

// CONTEXT

Cradle to Cradle, William McDonough



The argument behind Cradle to Cradle is that the manufacturing model today is one of a Cradle to grave philosophy. Meaning that this mindset has existed since the industrial revolution and casts off 90 percent of the materials it uses as waste. Cradle to Cradle challenges the notion that human industry must inevitably damage the natural world.

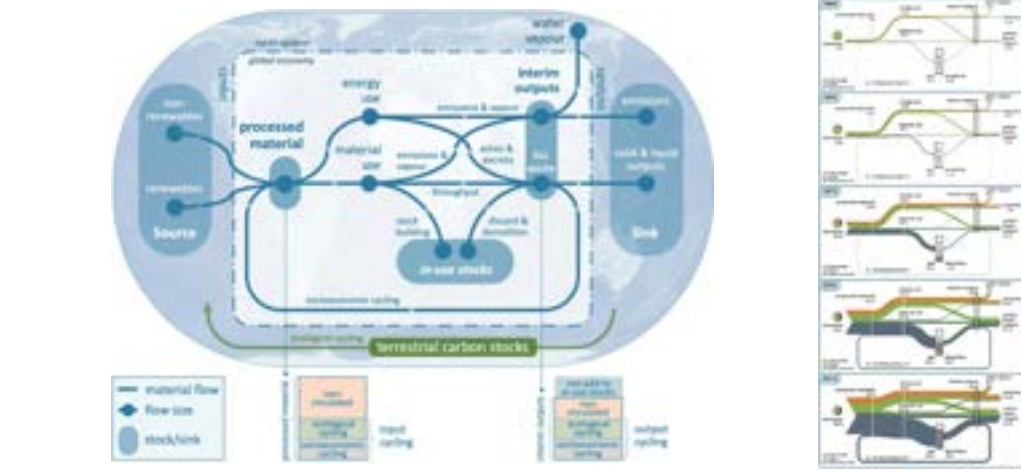
The authors of Cradle to Cradle ask, why not take nature itself as our model? A tree produces thousands of blossoms in order to create another tree, yet we do not consider its abundance wasteful but safe, beautiful, and highly effective: hence "waste equals food" is the first principle the book sets forth. Products might be designed so that, after their useful life, they provide nourishment for something new—either as "biological nutrients" that safely re-enter the environment or as "technical nutrients" that circulate within closed-loop industrial cycles, without being "down-cycled" into low-grade uses (as most "recyclables" now are).

There's Life After Demolition, Mass Timber and Circularity



As defined in the EPA (United States Environmental Protection Agency) manual, "the ultimate goal of the Design for Deconstruction (DfD) movement is to responsibly manage end-of-life building materials to minimize the consumption of raw materials. By capturing materials removed during the renovation or demolition of buildings and finding ways to reuse them in another building project or recycle them into a new product, the overall environmental impact of end-of-life building materials can be reduced. Architects and engineers can contribute to this movement by designing buildings that facilitate adaptation and renovation. Designing for Deconstruction is designing so that these resources can be economically recovered and reused."

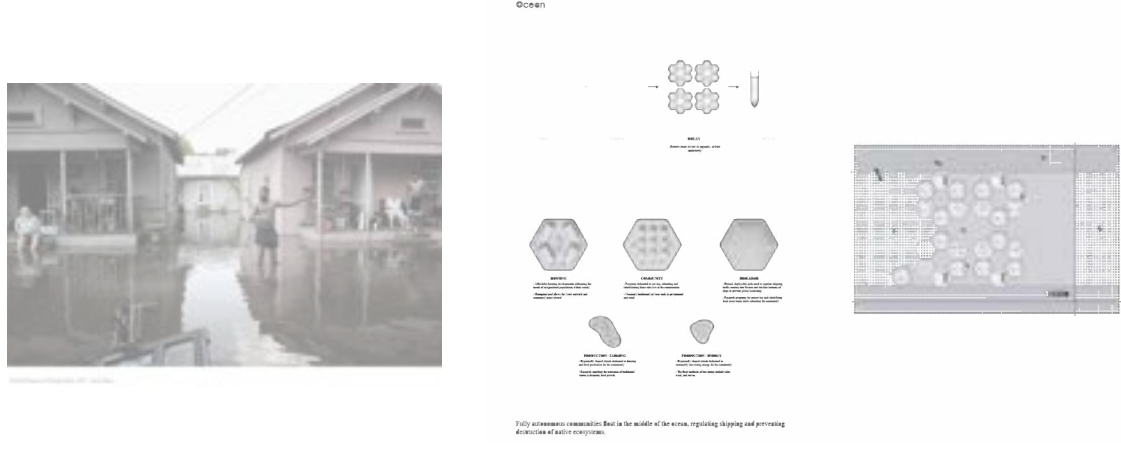
Earth's Odyssey to a Circular Economy, A Century Long Perspective



The circular economy is a rapidly emerging concept promoted as trans-formative approach towards sustainable resource use within Planetary Boundaries. To achieve such approach, policymakers, industry, and academia worldwide have to make a hard push. This approach promises to slow, narrow, and close socioeconomic material cycles by retaining value as long as possible, thereby minimizing primary resource use, waste, and emissions.

This article concludes with four key challenges to make this a reality: tackling the growth of material stocks, defining clear criteria for ecological cycling and eliminating unsustainable biomass production, integrating the decarbonization of the energy system with the circular economy and prioritizing absolute reductions of non-circular flows.

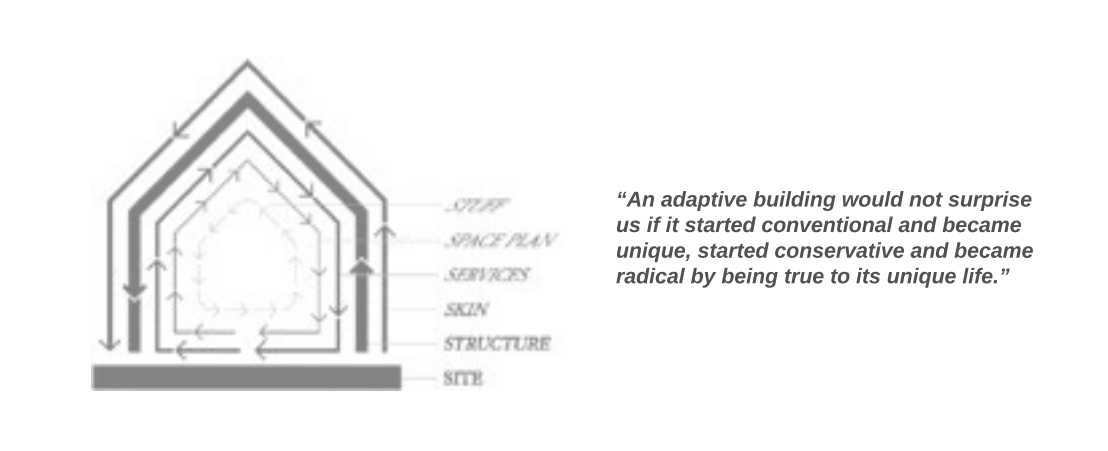
Future of American Housing, Jeffery Nesbit



Future of American Housing is a research studio in the School of Architecture at the University of North Carolina at Charlotte that investigates the role of climate change by providing design strategies for housing and its impact on the public realm. The studio focuses on the future challenges we face in the natural environment and contemporary issues surrounding climate change social equity, and affordable housing in the United States.

This source's relevancy comes from the investigations into climate change and the need to respond with architectural design strategies. Beyond climate changes, the studio also focuses on social equity and affordable housing. This source can be used as contextual background to support the use of prefabricated architecture in response to climate change, social equity, and affordable housing.

How Buildings Learn: Built for Change, Stewart Brand



How buildings learn sets the tone for necessity of an adaptive structure. Buildings are meant to change over time, but too often we don't design for change. The major difference in a "learning" building is its budget. Following Chris Alexander's formula, there needs to be more money than usual spent on basic structure, less on finishing, and more on perpetual adjustment and maintenance.

This source helps to define the reality that our housing construction must be designed to be adaptive for change. There is no reason our building materials and structure cannot be passed down to generations.

// QUESTION

How can one design adaptive buildings to revert from a linear economy approach, to a circular economy approach?

Prefabrication

Construction technique where elements are prefabricated within an enclosed factory space and later are assembled on site.

[Prefabrication]

Modular Construction

Construction technique of using three dimensional volumetric modules.

[Modular]

CLT Mass Timber

Cross-laminated timber is a wood panel product made from gluing together layers of solid-sawn lumber.

[CLT Mass Timber]

Adaptive Housing

Houses and apartments considered collectively that have the ability change over time.

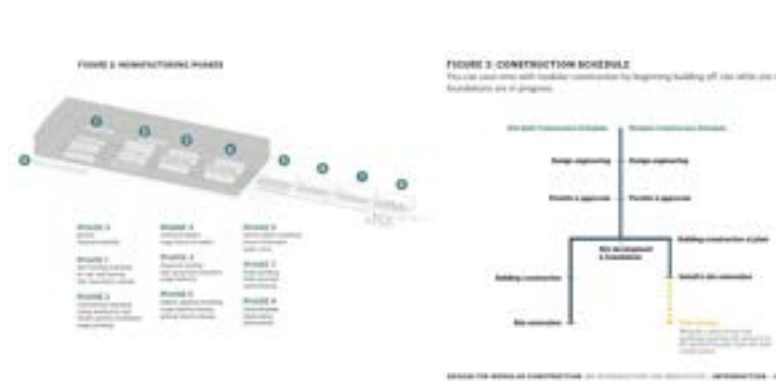
[Adaptive Housing]

Circular Economy

A circular economy is an economic system that tackles global challenges like climate change, biodiversity loss, waste, and pollution.

[Circular Economy]

Design for Modular Construction, American Institute of Architects Practice Guide



This source was a published document from the American Institute of Architects by James Wilson of BuildingGreen, Inc. This source provides an introductory overview of designing for modular construction and dives into the evolving strategy of modular construction. This document states that modular construction is not a novel approach and modular construction has been utilized as far back as he 1849 California Gold Rush where prefabricated houses were transported from New York to California.

This source is highly relevant for providing context and background in the modular construction industry, as well as providing quality case studies of best practice examples. The case studies provided are of housing typologies used at different scales and social equity. One of the case studies that bring up the most interest is the Vancouver Affordable Housing project, with the strategy of using modular construction to rapidly respond to the urgent need for affordable housing in the city.

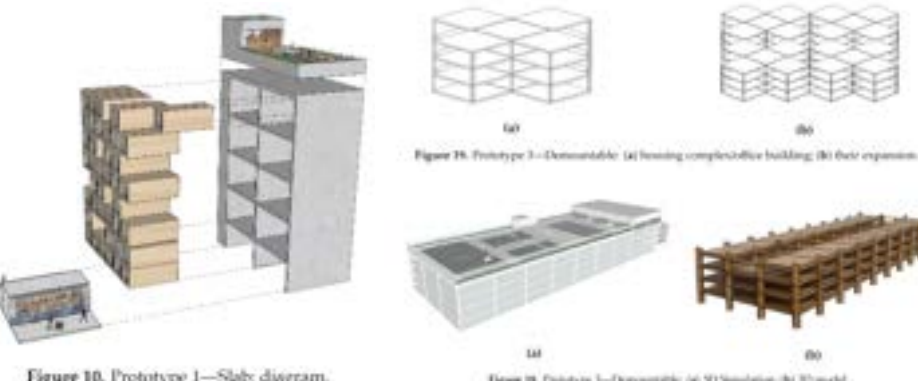
Fabulous Pre-Fab, Abigail R. Brown, AIA Hickok Cole Architects



This source is another great overview of modular construction, but also how it can be applied to multifamily residential projects in the major city of Washington, DC. This source provides valuable information on why and why not to do modular construction, and what some of the major difficulties are. This published document comes from iLab that is sponsored by Hickok Cole Architects, where the program creates a gap in day to day work life to foster innovation.

This source can be very helpful for providing insight into comparative analysis of modular construction vs. on-site construction. The publisher went as far to compare different construction materials and when it is more cost effective to go with traditional on-site construction.

Prefabricated and Recycled Typologies, Marielle Ferreira Silva, University of Luxembourg



This source is an interesting article published by the University of Luxembourg that takes the position that buildings are being demolished without taking into account the waste generated, and the housing shortage problem is getting more critical as cities are growing and the demand for built space and the use of resources are increasing. This article states that modular construction design methods have been used to solve these issues, but there's still an absence of structures that can be disassembled and reused when the structure's ran its life cycle. This article looks at prototypes of new recyclable architectural typologies: a slab prototype as a shelf where wooden housing modules can be plugged in and out, a tower prototype allowing for an easy change of layout and use of different floors, and a demountable prototype characterized by the entire demount ability of the building. This source helps to support studying one or more typologies. This article studies multiple typologies of how architecture that can be recycled and reused.

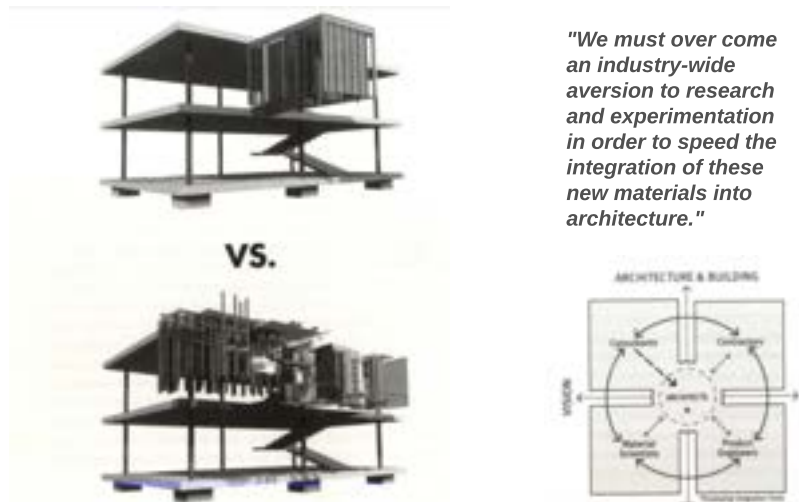
Regenerative Ecosystems, GG-Loop



Biophilic mitosis is a modular building system created by a parametric design tool following biophilic and user centric design principles. GG-Loop and Arup work together to create regenerative ecosystems with a positive ecological footprint. The vision focuses on generating urban clusters using prefabricated timber and bio-based modules that are cost efficient and flexible in its construction.

This source can be very helpful in fueling the position of coupling prefabricated design with biophilic design, resulting a sustainable and aesthetically pleasing design. Partnering biophilic design with prefabricated architecture can be used as a way to change the perception on prefab and increase its sustainability.

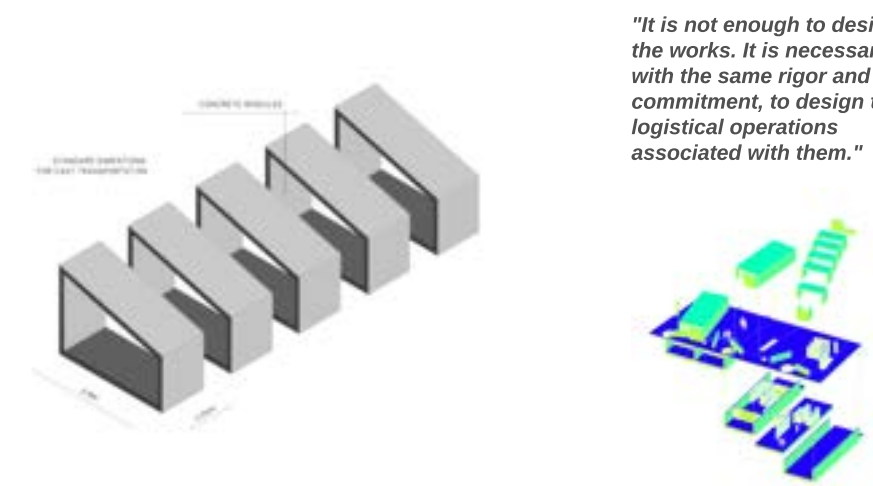
re-fabricating ARCHITECTURE, Stephan Keiran



Re-fabricating ARCHITECTURE sheds light into how the manufacturing process of architecture has fallen at the waist side. The automotive industry has been a great example of how products are produced in a component and modular way, and how the architecture industry has not caught up with this method yet.

Re-fabricating ARCHITECTURE takes the position that the architecture industry should adopt to a similar methodology to revolutionize the that industry and add more value to the designer.

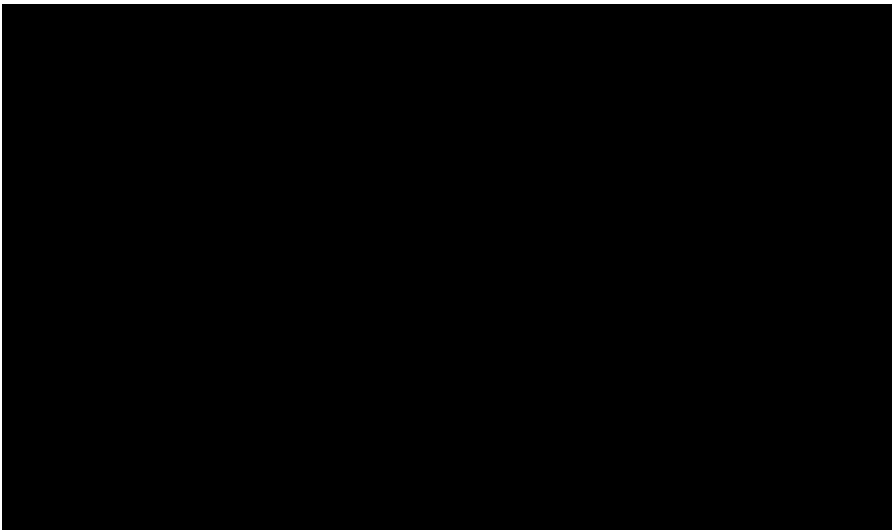
Traditional Construction is Doomed to Disappear, Interview with Portuguese architecture firm STUDIO



History has given us some lessons on this matter. The most paradigmatic case may be that of the German Democratic Republic, one of the pioneers of reinforced concrete prefabrication. In this case, prefabricated building systems were applied to respond quickly to the housing deficit that was felt in the country until the end of the eighties.

However, after the fall of the Berlin Wall, and with the consequent population exodus towards the West, there became a surplus of housing. Thus, parts of these buildings were dismantled, and the parts were transported and reused in new constructions not only in Germany but also in the Czech Republic, Poland, and Russia. This was the biggest ever "architectural recycling" operation and illustrates the potential of this type of circular architecture.

// POSITION



"Biological + Technical Cycles"

Products might be designed so that, after their useful life, they provide nourishment for something new-either as "biological nutrients" that safely re-enter the environment or as "technical nutrients" that circulate within closed-loop industrial cycles, without being "down-cycled" into low-grade uses (as most "recyclables" now are).

"Why not take nature itself as our model?"

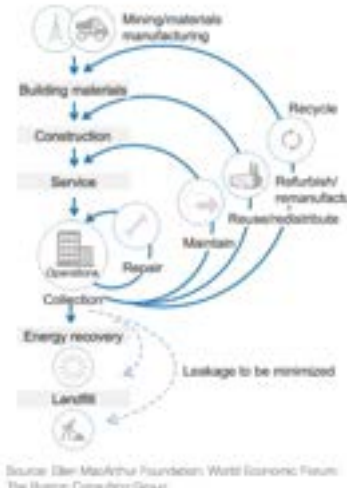
"Cradle to Cradle "

The argument behind Cradle to Cradle is that the manufacturing model today is one of a Cradle to grave philosophy. Meaning that this mindset has existed since the industrial revolution and casts off 90 percent of the materials it uses as waste. Cradle to Cradle challenges the notion that human industry must inevitably work against damaging the natural world.



"Design for Deconstruction (DfD) "

By capturing materials removed during the renovation or demolition of buildings and finding ways to reuse them in another building project or recycle them into a new product, the overall environmental impact of end-of-life building materials can be reduced. Architects and engineers can contribute to this movement by designing buildings that facilitate adaptation and renovation. Designing for Deconstruction is designing so that these resources can be economically recovered and reused."



"Circular Approach "

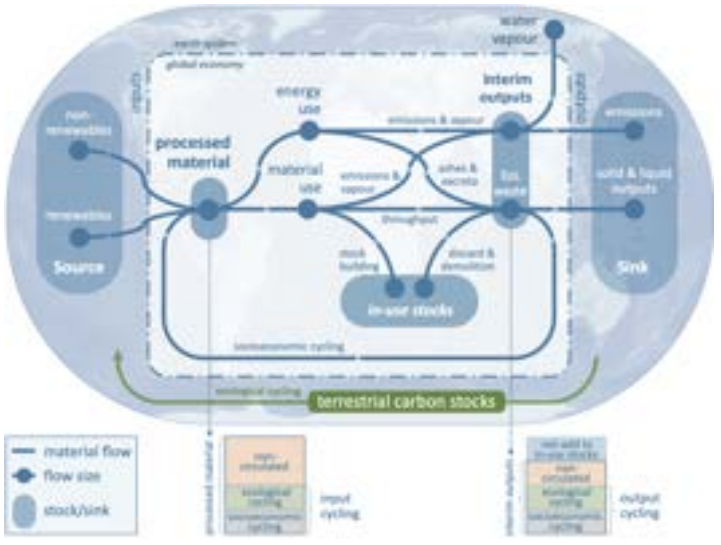
This can generate a number of benefits, including reducing waste and greenhouse gas emissions in buildings; improving the resilience of supply chains in construction; creating new economic, and employment opportunities, providing social benefits, and improving natural ecosystems through lower resource consumption.

"Since wood is versatile and durable, it can be disassembled and then reassembled into other buildings or other wood fiber products, sequestering the carbon even longer as long as it stays out of landfills"

"4 Key Challenges to Make Circular Economy a Reality"

1. Tackle the growth of material stocks
2. Define clear criteria for ecological cycling and eliminating unsustainable bio-mass production
3. Integrating the decarbonization of the energy system with the circular economy
4. Prioritizing absolute reductions of non-circular flows

"The proponents of a Circular Economy argue that closing loops creates green jobs and stimulates economic growth, while mitigating pressures on the environment."



"To achieve a Circular Economy approach, policymakers, industry, and academia worldwide have to make a hard push toward the future."

There's Life After Demolition

Cradle to Cradle

Spaceship Earth's Odyssey to a Circular Economy

[Circular Economy]

Eco-Social Resilience

[Prefabrication]

[Modular]

[Adaptive Housing]

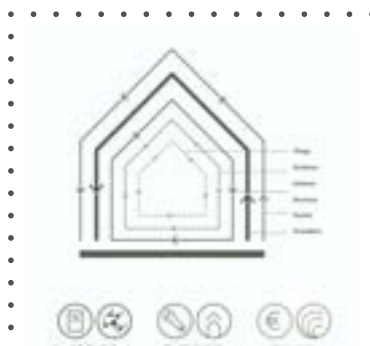
How Buildings Learn

Case Studies

Le Corbusier

Walter Gropius

Space 10



"Built for Change"

After reviewing Chapter 12: Built for Change of How Buildings Learn, the ad-vocation for adaptable design is echoed through the call on reducing the solid waste burden of demolished buildings, and promoting the longevity of structures to support generations of communities.

"A buildings foundation and frame should be capable of living 300 years"

"The major difference in a "learning" building is its budget. Following Chris Alexander's formula, there needs to be more money than usual spent on basic structure, less on finishing, and more on perpetual adjustment and maintenance."

"A New Way of Living Together"

The Urban Village Project aims to allow for cheaper homes to enter the market, make it easier to live sustainably and affordably, and ensure more fulfilling ways of living together. We envision that to happen by prioritizing livability, sustainability and affordability.

"Bottle Rack Principle"

A basic underlying structure allows for the removal and insertion of interchangeable components to suit a particular need at a specific time.

"We simply aren't building enough affordable homes to keep up with the demand. Our cities are becoming increasingly unaffordable, unsustainable and socially unequal."

"Adaptable CLT"

Components in building construction are always built to stay put, resulting in negative environmental impacts and difficulty renovating. If CLT mass timber was designed to support housing and to be disassembled in the future, then it could be recycled and reused while sequestering carbon.

"Design for an Assembly of Mass Produced Components"

Walter Gropius, the founder of the Bauhaus, advocated for the integration of industrial principles in the architecture industry. Gropius explored this principle in two different ways: 1. Designing for a flexible construction kit and 2. Producing through assembly line production facilities.

"Contemporary Challenges Require "

Contemporary challenges and developments in technology inevitably trigger changes in the way we design and build our cities. Striking a balance between pragmatism and experimentalism, the firm develops prefabricated solutions in order to respond to a driving challenge of contemporary architecture - to speed up and simplify the construction process.

"It is not enough to design the works. It is necessary, with the same rigor and commitment, to design the logistical operations associated with them."

"Design + Planning Determine Cost Savings"

Although modular construction can be more cost efficient than on-site construction, this does not automatically mean it will result in a reduction in overall project cost. However, the costs are often more predictable than with traditional construction methods. If affordability and controlled cost is of primary concern on a project, modular construction can be used to achieve it, but it will require greater intention in design and thorough planning.

"Designing for Modular Construction"

Projects using off site modular construction must comply with the same building codes that pertain to conventional on site construction; there are no special provisions pertaining to the use of modular construction.

"Unionizing Modular Construction"

With shorter construction times due to modular construction, the result is less harm on the environment and less time running heavy machinery on site. When modular construction is incorporated with unions, there will no longer be a competition against traditional construction and result in widespread acceptance.

"Design + Planning Determine Cost Savings"

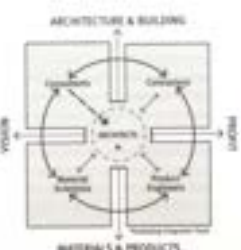
Wood frame stick-built construction is very affordable in some cities. Studies in this case study in Washington, DC, show that wood modular construction costs 35% more than conventional wood framing.

Research Question -

How can one design adaptive buildings to revert from a linear economy approach, to a circular economy approach?

re fabricating ARCHITECTURE

The Construction Kit and the Assembly Line



"re-fabricating ARCHITECTURE"

Compared to the automotive world, building contractors, as well as architects and product engineers, are still in the nineteenth century. Buildings continue to be assembled largely piece by piece in the field, in much the same way that car was put together before the advent of mass production.

"Where is the evolution in building construction and architecture industry? "

"Today, most architecture in the developed world requires at least some products that are not immediately at hand. These are products extracted from nature, often at remote locations, which are then reconstituted for use in building."

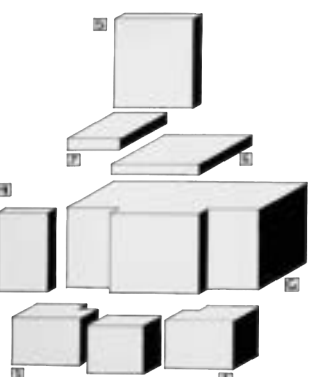


"Tesla-fy the Architecture Industry"

Architects and the building industry should adapt to prefabricated construction of components, like the automobile industry in order to add more value to the designer and the quality of the craft they produce.

"Fundamental Transformation of the Entire Construction Industry Towards an Industrial Direction."

Walter Gropius' goal with the construction kit is the dwelling as an industrially manufactured product, which is assembled from highly flexible construction kit elements. He claims that with this dry construction method the disadvantages and improbabilities of conventional building, such as "the annoying component changes...and the loss of time", can be eliminated.



"Modular construction has buildings opening 30% - 50% sooner than site built construction"



"Circular House"

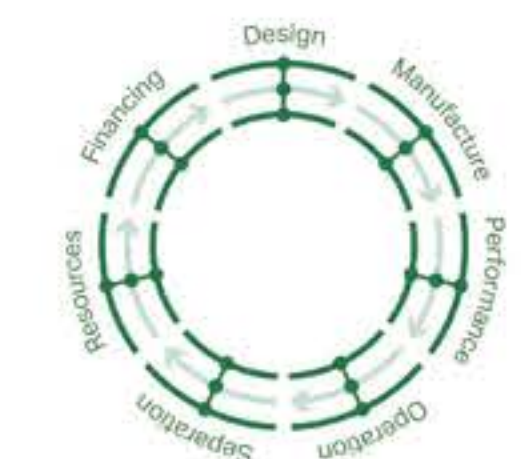
Designed to be a scale able building solution, the Circular House's goal is to build the world's first social housing units built entirely according to circular principals, where **90% of all material can be reused at a high value**. This means the home construction can be disassembled and the elements recycled without significant loss of value.

"Leasing, which is common practice in the automotive industry, is also not yet developed for building construction"

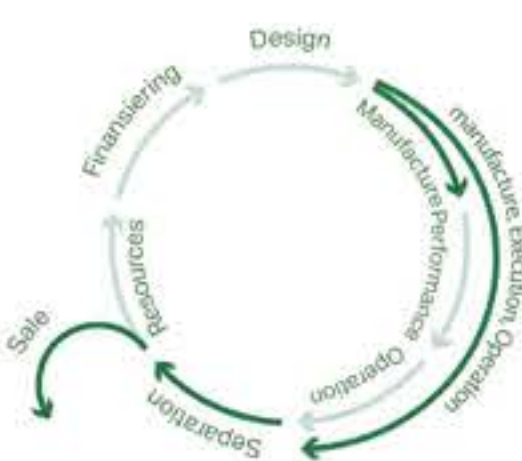


"Lease-able Components"

Since the automotive industry is doing it, why not the architecture industry? By designing building components with a circular frame of mind, said **components could be leased out to buildings for temporary use**. This would open the door for a **more controlled process of material circularity and design**.



"Sharing Platform"



"Product as a Service"



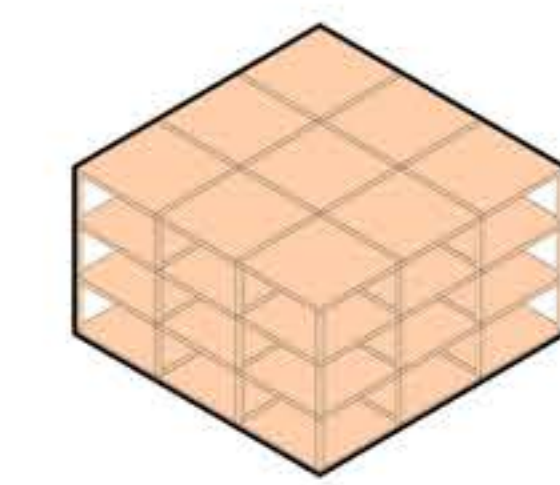
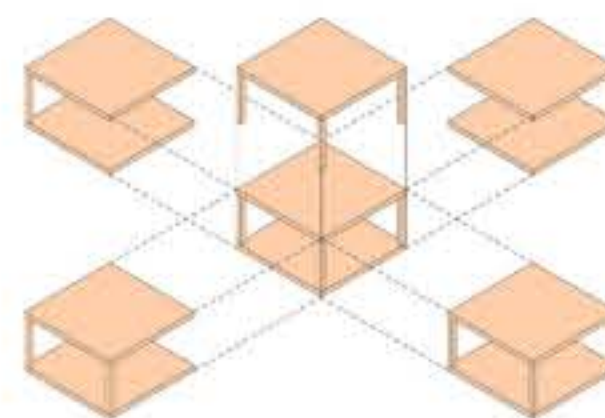
"Urban Village"

The Urban Village Project aims to allow for cheaper homes to enter the market, make it easier to live sustainably and affordably, and ensure more fulfilling ways of living together. One of the ways in which Space 10 accomplishes this is with **local mass timber**. Space 10 envisions a more fulfilling way to live together by **prioritizing livability, sustainability and affordability**.

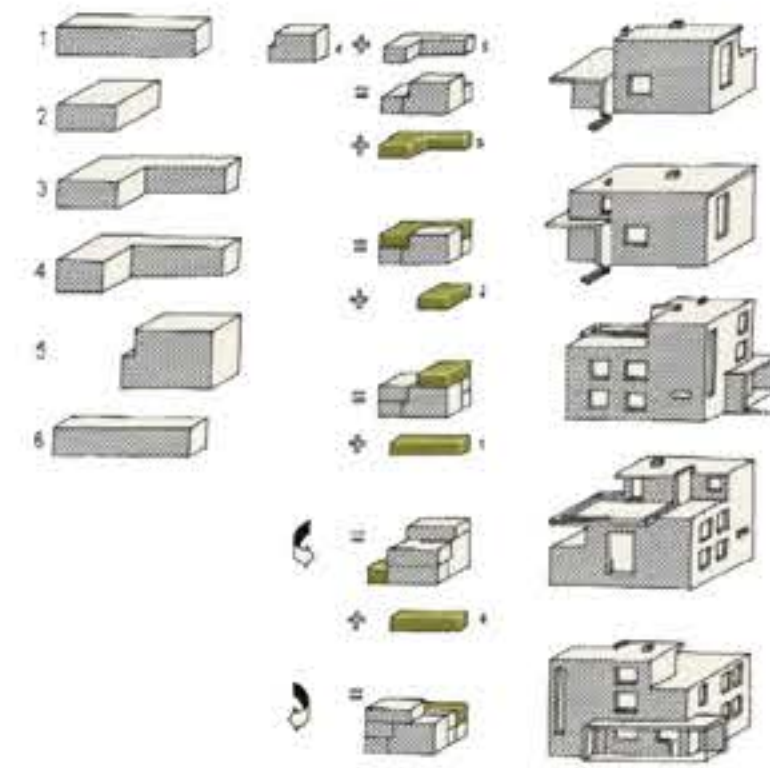


"Adaptable CLT"

Components in building construction are always built to stay put, resulting in negative environmental impacts and difficulty renovating. **If CLT mass timber was design to support housing and to be disassembled in the future, then it could be recycled and reused while sequestering carbon.**



"De-mountable Housing"

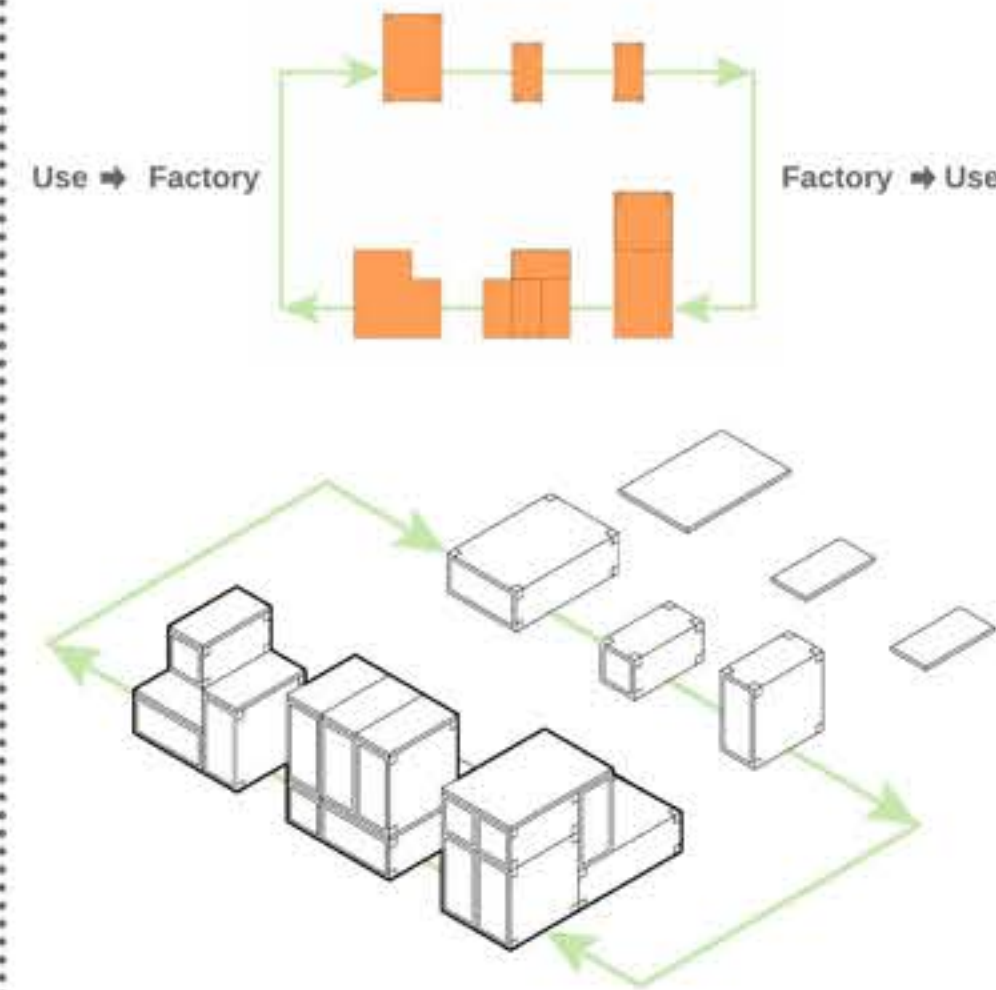


"Design for an Assembly of Mass Produced Components"

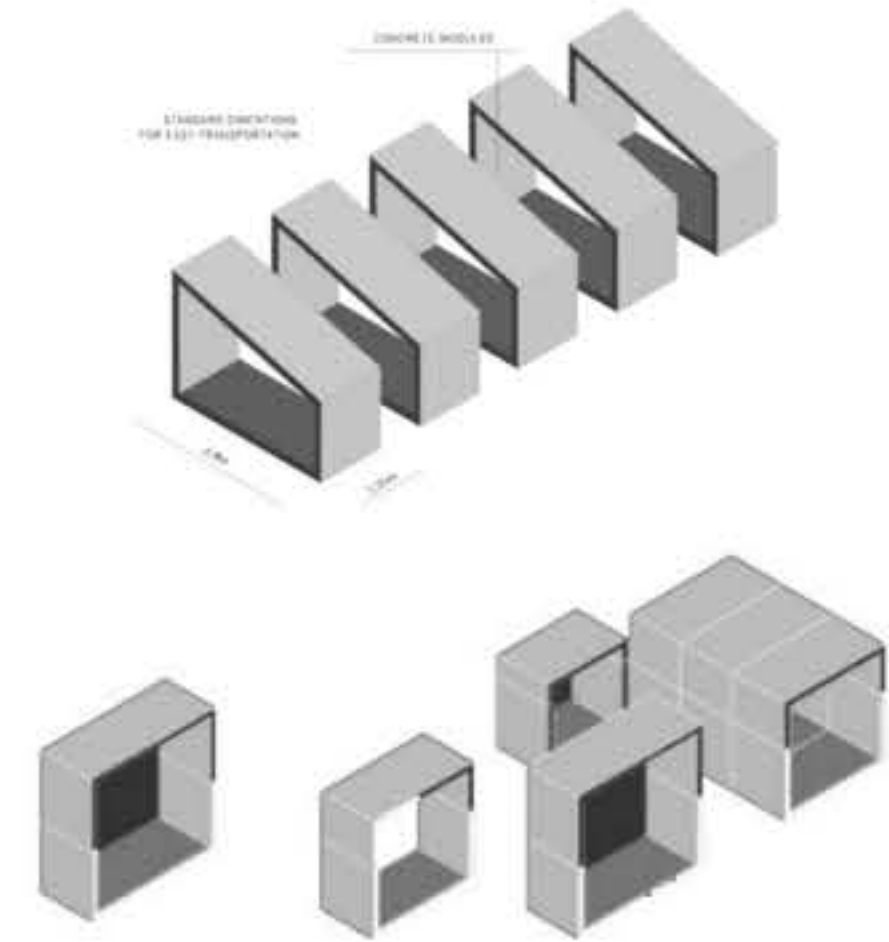
Walter Gropius, the founder of the Bauhaus, advocated for the integration of industrial principles in the architecture industry. Gropius explored this principle in two different ways: **1. Designing for a flexible construction kit and 2. Producing through assembly line production facilities.**

"Lego Principle"

As Walter Gropius advocated for the design for an assembly of mass produced components, the theory stops there and doesn't take into consideration of de-mount-ability and re-use. **By applying the "Lego Principle" mass produced components can be designed with de-mount-ability for infinite configurations and reuse. When the components have lived out there life cycle, the manufacture facility can take them back for recycling or reuse.**



"Recyclable Modular Components"



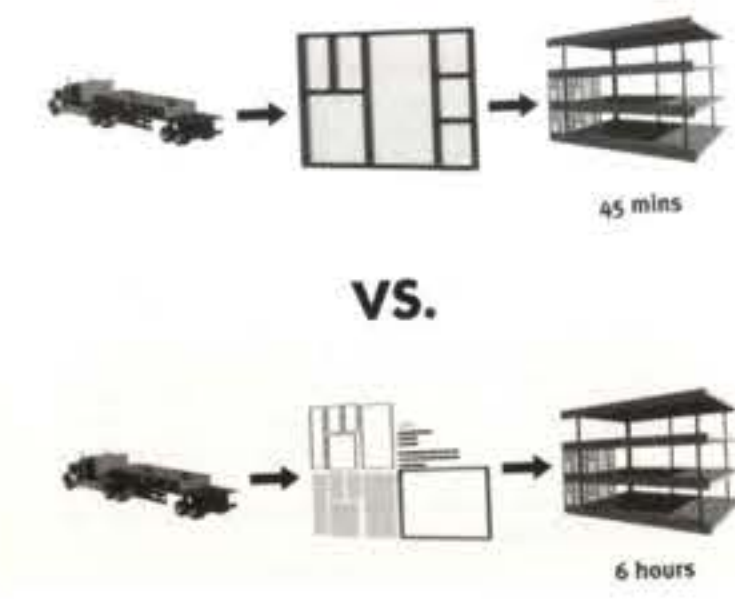
"Summary Studio"

Contemporary challenges and developments in technology inevitably trigger changes in the way we design and build our cities. Striking a balance between pragmatism and experimental-ism, the **firm develops prefabricated/modular solutions** in order to respond to a driving challenge of contemporary architecture - **to speed up and simplify the construction process.**

Prefabrication will become increasingly necessary to respond to new demographic challenges and the growing labor shortage. - Summary



"Recyclable Modules"



VS.

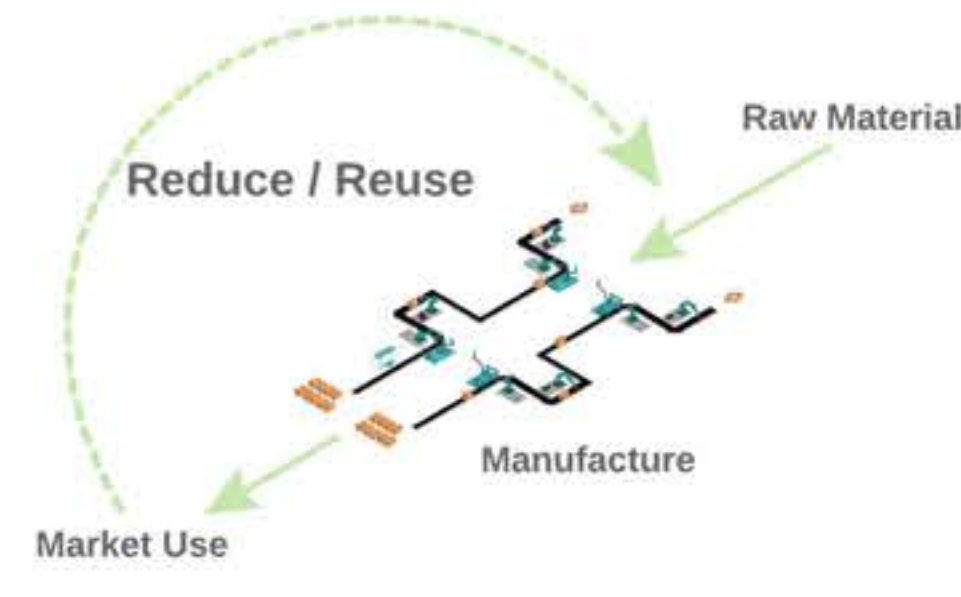
"re-fabricating ARCHITECTURE"

Compared to the automotive world, building contractors, as well as architects and product engineers, are still in the nineteenth century. **Buildings continue to be assembled largely piece by piece in the field, in much the same way that car was put together before the advent of mass production.**

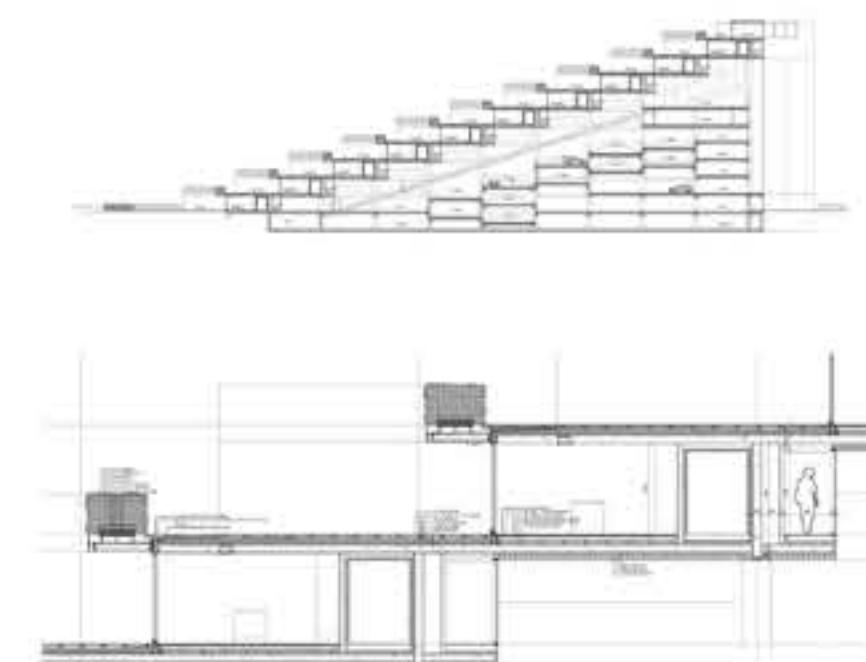
"Tesla-fying the Architecture Industry"

Architects and the building industry should **adapt to prefabricated construction of components**, like the automobile industry in order to **add more value to the designer and the quality of the craft they produce.**

Prefabrication



"Manufacturing Circularity"

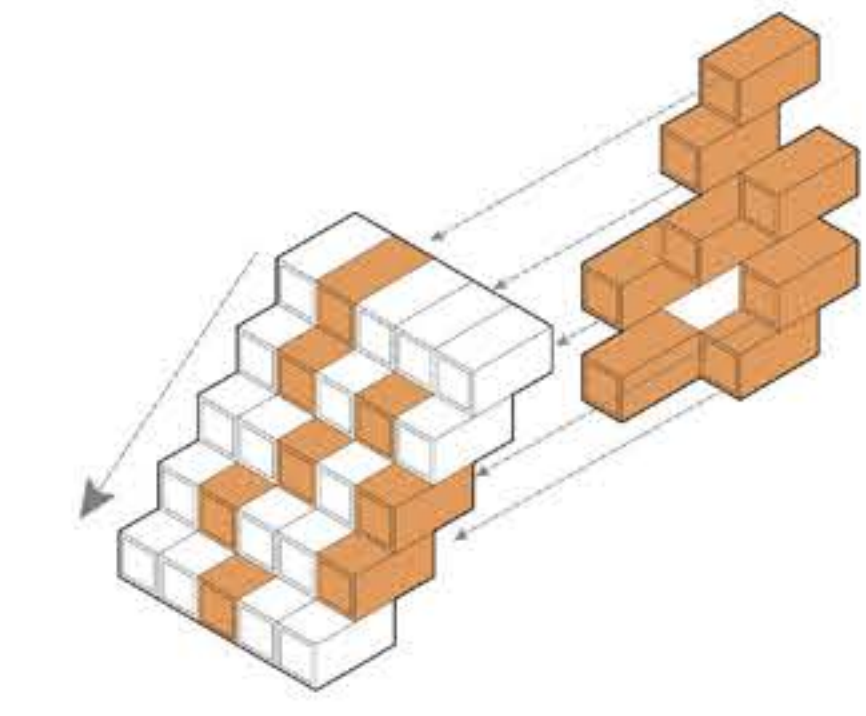


"Mountain Dwellings"

The mountain dwellings program is 2/3's and 1/3 housing. What if the parking area became the base upon which to place terraced housing, like a concrete hillside covered by a thin layer of housing, cascading from the 11th floor to the street edge.

"Avalanche Effect"

By treating the housing cluster like a the face of a mountain, dwellings can simply erode away, creating space for a new dwelling. This would allow for **adaptability, circularity, and availability.**

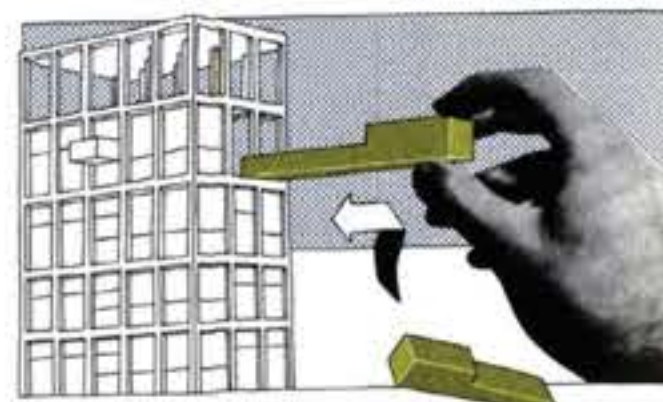
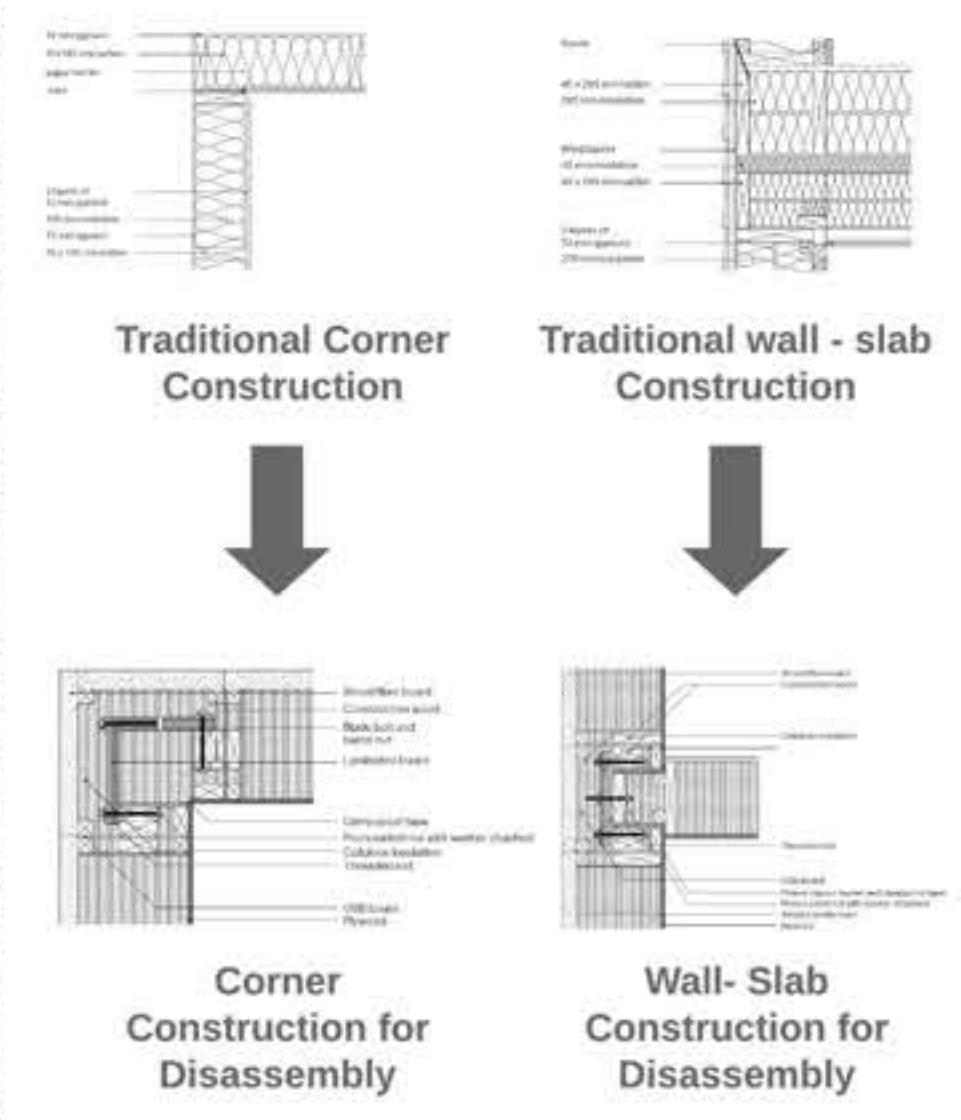


"Ever-changing Housing Landscape"



"A New Timber Building Element"

Developed by Tinus Peterson and Ingri Bollingmo at the VIA University College, with the primary goal to **create a standard timber element protected behind a removable envelope**, connections between the elements to provide **disassembly and reuse**, and made of timber that is **99% reusable "as is" and to be down cycled in the biological cycle.**



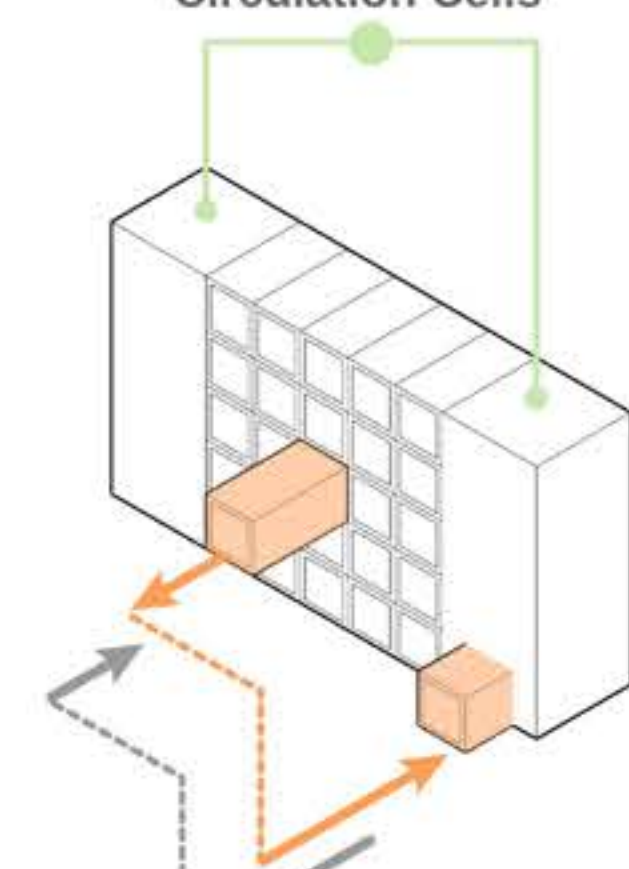
"Bottle Rack Principle"

A basic underlying structure allows for the removal and insertion of **interchangeable components to suit a particular need at a specific time.**

"Carvana Effect"

By having a basic underlying structure allows modules to be placed in whenever change is need or wanted. By adopting an operational strategy like the company Carvana, **modular housing units could be purchased through an "apartment vending machine."**

Circulation Cells

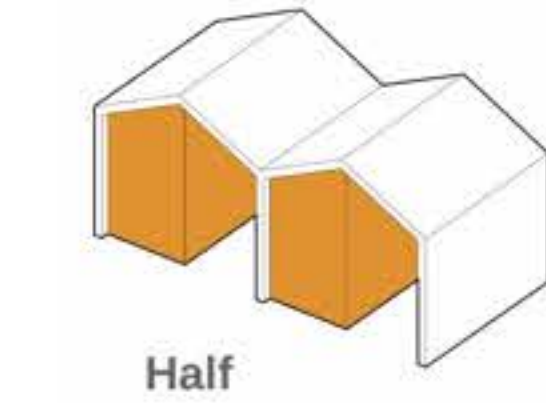


"Apartment Vending"

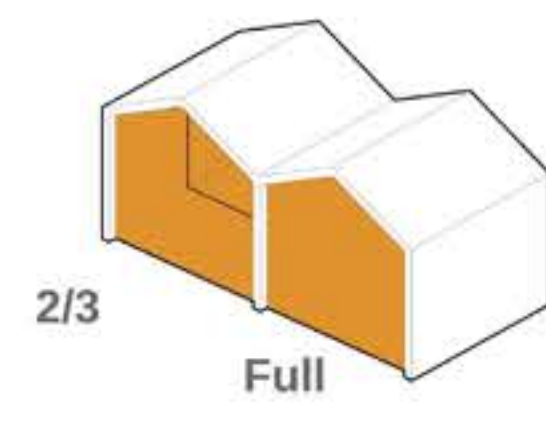


"Half a House"

In Chile, a middle class family may inhabit a house of around 80 square meters, whereas a low income family might be lucky enough to inhabit 40 square meters. They can't afford a large "good" house, and are henceforth often left with smaller homes or building blocks. Why not give them half a "good" house, instead of a small finished house?



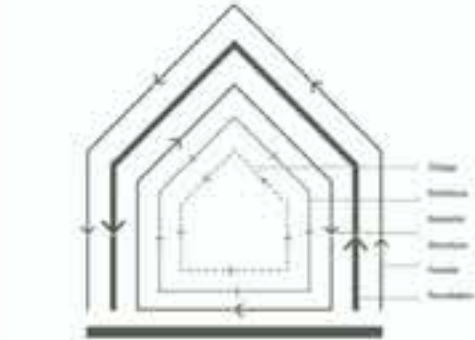
Half



2/3

Full

"Economic Adaptability"



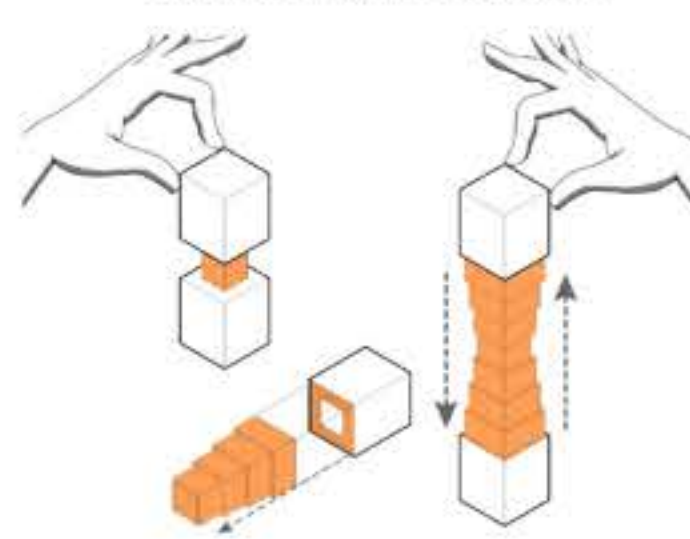
"Built for Change"

After reviewing Chapter 12: Built for Change of How Buildings Learn, the ad-vocation for adaptable design is echoed through the call on reducing the solid waste burden of demolished buildings, and **promoting the longevity of structures to support generations of communities.**

"A buildings foundation and frame should be capable of living 300 years"

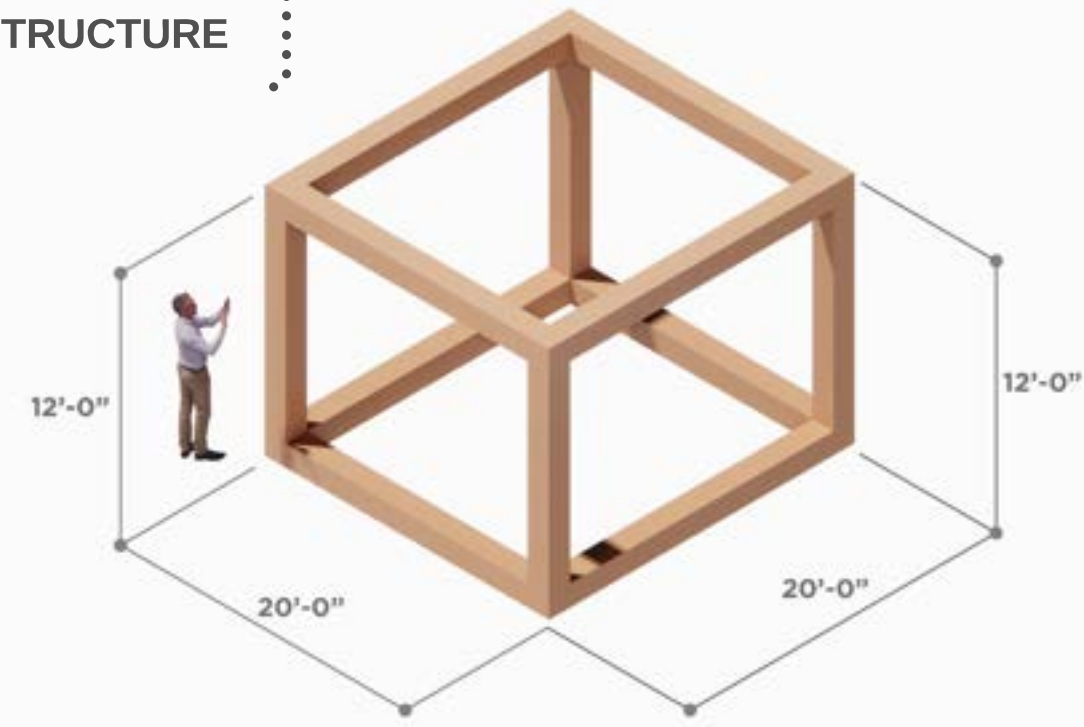
"Nesting Doll-itecture"

Since structure and foundations are the most resilient proponents to building construction, why not design them to **expand and contract to adapt to needed program space**. By following the method of nested dolls, buildings can be designed in a way to allow for expansion and contraction.



"Nested Adaptability"

STRUCTURE



[Circular Economy]

[Adaptive Housing]

[Prefabrication]

[Modular]

Eco-Social Resilience

ASSEMBLY



01
SPATIAL +
HOUSING
ARRANGEMENT



STUDIO



SINGLE



LOFT



DOUBLE DECKER

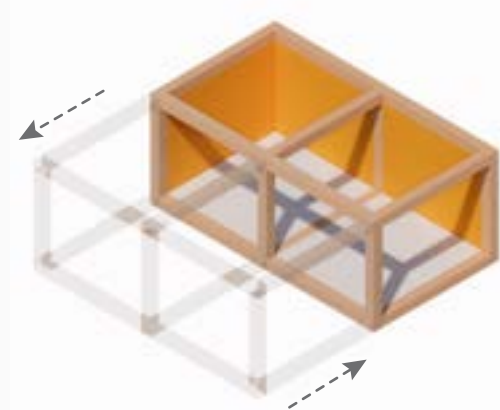


L CORNER

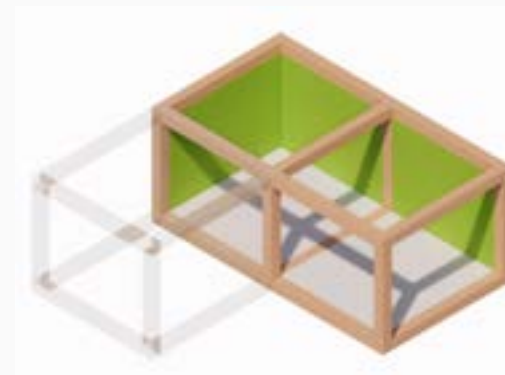


FULL

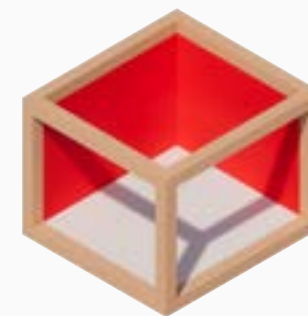
02
PROGRAM
INTERNAL CO-OP
EXTERNAL CO-OP



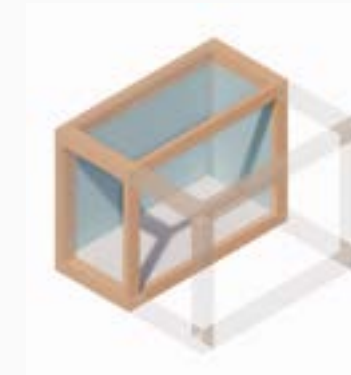
CO - LIVING ROOM



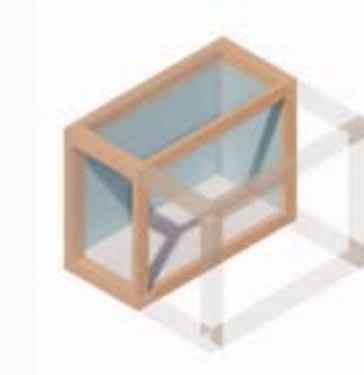
CO - KITCHEN



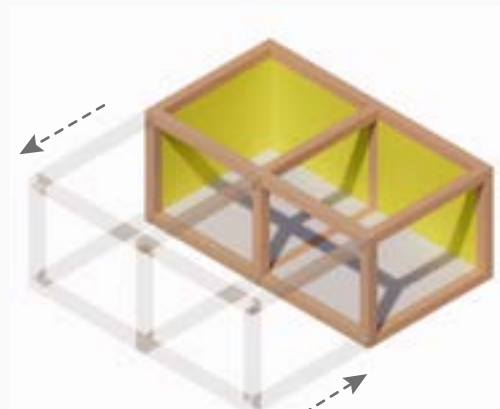
CO - MEDIA



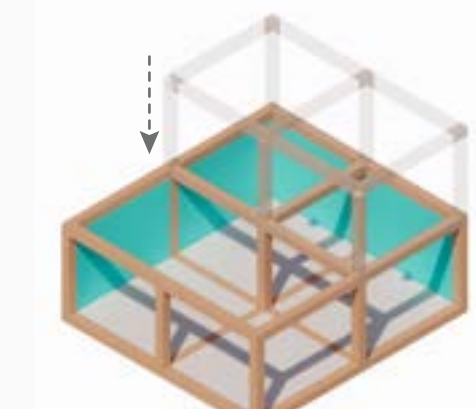
LAUNDRY



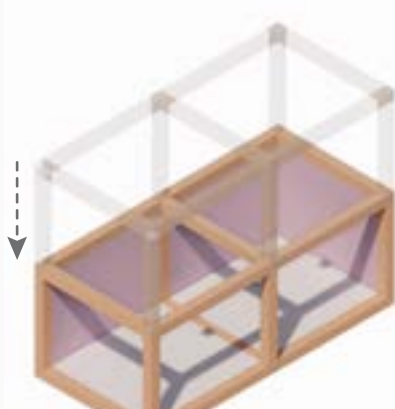
STORAGE



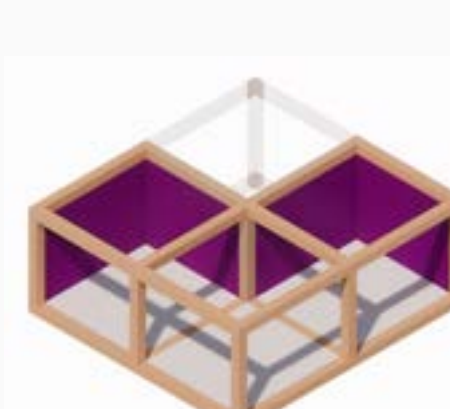
MAKER SPACE



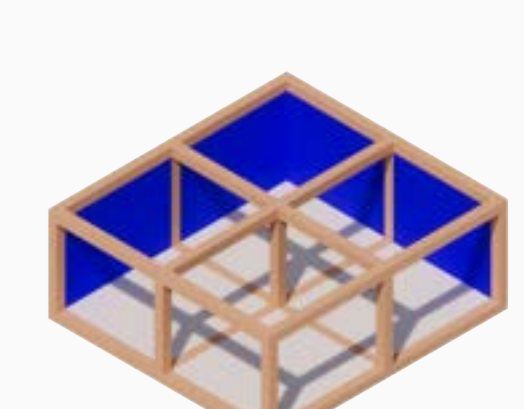
HEALTH AND FITNESS



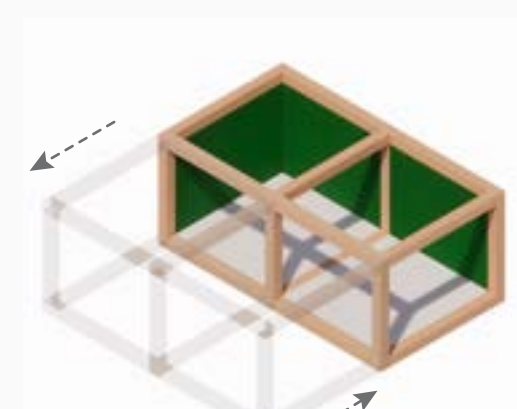
CAFE



CO - WORK



MARKET



VERTICAL FARM

03
SERVICES



CIRCULAR WASTE
MANAGEMENT



WATER RECLAMATION



SOLAR ENERGY



WINDOW



BALCONY



BENCH



LOUVERS



TRELLIS



PORCH

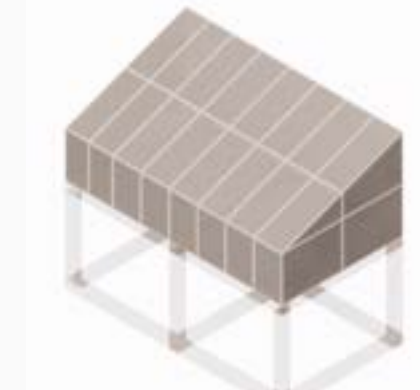


GREEN ROOF

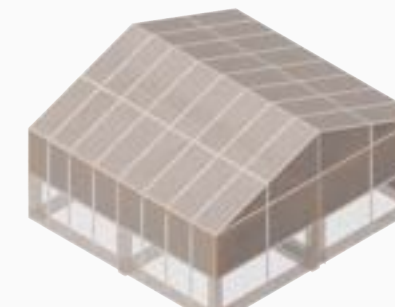
04
ASSETS



RECREATION



GREENHOUSE



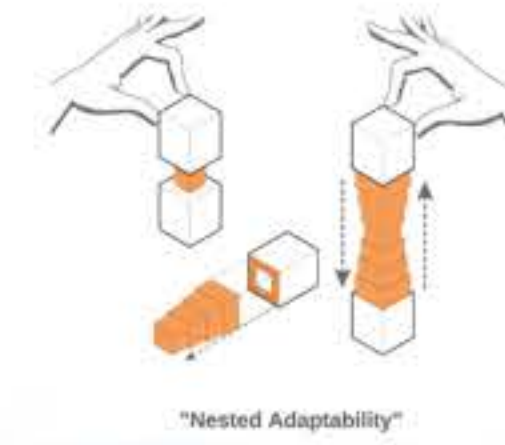
WINTER GARDEN



PROTOTYPE 01:

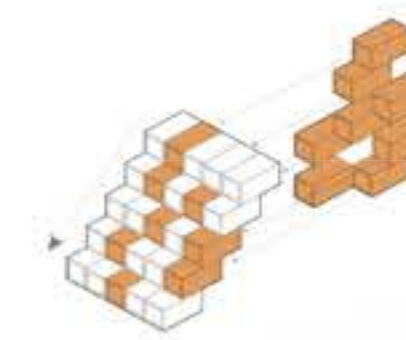
DENVER, COLORADO:

Denver is on the verge of a housing crisis. With more youthful generation flocking to Denver, a demand for housing is greater than ever. Colorado needs to produce roughly 50,000 housing units each year for five years to avoid economic downfall.



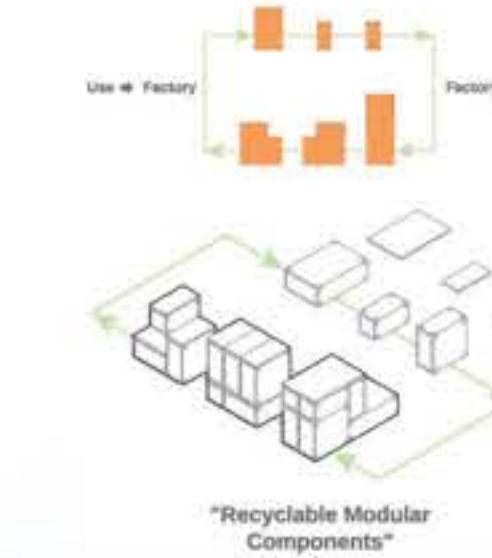
Nested Adaptability:

By designing the structure to be the most resilient component of the modular system, one can nest structure within a module, to allow for expansion of the module to adapt to increased program.



Housing Landscape

By designing the housing landscape like a face of a mountain, dwellings can simply erode away through demount-ability creating space for new/existing dwellings. This design initiative would allow for adaptability and managing of circular waste flows.



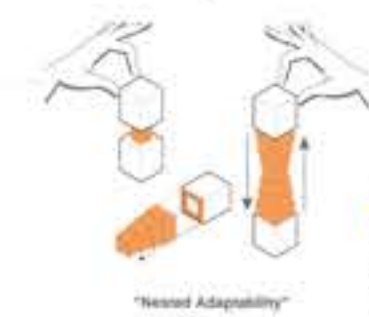
Lego Principle

By applying the Lego principle, mass produced components can be designed with de-mountability for infinite configurations and reuse. When the components have lice out there life cycle, the manufacturer facility can take back for recycling management.



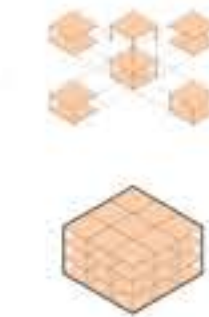
Apartment Vending

A basic underlying structure allows modules to be placed whenever change is needed. By adopting an operational strategy like the company Carvana, modular housing units could be purchased through an "Apartment Vending Machine".



Nested Adaptability:

By designing the structure to be the most resilient component of the modular system, one can nest structure within a module, to allow for expansion of the module to adapt to increased program.



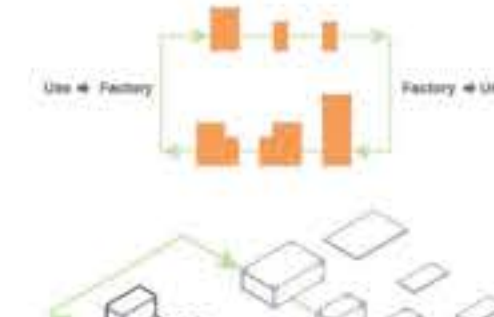
De-mountable Housing:

Designing the structure to be assembled and deconstructed with universal ideas, helps to manage the adaptability and circular economy of the structure, by extended its life cycle.



Sharing Platform

Following the principle of a shared platform, spaces within modules like co-working can reach a level of adaptability and sensibility without the need to build more space. Residents can interact with spaces in a sharing platform.



Lego Principle

By applying the Lego principle, mass produced components can be designed with de-mountability for infinite configurations and reuse. When the components have lice out there life cycle, the manufacturer facility can take back for recycling management.



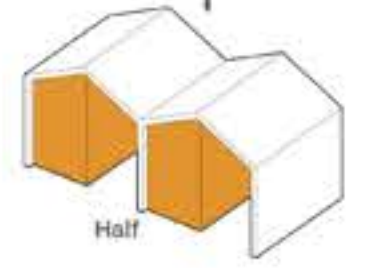
A New Timber Building Element

The creation of a standard timber structural component, protected behind a removable envelope, connections between the elements to provide disassembly and reuse. Along with being reusable, timber is 99% recyclable as is and can be biologically down-cycled.



Circular House

The goal of this tactic is to design the housing unit to conform to circular economy principles where at least 90% of all material can be reused at a high value. Facade components are an option to reclaim and recycle local material for envelope manufacturing.



Half a House

Often times, families and individuals can't afford a large "good" house, and are left with smaller homes or building blocks. Why not give them half a good house, instead of a small finished house?

