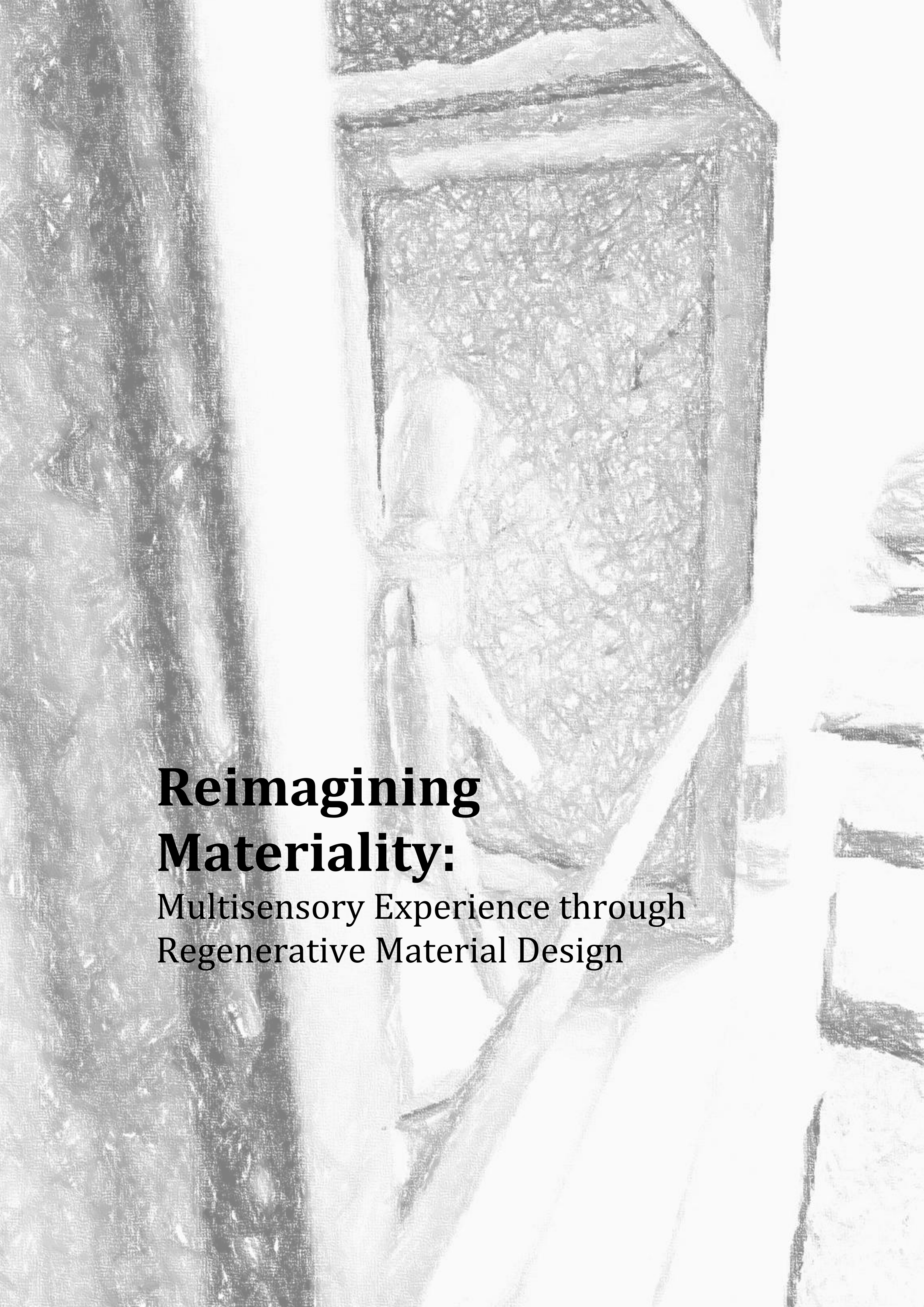

Reimagining Materiality:

Multisensory Experience through Regenerative Material Design

Reimagining Materiality:
Multisensory Experience through Regenerative Material Design

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A research component submitted to Auckland University of Technology in partial fulfilment of the requirements for the degree of Master of Architecture (Professional).

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Abstract

We must reconsider our relationship with materials. For too long, we have been extracting material from the earth and disposing of them in ways that damage our planet. However, there is a growing movement to find more sustainable and regenerative ways of making and using materials. This thesis explores materiality through an investigation of the sensory qualities of regenerative materials made from local waste and plant materials. Through extensive experimentation, a wide range of samples have been generated. These suggest future possibilities for deeper material connection, adaptable objects and environments. The research also addresses the challenges and opportunities of using regenerative materials in design.

The thesis develops novel design strategies for creating more sustainable, sensory, and embodied design experiences through materials. It draws on insights from philosophy, anthropology, and design studies to investigate how a multisensory approach to materiality can generate more sustainable and meaningful designs. Such regenerative materials are produced, used, and disposed of in ways that support and restore life. They are made from renewable resources and can be used, composted or recycled at the end of their life. While the samples and artefacts produced are speculative rather than functional, they contribute to a shift towards responsible materials with a focus on bio-loops, lifecycles and a deeper connection with the life world through our senses.

This thesis proposes that a multisensory approach to design through regenerative materials is critical to the creation of a more sustainable future. By engaging with material aesthetics, we can gain a deeper understanding of how we affect and are affected by the world. We can develop material strategies that support and restore life.

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Attestation of Authorship

I hereby declare that this submission is my own work and that, to the best of my knowledge and belief, it contains no material previously published or written by another person (except where explicitly defined in the acknowledgements), nor used artificial intelligence tools or generative artificial intelligence tools (unless it is clearly stated, and referenced, along with the purpose of use), nor material which to a substantial extent has been submitted for the award of any other degree or diploma of a university or other institution of higher learning.

Signed:

Date 26.02.25

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Introduction

This thesis explores the integration of sensory design approaches with regenerative materials resulting in samples and an installation that engage multiple senses including touch, sight, sound, smell, and taste thereby fostering a deeper connection between people, materials and the environment.

The motivation behind this investigation is twofold. First, it addresses the urgent need for environmental sustainability in design and architecture by reducing reliance on finite resources. Traditional materials, often derived from extractive, linear production processes, contribute significantly to climate change through high carbon emissions and resource depletion. In contrast, regenerative materials offer a promising solution by reducing reliance on non-renewable resources and minimising environmental impact through sustainable sourcing and production practices. Second, this research seeks to enhance the user experience through multisensory design. Conventional architectural materials are primarily selected based on visual and structural properties, often overlooking their potential to engage other senses. By exploring the touch, sight, sound, and smell qualities of regenerative materials, this study aims to foster deeper connections between people and their built environment, encouraging a more immersive and responsive material experience.

The research was guided by the following questions:

Can the sensory qualities of regenerative materials be utilised to foster deeper connections between people and the environment?

Can exploring the sensory qualities of local regenerative materials reveal their potential benefits and challenges in design?

How can the sensory aesthetics of regenerative materials inform architectural thinking, and in what ways might they enable speculative approaches to designing future sustainable environments?

An initial inspiration for this research was the edible cement developed by researchers Sakai and Machida from the University of Tokyo in Japan using food waste to produce cement (Ghisleni, 2023) In addition to producing a functional, sustainable, cement alternative, this material retained the smell, colour and taste of the source materials (e.g. orange peel, Chinese cabbage). I was intrigued by the contradictions this material posed to the predominantly visual and functional approach to the specification of materials in architecture.

Architecture has been recognised as a visually oriented discipline (Wastiels, Schifferstein, et al, 2013) While all the senses are involved in the way people experience architecture, architects have tended to focus on visual aspects during the design process (Pallasmaa, 2005). The association of aesthetics with sight – and its implicit objective distancing - has drawn from the philosophical ideas of Kant and Hegel who rejected the aesthetic and artistic relevance of the 'proximal' or embodied senses -of smell, touch and taste (Shiner 2021).

Architectural aesthetics have traditionally focussed on the visual, through form, shape, and style (Uzunoglu, 2012). However, the word aesthetics derives its name from the Greek term for sense perception (Shiner 2021). More recently there has been a revaluation of the importance of the proximal senses through both the empirical sciences and the philosophy of perception, demanding the rethinking the issue of aesthetics. As Laura Marks writes "Recent questions of the affective dimension of sensuous experience permit new dimensions of epistemology and ethics that are immanent, grounded in the particularity of experience. Sense experience operates at a membrane between the sensible and the thinkable." (Marks, 2008, p.123). I believe it is important for architects to anticipate and heighten people's experiences and awareness by considering different sensory inputs when making design decisions. In the context of material selection, this is not just an aesthetic consideration but also has ethical implications. The standardised, often imported materials we use are determinedly lacking aesthetic ‘proximity’ – if they smell, they smell of chemicals, produced elsewhere and sometimes keeping us at a distance. If they have textured its often mechanically produced or even just a visual representation of texture. The sense of interconnectedness with our environment and lifeworld develops through ‘a sustained awareness of the inter-relatedness between one's self and the rest of nature’ (Pramova, Locatelli et al. 2021. P,352). We need to extend this awareness into our material environments. Local materials and our relationship to them heighten a sense of place, enhancing peoples emotional and psychological relationships to local environments and the symbolic meanings they give to them. This project experiments with the development of localised, regenerative materials, with multisensory dimensions to explore ways of increasing this interconnectedness and awareness through materiality into architecture.

My passion for materials stems from a deep fascination with how they shape our environments and influences our sensory experiences. Coming from Sakai and Machida a design solution and architecture background with a focus on sustainability, I have always been interested in the intersection of materials, sustainability and the potential of it how it engages with the human experience. This project has allowed me to merge theses interest by exploring regenerative materials that challenges conventional design norm and encourage deeper engagement with built environmental. My experiences with locally sourced and waste-derived materials have further fuelled my commitment to rethinking materiality in architecture.

This thesis explores the architectural potential of regenerative materials through the lens of sensory design, investigating how locally sourced and waste-derived biomaterials can be used to foster deeper connections between people, materials, and the environment. The experimental approach employed an iterative process of material development and testing, drawing from ingredients such as coffee grounds, harakeke (New Zealand flax), seaweed, and cardboard composites. These materials were selected not only for their sustainable attributes but for their capacity to evoke sensory experiences through texture, colour, smell, and even sound.

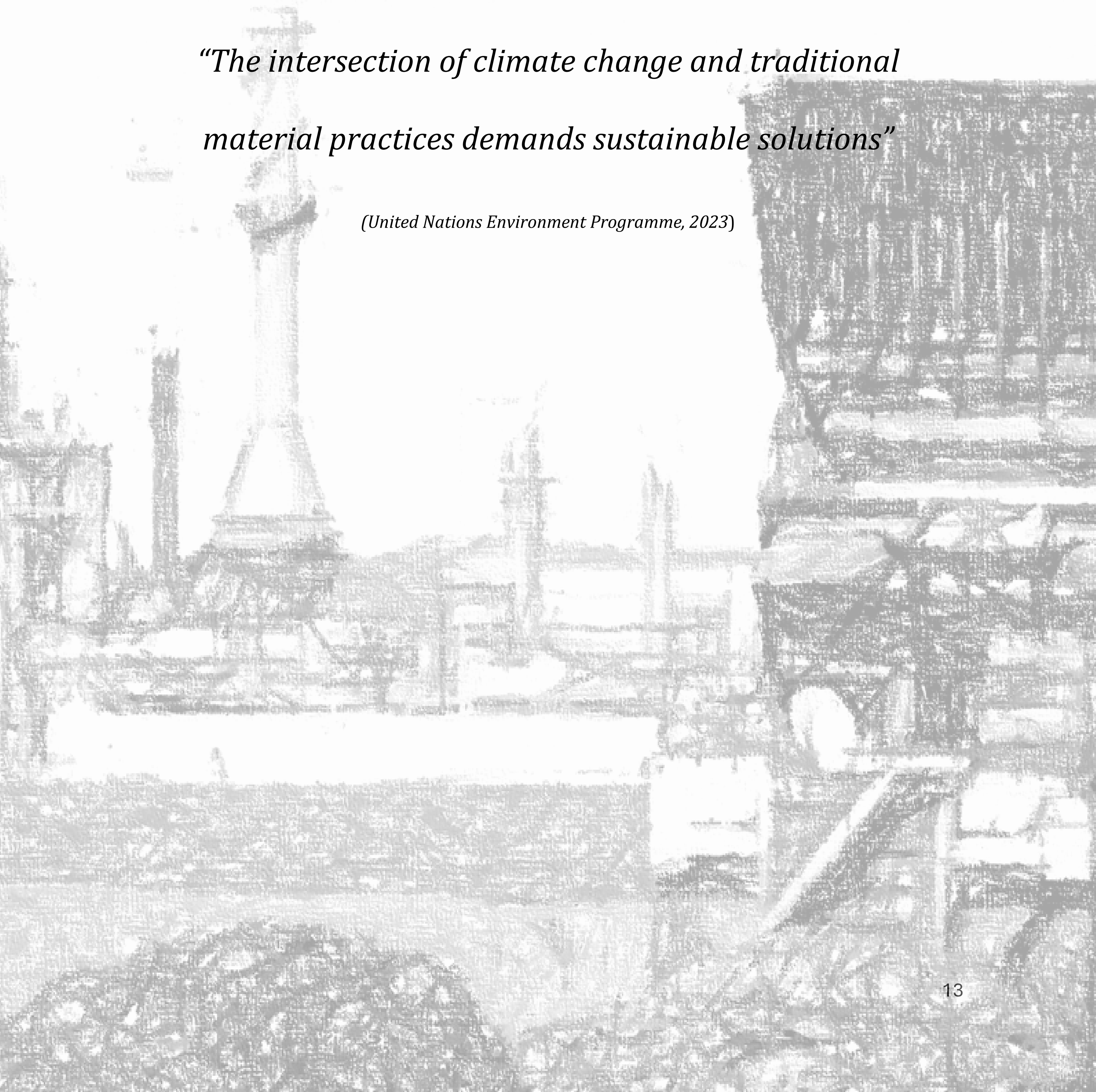
Each phase of experimentation spanning mixing, molding, and curing was used to develop a library of regenerative material samples. These were evaluated for their sensory, aesthetic, and functional properties, offering insights into how materials might contribute meaningfully to architectural atmospheres. Rather than focusing purely on functionality, the research emphasises the expressive and experiential qualities of matter, highlighting how materiality can engage the senses and elicit emotional and spatial responses.

The study positions regenerative materials as active contributors to architectural experience and spatial storytelling, challenging the traditional view of materials as passive or merely structural components. In doing so, it speculates on a future in which materials are integrated not only for their ecological performance but for their capacity to communicate, invite interaction, and shape perception. This reframing prompts a reconsideration of material aesthetics moving beyond visual form and structural logic toward a more embodied, multisensory, and environmentally attuned design ethos.

The culmination of this research is a multi-sensory material installation that translates these experiments into a spatial and tactile architectural experience. The installation acts as a conceptual and practical investigation, inviting occupants to engage with materials through more than sight alone. By organising materials into an immersive, colour-gradient display, the installation highlights material provenance, sensory richness, and the potential for regenerative resources to foster sustainable and emotionally resonant environments.

This thesis contributes to architectural discourse by expanding the palette of design thinking and material practice. It proposes that regenerative materials through their sensory and environmental narratives—can play a transformative role in shaping spatial experience and reimagining how architecture connects people to place, ecology, and matter.

Chapter One: Literature Review



"The intersection of climate change and traditional material practices demands sustainable solutions"

(*United Nations Environment Programme, 2023*)

Figure 1. Massive dump trucks by the Syncrude upgrader plant, Canada. The tar sands are the largest industrial project on the planet, and the world's most environmentally destructive (Watts, 2019).

Figure 2. Construction and demolition waste: challenges and opportunities in a circular economy (European Environment Agency, 2020)

Figure 3. Giving Demolished Building Materials a New Life through Recycling: Stockyard of recycled building materials waiting for reuse (Sorrentino, J., 2020)

1.1 Overview

This chapter considers relevant literature about the context and potential of regenerative materials, an innovative class of materials derived from renewable resources. The development of these new materials and ways they are being used to create multisensory experiences and promote sustainability are considered. The goal of this research is to explore how multisensory design principles can be integrated with regenerative materials to produce materials, objects and environments that engage multiple senses of touch, sight, sound, smell, and foster a deeper connection between people and their environment.

This chapter examines relevant literature and design precedents to identify successful strategies, potential challenges, and exciting opportunities within the fields of regenerative materials and multisensory design. The insights gained from this review and analysis form the foundation for the subsequent design investigation, which involves practical experimentation and analysis with a focus on architectural design applications.

1.2 The Need for Sustainable Material Solutions

Climate change is an urgent challenge that demands a re-evaluation of material usage across diverse sectors, particularly in construction and design. As the global climate crisis intensifies, the detrimental effects of unsustainable material practices become increasingly evident. This section explores critical aspects of linear material consumption, its contribution to environmental degradation, and the imperative for sustainable material solutions both globally and within New Zealand.

Linear material consumption, characterised by a "take-make-dispose" model, (European Commission, 2014) results in the depletion of finite resources and the accumulation of waste in landfills. This linear approach fails to account for the finite nature of natural resources and the long-term environmental consequences of unchecked material consumption (MacArthur & Heading, 2019). Consequently, landfills become inundated with non-biodegradable waste, releasing harmful pollutants into the air, soil, and water, further exacerbating the impacts of climate change (Vasarhelyi, 2021).

Moreover, the environmental impact of material production extends beyond landfill pollution to encompass the entire lifecycle of materials, from extraction to manufacturing and transportation. The sourcing of raw materials often involves resource-intensive processes that contribute to carbon emissions and environmental degradation. For example, the extraction of minerals and the production of materials such as concrete and steel are notorious for their significant carbon footprints, further exacerbating climate change (UN Environment Programme and Yale Centre for Ecosystems and Architecture, 2023).

In response to these challenges, there is a growing recognition of the need for sustainable material solutions globally. Sustainable materials offer an alternative paradigm to linear consumption and waste, emphasising principles of circularity, resource efficiency, and environmental stewardship. By prioritising materials that are renewable, recyclable, or biodegradable, designers and manufacturers can minimise the environmental impact of material production and consumption, thus contributing to climate change mitigation efforts.

Industrial building materials have a substantial carbon footprint, primarily due to the energy-intensive processes involved in their production. Concrete, for example, is responsible for approximately 8% of global CO_2 emissions, largely due to the calcination of limestone and the combustion of fossil fuels in cement production (Olivier et al., 2016). Similarly, steel production is highly energy-intensive, relying heavily on coal, which releases significant amounts of CO_2 and other pollutants (World Steel Association, 2020). Plastics, derived from petroleum, not only contribute to carbon emissions but also lead to persistent environmental pollution due to their non-biodegradable nature (Geyer et al., 2017). Additionally, the environmental degradation caused by raw material extraction, such as quarrying for aggregate and mining for minerals, disrupts ecosystems and landscapes, further exacerbating climate change.

New Zealand, like many other nations, faces similar challenges regarding material consumption and its environmental impact. The Ministry for the Environment reports that the building and construction industry in New Zealand is a major contributor to the country's carbon footprint, largely due to the embodied carbon in construction materials. This raises the need for potential changes to the Building Code to minimise waste and encourage more sustainable building practices (Ministry for the Environment, 2022).

However, there are some positive initiatives within New Zealand that are prioritising sustainable material solutions. The Scion Innovation Centre in Rotorua is a leading example, utilising timber and other renewable resources to create sustainable building solutions. The Centre's design incorporates cross-laminated timber (CLT) and other wood-based materials, demonstrating the viability of regenerative materials in large-scale construction (Scion, 2022).

SaveBOARD is a New Zealand based company that manufactures sustainable building materials from upcycled packaging waste. Their products are designed to be low carbon, durable, and moisture-resistant, contributing to a circular economy. The manufacturing process involves using heat, pressure, and time without any additives or chemicals, relying on the plastic in the packaging as glue. SaveBOARD aims to make a significant environmental impact by recycling waste into high-performance building materials, preventing millions of kilograms of packaging waste from ending up in landfills annually. (saveBOARD, n.d).

The need for sustainable material solutions is paramount in addressing the environmental challenges posed by climate change and unsustainable material practices, both globally and within New Zealand. By transitioning towards circular material economies and prioritising renewable, recyclable, and locally sourced materials, we can mitigate the environmental impact of material production and consumption, contributing to a more sustainable and resilient future (Ōhanga āmiomio, 2022).

Figure 4. Natural materials set on a few backings to create solution-based materials (CaraGreen LLC., n.d.)

1.3 Regenerative Materials and their Potential

Regenerative materials are a class of materials derived from renewable bio-based resources such as plants, fungi, algae, or even bacteria. They are typically designed with biodegradability or recyclability in mind, meaning they can decompose back into natural elements or be reprocessed into new materials at the end of their useful life. This creates a closed-loop system that minimises waste and environmental impact (Mbiu, R., 2024)

1.3.1 The two key principles of Regenerative Materials

Regenerative materials, as defined by Ellen, are derived from renewable sources, and are designed with biodegradability or recyclability in mind, thus facilitating a closed-loop system that minimises waste and environmental impact (MacArthur, E. 2013). These materials are founded on two key principles which are environmental restoration and closed-loop systems. Environmental restoration aims to ensure a positive environmental impact throughout a material's lifecycle, achieved through the utilisation of rapidly renewable resources, the integration of industrial byproducts to reduce waste, and the promotion of biodiversity through bioremediation properties (Fiksel, 2006). Closed-loop systems emphasise a circular life cycle for materials, emphasising reuse, recycling, or composting at the end of their useful life. This approach reduces the need for virgin resource extraction and fosters a circular economy, ultimately reducing the overall environmental footprint (MacArthur & Heading, 2019).

1.3.2 Benefits of Regenerative Materials

The environmental benefits of regenerative materials are evident when compared to traditional options, which often rely on unsustainable practices such as deforestation, fossil fuel extraction, and energy-intensive manufacturing processes. These unsustainable practices contribute significantly to greenhouse gas emissions, habitat loss, and pollution. In contrast, regenerative materials offer a sustainable alternative (Huo & Peng, 2023). For example, mycelium, the root structure of fungi, can be grown using agricultural waste and has the potential to replace plastics and building materials, thus reducing dependency on fossil fuels. Similarly, algae-based materials can capture carbon dioxide during growth, offering a sustainable alternative to leather and textiles. Bioplastics derived from plant sources provide a biodegradable alternative to petroleum-based plastics, contributing to waste reduction and environmental conservation (Attias et al., 2020)

1.3.3 Diverse types of Regenerative Materials

The diversity of regenerative materials encompasses various categories, each offering unique properties and applications. Plant-based materials include New Zealand Flax (Harakeke), hemp, bamboo, wood, provide strength, durability, and sustainability. Algae-based materials, such as seaweed and microalgae, offer fast-growing sources for bioplastics, biofuels, and building insulation. Fungal-based materials, including mycelium and fungal leather, provide lightweight, fire-resistant alternatives to traditional materials. Bacteria-based materials, such as bacterial cellulose, possess superior strength and biodegradability, suitable for textiles and bio-composites. Animal-based materials like wool and leather, sourced from ethically raised animals, offer natural and sustainable options for textiles and insulation. Other materials, including chiton based and food waste-based materials, promote circularity and waste reduction through innovative applications.

1.3.4 Local production imported materials and local supply chains

Local supply chains play a crucial role in enhancing the resilience of construction practices, particularly when integrating regenerative materials. By relying on locally sourced materials, the construction industry can mitigate the risks associated with external disruptions such as transportation delays, supply chain bottlenecks, or natural disasters. Local suppliers, being geographically closer, are often better positioned to respond swiftly and adapt to unforeseen events, ensuring a more stable and reliable supply of materials (TheBuildChain, 2024).

Prioritising local sourcing not only strengthens supply chain resilience but also aligns with sustainable construction practices. Regenerative materials, often derived from renewable resources, benefit from local supply chains by reducing the environmental impact associated with long-distance transportation and resource-intensive logistics. This approach supports the principles of a circular economy, where materials are sourced, used, and recycled locally, thus minimising carbon footprints and promoting sustainability (TheBuildChain, 2024).

Integrating regenerative materials through local supply chains can address industry challenges such as material shortages and environmental degradation. It fosters a more efficient, adaptable, and environmentally friendly construction process, ultimately contributing to the broader goals of sustainability and resilience in the built environment.

In the New Zealand context, regenerative materials hold significant promise for addressing environmental challenges and promoting sustainable development. New Zealand Flax (Harakeke), for instance, is a culturally significant plant that offers exceptional strength, durability, and fire resistance, making it suitable for various applications in textiles and construction (New Zealand Flax, 1950). Sustainable forestry practices and initiatives promoting the use of native wood species align with regenerative principles, supporting biodiversity and conservation efforts.

Algae-based materials leverage New Zealand's extensive coastline and marine resources, providing opportunities for research and innovation in sustainable materials (Sustainable Seas Challenge, 2023). Additionally, the growing interest in mycelium-based materials and fungal leather reflects New Zealand's rich biodiversity and agricultural heritage, offering sustainable alternatives for various industries.

Despite the benefits of regenerative materials, challenges like scalability, cost, and consumer acceptance remain. Solving these issues needs teamwork across fields and new ways to develop materials. Opportunities exist in technology, community support, and policies that promote sustainable design. By tackling these challenges, designers can use regenerative materials to create multisensory spaces that benefit both the environment and people. In New Zealand, these materials can address environmental issues and enhance cultural and ecological resilience, supporting a circular economy and driving innovation across industries.

Figure 5. Exploring the Future of Food Tech n Waste Management to create a potential material (Core77, n.d.)

1.4 Sensory Materials and Architecture

1.4.1 Introduction Sensory Materials and Architecture

The integration of sensory experiences into architectural design has gained considerable attention for its potential to enhance user well-being and interaction with built environments. Sensory architecture goes beyond visual aesthetics to engage multiple senses, creating spaces that are more immersive, enjoyable, and supportive of human health. Charles Spence's research on multisensory design underscores the significance of engaging the senses in architectural practice, highlighting how sensory stimuli can influence perceptions, emotions, and behaviours within a space (Spence, 2020).

Multisensory design in architecture involves the deliberate incorporation of sensory elements such as light, sound, texture, and scent to create environments that engage people on multiple levels. Spence argues that multisensory design can enhance the functionality and emotional impact of architectural spaces. By appealing to the senses, designers can create environments that are more engaging and memorable, which can improve the satisfaction and well-being of those who inhabit or interact with these spaces.

This project draws from these principles of multisensory design but approaches them through the lens of material exploration specifically, regenerative and waste-derived materials. Rather than starting with form or program, this research begins with matter, investigating how sensory properties inherent in locally sourced, biodegradable, and composite materials can inform architectural thinking. My approach does not aim to produce conventional architectural typologies, but rather to speculate on how materials themselves through their textures, scents, appearances, and sounds can become generative agents in design.

By creating a series of experimental material samples and an installation, this project explores the spatial and experiential possibilities of regenerative materials within architecture. The aim is not only to test the sensory potential of these materials but also to open new ways of thinking about sustainability where materials are not passive components but active contributors to spatial quality and environmental awareness. This material-led, sensory-driven approach challenges dominant visual paradigms in architecture and suggests that future sustainable environments might be shaped from the ground up by sensory-rich, ecologically attuned materials.

1.4.2 Benefits of Sensory Materials in Architecture

Sensory materials in architecture foster deeper engagement with the built environment by stimulating touch, sight, sound, and smell. These multisensory interactions enhance user experience, promoting comfort, well-being, and a stronger connection to space. Natural materials like wood and stone can reduce stress and improve mental health by creating a sense of calm and connection to nature. Textures and colours can stimulate or soothe the senses, aiding in focus and relaxation, while acoustic materials minimise noise pollution, improving concentration and communication. Sensory-rich environments are especially beneficial in therapeutic settings, such as for sensory processing disorders or autism. By integrating these elements, designers can create inclusive, accessible, and comfortable spaces.

Thoughtful use of sensory materials in architecture enhances aesthetic appeal and promotes overall well-being (Spence, 2020).

1.4.3 Relationship between Materials and the Senses

The relationship between materials and sensory experiences is an important element in architecture and design. Materials shape how we perceive and experience spaces and so they are the foundation of sensory experiences and crucial to affective architectural and design practices (Wastiels et al., 2013). Materials shape spatial perception and interaction by engaging multiple senses. The warmth of wood, the coolness of metal, and the softness of textiles influence how people navigate and experience a space. These sensory cues not only define atmosphere but also affect emotional responses and behaviour, reinforcing the connection between materials and spatial design. Visual textures and colours engage sight, while tactile qualities invite touch. Acoustic properties control sound, enhancing comfort and mood. Scents, though less emphasised, can also enrich sensory experiences. The careful selection and combination of materials can transform a space, making it more engaging and functional. In limited studies the aesthetic appreciation of materials through the senses is recognised as an important way to foster sustainability, promoting regenerative bio-based materials to a wider public, (Sauerwein, Karana and Rognoli, 2017). However, existing research often prioritises the technical and environmental benefits of regenerative materials, overlooking the experiential and sensory dimensions that could influence public perception and adoption. Exploring this gap could reveal new ways to integrate aesthetics and materiality into sustainable design practices, fostering a stronger appreciation of material culture and its role in environmental responsibility.

The aesthetic appreciation of materials through the senses is recognised as an important way to foster sustainability by promoting regenerative bio-based materials to a wider public, (Sauerwein, Karana and Rognoli, 2017). However, there are limited studies that have explored the subject in depth. Existing research often prioritises the technical and environmental benefits of regenerative materials, overlooking the experiential and sensory dimensions that could influence public perception and adoption. Exploring this gap could reveal new ways to integrate aesthetics and materiality into sustainable design practices, fostering a stronger appreciation of material culture and its role in environmental responsibility.

1.4.4 Challenges and Opportunities in Sensory and Regenerative Material Integration

Although sensory and regenerative materials offer many benefits, their integration into architecture faces challenges. Scalability, cost, and consumer acceptance are significant hurdles that require interdisciplinary collaboration and innovative material development. Advances in technology, community support, and policy changes are crucial to overcoming these issues. Sensory materials in architecture support the thesis's goal of creating multisensory experiences with regenerative materials. By leveraging the unique sensory properties of these materials, architects can design spaces that are sustainable and enhance their well-being. Future research should focus on addressing these challenges to promote a general, sustainable, and sensory-rich architectural design (Almusaed et al., 2024).

Figure 6. This top to bottom material creates a shared spatial sequence within the originally enclosed space, making people feel closer and more relaxed in surroundings. (Mooool, n.d.)

1.5 Relevant Project and Case Studies

Projects and case studies demonstrate how regenerative materials can create dynamic and immersive architectural environments.

1.5.1 Growing materials for product design

Research by Camere and Karana (2017) explores the sensory qualities of bio-fabricated materials, highlighting their potential to engage users on a deeper level. Working at the Delft University of Technology, their research focuses on materials grown through processes like fermentation and fungal growth. They investigate materials such as mycelium, bacterial cellulose, and kombucha leather, which offer unique textures, scents, and tactile sensations. These bio-fabricated materials create more immersive experiences compared to traditional materials, which are often static and functional. Traditional materials like concrete, steel, and plastic are primarily valued for their durability, strength, and uniformity, but they often lack the sensory richness that bio-fabricated materials can provide. By integrating these multisensory qualities into design, architects can evoke emotional responses and foster stronger connections between users and their environments (Camere & Karana, 2017) and these studies into material open out different ways of evaluating and understanding materials.

1.5.2 INBUILT project launches to transform European sustainable building practices

The InBuilt project, part of the EU Biobased Material Horizon initiative, seeks to transform sustainable building practices in Europe by integrating biobased materials into construction. Aiming to mitigate the environmental impact of traditional methods, the project focuses on using renewable resources to reduce carbon footprints and enhance material sustainability. It supports research and development of innovative materials like bio composites, hempcrete, and mycelium-based products to create healthier, more resilient buildings. This aligns with my thesis on the potential of regenerative materials in sustainable and multisensory architectural design. By promoting biobased materials, InBuilt highlights the environmental benefits of renewable resources and supports the idea that sensory-rich, sustainable materials can strengthen connections between people and their surroundings. The project's research and innovations offer valuable insights and real-world examples for exploring how regenerative materials can transform architectural practices in New Zealand and beyond (InBuilt, n.d.).

1.5.3 Reset Materials 2023

The Reset Materials exhibition underscores the role of biomaterials in achieving sustainable design goals, emphasising their low-carbon footprint and transformative impact on the built environment. Held at Copenhagen Contemporary from July 1 to September 30, 2023, and organised by the Copenhagen Institute of Interaction Design, the exhibition showcased a diverse range of biomaterial applications, from structural components to experimental surfaces that reimagine materiality in architecture.

Notable participants included Studio ThusThat, known for their innovative work with industrial waste materials, and Materiality Research, which explored mycelium-based structures that blur the line between organic growth and architectural function. The exhibition presented biomaterials not only as an ecological alternative but as an active agent in reshaping spatial and sensory experiences. Large-scale immersive installations, modular components, and material prototypes were strategically displayed to highlight how these materials interact with light, touch, and movement, encouraging visitors to engage physically and conceptually with their potential.

By incorporating biomaterials into architectural projects in ways that emphasise tactility, adaptability, and environmental responsiveness, the exhibition positioned these materials as more than sustainable alternatives they became tools for fostering deeper connections between inhabitants and their surroundings. This focus aligns with the ethos of my thesis, which seeks to explore how regenerative materials can create more immersive, sensorial, and sustainable design solutions that redefine our relationship with the built environment (Frearson, 2023).

Figure 7. Reset Materials is designed as a landscape of architectural fragments (Frearson, 2023)

1.5.4 Natural Building Project 2022

The Natural Building Project (NBP) has been a keystone for this thesis, offering practical insights into regenerative materials in construction. Managed by Lucas De Man and Pascal Leboucq, NBP operates in the U.S. and Europe, focusing on sustainable building practices since early 2022. The project, involving architects, builders, and environmental educators, emphasises the use of locally sourced and regenerative materials through workshops, educational programs, and hands-on projects. NBP's initiatives provide practical experience in using materials like mycelium and bamboo, enhancing the understanding of their functional and aesthetic integration in sustainable structures (De Man & Leboucq, 2022)

This exploration supports the research by highlighting the challenges and opportunities of incorporating regenerative materials into architectural design. "Moreover, NBP's educational materials have been instrumental in examining multisensory experiences, demonstrating how materials engage sight, touch, and smell to foster a more embodied and intuitive understanding of sustainability. By emphasising hands-on interaction, these materials cultivate a sensory awareness of regenerative resources, encouraging not just theoretical knowledge but a tangible, lived experience of sustainable practices. This approach supports deeper engagement with materiality whether through an immediate tactile response, a heightened appreciation for natural cycles, or a long-term commitment to regenerative design, particularly in educational contexts such as working with children to inspire sustainable values early on. This aligns with the thesis goals, showcasing effective communication methods for promoting sustainable futures through regenerative materials (NatureBuildingProject, 2024).

Figure 8. Nature Building Kit (NatureBuildingProject, 2024)

1.5.5 The Artist References

Artists Eva Hesse and Richard Serra explore materiality in sculptural ways to evoke strong sensory and emotional responses. Hesse's latex and fiberglass works emphasise tactility and organic form, while Serra's large-scale steel sculptures manipulate weight and space to engage the viewer physically. However, their use of industrial, non-biodegradable materials does not align with sustainable and regenerative design. This contrast raises questions about how regenerative materials can achieve similar sensory depth while maintaining ecological responsibility.

1.5.6 Eva Hesse: Five Sculptures

The exhibition “Five Sculptures” at Hauser and Wirth (2024) critically examines Eva Hesse’s innovative approach to materiality and form. Hesse’s exploration of non-traditional materials and tactile experiences resonates with contemporary discussions on regenerative materials and multisensory experiences in art and design. As a pivotal figure in the post minimalist movement, her work emphasises the relationship between the artist, materials, and viewer.

Hesse’s use of materials such as latex, fibreglass, and rope challenges conventional notions of sculpture, pushing boundaries between art and everyday life. Her organic shapes and forms invite viewers to engage with the artwork on a sensory level, prompting a revaluation of preconceived notions about form and space. This focus on the ephemeral and imperfect aligns with the thesis, advocating for the experiential influence of material choices through sensory perception. By embracing the inherent qualities of materials, artists can create immersive experiences that foster connection and reflection (Hauser & Wirth, 2024).

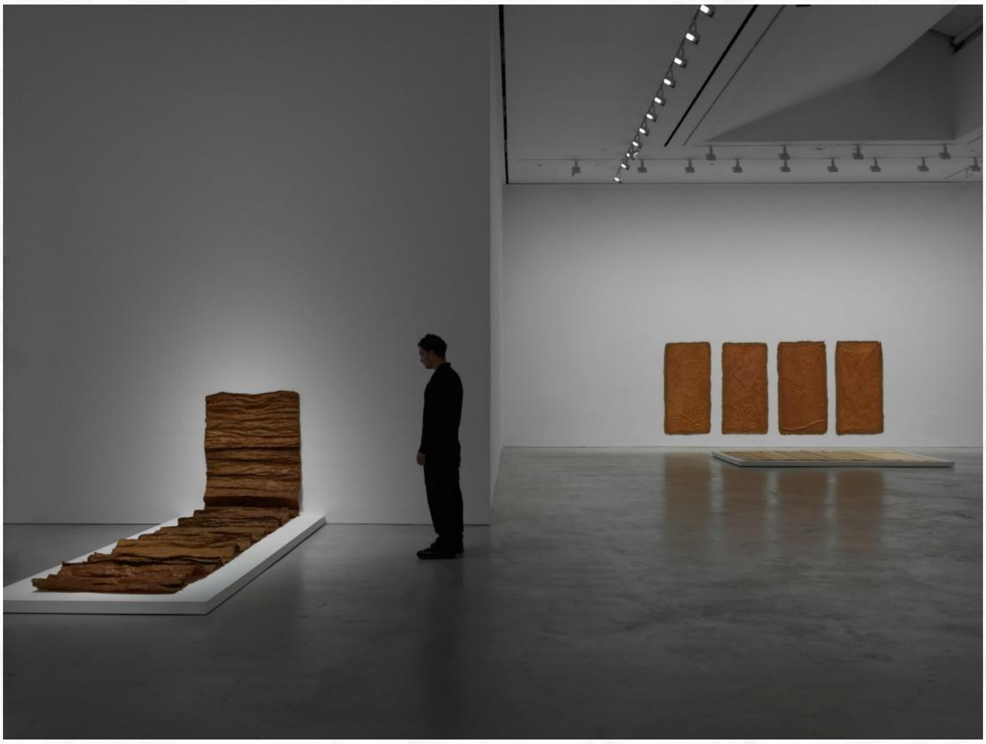


Figure 9. Eva Hesse Five Sculptures 2024 exhibition view (Hauser & Wirth, 2024).

1.5.7 Richard Serra Sculpture: Forty Years

The exhibition "Richard Serra" at the Museum of Modern Art 2007 (MoMA) closely aligns with the themes of my thesis. Serra's monumental sculptures, primarily crafted from industrial materials like steel, challenge conventional notions of sculpture and engage viewers in profound sensory experiences. His work emphasises the physicality of materials, inviting viewers to navigate and interact with installations. For instance, pieces like "The Matter of Time" create a dynamic relationship between space and viewer, illustrating how spatial engagement enhances material perception, which is central to my thesis.

Serra's use of steel is deeply tied to its material evolution over time he does not treat it as a static, finished object but as a surface that interacts with its environment, rusting, shifting, and responding to atmospheric conditions. His approach challenges conventional ideas of material permanence, instead emphasising the temporal and processual nature of materials. By exposing steel to weathering, Serra invites viewers to consider not just the immediate form of a material but its ongoing transformation and relationship to space.

This perspective resonates with contemporary discussions on sustainability and material lifecycles. Rather than viewing materials through the lens of linear extraction where resources are removed, used, and discarded. Serra's work encourages us to see materials as part of a continuous cycle. This idea is particularly relevant to regenerative materials, which are designed not for depletion but for renewal, reintegration, and adaptability within ecological and architectural systems. By reconsidering how materials exist and evolve over time, Serra's philosophy inspires new ways of thinking about sustainability, moving beyond static consumption toward a circular and regenerative approach. Ultimately, the MoMA exhibition exemplifies how Serra's material investigations and viewer engagement contribute to a broader discourse on multisensory experiences and sustainable practices in contemporary art (McShine, K., Serra, R., & Cooke, L., 2007).

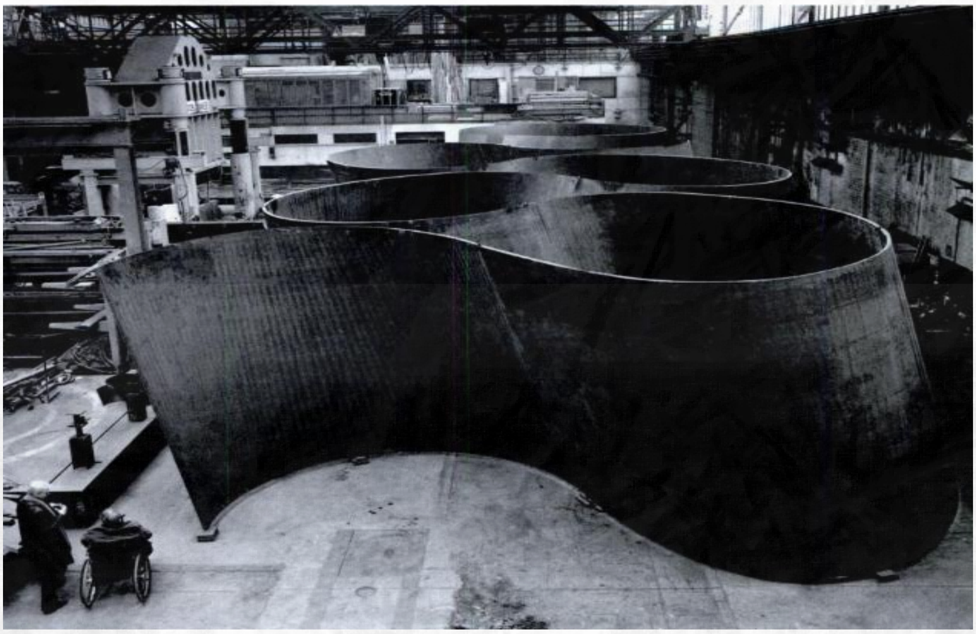
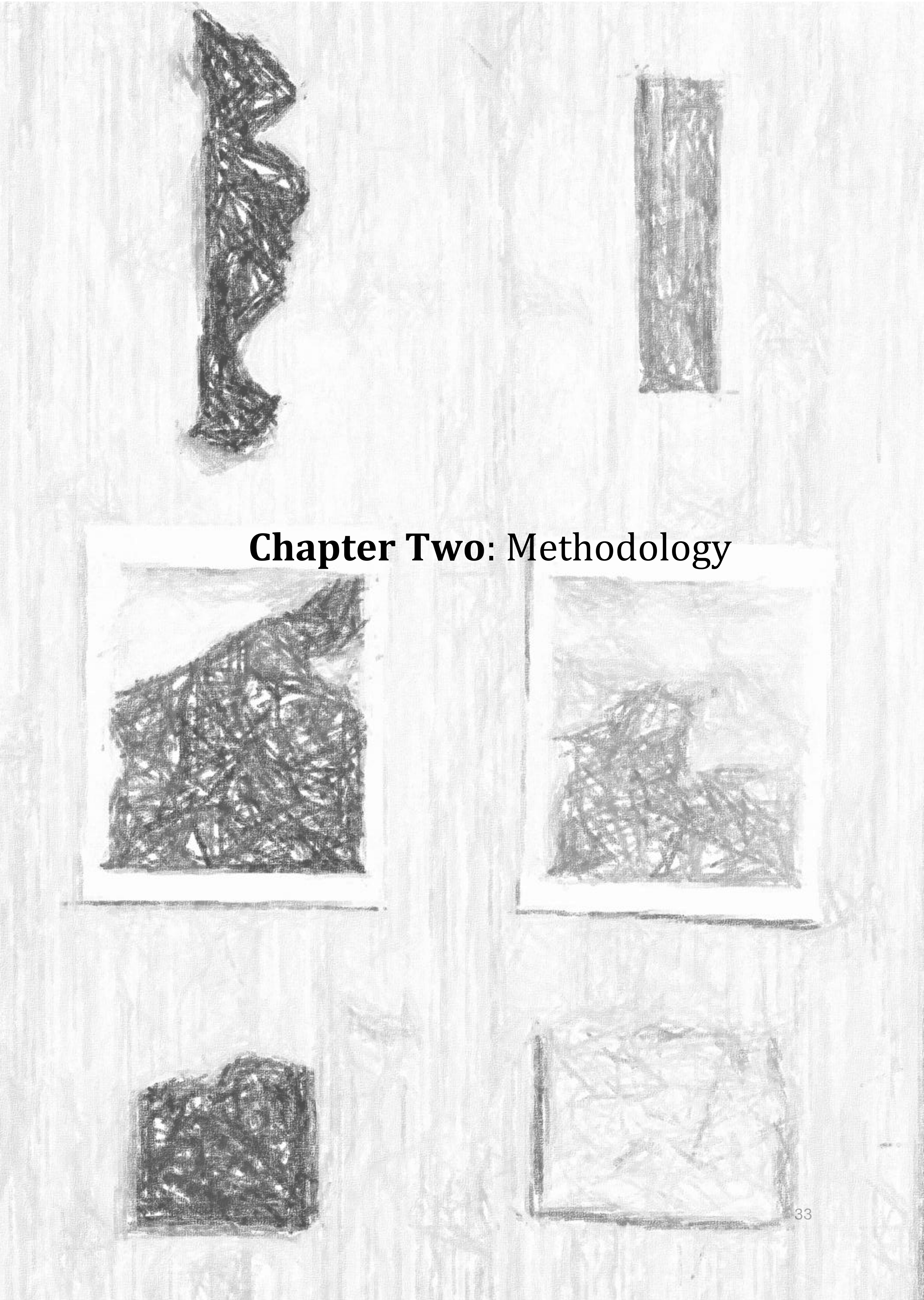


Figure 10. Richard Serra Installed Weatherproof steel (McShine, K., Serra, R., & Cooke, L., 2007)

1.6 Conclusion

The study of regenerative materials and multisensory design in architecture offers a vital approach to creating sustainable and engaging environments. By using renewable, biodegradable, and locally sourced materials, designers can lower the environmental impact of their projects while improving user experiences. Incorporating sensory elements like texture, light, sound, and scent helps create immersive spaces that promote well-being and emotional connections. The case studies reviewed showcase how regenerative materials can be practically applied to enhance sustainability and sensory engagement in architecture. These examples highlight the potential for thoughtful design to make spaces more inclusive and responsive to diverse user needs. As this thesis progresses into practical experimentation, it will further explore the sensory qualities of regenerative materials and their application in architectural design. By addressing the identified challenges and opportunities, this research aims to foster deeper connections between people and their environments, paving the way for a healthier and more sustainable future in architecture.



Chapter Two: Methodology

2.1 Introduction

This research investigates how regenerative materials can enhance sensory engagement and foster deeper connections between people and their environments in architecture. It follows a Material Driven Design (MDD) approach, emphasising experimental material exploration, sensory evaluation, and design integration.

To achieve this, the research adopts a practice-based mixed methods approach, integrating qualitative analysis (literature review, material exploration) with quantitative assessments (material testing, reflection, and material installation). The methodology is structured into three phases, each progressively refining materials from their raw form to final application.

2.2 Methodological Frameworks

The methodological framework for this research project on regenerative materials in architectural design is grounded in the principles of Material Driven Design (MDD). Material Driven Design emphasises the sensory qualities of materials and their potential to shape user experiences, environmental impact, and design outcomes (Karana et al., 2015). This approach is especially relevant as it aligns with the project's goal of exploring how regenerative materials can be integrated into sustainable architecture while enhancing sensory experiences. It also connects to the previous chapter, where the focus was on using the natural sensory qualities of materials to create meaningful connections between people and the material world.

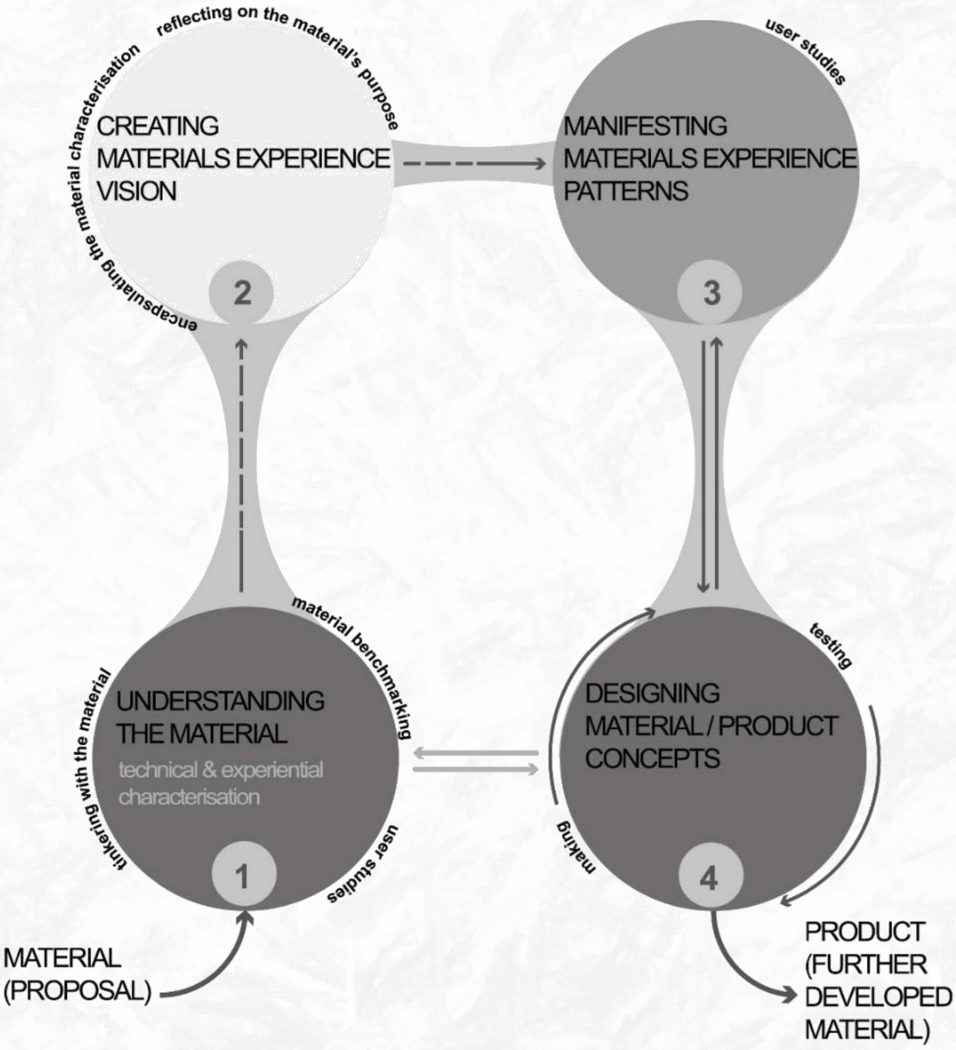


Figure 11. Material Driven Design (MDD) method (Karana et al., 2015).

The Material Driven Design (MDD) process offered a structured approach that was highly relevant to this thesis, which explored the integration of regenerative materials and multisensory design in architecture. By following the MDD framework, the thesis investigated how regenerative materials, such as bio-based and bio-waste, could be analysed, conceptualised, and developed into architectural solutions that prioritised both sustainability and sensory experience.

Understanding the Material (Step 1) was particularly crucial, as it involved a deep analysis of the unique properties of regenerative materials. This step aligned with the thesis's aim to explore the tactile, visual, and auditory qualities of these materials, providing the foundational knowledge needed to enhance user experiences.

Creating a Material Experience Vision (Step 2) allowed for a strategic reflection on how these materials could serve both functional and experiential purposes in architectural spaces. This aligned with the thesis's goal of fostering emotional and physical connections between people and their environments through sensory design.

By Manifesting Material Experience Patterns (Step 3), the thesis incorporated user studies and sensory engagement to explore how these materials performed in real-world scenarios, ensuring that the design was responsive to human needs.

Finally, Designing Material/Product Concepts (Step 4) provided the opportunity for practical experimentation, where regenerative materials were explored for their architectural applications. Rather than presenting finalised architectural solutions, this phase focused on testing how these materials could be integrated into design contexts examining their structural, aesthetic, and sensory potential. These explorations informed the final thesis presentation, demonstrating how regenerative materials contribute to sustainable design while embodying the core principles of this research.

2.2.1 Overarching Research Philosophy

The Material Driven Design (MDD) philosophy supports this research, emphasising that materials are not passive elements but active agents that shape architectural experiences. Ontologically, MDD considers materials as integral to design evolution, influencing form, function, and sensory perception. This is particularly relevant to regenerative materials, where properties such as texture, colour, and tactility foster more immersive and sustainable environments.

Epistemologically, MDD follows an iterative approach, where knowledge is constructed through experimentation, observation, and reflection. This aligns with the project's practice-ba sed methodology, which involves developing, testing, and refining regenerative materials. These insights inform material applications in architectural contexts.

A conceptual roadmap visually represents this evolution of materiality and sensory design in architecture. It contrasts traditional material practices with future innovations, positioning regenerative materials at the centre of sustainable design.

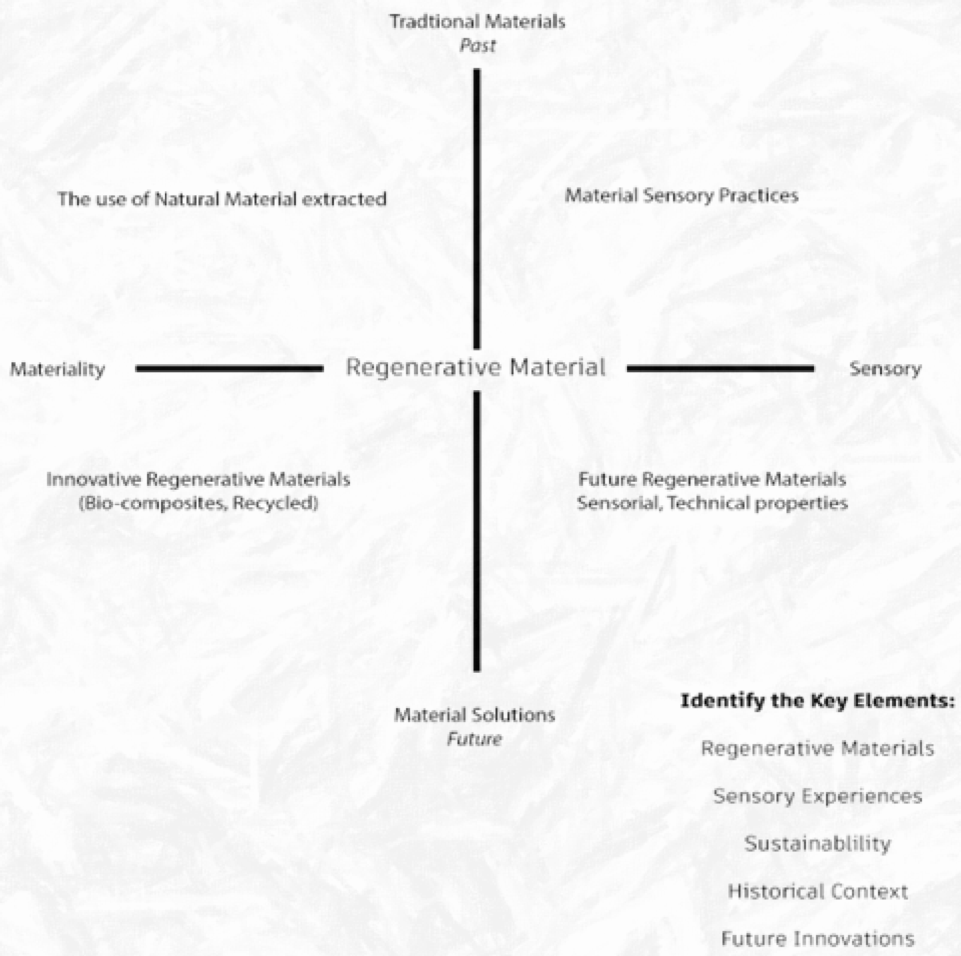


Figure 12. Overarching Research Philosophy Diagram of Regenerative Material

The diagram illustrated the overarching research philosophy, serving as a conceptual roadmap for the thesis. It contrasted past and future approaches to materiality and sensory experiences in architecture, with regenerative materials at the centre. This visual framework provided clarity on how traditional practices had evolved and where future innovations in regenerative materials could take architecture.

On the left side, the focus was on materiality, including the use of natural materials in the past and the transition to innovative, sustainable alternatives like bio-composites and recycled materials. This area emphasised the technical and environmental properties of materials, highlighting the shift towards more responsible and practices. It addressed the question of how materials could meet sustainability goals without compromising performance or aesthetic value.

On the right side, the focus was on sensory experiences, exploring how materials engaged the senses. The diagram contrasted traditional sensory practices in material use with future potential, where regenerative materials could offer enhanced sensory and technical properties. This reflected the growing interest in multisensory architecture, which not only looked aesthetically pleasing but also promoted well-being and emotional connection through tactile, auditory, and visual elements.

This framework guided the thesis by balancing material innovation with sensory richness, ultimately advancing sustainable architectural design.

2.3 Research Approach

This research follows a practice-based mixed-methods approach to investigate regenerative materials in architectural design. It combines experimentation, qualitative analysis, and quantitative assessment to gain a comprehensive understanding of the sensory qualities, technical feasibility, and environmental impact of these materials.

The qualitative approach includes an extensive literature review, which established a theoretical foundation by analysing trends, key themes, and gaps in research. This is complemented by hands-on material experimentation, exploring bio-based composites, waste materials, and plant-derived alternatives. Through sensory evaluation, materials are assessed for texture, colour, scent, and acoustic properties, helping to identify new opportunities for sustainable design.

The quantitative approach included material testing and empirical analysis, evaluating attributes such as aesthetic properties, flexibility, and durability. Experimental testing followed simple standardised protocols to assess the functional performance of regenerative material prototypes.

By integrating theory, experimentation, and application, this research advances multisensory design and sustainable materiality, bridging the gap between academic research and real-world architectural practice.

2.4 Research Method Tool

This project uses a Material Driven Design (MDD) approach with four distinct phases which has been refined to an architectural design approach applications to explore the regenerative materials and development multisensory approach.

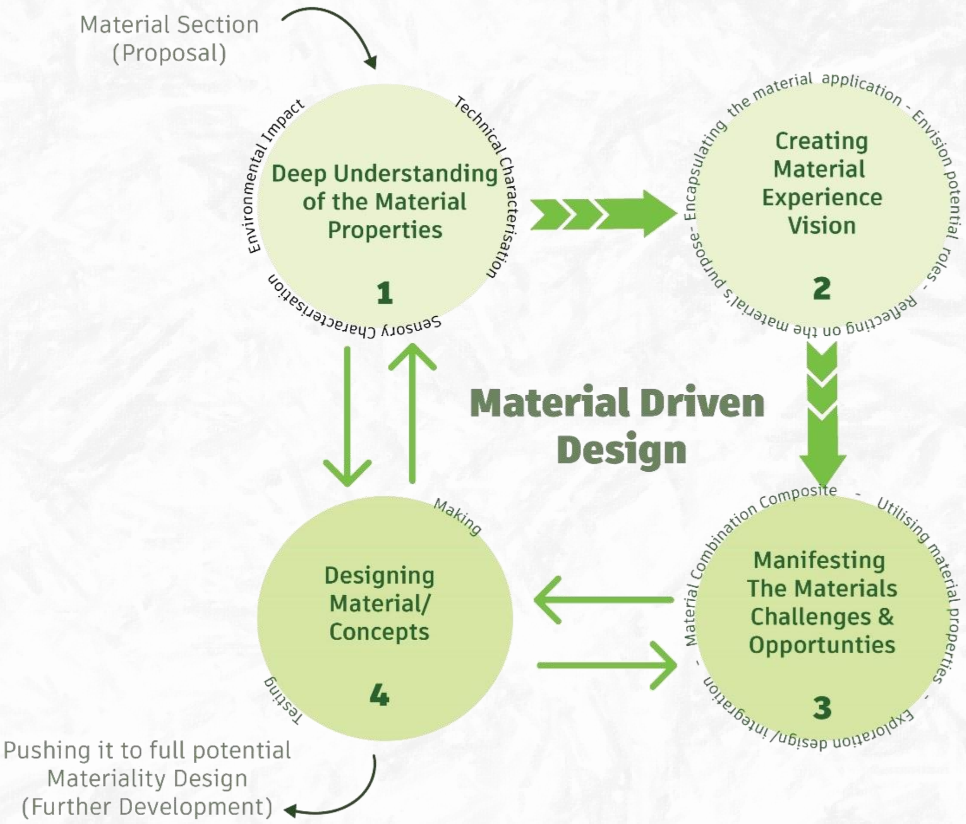


Figure 13. Refined Version of Material Driven Design

The refined diagram illustrated the Material Driven Design (MDD) process, which was applicable to the development of bio-composite materials and their integration into architectural design. The process began with a Deep Understanding of the Material Properties (Step 1), where it investigated the bio-composite's technical characteristics, sensory properties, and environmental impact. This foundational step was critical in evaluating how bio-composites, made from renewable resources like plant fibres and biodegradable resins, could contribute to sustainable design.

Next, Creating the Material Experience Vision (Step 2) involved envisioning how bio-composites could be integrated into architectural applications, considering both their functional and experiential roles. Processes of critical reflection identified how these materials could enhance sensory experience not only through their tactile textures and natural aesthetics but also in their interaction with light, adaptability to spatial contexts, and engagement with multiple senses. This phase emphasised how materials shape spatial perception, fostering deeper connections between users and their environment.

In Manifesting the Material's Challenges & Opportunities (Step 3), the research explored bio-composites' potential through real-world applications, examining how they could be combined with other elements and assessing their performance in different contexts. This stage highlighted key challenges related to material durability and scalability, revealing limitations in processing techniques and the need for further refinements in material stability. This process revealed that regenerative materials must be carefully adapted to achieve both sustainability and functional viability, reinforcing the need for an iterative approach to material design.

Finally, Designing Material Concepts (Step 4) translated these insights into iterative material experimentation, where bio-composites were refined and tested within the scope of the thesis. Rather than achieving a fully resolved architectural solution, this phase focused on advancing the material's properties to a point where it could meaningfully contribute to discussions on sustainability and experiential richness. This stage emphasised the sensory qualities of the materials texture, flexibility, and responsiveness demonstrating their potential to shape user interactions with space. By positioning material exploration as an evolving process rather than a finalised product, the research highlights how regenerative materials can inform future design approaches that prioritise circularity, adaptability, and multisensory engagement.

2.3 Phases of the Project: Overview

Figure 14. A diagram of the overview phase of the project

2.3.1 Stages of Producing Regenerative Materials

This section outlines the key stages involved in the production of regenerative materials, from sourcing raw materials to their final application in architectural contexts. The process follows a structured approach to ensure sustainability, functionality, and sensory engagement. Each stage sourcing, processing, material creation, and integration plays a crucial role in refining the properties and performance of these materials. The following table provides a concise overview of these stages, highlighting the methods and considerations involved in developing regenerative materials for architectural applications.

Stage 1: Sourcing Bio-Waste and Bio-Based Raw Materials

Identification and Collection	Sorting and Preparation
The first step involves identifying regenerative materials that align with project goals and sustainability criteria. Suitable materials include bio-waste such as agricultural residues (e.g., corn husks), food waste (e.g., coffee grounds, fruit peels), and forestry by-products (e.g., harakeke, sawdust). Bio-based polymers derived from plants (e.g., seaweed,) are also considered. The selection process evaluates material availability, cost, and suitability for intended applications to ensure they meet project objectives.	Once identified, raw materials are sorted and prepared for processing. This step involves cleaning to remove dirt and contaminants, sorting by type or quality to ensure uniformity, and treating materials if necessary (e.g., removing excess moisture, crushing large pieces). Proper preparation is crucial for consistent processing and high-quality output.

Table 1. Sourcing Bio-Waste and Bio-Based Raw Materials

Stage 2: Processing Raw Materials

Drying	Grinding	Baking or Air Drying
Depending on the moisture content of the raw materials, drying is essential to prepare them for further processing. Methods include air drying, which allows materials to naturally lose moisture over time, and using dehydrators or ovens for more controlled and accelerated drying. Proper drying helps prevent mould growth and ensures materials reach the appropriate moisture levels for processing.	After drying, raw materials are ground or shredded to reduce their particle size. This increases the surface area, facilitating better mixing and processing in subsequent stages. Grinding ensures that materials are consistent and easier to work with during material formulation.	Some materials may require additional treatments such as baking or further air drying. Baking can enhance the properties of materials by improving their hardness or structural integrity, while air drying continues to remove any remaining moisture. These steps help achieve the desired characteristics of the final material.

Table 2. Processing Raw Materials

Stage 3: Creating New Materials from Bio-Waste and Bio-Based Raw Materials

Material Formulation	Processing
In this stage, processed raw materials are combined with binders, additives, or processing aids to create new composite materials or bio-based polymers. Formulation aims to enhance the properties of the materials, such as strength, durability, and thermal insulation. This step may involve mixing various components in precise ratios to achieve the desired characteristics	The formulated materials are then shaped into their final forms using techniques like extrusion, compression moulding, or casting. Extrusion involves forcing the material through a Mould to create continuous shapes, compression moulding uses heat and pressure to form specific shapes, and casting involves pouring the material into moulds. These methods produce sheets, pellets, or moulded components ready for application.

Table 3. Creating New Materials from Bio-Waste and Bio-Based Raw Materials

Stage 4: Application and Integration

Design Integration	Prototyping	Installation
The newly created regenerative materials are integrated into architectural or product design concepts. This stage explores their application in various contexts, such as building components (e.g., panels, insulation). Design integration involves assessing how the materials fit within design goals and contribute to sustainability and functionality.	Prototypes or small-scale models are created to test the functionality, aesthetics, and performance of the regenerative materials. Prototyping allows designers to evaluate how the materials perform in real-world conditions, including their structural integrity, usability, and visual appeal. Adjustments and refinements can be made based on feedback and testing results before full-scale implementation.	The final stage involves installing regenerative material applications in actual architectural or product settings. This phase demonstrates the materials' suitability and performance in practical scenarios. Key considerations include ensuring structural integrity, durability, and positive user experience. Installation helps validate the materials' effectiveness and informs any further modifications needed for optimized performance. Each stage in producing regenerative materials is crucial for ensuring the final product meets sustainability goals, performs well, and integrates effectively into its intended application.

Table 4. Application and Integration

2.4 Phases of the Regenerative Materials

The development of regenerative materials followed a structured process, from theoretical investigations and preliminary studies to hands-on experimentation and iterative refinement. The final phase applied insights to prototype development and exhibition installation, showcasing their spatial and sensory potential. This approach emphasised sustainability, adaptability, and experiential engagement in architectural applications.

Literature Review	The literature review established a theoretical foundation for regenerative materials by examining academic journals, books, and case studies. This phase identified key material properties, benefits, and limitations while highlighting research trends and gaps. A particular focus was placed on experiential and sensory aspects, such as texture, smell, weight, and responsiveness, and their influence on spatial perception and emotional engagement.
Preliminary Studies	Initial experiments and case studies were conducted to evaluate the characteristics of regenerative materials. Key activities included documenting material behavior, durability, and aesthetic qualities. This phase aimed to collect empirical data that informed subsequent research, focusing on how materials interact with touch, light, and acoustics in spatial contexts.
Methods of Producing and Sourcing Materials	Research into traditional and innovative production methods, such as biomanufacturing and waste valorization, provided insights into material sourcing. Evaluations included supply chain logistics, transportation, and raw material availability. The study also considered the spatial implications of material sourcing, assessing how regional availability and distribution influence material integration into architecture.

Table 5. Phase 1 Deep Understanding of Material Properties

Selection of Materials	Identifying and categorizing regenerative materials, such as bio-based composites, algae-based bioplastics, and self-healing materials. Selection criteria were based on technical feasibility and sensory attributes, ensuring a balance between performance and experiential qualities for architectural applications.
Hands-On Experimentation	Practical testing of selected materials to explore their applications. Key properties assessed included texture, color, flexibility, and thermal performance. Samples and prototypes were created to evaluate real-world suitability, with an iterative approach refining both sensory and spatial potential.
Sensory Exploration	Evaluating the sensory attributes of materials through tactile, olfactory, and visual assessments via user studies or workshops. Examined spatial effects such as acoustic dampening, translucency, and airflow interaction to determine their adaptability for dynamic architectural applications.
Data Collection and Analysis	Compiling and analyzing quantitative and qualitative data from experiments and sensory evaluations. Identified trends, strengths, and weaknesses in material behavior across different scales and contexts, revealing opportunities for integration into architectural design.

Table 6. Phase 2 Material Experimentation and Sensory Exploration

Design Refinement	Developing and improving design strategies based on insights from earlier phases. This involved creating detailed concepts that incorporated regenerative materials and refining them based on feedback and analysis. The goal was to develop innovative and practical solutions that emphasized sensory, aesthetic, and spatial potentials.
Prototype Development	Constructing prototypes or mock-ups of architectural elements using selected regenerative materials. Early biomaterial tests assessed structural integrity, flexibility, and responsiveness. Testing prototypes provided valuable insights into functionality, performance, and validation of design concepts.
Exhibition Planning and Installation	Preparing and executing an engaging exhibition layout to showcase material applications. The exhibition aimed to create an immersive, sensory-driven space where visitors could experience regenerative materials through touch, light, and movement.
Integration of Communication Technologies	Enhancing visitor interaction through video projections and digital screens. These technologies captured microscopic details, visualizing material transformations over time and enabling a scalar shift in perception—allowing engagement at multiple levels.
Spatial and Sensory Experience	Emphasizing the spatial and sensory potential of regenerative materials. The exhibition encouraged movement through different material environments, highlighting variations in weight, translucency, flexibility, and acoustic performance. The installation positioned regenerative materials as dynamic, interactive elements in architectural spaces.

Table 7. Phase 3 Final Materiality Application Design and Installation Exhibition

2.5 Development of Criteria

The development criteria for material selection emphasised sustainability, performance, scalability, sensory qualities, and innovation, ensuring regenerative materials are environmentally friendly, durable, cost-effective, aesthetically pleasing, and offer novel architectural applications.

Sustainability	Materials must demonstrate environmental benefits, including low carbon footprint, renewable sourcing, and circularity potential.
Performance	Materials should meet performance standards in terms of durability, strength, flexibility, and functionality.
Scalability	The production processes for materials must be scalable, cost-effective, and feasible for large-scale applications.
Sensory Qualities	Evaluation of aesthetic attributes such as texture, colour, and tactile feedback to ensure materials contribute positively to user experience.
Innovation	Materials and design solutions should offer novel applications and enhance sustainability, aesthetics, and functionality in architecture.

Table 8. Development of Criteria

2.6 Limitations of the Study

The research studying regenerative materials has inherent limitations. One significant challenge lies in sourcing enough regenerative materials while maintaining their quality consistency. Variability in the quality and source of natural and waste materials can directly impact the results of experiments and the applicability of findings to other contexts. For instance, differences in raw material properties, such as moisture content and composition, can lead to inconsistent performance in prototypes, thereby affecting the overall conclusions drawn from the research.

Moreover, the use of regenerative materials in architecture often encounters obstacles related to production capacity, cost-efficiency, and compliance with regulations. These factors are crucial for ensuring that the research findings are both robust and applicable in real-world scenarios. The challenges of scaling up the production of regenerative materials can hinder the ability to conduct larger-scale experiments, limiting the research's generalisability. Additionally, fluctuating market prices for raw materials can pose financial constraints, making it difficult to conduct extensive studies without exceeding budgets.

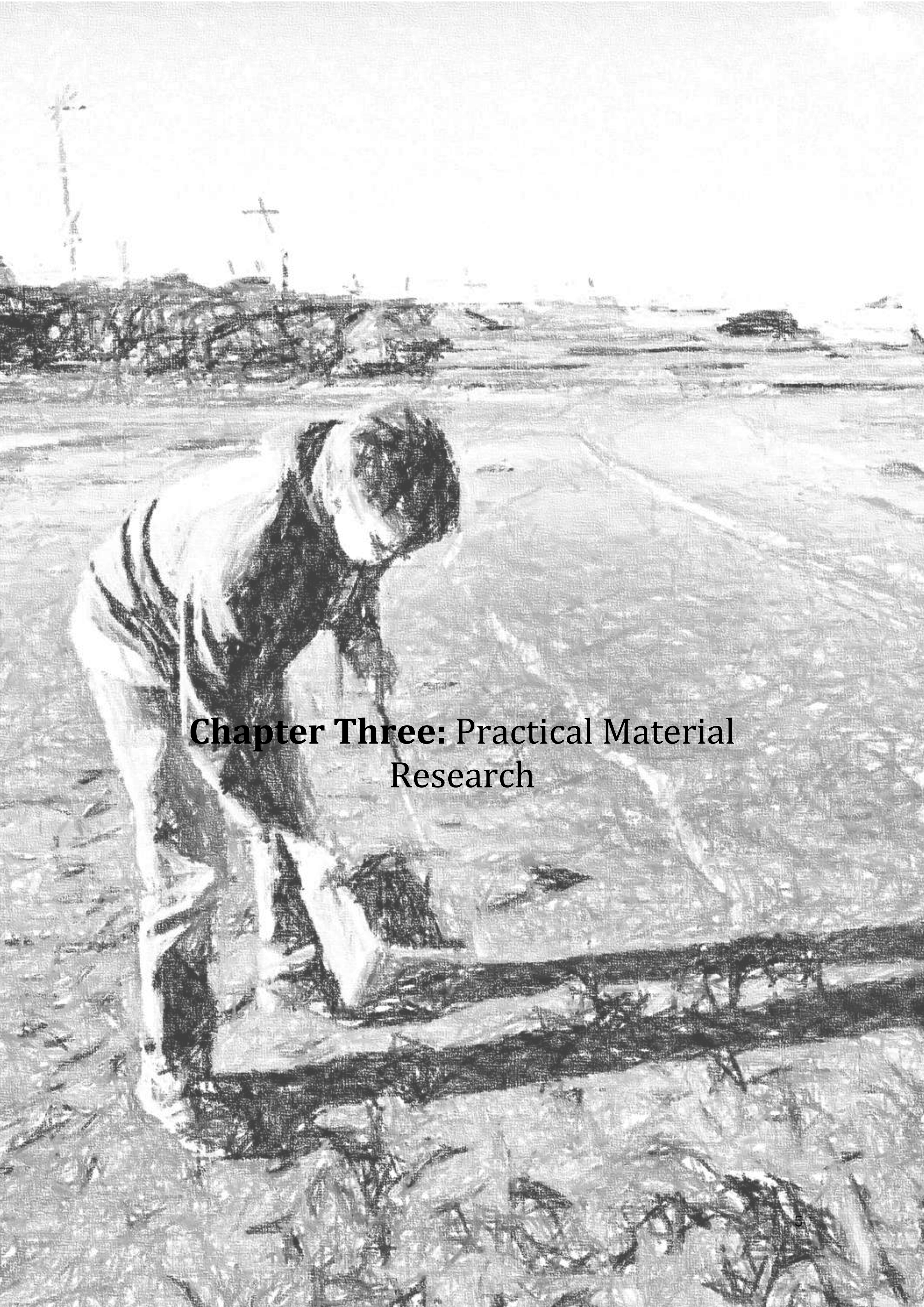
In the realm of materials experimentation, a common focus has been on functionality rather than broader material properties. Many unsuccessful experiments were attributed to issues such as mould growth, textural inconsistencies, structural failures, and drying problems. While some of these challenges were addressed during the research, there remains a pressing need for more effective solutions. For example, improved bio-control methods could help mitigate mould issues, while the development of specialised drying chambers could enhance material stability and consistency (Menneer et al., 2022). These innovations would not only contribute to better experimental outcomes but also expand the potential applications of regenerative materials in architecture.

Another critical limitation was the lack of consistent testing protocols across the study. Variations in testing methodologies can lead to discrepancies in data, making it challenging to compare results and establish reliable benchmarks for material performance. While functional testing was not a focus of this project, standardising testing procedures would be essential to enhance the reliability of findings and applications.

Despite these limitations, there is significant potential for innovation within the realm of regenerative materials. The ongoing exploration of new materials, production techniques, and testing methods opens avenues for developing groundbreaking solutions that can address both architectural needs and environmental concerns. By embracing creativity and collaboration, researchers can push the boundaries of regenerative materials, paving the way for sustainable practices that reshape the future of architecture.

2.7 Conclusion

This chapter outlines the comprehensive methodology for exploring regenerative materials in architectural design through a Material Driven Design (MDD) approach. The research employs a mixed methods approach, integrating qualitative and quantitative techniques to investigate the sensory qualities, technical feasibility, and environmental impacts of regenerative materials. The phased methodology ranging from material sourcing and experimentation to testing and final design ensures a thorough examination of the materials' potential and challenges. By systematically addressing each phase, the research aims to advance sustainable design practices and contribute to the development of multisensory architectural environments.



Chapter Three: Practical Material Research

3.1 Overview

The practical materials research outlined in this chapter focused on developing an understanding of regenerative materials and their potential architectural applications. This phase aimed to explore, document and analyse methods for sourcing and creating regenerative materials, providing insights into their sensory qualities and potential integration into architectural practice. By combining these insights into production methods with practical considerations, this research informs and identifies possibilities for the effective application of regenerative materials in design. The goal of this research was to bridge the gap between theoretical knowledge and practical use, supporting the development of sustainable architectural solutions. This approach ensured that the properties of the regenerative materials produced through this research were well-understood, setting the stage for further research and development into their application in architecture and contributing to the advancement of sustainable design practices.

3.1.1 Key Phases in Practical Materials Research

This chapter follows the Material Driven Design (MDD) framework from Chapter Two, outlining a systematic approach to sourcing, testing, and developing regenerative materials for architectural applications. The research was divided into three phases, beginning with a deep understanding of materials, followed by material sourcing and preparation, and concluding with experimental testing and material formulation.

The first phase, Deep Understanding of Materials, involved researching and analysing bio-based and bio-waste materials to assess their sustainability, availability, and functional potential. This stage ensured that material selection was based on cultural, ecological, and regenerative principles, setting the foundation for further experimentation.

The second phase, Material Sourcing and Preparation, focused on identifying, collecting, and processing selected materials while maintaining low environmental impact. Key materials, including Harakeke, Kawakawa leaves, coffee grounds, and eggshells, were cleaned, dried, and prepared for testing. This stage ensured that all materials were in a usable form for structural and sensory evaluations.

The third phase, Experimental Methods and Material Formulation, involved mechanical, sensory, and durability testing to determine material performance and adaptability. Key experiments included strength and flexibility assessments for structural applications, degradation analysis to evaluate material lifespan, and sensory evaluations examining texture, visual qualities, and scent. The final step focused on biopolymer formulation, blending natural binders like potato starch, agar-agar, and gelatine to enhance cohesion, flexibility, and moisture.

This structured, iterative research approach ensured that materials were scientifically tested, refined, and evaluated for real-world architectural applications, balancing functionality, sustainability, and multisensory engagement.

3.2 Material Selection

This section describes and provides an in-depth analysis of the materials selected for experimentation, focusing on their regenerative properties and suitability for innovative architectural applications. Each material was evaluated for its unique characteristics, and the experimental processes used to assess their potential are detailed.

In this practical research, a wide range of materials and combinations were explored, guided by specific selection criteria to ensure sustainability and functionality. The criteria for material selection included:

	Type of Material: Selected materials were either bio-based or bio-waste. Bio-based materials are resulting from renewable sources, while bio-waste consists of by-products from agricultural and food processes.
	Local Availability: Materials needed to be easy to find nearby, ensuring they came from local sources. This rule aimed to reduce transportation impact and help local ecosystems.
	Source of Waste: Waste materials were sourced from diverse origins, including garden waste (e.g., cabbage tree leaves) and food waste (e.g., coffee grounds). This approach promoted recycling and resourcefulness.
	Environmental Impact: Any additional binders or plasticizers selected were required to be environmentally friendly and, if possible, biodegradable. This criterion ensured that the materials aligned with sustainability goals.
	Performance Characteristics: Materials were evaluated for their mechanical properties, flexibility, and durability. This included assessing how well they could withstand environmental conditions and their suitability for architectural applications.
	Biological Stability: Materials needed to resist microbial growth and decay, particularly for those derived from food waste. Options that showed significant biological instability were rejected to ensure longevity and performance.

Table 9. Criteria for Material Selection

Through these criteria, materials that best met the project's sustainability objectives and practical applications were chosen, while those that failed to comply with these standards were set aside for further consideration

3.2.1 Mapping Local Availability of Regenerative Materials

Figure 15 illustrates the distribution of key material sources within the Auckland region, particularly between Auckland Central and Takapuna, emphasising the feasibility and accessibility of regenerative material collection in relation to my own movement between key locations. The map categorises sources such as home, university, supermarkets, and natural environments, demonstrating a localised, sustainable approach to material procurement. Each color-coded area represents different material types, such as coffee grounds from cafes near the university, harakeke from natural landscapes in Takapuna, and seaweed from coastal areas along the North Shore.

This localisation strategy was essential in ensuring that material collection was not only environmentally sustainable but also practical within my daily routines. Most material sources were within 5–10 km from my primary research locations, allowing for frequent, low-impact collection trips. Cafes in Auckland Central, close to the university (within 2–3 km), provided a consistent supply of coffee grounds, while supermarkets within a 5 km radius offered recycled cardboard and eggshell waste. In contrast, Takapuna and other coastal areas, located approximately 10–15 km away, required more intentional collection trips for harakeke and seaweed. These trips were planned efficiently to reduce travel emissions and ensure responsible harvesting practices without disrupting natural ecosystems.

By mapping these material sources in direct relation to my movements between home, university, and collection sites, I was able to streamline the collection process while reinforcing the importance of localised, sustainable sourcing methods. This approach not only minimised unnecessary travel but also highlighted the potential of integrating regenerative material sourcing into everyday urban life, making sustainable material use more accessible within architectural applications. (see Appendix A)

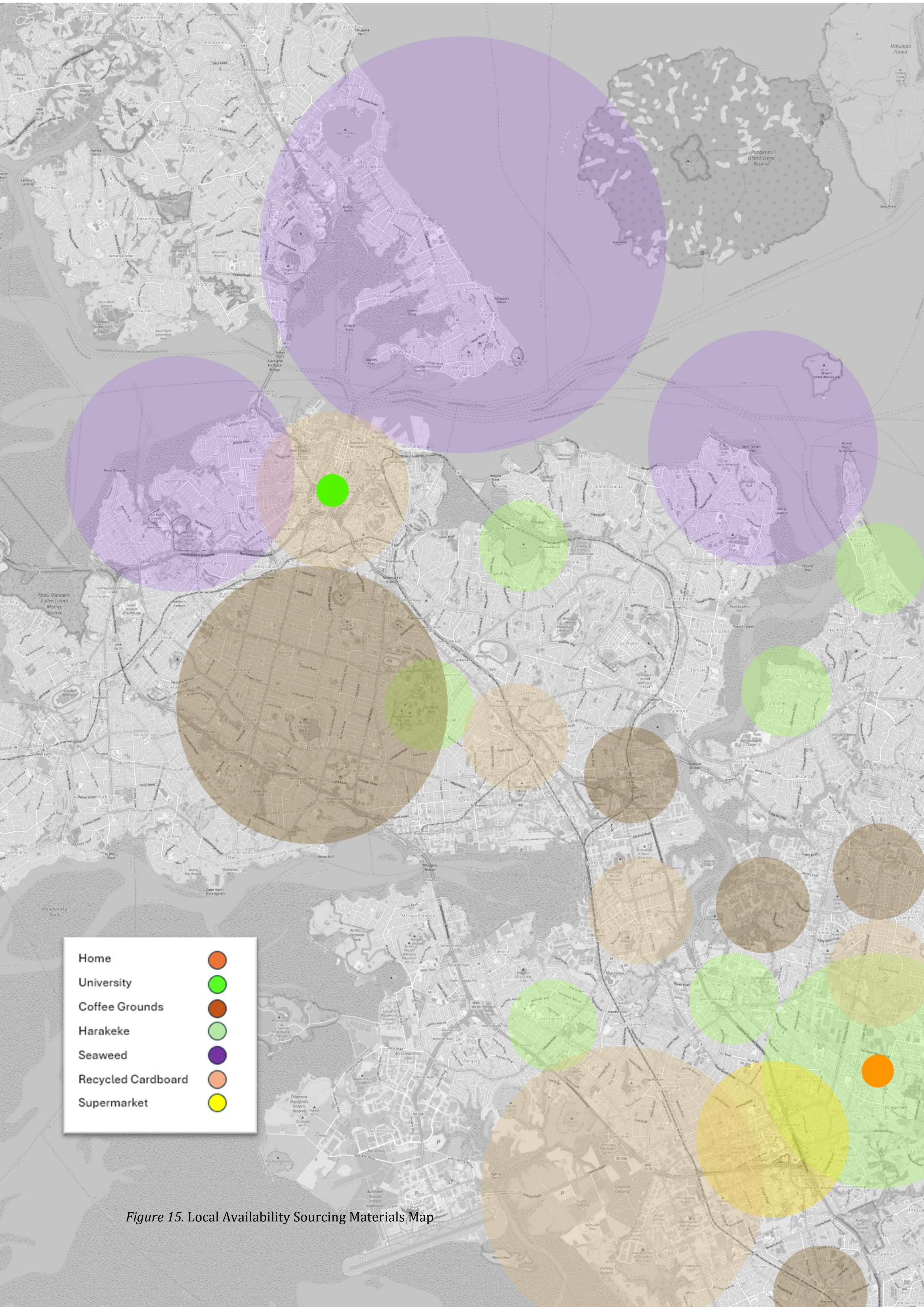


Figure 15. Local Availability Sourcing Materials Map

3.2.2 Material Description

This section provides an overview of the materials selected for experimentation, focusing on their regenerative properties and suitability for architectural applications. By categorising materials based on their functions such as structural strength, binding agents, and insulation the unique characteristics and potential applications of each material are highlighted. The following table offers a concise reference, while subsequent discussions will elaborate on the rationale behind their selection and use in the project.

3.2.4 Material List Table

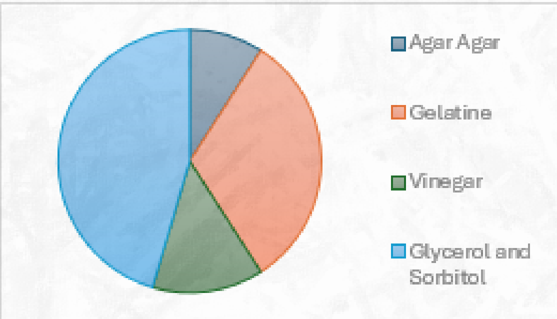
Rank	Material	Key Properties
1	Harakeke (NZ)	Tensile strength, durable
2	Kawa Kawa Leaves (NZ)	Medicinal, bioactive
3	Seaweed (NZ)	Flexibility, thermal insulation
4	Eggshells	Calcium carbonate, durable
5	Calcium Carbonate	Strength, durability
6	Glycerol and Sorbitol	Plasticizers, flexibility, durability
7	Gelatine	Natural binder, cohesive
8	Agar Agar	Natural binder
9	Vinegar	Preservative, binder
10	Coffee Grounds	Texture, binding
11	Sawdust	Adds bulk, sustainable
12	Sand (NZ)	Texture, thermal mass
13	Paper Pulp (Recycled)	Rigidity, bulk
14	Ti Kouka (Cabbage Tree)	Fibrous, flexible
15	Coarse Sea Salt	Preservative qualities, texture
16	Pasta	Structural bulk, binding
17	NZ Lemon Oil	Fragrance, antimicrobial

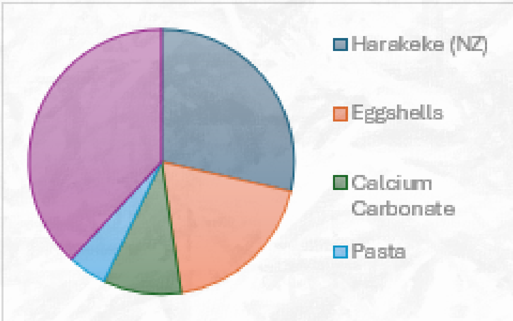
Table 10. Material List Table

The materials listed in Table 10 were organised based on their significance to the project, highlighting essential properties for sustainability and functionality. They were ranked by importance to emphasise structural integrity or categorised by functional properties, clarifying the roles of each material in achieving project goals. This approach enhanced understanding and application.

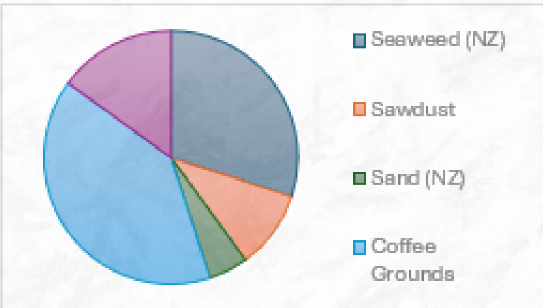
3.2.4 Material Ingredients Chart

Binding Agents	**Structural Materials**





Textural and Insulating Materials	**Preservative and Functional Additives**



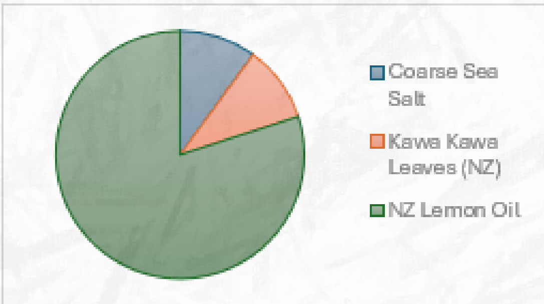


Table 11. Pie chart of Materials Research Ingredients

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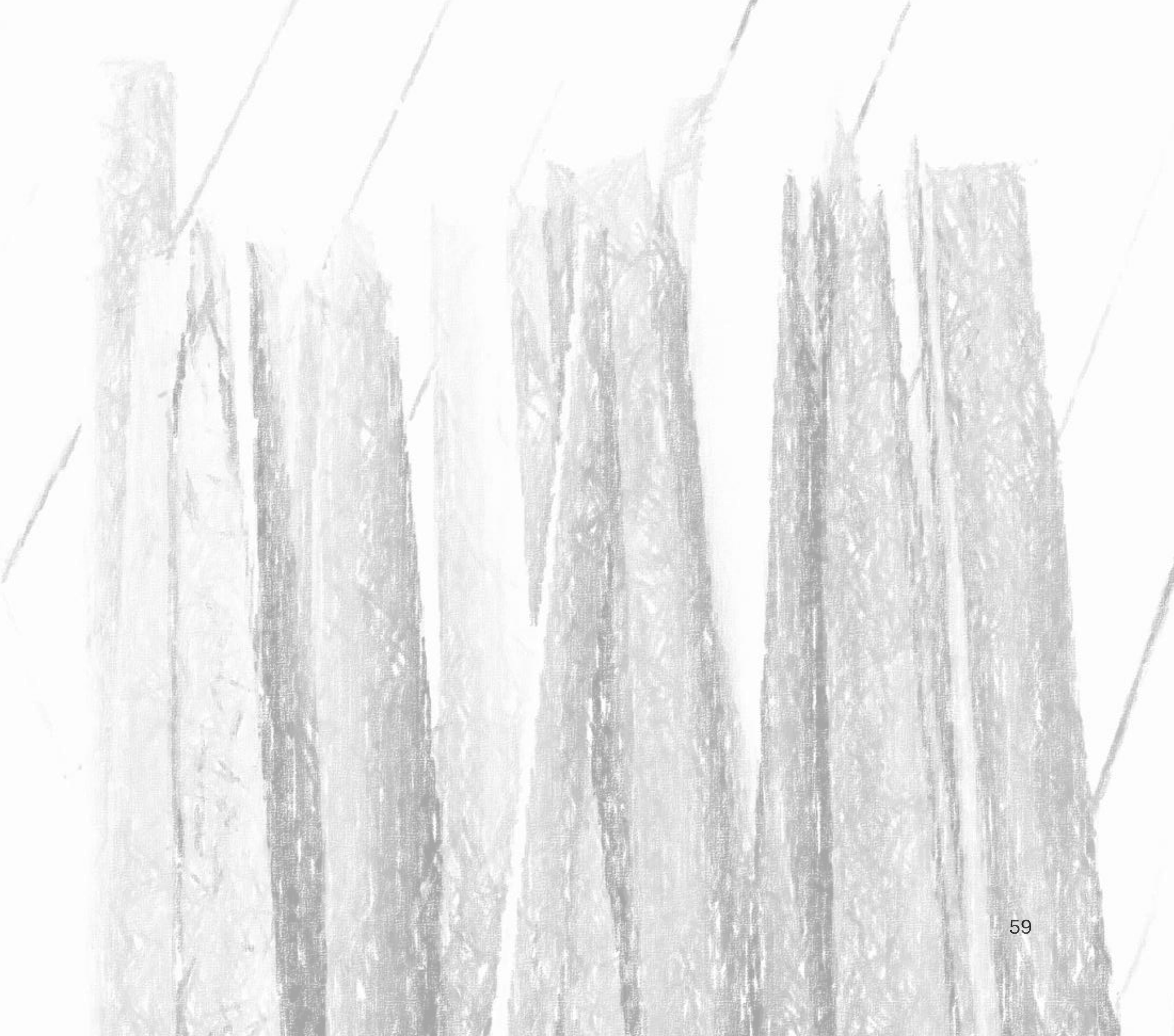
3.3 Experimental Methods

The production of regenerative materials encompassed three main stages: collecting, processing, creating. Each stage was designed to explore, discover, and optimise the properties of these materials for practical applications in architecture and design.

Stage 1: Collecting and Preparing Bio-Waste and Bio-Based Raw Materials

In this initial stage, I identified appropriate bio-waste and bio-based raw materials that aligned with the project goals and sustainability criteria. The key materials included seaweed, eggshells, coffee grounds, and Harakeke (New Zealand flax). Each material required unique handling procedures, contributing to its effective application in regenerative design. The collection and preparation of these materials ensured their suitability for sustainable projects.



Seaweed was beach cast that is it was collected from local beaches after storms, ensuring minimal ecological disruption. It underwent thorough cleaning to remove sand, salt, and debris, followed by rinsing in freshwater. Once cleaned, the seaweed was air-dried in a shaded area to preserve its properties and prevent degradation. The drying process enhances the flexibility and thermal insulation properties of biomaterials. In their 2024 study, demonstrated that controlled drying techniques improve the mechanical flexibility and reduce the thermal conductivity of seaweed-based materials, making them more suitable for sustainable building applications (Xhaxhiu et al., 2024). Conditions were closely monitored during drying to prevent mould growth, which could compromise the material's integrity. This careful collection and preparation maximised the seaweed's performance and reinforced the project's commitment to sustainable, locally sourced resources.

Figure 16. Seaweed collected from local beaches after storms

Eggshells were collected from my home kitchen as a common food waste material. After collection, they were thoroughly rinsed to remove any residual egg white and yolk, a crucial step in preventing odours and microbial growth. Once cleaned, the eggshells were dried in an oven at a low temperature, making them brittle and easier to process. After cooling, the dried shells were ground into a fine powder using a blender. This powder, rich in calcium carbonate, was then used as an additive in bio-composite formulations to enhance strength and durability (Li, Li, Luo, Pend et al, 2024), showcasing the potential of upcycled food waste in sustainable design.

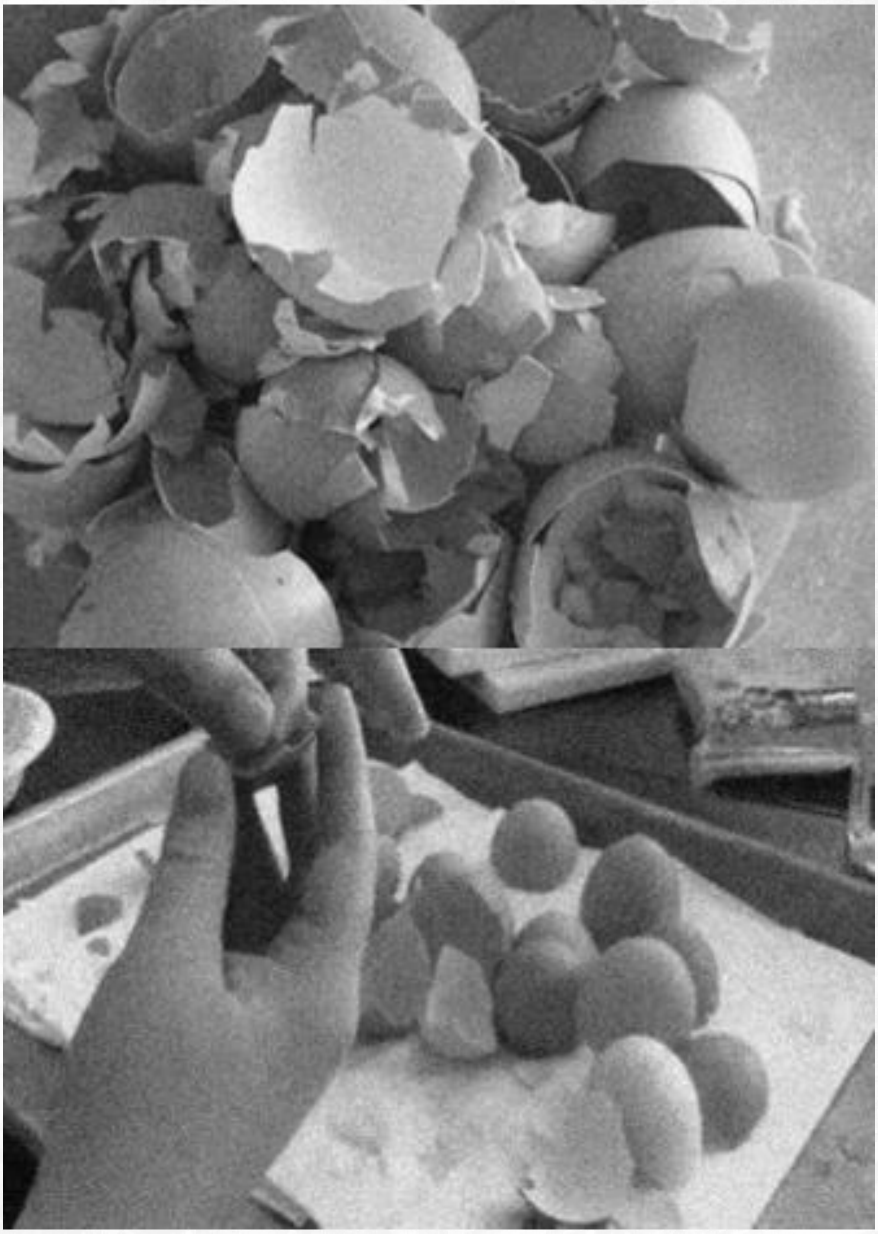


Figure 17. Eggshells collected from a local café, process cleaning

Harakeke was collected by carefully pruning the outer leaves of plants to keep them healthy. After gathering the leaves, damaged or brown parts were removed to ensure that only the strongest fibres were used for experimentation. The leaves were thoroughly cleaned to eliminate dirt and debris. They were then soaked in water to soften them, making them easier to work with. Once prepared, the Harakeke was cut into manageable lengths, leveraging its strong, fibrous quality, which made it ideal for use in structural bio-composites for regenerative design applications.

Figure 18. Harakeke was collected by carefully pruning

Ti Kouka (cabbage tree) leaves were collected as windfalls from the backyard. These leaves were fibrous and flexible, making them useful for reinforcing material experiments.

Kawakawa leaves were gathered from a friend's tree pruning, as they possessed medicinal properties (Liggins Institute 2023) that contributed cultural and protective elements to material design. While the cultural implications of bio-based material are not addressed specifically in this thesis, the significance of Mātauranga Māori in relation to indigenous plants and local substances, must be acknowledged. Kawakawa was used by Maori as an external and internal medicine. Research conducted at the University of Auckland identified that “kawakawa contains a great diversity and abundance of pharmacologically active metabolites.” (LIggins Institute, 2023)

Functional additives like lemon oil and glycerine were sourced from local suppliers. These were used to enhance flexibility and preservation in bioplastics. Coffee grounds were collected from university staff after their consumption, providing leftover grounds that added texture and helped bind materials together in composite experiments.

Figure 19. Ti Kouka leaves were collected as windfalls from the backyard

Stage 2: Processing Raw Materials

The second stage focused on processing the collected raw materials to prepare them for experimentation. This step was crucial for enhancing the properties of the materials and ensuring their suitability for architectural applications.

Preparation Processes for Raw Materials:

Material	Preparation Process	Details	Issues Encountered
Beach-Cast Seaweed	**Air-Drying**	Removed moisture to prevent mold growth, ensuring longevity.	Variability in strand toughness; inconsistent grind size affected integration.
	Grinding	Ground into smaller pieces to increase surface area for effective composite integration.	Required multiple passes through the grinder for tough strands, impacting efficiency.
Harakeke Leaves	**Fiber Removal**	Removed tough outer fibres to access the inner leaf material.	Difficulty in ensuring complete removal of tough fibres, affecting material quality.
	Shredding	Shredded the inner leaf material to provide strength in bio-composite formulations.	Ensuring uniform size; some fibres remained long, affecting composite consistency.
	Dehydration	Used a dehydrator to reach optimal moisture levels, preventing degradation of fibres.	Temperature monitoring was critical to avoid overheating, which could weaken structural integrity.
Fibre	**Extraction**	Extracted from natural sources like flax and processed for bio-composite use.	Challenges in maintaining uniform fibre length and avoiding breakage during processing.

Table 12. Preparation Processes for Raw Materials table

Detailed Discussion of Preparation Processes:

Beach-Cast Seaweed

Beach-cast seaweed was prepared by soaking it in hot water to soften the material and remove impurities [1]. After soaking, the seaweed was thoroughly rinsed to eliminate residual sand [2], with a quality check conducted to ensure suitability for further processing [3]. Next, the seaweed was air-dried to remove excess moisture, which was essential for preventing mould growth [4]. Once fully air-dried, the seaweed was placed in a dehydrator to further reduce moisture content [5]. Finally, the dried seaweed was ground into smaller pieces, but consistency issues arose during grinding, as some strands were tough, requiring multiple passes through the grinder [6] (see Figure 20).

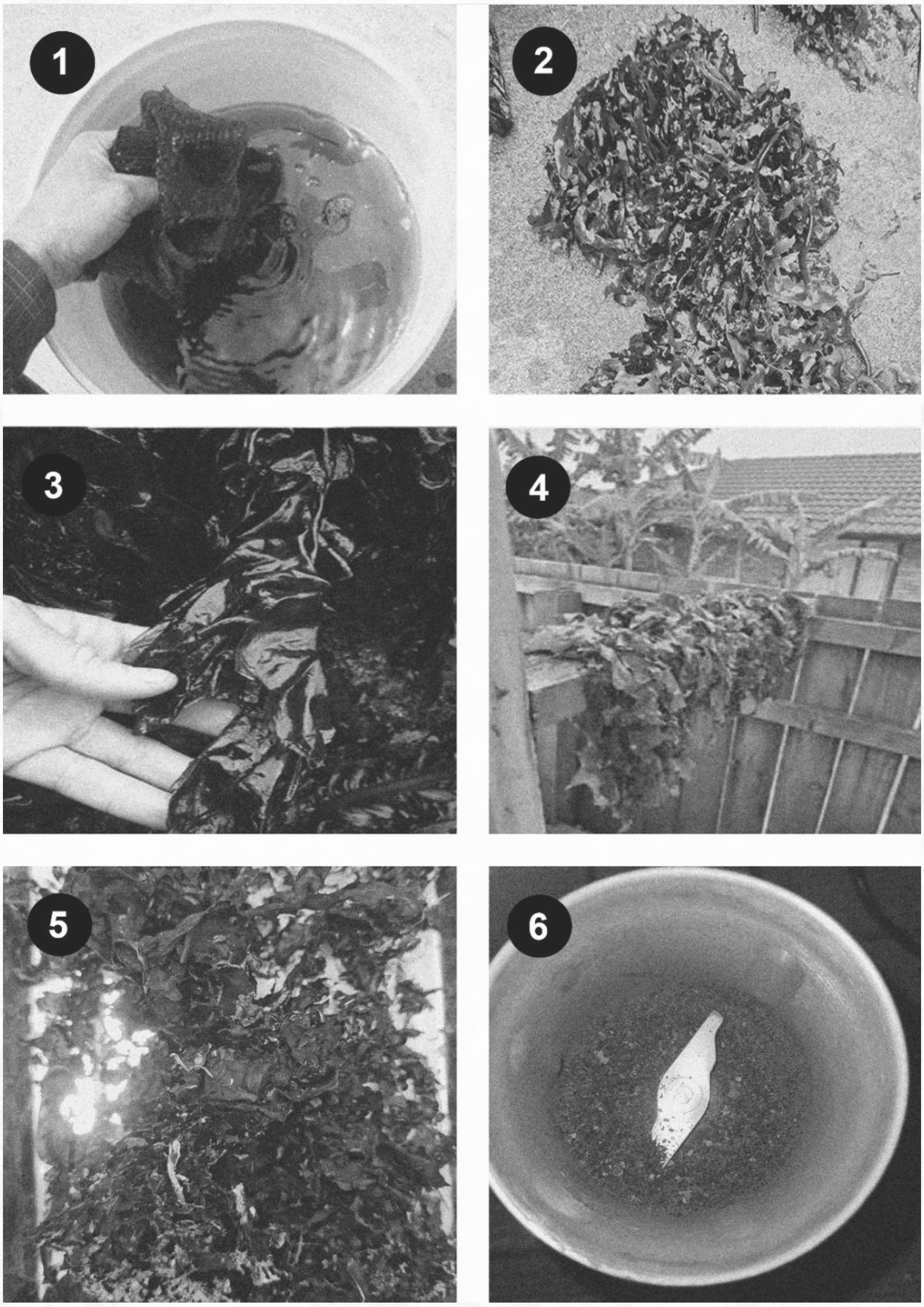


Figure 20. Seaweed Processing Raw Materials

Harakeke Leaves

Harakeke (NZ flax) was prepared by first collecting the leaves [1] and rinsing them to remove any dirt [2]. After rinsing, the leaves were cut into strips [3] and then chopped into smaller pieces to facilitate shredding [4]. A dehydrator was used to reduce the moisture content, ensuring that the fibres maintained their structural integrity [5]. Once dehydrated, the material was ground into a fine composite to enhance its suitability for bio-composite formulations [6]. However, some longer fibres remained intact during shredding, which compromised the mechanical strength and consistency of the final composite (see Figure 21)

Figure 21. Harakeke Processing Raw Materials

Stage 3: Creating New Materials – Experiment A and B Overview

In this stage, two key experimental phases (A and B) were conducted to explore different material and processing methods. The objective was to optimise formulations that enhance the strength, durability, and sustainability of both bio-composites and bio-based polymers.

Bio-composites consist of natural fillers or fibres (such as harakeke or coffee grounds) combined with a binding matrix to create structurally reinforced materials, while bio-based polymers are biodegradable binding agents derived from natural sources like starch, gelatine, or agar, forming flexible and mouldable materials.

These experiments aimed to create material prototypes that align with regenerative design principles. They involved combining processed raw materials with natural binders, additives, and refining processes to achieve specific performance characteristics, such as mechanical strength and flexibility.

By testing different formulations, the experiments provided insights into how various compositions influence structural integrity, environmental sustainability, and practical applications in material innovation.

3.4 Experimental Research Phase A

Materials Ingredients

Banana Leaves, Coffee, Coffee Grounds, Coffee Grounds (Heated), Clay
Kawa Kawa Leaves, NZ Cabbages, NZ Cabbages (Heated)
Onion Peel (Heated), Orange Peels, Seaweed

Figure 22. Experiment Research A Samples

3.4.1 Experimental Research Phase A: Food Waste Bio-Composites

The aim of this experiment was to create bio-composite materials using food waste and analyse their properties. Bio-composites offer a sustainable alternative to traditional building materials, reducing environmental impact and supporting circular economy principles. Various food waste sources, such as fruit peels and vegetable scraps, were collected and processed as base ingredients. However, this experiment was a preliminary exploration, and food waste was not continued in later phases due to challenges with biological stability, material consistency, and durability.

3.4.2 Methods

The process began with cleaning, drying, and grinding food waste into fine particles. Materials such as orange peels, banana leaves, and coffee grounds were chosen for their availability and potential for enhancing the mechanical properties of bio-composites. These materials were mixed with natural binding agents such as starch, gelatine, or agar to form cohesive mixtures. Different ratios of food waste to binders were tested to determine which formulations provided the best balance of strength, flexibility, and insulation properties.

3.4.3 Formation

The mixed materials were poured into silicone moulds to create test samples, which underwent various curing processes, including air drying, oven drying, and heat pressing. The curing conditions were adjusted to evaluate how different drying methods affected the composite's durability. Air drying, sun drying, oven drying, and dehydration techniques were tested to optimise strength and longevity.

3.4.4 Testing and Analysis

After curing, the food waste composite samples were assessed for mechanical strength, flexibility, and durability. These evaluations were conducted through compression tests, bending trials, and visual inspections. Some samples remained soft and brittle, particularly those made using the cold mixing process, while heat-cured samples exhibited better structural integrity. However, mould growth was a significant issue, especially in orange peel composites. This highlighted the need for further research into preservation techniques such as natural antifungal agents or modified drying processes to improve bio-composite stability. (refer to Appendix B)

3.4.5 Findings and Challenges

Preliminary findings showed that coffee grounds and seaweed powder enhanced compressive strength, while fruit peels improved flexibility. However, the presence of sugars in fruit peels promoted microbial growth, causing rapid degradation. Oven-dried samples generally performed better than air-dried or sun-dried ones, reinforcing the importance of controlled curing processes. The challenges of mould growth, inconsistent material properties, and short lifespan of food waste composites ultimately led to a shift away from these materials in subsequent experiments. (see in Appendix B)

3.4.6 Decision to Use Other Materials

Based on these findings, the research pivoted towards materials with greater biological stability, such as agricultural residues, biodegradable polymers, and natural fibres. These alternatives offered better durability and moisture resistance, making them more suitable for architectural applications. Food waste was not used beyond this experiment due to its tendency to degrade quickly, limiting its potential for long-term use. However, its findings informed the next phase of research, influencing material selection strategies.

3.4.7 Results and Next Steps

This experiment demonstrated the potential and limitations of food waste in sustainable material development. While promising for short-term applications, it lacked the long-term durability required for architectural use. Future studies may explore natural preservatives or composite reinforcement techniques to improve its viability. Moving forward, the focus shifted to biodegradable polymers and agricultural waste, ensuring that bio-composite development aligned with sustainability goals and practical applications in construction.

3.5 Experiment Research Phase B

Materials Ingredients

Mycelium Grain

Acorn

Coffee

Coffee Ground

Cornhusk

Cabbage Tree

Eggshell

Harakeke

Kawa Kawa

Pasta

Paper Pulp

Rose Petal

Sand

Sawdust

Seaweed

Shells

Wool

Green Tea

Figure 23. Experiment Research B Samples

3.5.1 Experimental Phase B: Exploring Bio-Composites

The aim of Experimental Phase B was to explore the potential of various organic and inorganic material combinations to create bio-composites with enhanced durability and functional properties, building on insights from Phase A. Unlike Phase A, which focused on food waste-based bio-composites, this phase expanded the material scope to include fibrous, mineral-based, and structural additives such as coffee grounds, wool, pasta, paper pulp, sawdust, harakeke (New Zealand flax), seaweed, sand, clay, eggshells, green tea, cabbage tree, kawa kawa, mycelium grain, acorns, rose petals, cork, and cornhusk. The objective was to identify the most effective material blends that could provide improved mechanical strength, water resistance, and architectural viability, addressing the biological instability and degradation issues encountered in Phase A. (see in Appendix B)

3.5.2 Methods

The experiment began by systematically combining different materials in various ratios to form cohesive mixtures. Each combination was carefully selected to leverage the distinct properties of the ingredients, aiming to enhance strength, flexibility, insulation, and aesthetic appeal. For instance, coffee grounds were paired with wool for their complementary textures, while pasta and paper pulp were combined with sawdust to explore their binding capabilities. Harakeke was frequently used due to its local availability and importance within New Zealand's natural landscape, making it a sustainable and regionally sourced material for experimentation.

3.5.3 Formation

Once mixed, the materials were shaped into standard test moulds and subjected to curing processes, including air drying, oven drying, and heat pressing. These curing methods were chosen to understand how each process affects the bio-composite's final properties. The cured samples were then rigorously tested for mechanical properties such as tensile strength, compressive strength, and flexibility.

Preliminary findings indicated that some combinations, like eggshell, coffee, and harakeke, showed enhanced compressive strength, making them suitable for structural applications. Blends involving seaweed and sand demonstrated good flexibility properties.

3.5.4 Potential and Future Research

These experiments demonstrated the potential of diverse material combinations to create innovative and sustainable bio-composites, aligning with the principles of regenerative design. These materials not only promote waste reduction but also offer new possibilities for building materials. Future research will focus on refining these formulations, optimising curing processes, and scaling up production for practical architectural applications. Emphasis will also be placed on improving the durability and biological stability of these materials to ensure their long-term viability.

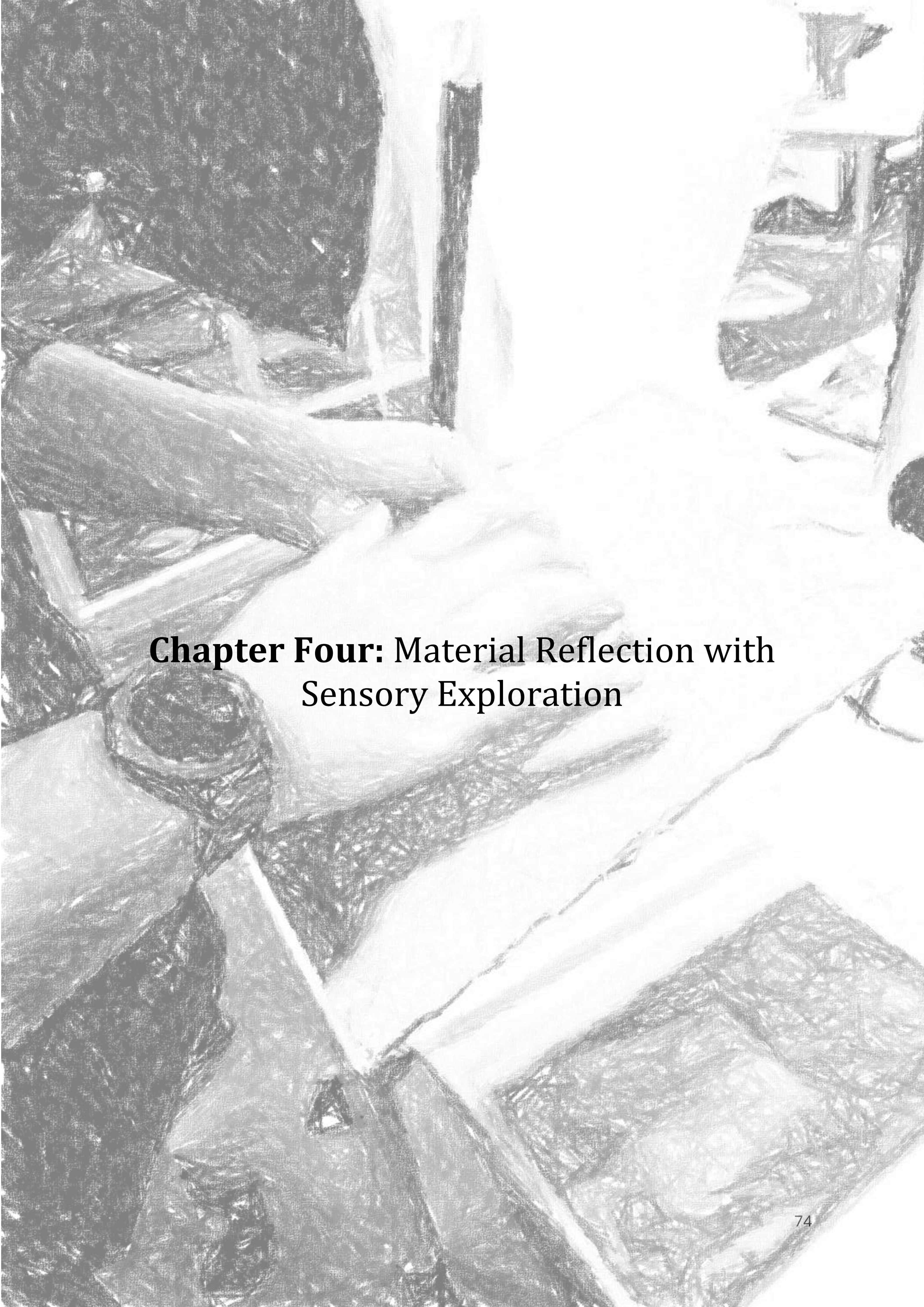
3.5.5 Experimental phase B: Seaweed, Sand, and Harakeke Combination

One notable combination in Experiment B was the blend of seaweed, sand, and harakeke (New Zealand flax). This mixture aimed to leverage the unique properties of each component: the flexibility of seaweed, the strength of harakeke, and durability properties of sand. However, a significant drawback observed was the lack of water resistance in this composite. The absence of a strong binding agent led to poor cohesion when exposed to moisture.

During testing, the seaweed and sand mixture tended to disintegrate upon contact with water, undermining the structural integrity of the composite. This finding highlights the critical need for integrating stronger binders to enhance water resistance. Future research will need to focus on identifying and incorporating suitable natural or bio-based binders that can improve the water resistance of such composites without compromising their environmental benefits. Addressing this issue is essential for developing durable, sustainable materials for architectural applications. (see in Appendix B)

3.5.6 Results and Next Steps

The success of Experiments conducted in phase B, I suggested that regenerative materials derived from food waste and natural fibres had potential for sustainable architecture. Preliminary findings suggest that certain formulations exhibit promising mechanical properties, such as strength, flexibility, and durability, which could make them viable for sustainable design applications. However, further testing and refinement are needed to fully understand their long-term performance and practical feasibility. The insights gained from these experiments suggested the next stages of the research process, particularly in refining material formulations to explore optimal combinations of organic and inorganic materials to enhance the mechanical properties of these bio-composites. Additionally, enhancing durability became a key focus, specifically by investigating natural or bio-based binders to improve water resistance and overall longevity, addressing challenges observed in previous experiments. Scaling production methods for larger-scale applications was also seen to be essential to facilitate practical use while maintaining sustainability. Furthermore, exploring new combinations of materials and ratios could uncover additional possibilities for innovative and building solutions. Overall, these next steps, presented in Chapter 4, aimed to further explore the potential of bio-composites in the context of sustainable architecture, promoting a circular economy and reducing environmental impact.



Chapter Four: Material Reflection with Sensory Exploration

4.1 Introduction

This chapter describes how the sensory qualities of regenerative materials fostered deeper connections between people and the environment in architectural design. The investigation focused on texture, colour, and smell, assessing their impact on aesthetic and emotional experiences. The central question guiding this study was: Can the sensory qualities of regenerative materials create deeper connections between people and the built environment?

The research explored seaweed composites, harakeke (New Zealand flax) fibres, and bio-based composites, all sourced from renewable and waste materials. Seaweed composites displayed unique textures and colour variations, harakeke fibres provided durability and natural appeal, and bio-based composites balanced sustainability with functionality.

Sensory exploration played a crucial role in this study, encouraging deeper engagement with the built environment (Pallasmaa, 2005). The chapter presents findings on how texture, colour, and smell influenced material perception and human interaction in architecture. The analysis is divided into three sections: general observations, specific material findings, and reflective insights.

The experimental process included small-scale tests, medium-scale prototypes, and full-scale applications, allowing for a detailed understanding of each material's sensory properties. The results demonstrated that ow regenerative materials can enhance user experiences, potentially promoting well-being, and inspiring stronger connections to nature.

4.2 Understanding Sensory Exploration with Materials

The integration of regenerative materials into architecture has increasingly gained attention, particularly regarding sustainability and sensory engagement. In this study, bio-based composites, seaweed, and harakeke fibres were sourced from renewable or waste materials as alternatives to traditional, resource-intensive materials. These materials not only promoted environmental sustainability but also provided opportunities to create spaces that engaged the senses in unique ways. Previous research emphasised the importance of exploring the sensory qualities of materials to enhance user experience and strengthen connections between people and their environments (Pallasmaa, 2005; Spence, 2020).

Sensory design principles focused on how architecture could evoke emotional and physical responses through multisensory interactions. Pallasmaa (2005) highlighted the importance of tactile experiences, suggesting that materials should not only be seen but also felt, smelled, and heard to encourage holistic engagement with the environment. Similarly, Spence (2020) emphasised that considering all the senses—sight, touch, sound, taste, and smell—resulted in more meaningful and engaging spaces. In the context of regenerative materials, their sensory qualities, including texture, colour, smell, and sound, played a crucial role in fostering deeper connections between people and the environment. Investigating the sensory characteristics of local regenerative materials revealed both opportunities and challenges in their design applications, highlighting their potential to create sustainable and aesthetically rich architectural alternatives.

The research of Kaplan and Kaplan (1989) further supported the idea that natural elements in architecture promoted emotional well-being. Their work on restorative environments demonstrated that exposure to natural materials reduced stress and improved cognitive function. In the case of regenerative materials, incorporating natural textures, colours, and scents into architectural design evoked biophilic responses, creating environments that felt more in tune with nature and enhancing people's emotional connection to space.

The Material-Driven Design (MDD) framework played a critical role in this research by shifting the focus from traditional design elements such as form and function to the materials themselves. By prioritising the sensory attributes of materials, the MDD approach encouraged a deeper understanding of how materials influenced architectural experiences. This approach moved beyond merely considering a material's aesthetic or structural properties and instead explored how it could create a more multisensory and immersive environment. The MDD framework aligned with growing research on the sensory and emotional impact of materials, emphasising the importance of engaging with materials at an intuitive level (Karana et al., 2015).

Through these perspectives, the sensory exploration of materials proved to be a crucial approach to creating architecture that fostered meaningful connections between people and the environment. By incorporating regenerative materials that engaged multiple senses, architects designed spaces that not only promoted emotional well-being and sustainability but also cultivated a stronger bond with nature.

4.3 Aim of the Experimental Process

The aim of the experimental process described in this chapter was to explore the sensory qualities of regenerative materials and their potential to foster deeper connections between people and the environment. This exploration focused on three key sensory attributes: texture, colour, and smell, and how they influence both the emotional and aesthetic experiences of architecture. The experimental design also investigated how regenerative materials, made from sustainable and renewable resources, can contribute to creating more sustainable architectural solutions.

4.3.1 Material Selection Criteria

The materials selected for this research were chosen based on their regenerative potential, sensory qualities, and environmental impact. Two primary criteria guided the selection process:

Sustainability: The materials had to be made from renewable or waste-based resources, reducing reliance on non-renewable resources and supporting a circular material lifecycle. Seaweed composites, harakeke (New Zealand flax) fibres, and bio-based composites were prioritised for their regenerative properties and low environmental impact.

Sensory Qualities: Each material needed to offer unique sensory attributes, such as texture, colour, and smell. These qualities were essential for understanding how materials interact with human perception and influence engagement with architectural spaces. For instance, seaweed offers unique textures and colour variations, while harakeke fibres provide tactile durability.

4.3.2 Testing Methods

The experimental process used various testing methods at different scales to evaluate the materials' sensory qualities and their potential in architectural design. These tests were categorised into small-scale material tests, medium-scale prototypes, and full-scale samples.

Small-Scale Material Tests: Small samples (cast in ,10 cm x 10 cm x 2 cm moulds) were used to assess texture, flexibility, and colour. These tests focused on the tactile qualities of materials such as seaweed composites and harakeke fibres, and how these materials interacted with light. The small scale allowed for rapid experimentation and adjustments in the material formulations.

Figure 24. 8 cm x 8 cm x 2 cm and 10 cm x 10 cm x 2 cm size casting

Medium-Scale Prototypes: Prototypes (e.g., 25.8 cm x 16 cm x 1.5 cm moulds) allowed for testing how the materials could be applied as larger architectural components like panels or partitions. These tests explored how the materials' sensory qualities influenced the design of spaces and the interaction between people and their environment.

Figure 25. 25.8 cm x 16 cm x 1.5 cm size casting

Full-Scale Samples: Larger samples (30.7 cm x 20.8 cm x 1.5 cm moulds) were used to test the materials in real-world conditions. This scale helped assess the structural integrity of the materials and their performance across larger areas, as well as the challenges related to durability and stability.

Figure 26. 30.7 cm x 20.8 cm x 1.5 cm size casting

Figure 27. Photograph of the material being dry up in the mould

4.4 Sensory Exploration

Sensory exploration in architecture was vital for creating deeper connections between people and the built environment. By examining the sensory qualities of texture, colour, smell, and touch in regenerative materials experimentation, this study assessed how these attributes influenced user experience, emotional response, and material engagement. Sensory attributes not only determined how spaces looked and felt but also shaped how people interacted with their surroundings, fostering stronger emotional connections. This approach aligned with the thesis's aim to create an installation that actively engaged the senses and formed lasting bonds between people and their environments through materiality.

4.5 General Sensory Observations

The sensory characteristics of the tested regenerative materials were evaluated across different physical scales, including small samples, medium-sized prototypes, and full-scale applications. These assessments revealed key patterns in texture, colour, smell, and touch, which shaped both material performance and user engagement. This process also highlighted the aesthetic possibilities of regenerative materials in architecture and provided insights into how these materials contributed to sustainable and engaging architectural experiences.

Figure 28. Sample One 8cm x 8cm x 2cm

Figure 29. Sample Two 8cm x 8cm x 2cm

Figure 30. Sample Three 8cm x 8cm x 2cm

Figure 31. Sample Four 10cm x 10cm x 2cm

Figure 32. Sample Five 10cm x 10cm x 2cm

Figure 33. Sample Six 10cm x 10cm x 2cm

4.5.1 Texture

Texture played a fundamental role in shaping interactions with the materials tested. The tactile experience of each surface facilitated specific emotional responses, guiding how these materials could be engaged within an architectural context. The following textures were observed:

Smooth and Fine Texture: Some samples had soft, velvety surfaces that naturally encouraged a light touch and a sense of calm. These materials felt particularly suited for quiet, reflective spaces where a soothing environment was essential. While handling them, I noticed how their fine texture evoked a sense of comfort and invitation (see Figure 32).

Coarse and Granular Texture: Other materials had a rough, uneven surface that required a more intentional touch, fostering engagement and curiosity. These textures effectively encouraged deeper interactions, making them ideal for high-touch surfaces or feature walls. I observed that rough textures demanded more active engagement, drawing attention to their distinctive tactile qualities (see Figure 33).

Fibrous and Textured: Materials incorporating flax fibres exhibited a distinct fibrous quality that reinforced their natural authenticity. These surfaces encouraged physical exploration, enhancing the material's connection to nature and its potential in sustainable design. I found that the fibrous texture created an organic and grounding sensation, aligning with sustainable and biophilic design principles (see Figures 29-33).

Throughout testing, it became clear that texture significantly influenced spatial perception. Consistent with Pallasmaa's (2005) findings, variations in texture contributed to enriching spatial experiences by engaging the sense of touch, reinforcing the material's presence within the built environment.

Figure 34. Photograph of Texture of Sample Four 10cm x 10cm x 2cm

4.5.2 Colour

The natural colour variations of regenerative materials played a significant role in defining their aesthetic and atmospheric impact. Observations under different lighting conditions revealed the following insights:

Earthy Tones Composites: These materials exhibited variations white and brown hues, reflecting organic characteristics. Their appearance changed with light exposure, transitioning from muted tones in dim lighting to vibrant earthy colours under natural daylight. During testing, I observed how shifts in light intensity altered the perception of these materials, influencing the emotional tone of the space (see Figures 29-31).

Warm Beige and Golden Tones in Flax Fibres: The warmth of flax fibres contributed to a sense of comfort and natural cohesion within a space. The colours subtly shifted depending on the angle and intensity of the light, enhancing the material's depth. Testing confirmed that these warm hues fostered a welcoming environment, reinforcing Kaplan and Kaplan's (1989) research on the calming effects of natural colours in architecture (see Figures 29-33).

By observing these materials in various lighting conditions daylight, artificial light, and dim environments I confirmed that colour significantly influenced spatial experiences. These findings support the argument that natural colours contribute to psychological well-being and encourage a deeper connection with nature.

Figure 35. Photograph of Colour of Sample 8cm x 8cm x 2cm

4.5.3 Smell

The olfactory qualities of regenerative materials were evaluated to understand their impact on spatial experience. Unlike traditional architectural materials, which often lack scent, bio-based materials introduced subtle, natural aromas that enriched the sensory environment:

Seaweed Composites: These emitted a mild, earthy scent reminiscent of the ocean, reinforcing their organic origin. This aroma was most noticeable in enclosed spaces and contributed to a calming, immersive experience (see in Figure 28).

Flax Fibres: These released a faint, grassy scent, enhancing the perception of natural authenticity. The smell was particularly evident when the material was freshly processed. Over time, the scent faded but remained present enough to reinforce the material's natural origins (see in Figures 29-31).

Bio-Based Additives: Some samples incorporated lemon oil or other natural additives to modify or enhance their scent. These additions helped create an inviting atmosphere while also acting as a preservative against material degradation. I observed that the scent variations influenced how the material was perceived, demonstrating that olfactory engagement plays a subtle but important role in material interaction.

These findings align with Bratman et al.'s (2024) research, which suggests that natural scents trigger emotional responses and enhance spatial experiences. Spence (2020) further emphasises that scent integration in architectural materials shapes interaction with the surrounding environment.

Figure 36. Smelling the Sample of 25.8 cm x 16 cm x 1.5 cm

4.5.4 Touch

Touch played a critical part in the material testing process, directly influencing engagement and perception. The following observations were made:

Soft and Flexible Materials: Some seaweed-based composites demonstrated flexibility, making them ideal for applications requiring adaptability, such as flexible partitions or sensory installations. When handling these materials, I noticed how their dynamic and responsive qualities made them well-suited for interactive settings.

Rigid and Structured Surfaces: Other samples, particularly those reinforced with flax fibres, exhibited firmness and durability. These materials were found to be suitable for structural applications where resilience was necessary. Testing revealed that rigidity conveyed a sense of stability and permanence, reinforcing their suitability for load-bearing surfaces.

Varying Temperature Sensations: Materials like flax and seaweed composites absorbed and retained temperature differently. Warmer materials encouraged a sense of comfort, while cooler surfaces introduced a refreshing tactile quality. While handling the samples, I subconsciously responded to these temperature variations, reinforcing the idea that touch-based thermal properties influence material perception.

Testing results confirmed that regenerative materials evoked specific tactile responses, reinforcing their suitability for multisensory architectural applications. By integrating these materials into design, spaces can offer diverse touch-based experiences, enhancing interaction and engagement.

Figure 37. Tactile responses of the sample

4.6 Specific Material Findings

Building upon the general sensory observations, this section presented the specific material findings derived from the testing phases. The evaluation process focused on sensory attributes such as texture, colour, smell, and touch to assess the potential of materials for architectural installation. By systematically testing material compositions at different scales, their functional viability, sensory engagement, and structural potential became more evident.

The experimentation process was crucial in refining material qualities, as it transitioned from initial trials to more advanced prototypes. Small-scale evaluations provided insights into surface characteristics, flexibility, and initial durability, while medium- and full-scale applications revealed challenges related to structural performance, environmental resistance, and consistency. This iterative approach enabled a deeper understanding of how materials responded to various conditions and their potential to foster meaningful spatial experiences.

Testing across different scales demonstrated that variations in formulation and treatment influenced not only the physical resilience of the materials but also their ability to interact with environmental factors such as moisture, weight, and temperature fluctuations. The findings indicated that while certain compositions retained their integrity under stress, others required additional modifications to improve stability, adaptability, and longevity in architectural applications.

These observations emphasised the importance of continued refinement to enhance consistency, durability, and scalability. The research highlighted the role of sensory-driven design in material innovation, advocating for the integration of multi-sensory considerations into sustainable architectural solutions. By aligning experimental findings with design methodologies, this work contributed to a broader discourse on material engagement, environmental responsiveness, and the evolving relationship between materiality and spatial experience.

Specific Material Findings: Harakeke, Sand, Seaweed, Coffee, Cornflour, and Glycerol

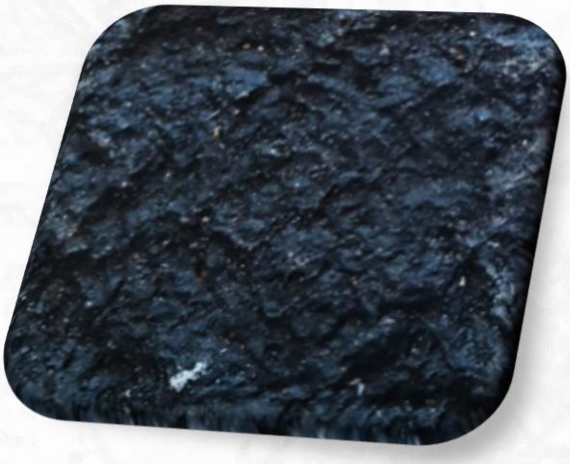


Figure 38. Small Sample One 8cm x 8cm x 2cm

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During the material development and testing process, I observed that this composite exhibited a coarse and fibrous texture with a deep black, organic appearance due to the high concentration of coffee grounds and seaweed. The harakeke fibres provided additional reinforcement, ensuring the material maintained structural integrity while remaining somewhat flexible. Sand contributed to a granular feel, making the surface rougher and visually textured. Cornflour and glycerol acted as binders, helping to achieve cohesion while preventing excessive brittleness.

The material emitted an earthy, slightly smoky scent, which was influenced by the combination of coffee and seaweed. The tactile experience was both firm and grainy, encouraging interaction through touch. Observations showed that the material's surface varied depending on drying conditions, with slower drying times resulting in smoother finishes and faster drying leading to more pronounced texture variations

Figure 39. Material Finding Description Small Sample One

Specific Material Findings: Harakeke, Clay, Cornflour, Paper Pulp, Glycerol, Calcium Carbonate, and Seaweed

Figure 40. Small Sample Two 8cm x 8cm x 2cm

During testing, I noticed that this composite had a light beige, porous, and fibrous texture due to the mix of paper pulp and harakeke fibres. Clay and calcium carbonate provided strength, creating a slightly rough but even surface. Cornflour and glycerol worked as binders, helping the material stay intact while remaining flexible and avoiding brittleness. Seaweed naturally aided bonding, improving durability.

The material gave off a mild, earthy scent from clay and seaweed, giving it a natural feel. The touch was soft yet firm, with a slightly grainy and chalky feel. I found that drying conditions changed the surface slower drying made it smoother, while faster drying made it rougher. This material is useful for acoustic panels, insulation layers, and decorative wall designs as potential material.

Figure 41. Material Finding Description Small Sample Two

Specific Material Findings: Harakeke, Eggshells, Cabbage Tree, Clay, Paper Pulp, Glycerol, and Sorbitol

Figure 42. Small Sample Three 8cm x 8cm x 2cm

While testing, I noticed that this material had a fibrous and slightly rough texture due to the mix of harakeke and paper pulp. Eggshells and clay added strength, making the material firm and compact with a grainy surface. The cabbage tree fibres helped reinforce flexibility and durability.

Glycerol and sorbitol acted as binders, keeping the material intact and preventing cracks. The colour was a natural beige brown with visible fibres and slight surface variations. It felt firm but had some give, making it pleasant to touch. The earthy scent reflected its natural composition.

Slower drying produced a smoother surface, while faster drying made it more textured. This material could be useful for wall panels, acoustic insulation, and eco-friendly interiors due to its durability and natural aesthetic.

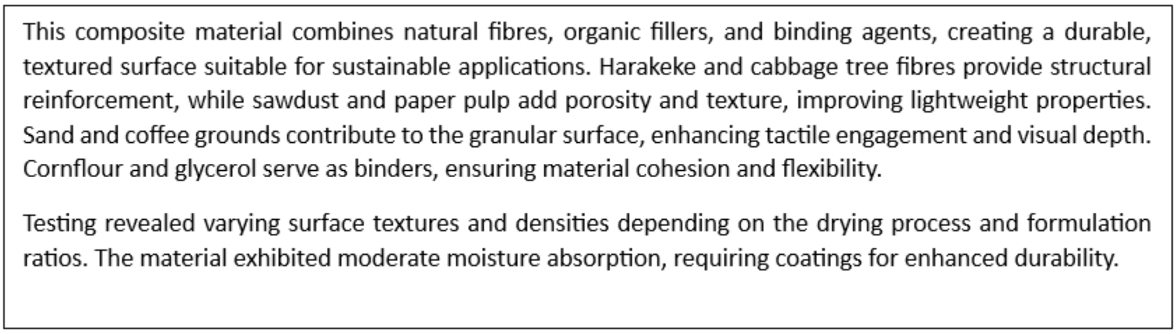
Figure 43. Material Finding Description Small Sample Three

Figure 44. Overall Small Samples 8cm x 8cm x 2cm

There are more samples (shown in Appendix B)

Specific Material Findings: Harakeke, Sand, Seaweed, Coffee, Cornflour, Glycerol, Sawdust, Cabbage Tree, and Paper Pulp

Figure 45. Small Sample Four 10cm x 10cm x 2cm


This composite material combines natural fibres, organic fillers, and binding agents, creating a durable, textured surface suitable for sustainable applications. Harakeke and cabbage tree fibres provide structural reinforcement, while sawdust and paper pulp add porosity and texture, improving lightweight properties. Sand and coffee grounds contribute to the granular surface, enhancing tactile engagement and visual depth. Cornflour and glycerol serve as binders, ensuring material cohesion and flexibility.

Testing revealed varying surface textures and densities depending on the drying process and formulation ratios. The material exhibited moderate moisture absorption, requiring coatings for enhanced durability.

Figure 46. Material Finding Description Small Sample Four

Specific Material Findings: Harakeke, Clay, Cornflour, Paper Pulp (Hard Mix), Glycerol (Gloss Finish), and Calcium Carbonate

Figure 47. Small Sample Five 10cm x 10cm x 2cm

This composite material combines natural fibres, mineral reinforcements, and organic binders to create a dense, smooth, and durable surface. The harakeke fibres add structural integrity, while the clay and calcium carbonate enhance stability and hardness, contributing to a firm, compact texture. Paper pulp (hard mix) provides fibre reinforcement, making the material sturdy and resilient. Cornflour and glycerol serve as binding agents, ensuring cohesion and flexibility.

The gloss finish, achieved through glycerol, creates a smooth, slightly reflective surface, enhancing aesthetic appeal and reducing porosity. The material's pale, off-white tone is influenced by calcium carbonate, giving it a clean, refined appearance.

Testing revealed high compressive strength, making it suitable for wall cladding, decorative panels, and architectural surfaces. While durable, further refinements could improve moisture resistance. This material exemplifies sensory-driven and sustainable material innovation, supporting eco-friendly architectural applications.

Figure 48. Material Finding Description Small Sample Five

Specific Material Findings: Harakeke, Eggshells, Cabbage Tree, Clay, Paper Pulp, Glycerol, and Sorbitol

Figure 49. Small Sample Six 10cm x 10cm x 2cm

This composite material integrates natural fibres, mineral elements, and organic binders, resulting in a textured, fibrous surface with a rich earthy tone. Harakeke and cabbage tree fibres contribute to structural integrity, making the material durable and flexible. Eggshells and clay enhance density and rigidity, providing a solid yet slightly porous texture. Paper pulp adds lightness and additional reinforcement, balancing weight and flexibility.

The combination of glycerol and sorbitol ensures binding stability while preventing brittleness, allowing the material to retain a slightly pliable yet firm structure. The rough, grainy texture adds a natural aesthetic, while the brown tones and visible fibres reflect its organic composition.

Testing revealed moderate moisture absorption, suggesting the need for surface treatment to enhance water resistance. With its earthy appearance and resilient properties, this material is well-suited for wall panels, artistic installations, and sustainable interior applications.

Figure 50. Material Finding Description Small Sample Six

More samples (shown in Appendix B)

Figure 51. Overall Material Samples for 10cm x 10cm x 2cm

Medium-Scale Specific Material Findings: Recycled Paper, Harakeke Paper, Locally Sourced Harakeke, Locally Sourced Seaweed, Cornflour, Coffee Grounds, and Glycerol

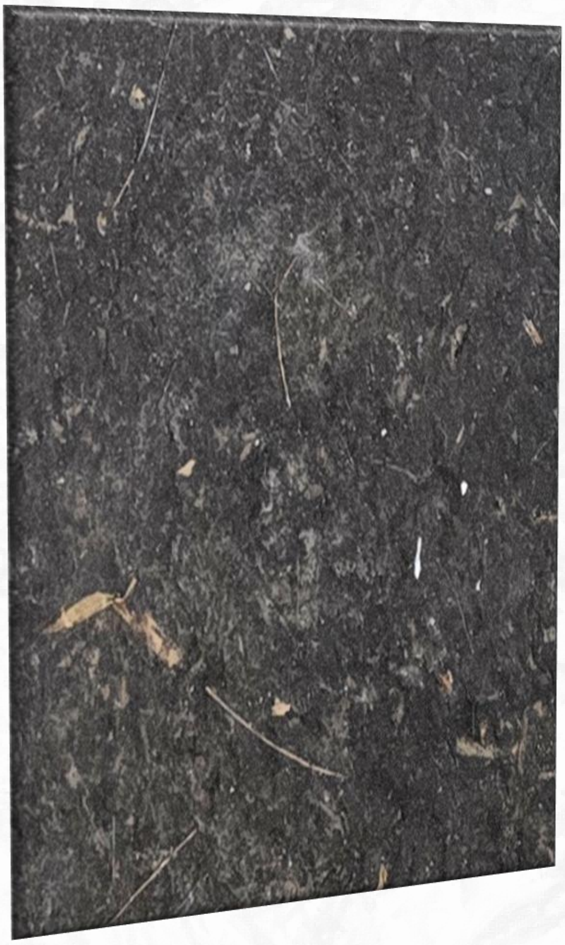


Figure 52. Medium Sample One 25.8cm x 16cm x 1.5cm

Finding (shown in Appendix B)

Medium-Scale Specific Material Findings: Recycled Paper, Locally Sourced Harakeke and Seaweed, Eggshells, Coffee Grounds, Gelatine, and Glycerol

Figure 53. Medium Sample Two 25.8cm x 16cm x 1.5cm

Finding (shown in Appendix B)

Medium-Scale Specific Material Findings: Calcium Carbonate, Locally Sourced Harakeke and Seaweed, Cornflour, Clay, Coffee Grounds, Gelatine, Eggshells, and Glycerol

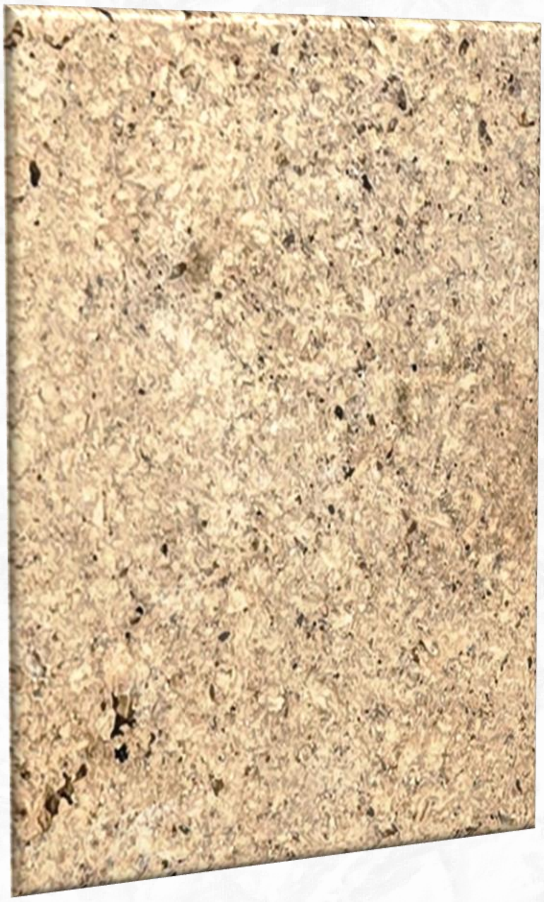


Figure 54. Medium Sample Three 25.8cm x 16cm x 1.5cm

Finding (shown in Appendix B)

All the Medium Samples (refer in Appendix B)

Figure 55. Overall Medium Samples 25.8cm x 16cm x 1.5cm

Full-Scale Specific Material Findings Sample One

Figure 56. Large Sample One 30.7cm x 20.8cm x 1.5cm

Full-Scale Specific Material Findings Sample Two

Figure 57. Large Sample Two 30.7cm x 20.8cm x 1.5cm

Full-Scale Specific Material Findings Sample Three

Figure 58. Large Sample Three 30.7cm x 20.8cm x 1.5cm

Full-Scale Specific Material Findings Sample Four

Figure 59. Large Sample Four 30.7cm x 20.8cm x 1.5cm

Figure 60. Overall Large Samples 30.7cm x 20.8cm x 1.5cm

All the Larges Samples Findings (refer in Appendices B)

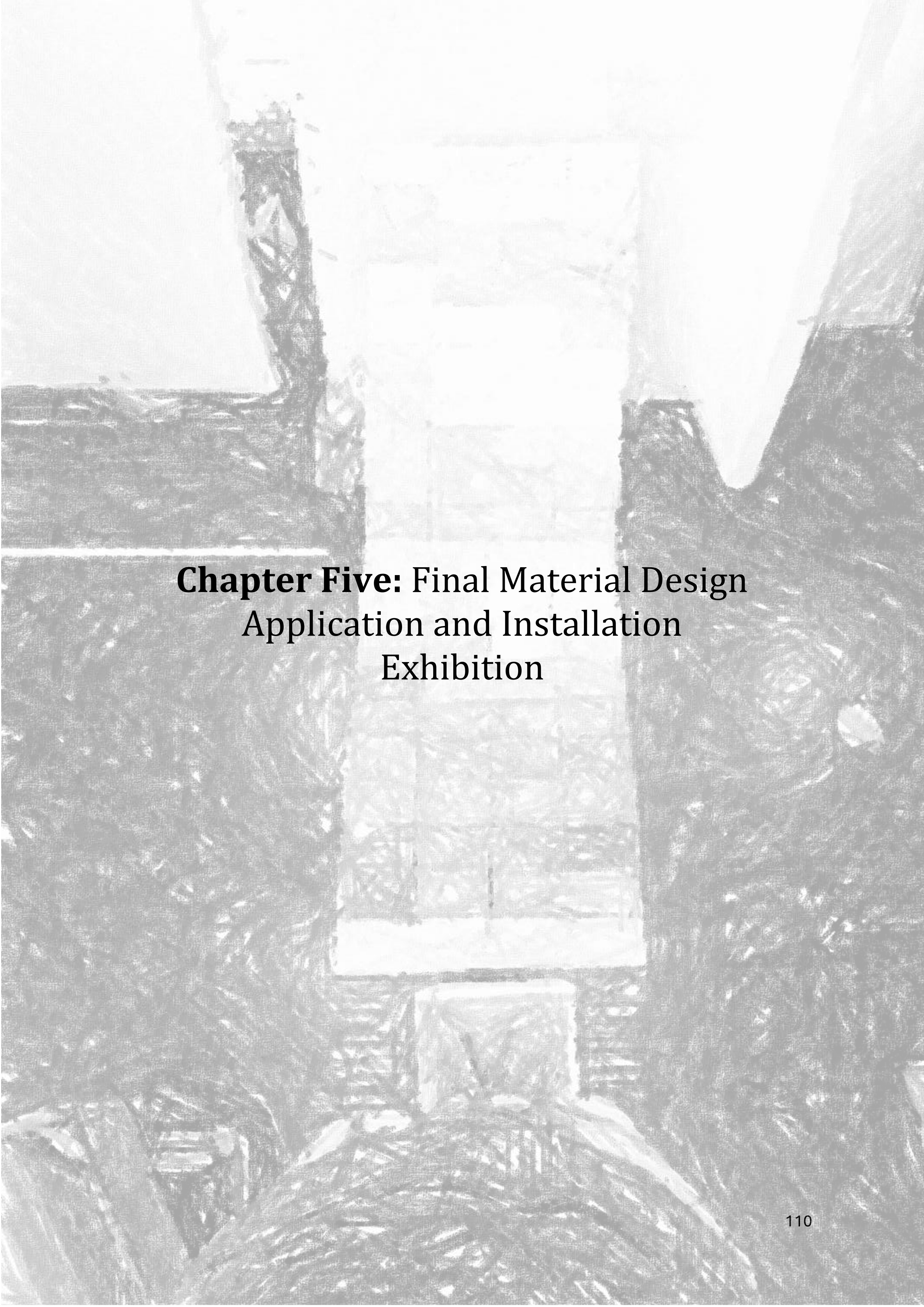
4.7 Reflective Insights

The findings from sensory observations and material testing, suggest that regenerative materials can play an influential role in sustainable and experiential architecture. These materials not only offer environmental benefits but can enhance the way people engage with spaces. The research demonstrated that sensory qualities such as texture, colour, smell, and touch significantly influence material perception and interaction. Seaweed composites, with their smooth flexibility, contrasted with the fibrous strength of flax-based materials, highlighting their diverse applications. Additionally, the way materials responded to lighting conditions reinforced their dynamic nature, while the subtle scents of natural materials added another layer of sensory engagement.

One of the most significant takeaways was the ability of regenerative materials to support sustainable architectural practices. Unlike conventional synthetic materials that contribute to environmental degradation, regenerative materials decompose naturally, reducing waste and promoting circular design. Many of the materials tested, such as flax fibres and coffee grounds, were sourced from organic waste, demonstrating the potential of repurposing discarded materials into viable architectural solutions. Moreover, the fabrication of these materials required lower energy consumption compared to synthetic alternatives, making them more sustainable in production. These findings reinforced the value of Material Driven Design (MDD), where material selection is based on both functional and ecological benefits. By using locally sourced, naturally decomposable materials, designers could reduce carbon footprints and create low-impact architecture.

The research also underscored how sensory engagement could transform architectural design. Touch, smell, and colour were as integral as structural performance in creating human-centred environments. The varied textures of these materials encouraged physical interaction, fostering an emotional connection between people and their surroundings. This aligns with Pallasmaa's (2005) argument that tactile engagement is critical to spatial experience. Furthermore, the olfactory qualities of materials such as flax and seaweed introduced an immersive element, often overlooked in architectural design. These findings suggested that integrating multisensory materials could enhance well-being by creating more interactive and responsive spaces.

Despite their potential, regenerative materials also presented some challenges. Some, like seaweed composites, lacked structural integrity and required reinforcement to be used in load-bearing applications. Others, such as those based on seaweed, were sensitive to humidity, leading to warping or softening. Additionally, scalability remained a key challenge, as fluctuations in the availability of bio-based raw materials could limit widespread adoption. However, these challenges also revealed new opportunities. The combination of regenerative materials with natural resins or biopolymers could improve durability while maintaining sustainability. Furthermore, these materials showed promise for temporary or modular applications, where flexibility and biodegradability were beneficial.



Chapter Five: Final Material Design Application and Installation Exhibition

5.1 Introduction

The final phase of this research involved presenting the regenerative materials developed throughout the thesis in an installation format rather than a conventional architectural model. This decision was a deliberate methodological and conceptual choice. While architectural models typically demonstrate how a material might be used in a finished built form, this project did not seek to resolve a final building outcome. Instead, it aimed to foreground the materials themselves their sensory properties, ecological narratives, and speculative potential—through an immersive and spatialised experience.

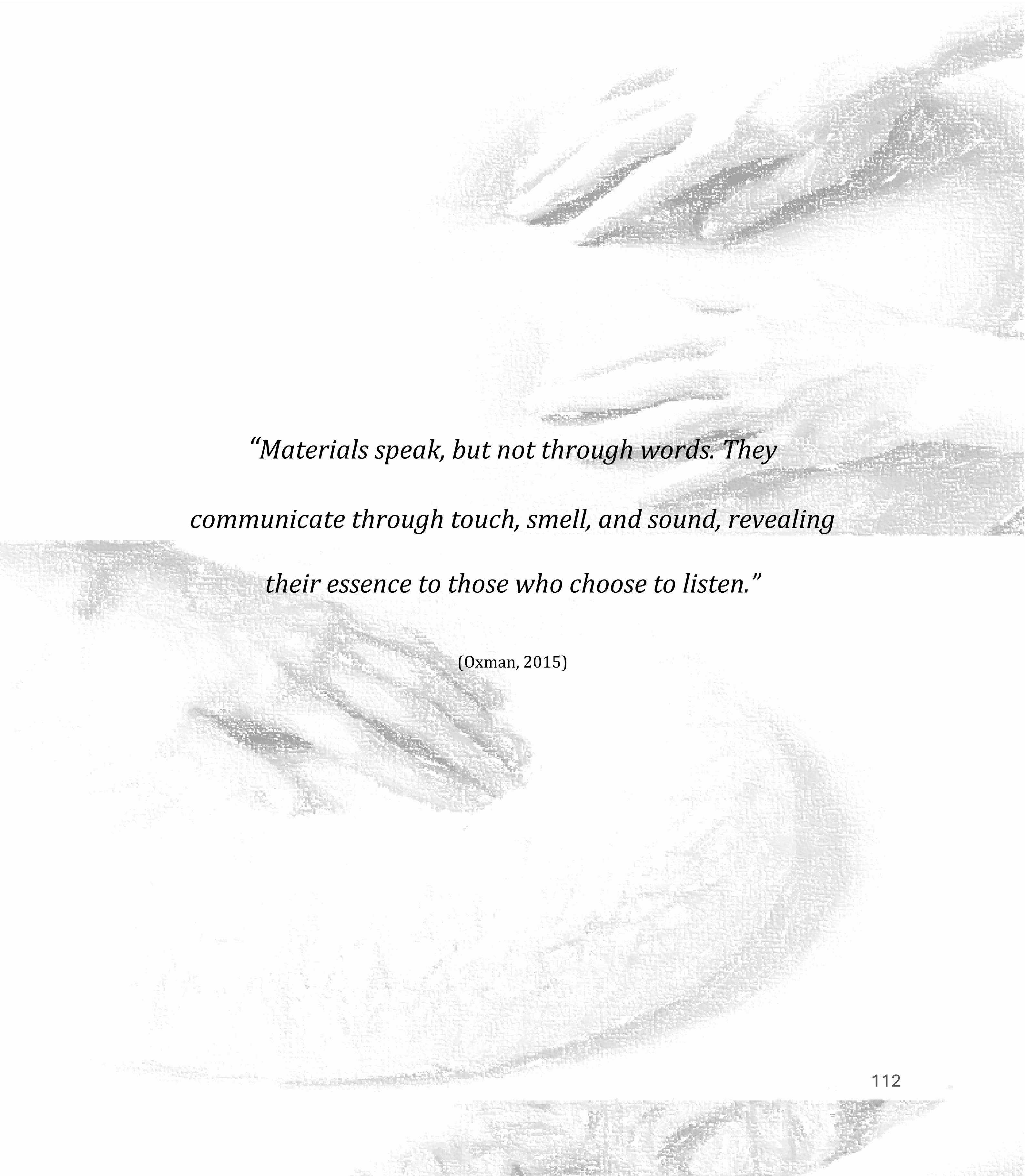
The installation of this was aims to change how viewers engage with materials by transforming the space around them and inviting multisensory, embodied interaction. Similarly, this installation sought to reposition architectural materials not as passive elements but as active agents in shaping perception and emotion. By doing so, the research remained aligned with the Material Driven Design (MDD) framework, where the material is the starting point and driver of design decisions.

The installation enabled visitors to touch, see, and smell the materials directly, inviting close engagement with their texture, weight, flexibility, and natural pigmentation. This would not have been possible with a traditional model, which tends to abstract or reduce material qualities in favour of scale, structure, or form. In contrast, the installation allowed for a more intimate dialogue between body and material, creating space for reflection on their architectural implications, even if those implications remain speculative.

Inspired by the sensory intensity and material vitality found in the works of Eva Hesse and Richard Serra, the installation was designed as a multisensory environment. It used curvature, rhythm, and scale to invite movement and attention, fostering emotional and intellectual responses to the materials. However, this project departed from their purely artistic aims by embedding a clear environmental agenda: to explore how regenerative materials can transform architectural thinking and practice.

The concept of “Material Conversations” framed this spatial outcome. Each material sample presented within the curved wall was arranged according to colour, texture, and light response, subtly narrating its life cycle and sensory identity. The use of digital video further enhanced this, enabling macro views of material surfaces, time-lapse recordings of different aesthetic textures, and projected scale shifts that extended the material imagination into architectural dimensions.

Ultimately, the installation served as a speculative and sensory interface not to represent how these materials will be used in buildings, but to raise questions about how architecture might feel, smell, and age if informed by local, biodegradable, and sensory-rich materials. It offered a framework for engaging materiality spatially and experientially, aligning with the thesis’ broader goals of environmental responsiveness



"Materials speak, but not through words. They communicate through touch, smell, and sound, revealing their essence to those who choose to listen."

(Oxman, 2015)

5.2 Material Conversations in Regenerative Design

The concept of "Material Conversations" frames my exhibition as an exploration of the sensory and ecological narratives within regenerative materials. By engaging with locally sourced and waste-material composites such as coffee grounds, harakeke, seaweed, and cardboard, the exhibition highlights the material lifecycle, from sourcing to application. These materials act as storytellers, revealing their adaptability, resilience, and potential in sustainable architecture.

The exhibition design embraces circularity, using biodegradable, repurposed, and modular structures to emphasise impermanence and regeneration. A curved wall installation creates an interactive space where people can see, touch, and smell the materials, fostering a deeper sensory connection. Data visualisations and filmed videos enhance the experience, capturing the tactility, flexibility, and transformations of materials over time. By integrating interactive and immersive elements, the exhibition challenges traditional material perceptions, inspiring people to rethink sustainable architecture and the role of regenerative materials in design.

Figure 61. Oxman's Material Exhibition (Oxman, 2020)

5.3 Conceptual Design Proposal

The conceptual design proposal aimed to demonstrate the potential of regenerative materials in architecture. showcasing the properties and possibilities of bio-based materials in sustainable design.

Inspired by Eva Hesse's exploration of organic forms and Richard Serra's focus on spatial experience, the installation adopts their principles of material vibrancy and tactile interaction. Hesse and Serra's works emphasise sensory engagement, fostering a dialogue between materials, space, and user. However, this project extends their ideas by positioning regenerative materials as central to both sensory exploration and education.

The installation immerses users in the textures, forms, and properties of regenerative materials while providing insights into their sustainable production and architectural applications. This dual focus integrates aesthetic experience with knowledge dissemination, addressing the evolving role of materials in architecture. Drawing inspiration from the Natural Building Project (NBP) and the Reset Materials exhibition, the proposal embraced the principles of environmental awareness, community engagement, and sustainable design (De Man & Leboucq, 2022; Frearson, 2023).

With this sense of environmental awareness by, the project addresses the issue of the role of materials in design, encouraging a deeper connection to their origins and uses. This approach not only raises awareness about sustainable practices but also challenges perceptions of materiality, by positioning architecture as a medium for environmental innovation and fostering more meaningful interactions between people and their environments.

Figure 62. Eva Hesse's Material Sculptures (Hauser & Wirth, 2024)

5.4 Initial Design

The “artefact” is an installation that utilises regenerative materials to explore how architecture can foster deeper connections between people and their environment. The design emphasises the sensory qualities of materials, such as their textures, strength, and organic forms, creating a multisensory experience that engages users beyond visual appeal.

This investigation reveals both opportunities and challenges. While regenerative materials offer unique sensory experiences and functional benefits, there may be challenges related to consistency, durability, and scalability in architectural applications. However, by prioritising sensory engagement, the design encourages a more meaningful interaction with materials, highlighting their potential to evoke emotional and cognitive connections.

The structure’s natural colours, organic forms, and biodegradable composition present a sustainable alternative to conventional materials. It suggests demonstrates how architecture can be both functional and emotionally engaging, promoting a deeper connection to the natural world while encouraging the use of environmentally responsible design practices.

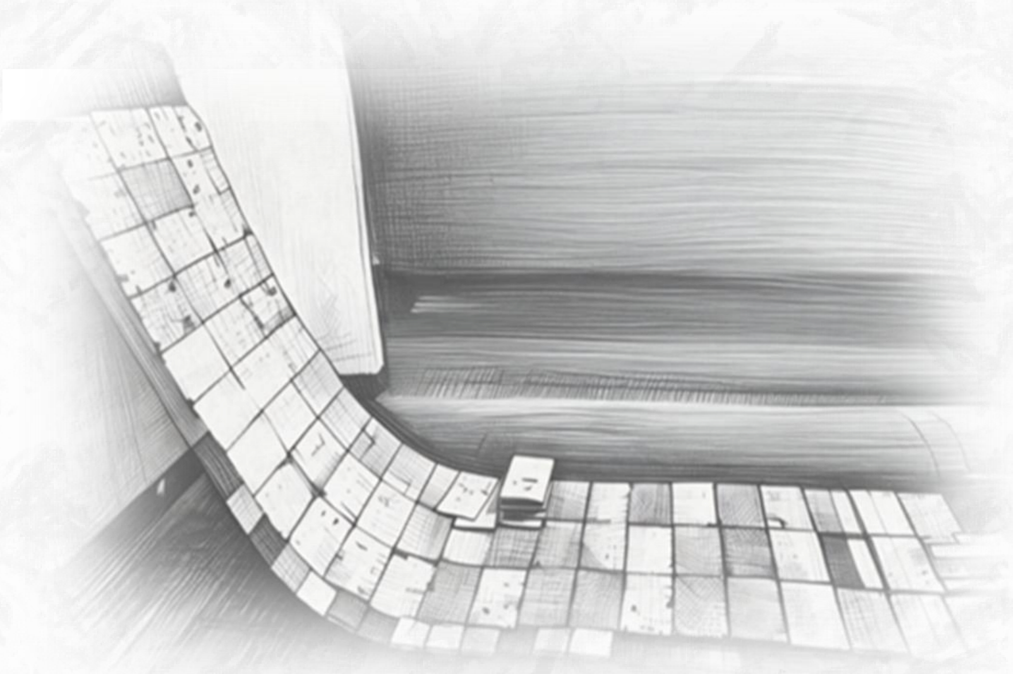


Figure 63. Perspective on the Artefact Final Form

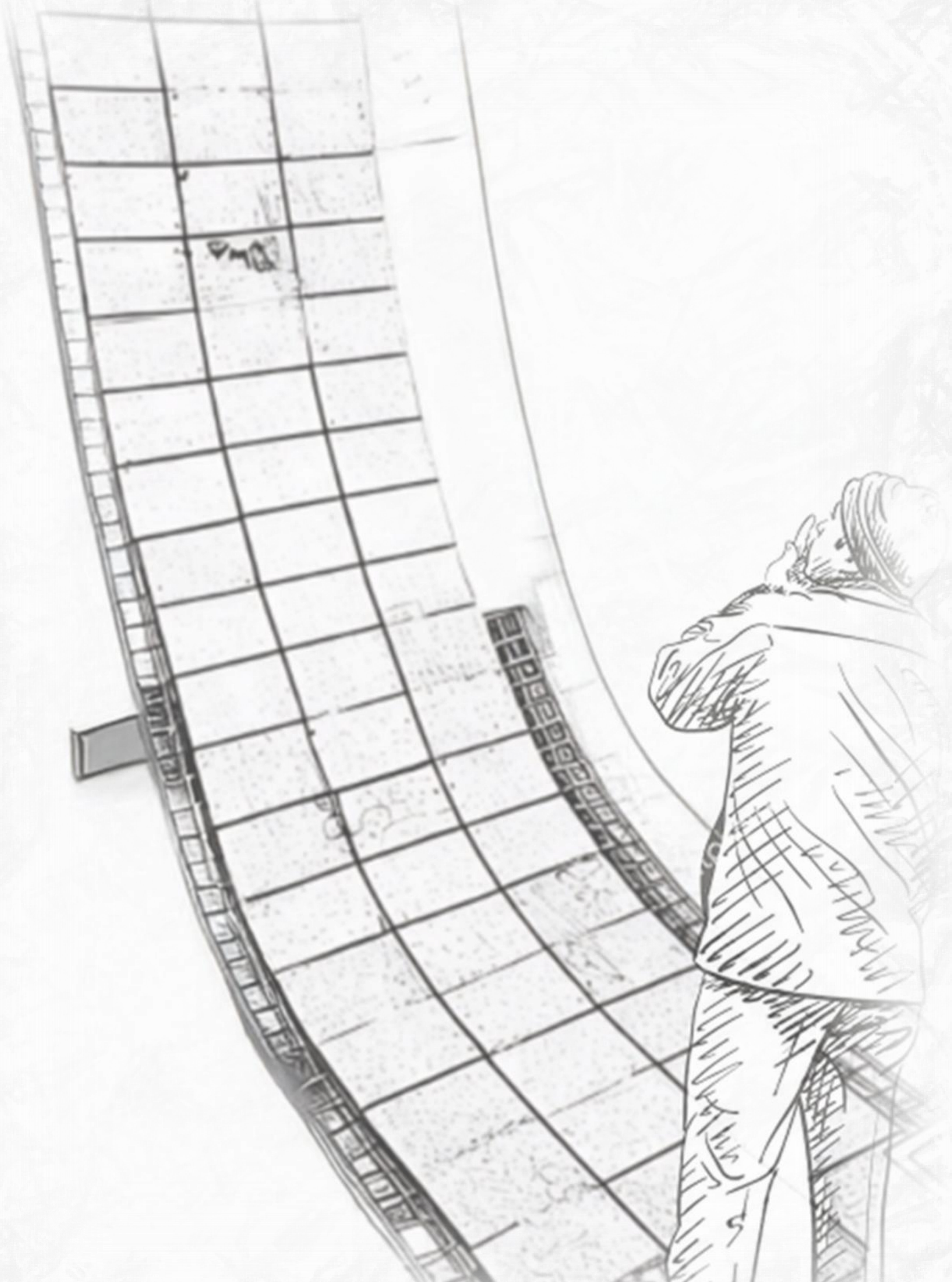


Figure 64. Conceptual Sketch of the Artefact Final Form

5.5 Final Samples Aesthetic and Functional Outcomes

The final material samples developed in this research demonstrate the potential of bio-composites made from locally sourced and waste-derived materials such as seaweed, harakeke, coffee grounds, and recycled cardboard. These sheet-based samples focus on both aesthetic and sensory outcomes, offering insights into how regenerative materials might be used in future design contexts. While not intended as fully resolved architectural components, they provide a platform for speculating on the sensory and environmental potential of regenerative materials in architecture.

The design process emphasised visual and tactile qualities such as texture, form, and surface feel to explore how materials might contribute to more engaging built environments. A key feature of the final presentation was the arrangement of samples along a colour gradient, producing a cohesive and immersive display. This gradient allowed subtle transitions in tone and material character to emerge organically, highlighting the inherent aesthetic diversity of the bio-based materials.

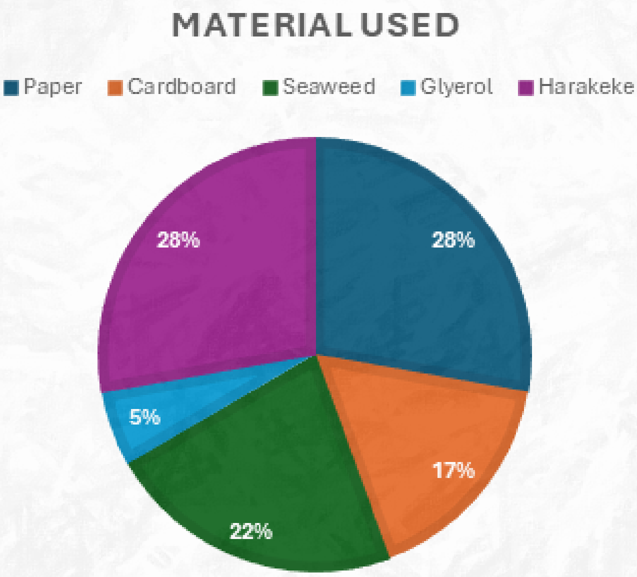
Natural pigmentation, aging effects, and light absorption properties informed the arrangement. Seaweed-based samples revealed deep greens and browns tied to their oceanic origin; harakeke fibres introduced golden and beige hues; coffee ground composites added warmth with rich browns, and recycled cardboard and paper composites brought neutral, cooler tones. This careful ordering invited viewers to explore the material collection not only visually, but also through touch, reinforcing the sensory-driven focus of the research.

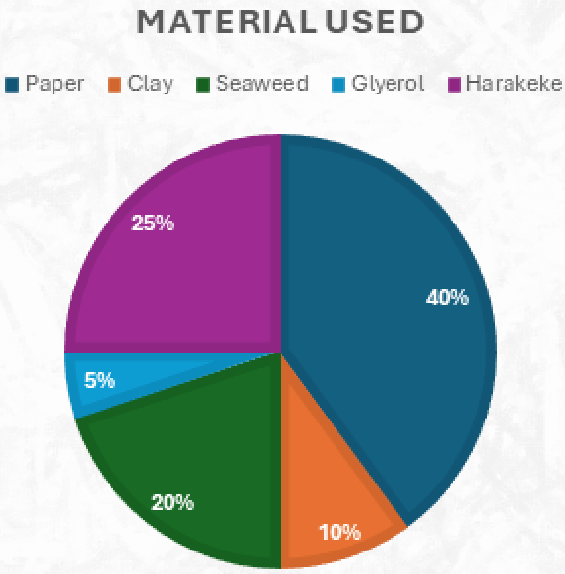
The 25.8 cm x 16 cm x 1.5 cm sample format encouraged close interaction, drawing attention to the subtleties in texture and form. While primarily experimental, these samples offer a speculative glimpse into how regenerative materials could support more sensory-rich, environmentally responsive approaches to architectural design. They reflect an ongoing inquiry into how material aesthetics when rooted in locality and sustainability might contribute to the emotional and sensory dimensions of future spatial experiences.

(See Appendix C for full sample documentation.)

Figure 65. The selected finalise panels

Sample 01

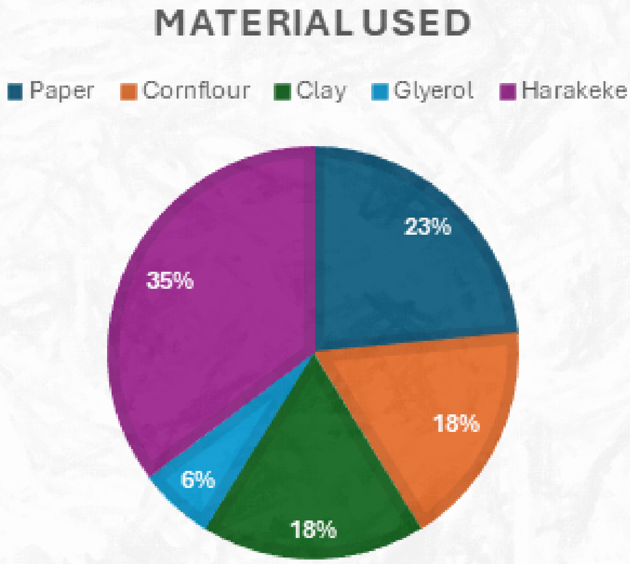




Sample 02

Figure 66. Finalised Samples One and Two

Sample 03



Sample 04

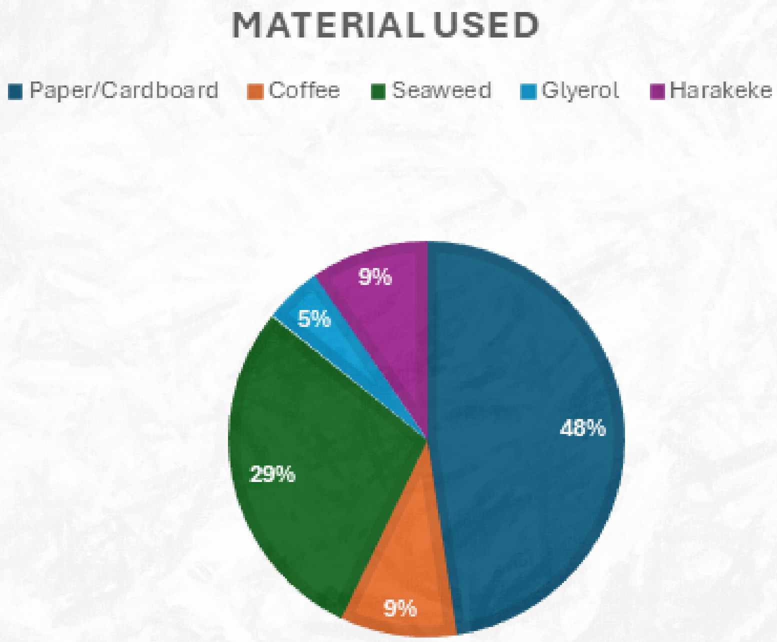
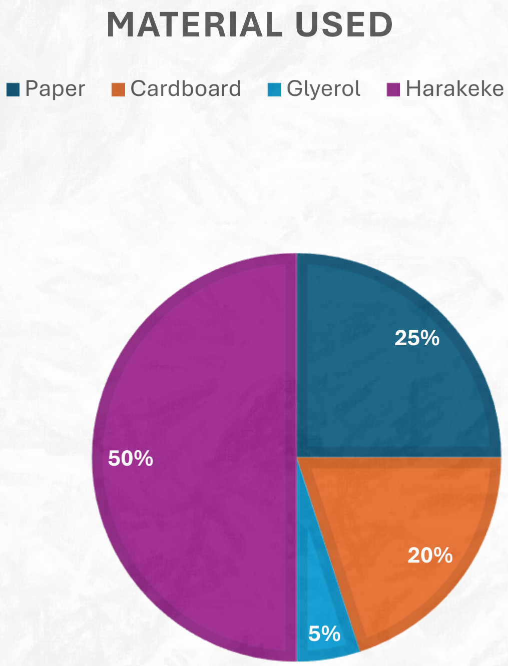
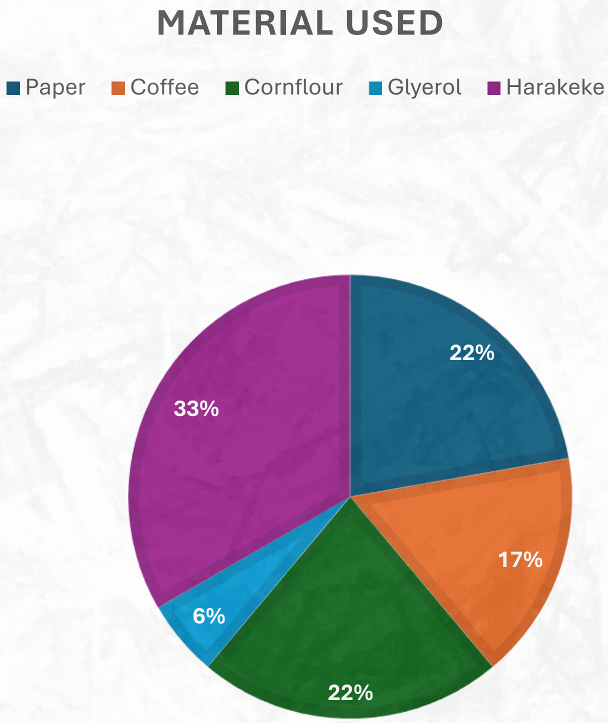


Figure 67. Finalised Samples Three and Four

Sample 05





Sample 06

Figure 68. Finalised Samples Five and Six

5.5.1 Curated Selection of Regenerative Materials for Application

In exploring more sustainable and sensory-rich possibilities for future architectural environments, this research focused on the development and sensory evaluation of regenerative materials. While the final material design samples crafted from locally sourced bio-composites such as seaweed, harakeke fibres, and coffee grounds are not integrated into resolved architectural spaces, they offer a speculative glimpse into how such materials might inform future architectural practices.

These materials were selected for their environmental benefits as well as their sensory and structural properties. Recycled coffee grounds added texture, scent, and colour; seaweed introduced flexibility and biodegradability; and harakeke fibres provided strength and cultural value. Together, these materials invite reflection on how sensory qualities touch, smell, and visual texture might foster deeper emotional connections with material in the built environment.

The work does not claim to test architecture directly. Instead, it presents a material-led inquiry, using research through design methodology. The installation offered a limited spatial expression, not as a representation of architectural form, but to speculate on the future use and perception of regenerative materials. The final material selection was guided by the five key criteria identified in Chapter 2 (2.5), based on data from earlier experiments.

The value of this work lies in identifying and operating within a research gap highlighting the potential of underexplored materials rather than proposing finalised solutions. It contributes to ongoing architectural conversations by expanding the role of materiality, emphasising environmental responsibility, and exploring sensory innovation as a meaningful design drive.
.

5.5.1 Fabrication and Technical Challenges

Several challenges arose during the fabrication process, especially when scaling materials from small test samples to larger architectural components. Each material needed specific processing techniques and tools to achieve the right structure and sensory qualities. The scale of the samples was 25.8 cm x 16 cm x 1.5 cm.

5.5.3 Seaweed Composite

One of the main challenges with seaweed was keeping it flexible while ensuring it stayed strong. Early tests showed that dried seaweed became brittle, making it unsuitable for load-bearing structures. To remedy this, plasticisers like glycerol and sorbitol were added to improve flexibility. The final material was pliable and would work well for non-structural elements like screens or partitions. However, it absorbed moisture easily, so protective coatings of glycerol were applied to prevent damage in humid conditions. The material was dried in a dehydrator for 12 hours to achieve the best mechanical properties.

5.5.4 Harakeke Composites

Making harakeke composites required special processing to turn the fibres into a usable form. The fibres were extracted, cut, and ground into a fine powder before being mixed with natural binders like potato starch to create rigid panels. A major challenge was making the panels strong but lightweight. Without a heat press, it was difficult to get even density and strength. To improve durability, extra layers of harakeke were added, and the panels were coated with natural resin. They were also dried for 12 hours to stabilise moisture and strengthen the structure.

5.5.5 Recycled Paper and Cardboard Composites

Recycled paper and cardboard were mixed with biodegradable binders to create a lightweight, insulating composite. One challenge was ensuring a consistent mixture for strong binding. Some samples had uneven textures and were structurally weak. After multiple refinements, a better mixing process was developed to create a uniform and sturdy material. The final composites were dried for 12 hours to improve durability.

5.5.6 Coffee Ground Composite

The coffee ground composite was designed to reuse waste material while adding a unique texture and scent. Coffee grounds were mixed with biodegradable binders like cornstarch and natural resins to create lightweight but durable panels. Getting the right balance between strength and flexibility was challenging because too much coffee weakened the bonding. A refined ratio of coffee grounds to binder was developed, and compression moulding was used to ensure uniform density. The final composite was dried for 12 hours to reduce moisture and improve stability. The finished material had a rich texture and natural coffee aroma, adding a sensory element to architectural applications.

The fabrication and technical challenges were visually documented, illustrating key processes, material transformations, and experimental refinements for clarity. (see in Appendix C)

5.6 Integration of Materials into the Installation

The integration of these materials into the installation was essential for evaluating their real-world application, ensuring they contributed to both structural performance and sensory engagement. The materials were not only tested for their functional viability but also carefully curated to enhance the aesthetic and interactive qualities of the exhibition.

A key organisational strategy in the installation was the arrangement of material samples according to a colour gradient. This gradient-based layout allowed for a visually cohesive and immersive experience, highlighting the natural variations in tone and texture inherent to regenerative materials. The transition between deep, earthy browns, muted organic shades, and lighter neutral tones reinforced the sensory narrative of the exhibition. For instance, coffee-ground composites introduced dark, warm hues, while seaweed-based samples exhibited rich green and brown tones, and harakeke fibres contributed golden and beige variations. This careful ordering guided viewers through the evolving aesthetic possibilities of bio-composites, enhancing both visual and tactile appreciation.

The samples were attached to a 1.2m x 5m wire mesh structure (100mm x 100mm grid), selected for its ability to hold a curve while providing a lightweight but stable framework. This wire mesh allowed for the arrangement of approximately 100 material panels, creating an unobtrusive yet structured surface for displaying the samples. The flexibility of the mesh facilitated an organic, flowing arrangement, echoing the natural forms and textures of the materials themselves. (see Appendix C)

By employing this organisational approach, the installation effectively showcased the potential of regenerative materials in architectural applications, emphasising their ability to engage users on both a functional and sensory level. The tactile nature of the samples, combined with the immersive colour progression and structured display, reinforced the exhibition's multisensory and sustainability-driven design ethos.

Figure 69. Material samples according to a colour gradient

Figure 70. The artefact installation testing

The artefact serves as a multi-functional installation, expanding beyond a static display to create a sensory-driven architectural experience. Designed to bridge the physical and digital, it provides a material-led dialogue where regenerative materials are not just observed but engaged with through touch, sight, and environmental interaction.

At the core of the artefact's experience is its curved spatial configuration, which enhances the perception of the material textures and the transitions between samples. This immersive quality invites people to move around and within the installation, dynamically engaging with the variations in texture, light absorption, and surface treatments across the displayed panels.

A key feature is the integration of film projections, which extend the physical qualities of the materials into a digital and scaled-up representation. The projection captures shifts in texture, undulation, and form, allowing viewers to see minute surface details and observe how the materials react to changing light conditions. This overlay of moving imagery and tactile elements amplifies the multisensory experience, suggesting a more fluid, evolving understanding of regenerative materiality.

By incorporating interactive and layered sensory engagement, the artefact shifts regenerative materials from merely experimental prototypes to active participants in architectural storytelling. The structure emphasises material tactility and atmospheric presence, fostering a deeper consideration of how bio-composites can reshape architectural aesthetics, construction methodologies, and user experience. (see in Appendix C)

5.7 Exhibition Concept: Material and Digital Interaction in a Multisensory Environment

The installation exhibition represents the culmination of research into regenerative materials, offering an immersive experience that explores their sensory, architectural, and digital potential. At its core, the exhibition is designed as a hybrid physical-digital space, where people interact with materials through touch, sight, movement, and projection-based technologies. It expands beyond traditional static displays by incorporating live screen projections that dynamically respond to both the material qualities and the surrounding environment, creating a constantly shifting sensory landscape.

Inspired by Eva Hesse’s exploration of materiality and Richard Serra’s engagement with spatial experience, the exhibition deepens the relationship between users and regenerative materials by integrating real-time sensing and projection technologies. Rather than simply presenting samples, the design seeks to capture and amplify the material’s behaviours from its textural variations to its light absorption qualities and environmental interactions through an augmented visual layer. The LED projection wall functions as both a documentation tool and an interactive medium, displaying close-up material textures and real-time environmental responses. It extends the tactile engagement into the digital space, allowing people to see microscopic surface details, shifting colour intensities under changing light conditions.

The exhibition structure is divided into three interconnected zones, each offering a distinct layer of material engagement:

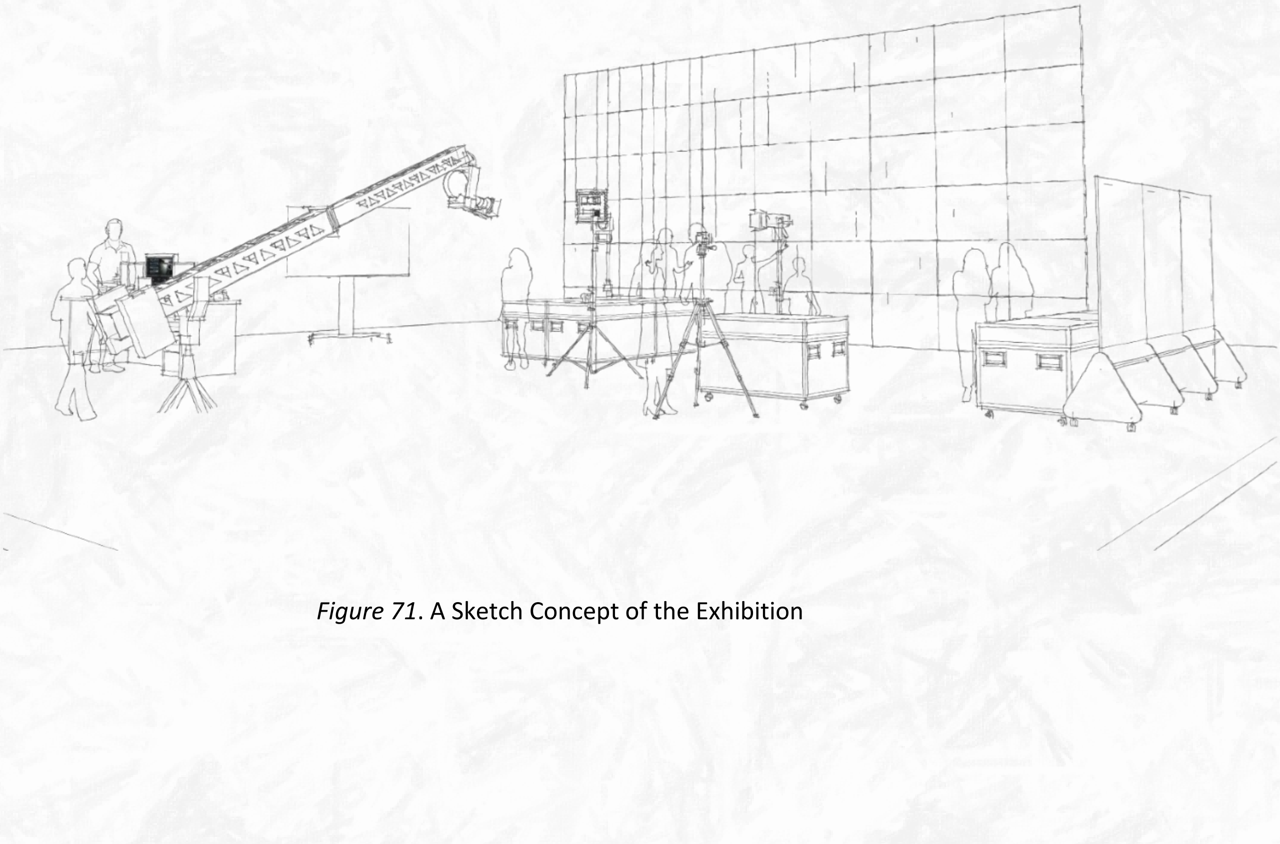


Figure 71. A Sketch Concept of the Exhibition

Material Interaction and Tactility Zone

This section presents raw and transformed regenerative material samples. These materials are displayed within a curved spatial framework, designed to encourage direct touch, movement, and close examination. People are invited to handle the samples, experiencing their surface textures, density, scent, and flexibility, reinforcing the idea that material aesthetics go beyond visual perception.

Figure 72. A Material Interaction Installation

Live Projection and Sensory Translation Zone

Digital projections translate material qualities into magnified visual narratives. Sensors capture subtle interactions between people and the materials, such as textures, movement, and shifting light reflections, and project these interactions onto the LED screen in real-time. This system allows people to see how materials evolve under different environmental conditions, emphasising the living, dynamic qualities of regenerative materials.

Figure 73. The artefact live projection captures to the digital LED wall

Environmental Engagement and Adaptive Materiality Zone

This final zone explores how regenerative materials respond to their surroundings, focusing on the relationship between material properties and atmospheric conditions. Natural and artificial light shifts across the surfaces, casting fluid shadows and accentuating organic patterns. The use of sensor-driven digital layering makes these reactions more perceptible, transforming the experience into an interactive and evolving spatial composition.

By merging material tactility with digital augmentation, the exhibition extends the concept of "Material Conversations" into a multi-dimensional experience. Each material tells a story not just through its origin and composition, but through its real-time interaction with people and the environment. The curved structure housing the material panels enhances this narrative flow, guiding people through a journey of sensory and technological exploration.

This approach invites reflection on how regenerative materials can actively shape architectural experiences, rather than being passive building components. The interaction between the physical and projected material representations serves as both a design tool and an experimental method, enabling a new way of perceiving and engaging with regenerative materials in architecture. By incorporating real-time responsiveness, the exhibition redefines materiality as a continuously evolving dialogue between the natural, the built, and the digital, reinforcing the necessity of sensory-driven sustainable design.

Figure 74. An Environmental Engagement on how regenerative materials respond to their surroundings

5.7.1 Filming the Multisensory Experience: Physical and Digital Translation

The filming and documentation process extended the exhibition’s impact by translating the tactile, visual, and interactive qualities of regenerative materials into a digital format, ensuring broader accessibility and preserving their sensory-driven transformations. By integrating real-time and recorded interactions, the documentation reinforced the idea that materiality is dynamic, shaping human-environment relationships through touch, movement, and light engagement.

Unlike conventional materials focused on durability, regenerative materials displayed fluidity and responsiveness to environmental conditions, encouraging a deeper emotional and cognitive connection with users. The filming process captured these organic changes, revealing how materials evolved in response to humidity, airflow, and lighting variations, reinforcing their sensory-driven architectural potential.

The exhibition positioned these materials as active participants rather than passive objects. People explored textures and finishes, observing how they shifted under various lighting conditions, fostering heightened material awareness. Filming techniques such as macro shots, slow-motion recordings, and time-lapse visuals documented fibrous details, colour shifts, and surface transformations, emphasising the depth and adaptability of these materials. Controlled lighting and shadow play enhanced their vibrancy and organic variations, highlighting their potential as living architectural elements.

The LED screen magnified material textures in abstracted forms, bridging physical and digital experiences in an immersive, interactive format. This process encouraged architects and designers to rethink material engagement, reinforcing regenerative materials as key components in sustainable, sensory-driven design. As Antunes & Grabowski (2016) suggest, film has the capacity to enhance multisensory perception by emphasising the interplay between different sensory modalities, offering a means to capture the depth and material expressiveness of regenerative substances in ways that extend beyond physical interaction.

Figure 75. A process to encouraged people to rethink material engagement, reinforcing regenerative materials as key components in sustainable, sensory-driven design

5.8 Summary

This research has demonstrated the development of sheet materials using locally sourced and waste ingredients such as seaweed, harakeke, coffee grounds, and recycled cardboard. Through hands-on experimentation and material testing, the project explored the aesthetic, tactile, and sensory qualities of these biodegradable composites. While not fully resolved for architectural application, the materials were presented in a hybrid physical-digital installation that speculated on their architectural potential. By incorporating sensory elements such as touch, sight, and movement, the exhibition encouraged reflection on how material experience might contribute to more sustainable and engaging spatial design.

Through filming and documentation, the project extended the exploration beyond physical interactions, capturing the fluid, dynamic nature of regenerative materials. Digital media magnified surface details, textures, and light interactions, allowing a broader audience to engage with the material narratives and their environmental responsiveness. By positioning these materials as active participants rather than passive elements, the exhibition challenged conventional notions of architectural materiality.

The research revealed both opportunities and challenges associated with regenerative materials. While they offer sustainability, adaptability, and sensory richness, practical considerations such as durability, scalability, and environmental sensitivity require further investigation. However, their ability to evolve with atmospheric conditions suggests new possibilities for responsive, human-centred architectural solutions.

By merging material tactility with digital augmentation, this research reinforced the idea that architecture is not just about structure but about experience and interaction. It highlighted how sensory-driven approaches can create more sustainable, immersive, and emotionally connected spaces. Ultimately, this study contributes to the growing discourse on regenerative design, advocating for a shift toward biodegradable, locally sourced, and sensorially engaging materials as the foundation for a more ecologically responsible built environment.

Chapter Six: Research Discussion

6.1 Introduction

This chapter critically reflected on the key findings of this research, establishing connections across all preceding chapters. It examined the sensory qualities of regenerative materials, their structural viability, and their potential for industry adoption. By synthesising insights from Chapters One to Five, this discussion evaluated how multisensory design strategies contributed to sustainable material innovation and broader ecological considerations.

The discussion was structured around the study's core research questions, ensuring a comprehensive synthesis of literature review, methodological frameworks, experimental findings (Chapters Three and Four), and final material applications. It explored how sensory characteristics such as touch, texture, smell, and colour shaped human engagement with materials while assessing the feasibility of integrating regenerative materials from physical to digital applications within architectural spatial environments.

6.2 Experimental Findings, Sensory Qualities, and Human-Material Interaction

As discussed in Chapter One, sensory engagement played a critical role in shaping material perception. Traditional architectural materials prioritised functionality, often at the expense of sensory experience. In contrast, regenerative materials, as explored in Chapter Three's practical material research, introduced new aesthetic and tactile dimensions that fostered deeper material-environment relationships.

The experimental exploration in Chapter Three emphasised how locally sourced materials, such as harakeke fibres, seaweed, and coffee grounds, provided diverse sensory experiences when integrated into architectural contexts. Chapter Four's reflection on material sensory qualities demonstrated that harakeke fibres and seaweed composites heightened user interaction, reinforcing themes from the literature on multisensory architecture (Pallasmaa, 2005; Spence, 2020). The interplay of texture, colour, and scent, previously examined through experimental research, underscored the potential of regenerative materials to transform static environments into interactive and emotionally engaging spaces.

The findings also aligned with Chapter Two's methodological framework, which emphasised the Material Driven Design (MDD) approach. By focusing on sensory perception as an integral part of material evaluation, this research built upon existing theories of material experience (Karana et al., 2015). The final exhibition, discussed in Chapter Five, demonstrated how these sensory-driven materials were implemented in spatial design, bridging the gap between theory and application. The use of LED-integrated installations further amplified sensory engagement, allowing visitors to experience the dynamic interactions between light, texture, and material response.

6.3 Structural Viability, Industry Adoption, and Locally Sourced Materials

While the sensory benefits of regenerative materials were well-documented in Chapters Three and Four, structural performance remained a critical challenge. As identified in Chapter Five, moisture sensitivity, brittleness, and inconsistent curing processes limited large-scale applicability. The introduction of bio-based reinforcements, inspired by the methodology in Chapter Two, offered promising solutions but required further refinement.

Chapter Three's material selection phase emphasised the importance of sourcing locally available materials, aligning with sustainable design principles discussed in Chapter One. However, as revealed in experimental trials, regulatory barriers and the lack of industry-standard testing protocols hindered broader adoption. Chapter Two's discussion on research limitations foreshadowed these constraints, highlighting the need for further industry collaboration and certification frameworks.

Despite these challenges, the findings in Chapter Five suggested that adaptive material applications—such as temporary installations and modular systems—can facilitate the imaginative integration of regenerative materials into mainstream architecture. The incorporation of LED lighting technology into experimental prototypes created a heightened sensory response, demonstrating how material aesthetics were further enhanced through digital and environmental interplay. These insights supported the need for cross-disciplinary engagement between designers, scientists, and policymakers to advance sustainable material development.

6.4 Theoretical, Practical, and Industry Implications

6.4.1 Practical Implications: Material Applications in Architecture

This research offered a practical application by demonstrating how regenerative materials, as explored in Chapters Three and Five, can be incorporated into temporary and permanent architectural structures. The final material exhibition exemplified the potential of these materials to serve both aesthetic and functional purposes, reinforcing key themes from Chapter Four's reflection on sensory engagement.

Additionally, experimental findings revealed that locally sourced materials such as harakeke and seaweed performed well when integrated with LED lighting and interactive digital elements. These enhancements allowed materials to transition from static elements to dynamic, responsive installations, further engaging audiences and fostering a deeper material connection.

6.4.2 Industry and Policy Implications: Certification and Adoption

As emphasised in Chapter Two, regulatory challenges remain a barrier to the mainstream adoption of regenerative materials. The literature review outlined the urgent need for sustainable material standards, while the analysis of industry applications in Chapter five highlighted the necessity for certification frameworks that evaluate sensory and ecological performance alongside structural properties.

The study recognises the need for policy changes that prioritise sustainable material innovation, supporting the arguments presented in Chapter One regarding circular economy principles. The findings also aligned with the project's material sourcing strategies, emphasising localised production to reduce environmental impact and enhance material accessibility.

6.4.3 Material Exhibition, Digital Documentation, and LED Integration

Building on the material experimentation processes outlined in Chapter Four, the final exhibition explored new ways of showcasing regenerative materials. The use of digital documentation such as macro photography, slow-motion recordings, and time-lapse sequences extended the material experience beyond the physical installation. The addition of LED elements provided further insights into how regenerative materials interacted with changing light conditions, enhancing their aesthetic and experiential appeal. These findings reinforced the project's methodological emphasis on sensory evaluation as a core aspect of material research.

6.5 Future Research and Recommendations

This study identified key areas for further research, linking back to the gaps highlighted in Chapter's Two and Three. Strengthening bio-based composites through advanced binders, improving moisture resistance through natural coatings, and conducting long-term weathering studies will enhance material viability. Additionally, exploring aesthetic and mechanical properties, as introduced in Chapter Five, could expand their application in passive design strategies.

To facilitate industry adoption, the scalability of production methods such as 3D printing and digital fabrication should be investigated. The need for real-world case studies, highlighted the importance of testing material performance in architectural contexts to validate findings from experimental research detailed in Chapter Three. A cross-disciplinary approach, combining expertise from design, science, and engineering, will be critical for advancing regenerative material applications.

This research demonstrates that regenerative materials foster sensory engagement and sustainability in architecture. Materials such as harakeke and seaweed composites enhance spatial experiences through texture, scent, and colour variations. While structural limitations present adoption challenges, innovations in processing and policy frameworks can bridge these gaps. The final exhibition underscores the importance of material storytelling and digital documentation. Future research should explore lifecycle assessment and advanced fabrication methods to integrate regenerative materials into mainstream architecture. A multisensory approach to materiality enhances spatial design and fosters a more sustainable and meaningful relationship between humans and their environments.

6.6 Conclusion

This thesis has investigated how the sensory aesthetics of regenerative materials can inform architectural thinking and enable speculative approaches to designing future sustainable environments. Through experimental material development, multisensory testing, and spatial installation, it speculates on the architectural potential of materials that are typically undervalued or overlooked in mainstream construction such as composites made from harakeke, seaweed, coffee grounds, and cardboard. These materials, derived from regenerative, low-impact sources, were explored not only for their ecological qualities but for their capacity to evoke rich, embodied spatial experiences.

Rather than positioning these materials as fully resolved construction solutions, this research frames them as catalysts for reimagining the role of materials in architecture as sensory, temporal, and affective agents. Their textures, colours, and scents prompt new ways of thinking about how buildings could engage occupants beyond visual aesthetics or structural performance. For instance, the translucency of seaweed composites, or the earthy scent of harakeke, opens atmospheric design possibilities that align with biophilic and human-centred principles. In this way, the thesis moves beyond conventional material performance metrics to engage with the speculative asking not only *what these materials are*, but *what they might enable* in future architectural practice.

The material exhibition and its digital documentation further reinforced this speculative stance. By curating and capturing sensory interactions with the materials both physically and virtually the research offered an experiential lens through which to consider their spatial implications. This speculative framework, grounded in sensory aesthetics, positions regenerative materials as design provocations that can expand architectural imagination, rather than as immediate industrial substitutes.

Yet, this speculative potential exists alongside real-world challenges. The research acknowledges limitations in durability, scalability, and industry acceptance. While experimental refinements like coatings and hybrid blends showed progress, fully resolving these challenges lies beyond the scope of this thesis. Instead, this study suggests that speculative material thinking in which sensory experience, sustainability, and design innovation intersect must precede and inform technical development. Future studies should investigate fabrication methods such as biobased reinforcements and 3D printing, alongside long-term environmental behaviour, to further translate these speculative insights into practical outcomes.

Ultimately, this research contributes to a growing discourse in material-driven design by asserting that materiality is not just a matter of construction but a critical terrain for architectural thought. Through a sensory and ecological lens, regenerative materials are positioned here as speculative tools for reimagining the future of sustainable architecture.

By embracing their sensory aesthetics and narrative potential, designers can design environments that not only minimise environmental harm but also deepen human engagement with place and material. In doing so, this thesis invites continued exploration of how regenerative materiality might shape the future of architecture not only through what it is, but through what it could become.

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Appendices

Appendix A Documentation of Sourcing Material

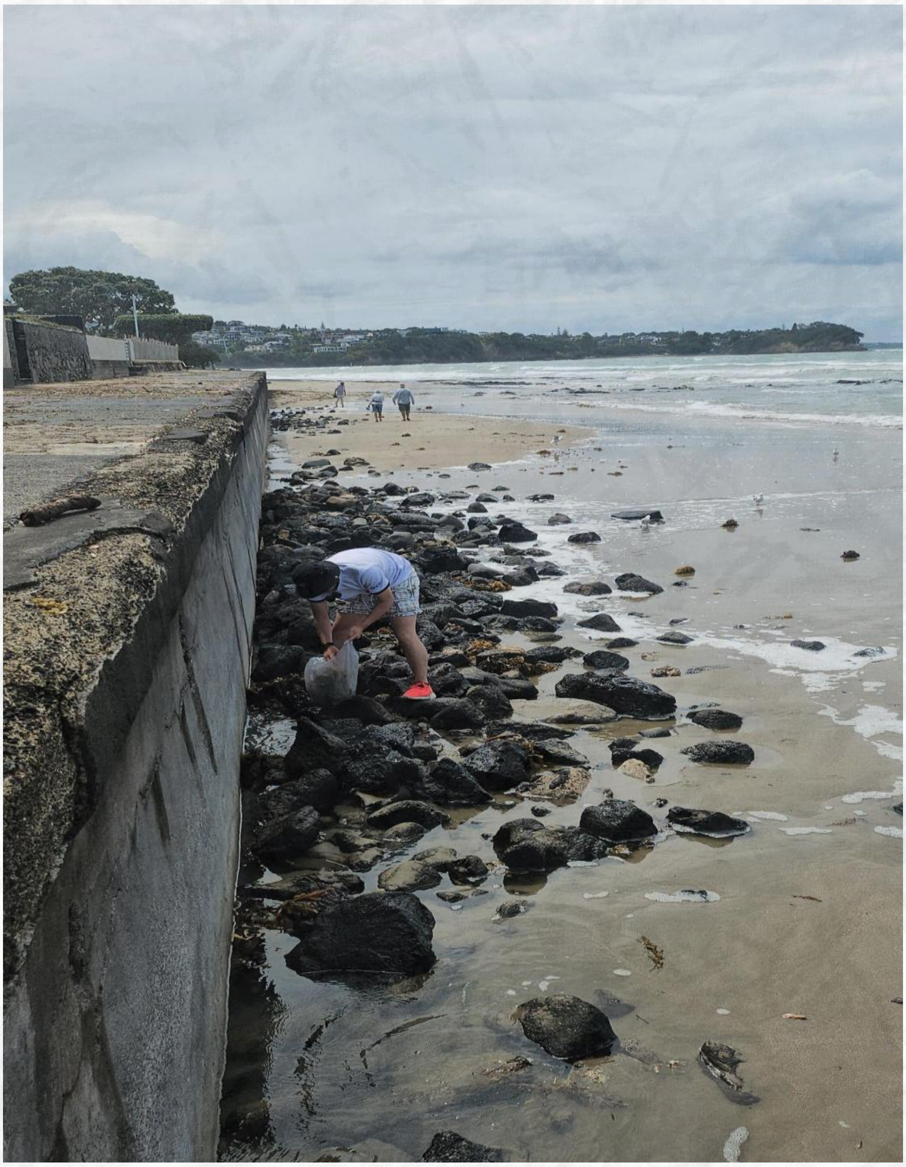
Appendix B Documentation of Experimental Work

Appendix C Documentation of the Concept Installation

Appendix D Documentation of Final Installation

Appendix A Documentation of Sourcing Material

3.2.1 Mapping Local Availability of Regenerative Materials




TAKE A
TRIP

Appendix B Documentation of Experimental Work

3.4.4 Testing and Analysis

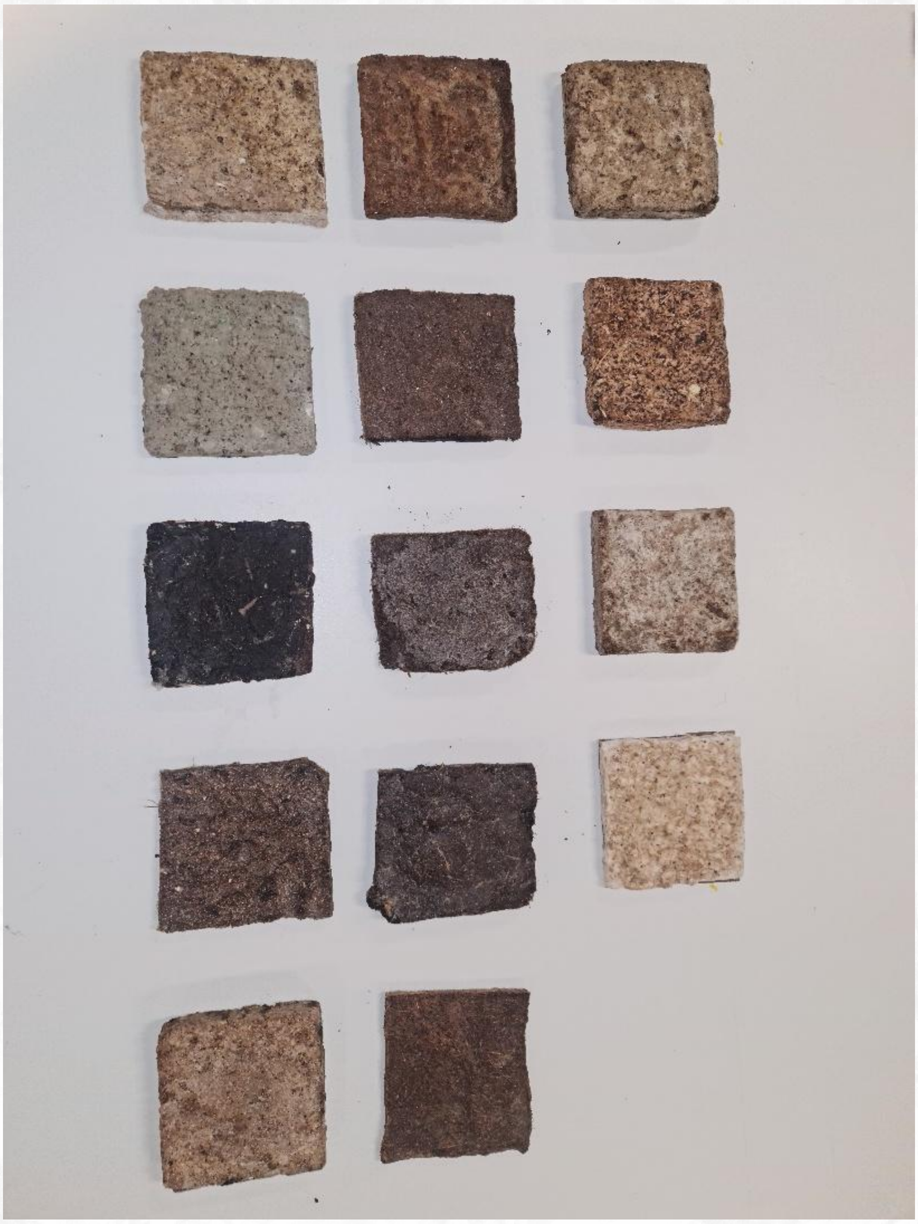
3.4.5 Findings and Challenges

3.5.1 Experimental Phase B: Exploring Bio-Composites

3.5.5 Experimental phase B: Seaweed, Sand, and Harakeke Combination

All the 8cm x 8cm x 2cm Samples completed

All the 10cm x 10cm x 2cm Samples completed.



Medium-Scale Specific Material Findings: Recycled Paper, Harakeke Paper, Locally Sourced Harakeke, Locally Sourced Seaweed, Cornflour, Coffee Grounds, and Glycerol

Through medium-scale testing, I observed how this material's sensory and structural properties responded under different conditions. The texture was the most immediately noticeable feature—firm, fibrous, and slightly grainy, with visible plant fibres and organic inclusions giving it a natural aesthetic. When handling the material, it felt rigid yet slightly pliable, meaning it could hold its form while still having some flexibility. Compared to smaller-scale tests, this version exhibited increased density and cohesion, suggesting that the composition was well-balanced in terms of fibre distribution and binder effectiveness.

Smell was another key characteristic. The earthy aroma of coffee grounds and seaweed was present but not overwhelming, blending with the mild, neutral scent of recycled paper and harakeke fibres. This created a subtle but distinct organic scent, reinforcing the material's natural origins. The smell became more noticeable when the material was exposed to moisture, hinting at its absorbent nature and the need for a sealing treatment to prevent degradation over time.

When testing moisture absorption, the material displayed moderate retention, meaning it absorbed some water but did not weaken immediately. The presence of seaweed and glycerol helped maintain structural integrity, preventing brittleness after drying. However, in prolonged humidity, some surface roughness increased, highlighting the importance of further treatments or coatings for durability.

In terms of tactile engagement, the balance of softness and rigidity made the material promising for interior surfaces and biodegradable packaging. The coarse texture with smooth patches suggested that different finishing techniques could alter the final feel. When pressed, the material flexed slightly but returned to its shape, confirming its elastic properties while maintaining stability under light pressure.

Overall, these observations highlight the material's potential for sustainable applications, while also pointing to areas for improvement, particularly in moisture resistance, surface uniformity, and scalability.

Medium-Scale Specific Material Findings: Recycled Paper, Locally Sourced Harakeke and Seaweed, Eggshells, Coffee Grounds, Gelatine, and Glycerol

This composite material presents a dense, textured surface with visible fibrous inclusions, resulting from the integration of recycled paper, harakeke, and seaweed. The paper fibres contribute to lightweight flexibility, while harakeke and seaweed enhance binding strength and durability. The coffee grounds and eggshells introduce granular texture and structural reinforcement, adding a subtle speckled effect to the material's natural earthy tone.

In sensory testing, the material felt firm yet slightly porous, with small flecks of organic matter visible throughout. The coarse yet compact texture suggested moderate abrasion resistance, making it suitable for wall panels and decorative surfaces. The smell was mild and organic, with faint traces of coffee and seaweed noticeable when exposed to moisture.

The gelatine and glycerol served as binding agents, preventing brittleness while maintaining some flexibility. Testing showed that the material absorbed moisture gradually, softening slightly when wet but retaining overall structural integrity. Further refinements in waterproofing would improve durability in humid conditions. Overall, this material demonstrates strong potential for eco-friendly applications such as biodegradable panels, sustainable interiors, and artistic installations.

Medium-Scale Specific Material Findings: Calcium Carbonate, Locally Sourced Harakeke and Seaweed, Cornflour, Clay, Coffee Grounds, Gelatine, Eggshells, and Glycerol

The composite material, made from calcium carbonate, locally sourced harakeke and seaweed, cornflour, clay, coffee grounds, gelatine, eggshells, and glycerol, demonstrated a rigid yet lightweight structure with a fibrous, granular texture. The calcium carbonate and eggshells added structural density and compression strength, ensuring firmness and durability. Clay enhanced surface compactness, while harakeke and seaweed fibres provided flexibility and reduced brittleness.

During sensory testing, the surface felt coarse and grainy, with visible fibres and organic inclusions. The roughness varied, as slower drying resulted in a smoother texture, while faster drying led to a rougher finish. The material emitted a mild earthy scent, largely influenced by coffee grounds, clay, and seaweed, which became more noticeable when exposed to moisture, suggesting moderate absorbency. When handled, it felt rigid yet slightly flexible in thinner samples, with a dry, chalky consistency that left some powdery residue on the hands.

Testing showed that the material absorbed moisture moderately, softening slightly in humid conditions but maintaining its structural integrity. Further sealing or coating could have improved moisture resistance. Its high compressive strength made it suitable for decorative panels, interior wall cladding, and biodegradable construction materials. The light beige coloration with speckled tones gave it a natural, organic aesthetic, which could have been adapted to architectural applications. Potential refinements, such as adjusting binder concentration and improving surface treatments, could have enhanced its moisture resistance and uniformity, increasing its viability in sustainable design. Overall, the material showed strong eco-friendly potential, balancing strength, aesthetics, and sustainability.

Variety of Medium Samples completed

Findings of Large-Scale Samples

Material Specific Insights: Cardboard Composites

Properties:

Flexible and adaptable: Easily shaped and modified, making it suitable for creative and experimental architectural designs.

Lightweight: Simple to install, transport, and modify, ideal for temporary or modular structures.

Fire resistance (in some composites): Enhances safety, particularly in interior spaces where fire hazards may be a concern. (see in Appendix)

Sustainable: Made from recyclable materials, reinforcing its environmental benefits for eco-conscious designs.

Limited durability: Prone to wear and tear in high-traffic or high-impact areas, suggesting the need for reinforcement in demanding applications.

Low cost: Affordable, making it an attractive option for large-scale or temporary installations.

Sensory Qualities:

Tactile: The material has a smooth yet slightly rough texture, offering a natural, papery feel that is soft to the touch.

Visual: Typically presents neutral brown or grey tones, which can be easily painted or treated to match various design aesthetics.

Smell: Cardboard has a faint woody scent, evoking a raw, natural feel that contributes to its organic aesthetic.

Material Specific Insights: Harakeke Composites

Properties:

High durability: Can withstand wear and tear, making it suitable for long-term use.

Structural strength: Ideal for use in load-bearing applications such as wall panels and furniture.

Natural aesthetic: Provides an organic and raw visual appeal, complementing biophilic design principles.

Rigid: The lack of flexibility limits its application in areas requiring dynamic movement or reshaping.

Sustainable: Sourced from regenerative materials, making it eco-friendly and low impact on the environment.

Moisture resistance: Shows resilience in environments with moderate humidity, adding to its practicality in diverse settings.

Sensory Qualities:

Tactile: The material feels coarse and textured to the touch, evoking a natural, raw sensation.

Visual: Harakeke composites exhibit a warm, earthy tone with organic fibre patterns, creating a rustic and nature-inspired visual experience.

Smell: The material has a subtle, earthy scent, reminiscent of natural fibres, which can contribute to an organic ambiance in interior spaces.

Material Specific Insights: Seaweed Composites

Properties:

Lightweight: Easy to handle and transport, making it ideal for use in interior partitions and decorative features.

Unique colour properties: Offers a range of natural hues, from greens to browns, which provide a distinct visual appeal in interior spaces.

Renewable resource: Seaweed is highly sustainable, though its limited availability currently poses a challenge for large-scale applications.

Moderate structural integrity: Suitable for small-scale or non-load-bearing applications, but less reliable for more robust architectural uses.

Limited availability: Sourcing issues restrict the scalability of seaweed composites for broader use.

Performance variability: Inconsistent material quality can affect overall performance and longevity.

Sensory Qualities:

Tactile: The material is smooth with a slightly rubbery texture, providing a unique touch sensation compared to other natural composites.

Visual: Seaweed composites display a range of deep, oceanic tones, with some transparency that can create visually striking effects in interior applications.

Smell: A subtle marine scent is present, which could either enhance or detract from the ambiance depending on the context of the space.

Material Specific Insights: Coffee Composites

Properties:

Good mechanical strength: Can support significant loads, making it suitable for structural applications such as furniture or interior panels.

Lightweight: Facilitates easier handling, transportation, and installation, ideal for modular or large-scale applications.

Sustainable: Utilizes coffee waste, contributing to the circular economy and reducing overall waste in production.

Warm, natural aesthetic: The deep, earthy tone of coffee composites bring a cozy, organic feel to interior spaces.

Versatile: Suitable for furniture, decorative elements, and some structural uses.

Odour neutralization: After processing, the material typically retains no noticeable scent from the original coffee grounds.

Sensory Qualities:

Tactile: Smooth and slightly grainy, offering a tactile experience like finely textured stone or polished wood.

Visual: Dark, rich tones ranging from deep browns to near black, providing a sophisticated and warm visual quality.

Smell: Although derived from coffee waste, the final product generally lacks any strong coffee aroma, resulting in a neutral scent profile

Appendix C Documentation of the Concept Installation

5.5 Final Samples Aesthetic and Functional Outcomes

5.4.2 Fabrication and Technical Challenges

Harakeke (Flax): A strong, biodegradable fibre native to New Zealand, harakeke serves as a renewable alternative to fiberglass. Its natural texture and earthy tones contribute to an organic aesthetic, while its strength and flexibility allow for diverse applications in sustainable design. Its cultivation supports ecological diversity and traditional sustainable practices.

Recycled Paper and Cardboard: These lightweight, thermally efficient materials help reduce landfill waste while offering a lower-carbon alternative to conventional materials like gypsum board. Their soft, fibrous textures and layered compositions create visually intriguing surfaces while maintaining insulation properties, making them functional and environmentally conscious design elements.

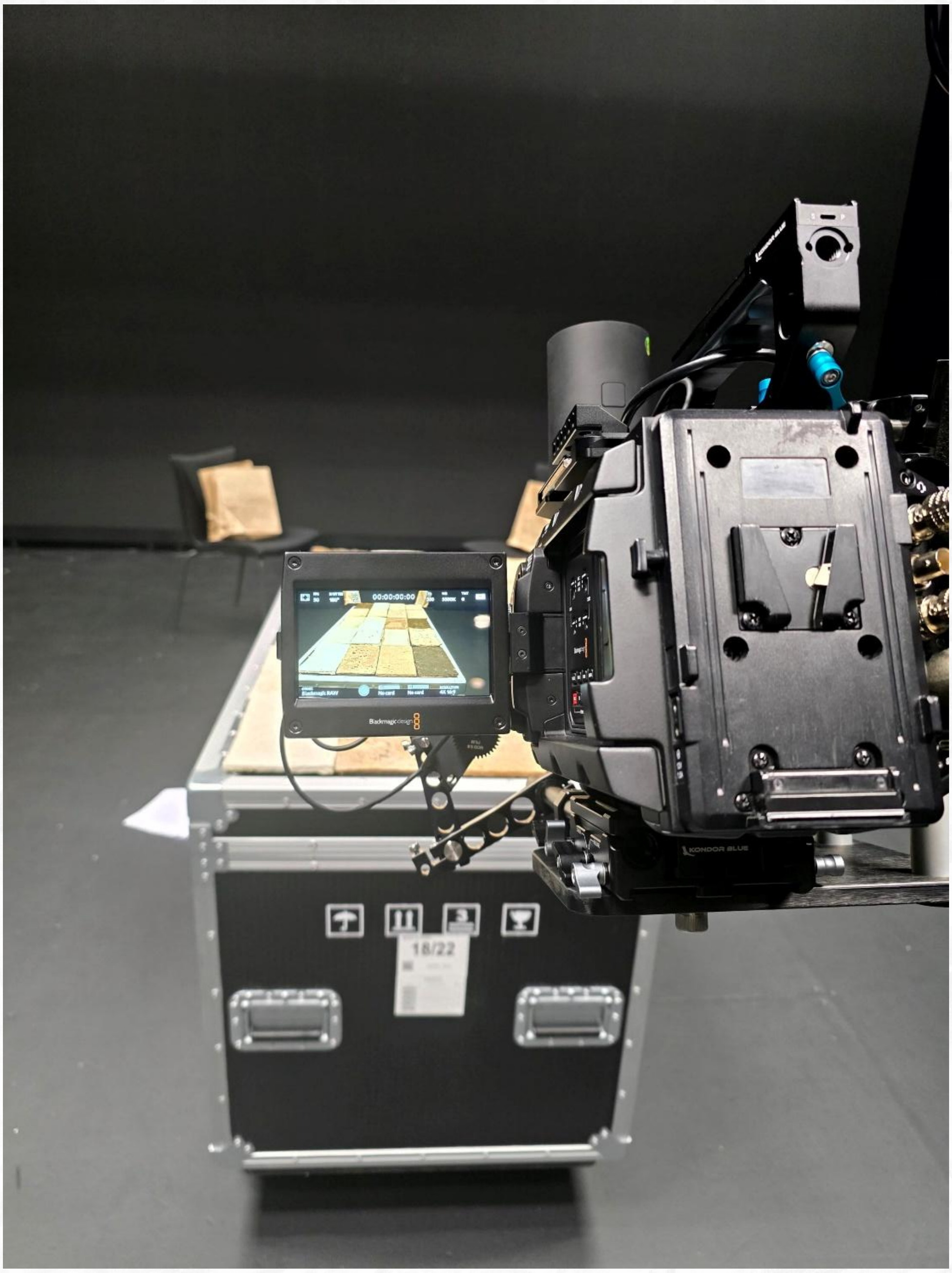
Seaweed: A rapidly renewable material that plays a crucial role in marine ecosystems, seaweed offers both aesthetic and functional benefits. Its organic patterns and translucent qualities introduce a unique, natural appearance. It is biodegradable, flexible, and can be used for non-structural elements such as partition screens, emphasizing its potential in eco-friendly architecture.

Coffee Grounds: Recycled coffee grounds provide a distinctive dark, granular texture and a natural aroma, adding depth to architectural elements. Combined with biodegradable binders, they form lightweight, durable panels that repurpose organic waste into functional and visually engaging materials. Coffee-based composites introduce warmth, tactility, and sustainability to design, supporting circular economy initiatives.

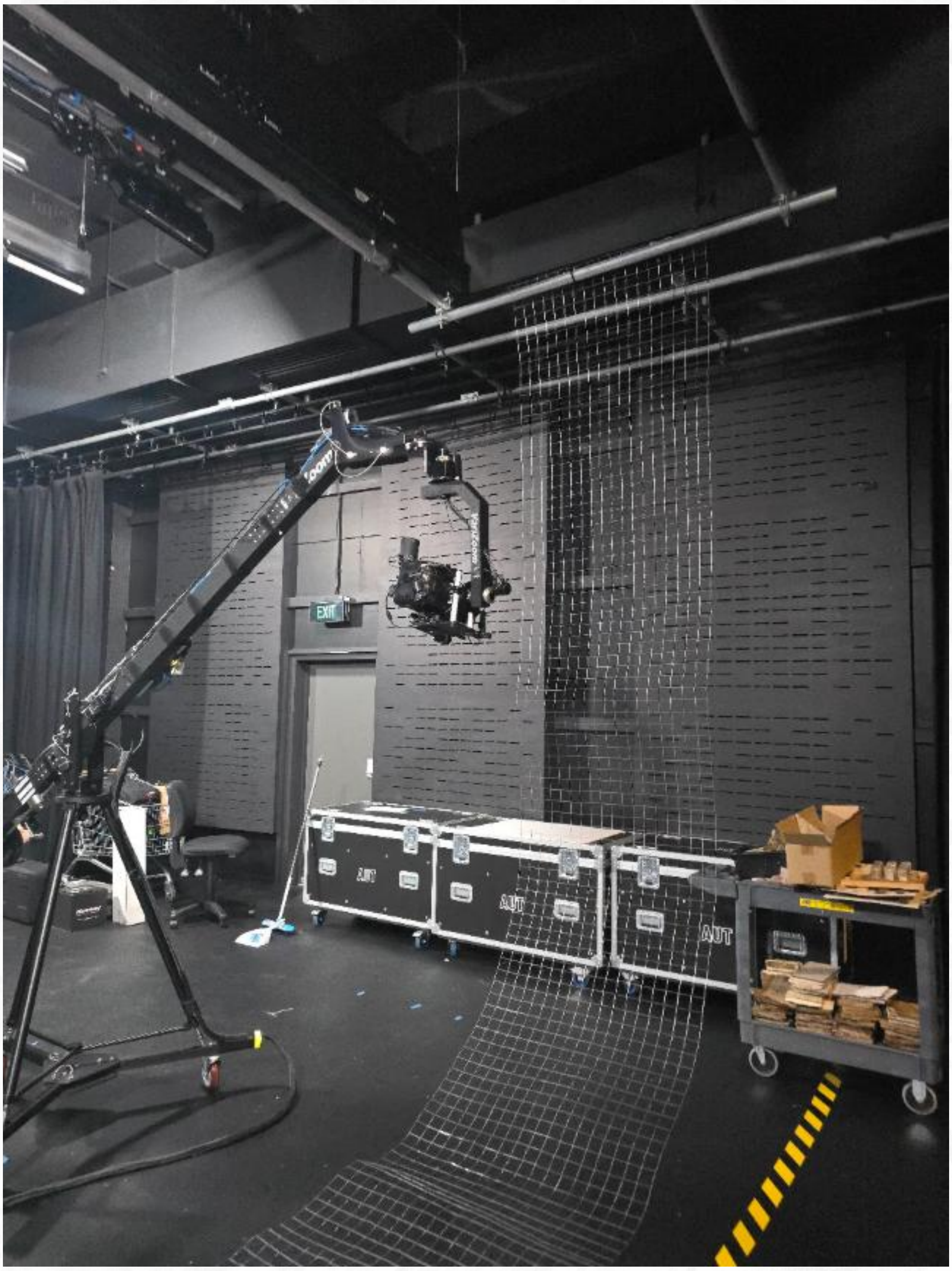
FRONT SMOOTH SIDE

BACK ROUGH SIDE

5.5 Integration of Materials into the Installation


18/22
KONDOR BLUE


EXIT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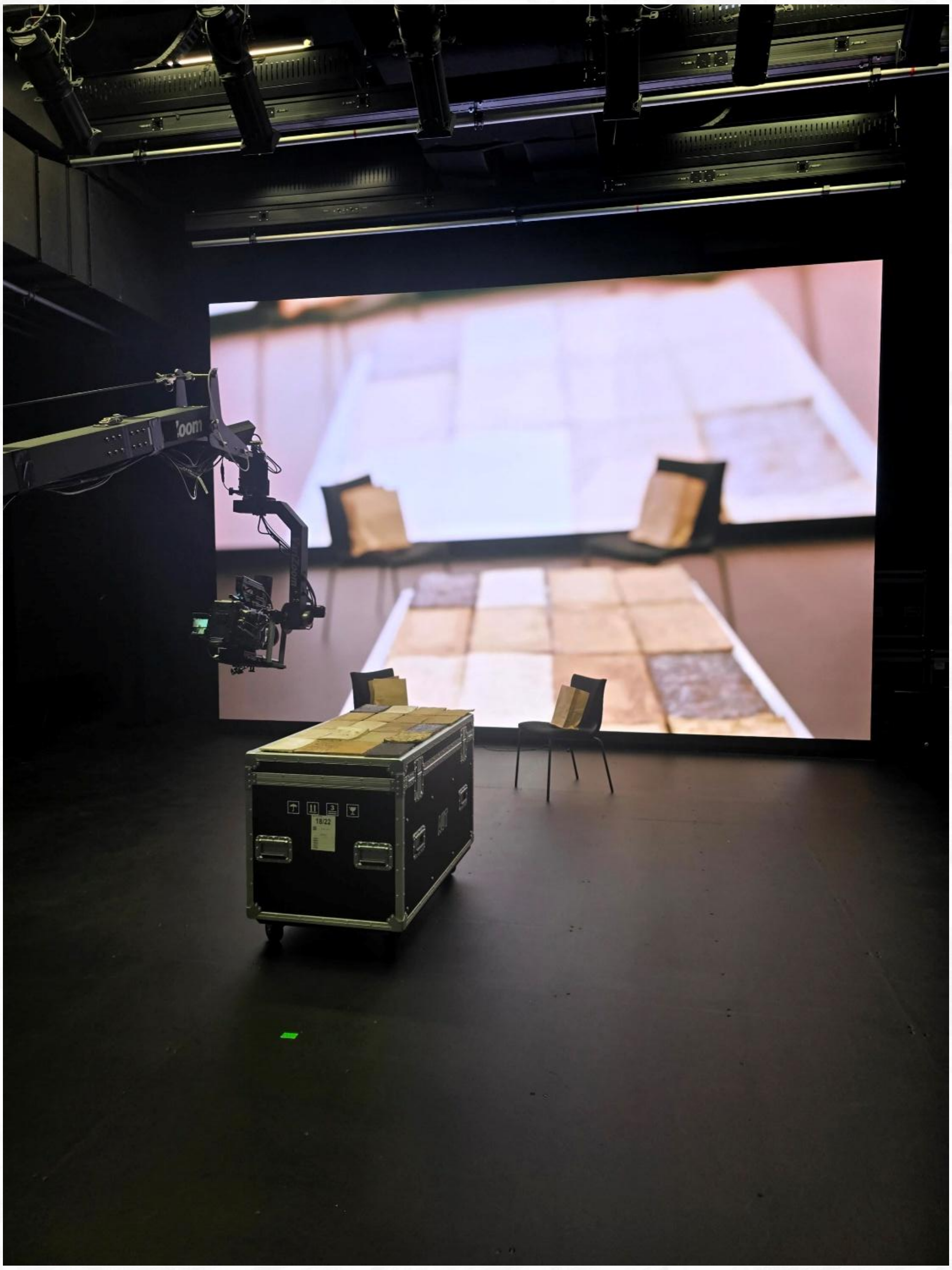
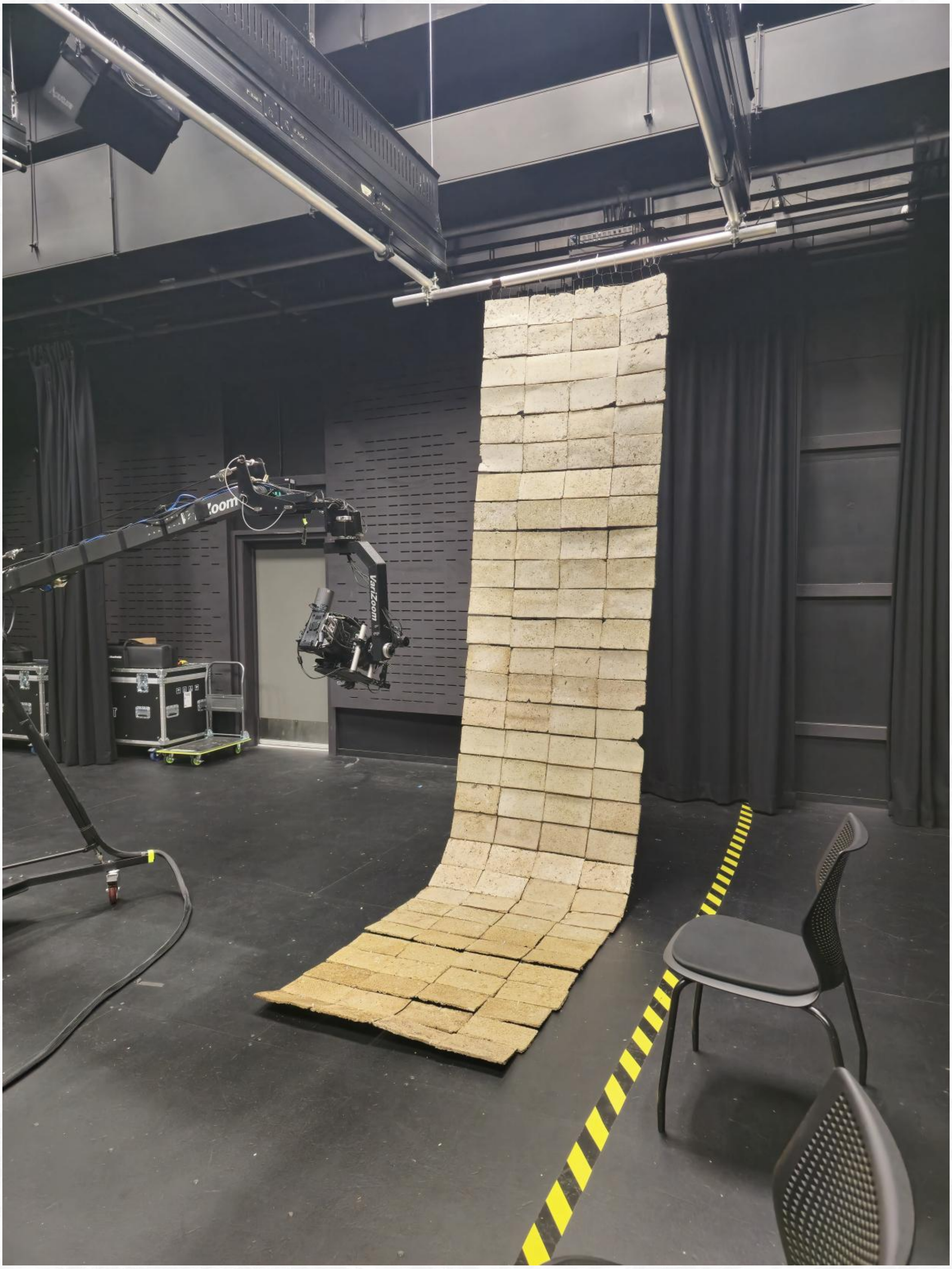
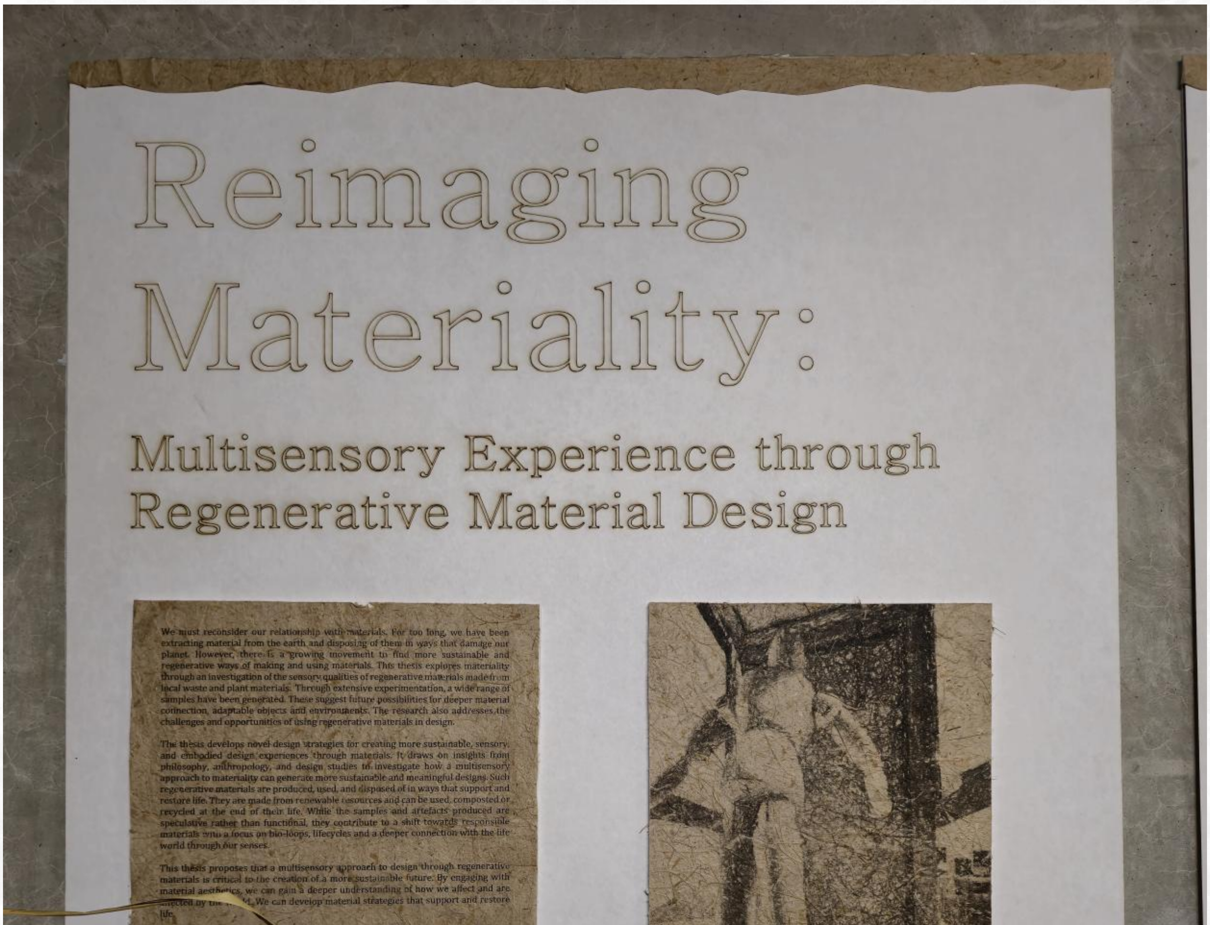
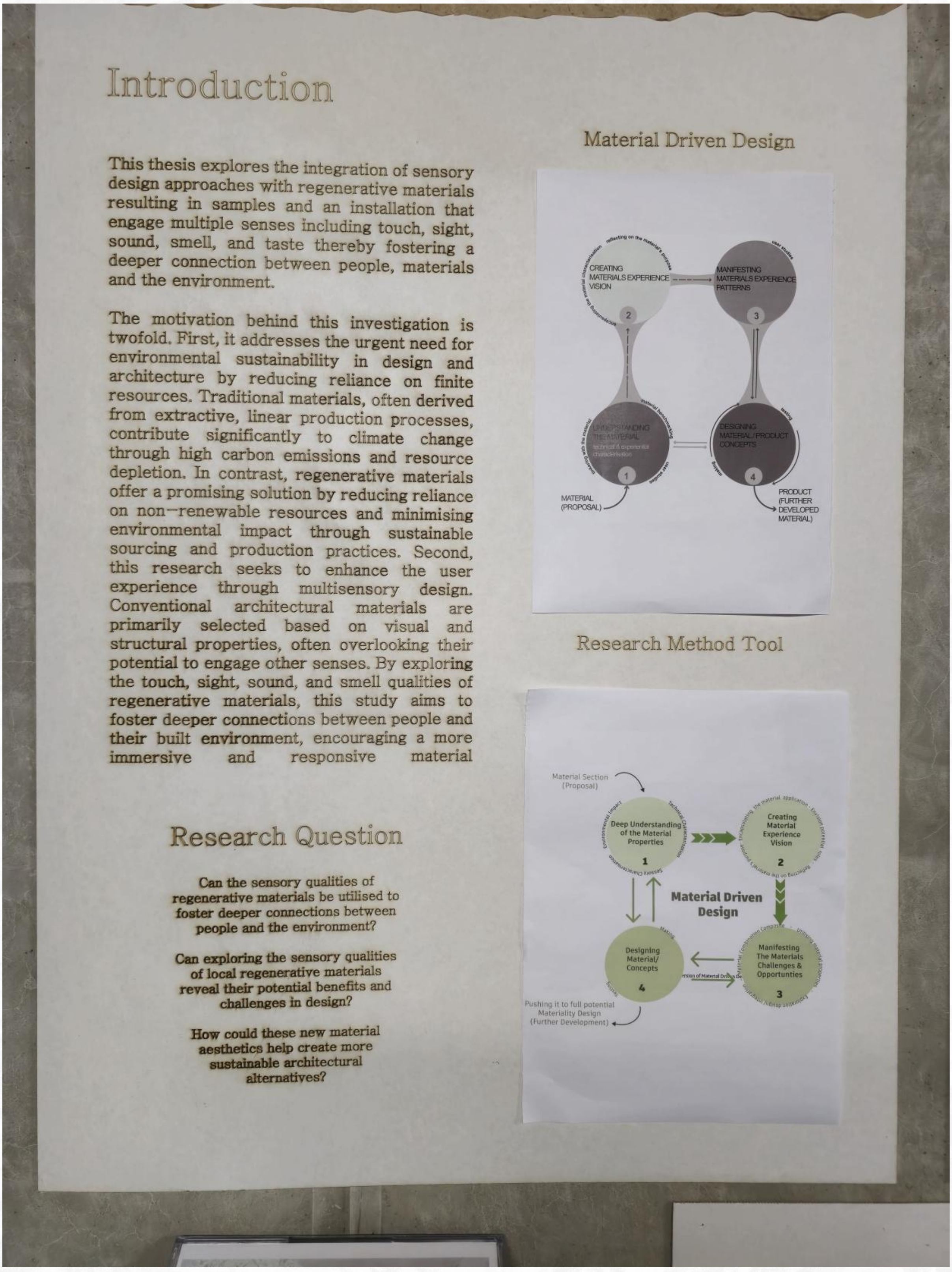


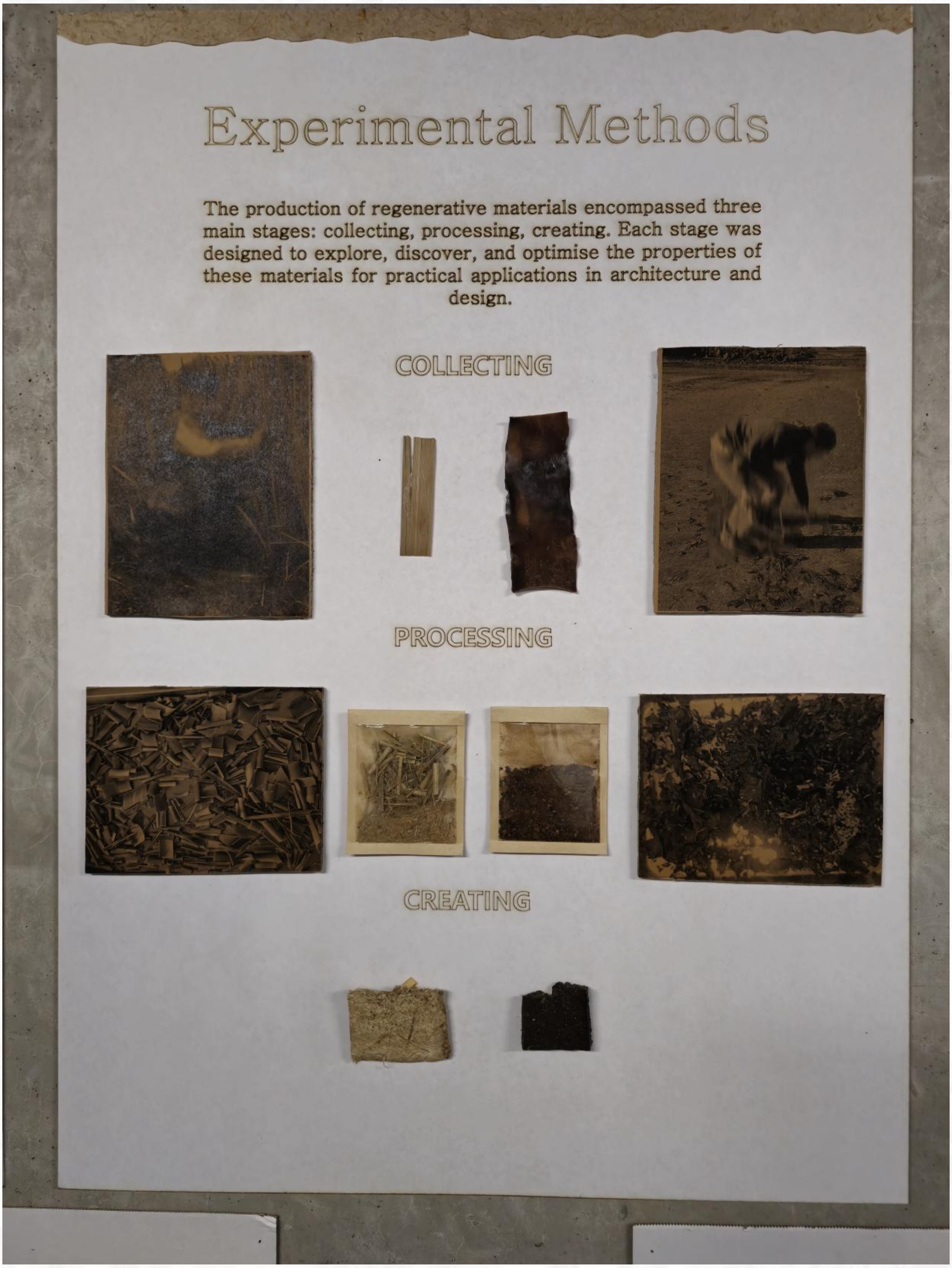
Appendix D Documentation of Final Installation



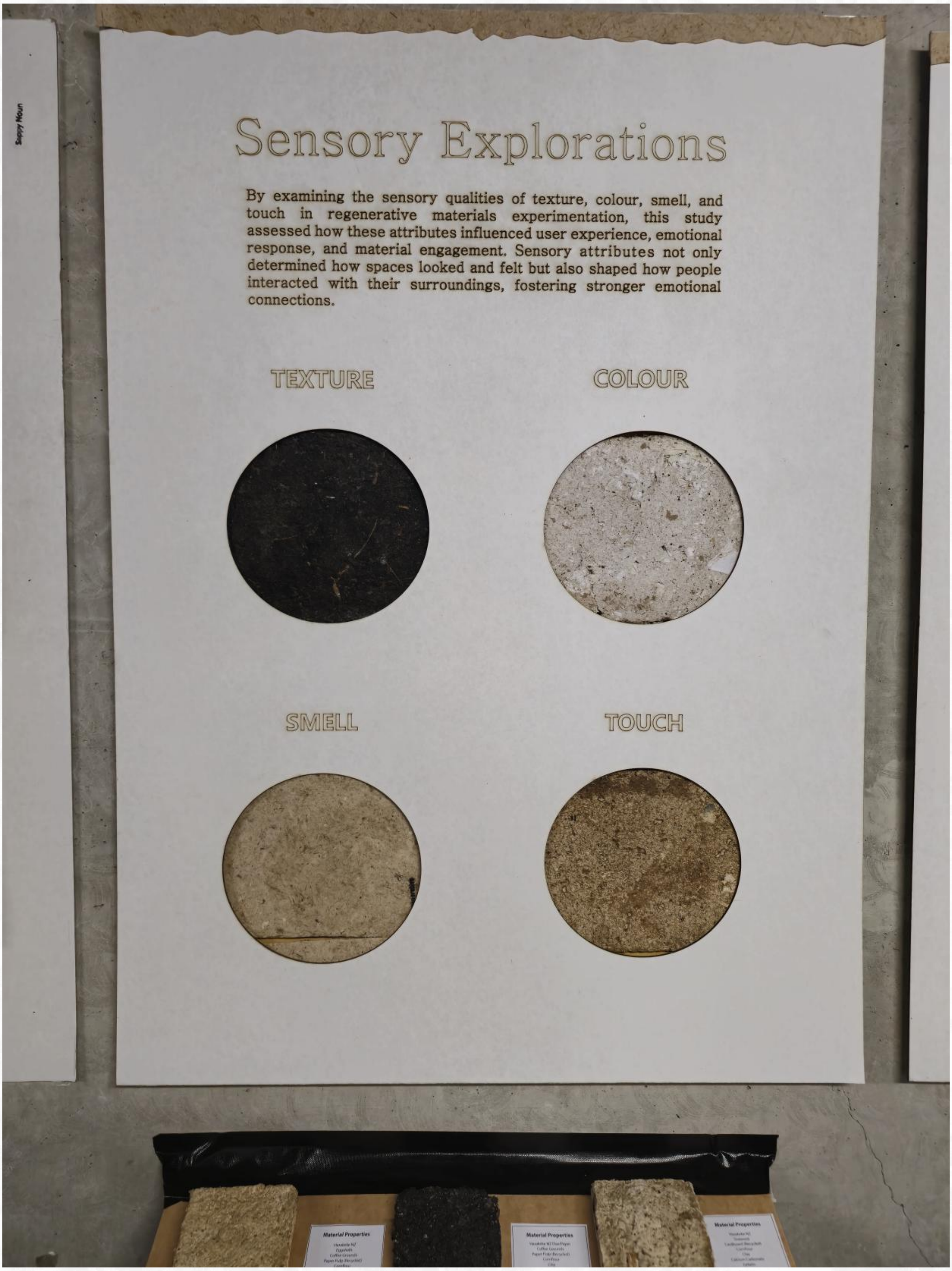

Reimaging Materiality:
Multisensory Experience through Regenerative Material Design
We must reconsider our relationship with materials. For too long, we have been extracting material from the earth and disposing of them in ways that damage our planet. However, there is a growing movement to find more sustainable and regenerative ways of making and using materials. This thesis explores materiality through an investigation of the sensory qualities of regenerative materials made from local waste and plant materials. Through extensive experimentation, a wide range of samples have been generated. These suggest future possibilities for deeper material connection, adaptable objects and environments. The research also addresses the challenges and opportunities of using regenerative materials in design.
The thesis develops novel design strategies for creating more sustainable, sensory, and embodied design experiences through materials. It draws on insights from philosophy, anthropology, and design studies to investigate how a multisensory approach to materiality can generate more sustainable and meaningful designs. Such regenerative materials are produced, used, and disposed of in ways that support and restore life. They are made from renewable resources and can be used, composted or recycled at the end of their life. While the samples and artefacts produced are speculative rather than functional, they contribute to a shift towards responsible materials with a focus on bio-loops, lifecycles and a deeper connection with the life world through our senses.
This thesis proposes that a multisensory approach to design through regenerative materials is critical to the creation of a more sustainable future. By engaging with material aesthetics, we can gain a deeper understanding of how we affect and are
We can develop material strategies that support and restore life.
Sappy Noun

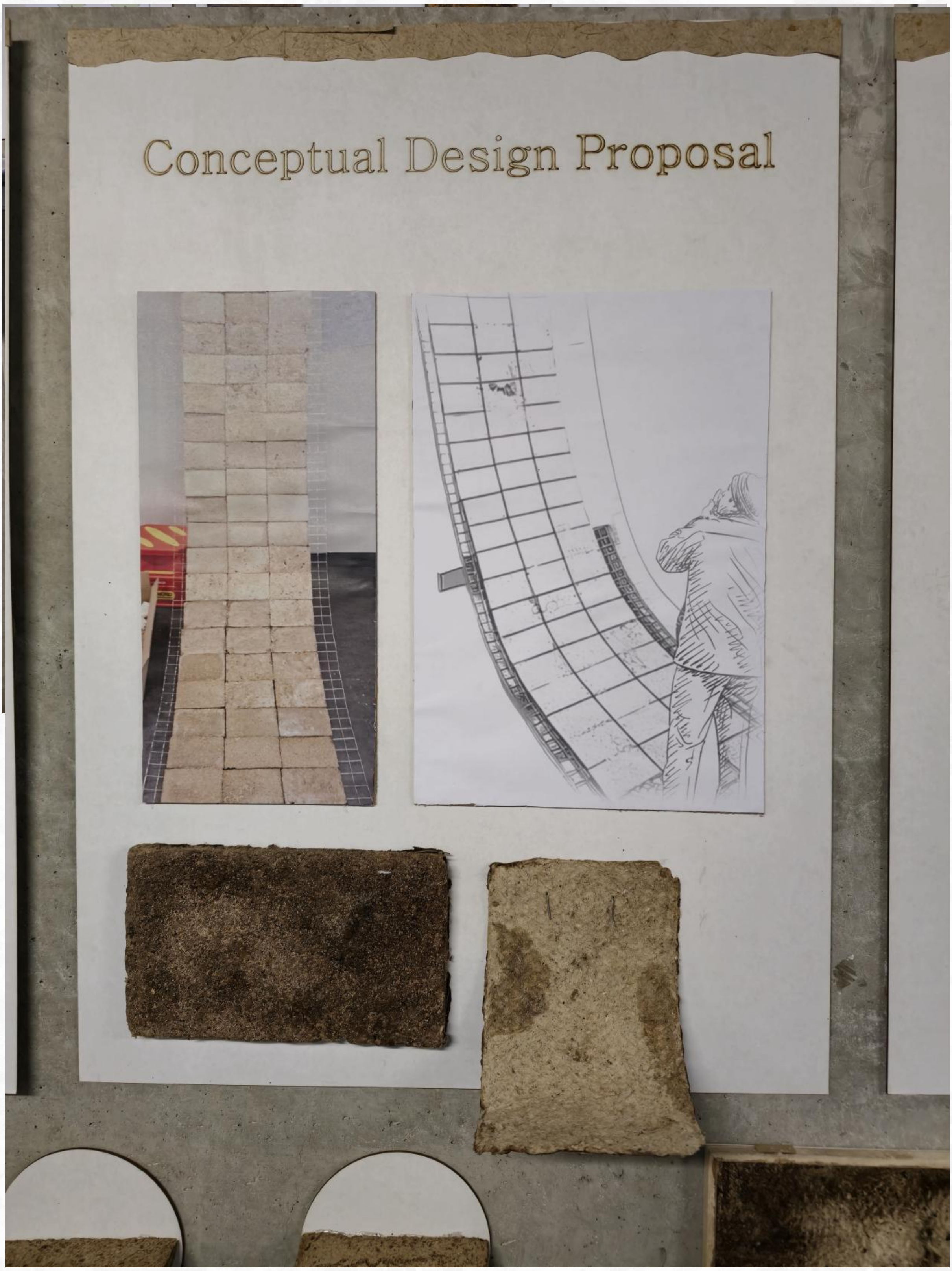


Introduction
This thesis explores the integration of sensory design approaches with regenerative materials resulting in samples and an installation that engage multiple senses including touch, sight, sound, smell, and taste thereby fostering a deeper connection between people, materials and the environment.
The motivation behind this investigation is twofold. First, it addresses the urgent need for environmental sustainability in design and architecture by reducing reliance on finite resources. Traditional materials, often derived from extractive, linear production processes, contribute significantly to climate change through high carbon emissions and resource depletion. In contrast, regenerative materials offer a promising solution by reducing reliance on non-renewable resources and minimising environmental impact through sustainable sourcing and production practices. Second, this research seeks to enhance the user experience through multisensory design. Conventional architectural materials are primarily selected based on visual and structural properties, often overlooking their potential to engage other senses. By exploring the touch, sight, sound, and smell qualities of regenerative materials, this study aims to foster deeper connections between people and their built environment, encouraging a more immersive and responsive material
Research Question
Can the sensory qualities of regenerative materials be utilised to foster deeper connections between people and the environment?
Can exploring the sensory qualities of local regenerative materials reveal their potential benefits and challenges in design?
How could these new material aesthetics help create more sustainable architectural alternatives?
Material Driven Design
CREATING MATERIALS EXPERIENCE VISION
reflecting on the material's purpose
encapsulating the material characterisation
2
MANIFESTING MATERIALS EXPERIENCE PATTERNS
user studies
3
UNDERSTANDING THE MATERIAL
technical & experiential characterisation
tinkering with the material
material benchmarking
user studies
1
DESIGNING MATERIAL / PRODUCT CONCEPTS
testing
making
4
MATERIAL (PROPOSAL)
PRODUCT (FURTHER DEVELOPED MATERIAL)
Research Method Tool
Material Section (Proposal)
Deep Understanding of the Material Properties
Environmental Impact
Technical Characterisation
Sensory Characterisation
1
Creating Material Experience Vision
2
Material Driven Design
Designing Material/ Concepts
Making
Testing
4
Manifesting The Materials Challenges & Opportunties
Utilising material properties
3
Pushing it to full potential Materiality Design (Further Development)

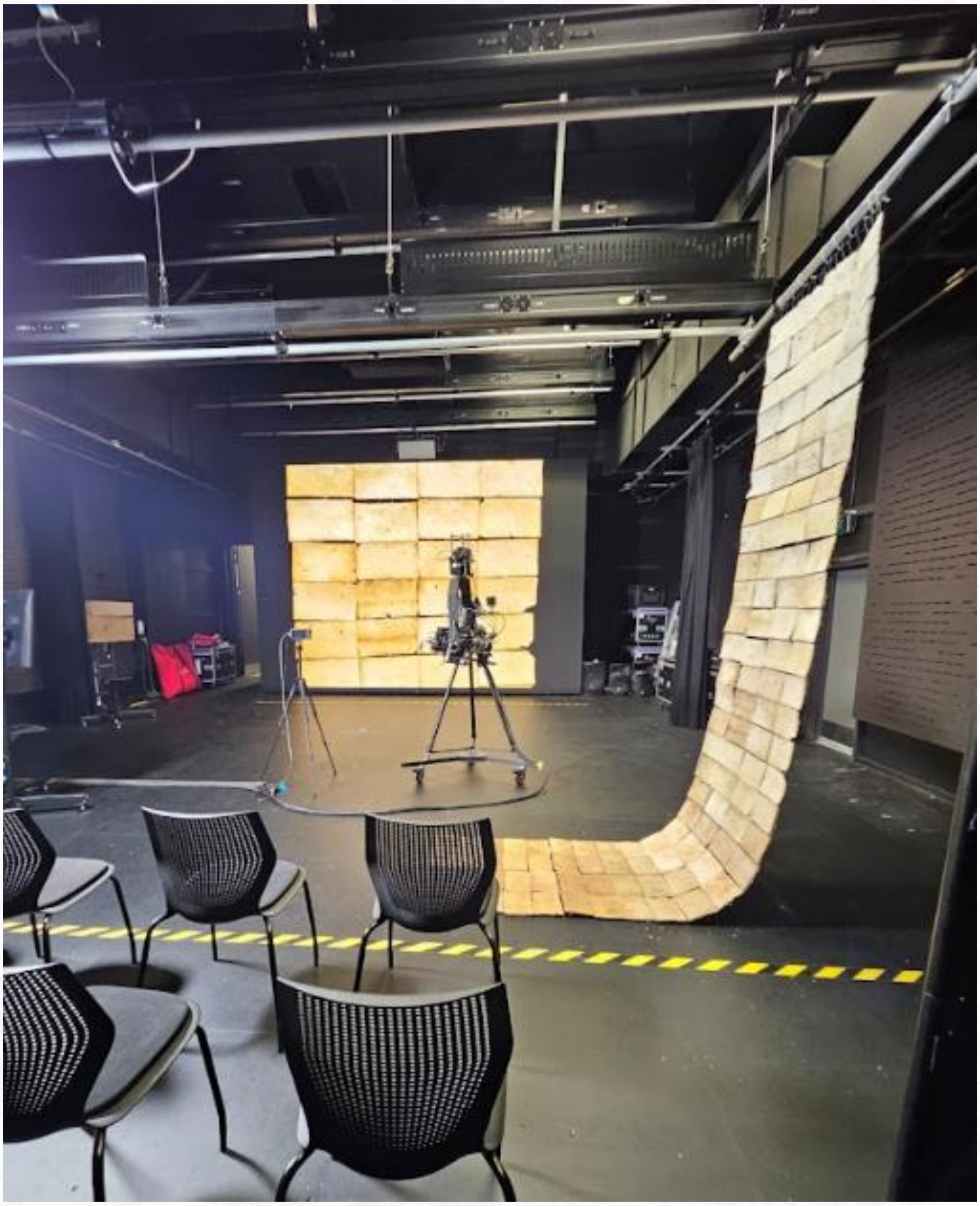

Experimental Methods
The production of regenerative materials encompassed three main stages: collecting, processing, creating. Each stage was designed to explore, discover, and optimise the properties of these materials for practical applications in architecture and design.
COLLECTING
PROCESSING
CREATING


Sappy Noun
Sappy Noun
Regenerative Material
Sappy Noun


Sensory Explorations
By examining the sensory qualities of texture, colour, smell, and touch in regenerative materials experimentation, this study assessed how these attributes influenced user experience, emotional response, and material engagement. Sensory attributes not only determined how spaces looked and felt but also shaped how people interacted with their surroundings, fostering stronger emotional connections.
TEXTURE
COLOUR
SMELL
TOUCH
Material Properties
Material Properties
Material Properties


Conceptual Design Proposal


Material Driven Design
CREATING



Sensory Explorations
Specific Material Findings
Conceptual Design Proposal
Material and Digital Interaction in a Multisensory Environment


Experimental Methods
Sensory Explorations
Specific Material Findings
Conceptual Design Proposal
Material and Digital Interaction in a Multisensory Environment