Term Project Proposal

My term project will focus on minimizing material waste in architectural design, particularly through implementing modular design and material choice. Modular design implements key strategies like prefabrication, ease of assembly and disassembly, and reusability to limit the material waste produced in the construction process. In comparison, traditional construction generates a significantly greater amount of waste at the construction site, leaving a greater negative impact on the environment and public health.

Modular design simplifies a building to consist of standardized, repeated components called modules. These modules can range from walls to entire rooms, and are prefabricated at the manufacturing site. The main aspects of modular design that reduce material waste are a more controlled manufacturing process, repetitive modules, and limited material choice. There are different kinds of modular design: volumetric modular construction, which are individual three-dimensional units with enclosed spaces to be connected on-site, and non-volumetric modular construction, in which sub-assemblies like steel frames, beams, columns, wall panels, building facades are built and assembled on-site, which requires more components and mainly focuses on standardization. There is also hybrid modular construction, which combines both two and three-dimensional components (Studio W Architects).

Construction waste derived from architectural and interior design projects is a massive source of the entire world's material waste, contributing to about one third of the global total. Construction projects can range from construction, demolition, restoration or remodeling, and all projects are messy processes that produce largely unusable scraps of material, such as nails, wiring, insulation, rebar, wood, plaster, scrap metal, cement, and bricks. As these materials are used, many are destroyed, rendering them unusable, becoming waste and ending up in already overflowing landfills (Clean Management Environmental Group). This excess waste releases toxic chemicals into the air and water, harming both the nearby ecosystems and public health, increasing the risk of many health issues (ETM Recycling). Materials are also needed to build architectural projects, and the fast pace at which new projects are started results in a much faster rate of resource depletion. Interior design projects are "churned" every five to seven years, not only placing a heavy burden on resources, but also creating large amounts of waste when the building and furnishings are inevitably thrown away (Hayles). The construction process weighs heavily on the environment: excessive timber use leads to deforestation, land churning to find minerals destroys soil quality, and mass excavation pollutes waters (ETM Recycling). Hence, architecture can exert a strong negative impact on the ecosystem and human health through both the waste produced and physical stress on the land during traditional construction.

The design of the modules themselves greatly contribute to reducing material waste. Standardizing materials that create an industry standard reduces need for excessive cutting, which results in many scrap pieces and off-cut waste. Similarly, since these modules are repeatedly produced, they often consist of simpler design elements, omitting complex or

irregular shapes that further produce unusable scraps (Olanrewaju and Olabode). Additionally, how the modules are used to create a space reduces the amount of additional components in a design. The modules are designed to be multipurpose, and modular design is a practice often used in flexible architecture. Flexible architecture is malleable, moveable, and multipurpose, and is ultimately designed to be modified to fit certain needs. With reusable modules that can perform multiple functions, allowing for changeable and multipurpose spaces, modular architecture is more sustainable because no additional resources or materials are used on temporary alterations for a building's different purposes. This kind of reusability saves time, energy, and resources in development and manufacturing through repeatable elements that speed up the manufacturing process, because one piece can be used for multiple purposes. There is a focus on the long term lifespan of the building. Ultimately, multipurpose rooms and furnishings allow the design to encapsulate more for less material (TerraMai). The modules can be oriented and arranged in many different patterns, and this ability to adapt keeps the architecture relevant and useful as time goes on, once again reducing the need for updates and renovations.

Modules are prefabricated at the manufacturing site, so the only action that needs to be taken on-site is assembly. As a result, a majority of the making process takes place in a factory setting, such as cutting, material calculation, and material experimentation, rather than having alterations take place at the construction site like in conventional design processes. Pushing changes and alterations to the initial manufacturing stages greatly reduces material waste, up to 90% of timber, cardboard, plastics, and concrete waste according to the Waste & Resources Action Program (Salman). In a factory setting, precise cutting of modules minimizes off-cuts and maximizes how much of an original material is being used. Modules, which are meant to be manufactured in repetitive steps, usually don't have irregular shapes that would produce a lot of offcuts. Additionally, factory settings are more suitable for material experimentation of eco-friendly materials because more accurate estimates for material are made, ensuring that everything that is prepared is actually utilized. Modular design minimizes irregular shapes and therefore waste in the form of offcuts. This manufacturing process reduces over-ordering or scrapping excess material due to mistakes in planning or last minute circumstances on-site. Factory settings are also better suited for material sorting and organization. There is more control and regulation in the manufacturing site compared to the construction site, allowing for optimized and effective sorting of material, ultimately wasting less. In contrast, with traditional construction, waste is generated and unsorted on site, contributing to more waste being sent to the landfill. Standardization is another important component of modular design that allows for repetitive and consistent work, saving time and material in both quality control and fewer excess from mistakes (Studio W Architects). Due to the nature of the modules being prefabricated, many modular architectural designs involve a practicable deconstruction plan. Deconstruction plans guarantee that a design can be taken apart and adapted. With modular designs, deconstruction requires less demolition than traditional architecture, reducing the waste that is demolition scraps and rubble. Pieces are easily detachable, as the modules maintain the structure that was built in during manufacturing as they are assembled for the final building. The intact

modules create opportunities for their reuse, taking previous ideas of multifunctional modules a step further. Ultimately, sustainable designs should minimize material usage while maximizing product life, allowing people to get more use out of less material, raising the value and longevity of material.

The Nakagin Capsule Tower is an example of modular architecture that demonstrates both successes and failures in terms of sustainability. The modules are housing capsules that have enough room for a person to live comfortably. Each module is a three-dimensional space that includes interior furnishings. The capsules are stacked and rotated to form a tower, and they are all connected to a central core. Additionally, the interior spaces can be altered by orienting the capsules to be connected. The Nakagin Capsule Tower is designed around the concept of adaptability and interchangeability, as the capsules are easily replaceable and moveable. Made of sustainable materials like wood, the tower succeeds in sustainability through its recyclability. However, because of the temporary nature of these materials, being natural and prone to rot, the tower ultimately fell into a state of irreversible disrepair, and is being demolished. Although designed with the intent of conveying a theme of temporality, the Nakagin Capsule Tower's short lifespan reveals the importance of selecting durable materials over purely eco-friendly ones. Additionally, unlike most modular constructions, this building was still undergoing design alterations during and even after construction, resulting in an ultimately unsustainable project (Sveiven).

I think that the Nakagin Capsule Tower is a very interesting structure with the inconsistencies of its concept, which aims to be sustainable yet was designed to be temporary. The sustainability of a material can be evaluated through two factors: eco-friendliness and longevity. Materials that are eco-friendly are often based in nature and biodegradable, bringing reduced harm to the environment with its use. However, the biodegradability of these materials, such as recycled paper, soy-based inks, and water-based varnishes, also mean that they have a shorter and more unpredictable lifespan, resulting in constant need for replacement. Eco-friendly materials often have the ability to be reused in some shape or form.

In the cradle to cradle ideology, which exhibits a cyclical life cycle for such materials, they can be sorted into either a biological or technological cycle. Materials that fall into the biological cycle can biodegrade and in the end, return to the ecosystem, such as natural fibers and bioplastic. In the technology cycle, materials can be recycled or reused to produce something of the same or better quality in closed systems, provided they are not mixed, including metals, chemicals, oil-based plastics (Sustainability Guide). On the other hand, materials that are long lasting may not necessarily be biodegradable, or pure enough to be repurposed, but are durable enough to not need continuous maintenance or replacement. The most sustainable materials are ones that are relatively durable and exist in a cradle to cradle cycle. However, these materials may also be limited in its structural integrity and ability to integrate with the rest of the structure. This paradox of material selection is an interesting concept: as a material is more environmentally friendly, it tends to be less durable and thus, less sustainable. Furthermore, both

long lasting and environmentally friendly materials are technically sustainable, but potentially unusable to the point where it is essentially useless.

There is a direct relationship between open-ended designs and reduced material waste, since the reason why these designs have so many different possibilities is that there is less material used to dictate how a space should be used. When implemented in tandem with modular construction, even less material waste is produced, lessening the resources used in the manufacturing, construction, and actual building itself. The flow of movement within the structure would thus be dictated by the placement of furnishings rather than excessive material used on physical walls dividing the space. The Serene House HCMC, for example, is a house that is modular in its steel frame structure, leaving the spaces largely open, creating divisions through movable furnishings. The prefabricated steel frame can also be disassembled easily, without needing a demolition crew, and then be easily reconstructed at new locations. Compared to conventional buildings that separate the space with walls and dictate a certain purpose for certain rooms, the Serene House boasts open spaces that can be used for virtually any purpose, getting rid of the need to distinguish between an office, community, and dining spaces. Flexibility is conceived not through the construction and use of new material, but through the movement of existing material.

Interior designers and architects play a central role in ensuring the sustainability of architectural projects, not only with the design itself, but also acting as the intermediary between client and environmental priorities. While not intentionally being unsustainable, clients and average consumers are often unaware or don't consider the material impact of design on the environment, usually focusing purely on aesthetics, luxury, and function. On the other hand, informed designers that are educated on material properties and longevity can select durable materials that also satisfy client tastes (Hayles). There is an important distinction that needs to be made about recycled and durable material when it comes to sustainability: recycled or reclaimed material that has already served an initial purpose, while it utilizes something that may have been simply scrapped, is often quick to need replacement of its own, ending up using more material and creating more waste. However, using a more durable material that doesn't need replacement and lasts longer is more sustainable, using less material in the long run (Olanrewaju and Olabode). Hence, an architect or interior designer's understanding of the qualities and complexities of a variety of materials is critical to directing the overall sustainability of a structure.

Modular design and its relationship to sustainability covers a range of topics, including multifunctionality, material selection, and contrasting factory and traditional construction waste production. The first of my scientific concepts is how multipurpose architecture minimizes material use while maximizing product potential by allowing people to get more use out of less, raising the value and longevity of material, as well as its sustainability with reduced material use. The second scientific concept is how difficult it is to find a sustainable and practical material. When trying to evaluate the sustainability of materials through 3 factors, being eco-friendliness,

longevity, and structural integrity, there appears to be no true “sustainable” material that can be used in practical application because one factor undermines another. Another scientific concept is how conventional construction processes negatively impact environments by generating large amounts of unusable, unsorted material that ultimately pollutes the environment. The final scientific concept is how a single module can be transformed to create many different compositions only through a change in placement, reducing material waste during construction by implementing a precise, repeatable manufacturing procedure and simple assembly process. For all of the creative project proposals, the goal is to educate architects, interior designers, and clientele on the different impacts of different construction methods, hopefully inspiring the audience to opt for more sustainable and less wasteful options.

These concepts can be integrated into a creative project that visualizes the amount of waste generated in traditional construction versus modular construction projects. Since the exact amount of material waste that is generated from a project greatly varies for both processes, the amount of waste can only be approximated based on general patterns, being that conventional construction generates more waste than modular construction. The waste can be visualized in blocks or cubes, and can also be sorted into material type. For modular design, where waste is made in the manufacturing factory, the material waste can be sorted into wood, metal, glass, and so on. However, since a majority of waste with traditional construction occurs at the construction site where there is less sorting, the waste can be visualized as a mixture of materials that are unable to be recycled.

Another proposal I have is an animation that demonstrates the capabilities of a multifunctional and reusable structure. Similar to the Serene House HCMC, I could illustrate a frame for a building constructed out of modular beams, and animate how it comes together. This frame would be maintained throughout the animation. Additional furnishings and panels would be introduced into the animation in various positions, moving in and out of the structure into different rearrangements. To demonstrate the reduced construction waste, I would also animate the disassembly and the structure’s move to different locations. In comparison, I would also animate the demolition of a traditionally constructed building, emphasizing the demolition waste and inability to be easily moved.

The third way that I could incorporate the scientific concepts into a creative work is through a poster, and conveying the information through illustrations, charts, and diagrams. The idea of materials existing in a cradle to cradle life cycle can be related to how the modules in modular design can be reused, showcasing how modular design reduces waste by comparing it to another sustainable concept. I would make a diagram illustrating the biological and technological cradle to cradle cycles, then make a similar diagram relating to the usability of modular frames or structures.

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