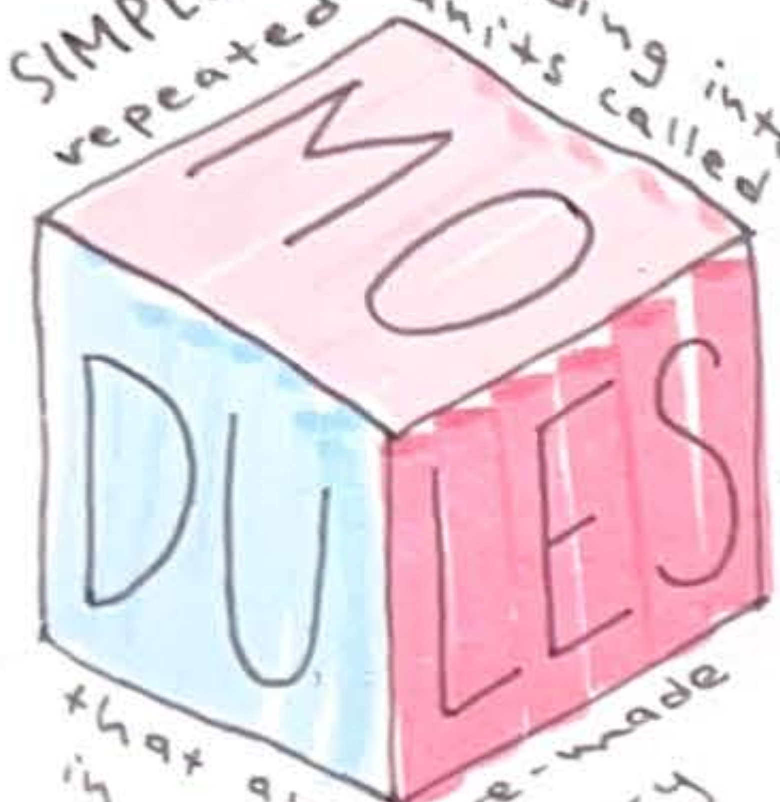

SUSTAINABILITY
IN
MODULAR
DESIGN
ELLA CHIAN

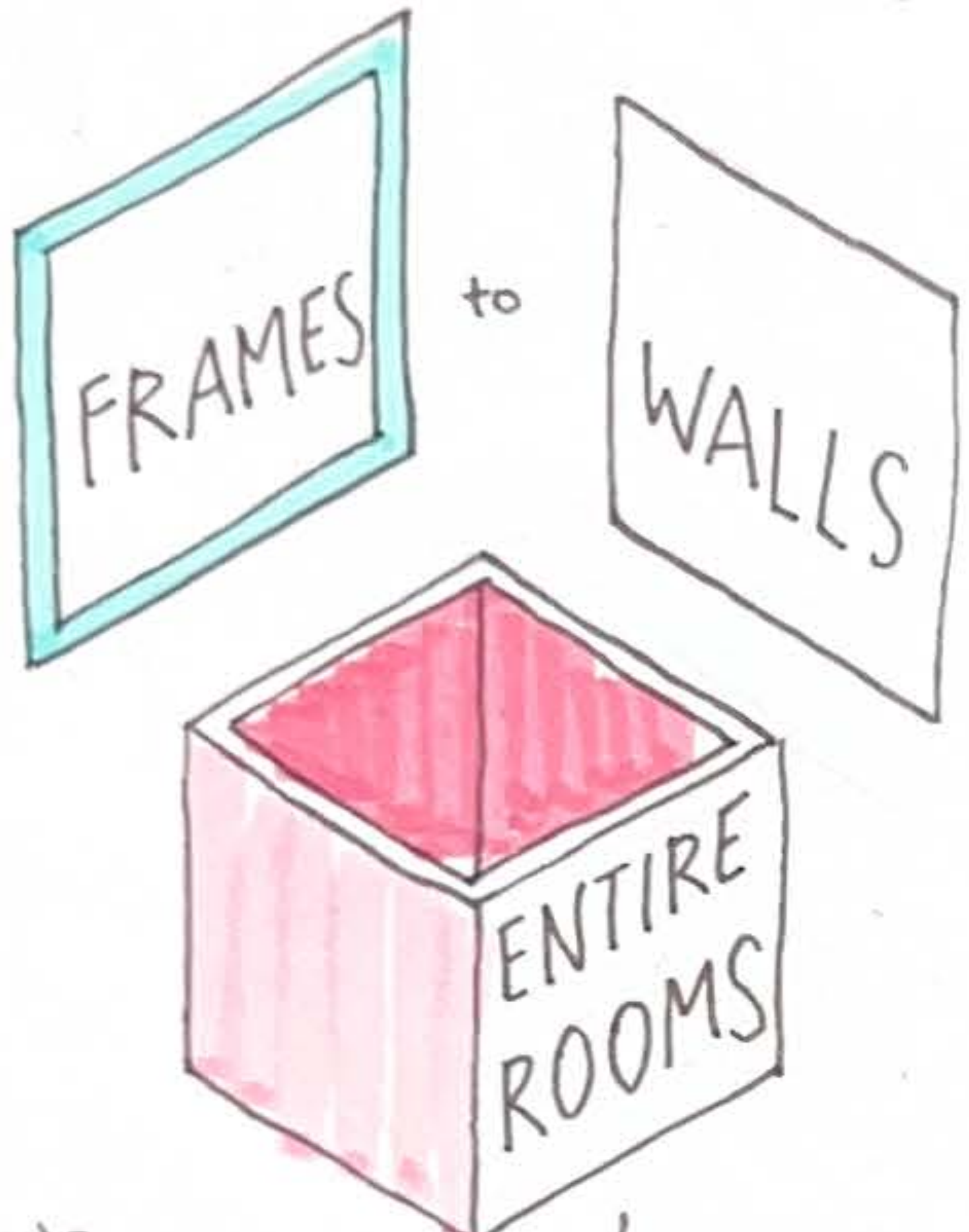
WHAT IS
MODULAR DESIGN?

SIMPLIFY a building into repeated units called

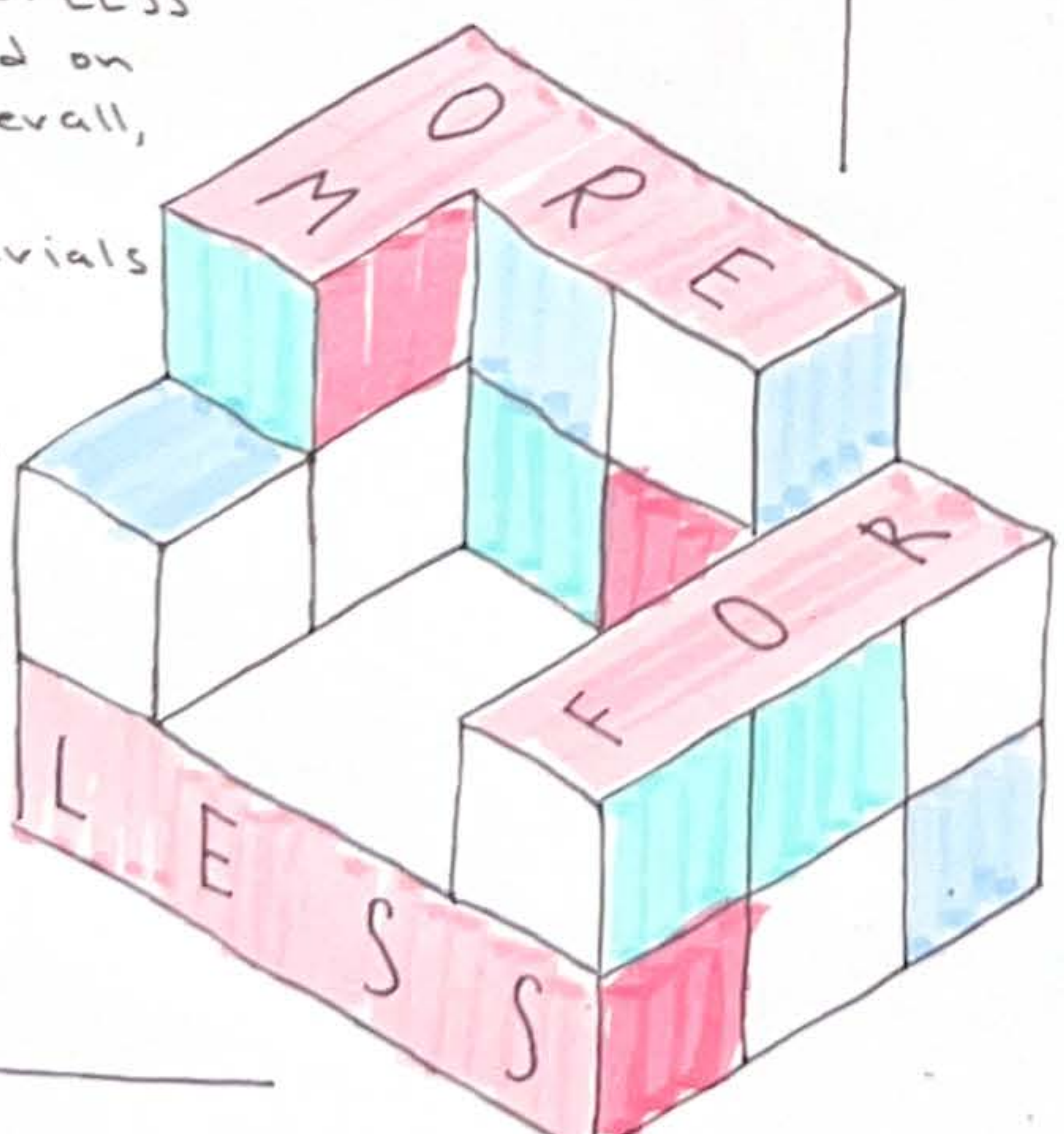


that are pre-made in a factory

can range from

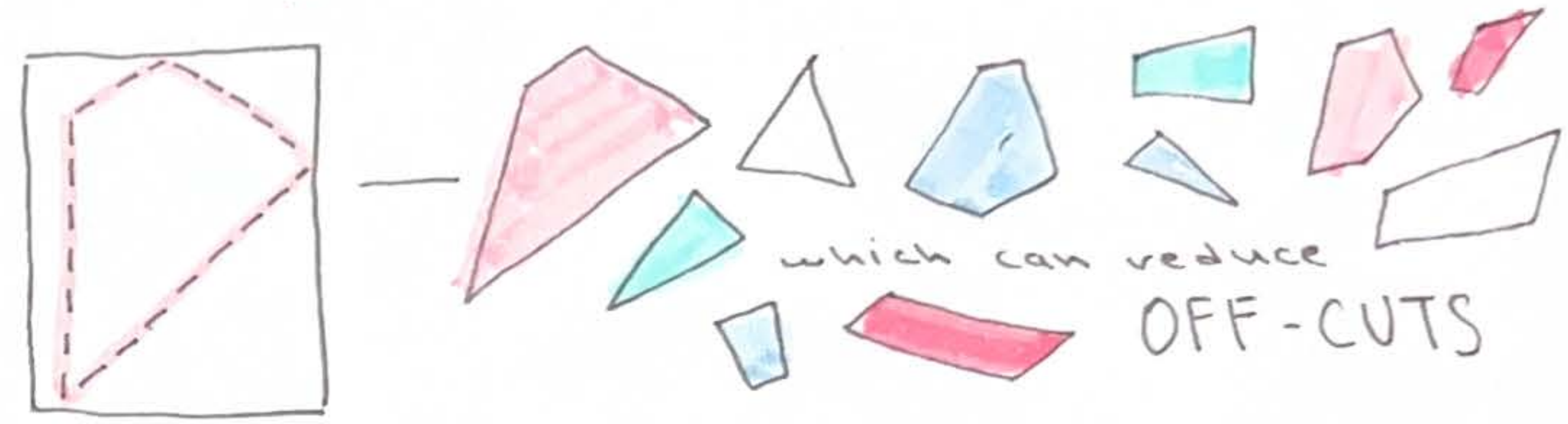


are OPEN ENDED and can perform multiple functions, allowing for spaces that are flexible, and multipurpose. LESS MATERIAL is used on the building overall, because no additional materials are needed for temporary alterations, also raising the LONGEVITY and VALUE of the material that is used to make the modules.



modules are designed to minimize

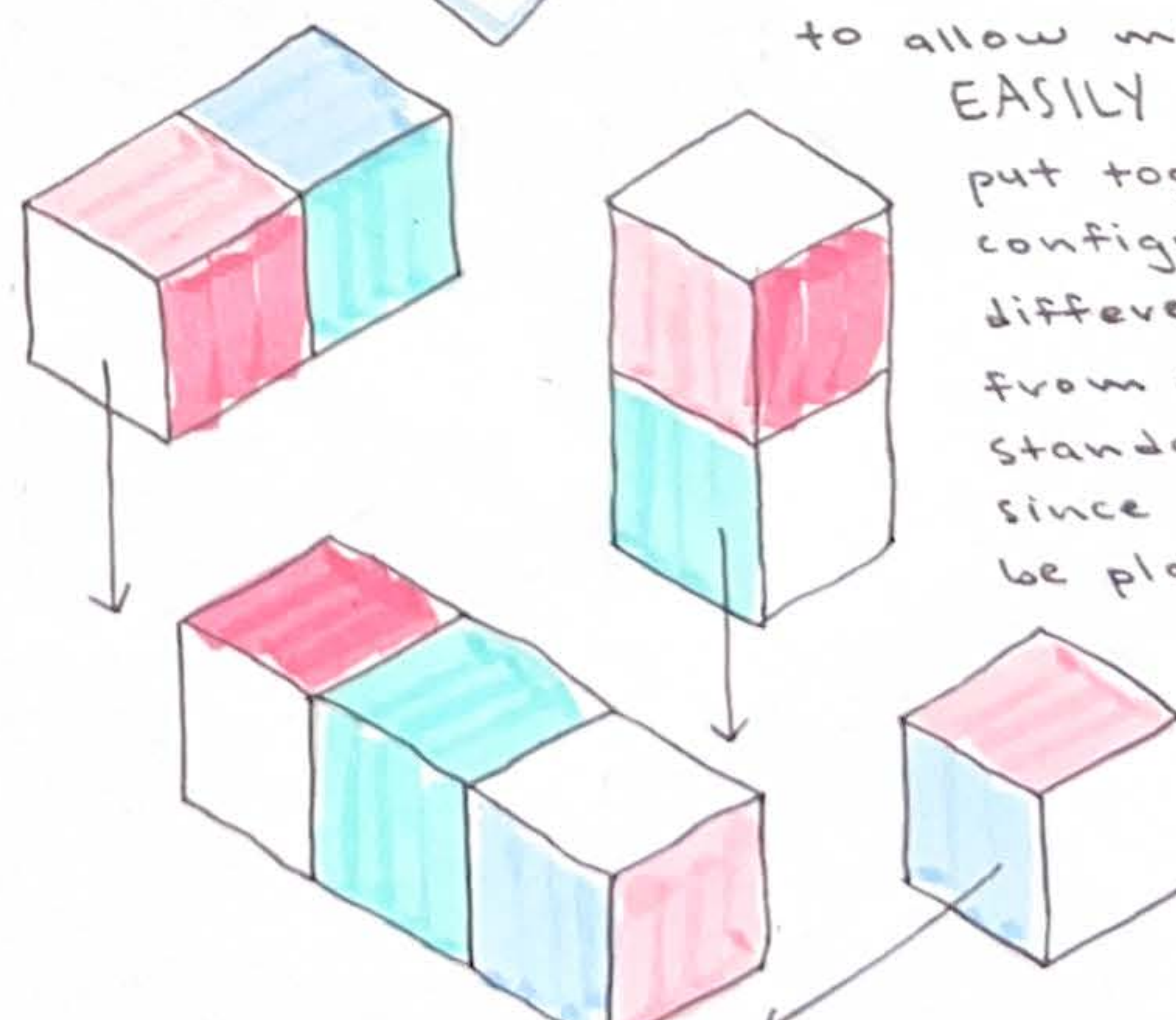
IRREGULAR SHAPES



which can reduce OFF-CUTS

USE SIMPLE SHAPES

to allow modules to be EASILY STACKED and put together in different configurations, creating different compositions from the same, standardized module. Since the modules can be placed virtually anywhere, they, along with the structure, are MULTIPURPOSE



FACTORY

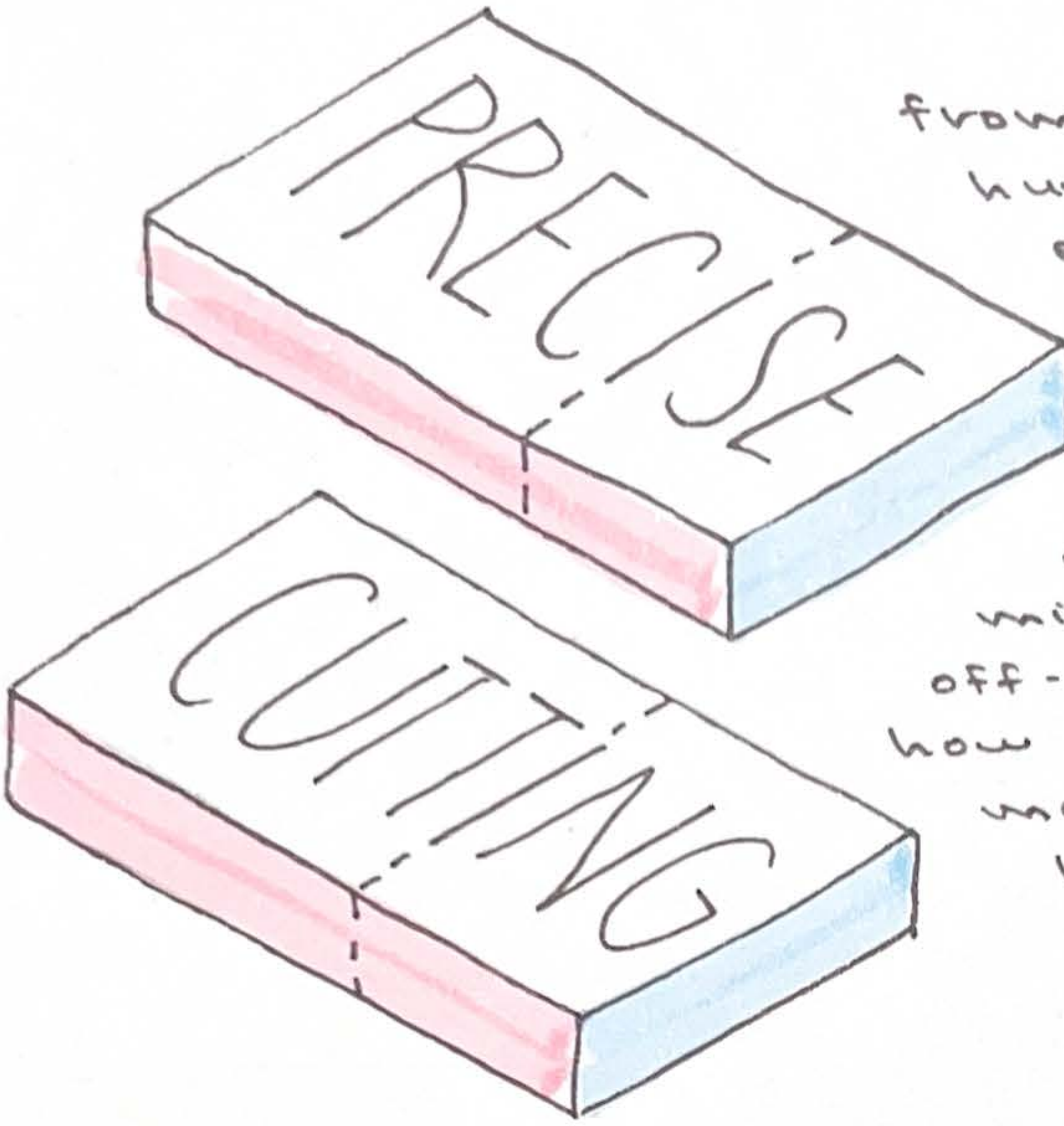
materials are stored inside the factory,

rather than outside, like in a traditional construction site.

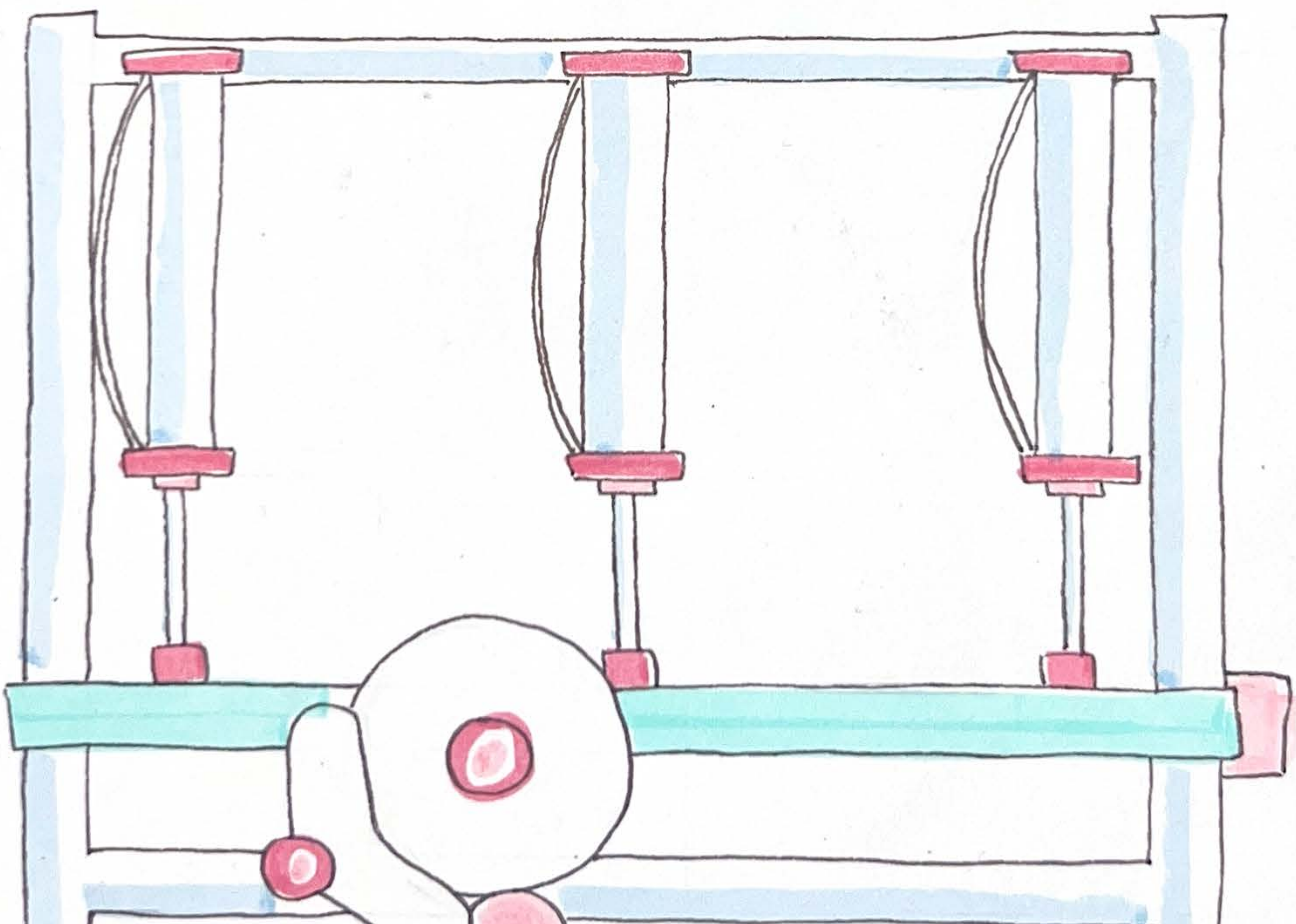
the materials are naturally protected from weather damage, preserving the quality.

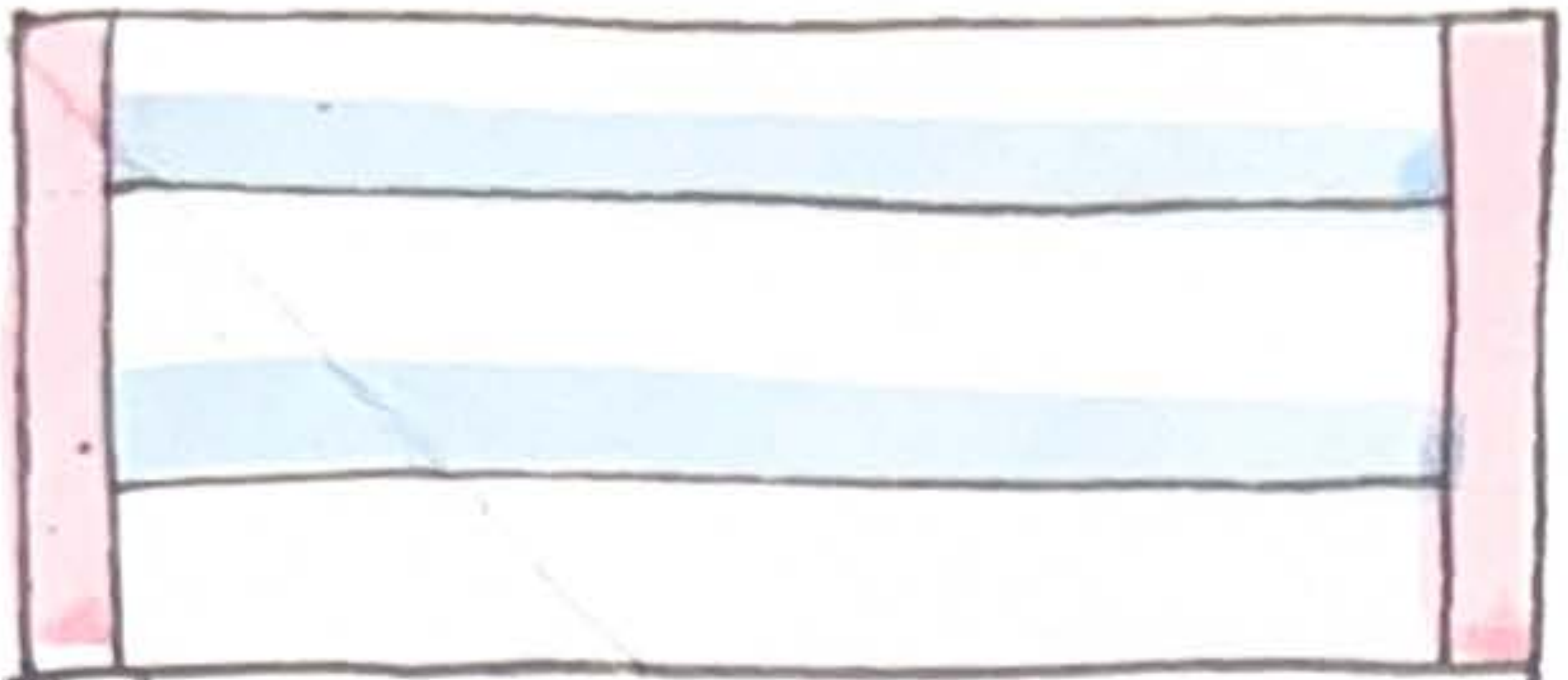
less material is rendered useless before it can be used

SETTING

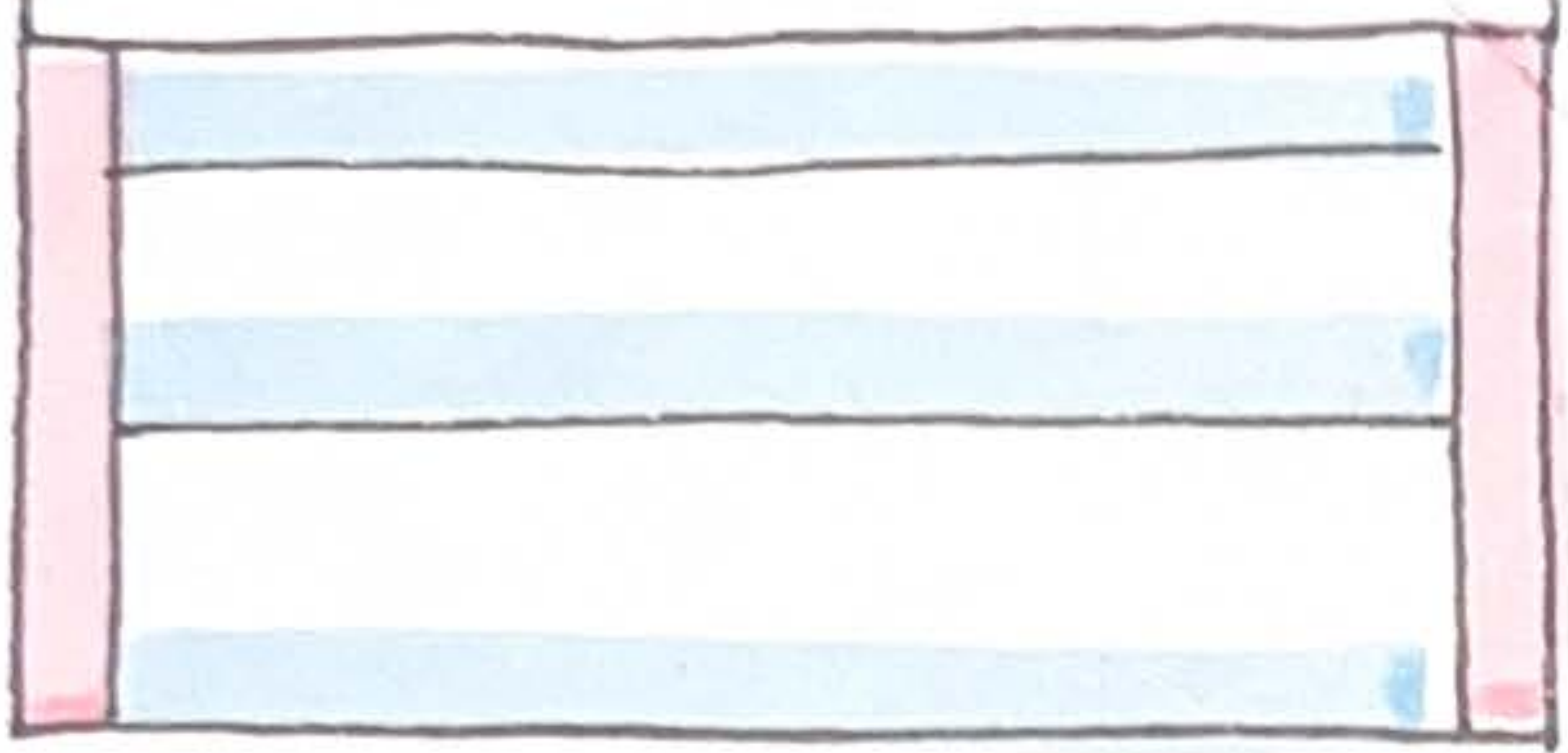


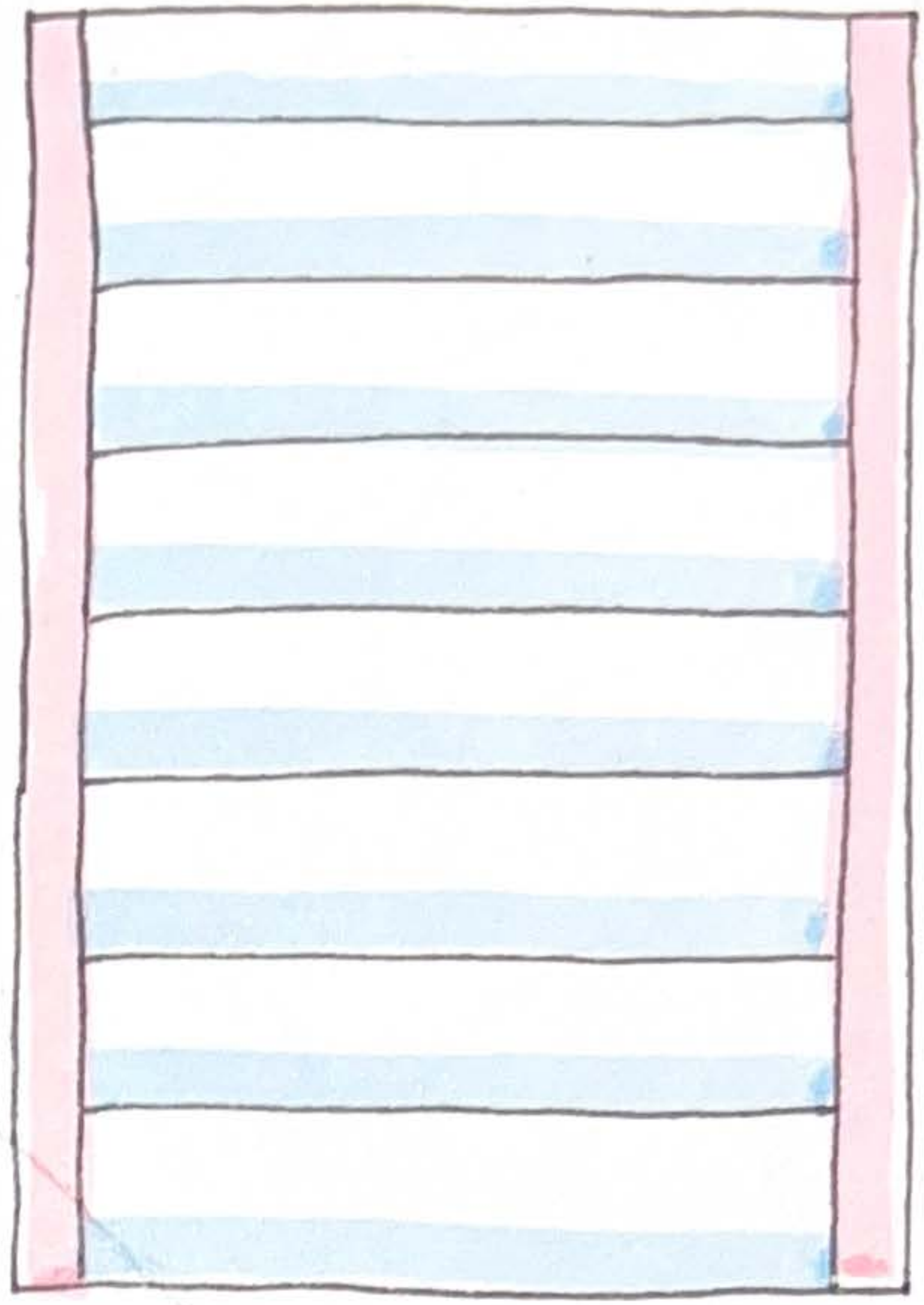
from both machines and human labor gain efficiency in the ORDERLY and ORGANIZED working environment, inside a factory, also minimizing waste from off-cuts and maximizing how much of the original material is actually being used.

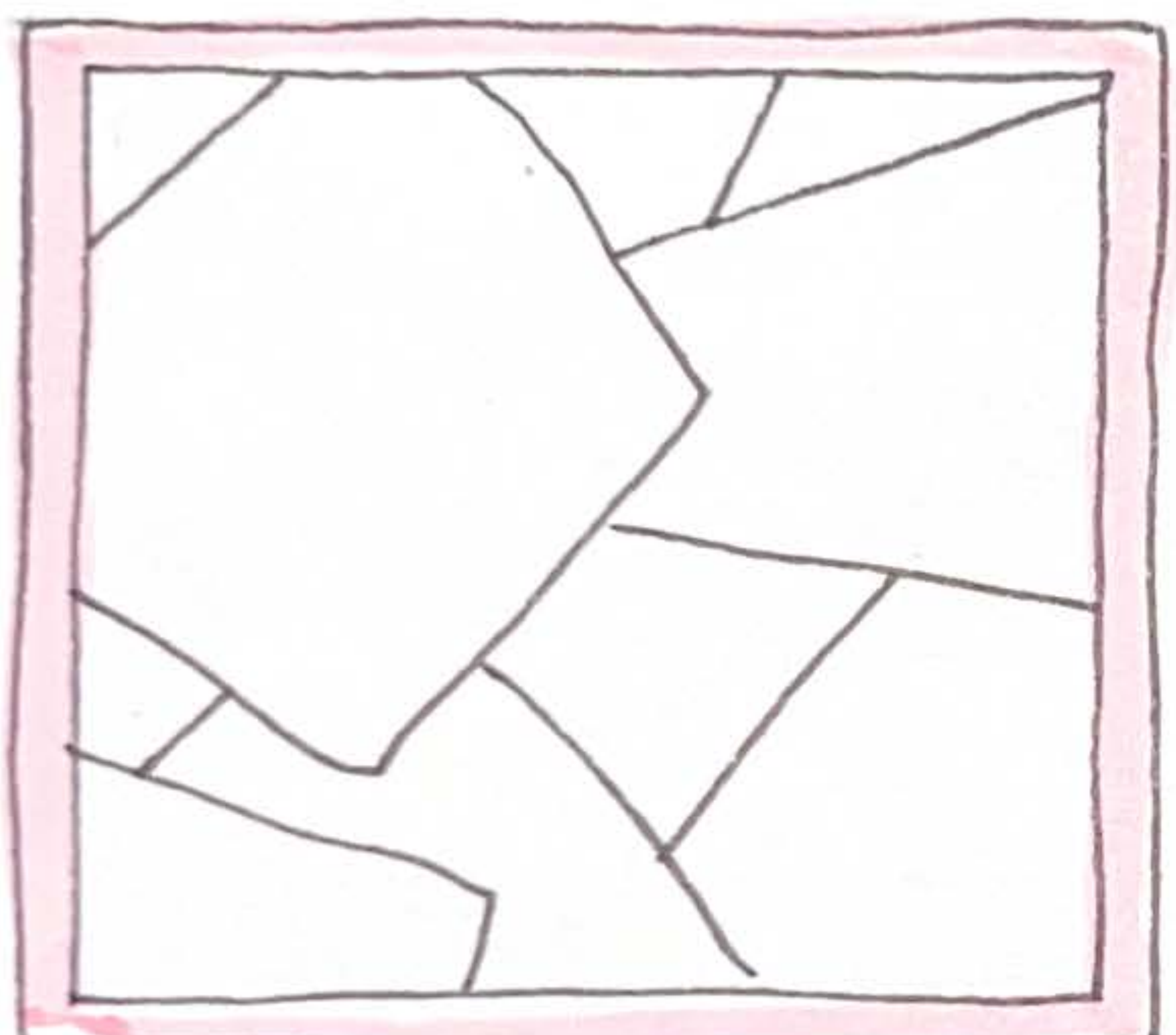




MATERIAL SORTING







more CONTROL and REGULATION in the factory makes a cleaner work environment, allowing for optimized material sorting and more recycling opportunity.

modular construction projects **FINALIZE** the design before manufacturing begins, allowing for accurate estimates of the amount of material needed, making sure everything prepared is actually used.

PLANNING

reduces the scrapping of excess material due to mistakes in planning or on site, as well as last minute changes that occur during assembly.

MANUFACTURE

TRANSPORT

ASSEMBLY

90%

of material waste is reduced in modular construction, compared to traditional construction

EASE OF ASSEMBLY

for MODULAR BUILDINGS, assembly consists of:

SEALING for weather proofing

BOLTING

STACKING

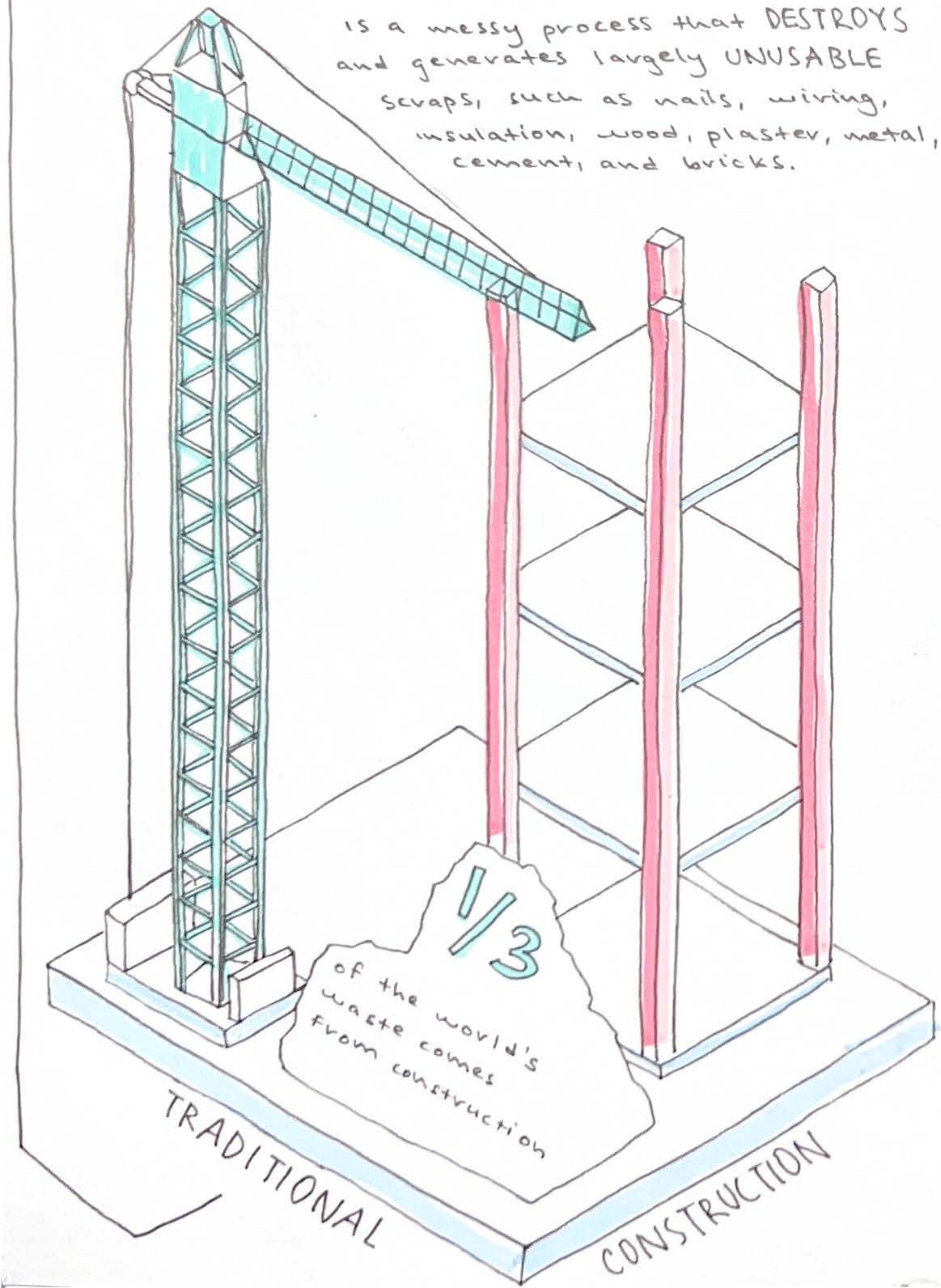
there is often a

DECONSTRUCTION PLAN

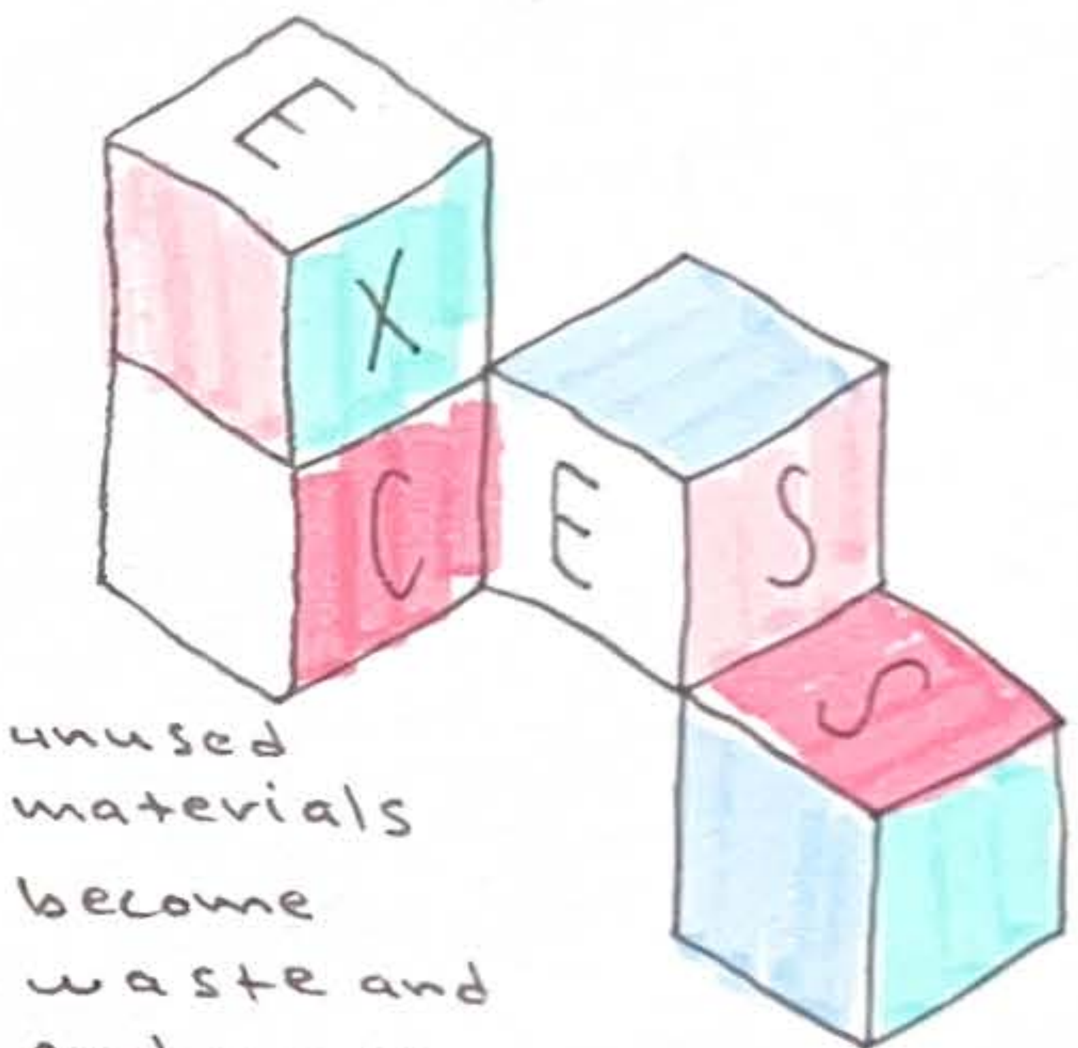
, which guarantees a design can be taken apart without the immense waste that comes with demolition, and the modules can be reused.

TRADITIONAL CONSTRUCTION

is a messy process that DESTROYS and generates largely UNUSABLE scraps, such as nails, wiring, insulation, wood, plaster, metal, cement, and bricks.



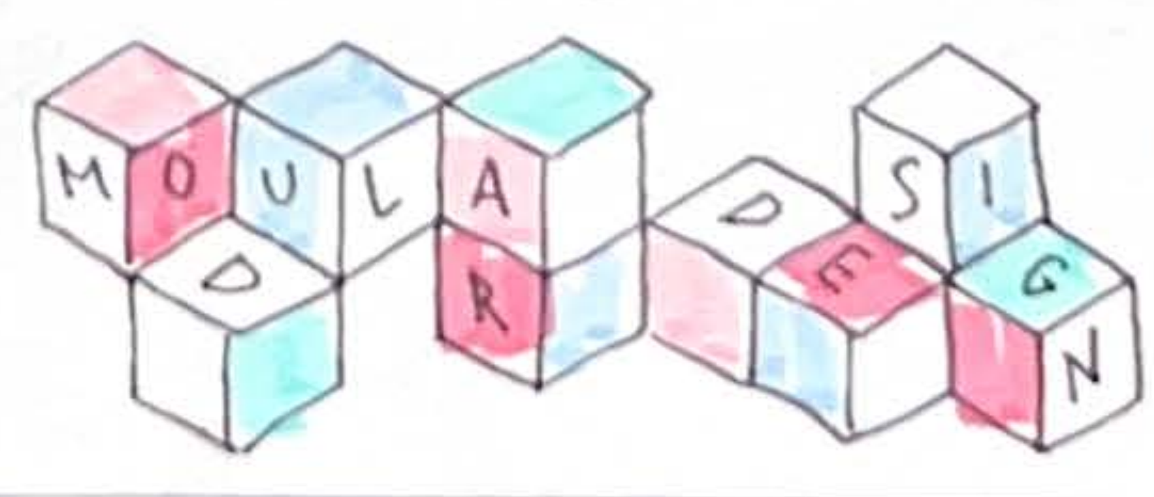
WHAT IS THE ENVIRONMENTAL IMPACT OF TRADITIONAL CONSTRUCTION?



unused materials become waste and end up in

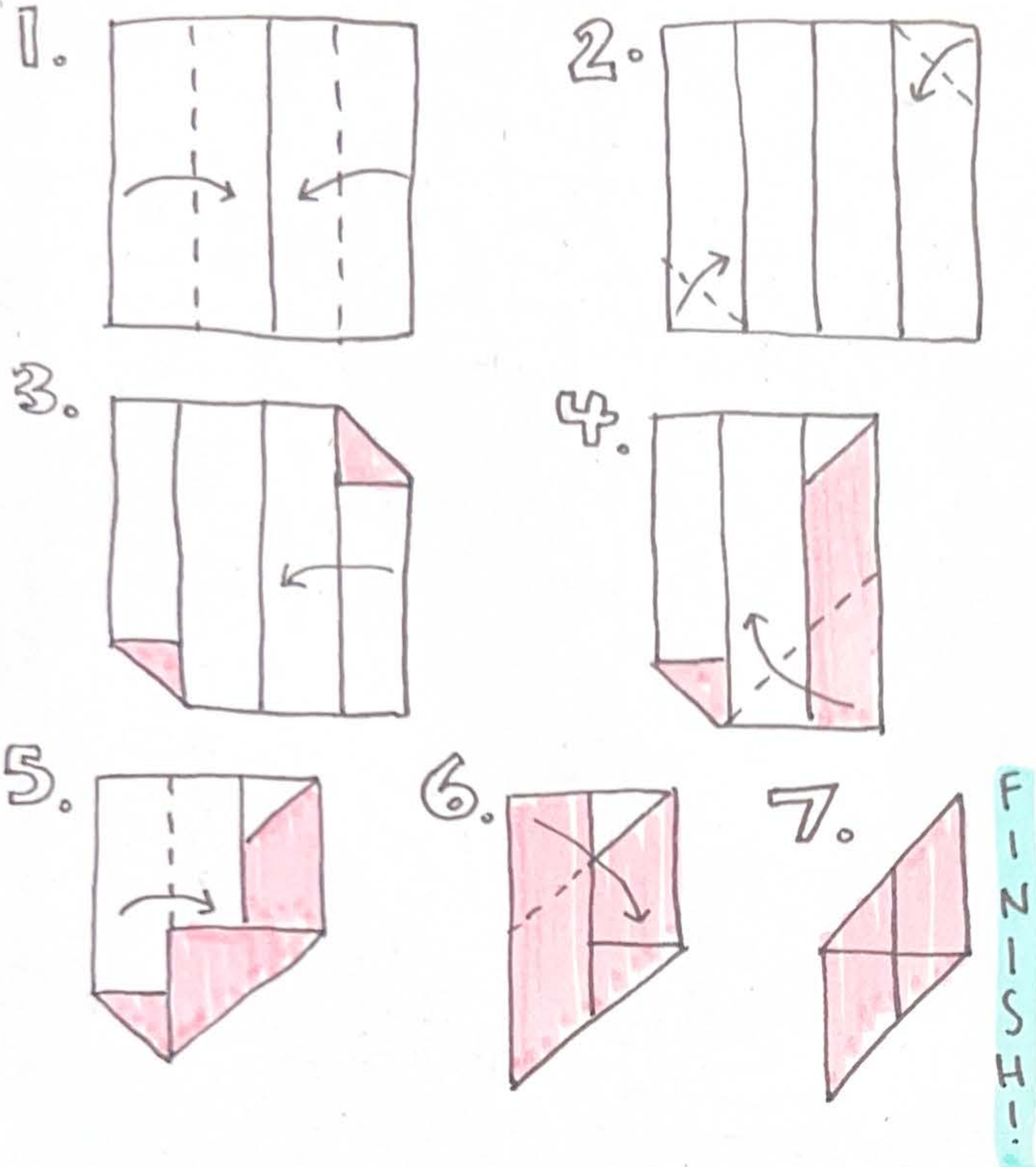
CONSTRUCTION WASTE

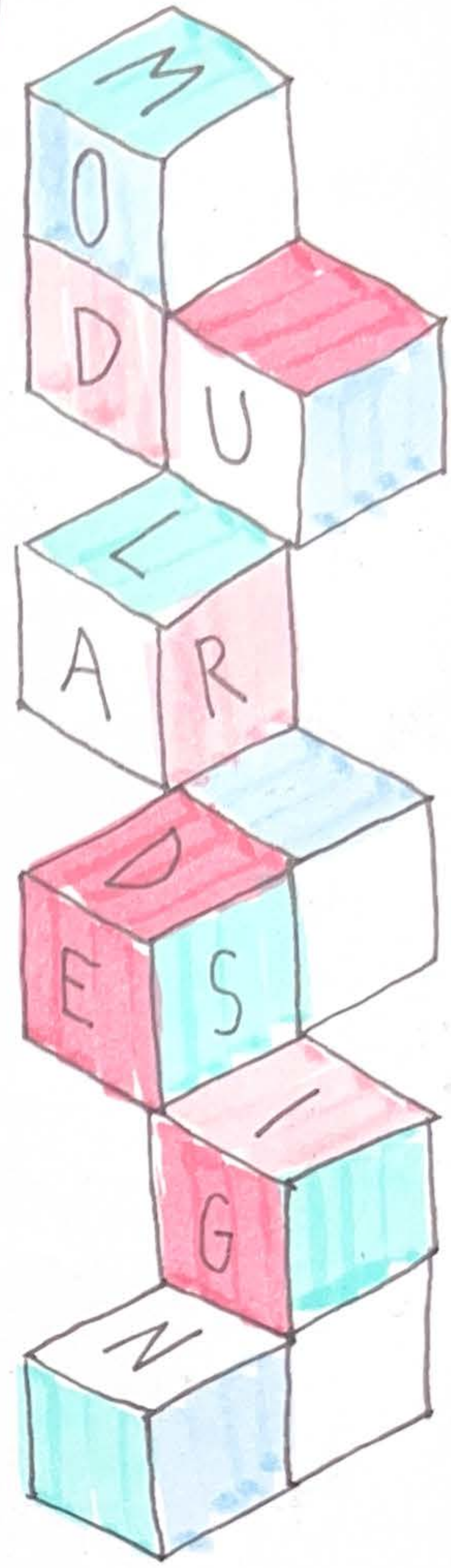
- can contain toxic chemicals that are released into the air and water
- leads to deforestation from excessive timber use
- pollutes water from mass excavation
- churns land, which destroys soil quality in excess



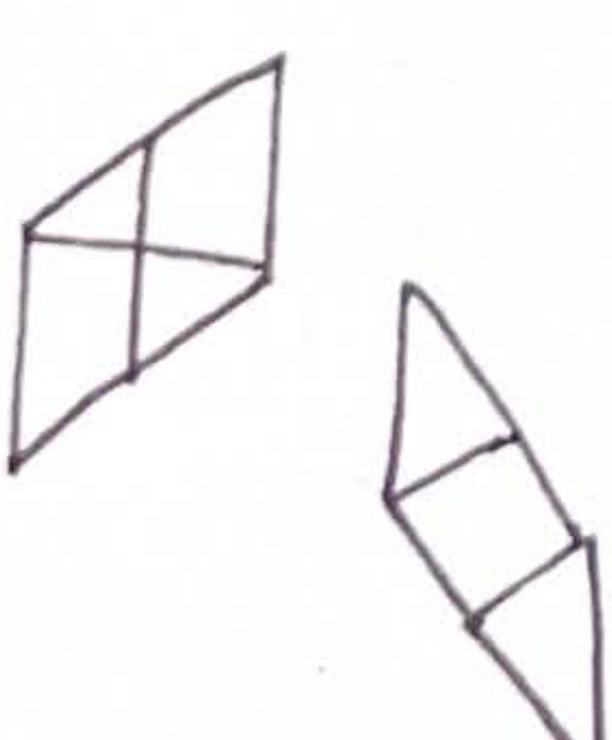
CAN REDUCE THIS WASTE AND NEGATIVE IMPACT!

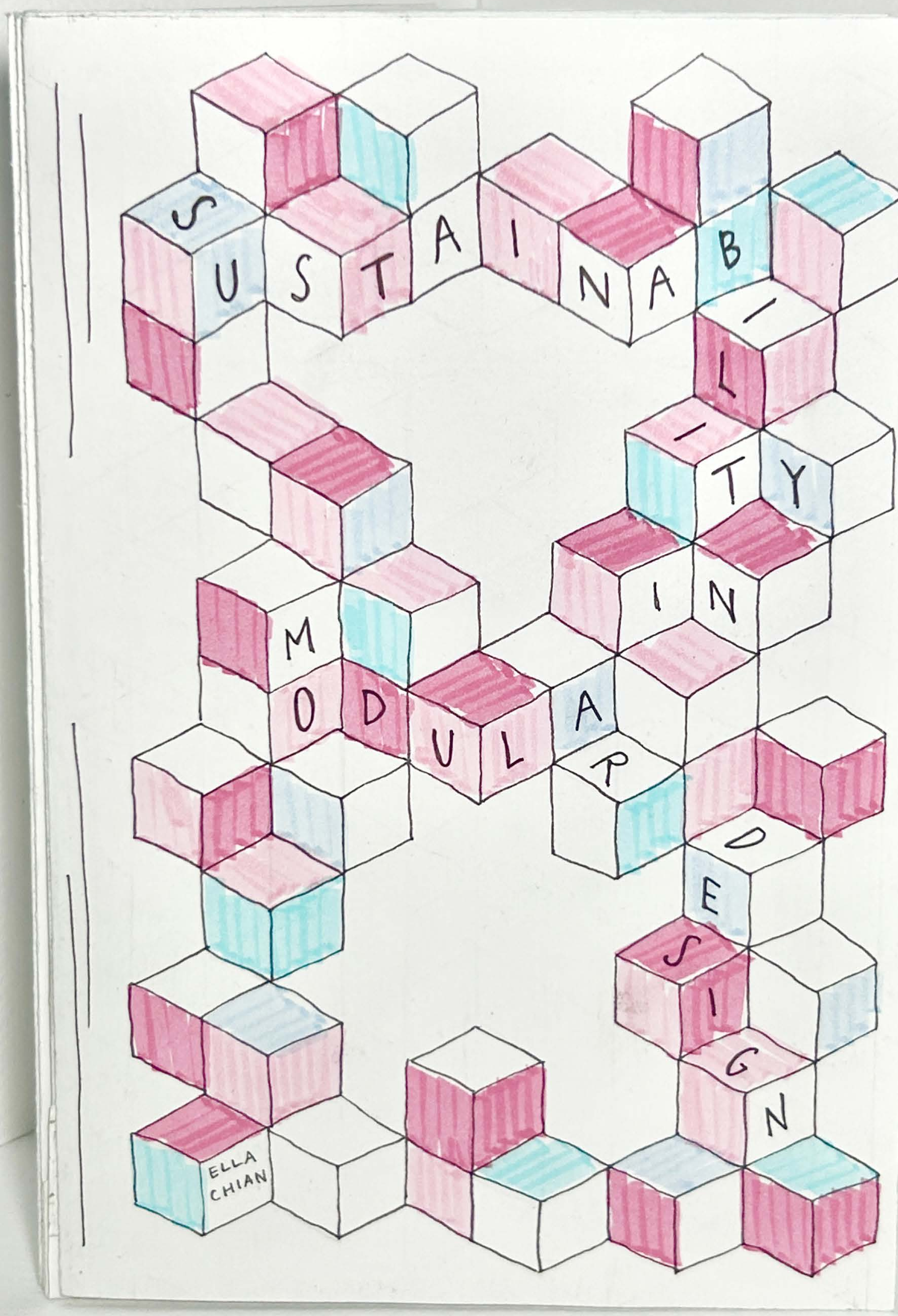
MAKE YOUR OWN





SONOBE UNIT

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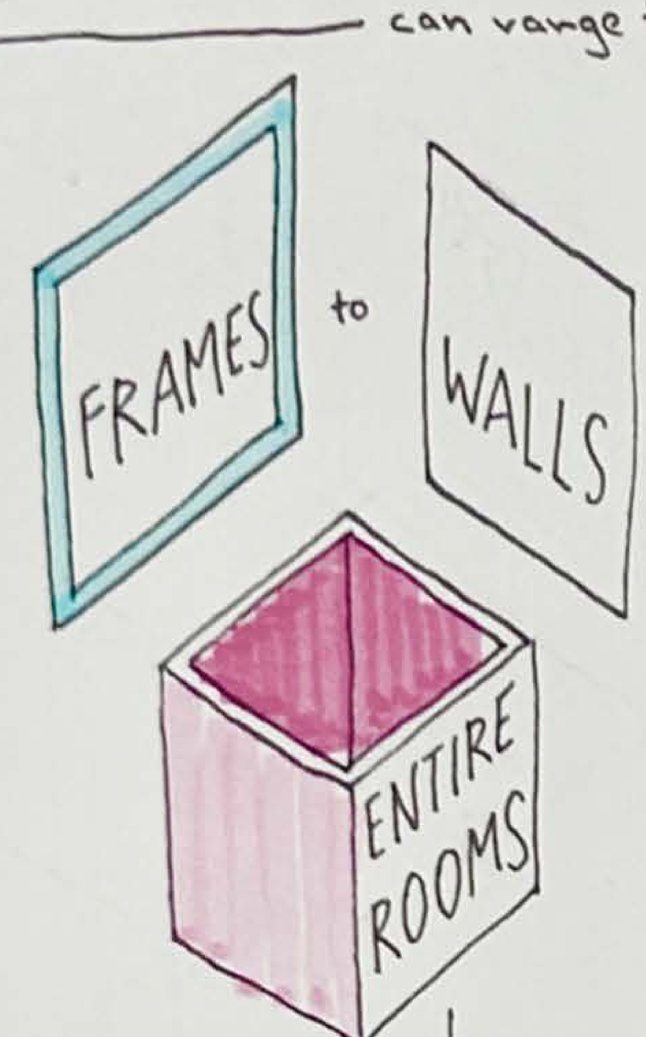

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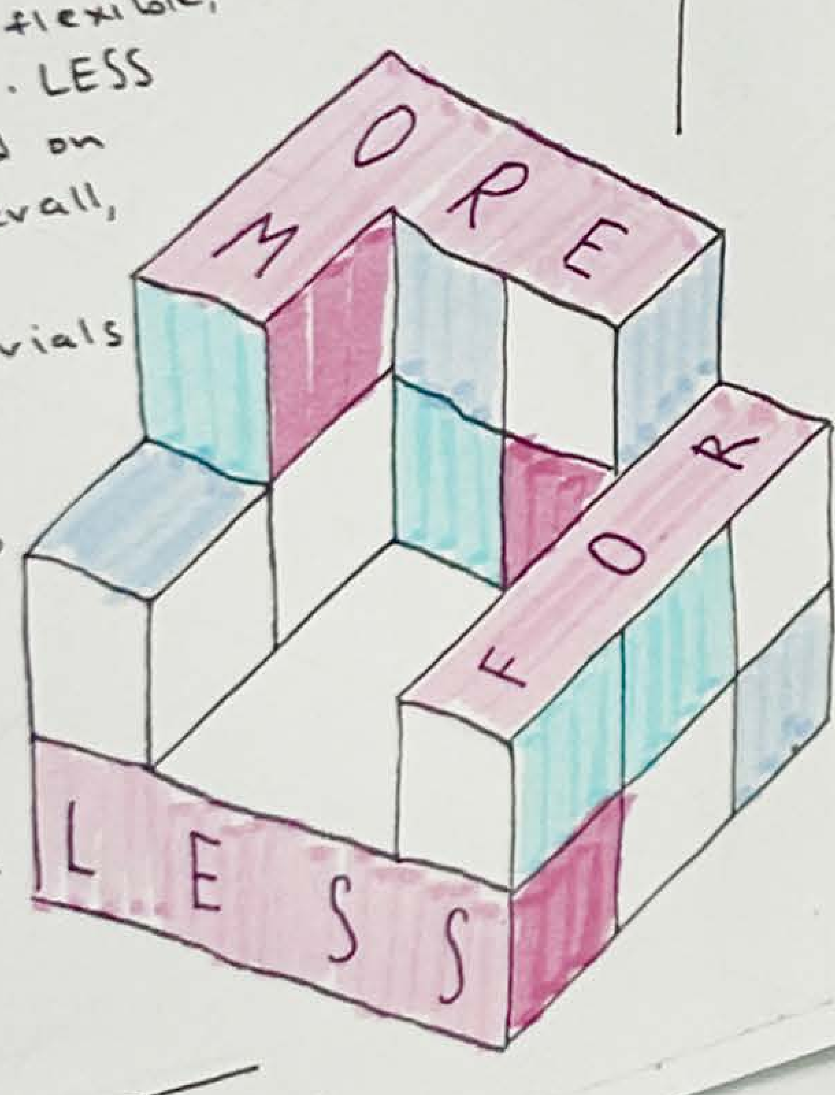

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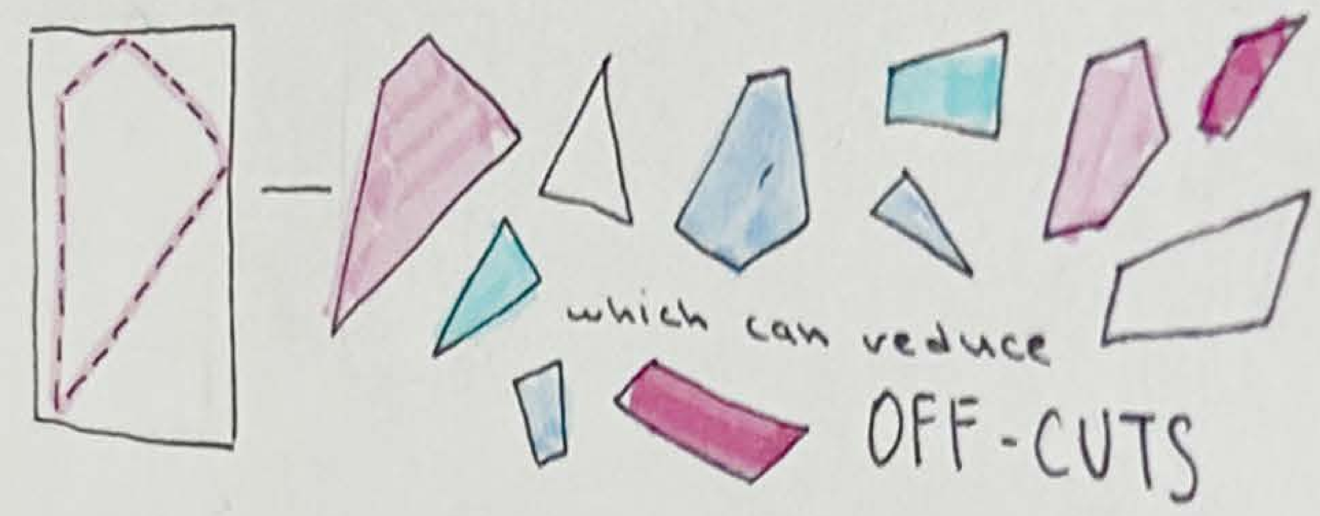

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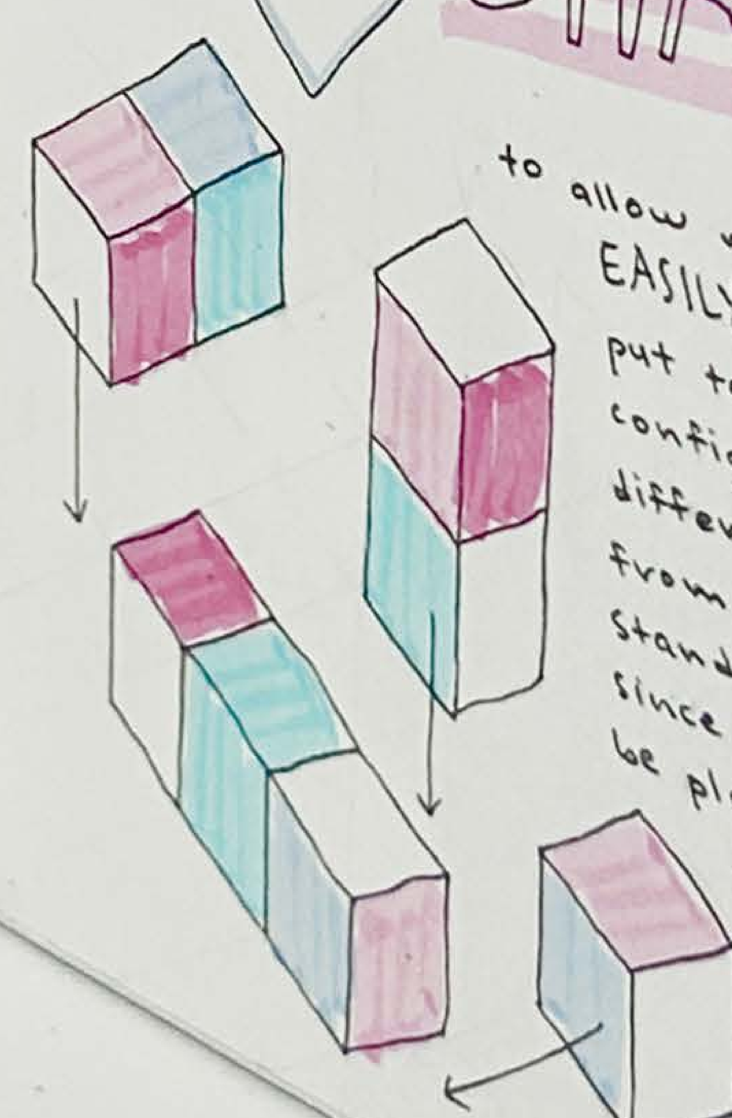

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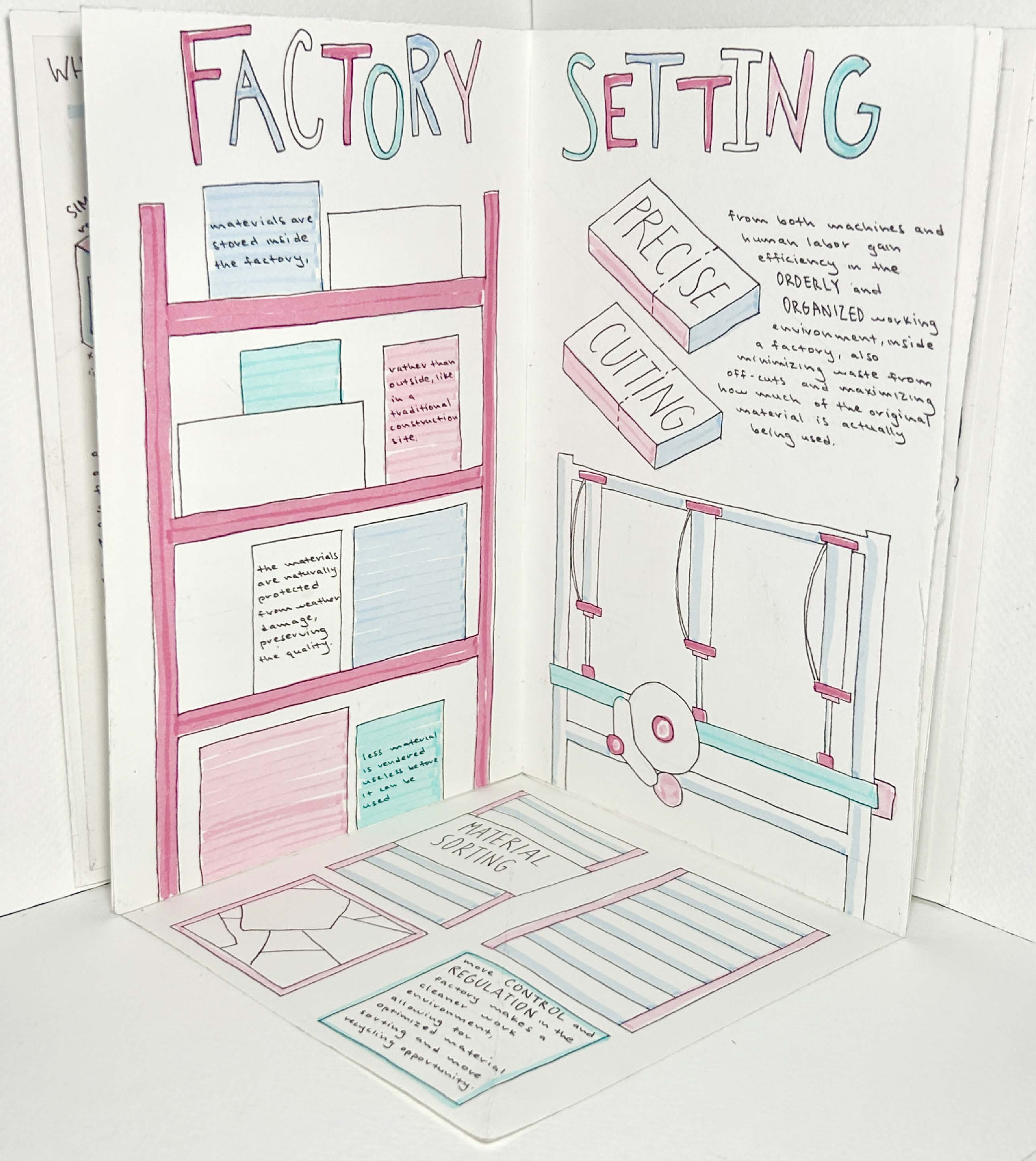
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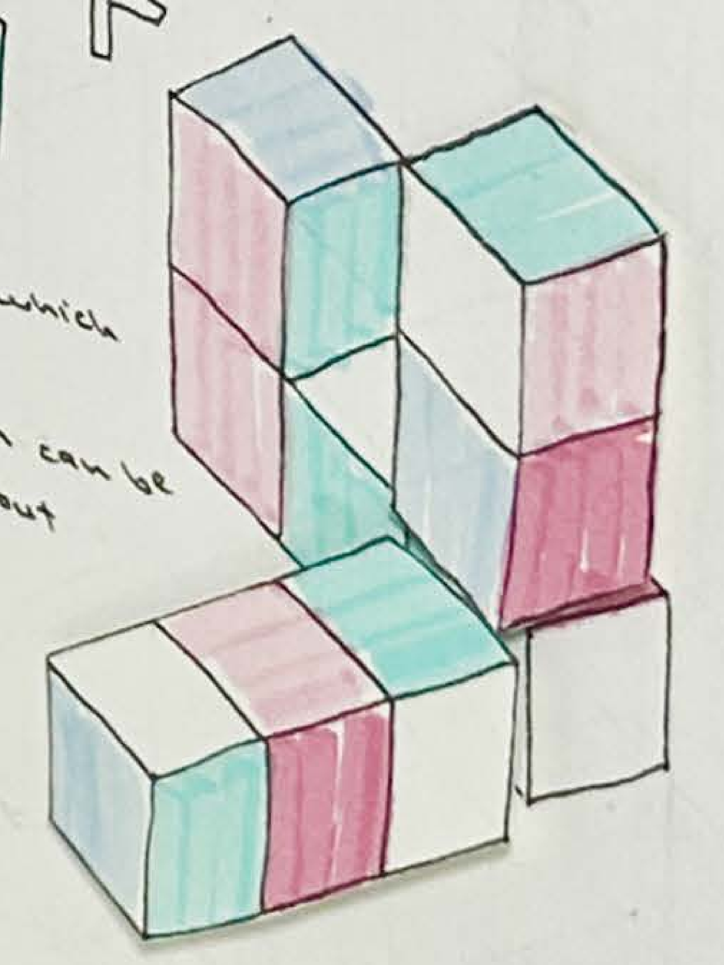

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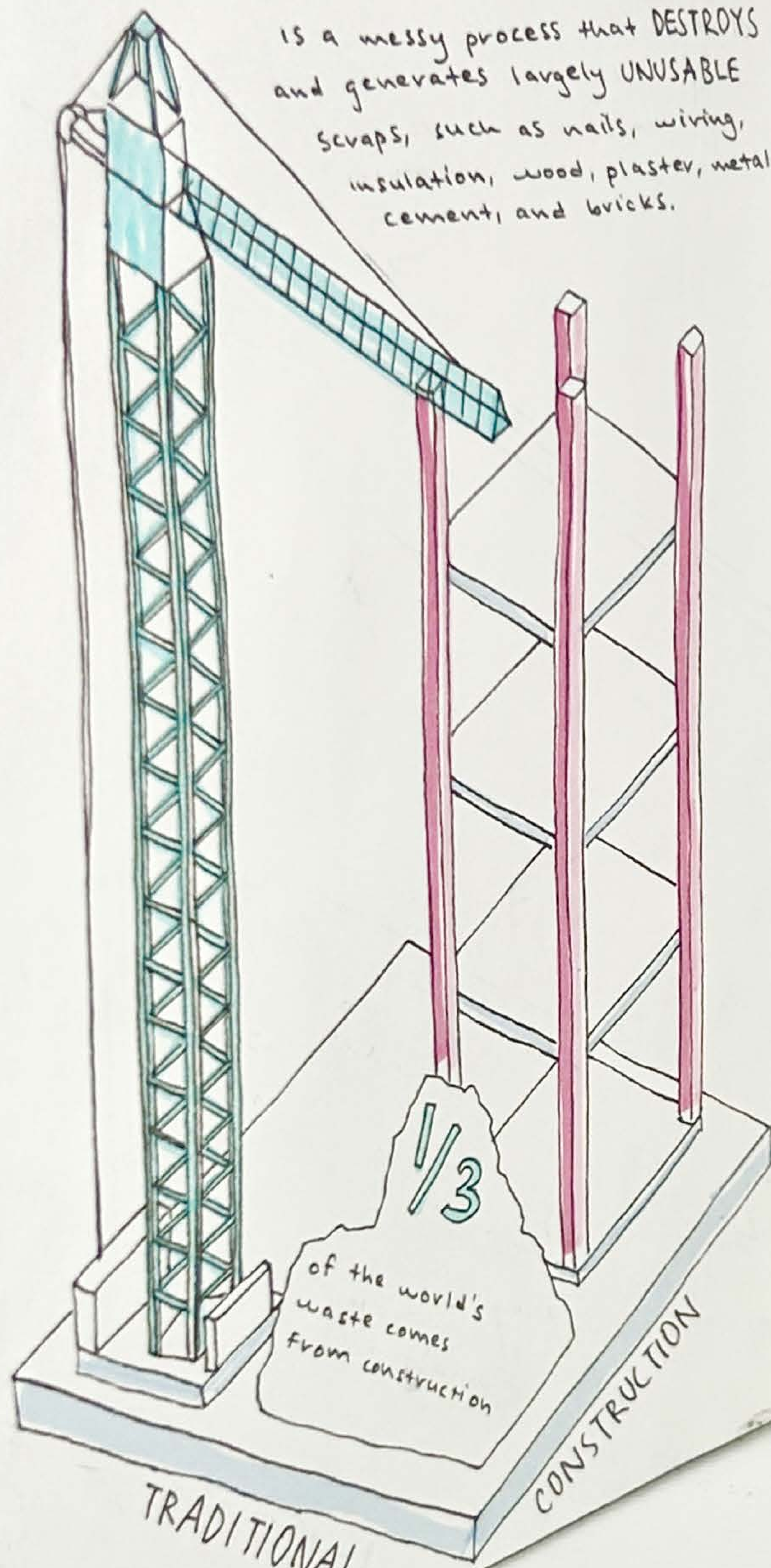

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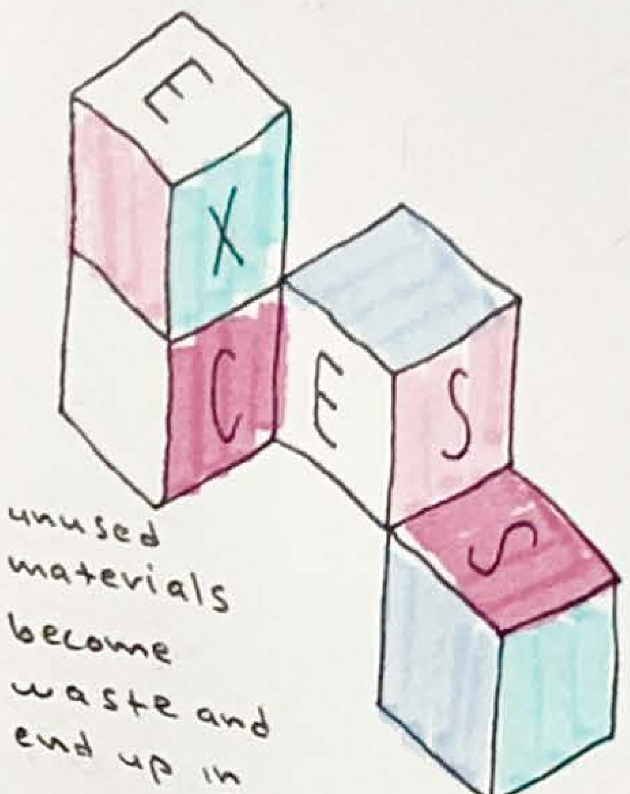

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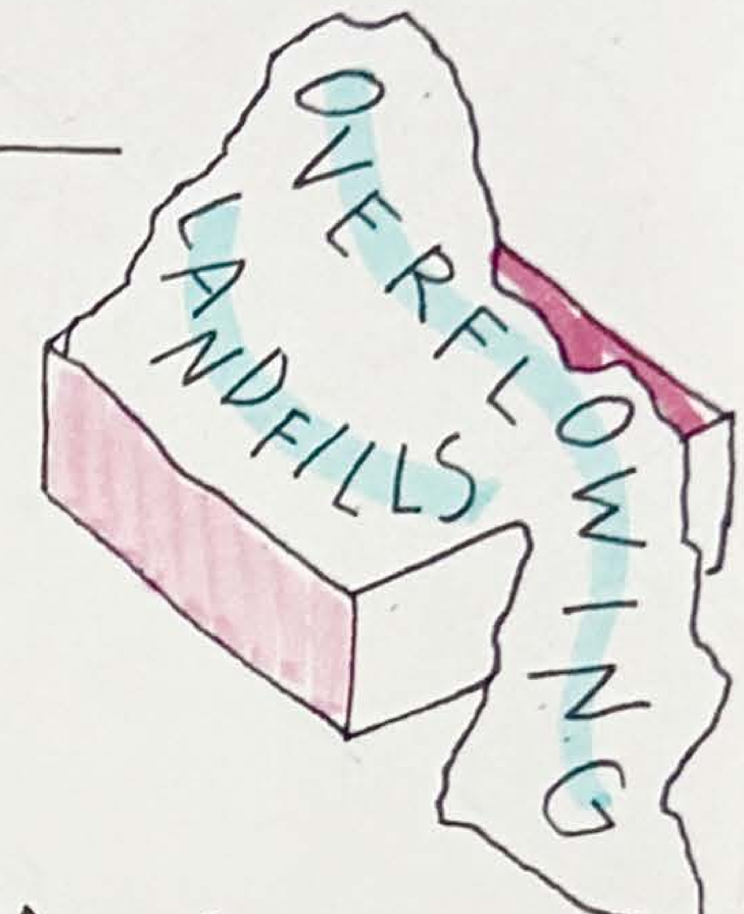

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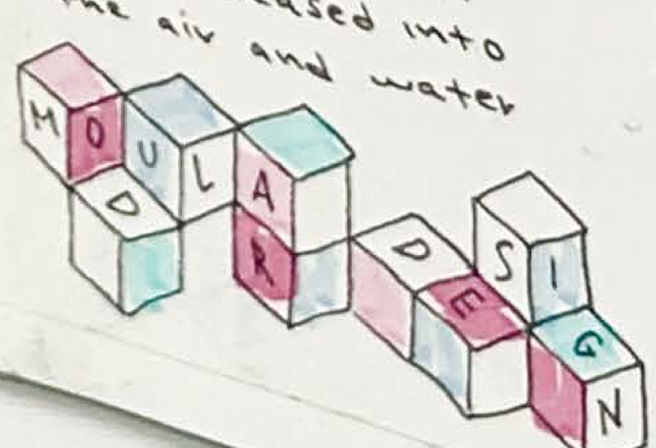

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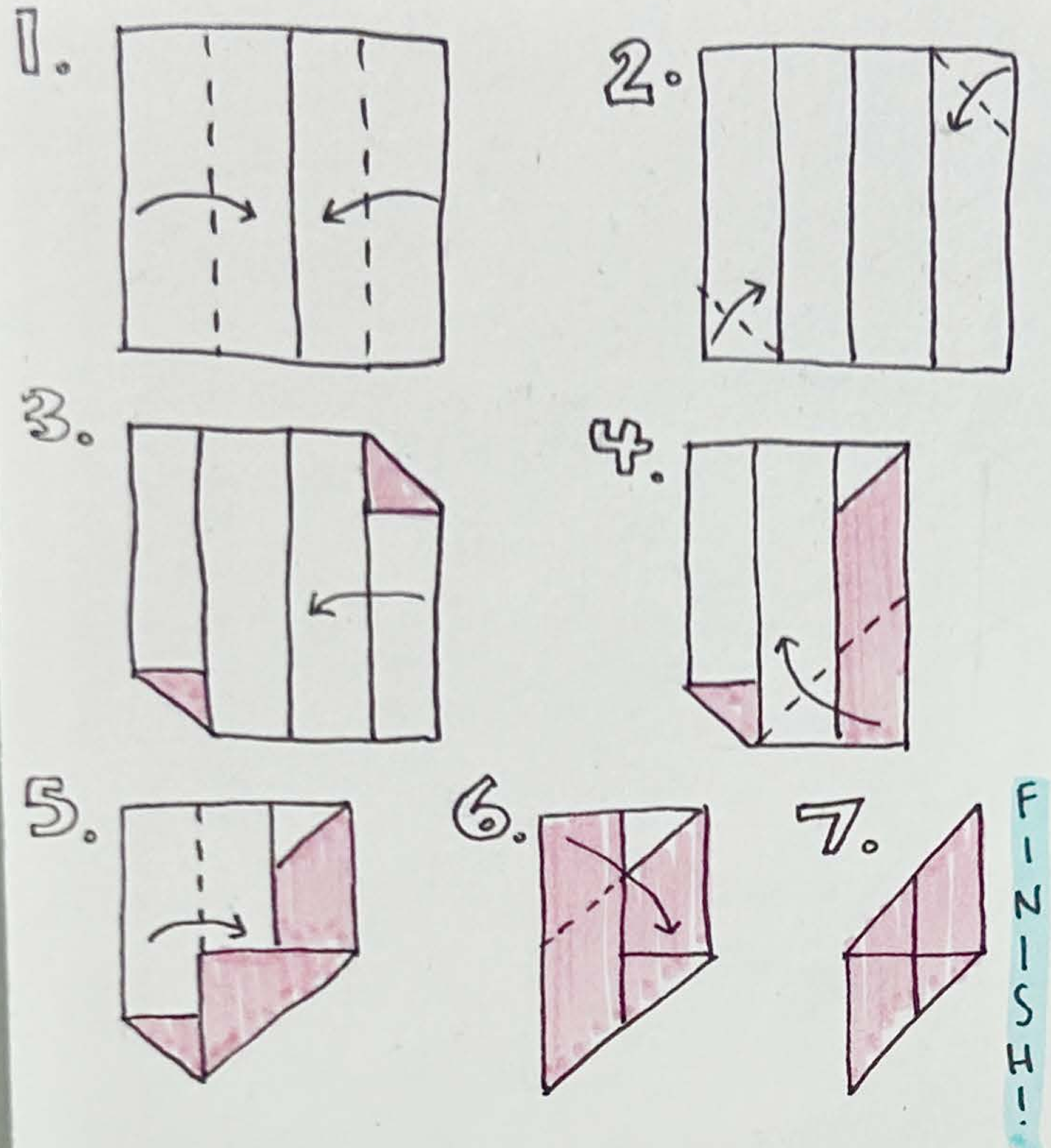

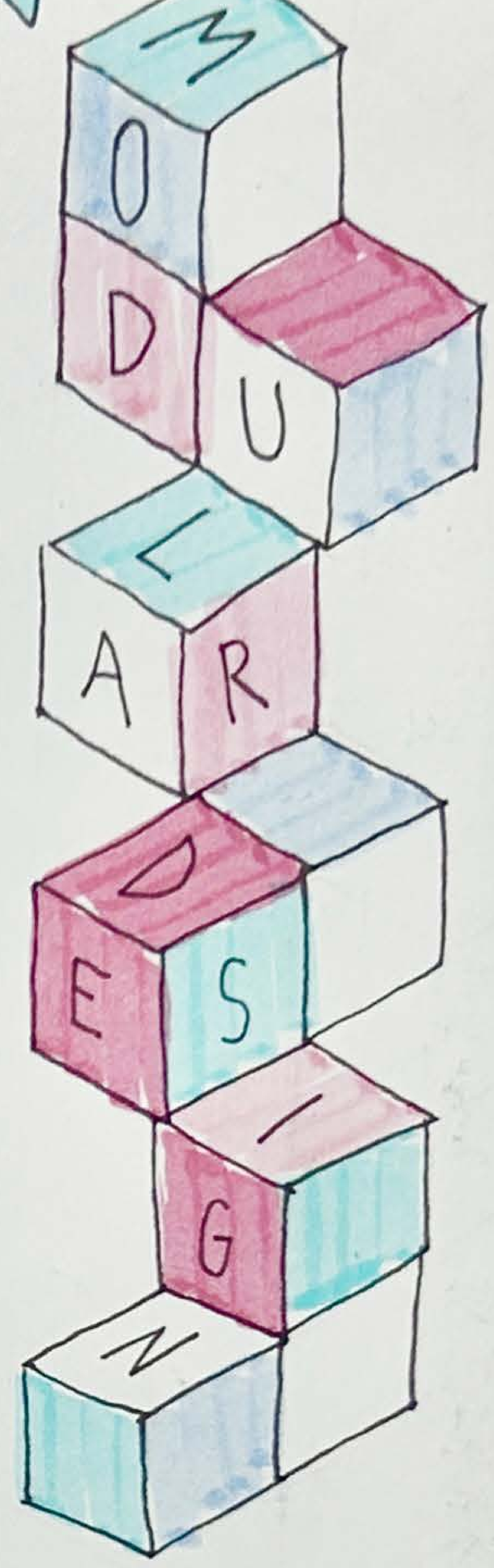

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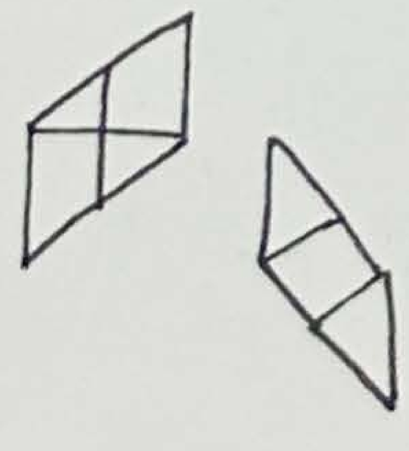

Term Project Summary

My term project demonstrates the qualities of modular construction that allow it to produce less material waste compared to the traditional construction process through an eight-page zine. Modular design consists of prefabricated modules that are finished in a factory setting, then connected at the building site cleanly and quickly. Traditional construction consists of sending raw materials to the building site, where they are then cut and assembled on-site, and is often a long and messy process. The zine compares the differences between traditional and modular construction, highlighting how the respective methods can either contribute or reduce material waste. I focused on four aspects of modular design that reduce material waste, each of which are demonstrated on a page of the zine: the storage of materials in a controlled environment, precise cutting in a factory setting, completely planned designs, and prefabricated modules that are easily assembled and deconstructed. Another page will demonstrate how traditional construction generates waste through on-site assembly of materials and destructive demolition processes. The final page is dedicated to underscoring the environmental impact of construction and demolition.

Modular design simplifies a building to consist of standardized, prefabricated components called modules. These modules can range from walls to entire rooms, and are prefabricated, or completed, during manufacturing, and are then transported to the building site for assembly (Studio W Architects). Modular designs are fully planned out before manufacturing begins, allowing for accurate estimates of material required, ensuring that everything that is prepared is actually utilized. (Modular Building Institute). This manufacturing process reduces over-ordering or scrapping excess material due to mistakes in planning or last minute circumstances on-site. Modules are prefabricated at the manufacturing site, so the only action that needs to be taken on-site is assembly, rather than having alterations take place at the construction site like in conventional design processes. Assembly for modular buildings is also simple: at the building site, assembly consists of stacking the modules, bolting them together, sealing them to be weatherproof, and installing final interior elements that weren't included put in at the factory (Modular Building Institute). Pushing changes and alterations to the initial manufacturing stages greatly reduces material waste: modular design saves 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. These off-cuts are the unused pieces leftover after the main shape is cut, and are too small to feasibly be used for other purposes. Modules are designed to minimize irregular shapes and therefore waste in the form of offcuts (Olanrewaju and Olabode). Factory settings are also better suited for material sorting and organization, leading to more opportunities for recycling. There is more control and regulation in the manufacturing site compared to the construction site with a cleaner working environment and precise cutting machines, allowing for optimized and effective sorting of material, ultimately wasting less

(Salman). In contrast, with traditional construction, waste is generated and unsorted on site, contributing to more waste being sent to the landfill.

Due to the nature of the modules being prefabricated, many modular designs involve a practicable deconstruction plan, guaranteeing that a design can be taken apart and adapted without demolition. Modules maintain the structure that was built during manufacturing as they are assembled for the final building (Olanrewaju and Olabode). With open-ended 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. Ultimately, multipurpose rooms and furnishings allow the design to incorporate more for less material (TerraMai).

On the other hand, traditional construction sites generate a considerable amount of waste, contributing to about one third of the global total of waste (ETM Recycling). 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 the building materials are cut and assembled on-site, the leftovers or mistakes are rendered unusable, becoming waste and ending up in already overflowing landfills. This excess waste releases toxic materials such as asbestos and lead into the air and water, harming both the nearby ecosystems and public health, increasing the risk of many health issues (Clean Management Environmental Group). The construction process also 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, construction exerts a strong negative impact on the ecosystem and human health through both the waste produced and physical stress on the land.

For the content of my zine, I focused on different portions of the modular construction process and elaborated how they reduce waste with text. I made the zine eye-catching with bright colors, and explained the information in an accessible way for a variety of viewer demographics, since the goal of my project is to raise awareness and introduce the general public to the concept of modular design as a more sustainable alternative to traditional construction. For the illustrations in my zine, I chose to use isometric cubes to represent a module, and kept this a consistent motif throughout the zine for both demonstration and format purposes. Overall, I wanted to keep the visuals of the zine simple and consistent, using only isometric or flat views for drawings and a limited color palette, but I experimented with different combinations of each, similar to how a single module can be transformed in different ways to get different end results. I did take some liberties on simplifying complex visuals like the factory interior, cutting machines, and construction sites, but the main points I wanted to convey were supplemented with text, for example the organization of the factory, or precision of the cutting machine.

To add another interactive aspect to the zine, I added a pocket to the back cover of the zine with origami paper to make sonobe units, which are modular origami units. I also included instructions on how to fold a sonobe unit and how to put them together to form different geometric shapes. The sonobe units simulate how a modular design works without necessarily making a miniature model of a module used in real life construction scenarios, making the information and concepts of modular design more accessible and digestible. Similar to how modular buildings are easily assembled without excess connecting materials that generate a lot of waste, sonobe units can be connected by inserting the units into slots. There is no need for additional cutting or external connecting methods to create the sonobe shapes. Additionally, the units can be put together in multiple configurations to create a variety of shapes and forms.

The audience of my creative project ranges from people who are interested in building new homes to people or kids who simply want to learn more about sustainability in construction. I chose a zine format because it attracts a larger audience demographic, using attractive visuals and depicting information in a method that is more simplified and understandable for people who aren't as familiar with the entire construction process. My goal is to make the general public more informed about modular design as an alternative that is readily available, as well as raising awareness of how much waste is truly generated during construction and demolition, which in today's society, is simply a widely accepted fact that is no longer questioned.

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. 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.

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