SOUND MATERIALS:

Exploring the Use of Strong Wool for Sustainable Acoustic Textile Design

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ABSTRACT

This research exists at the intersection between two industries; agriculture and architecture. The project is concerned with the production of wool, and its use within architecture for acoustic benefit. This practice based, material driven inquiry explores shared issues around sustainability and materiality within both agriculture and architecture. The practice addresses an oversupply of the strong wool fibre, alongside the increasing demand for affordable and sustainable building materials. The outcome of the research is a series of wool-based material experiments to inform the development of a future acoustic panel design. The research builds on existing findings around the mechanical properties of wool when applied in an acoustic context.

New Zealand strong wool is used as a base fibre for the experimental development of new materials in this research. Strong wool has historically been a champion fibre of the New Zealand craft and textiles industries. In recent decades, appreciation and demand for the fibre has dropped, this is reflected in the lowering market price of the raw material. Modern synthetic counterparts have become a more viable option as a base material for many mass-produced products formerly manufactured from strong wool. This decrease in appreciation has contributed to the label of ‘waste’ or ‘by-product’ being attached to strong wool. This research aims to assist in raising the value of strong wool and other by-product fibres and contribute to an increased perception of prematurely discarded or discounted materials. This research is funded by, and in collaboration with Palliser Ridge, South Wairarapa.

Figure 1. Sheep grazing at Palliser Ridge.

CONTENTS

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 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

FIGURES LIST

INTRODUCTION

The local conversation around the value of strong wool is one which has been circulating for five decades (Pawson & Perkins, 2013). Agricultural disciplines have put the challenge to design and manufacturing industries to develop commercially viable applications for the fibre. The problem remains that synthetic alternatives offer cheaper construction processes, especially for mass-produced products. The challenge for textile designers is to integrate this fibre into familiar and functional products valued by consumers. The ultimate goal is to generate demand for the strong wool fibre, and in turn, raise the market price.

Acoustics, is the broad definition given to the behaviors of sound waves within a space. This thesis focuses on the material of strong wool as a candidate for use within acoustic treatment products. The research is concerned with how both traditional and digital crafting techniques may be used to combine and mutually enhance a family of natural materials. A basic acoustic functionality is assumed among the materials based on existing initiatives involving strong wool and other by-product fibres. This positions the research as an exploration of new material combinations and textile design.

Palliser Ridge provides industry partnership, funding, and material supply for this research. The farm produces a vast quantity of strong wool annually, forming the motivation for investigating new avenues of re-valuing the fibre. Their contribution to research and development (R&D) aligns with the growing industry mandate to address the commercial imbalances surrounding strong wool production. Palliser Ridge also contributes to the narrative this research follows. The farm and its materials provide inspiration through the making and design decisions, embracing the material origins and biography. Strong wool is the underdog of fibres, trying desperately to shake popular nicknames of ‘by-product’ and ‘waste’. This research partnership aims to contribute to a collective push towards increased material value.

RESEARCH QUESTION:
What is the potential for New Zealand strong wool and other agricultural by-product fibres to be manipulated into sustainable materials to enhance spatial acoustics?

Through the investigation of this research question, the practice generates several strong wool-based composite materials to showcase the valuable qualities of the currently undervalued material. The construction of these new materials aims to highlight the versatility and potential applications of the fibre.

Strong wool is positioned as the central material for all making throughout the research. The practice based inquiry follows a Material Driven Design method and craft approach for establishing tactile knowledge around the material of strong wool. Through a process of experimenting and prototyping, these methods allow the material to reveal its characteristics, and how it relates to both the acoustic context and surrounding materials. Sustainable practices are continually referenced as core criteria. The research is designed in a way that encourages mutual nurturing from a range of disciplines. The outcomes reflect these interdisciplinary origins, showcasing a culmination of materials, tools, and technologies.

POSITIONING STATEMENT

To understand this research the reader must first understand the parties involved and motives behind this project. This exploration in materials and acoustics is a culmination of common interests stemming from both personal experiences and industry. The result of which is a thesis proposing a new direction in material value, process and use.

Palliser Ridge (2021), located in the South Wairarapa of New Zealand, is the main contributor of both material and funding towards this research. The farm has provided a full fees Master's scholarship and the material supply of strong wool. This contribution from industry has a number of motives. It sits among a series of environmental and economic initiatives both on the farm and in collaboration with the greater industry. The wool industry shortfalls described in the following literature mean the farm has a financial interest in stimulating a market which values strong, offcut, and waste wool. Through this funding, they aim to make a contribution to shifting both themselves and the greater industry towards a more efficient and sustainable position concerning strong wool. It is important to note that while Palliser Ridge occupies the position of industry partner, there is no expectation that this thesis will produce a marketable product. This allows the freedom to explore experimental avenues of material manipulation without a predetermined design outcome. This agreement is consistent with the attitude Palliser Ridge has towards holistic industry contribution and shared knowledge for mutual prosperity.

The connection between this research and Palliser Ridge follows a progression of making and prototyping towards the later stage of my undergraduate degree. The focus of my undergraduate projects was predominantly centred around audio, which considered sound as a harnessable and malleable material (Wanless & Newick 2019; Wanless 2019). The practice around audio manipulation shifted from conventional methods of audio production, towards the relationships physical materials have with sound in the built environment. A collection of modular panels was produced intended for the acoustic dampening of interior spaces (Wanless, 2019) (Refer to appendix B). These initial prototype panels formed the basis of discussion between myself and Palliser Ridge around proposed postgraduate research directions and funding. From an industry perspective, the research will bring value to an underappreciated natural fibre among both agriculture and textile disciplines

Figure 2. Palliser Ridge farm entrance.

LITERATURE REVIEW 1

This chapter seeks to bring context to the current issues surrounding strong wool production. Quantifiable data is referenced from both wider industry and independent Palliser Ridge reports. The chapter goes on to identify the proposed use-case and existing initiatives for strong wool within architecture and interior design. The importance of considering acoustics in human-inhabited spaces is discussed. The chapter ends by highlighting the responsibility of both makers and consumers towards sustainability in object design and ownership. Ideas of material attachment and sustainable narrative are unpacked in relation to wool and surrounding materials.

Figure 3. Scoured dag wool from Palliser Ridge.

STATE OF THE INDUSTRY

Strong wool is a historical cornerstone material for New Zealand makers. On the back of New Zealand's thriving lamb trade, 'strong' or 'coarse' wool makes up the vast majority of our total wool export (Beef and Lamb, 2019). Despite the material's celebrated history, in recent decades there has been a growing price disparity between the abundant coarse wool and its fine wool counterpart (Pawson & Perkins, 2013). With meat export being the main financial motivation for the farming of most of New Zealand's sheep, the resulting wool is the secondary material, often referred to as the 'by-product'. Modern consumer access to premium fibres and textiles further position strong wool as a perceived by-product.

As one of the Wairarapa's largest operations, Palliser Ridge is a good indication of the state of the surrounding industry. Palliser Ridge produces roughly 40,000kg of wool per year, spread across 9000 lambs and 6000 ewes (Palliser Ridge, n.d). At around the 29-micron count, their lambs wool is considered mid-micron and is appropriate for products such as blankets and outer garments (Palliser Ridge, n.d). The problem, however, is the ewes wool, reaching micron counts of near 40 and above. This thickness of fibre places the ewes wool firmly in the strong wool category. This means the bulk of the wool produced is subjected to strong wool market pricing which currently fluctuates either side of $2.00 per kg (PGG Wrightson, 2021; CP Wool, 2021). The shearing price per kg is $2.50, meaning a net loss of $0.50 per kg of wool produced (personal communication, Portas, 2020). This highlights the issue of market price being unsustainably low against the true cost of producing the wool. Farm manager Kurt Portas suggests the market price needs to rise to at least $7.50 per kg for their efforts to become worthwhile (personal communication, 2020). With this in mind, this research is positioned as an exercise in lifting the perceived value of the strong wool fibre. This thesis suggests a category of new applications and companion materials that aim to encourage the uptake of strong wool across new industries.

Multi-industry uptake of this material may be encouraged through open access to fibre processing and manufacturing technologies. It seems many textile innovations at the individual maker level go unrealised due to restricted access to tools and technologies. Auckland University of Technology, AUT's Textile Design Lab (TDL) advocates for the "democratisation of technology" (Joseph & Heslop, 2014), leveling the playing field for individual makers, corporations, and academics alike. The TDL plays an active and ongoing role in identifying industry issues. The facility incubates research around sustainable textile practices, innovative products, and material-based solutions. Key members of the lab Frances Joseph and Peter Heslop provide ongoing insights into the state of the industry focusing on innovative textile design. Their paper presented at the Shapeshifter Conference (2014) provides a snapshot of both successful initiatives and shortfalls of the textiles industry with relation to the TDL. They argue the importance of innovation in this sector and identify areas which need to improve for the sustainable growth of the industry. The approaches identified in the paper are rebuilding the connection between maker and products, empowering designers and artists to develop new markets and original designs that cannot be found anywhere else (Joseph & Heslop 2014). The TDL is the main facilitator for the practice component of this research. The facility houses the core machinery and expertise necessary for the experimentation and completion of the project.

The coffee industry becomes the secondary contributor to this research. This industry shares similar issues around waste and by-products with the wool and textiles industries. The coffee sack occupies this agricultural fibre by-product category. The sacks are made from a textile called hessian (also known as burlap or crocus), comprised of the woven fibres of the jute plant. Coffee sacks are used in the shipping process of the raw coffee material. Once the coffee is removed from the sack in the roasting process, the sack is no longer of use to the coffee industry, and is deemed a by-product. While a number of initiatives exist around the upcycling and reuse of this material, makers and recyclers simply cannot keep up with the volume of coffee sacks being disposed of. Inevitably a large portion ends up in landfill. The jute fibres of the coffee sack are 100% biodegradable, making it a prime material candidate for use in this research. The hessian sacks used in the research are supplied by Coffee Supreme. This is a company I have worked for in the past, so have a personal connection to the industry and organisation.

The Formary (n.d) is a notable organisation actively pursuing a shift in consumer and material thinking. They are positioned as a consultant, educator, and facilitator towards sustainable practices among businesses. They have developed a number of products and initiatives responding to the growing mandate towards sustainability in material and manufacturing industries. The Formary also identified jute coffee sacks as a usable and abundant by-product fibre. Their product WoJo Fabric (The Formary, 2010) is a blend of wool and jute fibres to produce a premium and hard-wearing textile for use in interior design. The initiative was an outcome of a partnership between The Formary and Starbucks, in an attempt to combat the vast number of coffee sacks used and discarded by the company. The success of this textile composite product proves the viability of my chosen base materials in an interior architecture application.

Figure 4. Wojo Fabric by The Formary.

Figure 5. Coffee sacks supplied by Coffee Supreme.

ACOUSTICS AND ARCHITECTURE

When we talk about the treatment of interior acoustics, generally we are trying to manage a phenomenon called reverberation. Reverberation is the lifetime or persistence of a sound wave in an enclosed space (Baux, 2020). Reverberation occurs when sound is able to reflect off one or more surfaces during the dissipation of the waveform (Refer to figure 6). In certain circumstances, reverberation and relating phenomenon can contribute to a degraded acoustic environment, which has been seen to influence the health and wellbeing of occupants (Celadyn, 2018).

There are two main methods of acoustic treatment which relate to the wool and other materials in this research; absorption and diffusion. Absorption occurs when sound comes into contact with a porous material. Due to the air gaps within the porous material, some of the sound will become trapped and not reflect back into the room (Refer to figure 7). Wool is a great example of a porous material, especially when processed into a textile or compressed mass. Diffusion occurs as a result of an irregular surface. Instead of reflecting directly back, sound will reflect off the surface in a number of different directions and disperse throughout the room (Refer to figure 8). These principles are referenced throughout the making portion of the thesis to inform design decisions.

Acoustics within the built environment is often overlooked. Context is everything when it comes to an appropriate sonic environment for an interior space. A concert hall thrives on the reverberation of a cavernous space, while a library relies on rows of bookshelves and carpeted walls to diffuse ambient noise. While these examples have a cemented sonic expectation among the occupants, less conventional spaces often require a similar level of acoustic consideration. Education, for example, is an industry in need of innovations in acoustics to benefit the learning environment. A recent study around the sonic characteristics of a special needs learning environment advocates for spaces composed of sound-absorbing materials (Ueno et al., 2019). The altered acoustics help facilitate calming spaces necessary in aiding the suppression of panic among students (Ueno et al., 2019). This research is intended to benefit a range of spaces and contexts. From the music industry to education, acoustic treatment can play a role in enhancing the health and wellbeing of a space’s occupants.

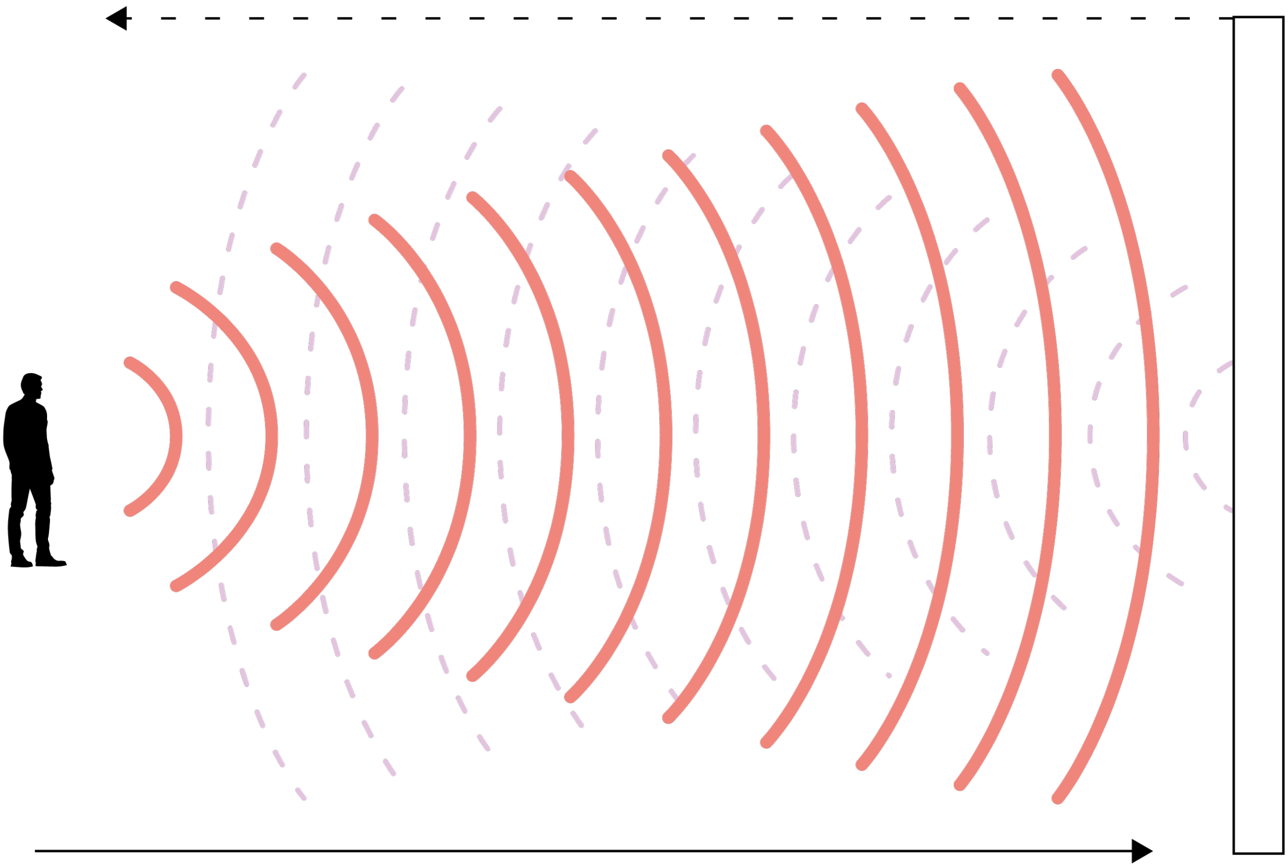

Figure 6. Sound behaviour in space. Diagram by Baux.

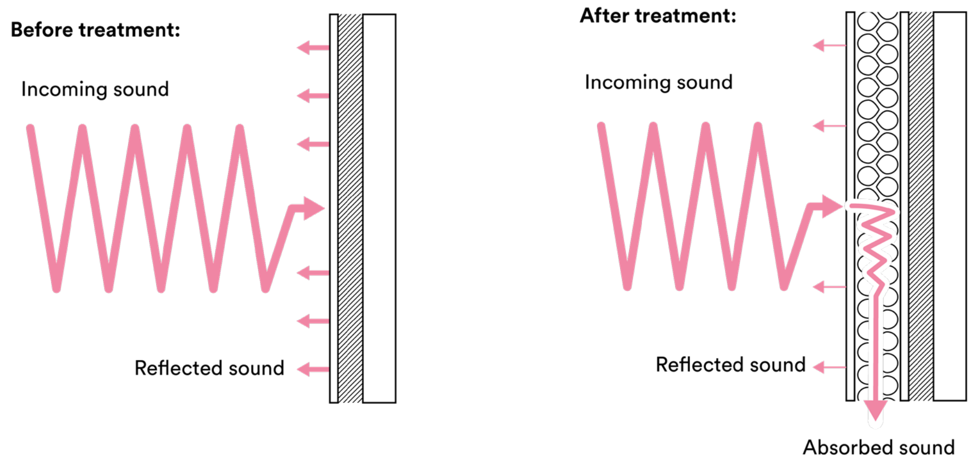

Figure 7. Sound absorption. Diagram by Baux.

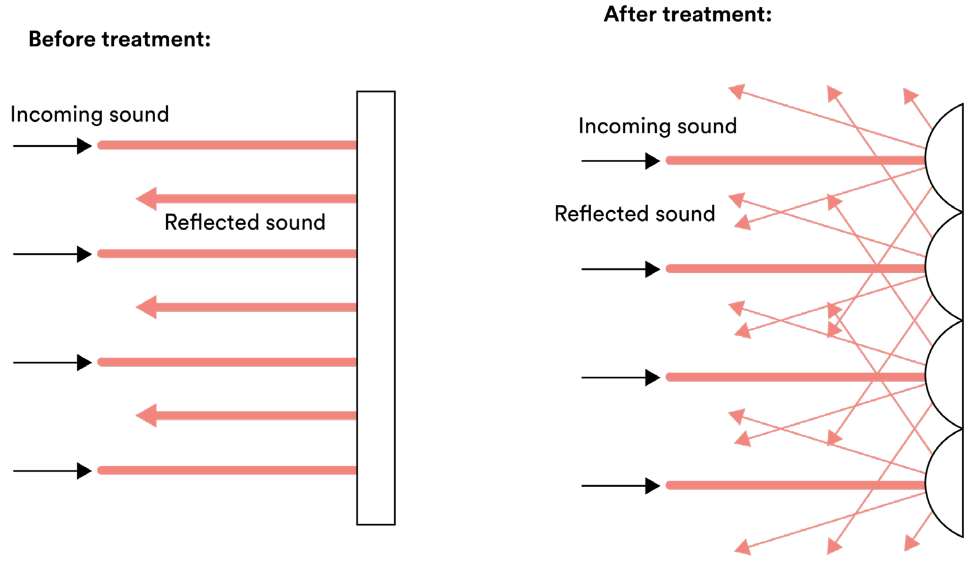

Figure 8. Sound diffusion. Diagram by Baux.

Wool has long been used as a fibre for dressing internal spaces. From tapestries to furniture, wool serves as a natural insulator for both heat and sound. Behind the existing products on the market, there is a wealth of research around the acoustic performance of wool. Based on this existing research, this thesis assumes a basic level of mechanical functionality among the wool used. Broda and Baczek (2020) confirm the desirable acoustic properties of non-woven wool structures through their research. The porous nature of wool structures ensures good insulating properties (Broda & Baczek, 2020). The Cartonala project (Bosia et al., 2015) backs up claims of a wool-based product's acoustic performance. Composite material construction among these products is a common approach. The majority of published initiatives base their structure around a main material, bound together with additional materials to form a new composite. This can be seen in Mogu's mycelium-based acoustic panel range (2020). Mushroom mycelium is grown to form a structure around waste fibres from the textile and wool industries (Refer to figure 10). Exceptional acoustic results were shown in testing the unique composite material (Mogu, 2020). This product displays a symbiosis of organic materials integrated to create a technology to enhance the quality of human life.

There are a range of products currently on the market which provide varying levels of acoustic insulation for internal spaces. Wellington-based company T&R Interior Systems (2021) produces *Floc 3D*, a series of geometric acoustic tiles made from New Zealand grown strong wool (Refer to figure 9). The panels themselves are a one-design-fits-all system for quick and customisable treatment of any space. Datasheets accompanying the product show a high noise reduction coefficient (NRC) from the wool-based tiles (2021). The documented success of this product justifies the use of wool as the primary material in enhancing interior building acoustics.

Additional by-products from agriculture and manufacturing have been used as base materials for several acoustic initiatives worldwide. A study in the acoustic and insulation properties of flax tow, a byproduct material from the flax fibre and textiles industry returned promising results (El Hajj et al., 2011). Interestingly, the sustainable manufacturing issues observed within flax for textiles share some very close similarities to the wool industry. The amount of the processed material which is considered ‘premium’ is dwarfed in comparison to the corresponding by-product (El Hajj et al., 2011). A notable organisation producing architectural panels from agricultural waste pulp is Swedish company Baux (2021). The motivations of Baux align closely with those of my own research, with efforts focused on the reintegration of waste materials into premium and useful composites for the built environment. Baux has developed a framework for understanding interior acoustics and the materials that may affect a sonic environment. This framework is published as The Book of Acoustics (Baux, 2020), breaking down the key concepts involved in acoustics to inform design decisions within their own products. This book forms a portion of the theoretical framework influencing the material and process decisions within my own research and making.

Figure 9. Floc Indian Arrow wall panel by T&R Interior Systems

Figure 10. Wave Hex Acoustic Panel by Mogu. (image withheld)

SUSTAINABILITY AND MATERIALITY

It is apparent that modern crafters, makers, and designers are battling unsustainable consumption patterns among end users (Niinimaki, 2012). The disposable and accessible nature of many consumer products of today have instilled a sense of temporary ownership among consumers. The challenge we as makers face is the reconnect of users to product. Carefully considered sensorial experiences may act as a gateway to more sustainable behaviour (Riisberg et al., 2014). Included in this sustainable behaviour is extending the perceived lifetime of a product from a consumer perspective. While the recycling and reintegration of waste products is a step in the right direction, the practice is obsolete if the products created from these materials are not valued for an extended lifetime. Ultimately the goal is to offer the customer new emotional experiences, postponing the inevitable disposal of the product (Niinimaki, 2012).

These proposed emotional and sensorial experiences may be achievable through creating a narrative around a product. New Zealand Fashion brand Maggie Marilyn (2021) is an example of a company which enhances value through a sustainable narrative. Each garment is traceable back through each stage of manufacturing, allowing the consumer to follow the journey from raw material to storefront. This trend of product traceability is becoming more common in a number of bespoke industries. Palliser Ridge embraces the locally produced and traceable narrative for all the products they offer. This informs the approach to the sustainable narrative surrounding my own practice.

For the purposes of this research, agriculture and architecture are considered companion industries occupying the start and end of a traceable textile supply chain. Both of these industries have a common mandate for innovation in sustainable material practices and manufacturing. Bergmann and de Magalhães (2018) identify a similar companionship in their design strategy analysis of the textile industry. They draw relationships between interior design and fashion industries through the commonality of textiles as a core material. They suggest that to effectively design for innovation we must “ignore the limits imposed by the specialisation of subjectors of the textile industry” (Bergmann & de Magalhães, 2018 p.19). Effectively we need to disregard the ‘correct’ use of a material according to specific disciplines. Wool may be predominantly associated with the fashion industry, yet variations of the fibre hold qualities which benefit users far beyond clothing. In the context of this research, textiles are being used for an interior design purpose, yet popular aesthetics cannot be the main motivation behind the use of the material.

Classifying a material as a ‘waste’ or ‘by-product’ is often a matter of context and perception. Highlighting desirable qualities and/or placing a material in a new context may offer new value. Payne and Binotto identify three key methods of utilising waste; Disguise, Elevation, and Enchantment (2017). Employing this structure of waste utilisation, the use of waste wool in this research sits primarily in the ‘elevation’ category. The intention is not to shroud the original appearance of the wool material, but to celebrate its natural form which contributes to the final aesthetic of the new materials. If we allow the visible traces of the original waste material to prevail through aesthetic and tactility, they may provide a “biographical insight that elevates waste, giving a value to the new product as well as revaluing the waste that was transformed” (Payne & Binotto, 2017, p.342). Additionally, what was once devalued and labelled as waste and by-products now finds value through experimental processing methods and new context. With this in mind, we have to consider waste not as a constant, but as “a state that things can move in and out of depending on context and according to who is judging” (Payne and Binotto, 2017. p.340). In the case of this research, strong wool has a proposed value within composite materials designed for interior acoustics. The value is tied specifically to this context, yet continued research may find added value in adjacent disciplines.

Utilising waste or by-product materials within textile design is becoming an increasingly popular research topic. Stacey Ellis explores processing methods to utilise waste wool into usable and desirable materials through her master's thesis *Transforming Waste. Textile Design Process Intervention: Adding Value to Waste Wool* (2013). A range of manufacturing processes including felting and weaving are explored and analysed for their merits in creating textile value. The research concludes with a collection of textile samples alongside a functional prototype of a viable product; a chair. The chair is constructed using processing methods explored through the thesis, with the wool textiles stretched over a wooden frame (Refer to figure 11). Michelle Macky's master's thesis *From Waste to Textiles. The Exploration of the Potential Application of Rice Straw Waste in the Development of Eco Textile Design Solutions* (2014) explores very similar themes of by-product reintegration among premium textiles. In partnership with The Formary (n.d), Macky's research proposes a series of composite textiles based around the agricultural by-product of rice straw waste (2014). The processing methods and industry implications seen in these bodies of research are precedences for the intended outcome of my own research.

LITERATURE REVIEW CONCLUSION

The issue of strong wool value and demand is a local conversation spanning decades (Pawson & Perkins, 2013). There are a variety of factors that have contributed to the current position of the industry. The numbers have revealed an unsustainable relationship between shearing cost and market price of strong wool, highlighting the need for new material innovations around the fibre. Utilising strong wool as a furnishing material for the built environment provides an opportunity to stimulate demand for the fibre at scale. It has been observed that a desire for natural materials within the lived environment is increasing (Farmlands, 2021; Edwards, 2021). The literature reveals a wealth of existing research and product development in wool and other agricultural byproduct fibres in the areas of interior furnishings and acoustics. This research seeks to contribute to the existing innovations around strong wool and strengthen the argument towards the fibre's use in the built environment.

Figure 11. Final Chair by Stacey Ellis.

"Visible traces of a wasted or even abject item transformed provide the biographical insight that elevates waste, giving a value to the new product as well as revaluing the waste that was transformed" (Payne & Binotto, 2017, p.342)

METHODOLOGY 2

This chapter establishes the methodological approach this research took. The aim of this research was to investigate the viability of a series of wool-based composite materials. The practice seeks to curate a selection of individual components into a family of interrelated and codependent materials. The methodologies chosen for this thesis facilitate the making and practice while cementing the material of wool at the centre point of the research.

Qualitative data was collected as a means of understanding the relationships between each material and process. This data was developed from experiential observation and interaction with each material sample. The experiential first-person approach to the practice meant personal data collection was the most appropriate.

PRACTICE BASED

Practiced based research forms the overarching methodology for this project. The research is done through making and experimenting with materials and processes, emphasising the practice and its outcomes. As the artefact(s) is dependent on the materials used and the experimental processes, true understanding of the field is only achievable through making and interacting with a tangible artefact. “A full understanding can only be obtained with direct reference to those outcomes” (Candy, 2006 p.3).

The broad nature of making through this research takes on characteristics closest to craft. Craft research is anchored by practice, and a holistic, evolving understanding of how materials may be manipulated (Niedderer & Townsend, 2014). Karana et al. interpret Ingold (2013), stating “material engagement in craft is a means to logically think, learn and understand through sensing and immediate experience of materials” (2017 p.7). While definitions of craft differ, this research chooses to aknowledge Niedderer & Townsend’s interpretation of craft as a “fluctuation on the continuum between art and design” (2014, p.626). They cite Britton (1991) stating the process and outcomes of craft have an apparent refusal to be one thing or the other. This approach distances the research from preconceptions and agendas that may seek to define a final outcome. As this research project occupies a multidisciplinary space between agriculture, textile design and architecture, it was paramount the practice itself reflected the same mixed method approach. Textile design is rapidly becoming an interdisciplinary area (Marr & Hoyes, 2016). Practicing within textile design allows the research to transverse several areas of making and knowledge. Marr and Hoyes (2016) state:

> “The discipline of textiles crosses over into many other design areas as well as into the field of material science, and, as a result, is well positioned to affect liminal space between disciplines. The application of textile processes offers the opportunity to manipulate materials in unfamiliar ways or within new contexts” (p.9).

Figure 12. Inspecting carded wool at Waione Carding.

DESIGNING WITH MATERIALS

The material of strong wool is the departure point and constant focus of the practice. Material Driven Design (MMD) operates on a similar principle to craft research by removing the agenda and preconception from a research outcome (Karana, 2015). Conventional product design methodologies would identify the need for a product, then apply a material to that product based on its performance and characteristics within the chosen context. To contrast, a material driven approach uses a chosen material(s) as the departure point for the design process. This allows the material to reveal its characteristics through experimentation, and in turn, revealing the most appropriate use and context. In this case, strong wool is the chosen material to build a scaffold of design decisions around. Each tangent of design and making is taken in direct response to the qualities of the wool fibre in relation to the processes and additional materials the wool is subjected to.

The MDD model developed by Karana et al. (2015) outlines a series of steps to act as a scaffold for a material led design project. While the importance of the process as a whole is noted and understood, this thesis chooses to concentrate primarily on step one of the process; Understanding the Material (Karana et al., 2015). This step is described as a space for material ‘tinkering’ - “to cut it, bend it, burn it, smash it, combine it with other materials etc” (Karana et al., 2015, p.41). This research seeks to understand how a collection of materials may be combined, processed, and utilised to raise mutual value. These tinkering explorations can further be described as “playtypes… material prototypes used in open-ended process-led textile research without a product or user in mind” (Marr & Hoyes, 2016, p.23). This playful making echoes that of MDD methodologies, following the material and its characteristics to inform an open ended outcome.

It is important to acknowledge that this research is not entirely free of agenda. The intended application of the materials developed within the research is architectural acoustics. The research utilises MDD within the scope of acoustics and textile design. This places contextual boundaries on how the materials may be applied, yet allows freedom of exploration within the design brief and material outcomes.

The practice incorporates a broad range of materials as part of the experimental textile design process. Textile design has historic connotations with fabrics and fashion, yet contemporary practitioners have expanded the area into an interdisciplinary practice (Marr & Hoyes, 2016). The cross fertilisation of materials introduces textile design to the composite material space, furthering the reach of textiles.

Material driven design methods have been seen in local master's theses mentioned in the above literature. Both Ellis (2013) and Macky (2014) follow a material driven design process through their explorations of agricultural waste and by-product fibres. The way in which both of these projects develop new textiles demands a process which values material exploration over design form. The material was chosen before the design process began, as novel use of the waste and by-product materials was the primary objective of the research.

The impact of materials outside of the primary use was a core consideration when sourcing and designing materials. McDonough & Braungart's Cradle to Cradle philosophy (2002) considers materials in a cyclical pattern of waste to biological and technical nourishment. The biological waste product of wool is processed in a way which brings technical nourishment to an interior design context. When the useful life of the processed material/product is over, it may then provide biological nourishment to the soil and in turn, the cycle begins again. When put simply this research project is about minimising waste. It would not make sense for the eventual product of this thesis to itself become a waste product at the end of its useful life. The cyclical motion of material use was considered at every stage of both acquiring and manipulating materials, with the intention of the material outcomes retaining their biodegradable qualities, thus adhering to some of the cradle to cradle principles.

DESIGN OF RESEARCH

Based on the model developed by Karana et al. (2015), three phases of practice were identified which exist within the understanding the material step. Each design phase should not be seen as a linear progression of stages, but as a number of oscillating and overlapping waveforms. As depicted in figure 13, three waveforms operate simultaneously at varying frequencies. Each design phase can be attributed to an individual waveform. These waveforms intersect and diverge constantly, representing the way in which ideas, materials, and samples interact and shift over the course of the research. The thesis reaches a point of resolution as each waveform becomes ‘in-phase’ with one another. This represents the combination of all phases/waveforms in the design process, and the natural culmination of the timeline of the research project.

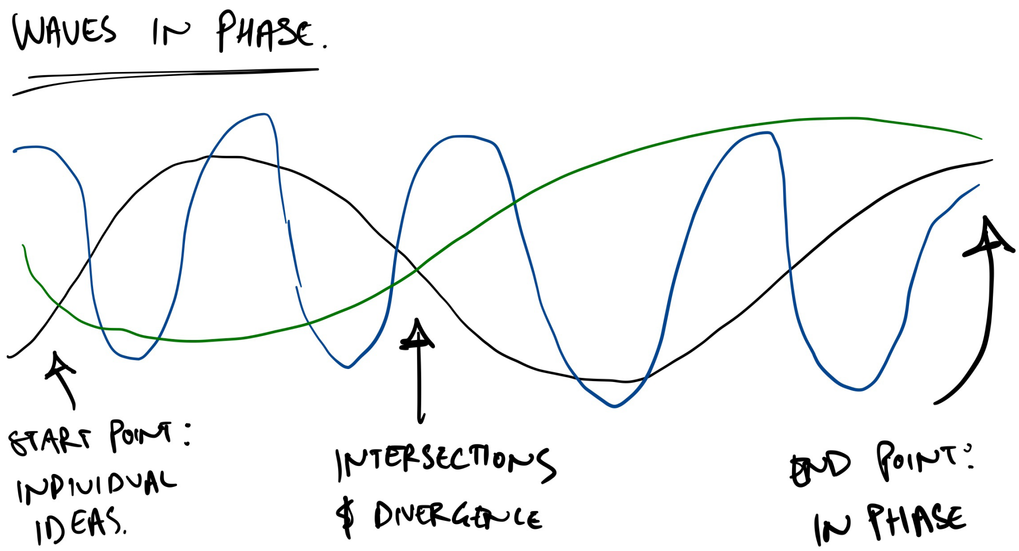

Figure 13. Waves in Phase: Depiction of methodological approach.

The scaffolds of both MDD and this research are laid out in a linear way for the purposes of publishing, yet it is important to note that these stages/phases are not expected to be followed in a sequential manner. “Rather, a simultaneous approach is preferred to create synergies and mutual nurturing” (Karana et al., 2015). As represented in the above waveform analogy, the practice of this thesis uses a back and forward motion between simultaneous research phases.

The three identified design phases are as follows:

PHASE 1 - MATERIAL UNDERSTANDING

The first step in understanding the material involved becoming familiar with the base material(s). New Zealand strong wool serves as the starting point for the MDD approach, so an understanding of this material was necessary. This phase develops a base knowledge of how Palliser Ridge strong wool behaves when processed by the researcher using different tools and methods.

PHASE 2 - THE COMPOSITE

Once an understanding of the base material was reached, new accompanying materials were added to create a composite. Each new material was introduced for its inherent characteristics and its potential contribution to the overall properties of the new composite materials. Each material introduction was experientially analysed for its benefits and shortfalls as a component of the composite.

PHASE 3 - FORM FINDING

From the findings gathered through the above stages of practice, exploring how the material may be formed became the final focus. This phase considered the mechanical characteristics of the materials in relation to malleability, strength, and rigidity. The forming of the materials takes inspiration from the natural shapes surrounding the fibre. Knowledge from the above stages informed ways to manipulate the material and explore potential forms.

DESIGN CRITERIA

A design criteria was established to explore which material experiments were taken forward. These decisions were made on a combination of the following benchmarks: ease of manufacturing, repeatability, the natural aesthetic and characteristics of the strong wool, and expected acoustic performance.

Design and sampling decisions were not entirely dictated by these criteria. It instead acted as an initial benchmark to quantify the success of a material experiment. A number of contextual and material specific aspects were mentioned in the individual discussions of each iteration. The aim was to consider each material and process in the wider holistic context of the project.

TOOLS AND TECHNOLOGIES

Tools and technologies were adopted as needed throughout the research practice. Materials informed the experiments and design decisions, and alongside those materials came a series of corresponding tools. The project did not set out to use a specific set of tools, technologies, and methods, but used the most appropriate tools that presented themselves in relation to materials and project direction. Much like the project's material ethos, the tools and technologies utilised were both accessible and low cost.

Traditional textile techniques were explored for the creation of a fabric surface during the initial material exploration phase. These techniques included weaving, plaiting, and smocking. Material melting through a double boiler, iron, and heat gun were used as means of integrating a number of additional molten materials. Both hand forming and vacuum bagging techniques were used to manipulate composite samples into desired shapes. Digital manufacturing tools of computer-aided design (CAD) softwares in combination with computer numerical control (CNC) routing machinery were also used in the shaping of the composite materials.

While the majority of tools and technologies were adopted along the course of the project, the main piece of technology used throughout the entirety of this research was the FeltLOOM® (Refer to figures 14, 15, and 16). The FeltLOOM® is an industrial needle felting machine capable of processing large-scale, multi-layer sheets of felted textile. This technology was selected as a foundation method of construction for its capability of mechanically interlocking a large range of fibres and fabrics without the need for additional adhesives. Donna Cleveland (2018) utilises the FeltLOOM® for reprocessing of waste textiles through her PhD research. The acquisition of the FeltLoom at AUT's Textile Design Lab was in direct correlation with the outcomes of Cleveland's research.

The significance of this particular tool is its similarities to what would be found in a commercial textiles manufacturing operation. Scaled down to a manageable size for a maker, the FeltLOOM® provides accessibility to a manufacturing technique typically kept behind the closed doors of a commercial operation. As mentioned in the literature, this access to tools and technologies is a core ethos of AUT's Textile Design Lab.

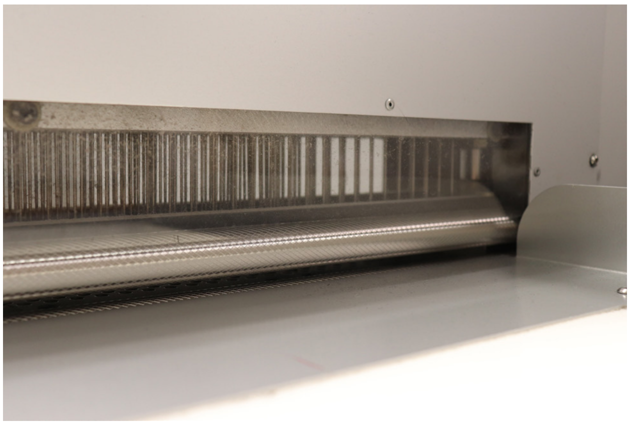

Figure 14. FeltLOOM® (Needles).

Figure 15. FeltLOOM® (Controls).

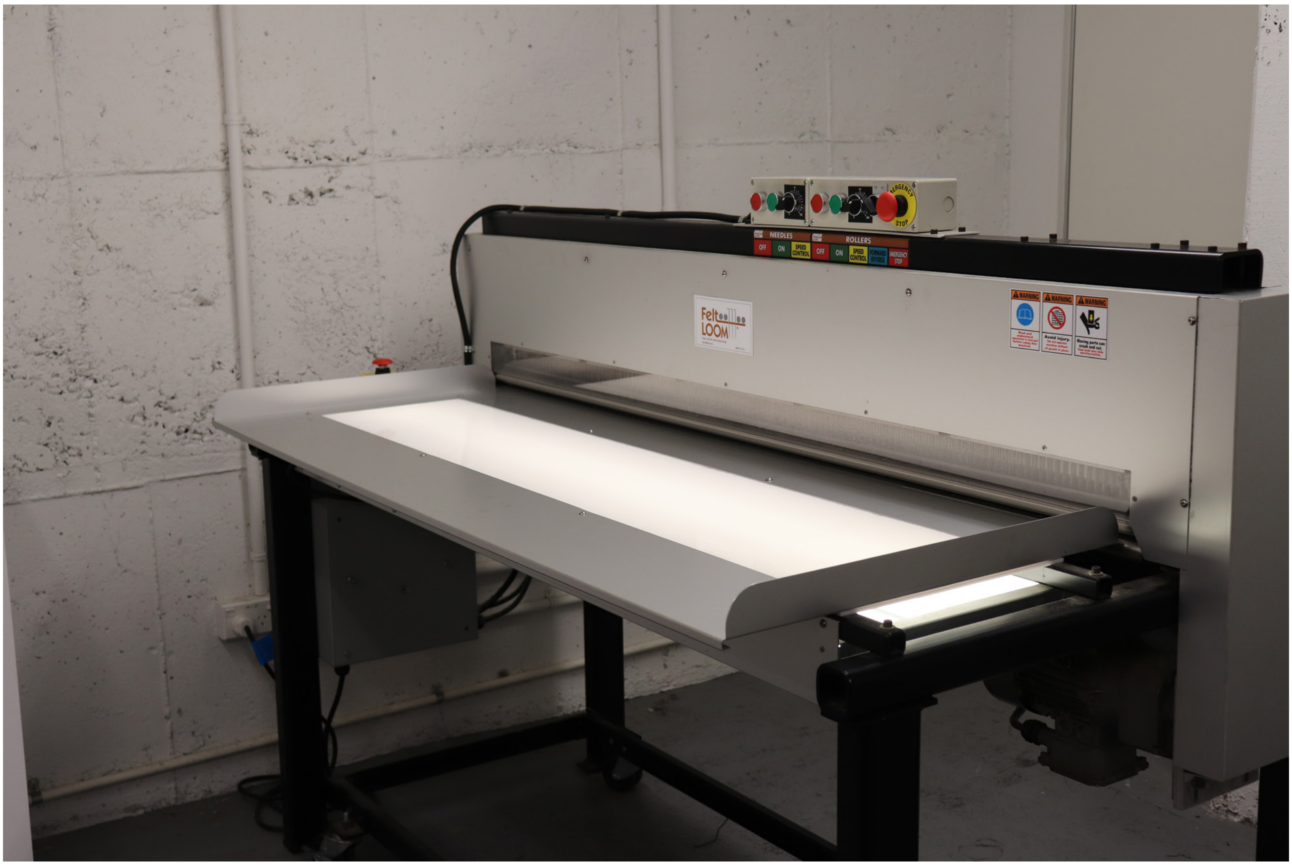

Figure 16. FeltLOOM® (Whole machine).

DOCUMENTATION AND REFLECTIVE PRACTICE

Samples and artifacts were documented by means of photography. Photography played a role in both reflection and documentation. The photography was consolidated through three main documentation methods; visual diary, mood board, and sample library. These three methods were used to complement each other, forming a symbiotic relationship between theoretical, tactile, and archival research knowledge.

A visual diary was used to sketch, design, and annotate material iterations throughout the experimenting and making process. Sketching was a key method used to both speculate future experiments and designs, and annotate and develop works in progress. Structuring a workbook in this way has been described as a ‘hybrid journal’. The combination of photographs, tangible design sketches, and handwritten annotations allows for a multimedia approach to the design process and reflective practice. Lau, Oehlberg, and Agogino (2009) observe that the hybrid journaling approach provides a greater representation of ideas in three dimensions instead of two (Lau et al., 2009). The visual diary was in digital form using an iPad and stylus. A digital workbook meant sketches and ideas may be easily rearranged, duplicated, and discarded as necessary. Abstracts of the draft workings were also able to be lifted from the digital workbook and developed further in more refined digital workspaces. Evan and Aldoy (2016) advocate for the creative freedom generated through sketching on a digital device. Their case study following a cohort of design students returned results suggesting greater confidence and a tendency to be more adventurous in design generations when sketching digitally (Evan & Aldoy, 2016). Figures 17 and 18 show examples of the hybrid journaling method used to document ideas and experiments around the technique of weaving.

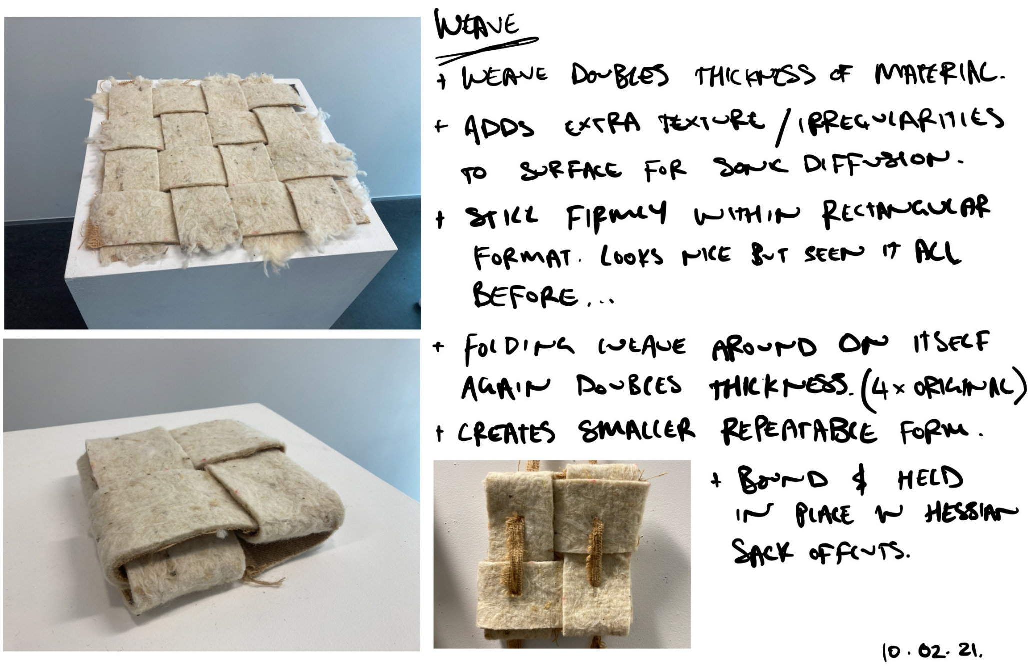

Figure 17. Visual diary (Annotations of experiments).

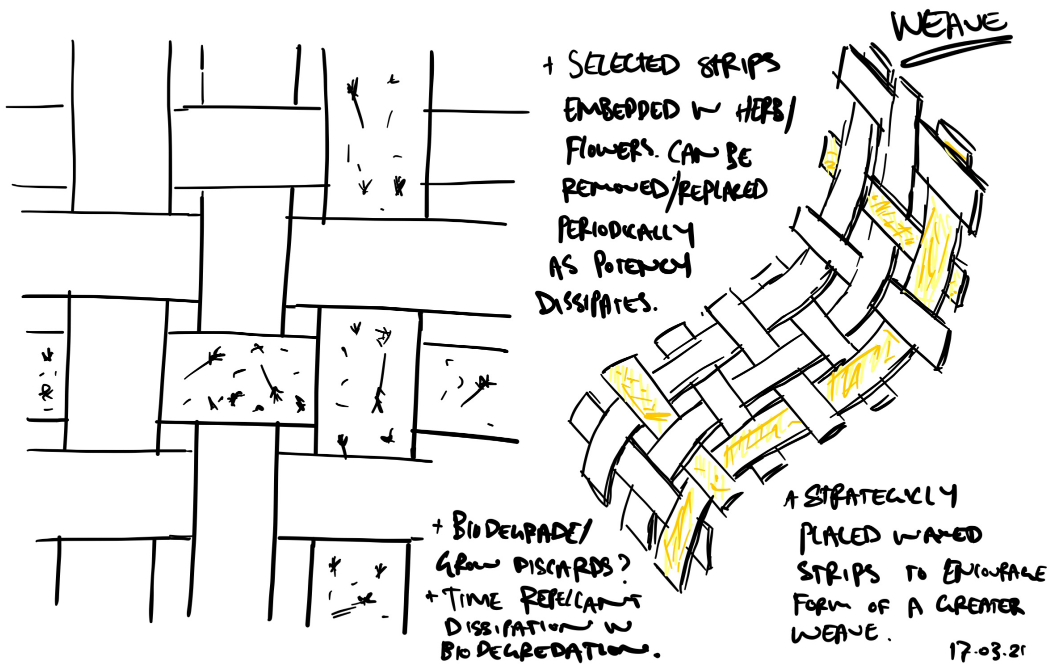

Figure 18. Visual diary (Concept sketches).

Supplementary to the visual diary, a pinboard or mood board was used as an ongoing visual representation of the development of the design process at any given time. The samples and resources on this board were manipulated and replaced as new iterations and experimentations were developed. The vertical surface was important as it provided a true representation of how a hanging sample looks and drapes when attached to a wall. Figure 19 shows the material experimentation at a central point in the research.

Information from the above documentation methods was further consolidated into a sample library. This library served as an archive for all physical material experimentations. Brief notes of material, method, and attributes were attached to each sample to provide an overview of all experimentations at a glance. Samples are referred to throughout the practice chapter. The sample library also offered a forum to assess the established design criteria and identify trends and trajectories within the making. For the full sample library see appendix A.

METHODOLOGY CONCLUSION

This mixed method approach was the most appropriate to the research inquiry with the strong wool being the focus. The project seeks to gain a holistic understanding of mechanical characteristics and possible processes involved in elevating and repurposing the fibre. The practice based, material driven approach highlights the importance of continued hands-on interaction with the material throughout the design process. These approaches suggest a sensorial interaction with the chosen materials may positively influence creative practice (Bergmann & de Magalhaes, 2018; Karana et al., 2015). Each identified design phase references this mixed method approach as the project follows the experimental and iterative motions. The outlined methods of documentation serve as continual reflective practice for the duration of the research.

Figure 19. Mood board.

CREATIVE PRACTICE 3

This chapter discusses and examines the making and practice of the research. The practice can be grouped into three key phases; Material Understanding, The Composite Material, and Form Finding. Each phase considered the potential of strong wool in relation to various design criteria. These phases are written about sequentially, yet it is important to note that many aspects of the practice were happening simultaneously. There was a considerable amount of crossover between phases as the project developed. This idea of a holistic or whole approach is discussed as being an important process of the Material Driven Design (MDD) framework (Karana, 2015). The chapter concludes with a final textile sample, developed from the material knowledge gained through the making and practice.

Figure 20. Acquiring materials. Foraging for herbs.

MATERIAL ACQUISITION

Basing all making around the strong wool fibre was an integral criteria in the design of this research. As the project progressed through various iterative stages, secondary materials were identified and utilised as accompanying mediums to the wool. These materials were selected for their mechanical and biological properties to aid in manufacturing, performance, and form. Secondary materials were discovered and adopted through a process of contextual and circumstantial inquiry. Exploring other usable natural materials that originate from Palliser Ridge farm was an ongoing consideration. Each additional material was considered for its biodegradability, abundance, access, and affordability. A series of tools and technologies were adopted throughout the practice as part of the material acquisition process. These tools and technologies are introduced according to the appropriate materials and phases.

PHASE 1: MATERIAL UNDERSTANDING

The introduction to this practice involved spending time processing, handling, and forming the core fibres involved in the research. With the main material being strong wool, it was important to understand exactly how this material responds when processed through the chosen tools. As discussed in the methodology chapter, the main tool used to process the wool was the FeltLOOM®, an industrial needle felting machine.

NEEDLE FELTING

All wool behaves differently depending on a range of factors including micron count, breed, scouring process, carding process, etc. This difference in behaviour is particularly evident when needle felting wool. A selection of samples were produced using Palliser Ridge wool to understand how this exact combination of environmental and manufacturing aspects contribute to the behaviour and characteristics of a resulting textile.

COFFEE SACKS

Hessian coffee sacks sit in a similar by-product category to strong wool. The excess of the fibre is a result of large scale agricultural practice. It had already been established through previous research that the wool fibre responds well when needle felted to hessian coffee sacks (Refer to appendix B). These experiments build off this knowledge, introducing the coffee sack byproduct into the making process from the start. The main motivation for incorporating hessian into the composite is to provide strength and rigidity in the textile. The following experimentation was done to establish how each format of wool would needle felt to the hessian sacking. Coffee sacks were provided by Coffee Supreme.

DAG WOOL

This particular section of the fleece is rejected by the greater industry for its inferior quality as it comes from the rear and underside of the sheep and normally has fecal matter attached. Despite its unlucky origins, this fibre still shares the porous qualities identified in the literature which make wool a desirable option for use in interior acoustics. This set of circumstances makes dag wool the perfect candidate as a base fibre for reintegration into a functional product. Scoured dag wool was provided by Palliser Ridge in a natural colour (Refer to figure 3).

CARDED WOOL

Carding is a process common to the wool and textiles industry. The carding process aligns the fibres of the wool into a uniform direction. The process also takes the wool from loose fleece to a usable batt, marketable by size or weight. The fibres come off the carding machine as a fine web which cumulates onto a rotating drum. When you take the fibres off the drum they have formed in a multilayered sheet (batt) of fibres. Batts of carded wool were provided by Palliser Ridge in both natural and dyed navy blue colour.

Figure 21. Fibre alignment teeth of the carding machine at Waione Carding.

NEEDLE FELTING DISCUSSION

All variations of wool needle felted exceptionally well to the hessian. Two layers of hessian plus a thick layer of wool proved the most manageable construction within the capabilities of the FeltLOOM® (Refer to figures 23 and 24). The undyed and dyed carded wool performed similarly through the FeltLOOM®. Both provide a uniform finish with a light surface texture (Refer to figures 22 and 23). The manageability of the uniform batts meant the wool could be easily layered to build up thickness in the textile (Refer to figure 22). The navy dyed samples create a slightly speckled visual as the felting needles push and pull individual fibres from the hessian through to the surface (refer to figure 23). Both the dyed and undyed felted materials have a ‘premium’ look and feel, reminiscent of commercial felt.

Comparatively, the dag wool was less manageable when fed through the FeltLOOM®. The dag wool is made up of clumped fibres as opposed to a uniform sheet or batt (Refer to figure 3). This meant more attention and encouragement was needed for the dag wool to compress evenly below the rollers of the FeltLOOM®. The clumps of wool also tended to get pushed around in the felting process creating uneven areas of thicker or thinner material. Once the dag wool was fed through the first time the fibres were compressed and interlocked enough to make each consecutive pass easy. On the second pass, it was important to patch up the thinner areas with extra handfuls of loose dag wool. The surface texture of these samples resembles the irregularity of the raw dag material. The material still looks ‘wooly’, and provides more of a tactile experience (Refer to figure 24 and 25).

The carded wool samples provide a premium and uniform finish, while the dag wool samples are irregular and wooly (Refer to figure 25). This irregularity and visual nod to the raw wool material aligns more closely with the aims of this creative practice. The aim is to showcase this byproduct material in a context of value to elevate its status from waste to desirable. The research does not wish to hide the origins of the material unnecessarily. It is also important to note that the manufacturing process of carding the wool uses resources. If the total manufacturing process is able to be minimised, the overall environmental impact of producing these materials may also be kept to a minimum. For these reasons, the dag wool and hessian felted samples were chosen as the preferred base textile to be taken forward into further material exploration.

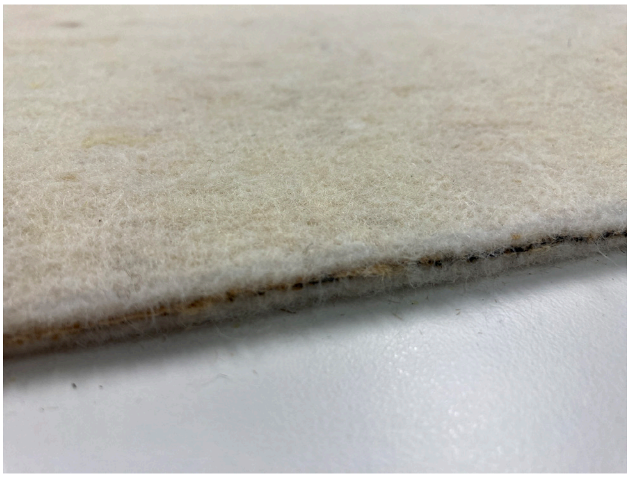

Figure 22. Needle felted carded wool and hessian (Natural colour).

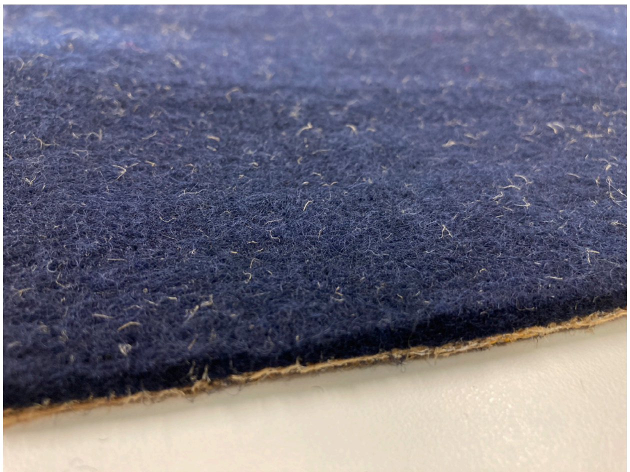

Figure 23. Needle felted carded wool and hessian (Navy dyed colour).

Figure 24. Needle felted dag wool and hessian (Natural colour).

Figure 25. Comparison of needle felted surface texture. Carded (left) and dag (right).

BASE TEXTILE CONSTRUCTION

Once an understanding of the raw component materials was reached, the need for material understanding now shifted onto the new base textile produced. The best combinations of wool and hessian were needle felted into large scale sheets to be cut and formed to establish material behaviour. The shape and size of the large-scale felted samples were determined by the existing dimensions of both the hessian coffee sacks and the FeltLOOM®. The thick seams of the coffee sacks were removed leaving a large single layer hessian sheet. This sheet was then re-folded in the opposite direction and processed through the felt loom with a thick layer of dag wool on top. The resulting textile was approximately 1400mm in length and 450mm in width. See figure 26 for a visual representation of this process. This size and shape provides ease of manufacturing when processing through the FeltLOOM®. The textile can pass through both lengthways and crossways, while remaining a manageable size when handling and arranging the loose fibres.

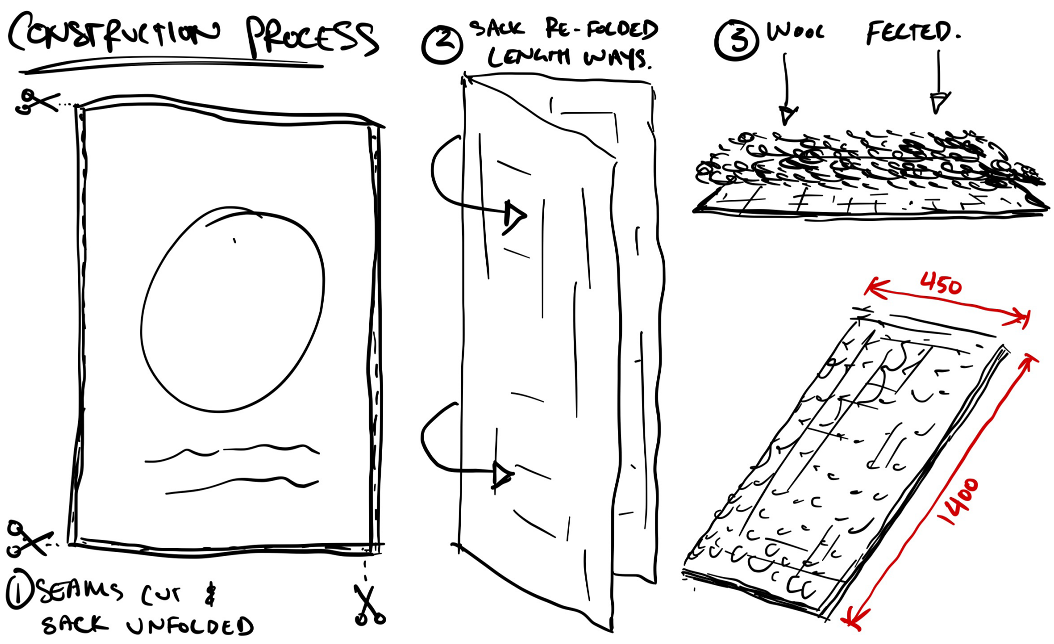

Figure 26. Base textile construction process.

Figure 27. Base textile (in rolls).

Figure 28. Base textile (hung).

TRADITIONAL TEXTILE TECHNIQUES

After the coffee sacks and wool had been laminated together. The main objective was to discover how this material may drape, form, and settle at scale when mounted on a wall or ceiling. A range of traditional textiles manufacturing techniques were used to form the material. Acoustic performance was kept in mind when arranging and forming the material.

WEAVING

A basic weave was produced using thick gauge strips of felted dag wool and hessian. Strips were cut to 450mm in length x 50mm in width and interlocked in a standard weft and warp formation. The motivation for the weave was to integrate the total surface of one layer of material to the other (Refer to figure 29).

PLAITING

A plait creates a thick woven strand from multiple smaller stands of an original material. Plaiting techniques were explored with a similar intention to the above weaving method, to integrate multiple layers of material into a singular surface. The sample in figure 30 is woven from a single piece of material with several strategically placed cuts. This technique is derived from ‘woggles’ used to secure a scarf around a scout’s neck. While scouting woggles are typically leather, the technique is transferable to a range of semi rigid materials.

SMOCKING

To achieve an exaggerated surface the crafting technique of smocking was used. Smoking uses inserted threads to pull a fabric into a desired form. Complex thread placement is often derived from a template. The pattern created in figure 31 is one of the most basic, single directional smocking templates. Offcuts from the seams of the coffee sacks were used in place of thread to match the heaviness and robust nature of the textile in use.

Figure 29. Weave.

Figure 30. Plait.

Figure 31. Smock.

TRADITIONAL TEXTILE TECHNIQUES DISCUSSION

Experiments using different textile techniques outlined above provided an understanding of how this laminated felted dag wool and hessian material drapes, folds, and twists. A large-gauge weave provides an opportunity to incorporate two layers of textile into a singular form, therefore, doubling the thickness, and in turn, the material's ability to absorb sound. Certain rigidity is lost from the original uncut sheet, yet this structural loss is negligible, and the material still holds its form when hung and can support its own weight. All of the techniques that were explored created dips and ridges in the surface texture. This variation in the surface is known as a desirable quality for diffraction of soundwaves (Baux, 2020). The forming nature of all of these techniques means the total wall-covered area of the material becomes smaller. This is particularly apparent with the weave and smock, providing 30-50% less wall coverage when formed. The plait technique, however, exhibits a minimal loss in wall coverage while still maintaining a good variation in surface texture. In all cases, the textile has a certain resistance to being folded, but once formed, gains some memory about the new form imposed on it. The textile prefers to be bent and folded in straight lines, yet will crease in irregular forms if given encouragement.

PHASE 1 CONCLUSION

This initial phase set out to grasp an understanding of the core materials contributing to the making. Through a process of 'tinkering' (Karana et al, 2015), the most appropriate combinations of materials and techniques were chosen to take forward into the following phases of practice. A thick layer of dag wool plus two layers of hessian was determined as the most appropriate use of the material due to ease of production, aesthetic, and further textile manipulation possibilities. Though this material combination was identified as the preferred format, findings from the greater phase influence the following areas of making. Each technique of textile manipulation exhibited different attributes when considering both structure and acoustic performance. While emphasised in this phase of the practice, tinkering exists throughout the making as a core approach. Material learning and understanding continues to progress for the entirety of the practice.

PHASE 2: THE COMPOSITE

A composite is created when two or more materials are combined to form a new material in its own right (Masuelli, 2013). A composite is generally created when the performance of a standalone material does not fit the intended use. The combined components often have significantly different characteristics which remain distinct within the resulting material (Masuelli, 2013). This phase builds off preliminary findings from the previous phase to introduce further materials. The experiments within this phase use felted wool and hessian as base materials for several new textile composites. Each of the new component materials are introduced to improve both performance and appearance of the base textile material.

THE MOTH PROBLEM

On a research trip to Waione Carding, a wool processing facility used by Palliser Ridge, the research was challenged on how it might combat the destructive nature of moths on interior wool panels (personal communication, Watson & Clarkson, November 5, 2020). This was an issue that was not yet known to the research as something that needed to be dealt with when designing interior textile furnishings for long term use. This inspired a need to integrate additional materials into the textile to act as a deterrent for insects.

HERBAL REPELLENTS

Household folklore suggests the use of scented herbs and flowers to ward off the unwanted moth intruders. Moth balls and scented bags are commonplace in domestic clothes drawers and linen cupboards. The contents of these products often contain plants or plant extracts with naturally occurring insect deterrent or repellent chemicals. Lavender and rosemary are two herbal plants which emit a scent to deter a broad range of insects. Both lavender and rosemary derived essential oils are documented as having repellent characteristics towards moths and other insects (Badreddine et al., 2015; Udakhe et al., 2014).

Lavender and rosemary clippings were collected (Refer to figure 32). The clippings were cut up and dispersed evenly across felted wool and hessian textile samples (Refer to figure 33 and 35). The flowers, leaves, and stems themselves are not fibrous enough to interlock with the wool and hessian in the felting process. A thin layer of carded wool was applied over top of the lavender, then passed through the FeltLoom®. This held the lavender in place while still allowing the form and limited colour from the flower to be visible on the surface.


Figure 32. Collected lavender and rosemary.


Figure 33. Dispersing herbs and wool for felting (small).


Figure 34. Felted herbs (whole lavender).

Figure 35. Dispersing herbs for felting (large).

Figure 36. Felted textile with herbs.

HERBAL REPELLENTS DISCUSSION

Both lavender and rosemary hold securely in the textile when felted. The thin layer of carded wool covers the plant matter enough to hold it in place, yet still allows silhouettes of the flowers and leaves to show through to the surface as seen in figures 34 and 36. The smell of both lavender and rosemary is very present in the freshly felted sample. Over time, this smell faded as the textile hung. The smell of the wool is also still present, and slowly overpowers the herbal smell as the plants dry further. It is unknown exactly how long the lavender and rosemary might keep their repellent qualities when combined in this way with the wool and hessian. This may depend on a range of environmental factors of where the textile is situated.

A unique visual was created as a result of the randomly distributed plant matter. As seen in figure 34, whole flower forms are also visible when an entire flower is felted in place. These visuals begin to take the textile towards a distinct botanical aesthetic. The samples chosen to be taken forward into larger felted textiles were ones with more deconstructed flower forms. It was determined that a whole flower form was not appropriate to the context of the project. This floral aesthetic may be something that an individual may want to incorporate if it suited the context of the space they were to be installed in.

Long term it is predicted that the additional plant matter may aid the biodegradation when the composite is disposed of. Seeds from the plant matter may remain active within a certain timeframe to be germinated through planting in soil. This could allude to a system in which these composite materials are only used indoors temporarily, with the intention of them being used as nutrients for plant life in the second iteration of their useful life. Exploring the biodegradation and germination capabilities of the new composites was outside of the scope of this research. Further inquiry in this area would benefit future research.

BEESWAX

Beeswax is a natural, heat activated polymer which can exist in both liquid and solid states. The combination of beeswax and textiles was first introduced to this practice via an adjacent summer research project supervised by Dr. Clinton Watkins. The beeswax was used as a component for experimental textile surface design in an investigation of tactility in relation to audio (Refer to figures 38, 39, and 40). The findings from this project influenced the following experimentation. Beeswax is also another organic material which is produced on the Palliser Ridge farm. A series of samples were produced to explore how beeswax may interact with the felted wool and other materials

Pure beeswax was grated into shavings and dispersed over a small sample of the base dag wool and hessian felted textile (Refer to figure 41). Figures 41 and 42 show both a heat gun, and an oven set to 80°C being used as methods of melting the wax into the textile. Melting the wax onto both the wool and the hessian side of the textile was trialed. Sheets were laminated to explore the capabilities of using wax as a bonding medium.

Figure 37. Beeswax 1kg block.

Figure 38. Wool knit and beeswax.

Figure 39. Woven textile and beeswax.

Figure 40. Woven textile and beeswax (Close-up).

Figure 41. Melting beeswax into textile via oven.

Figure 42. Melting beeswax into textile via heat gun.

Figure 43. Textile laminated with beeswax.

Figure 44. Beeswax clumping on wool side of textile.

Figure 45. Closeup of beeswax melted into hessian side of textile.

Figure 46. Grated beeswax on hessian (Close up).

BEESWAX DISCUSSION

Initial samples of melting pure beeswax into the felted textile yielded mixed results. The wool fibre resisted absorbing the molten wax. The wax appeared to fill the gaps between the fibres, as opposed to absorbing into the fibre itself (Refer to figure 44). Despite this, the added wax gives the textile a significant rigidity over the original unwaxed textile. The multi layered sample was held together with the cured wax as seen in figure 43, yet came apart with minimal force. Upon turning the wool/hessian textile over and melting wax through from the hessian underside of the material, the wax absorption and dispersion patterns changed radically. The hessian fibre is significantly more porous than wool, and readily absorbs the molten wax. The molten wax disperses evenly as it melts through the hessian (Refer to figure 45). Most importantly in these staples, the wool on the 'topside' of the textile remains relatively untouched by the wax. Once cured, the wax turns the hessian into a rigid shell, while the wool retains its soft, 'wooly' texture. This surface texture is what originally positioned wool as a candidate for use in interior acoustic products. Findings from this series of experiments positioned beeswax as a core component for structure and rigidity in the textile design.

DAMAR RESIN

Once beeswax was established as a workable material within the context of this project, additional materials were investigated for their ability to enhance the natural characteristics of the wax. Beeswax had been identified as capable of increasing the rigidity of the hessian/wool, yet lacked some qualities necessary for stability and longevity. Beeswax begins to deform around 40°C, and becomes molten shortly after 60°C. While ambient room temperatures would not often reach this high, hotter climates and direct sunlight may cause deformation.

Damar resin is a core export from a number of South East Asian countries including Malaysia and Indonesia (Eugenia, n.d). Damar resin is a non-destructive crop, and often contributes to diversification in horticultural practices. The trees are grown in ‘agroforests’, where a number of crops including rice, coffee, and fruit trees grow in mutual dependence (Sukandi, 1997). Being a naturally occurring substance, the resin is biodegradable. These sustainable attributes position damar resin as an acceptable material for use within this research (Refer to figure 47 for image of damar resin).

The use of damar resin as a stabiliser for beeswax is an ancient technique borrowed from encaustic painting (wax painting). Encaustic medium is typically a mixture of white refined beeswax, tree resin, and pigment. For the purposes of this research, clarity and pigment were not required. The properties of this medium that was of interest was the increased hardness and melting temperature over pure beeswax (Eugenia, n.d).

Figure 47. Damar resin.

Sample blocks of beeswax and damar resin were produced. Beeswax and damar resin was melted together via a double boiler to maintain stable temperature and avoid burning the wax (Refer to figure 48). Ratios of 4:1 and 8:1 wax:resin were produced as recommended by encaustic painting practitioners (Eugenia, n.d.; Noblin, 2014). Samples were formed into 100g blocks for ease of use (Refer to figure 49).

Once cured, these blocks were grated and dispersed as seen above. Additional methods of heat transfer were adopted alongside the incorporation of damar resin. Both a heat gun and iron were used as handheld methods for melting the wax/resin blend. At this point, it was established that the hessian underside of the textile was the most successful receiving surface for molten materials. Mixtures of 4:1 and 8:1 were trialed on the base dag wool/hessian textile.

Figure 48. Combining beeswax and damar resin in a double boiler.

FIgure 49. Beeswax and damar resin (100g blocks).

Figure 50. Beeswax and damar resin (grated).

Figure 51. Ironing beeswax and damar resin into textile

DAMAR RESIN DISCUSSION

When comparing samples incorporating damar resin there is a noticeable increase in strength and hardness over pure beeswax. The resin also provides better workability in the wax, as the wax/resin blend appears to stay molten at a greater temperature range. Samples using a 4:1 ratio of wax:resin have a greater hardness over those with an 8:1 ratio. These findings are consistent with the recommendations from encaustic practitioners (Eugenia, n.d.; Noblin 2014).

The use of an iron shown in figure 51 provides a more consistent tool for melting the wax/resin blend into the textile. There is less risk of burning both wax and textile when using this method over a heat gun. The iron method melts the wax/resin from a smaller heat source, differing from the previously used oven method which creates a whole heated environment. The oven method has the ability to evenly melt an entire mass of material at once and keep the molten mixture at a stable temperature. Its main shortfall, however, is that the textile sample size is limited to the internal dimensions of a domestic oven. Use of an iron increases the potential size of the workable material, but only to a certain extent. The wax begins to cool as soon as the iron is moved to a different section of the textile. This creates a constant juggle between heat and time in an attempt to bring the whole mass of wax up to temperature.

The iron works in favour of the overall outcome of the composite as it only melts the wax into the immediate surface of the textile. Where an oven evenly heats all materials, the iron only heats the wax/resin blend and the hessian surface directly below it. By the time the wax melts through the hessian and reaches the wool layer, the internal temperature of the textile is lower than the surface temperature of the iron. This is believed to help the wax/resin stay in the hessian layer with little to no bleed through to the wool surface, as the molten material cures as it passes through the textile. The natural hydrophobic qualities of wool are also thought to be aiding this method. The result is a rigid shell-like construction which retains the ‘wooly’ surface texture of the original felted textile.

The bond observed on the samples produced can be described as “mechanical interlocking” (Eugenia, n.d). The molten medium melts over the textile and sets to form an interlocking pattern. Most importantly, mechanical interlocking forms higher resilience to thermal stress, “preventing any accidental fractures and splinting during extreme weather conditions and thus increasing encaustic durability” (Eugenia, n.d).

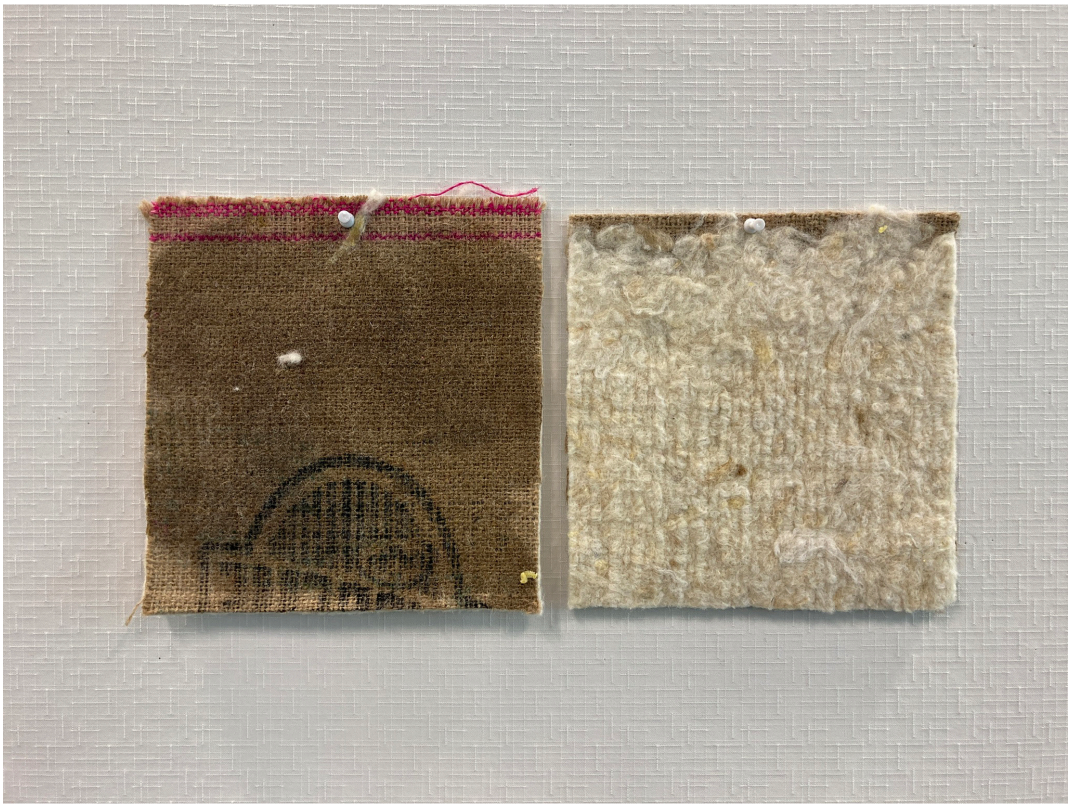

Figure 52. Felted dag wool and hessian with beeswax and damar resin (ironed in).

PHASE 2 CONCLUSION

This phase explored how a base wool textile would respond when combined with additional materials. Extra material components were carefully selected for their natural qualities, availability, and relationship to the context of this project. Each experiment provided new insight into the characteristics of strong wool and its willingness to coexist with other materials in a single composite. Further experiments involving water soluble polymers were conducted yet discontinued for their production restrictions with the tools available. Refer to samples 23-28 in appendix A for water soluble polymer experiments. ‘Tinkering’ and ‘playtyping’ remained as core approaches to handling and manipulating the materials. The new behaviours observed in these composites, in addition to the findings from the initial phase, influence the experiments in the following phase.

PHASE 3: FORM FINDING

The above sections covered a range of material experiments resulting in a series of textile samples exhibiting unique characteristics. Phase one established a base material and investigated how it may drape and be arranged. A key finding from the phase two composite experiments was the use of beeswax and tree resins as structural mediums. This section brings together these and other findings from earlier phases to explore 3-dimensional forms in textile surface design.

Inspiration for form came from the mimicry of structures and shapes appropriate to the context of the materials used. A number of forms were explored for their suspected acoustic qualities and contribution to the material narrative.

MICRO SHAPES

AUT's scanning electron microscope (SEM) was employed to observe the structure of the individual fibres of the supplied strong wool. This exercise links back to motivations of material understanding, furthering the understanding of wool as a base material. The surface of the wool fibres can be seen in figure 53 to have an intricate pattern of interlocking scales. The irregularity and overlapping nature of these scales were suspected to have desirable acoustic characteristics when enlarged to macro size. A trace sketch was taken from the captured SEM images to refine the structure down to its basic shape (Refer to figure 54). From these sketches, the microstructure was able to be mimicked with physical materials and an analogue mode of making.

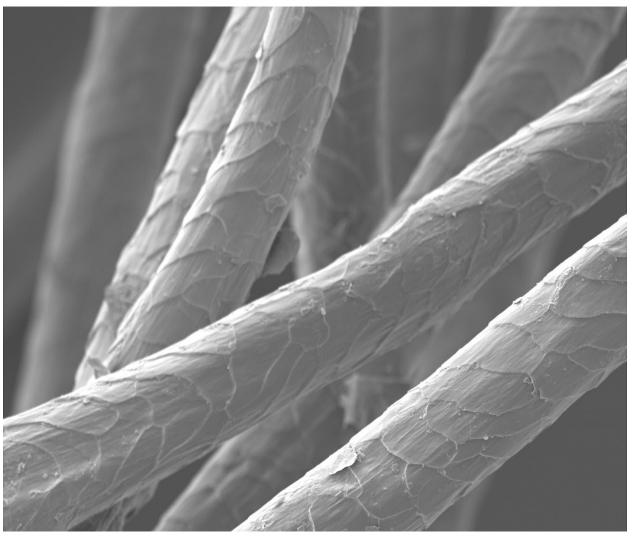

Figure 53. Strong wool under SEM.

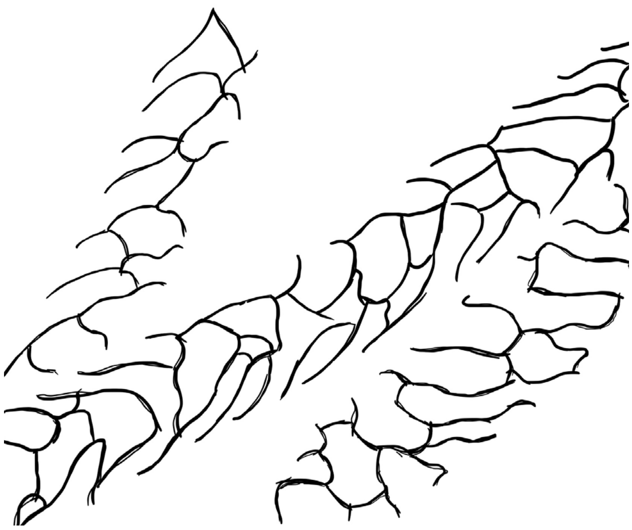

Figure 54. Trace of strong wool under SEM.

A variety of materials and techniques were used to mimic the form of the scaled wool fibre. The scaled forms were initially cut and arranged in cardboard to see how scale-like shapes may overlap in a material of a similar thickness to the base textile (Refer to figure 55). This exercise was also to determine how a scaled surface may be created from a larger single textile sheet. Felted offcuts from previous sampling were used as individual scales to collage a wool and hessian rendition of the microscopic structure (Refer to figure 57). A punch needle and Palliser Ridge yarn was used to construct a simplified 2-dimensional form using the hessian weave as the base textile (Refer to figure 56). 3-dimensional forms emerged as stylised depictions of the wool fibre, with angled sections of cut textile representing the individual scales (Refer to figure 58).

Figure 55. Carboard depiction of strong wool under SEM.

Figure 56. Yarn on hessian with punch needle. Depiction of strong wool under SEM.

Figure 57. Felted collage of textile offcuts. Depiction of strong wool under SEM.

Figure 58. Textile strips arranged into scales. Depiction of strong wool under SEM.

MICRO SHAPES DISCUSSION

These experimentations exist as abstracted representations of the microscopic wool structure. The purpose of this exercise was to draw inspiration in shape, form, and aesthetic for a stylised textile surface. Each of the samples provide a different surface texture, and in turn, a slightly different acoustic performance. Many of these samples found their way to the mood board mentioned in the methodology chapter to inform further shaping experiments.

The 3-dimensional forms seen in figure 58 inspired by the wool fibre structure question the appropriate form for an acoustic artefact. This project refers to a future acoustic 'panel' design being informed by the experiments and materials in this research. The word 'panel' has a certain connotation and expected shape, often square and flat. These particular samples help to broaden the scope of what a panel could be within the context of this research.

WASTE SHAPES

The base fibres used in this research originate from either a waste or by-product status. This creative practice follows a narrative of waste appreciation, and comments on the subjective nature of defining a material to have waste or by-product status. In keeping with this theme, the irregular physical appearance of waste and discarded materials was employed as an inspiration for textile form. Offcuts from the shearing shed floor were photographed on a field trip to the Palliser Ridge farm (see figure 59). The way in which the raw fibres fall produces an irregular surface, expected to be desirable for acoustic performance.

Figure 59. Offcut dag wool.

Figure 60. Textile and beeswax (Thin layer of carded wool, single layer of hessian).

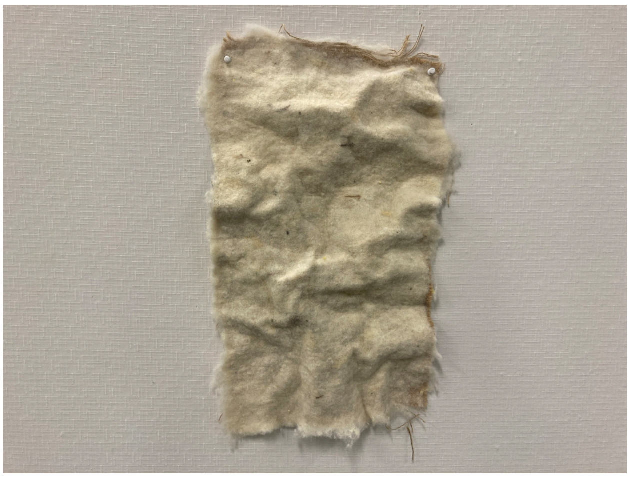

Figure 61. Textile and beeswax (Thick layer of carded wool, single layer of hessian).

Figure 62. Textile and beeswax (Thin layer of dag wool, single layer of hessian).

Figure 63. Textile and beeswax (Thick layer of dag wool, double layer of hessian).

To achieve this irregular form, irregular methods were explored. Both pure beeswax and wax/resin blends were melted into variations of the base textile using methods from earlier experimentations. To achieve a 3-dimensional form, the textile composite was scrunched into a ball immediately after the wax/resin was applied. This ball was maintained for a moment to give the wax a chance to partially set yet still remain malleable. The ball was then released to the point where the four corners of the textile were able to lie flat on a surface. The creases and folds of the textile remained to form a network of raised areas. The sample was left to set in this form. After a few minutes, the formed textile took on the properties of a hardened shell. This process was repeated with a variety of wool/ hessian layers and thicknesses.

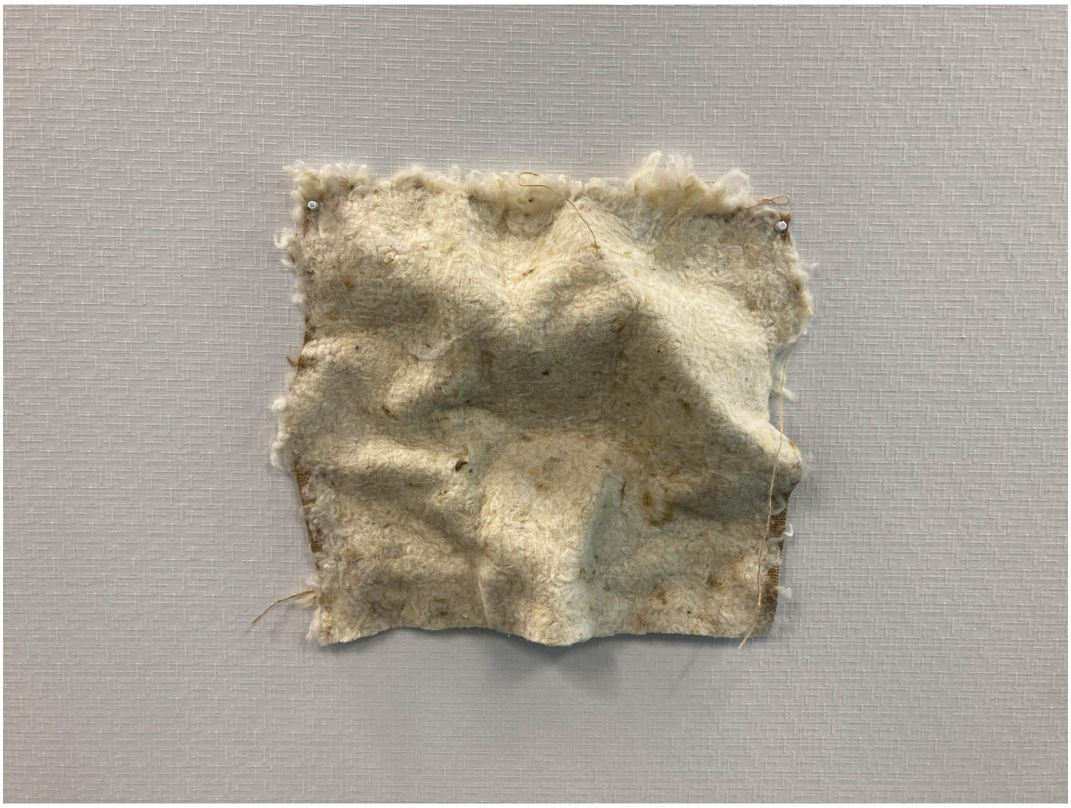

Figure 64. Hand formed wool, hessian, beeswax, and damar resin (Dag wool).

Figure 65. Hand formed wool, hessian, beeswax, and damar resin (Carded wool, dyed navy blue).

WASTE SHAPES DISCUSSION

Each sample exhibited different structural characteristics depending on differing wool, hessian, wax, and resin combinations. All samples were able to self-support their new form when hung vertically. The textiles with a single layer of hessian and less wool were able to hold a more defined crease. This appears as a higher fidelity form compared to those created using double layer hessian construction and more wool. The level of fidelity can be seen moving through figures 60-63. The thicker construction samples, however, have the ability to absorb a greater amount of wax, resulting in a stronger overall composite. Differences in fidelity can also be seen between samples using carded wool and dag wool. Samples formed using a blend of beeswax and damar resin result in a further strengthened and hardened final form, while samples using pure beeswax remain somewhat malleable. The panels incorporating damar resin seen in figures 64 and 65 feel less likely to deform from body heat when handled due to the increased melting temperature the resin provides.

When left hanging for a number of weeks the textiles formed with pure beeswax decreased in rigidity. It is known that the properties of beeswax change due to a number of factors including both heat and age (Eugenia, n.d). Each time beeswax is heated to molten form, it goes through a process of recrystallization as it cools. This process may not be fully completed for a number of months (Eugenia, n.d). As the samples are handled, it also appears that small stress fractures occur in the wax when areas are fatigued. The presence of damar resin appears to both stabilise the changing wax and help strengthen these points of fatigue. However, the panels incorporating the resin still seem to suffer from a lesser version of the same handling and fatigue issue. When inspecting the samples incorporating damar resin one month after forming, there is a noticeable increase in hardness. The panels now took considerable force to deform by hand. After this period of time the panel is no longer considered fragile. This curing process will need to be taken into consideration when establishing total production time for the material.

The forms created through this method align closer with the narrative of the research outlined in earlier chapters. These moulded surfaces seek to capture the beauty in the irregularity of discarded material. Through highlighting these forms and presenting them as artefacts of value, perceptions of waste surrounding the material may start to shift. It is these biographical insights into the origins of the material that may assist to elevate and revalue the fibre (Payne & Bonitto, 2017).

TERRAIN CAD (COMPUTER-AIDED DESIGN)

Through the process of mimicking the waste fibre form, the moulded panels began to resemble topographic landscapes. Palliser Ridge is located in the South Wairarapa of New Zealand's North Island, a region known for its mountain ranges and rugged landscapes. This topographic resemblance became an equally appropriate form for the panels, giving a subtle nod to the geographic origin of the core strong wool fibre. While the initial hand-formed panels held a resemblance to the Wairarapa landscape, a true representation of the landscape was desirable to further the narrative of location. Figure 66 shows a screen capture of terrain from Palliser Ridge accessed through Google Earth (2021).

Terrain data from Aorangi Forest Park, a regional park neighbouring Palliser Ridge was captured through the online service Terrain2STL (2021). This tool generates a Standard Tessellation Language (STL) file of a chosen section of terrain anywhere in the world. Once downloaded, the STL file was imported into Blender, a 3-dimensional computer graphics software (2021), to be scaled and formatted correctly (Refer to figure 67). From Blender, the terrain was exported as an object (OBJ) mesh file and imported into Fusion 360, a software architecture for digital fabrication (2021). A solid object was constructed from the mesh as seen in figure 68. This process was derived from the YouTube tutorial *3D Terrain Carving CNC Step-By-Step Guide* (BG Precision, 2020).

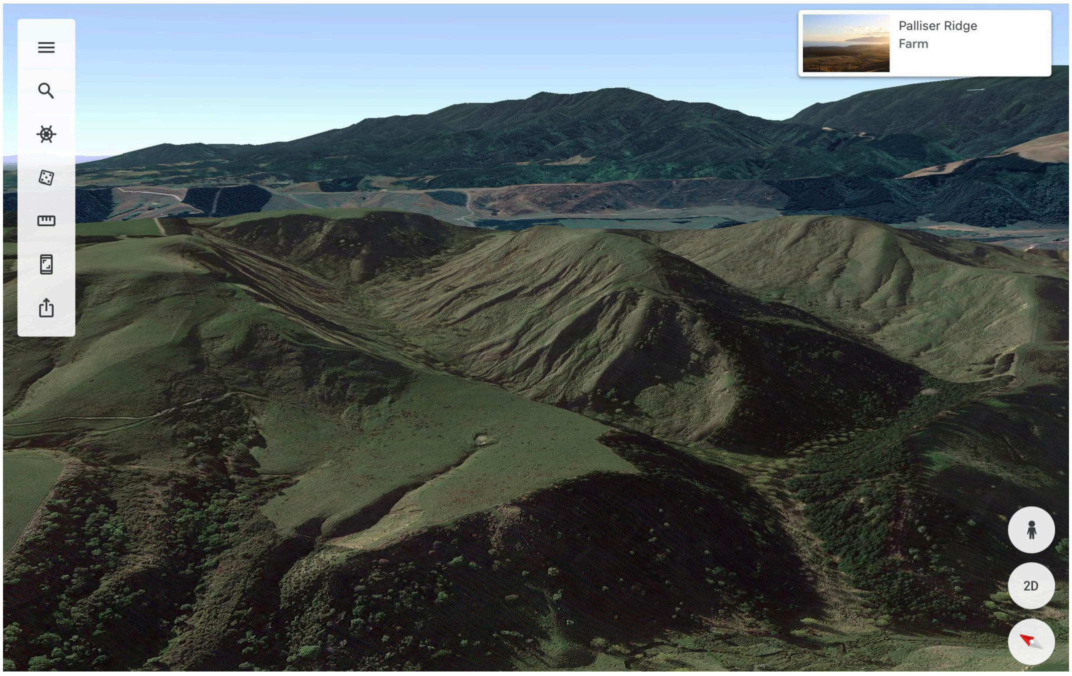

Figure 66. Screen capture of Palliser Ridge.

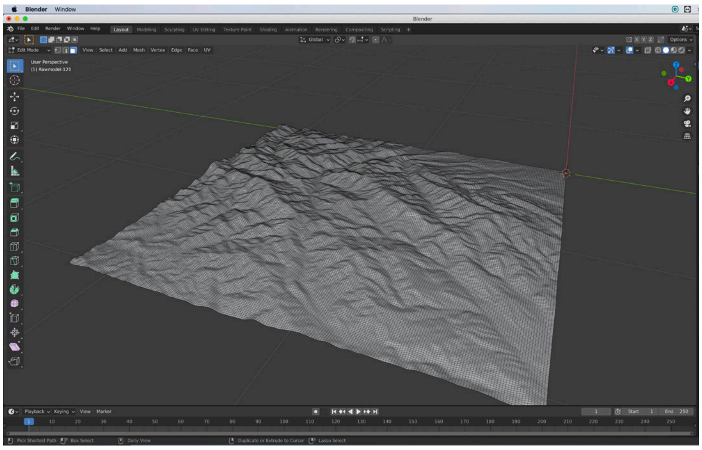

Figure 67. Terrain in Blender.

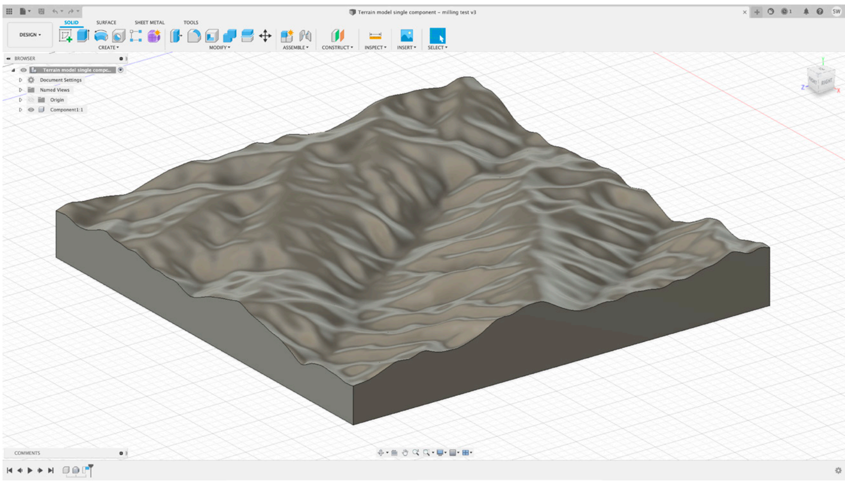

Figure 68. Terrain in Fusion 360. Final CNC cut file.

TERRAIN CAD DISCUSSION

The actual terrain of the farm proved too flat for creating a detailed mould. The forms in the terrain needed to be large enough to transfer onto the intended wool textile when moulded. The desire for a more dramatic and variable landscape meant the search area of topographic data needed to be widened. While not of the farm, the chosen section(s) of terrain pays homage to the region of South Wairarapa where the material originates.

One of the material gathering strategies used throughout the making process has been considering what materials exist on the farm. When it came to exploring form in the materials, the farm was looked to again for inspiration. The topographical data derived from the farm and surrounding region can be seen as another contributing material. This data was foraged from a digital environment much like the lavender and rosemary used in previous sampling was foraged from physical surroundings.

CNC (COMPUTER NUMERICAL CONTROL)

Translating the digital 3-dimensional file into physical material was the next stage in working towards a mould. CNC routing was used as a tool to cut down a stock material into the appropriate form.

The form of the finished panel is intended to be as close to the original terrain shape as possible. To achieve this the top side of the textile was to be formed against a mould. As the top side was the point of contact, the mould needed to be the negative of the true form of the terrain. A Fusion 360 file was generated to capture the negative form of the downloaded terrain data (Refer to figure 68).

Medium density fibreboard (MDF) was chosen as the stock material. Three sections of 18mm MDF were laminated together using Polyvinyl Acetate (PVA) glue to produce a 56mm total stock height. A smaller section of the larger model was chosen as a trial section to be machined, approximately 1/9 of the full size (Refer to figure 69). Both rough and smooth finishes were machined into the model as seen in figure 70 to determine the level of fidelity needed for a successful mould.

The small section model was used as a test subject for the machine settings needed to cut the model. The knowledge gained through this process was then applied to a full size, 450x450mm model to be used for the final mould (refer to figures 71, 72, and 73). This was cut from the same stock thickness, making sure the depth of cut was maximised within the specified stock.

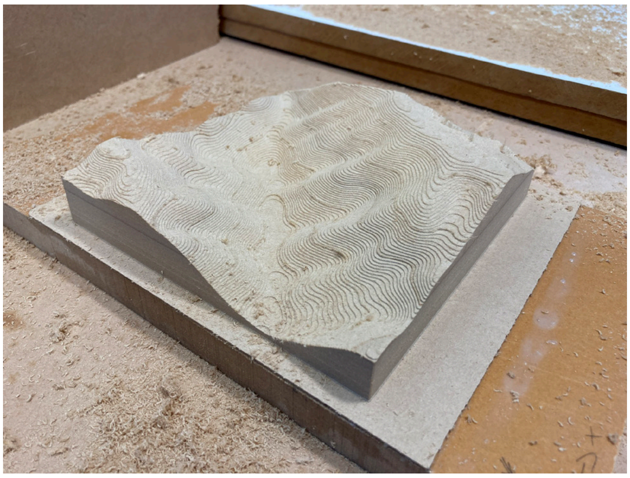
Figure 69. Small topographic model (During CNC cut).


Figure 70. Small topographic model (Varied surface finish).

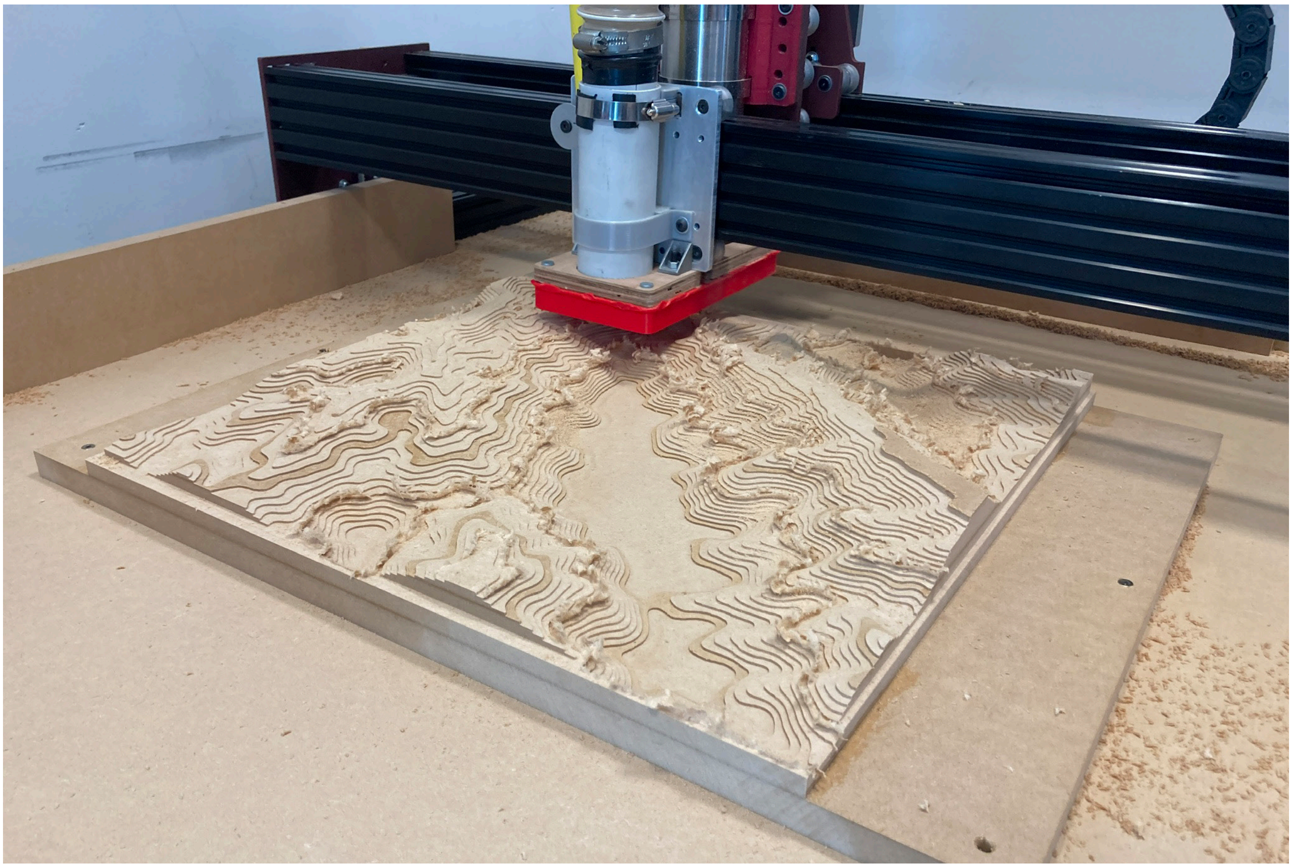
Figure 71. Large topographic model (During CNC cut).

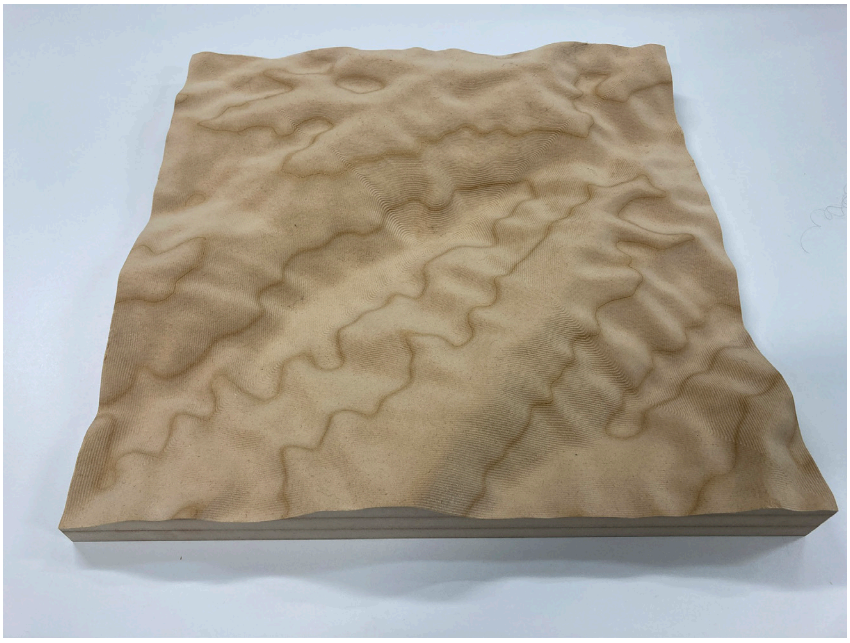

Figure 72. Large topographic model (Unsealed).

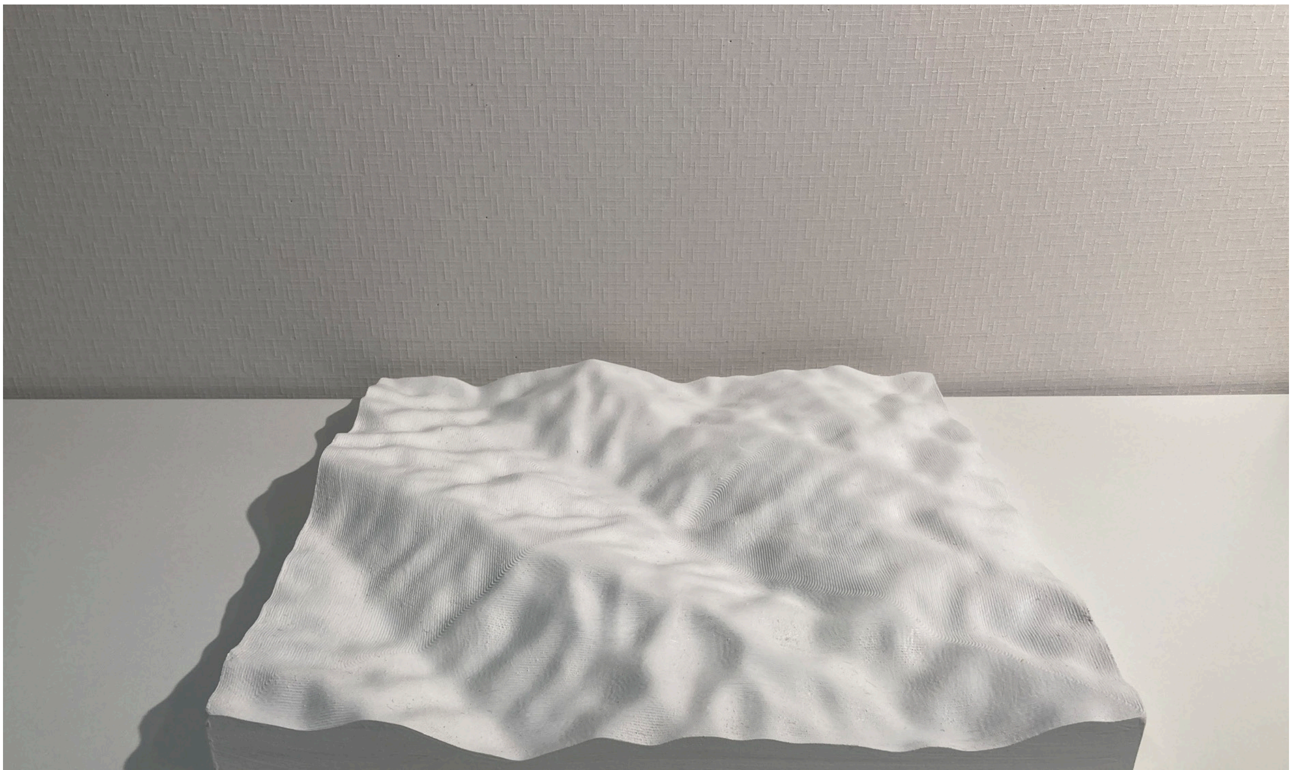

Figure 73. Large topographic model (Sealed).

CNC DISCUSSION

Capturing the geographic data and translating it to a physical model provided an intimate knowledge of the topography of the farm and surrounding areas. The design process involved inspecting large areas of terrain to determine the best sections for textile moulding. This meant the landscape of and around the farm inherently became very familiar.

MDF was chosen as a material for its abundance, machinability. and price. While health and sustainability concerns are known, the material was selected in the interest of time. The composite nature of the wood/glue construction means this material is neither sustainably sourced nor biodegradable. Unfortunately, there are very few options for uniform material stock when using subtractive manufacturing methods such as CNC routing for a detailed model. The decision to use MDF is justified as the resulting model is considered to be a tool. It provides a method of processing the by-product materials into a functional artefact. The intention would be to only produce a small number of these models to be reused many times. Future developments may also look to more sustainable materials for mould making.

For the intended purpose, the models were successful. The initial small scale model provided a low risk forum to test variables of CNC routing including appropriate tool paths, spindle speeds, feed speeds, and tooling specific to this material and cut. The presence of moisture in the following experimentation prompted the need to seal the MDF to limit moisture damage and swelling of the mould (Refer to figure 73). A future design of the mould may be cut from a more moisture resistant material.

VACUUM MOULDING

Forming the composite textile over the above mould was the last iteration in the form finding phase. All experimentation through CNC and digital manufacturing was working towards an imprintable topography form intended to be impressed into the textile and polymer structure.

The tool of choice for pressing the textile into the mould was a vacuum bag. A conventional two part mould was explored, yet this method would require double the material and time to model, program, and cut a corresponding side. Vacuum bagging was chosen for its accessibility, low cost, and versatility for moulding irregular forms. A heavy duty plastic bag originally intended for construction was purchased online. This, paired with a standard domestic vacuum cleaner formed the basic components for vacuum bag moulding.

To test the chosen tools a small scale sample was waxed and moulded. This was done using the original smaller test model plus a small 150x150mm base textile sample. A wax/resin blend was applied to the sample using the iron-on method shown earlier. Once melted and absorbed, the sample was positioned face down on the mould and placed in the vacuum bag as seen in figure 74. Duct tape was used to seal the opening of the bag to a table leaving a small opening for the vacuum cleaner to be inserted. The vacuum cleaner was switched on for a period of approximately 5 minutes until the wax/resin had cooled and set enough to hold a rigid structure. Once removed from the bag (Refer to figure 75) the sample was left to cure for a further 30 minutes before handling.

Figure 74. Small textile sample and topographic model (In vacuum bag).

Figure 75. Small textile sample and topographic model (Removed from vacuum bag).

The success of the small scale mould experiment gave confidence to repeat the process on the larger scale topographic model. A 450x450mm section of navy dyed wool/hessian felt was combined with wax/resin and placed in the vacuum bag with the full size mould using the same method as above (Refer to figure 76 and 77).

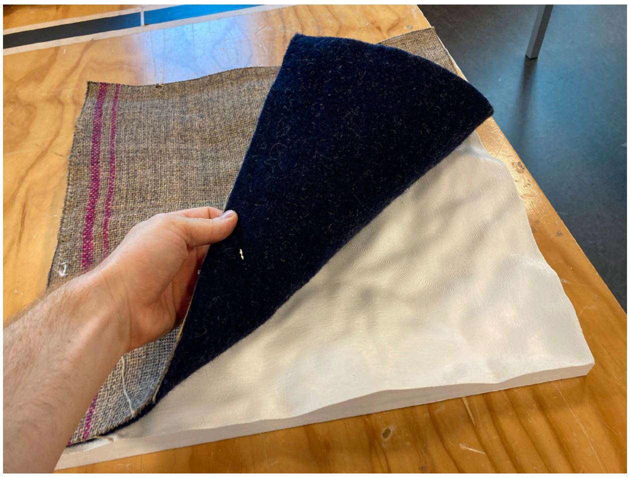

Figure 76. Large textile sample and topographic model (before vacuum bag).

Figure 77. Large textile sample and topographic model (In vacuum bag).

Figure 78. Large cured textile moulded over topographic model.

VACUUM MOULDING DISCUSSION

The moulded detail of the smaller ridges seen in figure 78 was an unexpected outcome. It was thought the construction of the base textile may not respond well to being conformed to smaller pockets. While the textile did not entirely adopt the true form of the mould, the wool of the surface side seemed to compress differently according to the section it was moulded against. This compensated for any lack of conformity from the structural hessian backing. The hessian took on the general form, while the wool adopted the surface detail. The heat and moisture introduced through the ironing process were believed to be contributors to this. Condensation was collected in the wool fibre as the hot iron turns any water within the wax blend or textile fibres to steam. When placed in the vacuum bag, the wool is effectively being steam pressed or wet felted into shape. The longevity of this compression in the wool is unknown. Over time the wool may partially decompress to show a lower fidelity form.

While detailed, the forms created through this method are less dramatic and exaggerated than the previously described hand-formed samples. The CNC cut model captured the exact topography, which was then transferred onto the textile. While these mountains seem enormous and steep when viewed in person, the actual incline of the slopes from ridge to valley are seemingly tame when observed in a scale model. The geometry of these forms could be exaggerated through vertically scaling and warping the model. This would result in a misrepresentation of the topography, yet would arguably create a more recognisable form to a viewer. This model made the most of the material size and capabilities of the available machinery. An exaggerated model would require a thicker stock size and a CNC machine capable of a larger depth of cut.

When viewing the panels, light plays an important role in defining form and detail. When the sample is laid horizontal, it is difficult to make out much of the intricate detail described above. When the sample is hung vertically, however, light from above casts shadows on the textile highlighting the smaller pits and ridges of the panel as demonstrated in figure 80. This was a significant realisation for deciding how the panels may be situated when installed. While the function of the material does not change whether horizontal or vertical, the origins of form become clear when arranged according to environmental light.

The use of a mould creates repeatability in the practice. While one sample will never be exactly the same as the next, a recognisable form was now able to be imprinted onto an indefinite amount of material. Other sections of terrain from anywhere in the world could be applied to this process to suit a range of different contexts. The introduction of a mould suggests how manufacturing methods may be combined for the streamlined production of a product.

This final sample embodies the narrative surrounding the materials, context, and motivations of this research. The panel-like, wall hanging nature of the sample alludes to new material value as an acoustic treatment product. The topographical form of the South Wairarapa gives a subtle nod to the geographic origins of the wool, imparting biographical insight to the end user (Payne & Bonitto, 2017). The topographic form doubles as an irregular surface for sound diffraction to occur (Baux, 2020).

PHASE 3 CONCLUSION

This phase of practice explored how the materials involved in the earlier phases may be resolved into a form beyond a flat textile. Shapes and structures relating to the wool fibre and its biographical origins were investigated as contributors to experimental surface design with acoustic performance in mind. Material samples took influence from microstructures, waste forms, and land topography, spanning a spectrum from micro to macro. The moulding techniques used suggest how this process may be developed to facilitate repetition and production at scale. Topographic forms from South Wairarapa resonate strongly with the narrative of this research, paying homage to the geographic origins of the base material. In all cases, these forms aimed to elevate the strong wool through both empowering the materials with biographical knowledge, and adding acoustic functionality.

Figure 79. Progression of topographic form. Fusion 360 (top), CNC mould (middle), Moulded textile sample (bottom).

Figure 80. Light casting shadows on the topographic formed textile.

RESEARCH OUTPUTS

During the research project, I participated in a symposium, an exhibition, and a conference. These research outputs were useful in gaining feedback on my research from both other academics and industry professionals.

ARCINTEX

ArcInTex (2021) is a global research community committed to the development of architecture, interaction design, and textiles. The ArcInTex Future Living Environment Symposium (https://www.futurelivingenvironments.org) hosted by AUT gave an opportunity for this research to be displayed as a 'work-in-progress' during the making phases (Wanless, 2021). This symposium and exhibition afforded an opportunity for presenting this research at an early stage. It also provided essential feedback from a broader audience outside of the studio environment. Watching attendees interact with the exhibited textiles provided new knowledge on people's intuitive response to experimental tactile surfaces. Refer to figure 81 for image of exhibition.

VIRTU-WOOL

AgResearch (2021) is a Crown-owned organisation established for research and development in the agricultural industries. Virtu-Wool is an online wool research conference run by AgResearch focusing on research and innovation surrounding the wool fibre. The research output was a conference presentation outlining the motivations, materials, and processes involved in the project (Wanless, 2021). The conference gave this research an industry specific platform towards the later stages of the thesis. Strong wool and the proposed new uses for the fibre is a topical conversation among agricultural communities, cementing the relevance of this research alongside the current state of the industry.

Figure 81. Material samples displayed at the ArcInTex Future Living Environments exhibition of practice.

CONCLUSION

This research explored the potential of New Zealand strong wool as a base fibre for new composite materials. The project showed how these materials can be part of a sustainable solution for enhancing spatial acoustics. The research contributed to practical ways of revaluing strong wool as a fibre for dressing the built environment. Through the material driven design process, traditional making techniques were paired with modern tools and technologies to produce a series of new material composites. These composites showcase the possibilities for strong wool to be used in partnership with natural companion materials to produce new textiles of value. The processes developed through the practice suggest new ways to approach materials research, accompanying the natural characteristics of the material with interdisciplinary tools and methods for sustainable enhancement.

The research illustrates how careful material consideration can complement a sustainable design criteria. The inherent nature of the materials was considered throughout the making process, ensuring biodegradation of all material composites was possible at the end of its useful life. The practice highlights the manufacturing possibilities when using abundant and undervalued natural materials, arguing the needlessness for synthetic material production in this context. A narrative around material biography was continually referenced throughout the research to elevate perceptions of strong wool, influence design decisions, and acknowledge the contribution from Palliser Ridge.

The research followed a qualitative set of methodologies responding to tactility and observable characteristics of each material sample. Although scientific testing and collecting technical data around the acoustic performance of the materials was outside the scope of this research project, existing materials research related to wool and its acoustic qualities was referenced to inform the material experiments and decisions. It is recommended that this is an area for future research to justify the material choice for acoustic performance.

Although this research chose to focus specifically on machine needle felting as a means of laminating waste fibres, other textile manufacturing techniques such as wet felting could be explored to assess the ability to create thicker, more porous textile structures well suited for acoustic applications. Additionally, processes such as digital weaving and digital knitting could be explored as a means to design with the wool fibres. New processes may also introduce new materials to the practice. The intention is to broaden the scope of the research to additional devalued materials also considered as waste or by-products. Future research may look to incorporate these manufacturing techniques into further playtyping and experimentation.

In addition, future research may look for ways to extend the characteristics and longevity of the new material composites. The new herb and flower textiles developed in this research show potential for seed germination, further aiding biodegradation. The volatile nature of natural materials such as beeswax means the characteristics of the developed composites will shift over time. Whilst exploring these variables was outside the scope of this research, it is important when considering the life and function of the new materials.

The ultimate intention of the material experiments in this research is to inform the development of an acoustic panel product. The final textile samples exhibit a panel-like form, alluding to a prototype panel design. This collection of methods, materials, and tools may now act as the starting point for a sustainable initiative towards both enhancing human inhabited spaces and revaluing strong wool.

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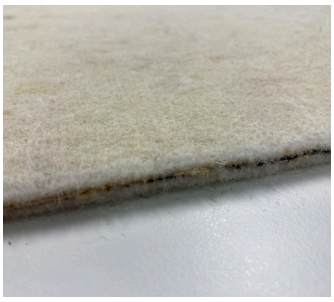
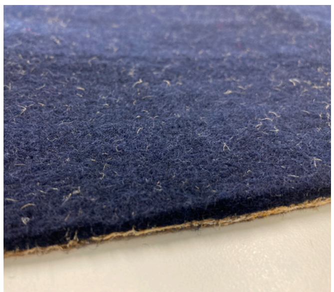
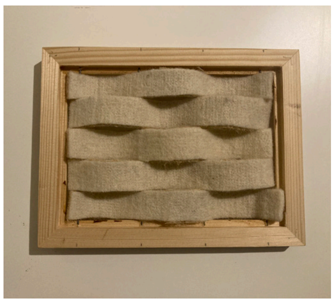
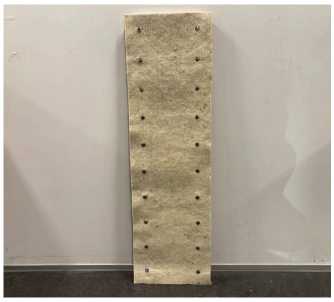
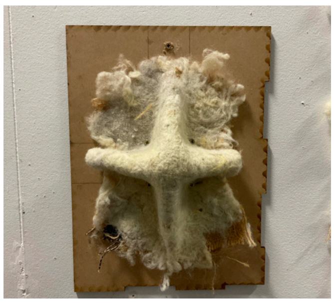
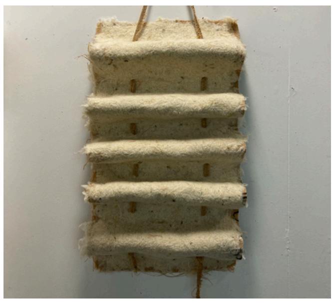
APPENDIX A:

SAMPLE LIBRARY

This appendix consolidates the material samples developed throughout the creative practice. The sample library was used as an archival repository, contributing to both documentation and reflective practice. Many of these samples did not make it into the final thesis, yet are important to recognise in relation to the surrounding materials and processes. Each sample is labelled with the materials and tools involved in the making process. Brief notes were recorded, outlining the main attributes and behaviours of the resulting samples.

MATERIALS/TOOLS	ATTRIBUTES	IMAGE	
Dag wool, hessian. Needle felted.	Thick layer of dag wool plus two layers of hessian. Very stong, dense textile with irregular dag wool texture on surface.		1.
Carded wool, hessian. Needle felted.	Thick layer of carded wool sandwiching two layers of hessian. Very stong, dense textile with premium smooth wool texture on surface.		2.
Carded wool (dyed navy blue), hessian. Needle felted.	Thick layer of carded wool (dyed navy blue) plus two layers of hessian. Fibres from hessian create speckled effect on wool surface.		3.
Carded wool, hessian, wire. Needle felted.	Small framed strips of cut textile. Waves able to be manipulated and ‘snap’ between forms.		4.

Carded wool, hessian, steel staples, bolt. Needle Felted, sewn.	Formed from a single piece of cut textile. Uniform folds create a structural shape. Central bolt serves as a mount point to wall or frame. Small repeatable shape.		5.
Carded wool, hessian, snap fasteners, wood board. Needle felted.	Large thick textile sheet snaps to backing board/frame via snap fasteners. Easially removable and reconfigurable. Flat configuration.		6.
Carded wool, hessian, snap domes, wood board. Needle felted.	'Twist' configuration of sample 6.		7.
Carded wool, hessian, snap domes, wood board. Needle felted.	'Wave' configuration of sample 6.		8.
Dag wool, hessian, MDF, screws, Needle felted.	Textile formed and perminently fastened with screws. Difficult to deform once secured.		9.
Dag wool, hessian. Needle felted, Smock.	Large textile held in 'wave' form via offcut seams from coffee sacks. Hung from a single point. Drastic variation in surface form with large air gaps expected to perform well acoustically.		10.

Dag wool, hessian.

Needle felted, weave.

Large gauge weave constructed from cut stips of textile. Incorperates two layers of textile into a single fabric with the same surface area, doubling original thickness.

11.

Dag wool, hessian.

Weave.

Variation of sample 11. Strips further woven behind to double thickness again. Pouch-like form.

12.

Dag wool, hessian.

Weave, smock.

Combination of sample 10 and 12. Woven pouch form held together via smocking techniques.

13.

Dag wool, hessian.

Plait.

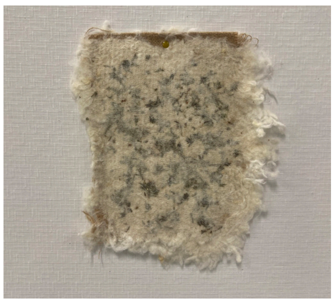
Large gauge plait formed from a single larger strip of textile. Technique borrowed from scout toggles. Tight yet malleable. Structure naturally wants to curl in on itself.

14.

Dag wool, carded wool, hessian, rosemary.

Needle felted.

Cut up rosemary visible through a thin felted layer of carded wool. Plant matter well secured and embedded. Fragrance of rosemary.



15.

Dag wool, carded wool, hessian, lavender.

Needle felted.

Cut up lavender visible through a thin felted layer of carded wool. Plant matter well secured and embedded. Fragrance of lavender.

16.

17.

Dag wool, carded wool, hessian, lavender.

Needle felted.

Whole lavender visible through a thin felted layer of carded wool. Silhouettte distinct and recognisable. Plant matter well secured and embedded. Fragrance of lavender.

18.

Dag wool, hessian, beeswax.

Needle Felted, oven melted.

Beeswax incorperated into whole textile, yet clumps into the less dense pockets of the textile. Increased rigidity. Fragrance of wax and honey.

19.

Dag wool, hessian, beeswax.

Needle felted, oven melted.

Laminated variation of sample 18. Beeswax holds textile layers together yet can be pulled apart with minimal force.

20.

Carded wool, hessian, beeswax.

Heat gun.

Beeswax clumps and disperses unevenly when melted into the wool side via heat gun. Speckled wax pattern visible on surface.

21.

Dag wool, hessian, beeswax, damar resin.

Needle felted, ironed.

4:1 ratio of beeswax and damar resin. wax/resin absorbs into hessian yet doesn’t penetrate felted wool. Hard shell-like texture on back, with soft ‘wooly’ texture on front.

22.

Dag wool, hessian, beeswax, damar resin.

Needle felted, ironed.

8:1 ratio variation of sample 21.

Dag wool, hessian, flour (wheat paste). Needle felted, painted-on solution, oven dried.	Shiny crust formed on top of hessian. Crust cracks when textile is bent. Slight increase in rigidity.		23.
Dag wool, hessian, flour (wheat paste), acacia gum. Needle felted, painted-on solution, oven dried.	Starch/gum solution absorbs further into hessian than pure starch in sample 23. Surface does not crack or damage when bent. Further increased rigidity.		24.
Dag wool, hessian, flour (wheat paste), acacia gum. Needle felted, painted-on solution, oven dried.	Laminated variation of sample 24. Strong bond and increased rigidity. noticeable increase in weight.		25.
Dag wool, hessian, acacia gum, water Needle felted, submerged in solution, oven dried.	Drastically increased rigidity and strength. Surface texture rough, resembling a dry Scotch-Brite. Minimal increase in weight. Small amount of gum residue left on hands when handled.		26.
Dag wool, hessian, acacia gum, water. Needle felted, painted-on solution, laminated, oven dried.	Textiles laminated on hessian side show some bond, yet come apart with minimal force.		27.
Dag wool, hessian, acacia gum, water. Needle felted, painted-on solution, oven dried.	Textiles laminated on wool side show little/no bond, and come apart without force.		28.

Dag wool, hessian, beeswax.

Needle felted, heat gun.

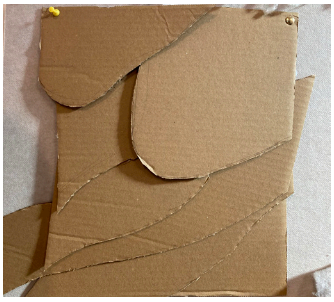
Thick strip of wool formed into twist shape with partial wax coverage. Holds form, yet is easilly re-formed.

29.

Cardboard.

Cut.

Thickness of cardboard close to that of wool/hessian textile. Cut forms overlap to mimic scales of wool fibre under SEM.



30.

Dag wool, carded wool, hessian [sample textile offcuts.

Collage, needle felted.

Offcut edges of previous textile experiments collaged to mimic the scale of wool fibre under SEM. Rough edges create natural look/shape.

31.

Hessian, 8 ply wool yarn.

Punch needle.

Weave of the hessian accepts the yarn well. Small ridges created.

32.

Dag wool, hessian.

Needle felted.

Cut stips arranged to form scales. Strips held in place yet whole form is fragile. Shape moving away from conventional wall-hanging flat panel form.

33.

Dag wool, hessian, beeswax.

Needle felted, heat gun, sewn.

Progression from sample 33. Textile strips parcially waxed and sew together for added structure. Shape more defined and holds together well.

34.

Carded wool, hessian, beeswax.

Needle felted, heat gun.

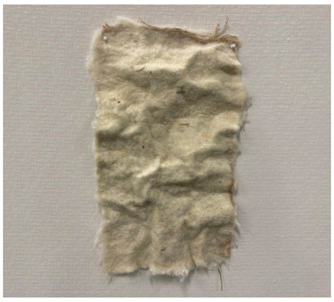
Irregular ‘scrunched’ form to resemple waste and offcuts. Thin layer of carded wool plus single layer of hessian folds easily for more defined creases.

35.

Carded wool, hessian, beeswax.

Needle felted, heat gun.

Irregular ‘scrunched’ form progression. Thick layer of carded wool plus single layer of hessian holds less definition.



36.

Dag wool, hessian, beeswax.

Needle felted, heat gun.

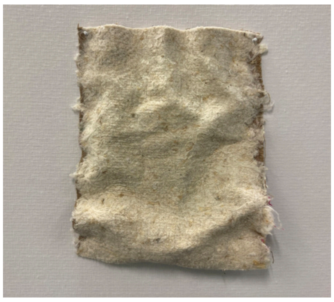
Irregular ‘scrunched’ form progression. Thick layer of dag wool plus single layer of hessian holds less definition.

37.

Dag wool, hessian, beeswax. Waste form.

Needle felted, ironed.

Irregular ‘scrunched’ form progression. Thick layer of dag wool plus double layer of hessian holds less definition, yet is able to absorb more wax, resulting in increased rigidity.



38.

Beeswax, damar resin.

Double boiler.

Combination of 8:1 and 4:1 beeswax and damar resin blends. Cured into 100g blocks.

39.

Dag wool, hessian, beeswax.

Needle felted, ironed.

Irregular ‘scrunched’ form progression. Thick layer of dag wool plus double layer of hessian. 4:1 ratio wax blend creates rigid and stong shell-like structure.

40.

41.

Dyed/carded wool, hessian, beeswax.

Needle felted, ironed.

Variation of sample 40 with navy blue dyed carded wool. Carded texture and dark colour creates more defined forms.

42.

MDF, PVA.

CNC router.

Trial model in prep for sample 43. Variation in surface finish tested: Smooth (left) and contour lines (right).

43.

MDF, PVA.

CNC router.

Large model progression from sample 42. Smooth finish chosen.

44.

MDF, PVA, sealer.

CNC router.

Sealed progression from sample 43.

45.

Dag wool, hessian, beeswax, damar resin.

Needle Felted, ironed, vacuum bagged.

Small trail textile vacuum moulded over sample 42. Some finer detail of topography seen on surface. Vacuum mould process further compressed textile.

46.

Dyed, carded wool, hessian, beeswax, damar resin.

Needle Felted, ironed, vacuum bagged.

Large textile moulded over sample 44. Further surface detail emerges at this scale. Darker colour accentuates form and shadows.

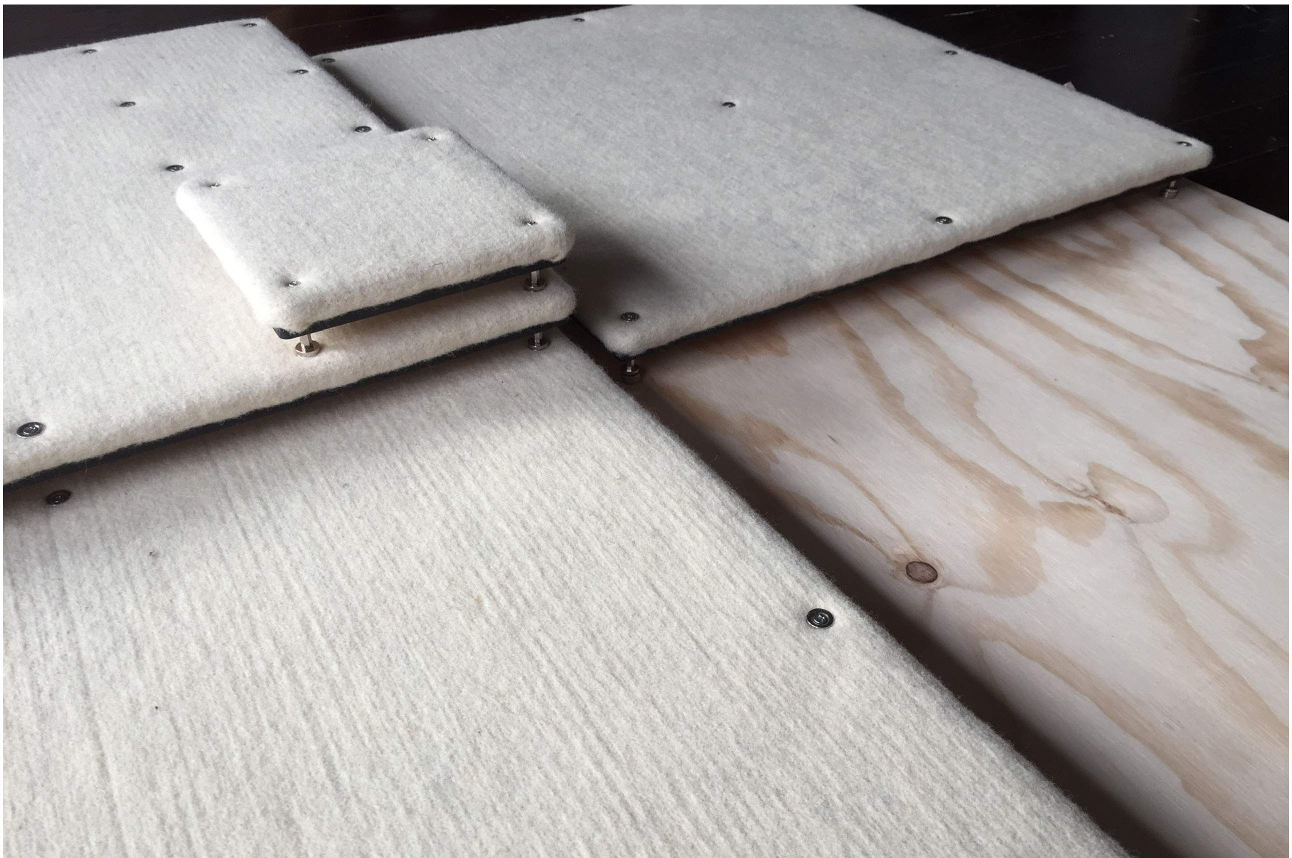
APPENDIX B:

PANEL DESIGN 1.0

This appendix is a brief analysis of the original project that formed the conceptual basis for this thesis. The project was completed as submission for a final year Bachelor of Technologies studio paper.

OVERVIEW

This project explored designing a modular, reconfigurable system for acoustically treating a space. Most premium products on the current market are costly and require expert installation. This design offers a functional alternative from low cost materials. NZ strong wool is used for the base fibre in the textile construction towards an acoustically responsive material. The strong wool used in this prototype design was gifted by AUT's Textile Design Lab.



AESTHETIC

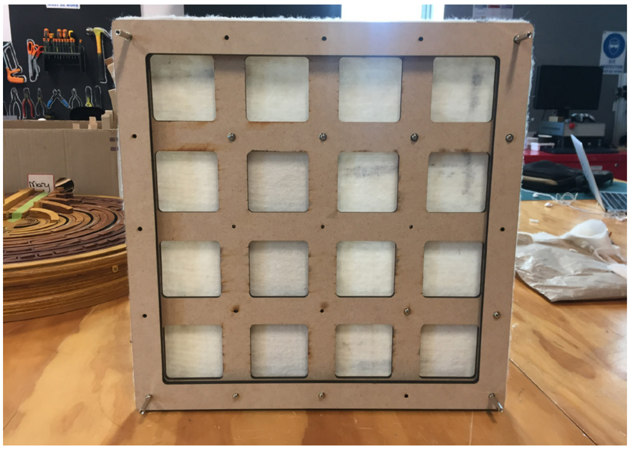
The panels were simple and non-intrusive. The refined square design meant the panels would not look out of place when used within a range of interior design styles from traditional to contemporary. Industrial needle felting provided a premium look and feel to the textile, especially when tightly upholstered to a frame.

WOOL AND HESSIAN

The felted construction of strong wool and hessian was seen as the greatest material success of the project. The hessian sack being both fibrous and a weave meant the wool fibres amalgamated exceptionally well when processed through the FeltLOOM®. The resulting material was a very strong, thick, dense textile. The sandwich-style construction of hessian encased by multiple layers of wool on both front and back hid the hessian from sight while adopting its rigidity and strength.

MODULAR DESIGN

The modularity of the design resonated well with people when exhibited. Conversations with both audio industry professionals and amateur home producers pointed towards a common interest in an acoustic treatment product that could be temporary and/or reconfigurable. The magnetic attachment system meant reconfiguring the components was intuitive, where the individual components would always snap to an existing grid. The construction of the panels could be broken down into three core components; textile, frame, and hardware. This simple construction leant the system well to being a kitset style product. This further adds to the modularity of the design, encouraging the customer to build up a selection of panels appropriate for their specific space.



MDF

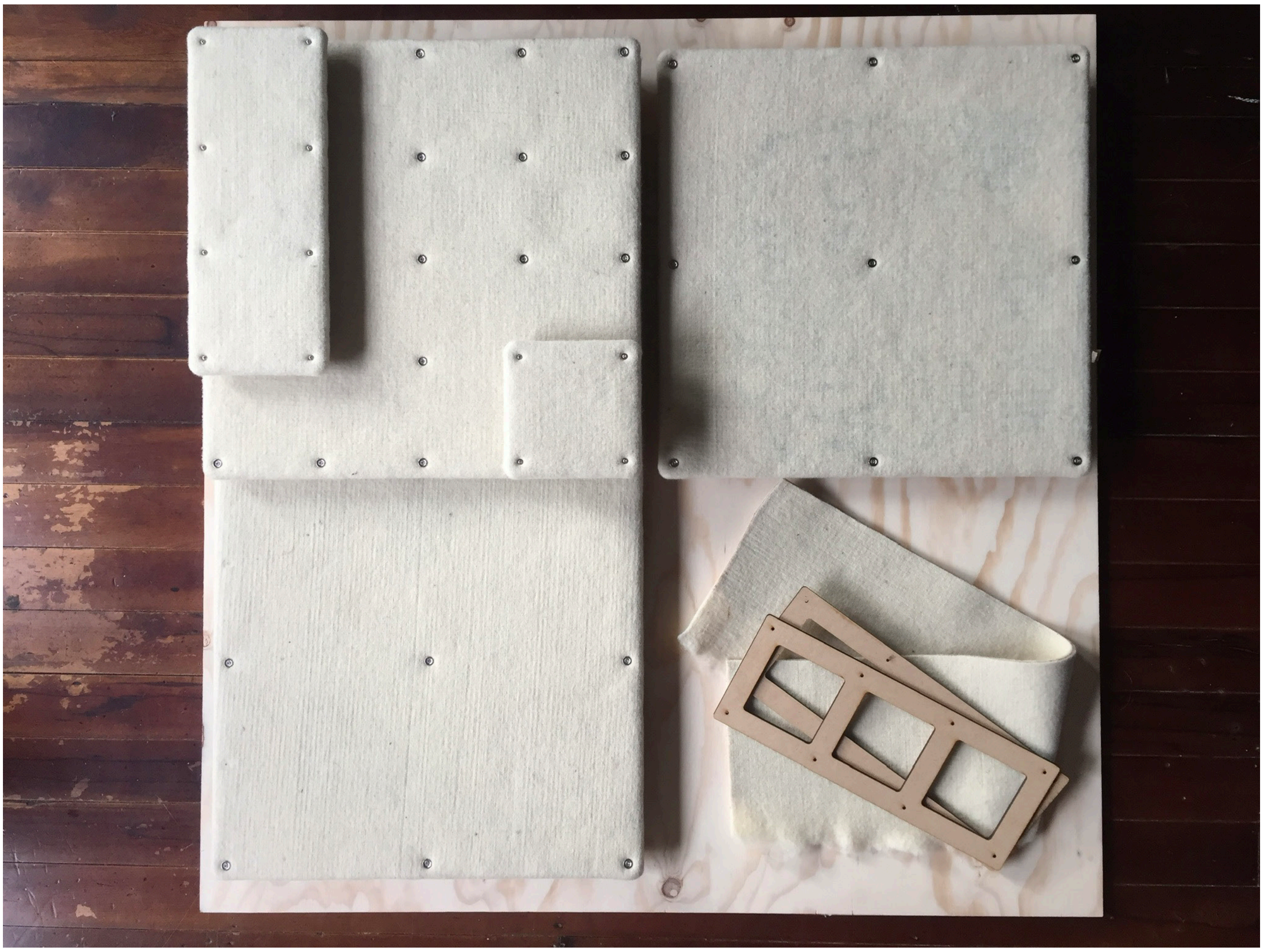
The decision to use MDF as a material for framing was one of both accessibility and price. The material is widely available and easy to manipulate through digital manufacturing techniques such as laser cutting. There are, however, a number of well known heath and sustainability concerns surrounding MDF as a material. The subtractive manufacturing style of cutting a frame out of a single sheet of material also creates additional waste. This project stems from the need to find a use for strong wool, so other materials and practices involved should reflect this sustainable intention where possible.

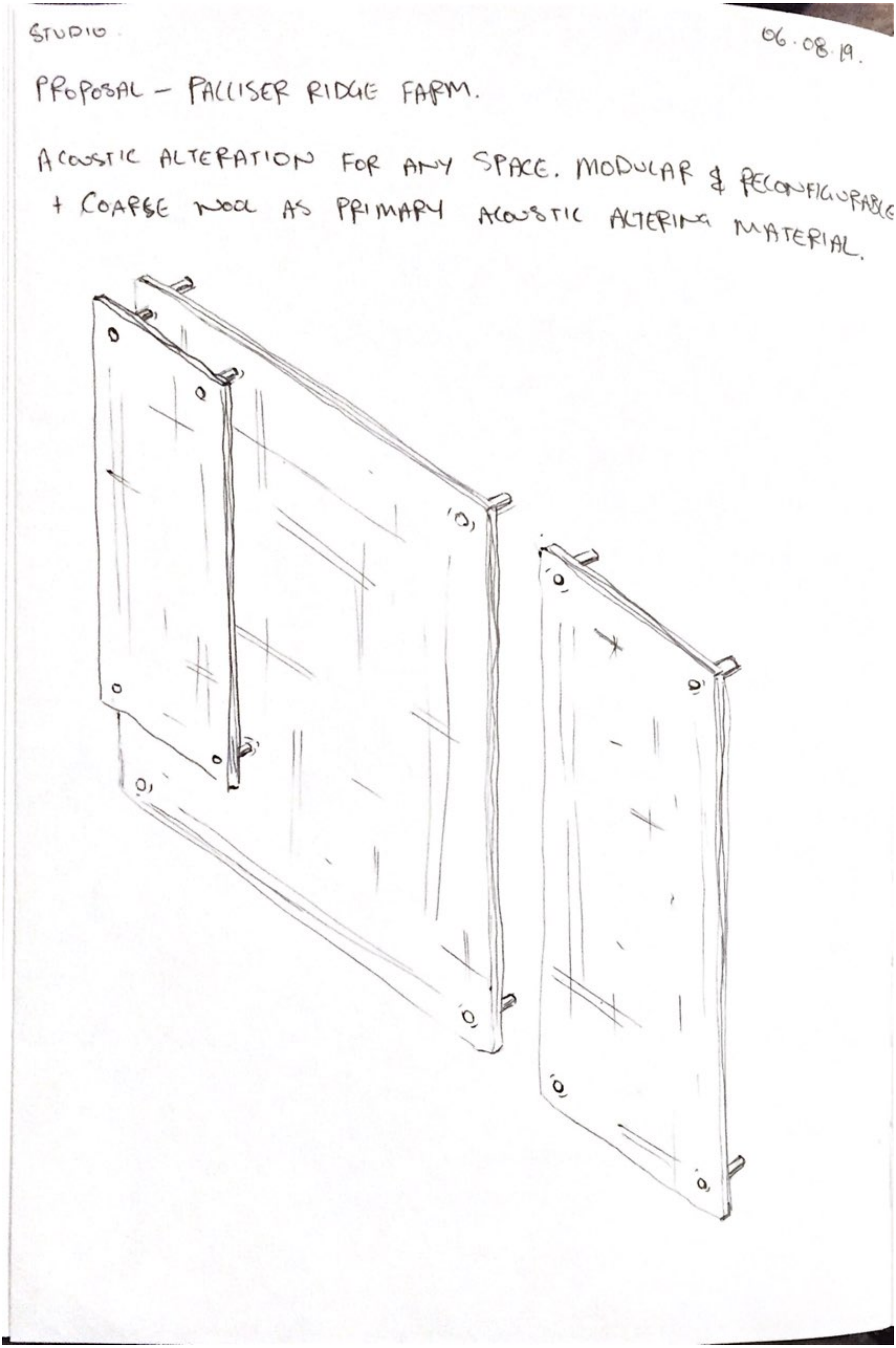
MAGNETS

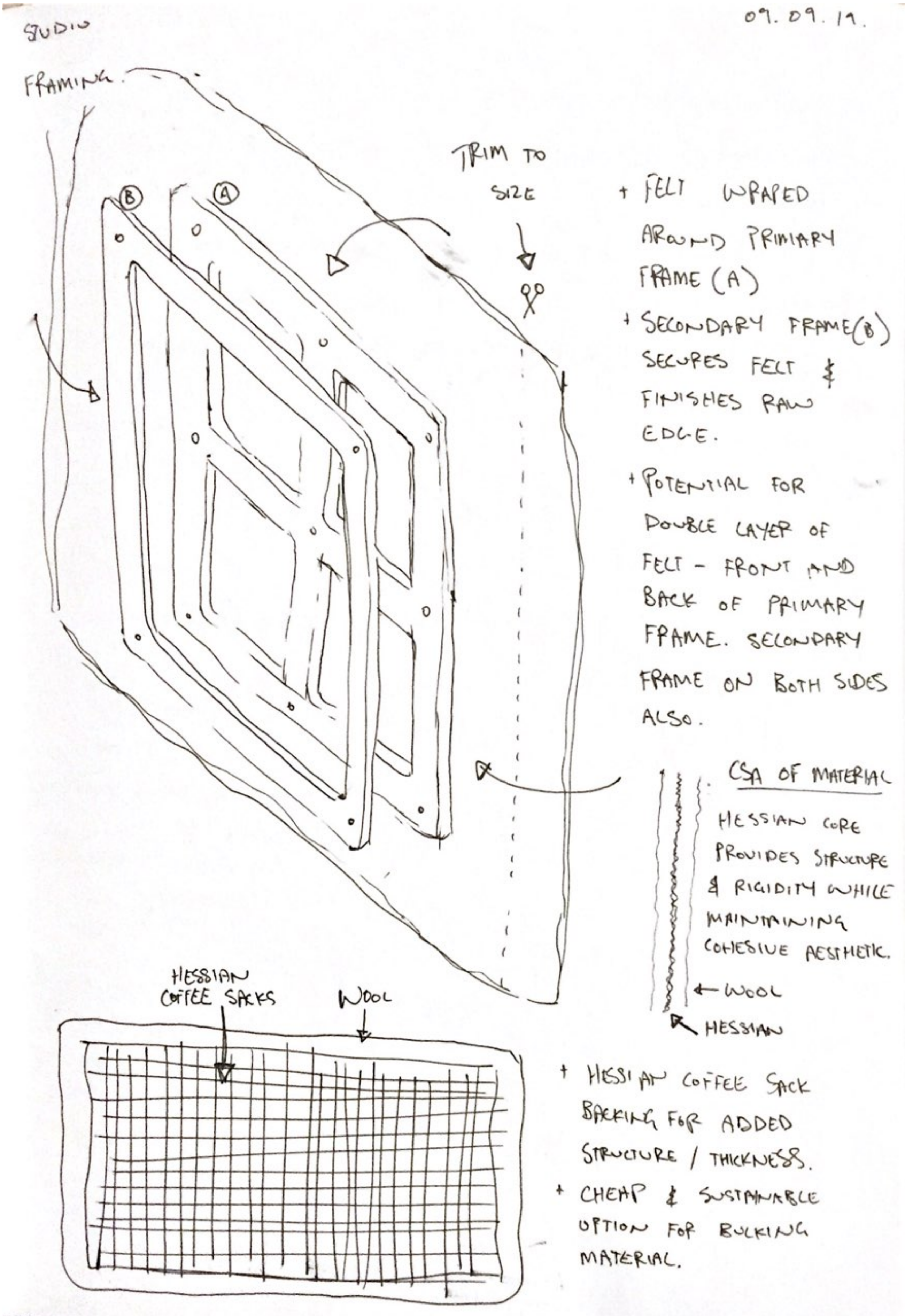
Using magnets as a means of securing the panels works for quick reconfiguration, yet lacks strength. Magnets have great pull strength, yet they have a tendency to slip when a shear force is applied. As the panels are designed to hang vertically on a wall, gravity is constantly applying a force in the direction of this weakness. The smaller panels hold well, yet when larger panels are added and stacked the bond of the magnets will often fail.

CONCLUSIONS

This project explored how a modular acoustic panel design may be both functional and sustainably manufactured. The use of multiple by-product fibres creates a product using minimal virgin materials. This design was an initial prototype, acting as a proof of concept to inform future wool-based acoustic initiatives. The shortfalls of the system design including MDF framing and magnetic functionality leave room for further developments in future iterations of the design. The completion of this project formed the basis of a conversation towards research funding with Palliser Ridge.




STUDIO.
06.08.19.
PROPOSAL – PALLISER RIDGE FARM.
ACOUSTIC ALTERATION FOR ANY SPACE. MODULAR & RECONFIGURABLE
+ COARSE WOOL AS PRIMARY ACOUSTIC ALTERING MATERIAL.


STUDIO
FRAMING.
09.09.19.
TRIM TO SIZE
B
A
+ FELT WRAPED AROUND PRIMARY FRAME (A)
+ SECONDARY FRAME (B) SECURES FELT & FINISHES RAW EDGE.
+ POTENTIAL FOR DOUBLE LAYER OF FELT - FRONT AND BACK OF PRIMARY FRAME. SECONDARY FRAME ON BOTH SIDES ALSO.
CSA OF MATERIAL
HESSIAN CORE PROVIDES STRUCTURE & RIGIDITY WHILE MAINTAINING COHESIVE AESTHETIC.
← WOOL
HESSIAN
HESSIAN COFFEE SACKS
WOOL
+ HESSIAN COFFEE SACK BACKING FOR ADDED STRUCTURE / THICKNESS.
+ CHEAP & SUSTAINABLE OPTION FOR BULKING MATERIAL.

APPENDIX C:

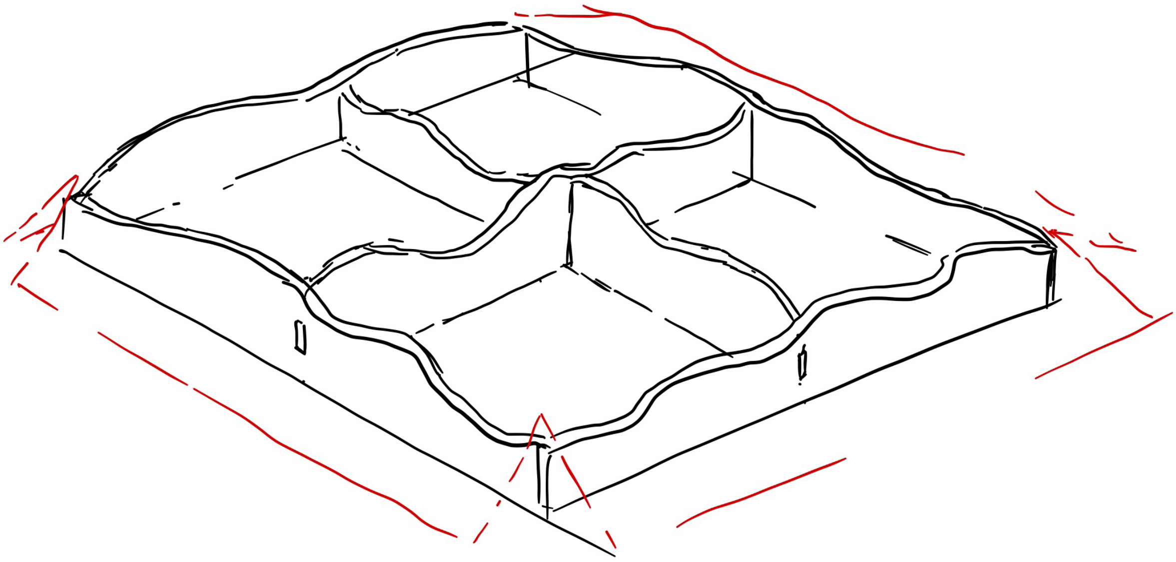
PROTOTYPE ACOUSTIC PANEL

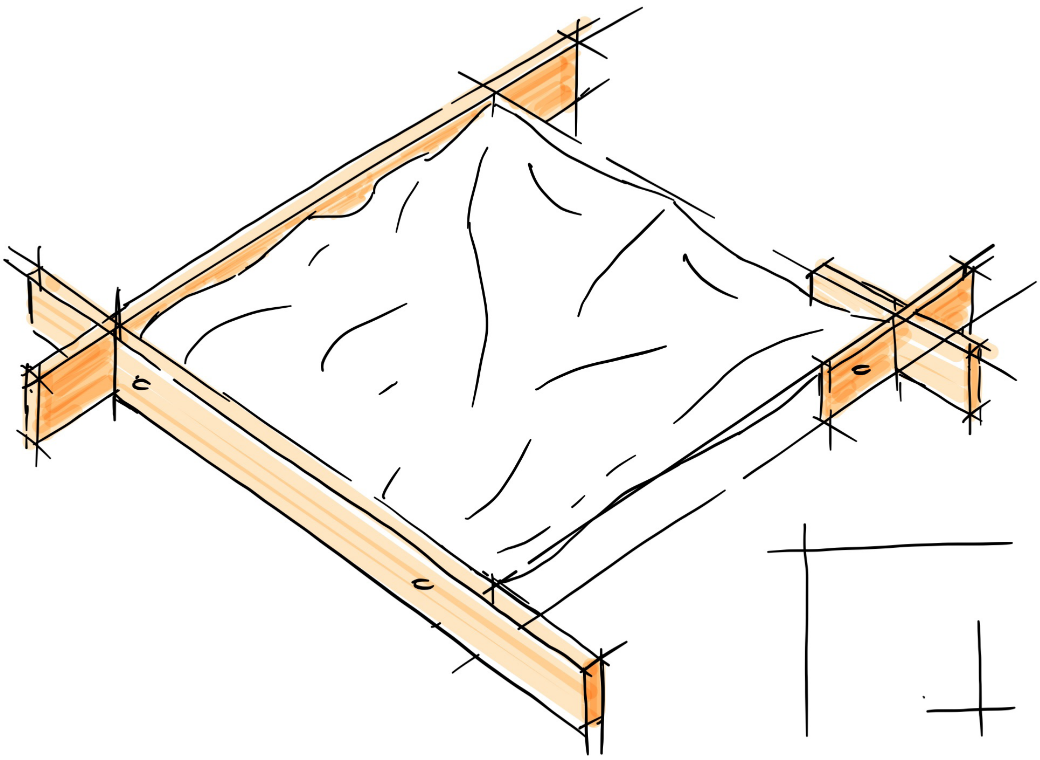
A prototype panel was produced using the new materials developed through the research. This design suggests how the wool based textiles may be used within a future solution for enhancing interior acoustics. Though the project itself is not centered around the development of a product, visualising the research findings within a prototype design helps to contextualise the intended use of the new materials.

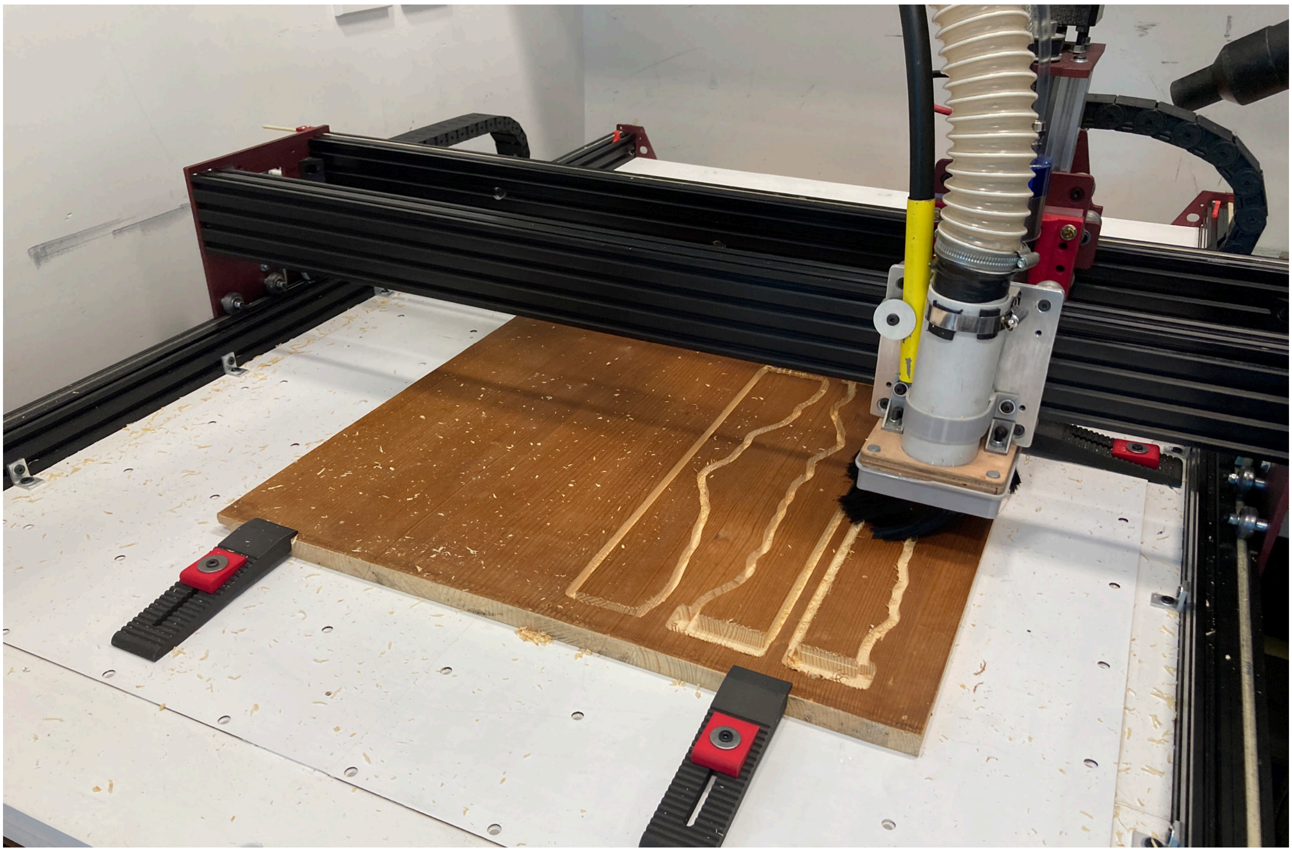
This design adopted an internal frame to give structure to the panel. This frame follows the contour of the original topographic mould ensuring majority sections of the textile surface are supported. The frame was modeled using Fusion 360 and cut using CNC techniques similar to the processes seen when developing the topographic mould. In keeping with the material sourcing ethos, the frame was cut from recycled pine panels salvaged from a discarded cabinet.

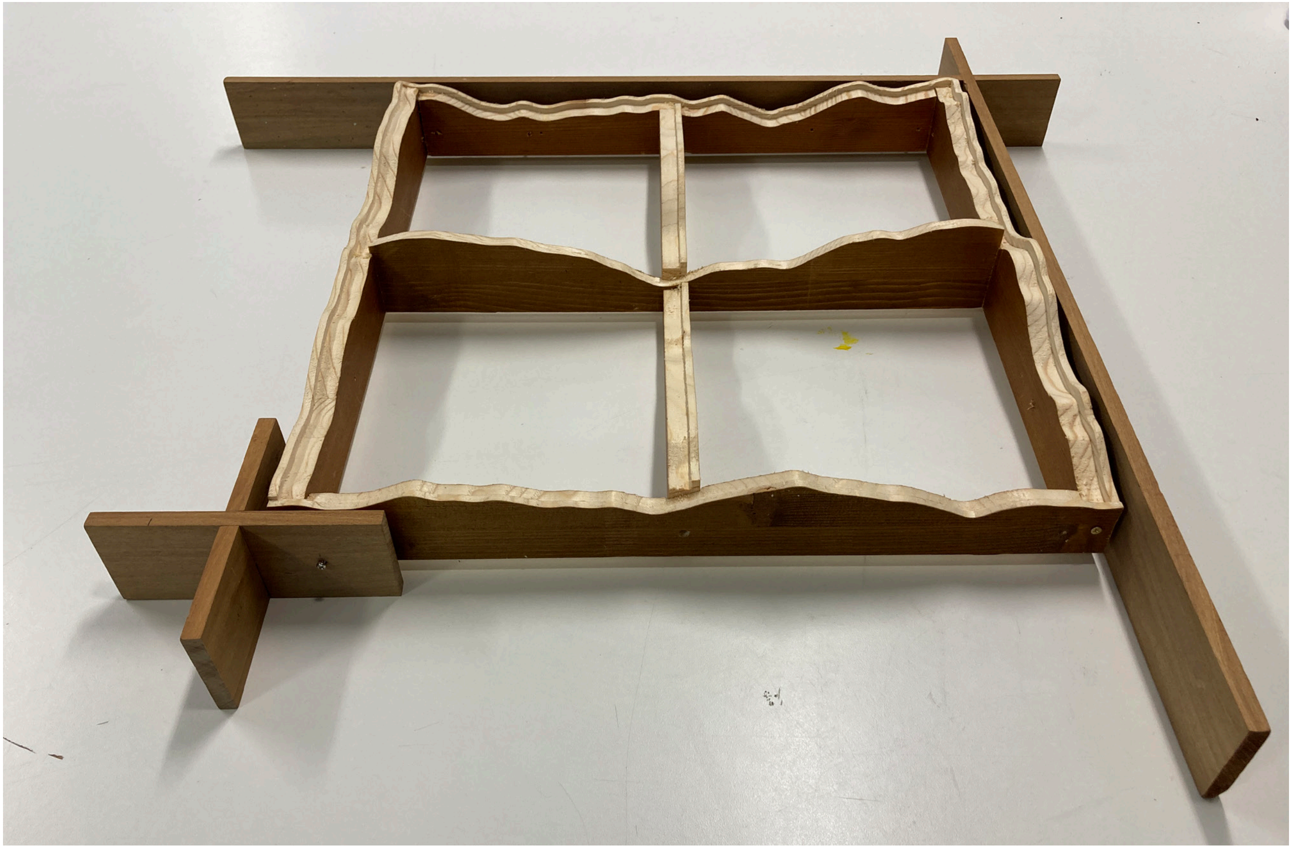
A section of textile was formed face up over the mould to ensure the correct fit over the new frame. Once formed, excess material around the corners was cut so the textile may follow the angles of the wood frame. The cut edges were stitched, before extra wool was hand felted over the join to form a seamless corner.

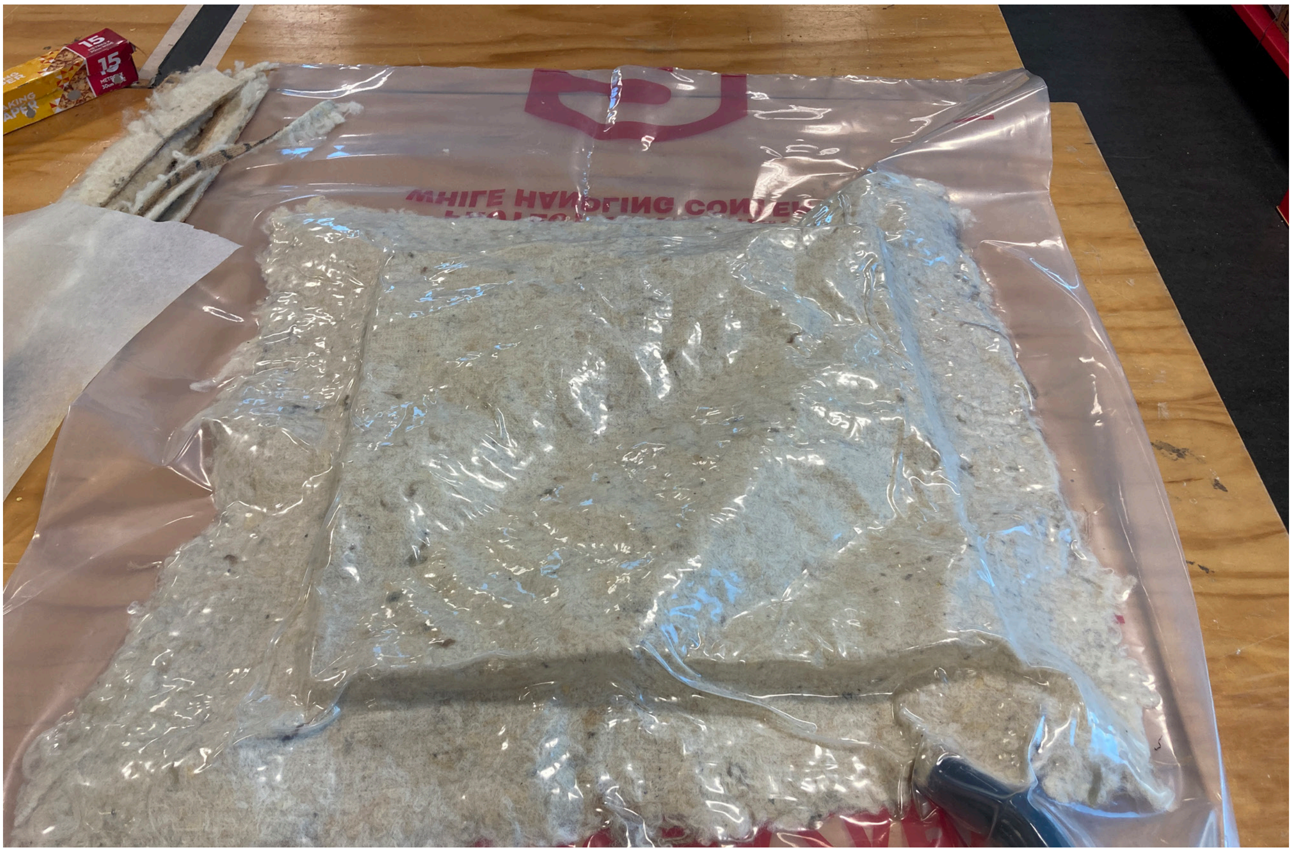
The external hardwood trimmings of the panel were designed to mimic the construction lines commonly used in design sketching. These construction lines can be observed in my own sketched designs throughout my visual journal. This aesthetic alludes to the prototype nature of the panel, suggesting expected future refinement of the design.












14.4V

APPENDIX D:

EXHIBITION OF PRACTICE