road, a concept that both the designers and the inhabitants need to be aware of [77]. We also run into the consumer way of life, being the idea that everything needs to be new, completely disregarding the once popular expression, "if it isn't broken don't fix it." The problem is not only with what we are building but also how we are building and especially who we are building for. For example, over-engineering a product with the sole goal of making everything reusable may result in a building's performance suffering. In order to be fully sustainable, we need to learn to reduce our waste and to love our waste in the process.

REUSE AS THE SOLUTION

To say there is a solution to reducing the carbon emissions of building materials is a bit arbitrary to say the least. As discussed previously there are multiple pros and cons to everyday materials, possible sustainable or cultivated materials, and applications or practices just to make the materials last longer. Regardless of what process the material goes through there will always be an excess of greenhouse gases produced. Realistically there is no real solution, but is there a best practice that outranks the rest? To reuse waste is the most practical approach to conserving building materials. We already created the thing and we know that whatever it is can probably be recycled easily if it's not on that train already. So, lets track back to reusing and try to understand why it's not being done more. The most obvious answer: No one wants old garbage. We are consumers in every sense of the word. As a society we do not think to clean our Ziplock bags for a secondary use or save old jars and cans for a project down the road. It is much easier to go to the store and get another box of Ziploc or to get a perfect set of plastic containers. The solution is simple, yet we seldom think to follow it. This poses the question of how we can influence this change by persuading others to follow suit. This can be done in a few ways, including those spoken about previously:

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[75] Ibid., 2017.
[76] Ibid., 2017.
[77] Ibid., 2017.

1. Convince society to reduce their waste and consumption

2. Design materials with the intent of them being recycled or reuse

3. Create goals or motives for companies to influence their clients to lean towards more sustainable materials and practices.

These approaches are all being deployed in their own ways and forms in which some case studies display an incredible effort in recycling and reusing. A few case studies will be discussed in brief, both to engage and in hopes to influence as well.

Applications of Recycled Materials:
A Case Study

The Lavezzorio Community Center, Steve Hall

The Lavezzorio Community Center, built for the SOS Children's Village, is a civic center with intentions of reuniting siblings subjected to foster care systems while also offering housing, services, and educational enrichment for those families[78]. The program consists of multiple offices for both counselling and administration, after school programs spaces as well as a daycare, recreational areas and exterior play areas, and a multi-purpose community center[79]. The hope of the center was not only to connect children and residents of the area but also the surrounding Auburn-Gresham neighborhood to the north[80]. Being a non-profit, the budget for the two-story building was very limited. Due to this restraint, the project was built rather unconventionally, using ordinary materials in very different applications. Most of the materials used in the project were donated, especially concrete, seen in the liquefied form of the exterior cast-in-place facade. The mix is a compilation of cement, fly ask, and slag-aggregate seen in bands of color variation, almost like a natural rock[81]. This interesting use of materials allows the space to be cantilevered, creating a playful geometric interior full of a mountain-like interactive staircase crossing over the lobby area and connecting the adjacent spaces. The interior itself appears almost as a giant jungle gym for the children to play and engage with. The structure is not only a great use of recycling on a budget, but also an incredible community center that was made possible by

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[78] Wang, "Aviator's Villa Built from Salvaged Airplane Parts Simulates Life in the Clouds," 2015.
[79] "SOS Children's Village Lavezzorio Community Center," Architectural Record RSS, Architectural Record, January 3, 2017.
[80] "SOS Children's Village," January 3, 2017.
[81] Ibid., 2017.

the help of donations and the surrounding environment.

QUESTIONS

1. Is there a way to reduce CO_2 emissions in the production of everyday materials?

2. Can we develop more sustainable materials that offset CO_2 emissions?

3. Are there materials we can cultivate or grow that have inverse effects to carbon emissions

4. Would it be easier to enforce recycling and reuse of current materials?

5. How do we influence society to reuse waste?

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ADDENDUM

Written Thesis to Design

Stage 1: *Site and design research*

Summer term consisted of researching and analyzing potential site options. During my research I had narrowed down my content to the following locations: Aspropyrgos Greece, Jona Switzerland, and Atlanta Georgia. These locations were decided due to the following criteria. I wanted to focus on a place where waste was both utilized and neglected, in addition to a place in the US for it produces the highest quantity of waste in the world.

CONCRETE PRODUCERS

OLDCASTLE: ATLANTA 1
CEMEX: MEXICO 2
LAFARGE: FRANCE 3
HEIDELBERG CEMENT: GERMANY 4
HOLCIM INC: SWITZERLAND 5

LARGEST IN NORTH AMERICA WITH RESPECTIVE HEADQUARTERS

CEMENT PRODUCERS

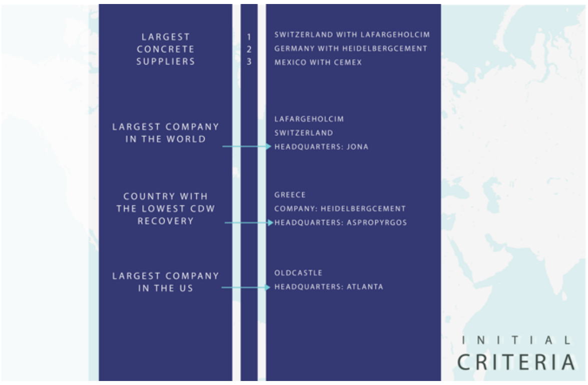
CHINA 1
INDIA 2
UNITED STATES 3

CEMENT SUPPLIERS

LAFARGEHOLCIM: SWITZERLAND 1
HEIDELBERG CEMENT: GERMANY 2
CEMEX: MEXICO 3

CONCRETE
CEMENT
CEMENT

MATERIAL STATISTICS



LARGEST CONCRETE SUPPLIERS

1 SWITZERLAND WITH LAFARGEHOLCIM
2 GERMANY WITH HEIDELBERGCEMENT
3 MEXICO WITH CEMEX

LARGEST COMPANY IN THE WORLD

LAFARGEHOLCIM
SWITZERLAND
HEADQUARTERS: JONA

COUNTRY WITH THE LOWEST CDW RECOVERY

GREECE
COMPANY: HEIDELBERGCEMENT
HEADQUARTERS: ASPROPYRGOS

LARGEST COMPANY IN THE US

OLDCASTLE
HEADQUARTERS: ATLANTA

INITIAL CRITERIA

To go into more detail, the chosen sites were picked for the following reasons:

Aspropyrgos

- Waste where it is neglected
- Location of Halyps Cement (HeidelbergCement Group)
- HeidelbergCement is the second largest world producer of cement

Jona

- Location of LafargeHolcim, the top world producer of cement = influence in the cement field.
- LafargeHolcim has goals to:
- Multiply recycled content
- Uses resources from resources made from waste

Atlanta

- Closeness to CarbonCure
- Big city
- Oldcastle, a top US concrete supplier also located in Atlanta

ASPROPYRGOS

SITE

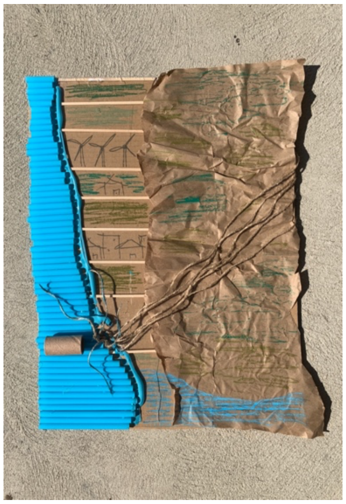
- Remote location may influence more local goods
- Lower economy could benefit with recycled content if it reduces costs
- Industrial warehousing segment of Greece

← DIAGRAM

COLLAGE

- Displaying an industrial hub through the use of recycled materials.
- How can we bring "green" into the site?

JONA



SITE

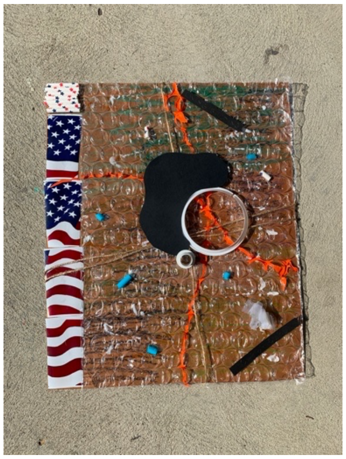
- Chosen based on the opportunity to connect with the adjacent university, zoo, and sports complex.
- Proximity to lake is also beneficial for views
- Transportation including train system
- Proximity to lake as well as city center

← DIAGRAMS

COLLAGE

- How is Switzerland on the best green route? How can we show this clean natural element?

ATLANTA



SITE

- Choosing a location that can be used for material recycling
- Abandoned lot for sale allows for a revival of the site
- Proximity to college offers opportunities
- City is highly influenced by alternatives and green initiatives

← DIAGRAMS

COLLAGE

Can we sway it one way? How does being in the US influence the city's makeup.

WHAT'S NEXT

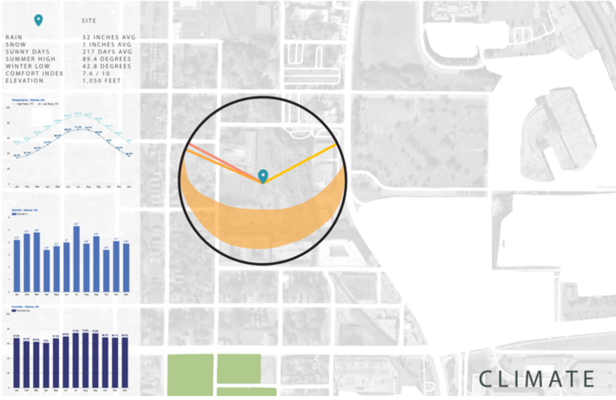
- Understanding the ecology of site and what these locations/community NEED
- Program: What am I building? What impact will it have?

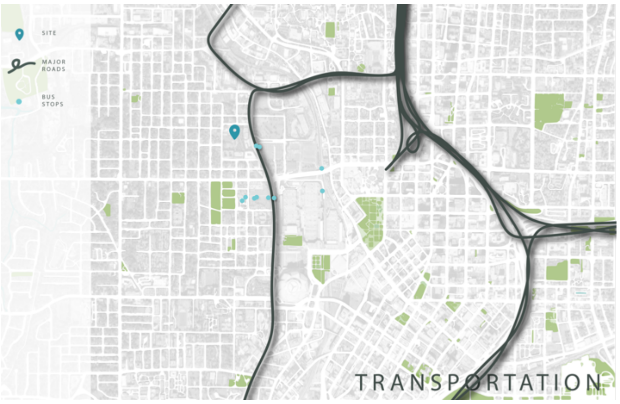
If we change concrete, can we change the industry?

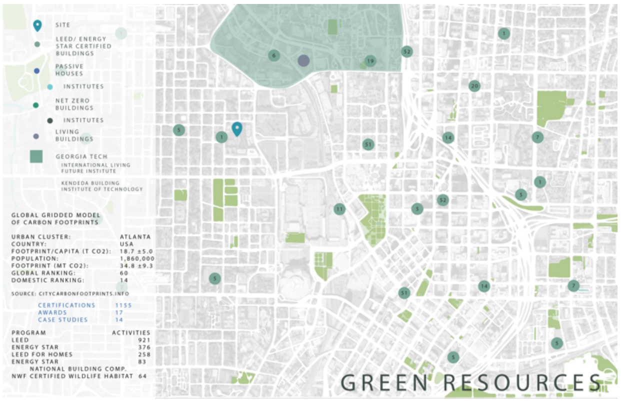
Stage 2: *Site and Design Iterations*

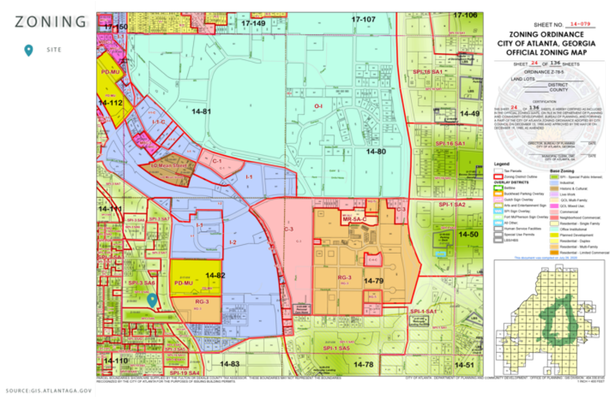
During the fall design portion of this thesis, I deployed my knowledge conducted during the summer term to design for a building and site utilizing waste resources and the application of building with waste. I ended up choosing Atlanta as my final site and began analyzing it further as well as case studies and research on the areas spoken about throughout this paper.

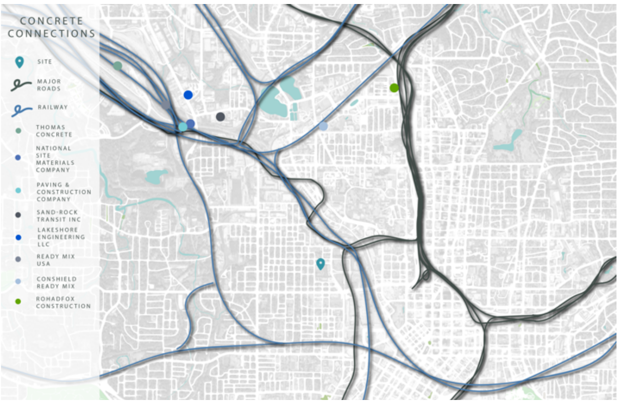
DIAGRAMMING



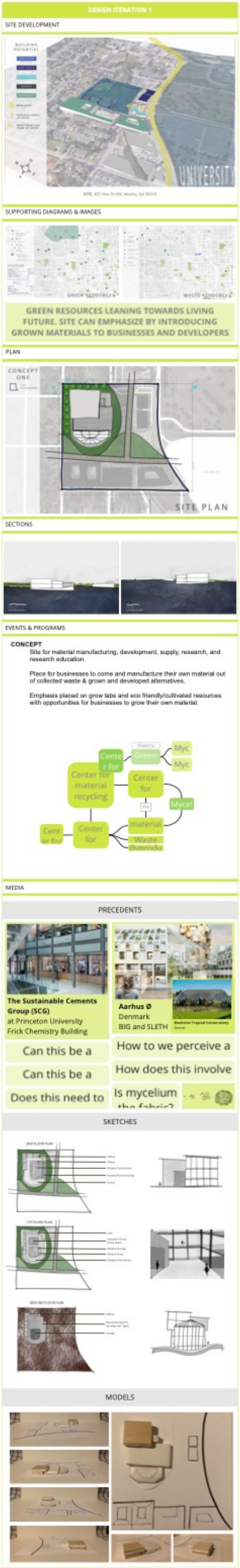








ITTERATIONS



GREEN RESOURCES LEANING TOWARDS LIVING FUTURE. SITE CAN EMPHASIZE BY INTRODUCING GROWN MATERIALS TO BUSINESSES AND DEVELOPERS

CONCEPT

Site for material manufacturing, development, supply, research, and research education.

Place for businesses to come and manufacture their own material out of collected waste & grown and developed alternatives.

Emphasis placed on grow labs and eco friendly/cultivated resources with opportunities for businesses to grow their own material.

The Sustainable Cements Group (SCG)
at Princeton University
Frick Chemistry Building

Aarhus Ø
Denmark
BIG and SLETH

Can this be a

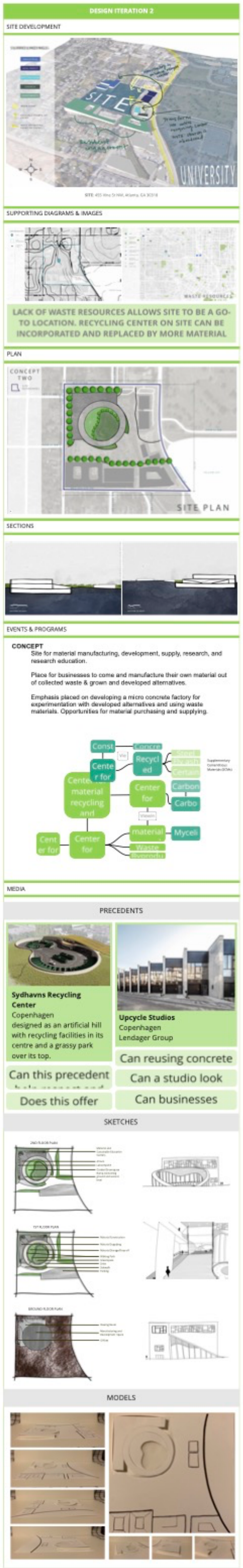
Can this be a

Does this need to

How to we perceive a

How does this involve

Is mycelium the fabric?



LACK OF WASTE RESOURCES ALLOWS SITE TO BE A GO-TO LOCATION. RECYCLING CENTER ON SITE CAN BE INCORPORATED AND REPLACED BY MORE MATERIAL

CONCEPT

Site for material manufacturing, development, supply, research, and research education.

Place for businesses to come and manufacture their own material out of collected waste & grown and developed alternatives.

Emphasis placed on developing a micro concrete factory for experimentation with developed alternatives and using waste materials. Opportunities for material purchasing and supplying.

Sydhavns Recycling Center
Copenhagen
designed as an artificial hill with recycling facilities in its centre and a grassy park over its top.

Upcycle Studios
Copenhagen
Lendager Group

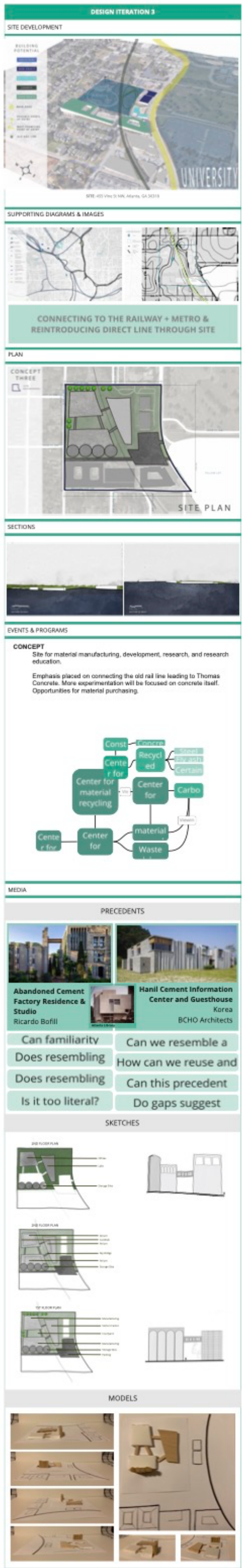
Can this precedent

Does this offer

Can reusing concrete

Can a studio look

Can businesses



CONNECTING TO THE RAILWAY + METRO & REINTRODUCING DIRECT LINE THROUGH SITE

CONCEPT

Site for material manufacturing, development, research, and research education.

Emphasis placed on connecting the old rail line leading to Thomas Concrete. More experimentation will be focused on concrete itself. Opportunities for material purchasing.

Abandoned Cement Factory Residence & Studio
Ricardo Bofill

Hanil Cement Information Center and Guesthouse
Korea
BCHO Architects

Can familiarity

Does resembling

Does resembling

Is it too literal?

Can we resemble a

How can we reuse and

Can this precedent

Do gaps suggest

Stage 3: *Design Stage & Project Proposal*

For executing the design portion, I began to focus strongly on concrete, concrete alternatives, and grown solutions. It became important to understand the process each of these categories go through and how to design a space that could utilize this process in order to make a site meant for making.

THESIS QUESTION

Can concrete be made more sustainable using means of cultivated solutions or alternative materials developed from a more experimental approach?

DESIGN QUESTION

This project works towards the development of a research and manufacturing center with educational and collaborative initiatives focused towards creating more sustainable concrete as well as other building materials.

DESIGN GOALS

To create a site that experiments with concrete and concrete-like materials as a way to then produce a cleaner material for fabrication and educational purposes.

ATLANTA, GA

Site Map

Key Takeaways: Site contains existing rail line that cuts the space diagonally. Peak of the site is 30' high in a mound like application.

Existing

- ➔ Reuse Clothing store
- ➔ Church
- ➔ Apartments
- ➔ Recycling Center
- ➔ Industrial warehouse

Proposed

- ➔ *Gallery & shop*
- ➔ Reuse Clothing store & handmade goods
- ➔ *Studios*
- ➔ *Research & Manufacturing Facility*
- ➔ *Community engagement learning center*

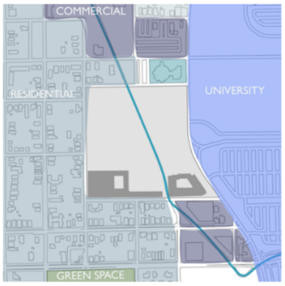
For the layout of the site, I decided to demolish all of the existing buildings, other than the apartments, and incorporated the recycling center as well as the reuse clothing store back into the site.

In addition to the recycling center and clothing store, there will also be a handmade goods store, studios, research and manufacturing facilities, community engagement learning centers, and outdoor activity areas incorporated into the site.

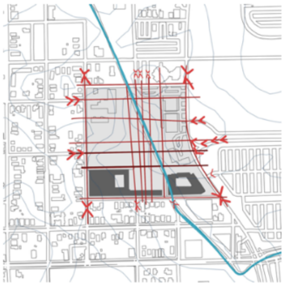
*The map is labeled to make it easier to comprehend through this project.

The following diagrams show the site layout and how the building forms were developed

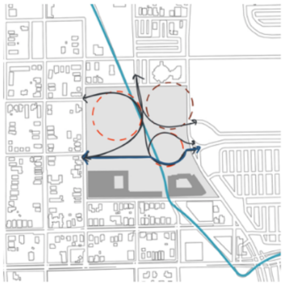
SITE ANALYSIS



SURROUNDINGS



STREETS

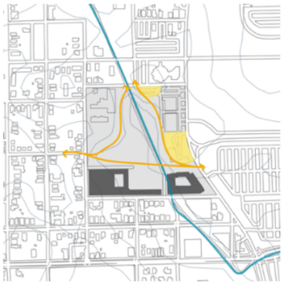


SITE CIRCULATION

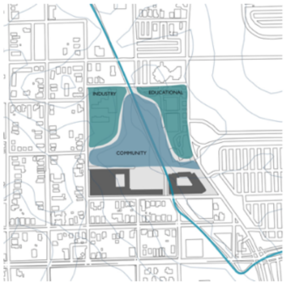
FOCUS

LEVELS

PATH



PASSAGE



USAGE

BUILDING ANALYSIS

Feature 1

LOADING + TUNNELS

Ground Level

MID

Buildings A+B

Level starts at 16'

PEAK

Building C

Level starts at 30'

RECYCLING CENTER

Feature 1

STORGE YARD

Feature 2

PARK

Feature 3

QUAD

Mid Level

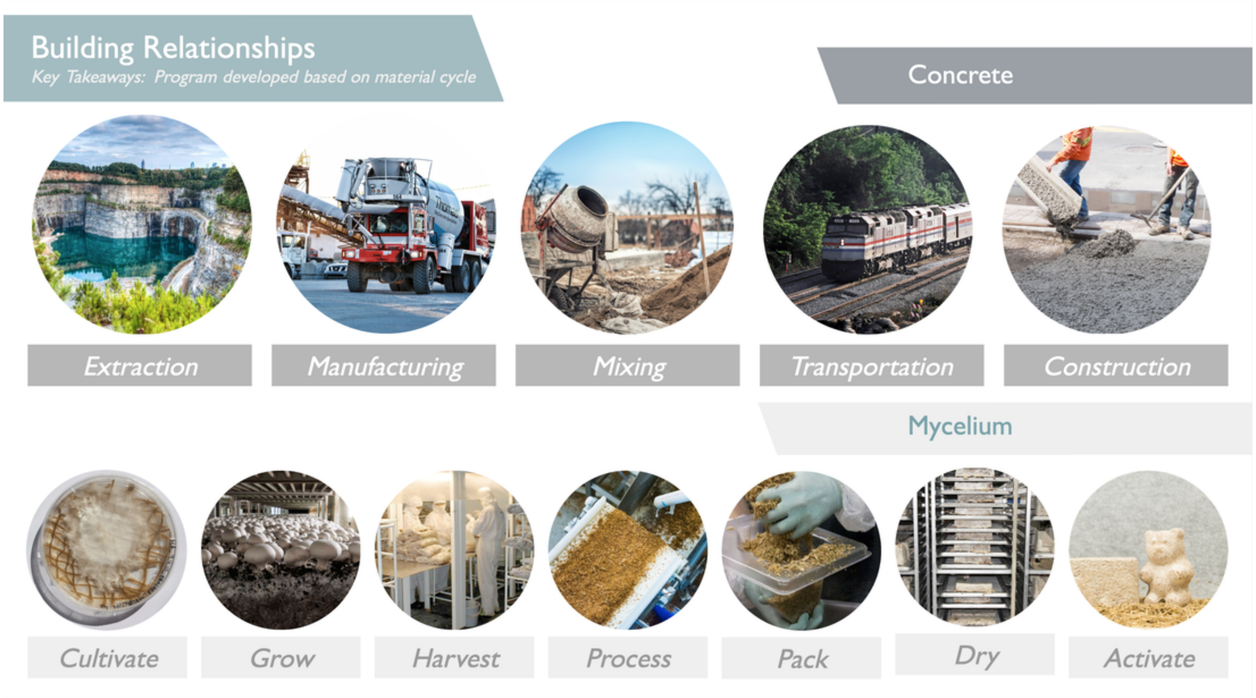
ROAD

PARKING

RAMPS

STAIRS

BUILDING FUNCTIONS



Building Relationships

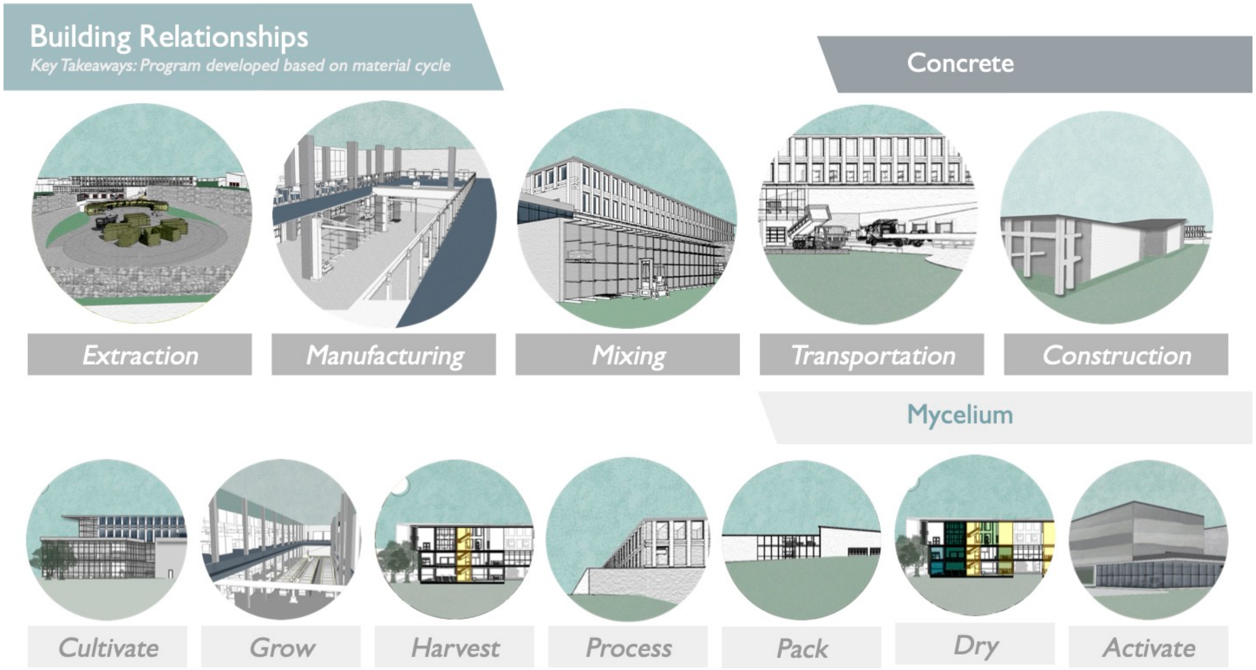
Key Takeaways: Program developed based on material cycle

Concrete

Extraction
Manufacturing
Mixing
Transportation
Construction

Mycelium

Cultivate
Grow
Harvest
Process
Pack
Dry
Activate



Building Relationships

Key Takeaways: Program developed based on material cycle

Concrete

Extraction
Manufacturing
Mixing
Transportation
Construction

Mycelium

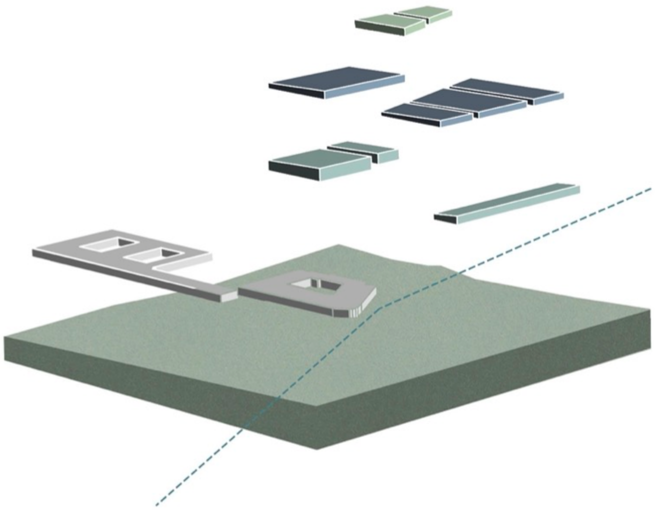
Cultivate
Grow
Harvest
Process
Pack
Dry
Activate

As mentioned, I wanted to focus on concrete and how concrete and concrete alternatives are produced and manufactured. With that being said, I took all these different components in the building process and incorporated that into my site in different aspects of my buildings.

BUILDING AXON

Building Relationships

Key Takeaways: User based on building function



Peak

Studio 1 + 2

16,000sf

Middle Level

Material Gallery + Shop
Handmade Goods
Reuse Clothing
Public Concrete + SCM Labs

145,000sf

Ground Level

Visitor's Center
*Concrete Facility + Fabrication
*Biomaterial Facility + Fabrication
Storage Yard
Recycling Center

72,500 (+135k circulation & recycling)

SITE FEATURES

Site Features

Feature 1: Recycling Center

Precedent

Sydhavns Recycling Center, Copenhagen

Site Features

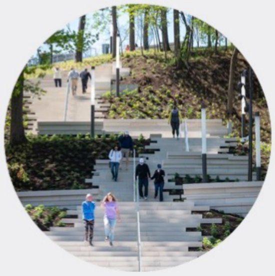
Feature 2: Storage yard

Precedent

Storage Barn, New Haven

Site Features

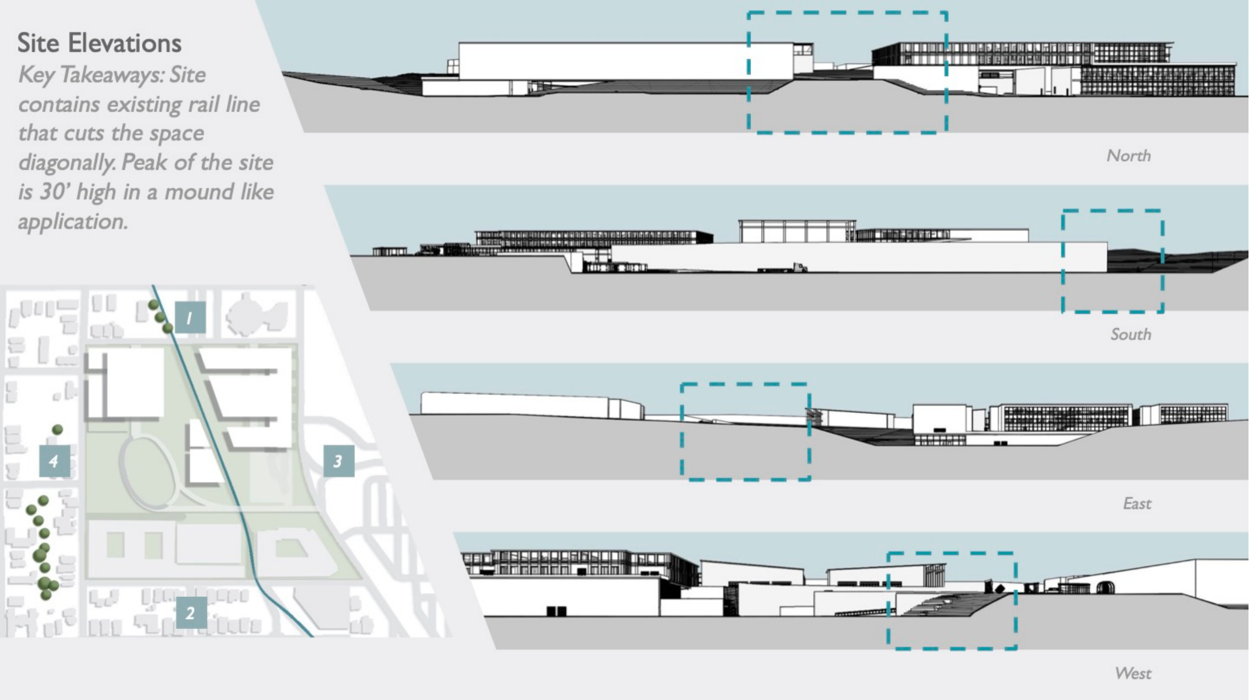
Feature 3: Community park



Precedent

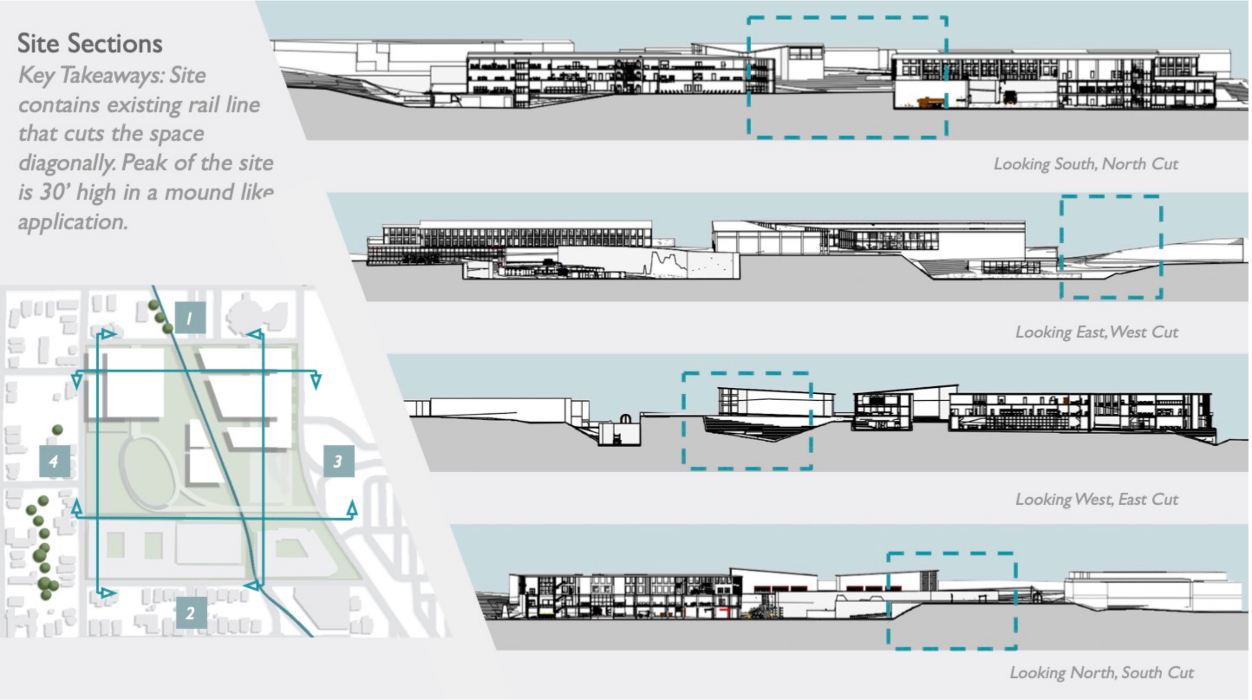
Art Museum, Cincinnati

SITE ELEVATIONS & SECTIONS



Site Elevations

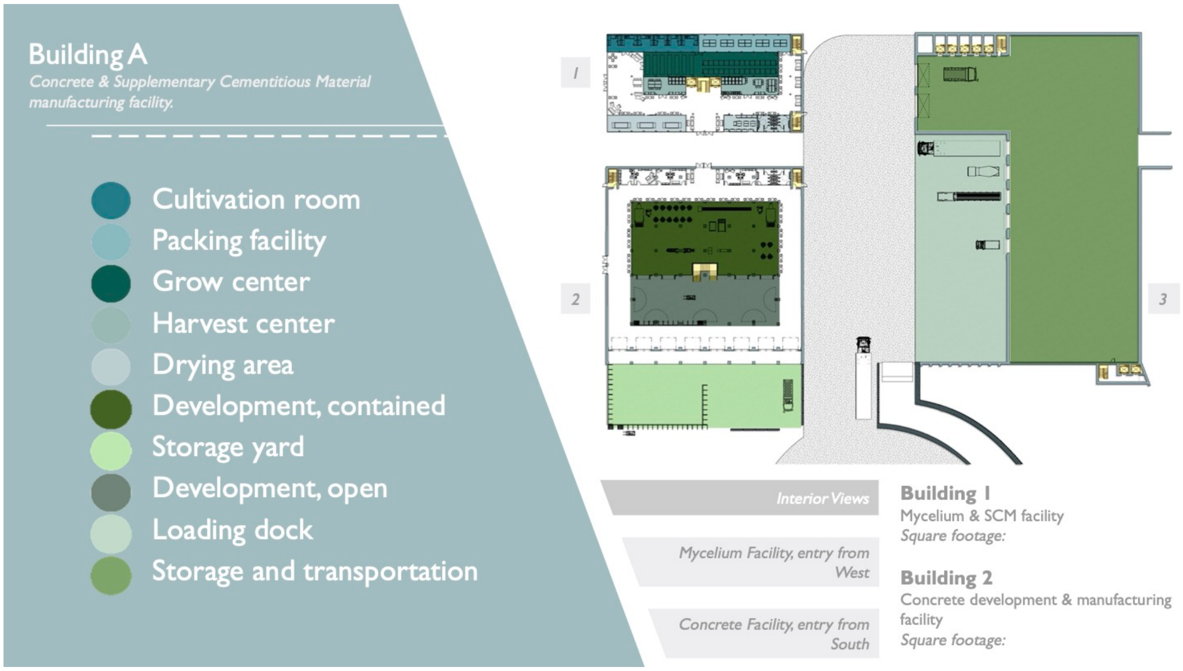
Key Takeaways: Site contains existing rail line that cuts the space diagonally. Peak of the site is 30' high in a mound like application.



Site Sections

Key Takeaways: Site contains existing rail line that cuts the space diagonally. Peak of the site is 30' high in a mound like application.

BUILDING A



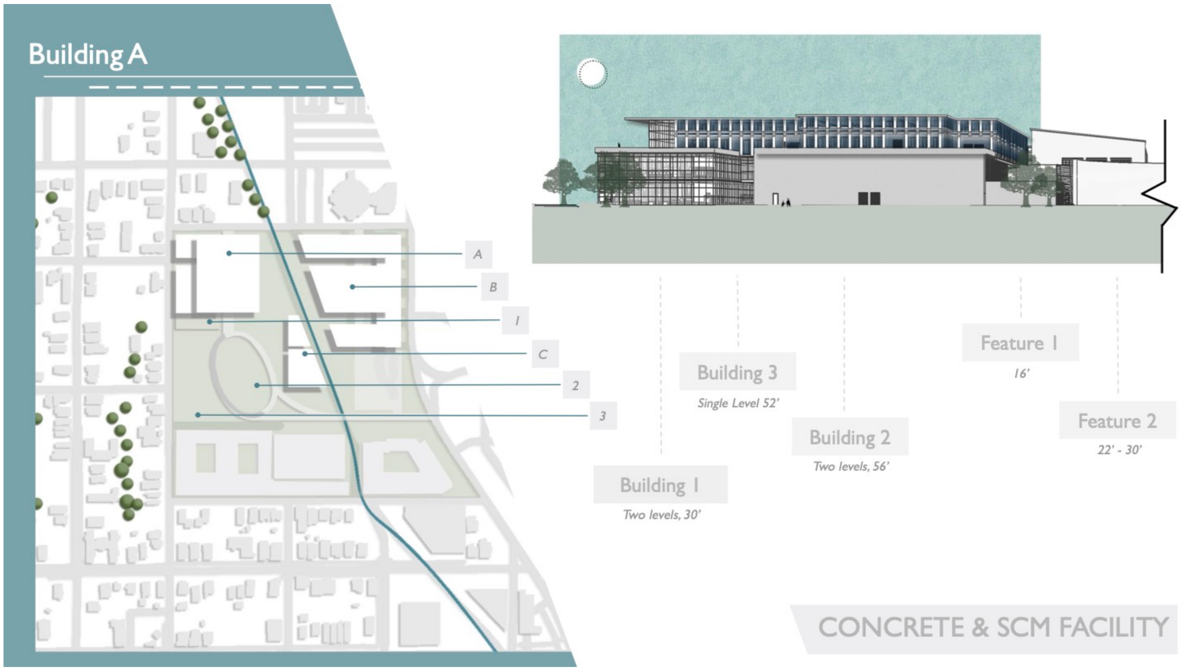
Building A

Concrete & Supplementary Cementitious Material manufacturing facility.

- ● Cultivation room
- ● Packing facility
- ● Grow center
- ● Harvest center
- ● Drying area
- ● Development, contained
- ● Storage yard
- ● Development, open
- ● Loading dock
- ● Storage and transportation

Building 1
Mycelium & SCM facility
Square footage:

Building 2
Concrete development & manufacturing facility
Square footage:



Building A

CONCRETE & SCM FACILITY

Lower Lever

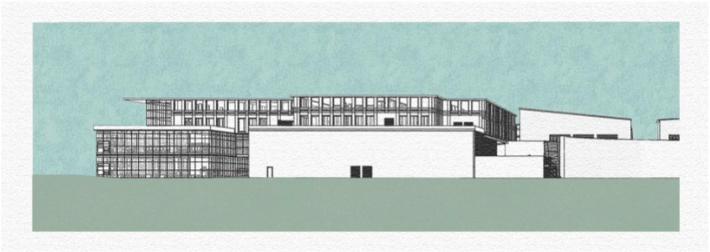
Building A: Concrete & Supplementary Cementitious Material manufacturing facility.

- ● Research + experiment
- ● Additional lab space
- ● Clean room & lockers
- ● Stay-in researcher space
- ● Individual clean labs
- ● Development, contained
- ● Prep room
- ● Development, open
- ● Control room
- ● Technical room

Sections & Elevations

Building A: Concrete & supplementary cementitious material manufacturing facility.

- ● Cultivation room
- ● Research + experiment
- ● Grow center
- ● Harvest center
- ● Clean room & lockers
- ● Development, contained
- ● Manufacturing Area
- ● Development, open
- ● Technical room



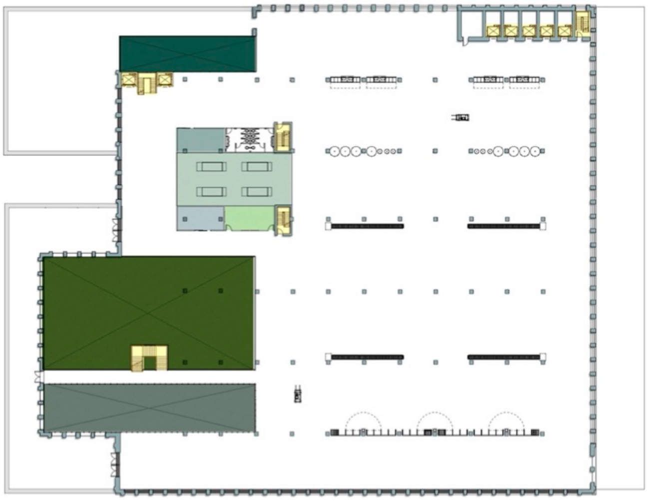
West Elevation

West Section

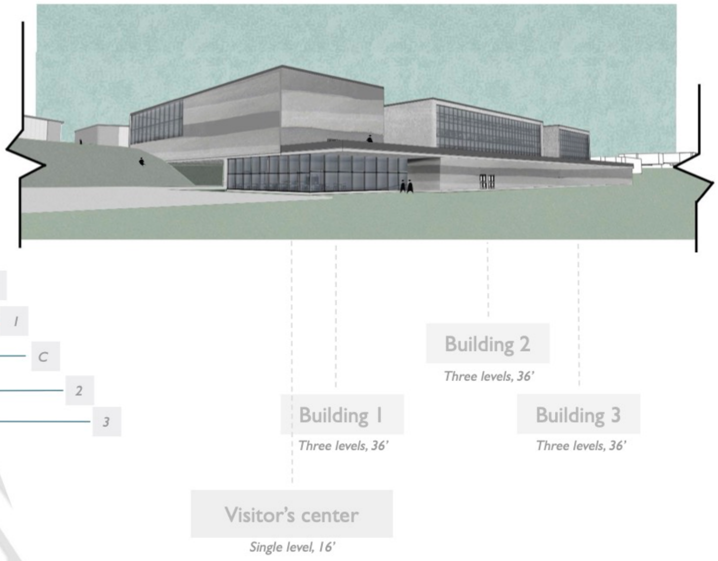
Middle Level

Building A: Concrete & Supplementary Cementitious Material manufacturing facility.

- ● Technical room
- ● Prep room
- ● Development, closed
- ● Control room
- ● Development, open
- ● Storage



Building B



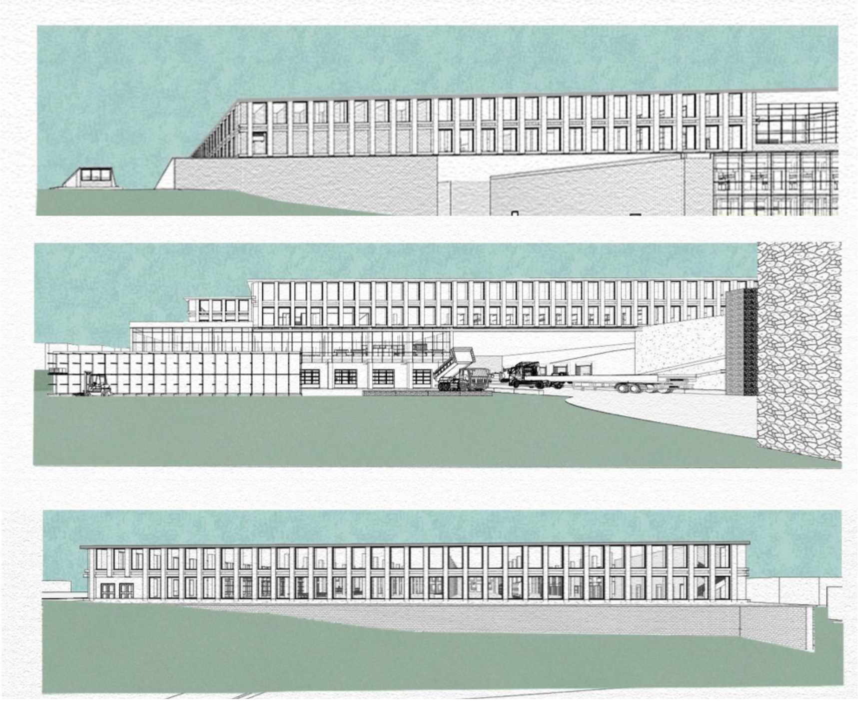
VISITOR'S CENTER & LAB

Elevations

North

East

South



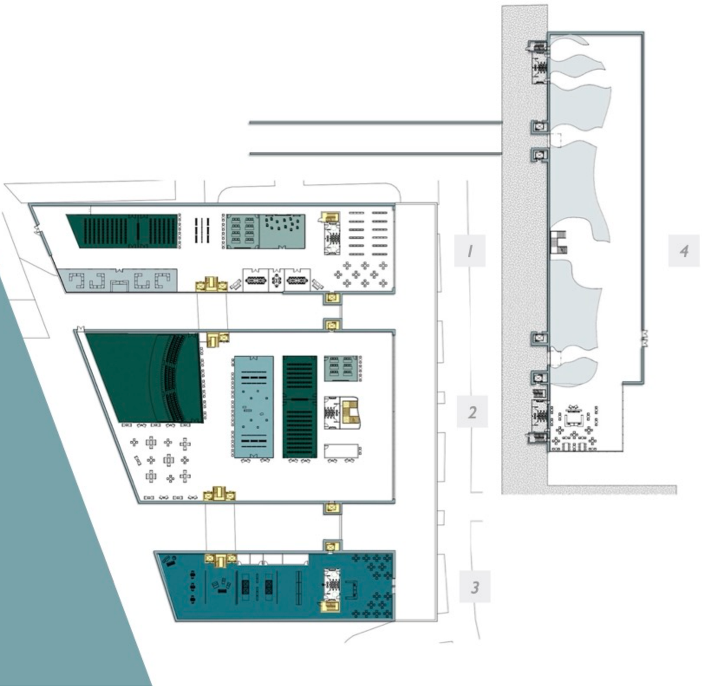
BUILDING B

Building B

Visitor's Center & Learning Lab

- ● Site shop
- ● Gallery
- ● Lecture hall
- ● Classrooms
- ● Material Expo

- 1 Students & professionals
- 2 Community & Students
- 3 Community

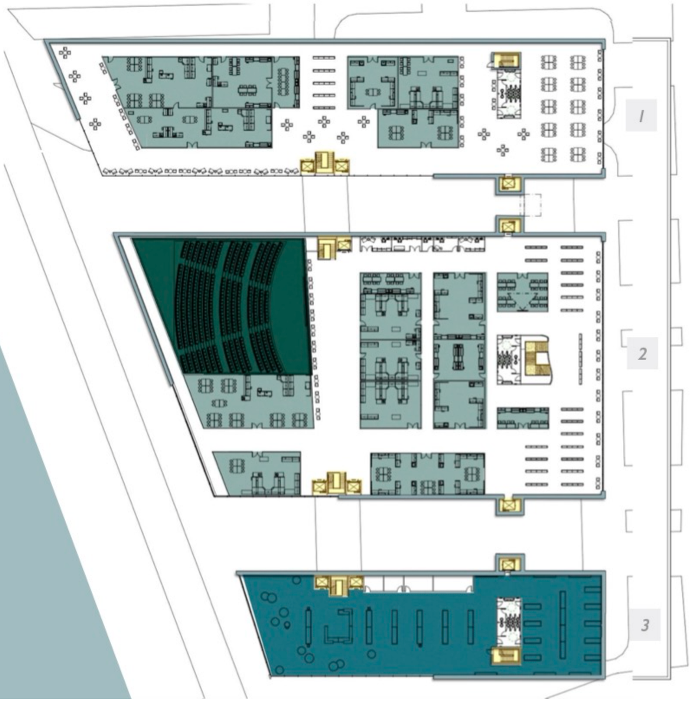


Program

Building B: Visitor's Center & Learning Lab

- ● Handmade goods store
- ● Labs
- ● Lecture hall

- 1 Students & professionals
- 2 Community & Students
- 3 Community



Program

Building B: Visitor's Center & Learning Lab

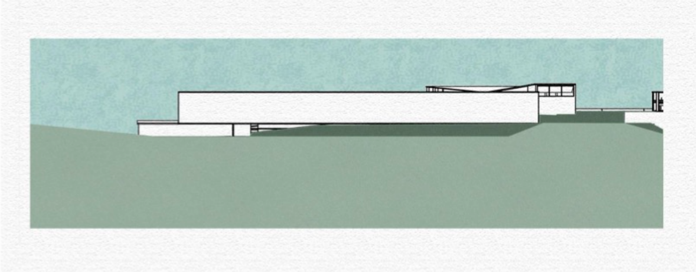
- ● Recycled clothing store
- ● Lecture hall
- ● Classrooms
- ● Concrete application
- ● Mycelium application

- 1 Students & professionals
- 2 Community & Students
- 3 Community

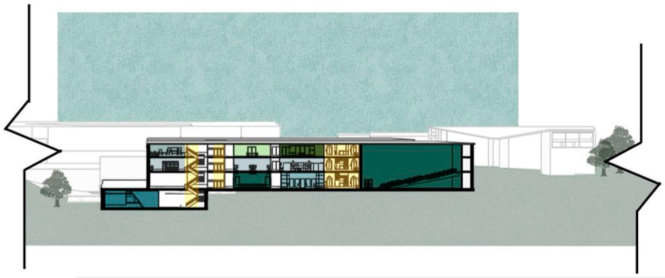
Sections & Elevations

Building A: Concrete & supplementary cementitious material manufacturing facility.

- ● Visitor's center
- ● Gallery
- ● Lecture halls
- ● Labs
- ● Classrooms
- ● Concrete application
- ● Mushroom application



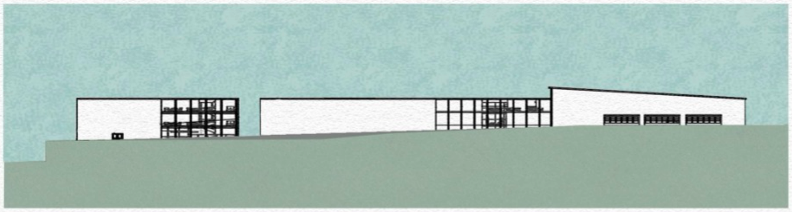
Elevation



East Section

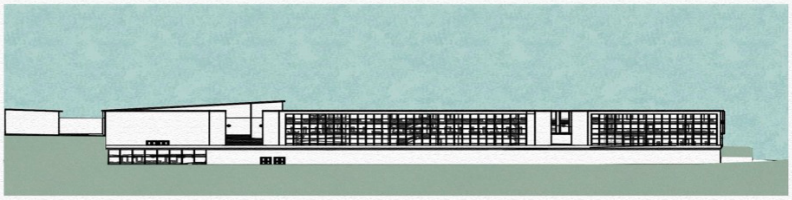
Elevations

North



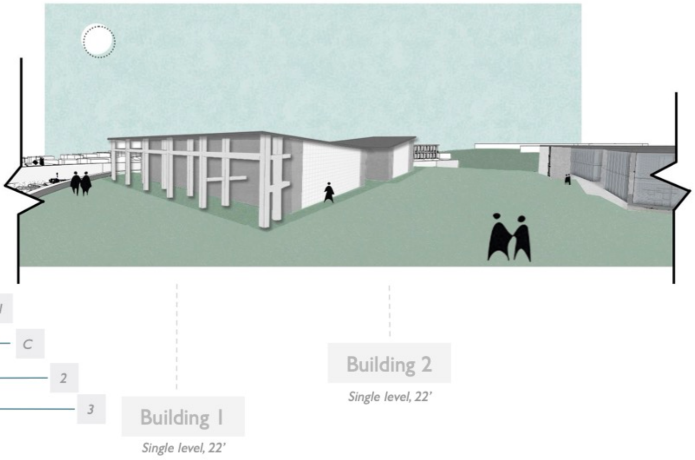
East

South



BUILDING C

Building C

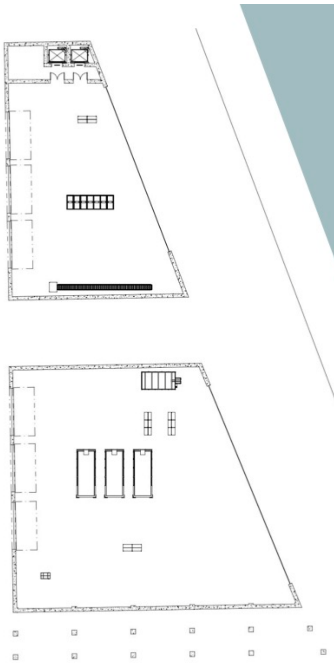


STUDIO & MAKERS SHOP

Program

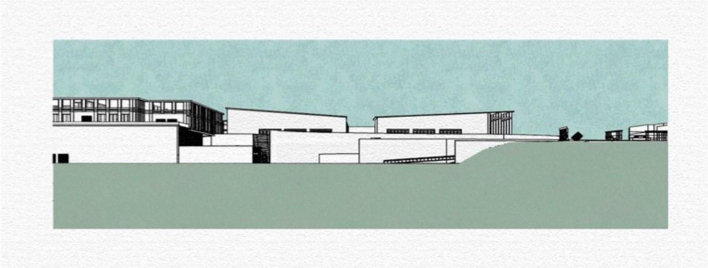
Building C: Studio & Maker Shop

Open studios allow for program & activity flexibility



Sections & Elevations

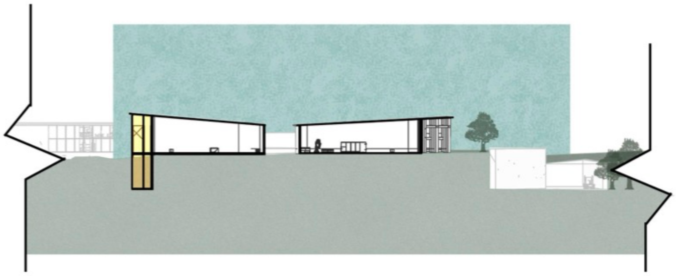
Building A: Concrete & supplementary cementitious material manufacturing facility.



Elevation

Open studios allow for program & activity flexibility

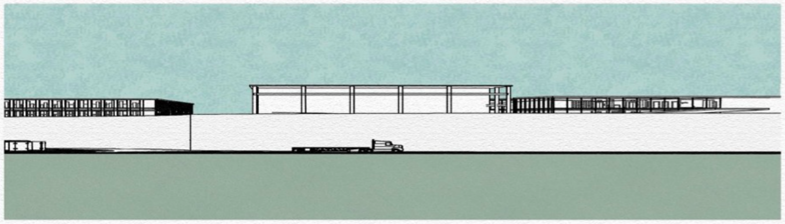
Access to loading dock from tunnel



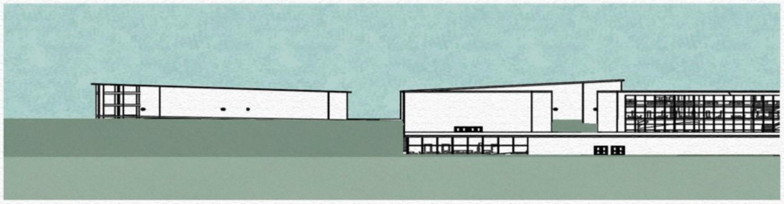
Section

Elevations

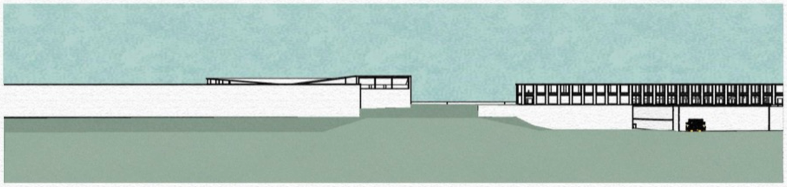
North



East



South



BUILDING MATERIALS

Materials & Facades

Key Takeaways: All Recycled / sustainable materials

1 Layered Concrete

Material Features

- *Low cost*
- *Sustainable*
- *Strong + durable*
- *Low maintenance*
- *Noise reduction*
- *Thermal mass*
- *Fireproof*
- *Pest proof*

In project

Building B

Precedent

SOS Children Village

Conceptual Reasoning

- *Layers represent process of material production*
- *Reused + donated material emphasizes reuse concept of site*

2 Carboncure for Precast

Material Features

- *25-40 lbs CO2 saved/yard^3*
- *Increased strengths*
- *Reduced cement content*

In project

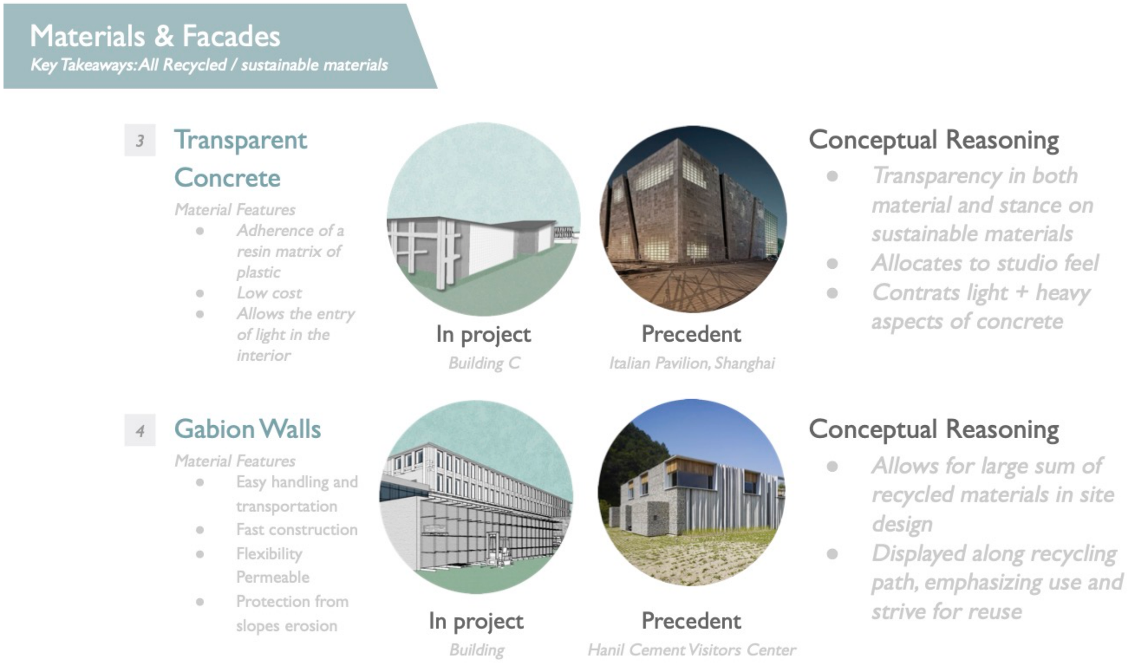
Building A

Precedent

725 Ponce, Atlanta

Conceptual Reasoning

- *CarbonCure displays strive for concrete improvements*
- *CarbonCure creates connection with TC*
- *Factory like aesthetic to display building intention*



Materials & Facades

Key Takeaways: All Recycled / sustainable materials

3 Transparent Concrete

Material Features

- *Adherence of a resin matrix of plastic*
- *Low cost*
- *Allows the entry of light in the interior*

In project

Building C

Precedent

Italian Pavilion, Shanghai

Conceptual Reasoning

- *Transparency in both material and stance on sustainable materials*
- *Allocates to studio feel*
- *Contrats light + heavy aspects of concrete*

4 Gabion Walls

Material Features

- Easy handling and transportation
- Fast construction
- Flexibility Permeable
- Protection from slopes erosion

In project

Building

Precedent

Hanil Cement Visitors Center

Conceptual Reasoning

- *Allows for large sum of recycled materials in site design*
- *Displayed along recycling path, emphasizing use and strive for reuse*

ADDENDUM P2

Design Critique

A number of critical topics and comments were brought up during my thesis review that helped pose a series of questions and next steps. The questions brought up are the following:

1. How is the building's experience transformed by the materials used?
2. How does this campus fit into the larger urban context?
3. What are other sustainable solutions that could be incorporated (solar, glazing, etc.)?
4. Why were the existing buildings not reused for materials? How are they being disposed of from the site?
5. How can the focus be narrowed down into a more intimate aspect? Can the used materials be analyzed further?
6. What is the relationship between the pedestrians and the car traffic?
7. How can an industrial feel be avoided if positioned in a residential area?
8. What does it feel like to live here and see this?
9. How could the site be affected by non-normal forms?
10. Can the recycling component become less isolated?

Design Reflection

As my committee addressed, I would agree that my final did stray away from my original thesis question a bit. Although I am happy with my end product, I do believe a lot more detail is necessary to enhance the intent of the design. When considering next steps, a deep dive into materials being used throughout the site is necessary. I did dabble a bit in a potential wall section that could utilize recycled concrete and mycelium insulation in its construction, but additional research is needed. In addition, with more time LEED initiatives would be thoroughly deployed throughout the project as well as sustainable site strategies. This component was unfortunately overlooked due to the time spent developing the site with the existing topography. As stated in this paper, my thesis goal was to look into ways to build from waste. I believe my execution demonstrated this process but lacked in applying it to the design itself. Although recycled and low CO2 producing materials were used in façade design, the application of these details was overlooked. Next steps would include looking to these features more intensely and developing sections as well as material product sheets to completely understand the materials being used. To further address the questioned posed in the critique, a better understand of how the existing buildings are utilized is crucial for the thesis design. This could be done by incorporating the exiting brick into an area of the site either as an exterior or interior feature. Lastly, I want to address the question of living here and the neighborhood feel. This was a main component I thought about in my design layout. Utilizing the middle of the site as well as the tunnels helps limit the appearance and noise of transportation. Not to mention that the facilities house manufacturing and therefore industrial aspects are contained. Having multiple greenspaces, a park, and a designated quad also helps incorporate the site into the surrounding campus and residential area. The area in which Georgia Tech sits in not fully developed in view of the site. This is both an advantage and disadvantage for the site. Choosing a street faced view then became difficult due to the uncertainty of what may be developed across the street. Due to this, all elevations of the site became very important to develop to ensure any exterior developments would not harm the view of the site or the site in view from its surroundings

Design Application

I believe this thesis topic is crucial to developing more sustainable building practices. As a CPHC and prospective LEED Green Associate, I feel as if sustainable practices will always be in my line of work. I hope to one day work at a firm with green values in which having the knowledge I do and interest in this subject, I believe this thesis will be with me for the rest of my career. And as mentioned in my reflection, there were many details I was unable to complete in which I can see myself revisiting my work in the future in order to do more research and development on the topic.

ACKNOWLEDGMENTS

I would like to thank my committee, J.E.Elliot, Mary Ben Bonham, and John Blake for their help, critique, and feedback guiding me along through this process.

I would also like to thank my professors, Craig Hinrichs and Nodas Papadimas for their role in starting off our graduate experience.

I would like to send an extra note of gratitude to Diane Fellows for her dedication and commitment to our thesis, graduate studies, and our growth as individuals.

I would also like to thank Jeff Kruth, for his support and guidance as we brought this entire process home.

Lastly, I would like to thank my friends and family, for without them, I might not have survived!

A big thank you to the Department of Architecture & Interior Design for allowing me to study and succeed through their undergraduate and graduate program here at Miami University.

LOVE & HONOR
2015 - 2021