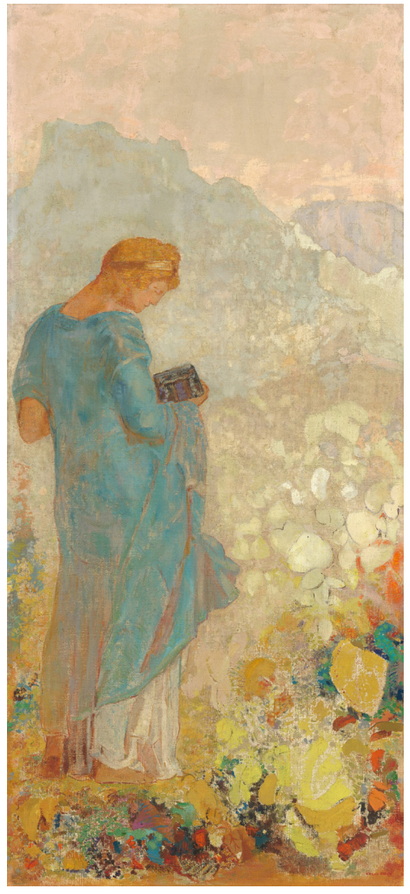
Research Plan

A CRAFTED KIT-OF-PARTS



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Re-designing the Hugo R. Kruytgebouw with a biophilic design approach as a proof-of-concept to re-nurture natural and traditional ways of making.

keywords : *biophilic design, craftsmanship, circular economy, linear economy, demountability, dry connections, design-build, CO_2 emissions, thinking through making, material awareness*

Image on Cover

Odilon Redon
French, 1840–1916
Pandora, 1910/1912
oil on canvas, 143.5 x 62.9 cm (56 1/2 x 24 3/4 in.)
National Gallery of Art, Chester Dale Collection

"In both natural resources and climate change, we are facing a physical crisis largely of our own human making. The myth of Pandora has become now a secular symbol of self-destruction. To deal with this physical crisis we are obliged to change both the things we make and how we use them. We will need to learn different ways of making buildings and transport and to contrive rituals that accustom us to saving. We will need to become good craftsmen of the environment." —Dr. Richard Sennett, *The Craftsman*[1]

1.0 Motivation

The Netherlands is one of many European countries facing challenges with its existing building stock, some of which include: vacancy, poor energy performance and lack of integrated sustainable and circular practices[2]. In fact, the Dutch Government has set itself a goal to, reduce "the energy consumption in the existing building stock by 50% compared to 1990 levels, and construct only energy-neutral buildings by 2020."[2] The demands have caused a shift in Dutch municipal and national policies in order to achieve the climate goals. The Dutch government added Chapter 5 to the National building code (*Bouwbesluit*) to address energy efficiency and environmental construction[2]. The ultimate goal of the *2012 Bouwbesluit* is to "encourage the use of energy efficient technologies of new and existing buildings and to support the reduction of CO_2 emissions."[2] A recent hindrance in new construction, however, is the *Urgenda* Climate Case due to the ambitious climate goals set by the government[3].

One could argue that the most concerning issue with the global building and construction sector today is its model of production. According to the IEA Global Status Report for Buildings and Construction 2019 the industry accounts for 36% of final energy use and 39% of energy and process related CO_2 emissions, 11% of which results from steel, cement and glass materials and products[4]. In fact, concrete remains as the most commonly used materials for construction in the Netherlands[5]. Adopting more bio-based materials for construction could save and protect the biodiversity of the natural environment and rapid depletion of natural resources[5]. Many United Nation Sustainable Development Goals (SDGs), which the citizens of the world are asked to meet with urgency by 2030 in order to "achieve a better and sustainable future for all" also focus on addressing the impact current building and construction industries have: SDG 3 – Good Health and Wellbeing, SDG 7 – Affordable and Clean Energy, SDG 8 – Decent Work and Economic Growth, SDG 9- Industry, Innovation and Infrastructure, SDG 11 – Sustainable Cities and Communities, SDG 12 – Responsible Consumption and Production, SDG 13 – Climate Action, SDG 15 - Life on Land and SDG 17 – Partnerships for the Goals[5]. Architects and engineers, however, need familiarity with the design of sustainable buildings in order to contribute to the SDGs[6].

According to Antony Funnell from ABC Radio National, there are problems surrounding the SDGs since there is no agreement on what "sustainable development" means and how it should be measured. With global industries joining the SDGs movement, they are developing their own green reporting standards—meeting these goals has become a trillion dollar industry. Some researchers claim that this movement is a form of corporate greenwashing, while others see it as a misplaced ideal that could worsen, rather than prevent social and ecological destruction. The term sustainability also recieves criticism, since some think it may be too late for sustainable development[7]. MIT Emeritus Professor Dennis Meadows, for example, states that he feels it is too late for sustainable development and it is now time for resilience[8]. Meadows states that he is talking about long-term resilience, a system that absorbs shocks and continues functioning in order to take care of basic needs. He warns that people using the term sustainable development cannot purley rely on the "magic of technology" to prevent less harm to the environment or depletion of resources, it requires cultural and social change as well (i.e., changing how we live, using fewer resources, valueing things in another way[78]). Meadows states, sustainable development may have been possible back in the 1970s, but not when we're at 150 percent of the global carrying capacity[7]. This graduation project, however, will not clarify or investigate the term "sustainable development", instead, simply use Dr. Meadow's term "resilience[8]."

One concern, however, is clear: new and existing buildings need to be built and re-designed differently in order to drastically lower the emissions of the building and construction sector and to save what remains of the natural environment. Possible solutions could be: to implement a biophilic design[9] approach, which focuses on reconnecting humans with their natural environment,

[1] Sennett, R. (2009). The Craftsman. London: Penguin Books.

[2] Brilhante, O., & Skinner, J. (No. 1, 2014). *European Experiences of Building Codes for Promoting Sustainable Housing.* Institute for Housing and Urban Development Studies (IHS) Rotterdam, The Netherlands.

[3] Environmental Law in the Netherlands: A Whole New Ball Game. (n.d.). Retrieved from https://whoswholegal.com/features/environmental-law-in-the-netherlands-a-whole-new-ball-game

[4] IEA. (n.d.). Global Status Report for Buildings and Construction 2019 – Analysis. Retrieved from https://www.iea.org/reports/global-status-report-for-buildings-and-construction-2019

[5] Sustainable construction, a way to decrease deforestation and face global warming. (n.d.). Retrieved from https://www.innovate.community/deelnemer/sustainable-construction-a-way-to-decrease-deforestation-and-face-global-warming/

[6] Take Action for the Sustainable Development Goals – United Nations Sustainable Development. (n.d.). Retrieved from https://www.un.org/sustainabledevelopment/sustainable-development-goals/

[7] Brilhante, O., & Skinner, J. (No. 1, 2014). *European Experiences of Building Codes for Promoting Sustainable Housing.* Institute for Housing and Urban Development Studies (IHS) Rotterdam, The Netherlands.

[8] Magazine, S. (2012, March 15). Is it Too Late for Sustainable Development? Retrieved from https://www.smithsonianmag.com/science-nature/is-it-too-late-for-sustainable-development-125411410/

[9] Kellert, S. R. (2018). Nature by design: The practice of biophilic design. New Haven, CT: Yale University Press.

re-nurture natural building materials during construction and implement dry building connections to reduce future material waste. Another possible alleviation lies with the implementation of the circular economy[10]. Most industries today follow a traditional linear economy production model which is based on a take, make, dispose model, while a circular economy is based on a regenerative approach[11]. Alternative building processes that place a high priority on how materials are joined in construction and the impact they have on the environment are in urgent need. In this way, existing buildings could acquire a second-life that is more resilient and climate friendly.

1.0.1 Why focus on existing 1960s concrete buildings?

Buildings from the 1960s are in need of refurbishment, reaching a building life-cycle of sixty plus years and several sheathing layers are in need of an upgrade[12]. Many urgently need a new facade, yet, one must also remember that within the facades of 1960s buildings there often lie toxic materials such as asbestos[13]. Having to face challenges of re-furbishment such as toxic materials, questions of material awareness and future construction methods arise. The ways in which buildings were constructed in the 1960s should not persist today. Therefore, revisiting traditional ways of making like building with timber, using dry connections and implementing natural materials could help create a more circular building process that does not harm users, pollute the environment or deplete natural resources[14]. Following a biophilic design approach harnesses all of these mentioned aspects.

Additionally, existing concrete buildings have accumulated layers of history and stood the test of time, they are also rooted in a place and thus have many stories associated with them — a rich *genius loci*[15]. One could also argue that existing structures are the most sustainable building since, depending on the way of calculation, "more carbon is emitted during the construction phase than during its entire lifetime."[16] This graduation proposal thus argues for the reclaiming of existing structures and providing them with a second life of state-of-the-art standards through the implementation of a biophilic design approach, aiming to challenge the contemporary building practices in the Netherlands, enhance the sensory relationship humans have with the built environment and advance people's health, fitness and well-being[17].

The collective fascinations examined in this study are as follows: biophilic design strategies, nature inclusivity, material appreciation, craftsmanship, demountability, dry-connections, the circular economy and bio-based materials. The addressed themes of the TU Delft architectural engineering studio are: *STOCK*, *MAKE* and *FLOW*[18].

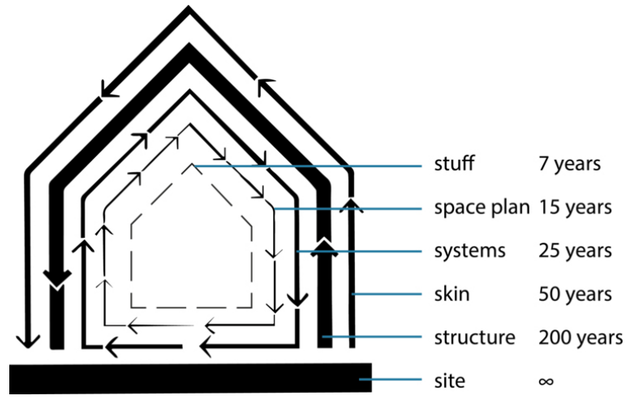

Figure 1 : Manifesto. (n.d.). Shearing Layers of Change by Stewart Brand. Retrieved from https://www.openbuilding.co/manifesto

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[12] Manifesto. (n.d.). Shearing Layers of Change by Stewart Brand. Retrieved from https://www.openbuilding.co/manifesto

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1.0.2 Revisiting Craftsmanship

To merge the design and research ambitions for this aE graduation project, an interest in traditional ways of making is revisited—this starts with revisiting the term "craftsmanship." Dr. Richard Sennett states in his book, *The Craftsman*[1], that craftsmanship focuses on the intimate connection of the hand and the head. There is a dialogue between concrete practices and thinking; these dialogues evolve into habits which then evolve into habits establishing rhythm between problem solving and problem finding[1]. Sennett argues that craftsman gain knowledge through the hand by touch and movement and that motivation matters more than talent[1]. Thus, good craftsman use solutions to uncover new possibilities, the process of asking questions such as "Why?" and "How?" are intimatley related in his or her mind. In this way, craftsman can both step into Pandora's shadow and step out of it[1].

Personally, I have been fortunate that my past studies have opened me to the world of the analogue design process. In my bachelor studies I worked closely with my hands, I made physical models and spent hours drawing on a drafting board. Digital tools such as CAD and 3D modeling tools were used as well, but that was not the way my design process commenced—it always relied on good old-fashioned handwork first. This was due to the pedagogy my University practiced, a method of teaching that was adopted from Josef Alber's foundation course taught at the Bauhaus in Dessau, Germany[19].

According to Elizabeth Cronin and Zachary Wignall, both editors of the first VORKURS book, Making[17], analyzing craft and experiential learning is a method for understanding materials and their limitations in the field. It results in a search for a more fluid future of the profession, one that resides in the foundations of making and material processes—bridging further the gap between academia and practice[19]. Methods of learning become the foundational tools for developing individual design processes; thus, this graduation project acts as a point of departure to collect my academic and personal interests and become a skilled and independent craftsman in the architectural field[19].

Referring back to Dr. Richard Sennett's quote[1] seen written above the section, 1.0 Motivation, we are are currently facing a crisis of our own making which is impacting natural resources and the global climate. To deal with this, we urgently need to change both the things we make and how we use them—this includes finding different ways of making buildings[1]. Could a design process which mediates between drawing and construction, start by researching historical and modern wood-to-concrete connections in order to discover an approach that provides alternatives for the building process and way in which materials are joined in construction? Could this then result into a design exploration of demountable bio-based materials and architectural craftsmanship, contributing to the en-richment of the existing brutalist Hugo R. Kruytgebouw? A process of thinking through making will prove relevant when conducting this graduation research.

1.1 Problem Statement

Existing 1960s concrete buildings in the Netherlands do not meet state-of-the-art standards, they also lack the integration of natural materials and the sustainable use of natural resoures[20]. Integrating dry connections, like those present in historic timber frame construction, along with bio-based materials (i.e., timber, clay and hemp) can serve as a circular building model for the Dutch government to adopt today to help lower CO_2 emissions, reduce waste and foster resilient[8] growth and development in tune with the natural environment. Using a biophilic design model could help harness there circular aspects and reveal the importance of nature in the built environment[9].

1.2 Objective

This graduation project analyzes case-studies of existing historic and modern wood-to-concrete connections (although historic case-studies may instead refer to wood-to-stone connections) in order to make the construction of the Hugo R. Kruytgebouw in Utrecht's Science Park up to state-of-the-art standards and circular. Reiterative physical prototypes of wood-to-concrete connections are made throughout the study to put the research into practice. Overall, this study uses a hands-on approach that searches for alternative building methods which promote circular and resilient building practices as well as the contact with nature in our built environment. The notion of craftsmanship is revisited in order to argue for a more tactile approach in the current architectural field of practice.

[19] MAKING (Vol.1, 2019). *VORKURS*. The University of Florida, Graduate School of Architecture, p. 7.

[20] Larsen, K. E., & Marstein, N. (2000). Conservation of historic timber structures: An ecological approach. Oxford: Butterworth-Heinemann.

1.3 Overall Design Question

DQ : How can a biophilic design approach guided by exploring historic and modern wood-to-concrete connections lead to the harnessing of nature and bio-based materials in existing 1960s concrete buildings in the Netherlands such as the brutalist Hugo R. Kruytgebouw?

1.4 Thematic Research Question

TRQ: How does examining historical and modern wood-to-concrete connections lead to an approach that provides alternatives for the modern Dutch building process and way in which materials are joined in construction?

1.4.1 Sub-Research Questions

SRQ1 : How can dry-timber connections contribute to reducing material waste and CO_2 emissions during the construction process?

SRQ2 : What are the advantages and disadvantages of historic and modern wood-to-concrete joinery methods?

SRQ3 : How can new timber additions affect human health and well-being in the existing brutalist Kruytgebouw?

Figure 2 : van Hemert, I. (2018). The Hugo R. Kruytgebouw. [Photograph]. Your Captain Luchtfotografie.

2.0 Key Concepts (Epistemes)

This project deals with the following fields of knowledge:

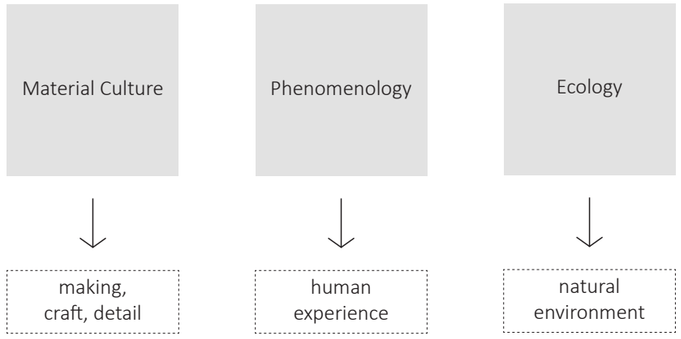


Figure 3 : Epistemes Diagram

During research, a brief discussion on the hand and traditional role of the architect occurs, as well as an examination of the term “architectural craftsmanship.” A historical analysis of joining wood-to-concrete follows with a material analysis in order to understand the advantages and disadvantages of different wood types. How were timber buildings joined in the past? What tools and techniques were used? What role did the architect have? Was there a difference between craftsman and architect? How circular were these methods? What if these historic ways of joining timber were used in modern timber production? Has the role of the machine placed craftsmanship in jeoprady? These are some questions that help guide the historical analysis work for the research paper. The episteme, material culture is most relevant throughout the research phase since a thorough historic and modern analysis is needed in order to develop reiterative material connection prototypes of timber (new) and concrete (existing) throughout the project development.

During design, knowledge acquired from the research phase is applied to a specific case-study: the Hugo R. Kruytgebouw in Utrecht’s Science Park. To apply the knowledge accordingly, an investigative study of the site first takes place, stemming from site visits and analytical drawing. Soon after, an analysis is conducted to see how current inhabitants of the Kruytgebouw use the building. In this way, the episteme phenomenology plays a role in uncovering the existing user demands and needs of the building as well as existing design qualities that need improving. The episteme ecology is present in order to nurture and enhance the existing natural environment of the site for future resilient growth and development. The overall design process relies on a tactile approach, using the hand to mediate between drawing and construction, resembling the traditional approach of an architect.

The research and design phases are addressed simultaneously in order to meet the target goals of the working schedule shown under section 3.0 Planning.

2.1 Methods & Methodology

This graduation research relies heavily on thinking through making. A process more typically associated with the traditional role of the architect. Making allows for the reiterative development of of 1:1 scale material prototypes which merge historic timber connection techniques with new ones. An analysis of historic and modern case-studies is conducted in which dry timber is applied to concrete and where the celebration of the joint proves important. An inquiry into relevant practicing firms which rely heavily on the process of thinking through making is also done (i.e., Renzo Piano Building Workshop (RPBW), Studio 804 by Dan Rockhill and Werkstatt in Eindhoven[21]). To make clear how the research and design phases are to be conducted, a list of methods are provided below:

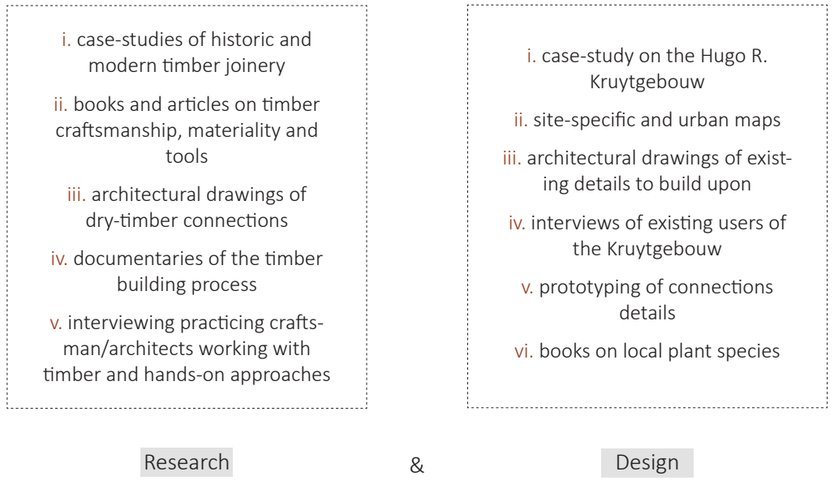


Figure 4 : Methods Diagram

2.2 Reflection on Methods

The selected methods revealed in section 2.1 Methods & Methodology, contribute to a methodology that seeks to build upon state-of-the-art research already available in multiple forms. It is important to learn from previous works through means of: case-studies, books, articles, architectural drawings, mappings, documentaries and interviews since this allows for an enriched architectural study.

It is, however, important to note that some methods are more advantageous than others. In addressing the overall design question (DQ), thematic research question (TRQ) and sub-research questions (SRQ1, SRQ2), exhibited on page ix, information collected from these methods may not be as unbiased or neutral as expected unless further revision is taken. This is in part due to the short-comings these methods may have such as overseen biases and limited citation credibility. It is important to re-examine all methods used since some may not be as meticulously peer-reviewed as originally expected.

Analyzing architectural drawings and maps may prove to be two of the most difficult methods used for this investigative study, since they involves subjective thinking unlike the rest. Finding a way to analyze these methods with the use of other cited sources, however, may prove to more beneficial since this then allows a subjective approach to be strengthened by other credible peer-reviewed sources.

Interviews could serve to be most beneficial when acquiring relevant knowledge from primary sources. As previously stated however, thorough revisions are needed in order to see whether credit is correctly given. The same applies to books and articles used as primary sources or secondary and tertiary sources like documentaries.

Making material prototypes during the design phase is the result of merging conducted research with practice. The advantage of this method is that it is an objective analysis; however, shortcomings may be that there are limited testing opportunities or that the degree of testing may not be up to the standards of other conducted studies.

[21] Pallasmaa, J. (2015). The thinking hand existential and embodied wisdom in architecture. Chichester: Wiley, p 068.

3.0 Planning

Research Questions	What data is required?	How is the data collected?	How is the data analyzed?	Whats are the hypotheses?
DQ : How can a biophilic design approach guided by exploring historic and modern wood-to-concrete connections lead to the harnessing of nature and bio-based materials in existing 1960s concrete buildings in the Netherlands such as the brutalist Hugo R. Kruytgebouw?	• Technical understanding of dry timber connections • Site analysis to see what other natural materials could be harvested or added to the refurbishment — Hempcrete with clay plasters?	• Case-studies • Reviewing drawing archives • Site visits/Site analysis/Mappings • Physical and Digital model making • Analogue drawing with some CAD • Interviews	• Through the act of making • Iterative drawing and constructing	• Will be revealed after an iterative design process
TRQ : How does examining historical and modern wood-to-concrete connections lead to an approach that provides alternatives for the building process and way in which materials are joined in construction?	• Quantitative data on timber and concrete properties i.e. connection types (Historic case-studies may refer to stone rather than concrete)	• Literature • Case-study analysis • Architectural drawings • Documentaries • Physical model making	• 1:1 Material Prototyping of timber (new material) and concrete (existing material)	• Historic techniques relied on available local resources and used a more circular approach in order to reuse structural elements. Learning from these techniques could help make dry connected bio-based materials be the norm again
SRQ1 : How can dry-timber connections contribute to reducing material waste and CO_2 emissions during the construction process?	• Quantitative data on timber and concrete properties • Quantitative data on CO_2 emissions	• Literature • Case-study analysis	• Data gathered from the overall TRQ will be used to build-upon with new findings from SRQ1	• Dry timber connections can be 100% biodegradable, especially if timber frame elements are used without glues. This process can be prefabricated off site to reduce waste and lower emissions
SRQ2 : What are the advantages and disadvantages of historic and modern wood-to- concrete joinery methods?	• Quantitative data on timber properties i.e. connection types • Knowlede on the circular and linear economy	• Literature • Case-study analysis	• Data gathered from SRQ1 will be used to build-upon with new findings from SRQ2	• The overall building process can be re-designed by looking back at traditional ways of timber construction. This can help reduce waste, lower emissions and aleviate the depletion of natural sources used to make non bio-based building materials
SRQ3 : How can new timber additions affect human health and well-being in the existing brutalist Kruytgebouw?	• Quantitative data on timber and concrete properties • Archival information of the Kruytgebouw's existing structure • Qualitative data from interviewing existing users of the Kruytgebouw	• Literature • Case-study analysis • Material analysis of timber and concrete •Interviews	• Data gathered from SRQ2 will be used to build-upon with new findings from SRQ3	• Timber provides a soft quality, while concrete a harsh one, merging both could be appriciated by the users in the Kruytgabouw

Figure 5 : Research Question Breakdown

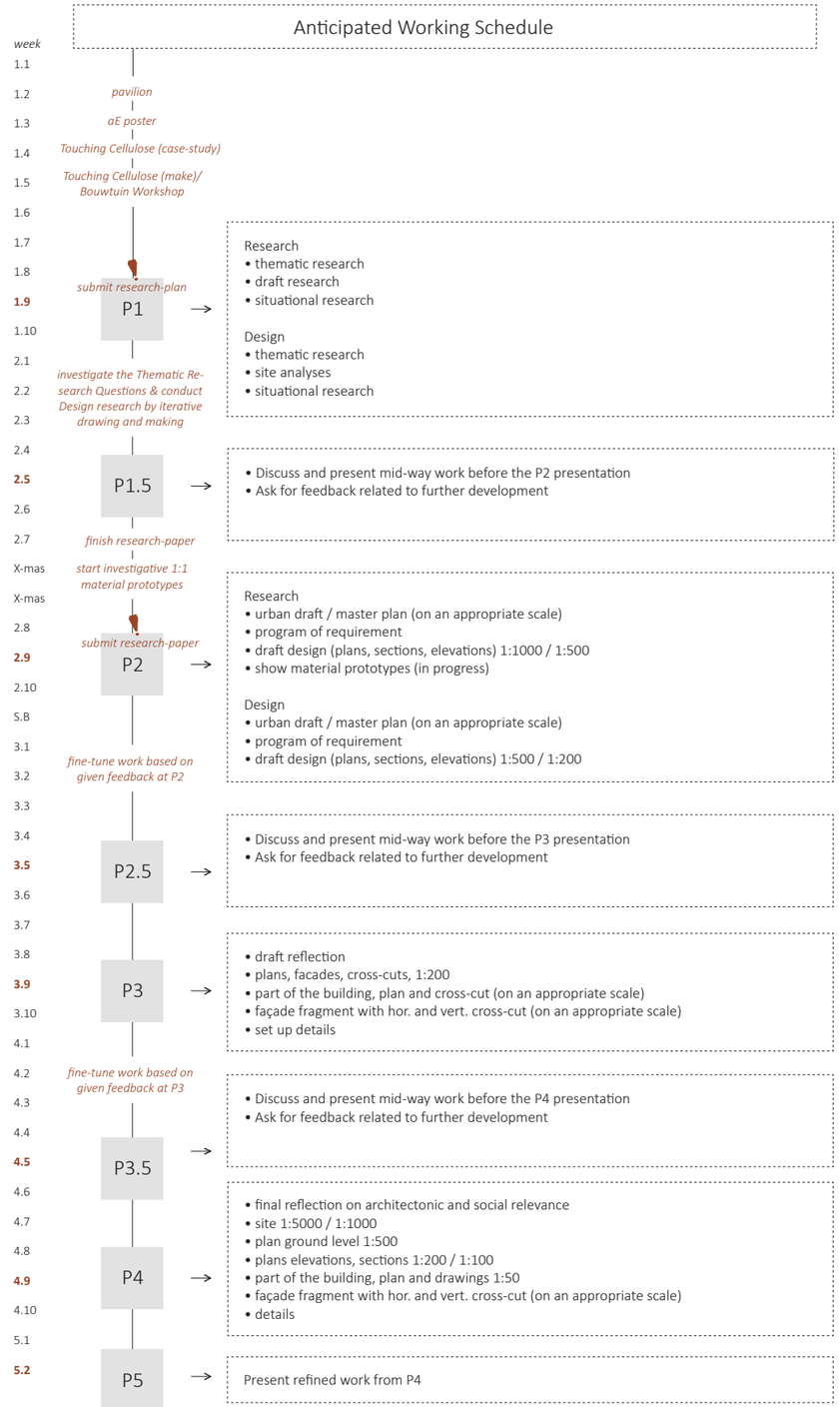


Figure 6 : Schedule (Based on Appendix 1 in the Graduation Manual) (2019). Graduation Manual. TU Delft. p 18.

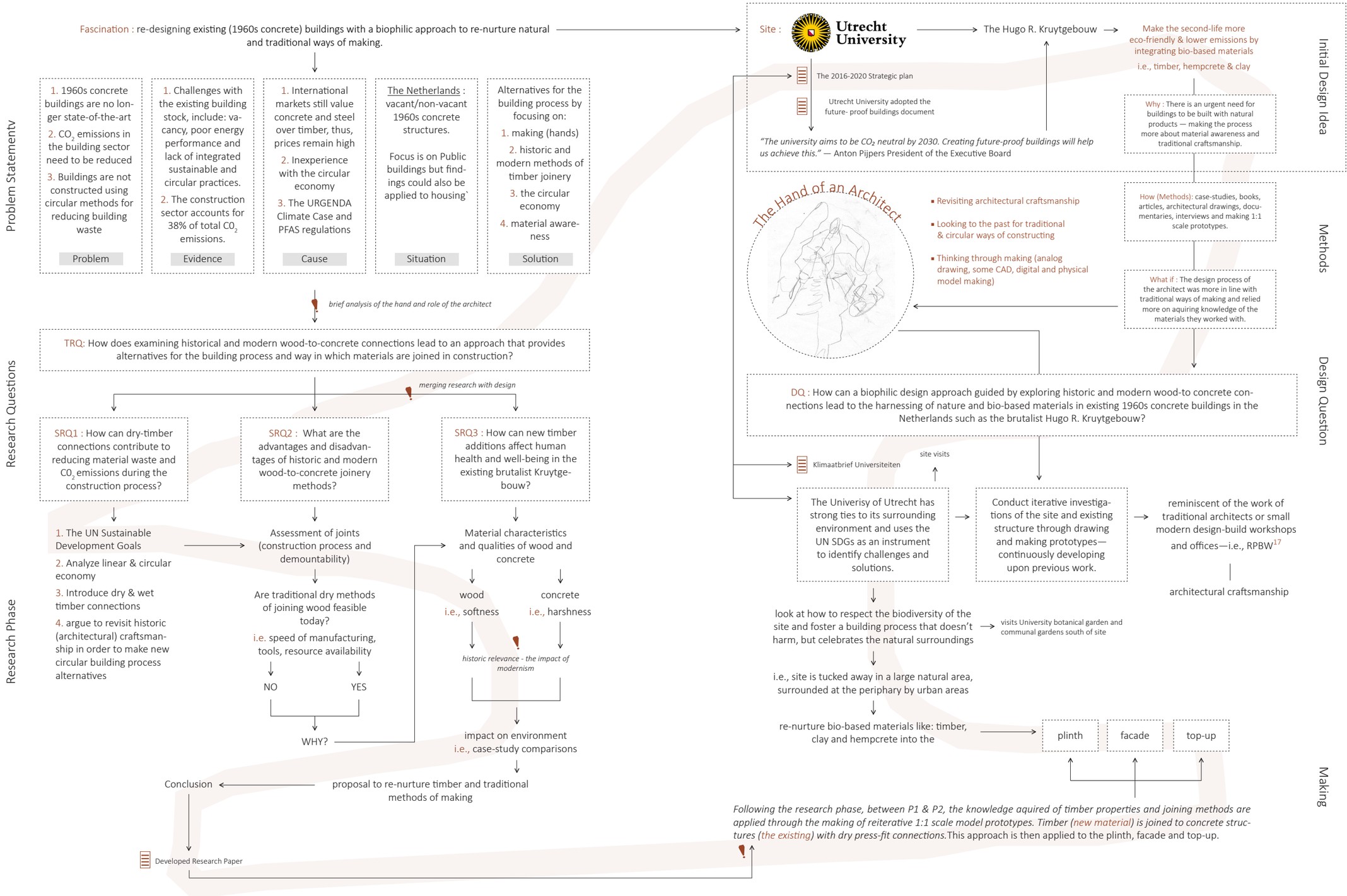
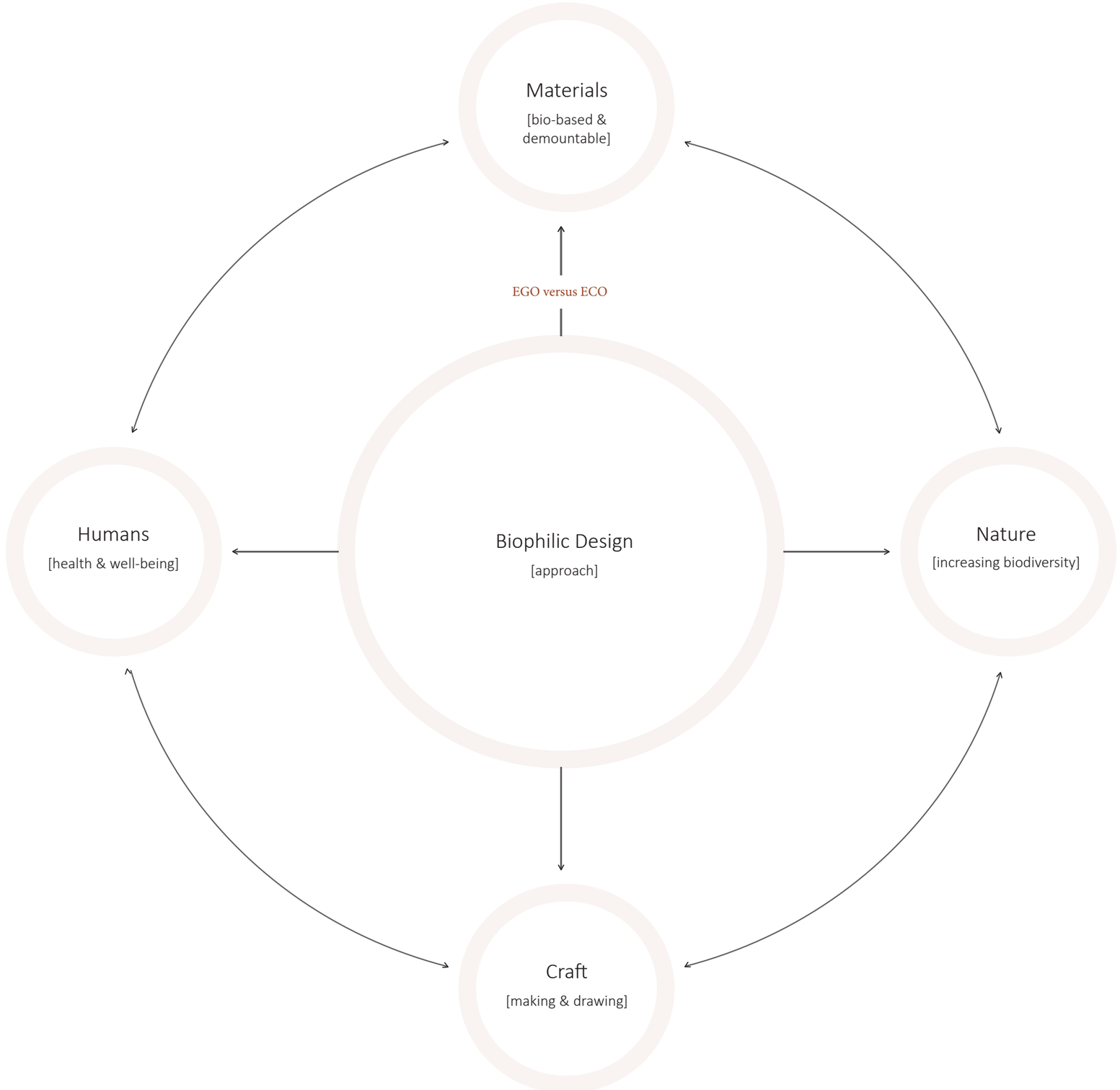


Figure 7 : Research Plan Diagram


Materials
[bio-based & demountable]
EGO versus ECO
Humans
[health & well-being]
Biophilic Design
[approach]
Nature
[increasing biodiversity]
Craft
[making & drawing]

3.1 Key Terms

Biophilic Design

is used as a design approach to stress the importance of nature in the built environment. Rather than seeing nature as an obstacle to dominate or overcome, biophilic design demonstrates how the natural environment and its resources (i.e., bio-based materials) can enhance human physical and mental health, performance and well-being[9]. Principles and practices of biophilic design are obtained from Stephen Kellert's book, *Nature by Design: The Practice of Biophilic Design*[9].

Craftsmanship

is defined by Dr. Richard Sennett in his book, *The Craftsman*[1], as a practice intimately connected by the hand and the head. There is a dialogue between concrete practices and thinking; these dialogues evolve into habits which then evolve into habits establishing rhythm between problem solving and problem finding[1]. Sennett argues that craftsman gain knowledge through the hand by touch and movement and that motivation matters more than talent[1]. He also states that due to the human-made crisis involving natural materilas and the climate, there is an urgent need for good craftsman of the environment[1]. In this context, this is applied to the methods in which buildings are constructed.

Sustainable Development

is used in the context of the United Nations Sustainable Development Goals (SDGs), in which the citizens of the world are asked to meet with urgency by 2030 in order to "achieve a better and sustainable future for all." In this graduation project, however, the term "sustainable development", is replaced by Dr. Meadow's term "resilience[8]."

Resilience

is usually attributed to MIT Emeritus Professor Dennis Meadows. It refers to a system that absorbs shocks and continues functioning in order to take care of basic needs.

Circular Economy

is based on a regenerative approach[11]. It is an alternative building processes that places a high priority on how materials are joined in construction and the impact they have on the environment (i.e., demountable connections, up-scaling and downscaling of products). Circular production methods aim to reduce waste by creating design strategies which help lower the amount of materials ending up in a conventional landfill[1011].

Linerar Economy

is a traditional production model which is based on a take, make, dispose model[10].

Demountability

involves the process of being able to take things apart. Buildings that are able to conduct such a process are deemed more circular and waste friendly. This is a process that will prove important for all circular buildings and products in the future. This process if typically mentioned when designing for deconstruction is involved[11].

Dry connections

involve moments of joining two or more elements without glues or adhesives. This makes the demountability process quicker and the reusability factor much great, resulting in parts to be up-scaled in the circularity approach, rather than down-scaled. Connections such as these usually still rely on metal components but historic techniques also purley relied on complex joints (i.e., japanese joints)[11].

Wet connections

usually are moments where joints are glued or poured over, resulting in fewer materials to be upscaled or re-harvested. At the end-of-life these materials will mostly be down-cycled or sent to the land-fill as waste[11].

Design-build

is a process usually conducted in smaller sized offices practicing architecture or other building practices in which they work closely with the design process as well as the production process. Firms referred to this way of working in this study are the Renzo Piano Building Workshop (RPBW), Studio 804 by Dan Rockhill and Werkstatt in Eindhoven[17].

CO_2 emissions

is used to refer to carbon-dioxide emission, usually in the context of the construction process.

Bio-based materials

usually refers to materials that are made from natural products such as plants, trees and animals. They may be modified/treated in combination with other materials. Some bio-based building materials are: wood, straw, leather, hemp, flax and coconut fiber[22].

Thinking through making

is a process closely involving the hand and its works, resulting in questions such as "Why?" and "How?". This term is closley used in combination with architectural craftsmanship.

Material Culture

is a field of knowledge that involves making, craft and detail.

Phenomenology

is a field of knowledge that involves the human experience. This proves relevent when conducting site analysis work such as mappings or interviewing users of the Kruytgebouw.

Ecology

is a field of knowledge that involves the natural environment. When re-designing an existing building the involvement of the existing landscape is an important aspect. There could be aspects that need improving in order to increase the biodiversity of the site and connection existing users have with the natural environment around them.

Nature- Culture Divide

refers to the relationship that nature and culture have, some think that they are opposite; however biological and cultural diversity are intrinsically linked and as regarded as the "key" to sustainable development[23]. It is time for architects to place a higher importance on the unity of nature in the design process.

[22] (2021, October 5). 2.5 Bio-based Products in the Built Environment Lecture. [Transcript of video file]. Circular Economy for a Sustainable Built Environment. Retrieved from https://learning.edx.org

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