Floppy Effects

A project submitted in fulfilment of the requirements for the degree of Doctor of Philosophy

Leanne Zilka
Bachelor or Arts, University of New South Wales
Bachelor of Arts (architecture), University of Technology Sydney
Bachelor of Architecture, University of New South Wales, Sydney
Master of Architecture, Harvard University

School of Architecture and Design
College of Design and Social Context
RMIT University

December, 2017
FLOPPY EFFECTS

Experimenting in the territory between architecture, fashion and textiles.

Leanne Zilka
Submitted for Doctor of Philosophy
RMIT University August 2017
FLOPPY EFFECTS
Experimenting in the territory between architecture, fashion and textiles.

Leanne Zilka
Submitted for Doctor of Philosophy
RMIT University December, 2017

Supervisors
Professor Vivian Mitsogianni
Professor Martyn Hook
DECLARATION

I certify that except where due acknowledgment has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the project is the result of work which has been carried out since the official commencement date of the approved research program; any editorial work, paid or unpaid, carried out by a third party is acknowledged; and, ethics procedures and guidelines have been followed.

I acknowledge the support I have received for my research through the provision of an Australian Government Research Training Program Scholarship.

Leanne Zilka
December 2017
ACKNOWLEDGMENT

I would like to thank my supervisors, Professor Vivian Mitsogianni and Professor Martyn Hook who have been patient, supportive and encouraging throughout the PhD. I would also like to thank the supervisors I had in the early part of the PhD, Prof. Sue-Anne Ware and Professor David Mainwaring who gave me direction and encouragement, allowing me to pursue my interest and hunches. There has also been generous support from the architecture program and my colleagues at RMIT which has been a valuable source of knowledge, collaboration and encouragement. The Student body at RMIT architecture have been extraordinarily generous in working on some of the project and committing to the design studio teaching I have developed. I would especially like to thank the fashion and textile practitioners and students who I have collaborated with particularly Dr Jenny Underwood, as her patience, dedication to her field and unique way of working has been a source of inspiration and motivation to pursue the work in this PhD.

Lastly I would like to thank my family, James, Ben, Josh and Leo who have never complained about the time taken to work on this PhD and have been helpful in giving their opinion on some of the work.

This PhD is a product of collaboration and shared discussion. I thank all who have come in contact with me during this process.
2 ABSTRACT
15 SPECULATIONS IN THE FIELD
21 Practices that work to express material character
21 Practices that work with new materials
23 Practices that use digital fabrication as a way to reconsider materials
23 Poetic materialists
25 Recycled materialists
26 Architecture and textiles
27 Fashion and textiles
31 Establishing the practice and the PhD
31 On track projects
39 Off track projects

5 INTRODUCTION
43 FLOPPY LOGIC
45 Research led design studio teaching
47 Working with fashion design
49 Working with textile design
57 Glow

93 PLEAT
94 Pleat vs Fold
97 PleatPod
151 Pleat Pavilion
165 Pleatent

175 Conclusion
181 Endnotes
186 Terminology
189 Table of images
197 Bibliography
Abstract
This PhD is a reflection on a body of work that represents my practice as it developed prior to and during the PhD. The driving interests of the PhD are in the ‘architecture’ of fashion and textiles, and how the concepts, aesthetics, techniques and construction of this architecture might be understood and used to design and fabricate objects and space differently. I investigate how seemingly diverse disciplines can be used to traverse from the scale of material and garment to that of rooms and buildings. By working with fashion and textile techniques on form and material simultaneously, I have developed ideas for architecture where structure form and material can also be developed simultaneously revealing new ways of approaching the design and fabrication of architecture.

A key concept I develop in my PhD is the Floppy. I define the Floppy as a quality in material that requires extraneous support to produce architecture. Floppy generally refers to fabric but can also refer to any material that fails when there is not enough support, as is the case with sheet materials when the span between supports exceeds a certain length. During the PhD I have worked to define and redefine the term Floppy, to assist in distilling the large body of work in the material field, the material palette and the relevant techniques. This narrowing works to clarify where the contribution to knowledge lies, as well as allowing for the rigorous testing of approaches.

I have been drawn to the aesthetic, tactile nature of fabrics and sheet materials where I work to bring these qualities into architecture. From this I have discovered novel ways to judge material behaviours, and techniques to create form. This PhD unearths new ways of working with the selected materials to draw out their inherent qualities or characters rather than subjugate them to only support, or only skin, or only surface. The PhD is about the potential of material, and understands material as having intrinsic qualities that can be exploited. I don’t take a condition to the material, but rather look for the condition in the material.

Working on the Floppy range of materials requires extensive testing to produce architecture. The distance needed to travel to create architecture from the Floppy has exposed a series of issues and concerns that have led the research and the establishment of my practice. The practice is one that uses the physical and/or digital model to traverse the uncommon language between the disciplines, working to inform terms, techniques and approaches so that they may be used by others in the design and fabrication of architecture.
Introduction
The PhD is titled Floppy Effects. Fashion and textile design have a unique way of working with materials that have no inherent strength and architecture can learn from these techniques, approaches, sensibilities and aesthetics. I have coined the term ‘Floppy’ and define it as the quality in material that requires extraneous support to produce architecture. Floppy generally refers to fabric but can also refer to any material that fails when there is not enough support, as is the case with sheet materials when the span between supports exceeds a certain length. During the PhD I have worked to define and redefine the term Floppy, to assist in distilling the large body of work in the material field, the material palette and the relevant techniques. This narrowing works to clarify where the contribution to knowledge lies, as well as allowing for the rigorous testing of approaches. I have been drawn to the aesthetic, tactile nature of fabrics and sheet materials and my practice has involved bringing these qualities to architecture. From this I have discovered novel ways to judge material behaviours, and techniques to create form. This PhD unearths new ways of working with the selected materials to draw out the inherent qualities or characters rather than subjugate them to being considered only support, or only skin, or only surface. The PhD is about the potential of material and understands material as having intrinsic qualities that can be exploited. I don’t take a condition to the material, but rather look for the condition in the material.

The advance of digital modeling and fabrication tools has allowed for the inclusion of the Floppy palette of materials. We can model, and build with the techniques taken from fashion and textile design that looks to integrate form, skin and structure. We are no longer held to the restricted architectural palette of techniques around concrete, steel, glass and brick but have the option to look to a broader, non-architectural material approach. Architecture does not have the knowledge to deal with the Floppy, so sharing my explorations of the techniques from fashion and textile design is an important step in the development of an architecture that can look beyond the abilities of concrete, steel, glass and brick.

The work produced in the PhD investigates the relationship between architecture, textile and fashion design to expand approaches to design and fabrication. The projects discussed here range from small experiments and installations to larger objects that test design, material limits, fabrication technologies and techniques. Interest in fashion and textiles propelled the projects and allowed for further reflection and the development of new projects. This process of reflection, developing projects, and further reflection has uncovered questions, dilemmas and observations that contribute to knowledge in the field of design and fabrication.

There have been several shifts during the PhD that I will discuss. These have steered the PhD away from a pure material investigation, where material sets such as textiles, laminates and veneers were investigated on their own, towards a practice that uses fashion and textiles to overcome distinctions between pattern, form and structure. I am a practicing architect as well as an academic teaching design at RMIT University. When referring to my ‘practice’ I consider my teaching, research, installations, competitions and my architectural projects as part of this ‘practice’. My work has led me to understand that the ideas and motivations that start a project undergo a rationalisation process when they approach fabrication. Typically architects work with an idea of how a design might be built or select a material system that has been pre-designed and engineered. My approach differs from this, as I develop ideas that work to express a textile or fashion idea that does not start with a structural logic, or a material system. Through a fabrication process I work with small tests to find the hidden structural and material logic. It is the process of fabrication that converts this Floppy approach into architecture.

This process of conversion from idea into built form is where the PhD makes its major contribution to knowledge, as it considers how large scaled elements can still be intricate despite their size. It also considers how working in this way requires input from other disciplines well versed in the intricate, and that the combination of this way of working and limitations of the materials produce an architecture that while combining skin, structure and form, also deals with illusion and effect.
This is a summary of the methodology of the PhD which has revolved around the reflective practice model. I have used the process of the RMIT Design Practice PhD model to reflect on the work and locate any shifts that have then been used to form new bodies of work, and direct the PhD. The PRS (Practice Research Symposium) is a biannual symposium where current PhD candidates present their work to an academic panel consisting of their first and second supervisors, and one to three guest critics. The PRS has been the place where I discussed the work and test ideas, propositions and contributions to a diverse audience. The practitioners and academics on these panels did not privilege my point of view and so forced a clarification of the ideas and processes. This PRS process assisted in the development of the PhD, where the presentations allowed me to reflect on the on-going projects and edit my direction even if this was in the midst of a project.

The practice I have developed has been a direct outcome of the practice based research model at RMIT University, Melbourne. It has allowed me to confidently claim the territory of the PhD which makes contributions to the material discourse, a rich but large body of work. The PRS sequence of presentations are described here to allow the reader to understand the process of the practice research model and where the key shifts have occurred.

PRS1 – ‘Materialities’. This was the first title of the PhD. It was originally directed at a singular research focus around functional polymers (i.e.: plastics that are embedded with functional aspects such as light). This was a narrow understanding of the PhD by practice, that involved Professor David Mainwaring, as second supervisor. I had involved Prof. Mainwaring early in the PhD to guide the research around the Glow materials, my focus at the time. The Nano particles that he had improved were long life photo luminous materials (a passive lighting source that absorbs light then releases it) were so small that they could be embedded in fibres and plastics.

PRS2 – ‘Fibre Focus’. This PRS was dedicated to revealing the work done in research led design studio teaching at RMIT University that looked at glow materials and how they might be deployed in public space. These nano-particles were embedded in fibre and my focus shifted from glow qualities alone to a fibre based exploration, and how these fibres could be used in the design of architecture.

PRS3 – ‘Materialities’. This PRS expanded the work from the functional polymers and Glow materials to include work done in my broader practice. I presented the Brick Curtain house, experiments done in the design studio teaching around sheet materials; where one material palette was used to create structure, form, and skin; more detail on the glow project; and for the first time a mention of the material discourse as a way to position my practice. My selected material practitioners and projects sat in either the research around particular materials and their qualities or in local Melbourne practices such as Kerstin Thompson, Sean Godsell and Phooey Architects. I had not yet situated myself in the broader body of work or the material discourse and therefore I was unclear where my contributions would lie and which key figures in the material discourse were most relevant. A more expansive view of the discourse and projects was needed.

PRS4 – ‘Material Practice’. Another title change to reflect the broadening focus of the PhD and the focus on materials as the basis of the research. The community of practice in the material discourse was clarified and showed a way of editing the discourse based on the projects from my practice and work done in the research led design studio teaching.

PRS5 – ‘Material Practice’. This PRS explained a way of working that begins with the material condition. I disguised the way the design studio teaching content is tested through design electives as a model to explore different ways of working with materials. The design studio teaching worked with several types of materials including concrete, steel, plywood, aluminium sheet, PETG, laminates, veneers, and plaster, as a way to test which materials could produce the results without the need for too much additional support. From these explorations, sheet materials and materials that displayed structural vulnerability were selected, as I felt there was a gap in knowledge around exploring the material condition as a way to generate architecture. I described several criteria for material selection: How does it behave? How does it relate to its surroundings? What can be done with it? What tools (digital or analogue) can be used to manipulate it? Does it have the potential to create space on its own? What program, or architectural issue could the material address? What could the spatial strategy be for using the material? These questions were used to narrow the material selection.

PRS6 – ‘Immaterial’. Mid candidature. This PRS explicitly described a practice that was looking towards material as the starting point in the design of architecture. This title attempted to describe the investigation of singular material selections and their possibilities for enclosure, then finding a use for the material, based on these discovered qualities. I was framing a practice that sought to understand the material condition before it is incorporated into a structural system or program. This PRS did two things. Firstly, it included all projects, investigations, explorations, and design studio teaching I had undertaken as a way to draw a thread through the work, and secondly, it provided a summary of the community of practice I was part of, editing the material discourse as it related to my practice.

PRS7 – ‘Immaterial’. This PRS reflected on a large practice map of work that I had introduced into the previous PRS to focus on the discussion around the threads emerging in the work.

PRS8 – ‘The Floppy and the Formless’. Developing space from the non-architectural. This PRS focused on the strategies used to develop space from Floppy materials. Here Floppy was clearly defined as the key quality I looked for when selecting a material. This PRS went back to the work from the Paint On Structure explorations that used glue as the structure, fusing together form, skin and structure. This PRS also introduced the new work done with the technique of pleating. The significance of the collaborative work done with fashion and textile design became clear when looking at pleating and the benefits emerging with the Floppy.

PRS9 – ‘Synthetic Practice’. Experimenting in the territory between architecture, fashion and textile design. This PRS solidified my direction and indicated the PhD could be completed. I acknowledged that the collaboration between architecture, fashion and textile design was where the new knowledge was, and the significance of the Pleat work as a way to show the application of this knowledge.

PRS10 – ‘Floppy Effects’. 3rd milestone: The draft of this document explaining the contribution to knowledge and plan for the exhibition.
STRUCTURE OF PHD
The PhD is laid out in three main sections. The first is a fleshing out of the speculations in the material field exploring work among architects, fashion and textile designers who have influenced the development of my practice. This fleshing out firstly defines the figures and projects that I find relevant in the large material discourse, and secondly identifies gaps for further investigation. The process of fleshing out involves research as well as physical testing of the ideas in order to define the territory of the PhD.

The second section, Floppy Logic, looks at the work done directly with fashion and textile designers that has helped to develop the term Floppy. This section also tests a variety of techniques and collaborations as a way to flesh out how to work with this material condition, illustrates what is successful and what is not, and develops a common language between the disciplines.

The third section, Pleat, documents and discusses the work around a specific technique, the Pleat, and how this can be used to create structure, form and architecture, through several projects. By working on a specific technique that travels from small scale experimentation with paper and concludes with the demonstration of how this technique can be used in large architectural projects, the incremental knowledge gained at particular moments is evidenced.

Within these sections are several projects that work to test the direction of the PhD. The images should be read as evidence of the significant moments of reflection. They form a catalogue of issues, questions, resolutions, techniques, and outcomes in the development of the PhD. Images are generally to be read in columns from left to right and the captions work as descriptors and to explain the thinking behind the images.

As a practitioner who works on projects, the text is used as a reflective tool to draw out and clarify observations and conclusions around the physical tests. The documentation in the PhD is done to allow an ease of communication with future practitioners who may have an interest in the nexus between architecture, fashion and textile design in design and fabrication so this discussion needs to be a visual one.

The diagram adjacent illustrates the path of the PhD. This path became clear at the conclusion of the PhD as my interest in working with fashion and textiles underwent a series of projects and reflections in order to find where the work can contribute to knowledge. The path begins prior to the commencement of the PhD where my interests were seeded and then tested and I understood that there was scope to begin a PhD. The project selection is based on tests needed to flesh out the gaps in my knowledge, and gaps in the discourse.

Larger projects are then undertaking to propose solutions and ways to fill these gaps in knowledge. The application of knowledge from fashion and textile design to architecture is shown in the Pleat set of projects, which capture the reflective process and test this knowledge through the construction of a meeting space and the design of two pavilions, Pleat Pavilion and Pleatent.
BEGINNINGS

My early work in the material discourse began when I was a Master’s student at the Graduate School of Design (GSD), Harvard in early 2000. At the time I was interested in practitioners who were engaging with the emerging and growing material discourse. These practitioners were incorporating new materials and new fabrication techniques and technologies. The new materials were lighter and more flexible and included composites, carbon fibre and polymers. The new technologies included robotic arms, 5 axis CNC (Computer Numerically Controlled) machines, laser cutters and 3D printing and scanning which together made it easier to prototype and build physical models. The combination of new materials and new technologies allowed me to investigate the possibilities of working with a range of new and existing material sets, as well as complex and intricate geometries. The material discourse I was exposed to was not restricted to architecture, but involved looking towards disciplines such as fashion and textile design where complex geometry and intricacy are embedded. For me, this exposure to other disciplines opened up an interest in alternative design approaches that could inform and broaden the design and fabrication of architecture.

The discovery of ideas and ways of working happened through the medium of making. I used the process of making as a way to form an idea, uncover questions, answers and approaches. During the PhD I have understood that the translation of an idea into space occurs when the constraints of gravity, material selection and its limitations, connection and assembly are considered and integrated. This can only be done through physical and digital testing and experimentation, and is the key method used in the PhD. By working through the physical tests a direct conversation with fashion and textile design has been possible, and a common language has subsequently developed; a language that adjusts terms from each discipline. The discussion revolves around common issues and constraints that face both disciplines, such as gravity, material selection and performance, connection, assembly and aesthetics. In this sense my practice is a material one that can be described by Stan Allen as, “one that does not comment on the world but operates in and on the world”, where material practices produce ideas and effects through the volatile medium of artifacts, short-circuiting the established pathways of theory and discourse. And the ability of “architecture to generate perceivable experiences and sensations in the world, practical consequences and effects – is more important than its conformance or non-conformance with some abstract set of theoretical criteria.” Allen continues that visual culture and material practices have their own rules, and those rules are different from those that govern texts. In this way, the PhD has looked at the rules that govern architecture and the rules that govern fashion and textile design, working to reconcile the differences between them and allow for a new dialogue that uses the physical artifact as the language of invention.

While there are a range of structural principles that we (architects) work with to deal with load paths or making buildings stand up; by simultaneously working with structure from and skin I have been able to develop architecture that adjusts when the scale, material and form needs to shift. Through the PhD, I have looked at materials before they form a ‘kit of parts’ typical of building systems employed by architects, because the pre-engineered systems conflate issues of structure, weathering, fire resistance, deflection, health and safety and other controls that obfuscates the material potential and the opportunities possible. By isolating materials and reworking how they perform prior to their application into a system, their qualities and structural capacity can be revealed. This thesis looks at materials prior to their systemization, where each material is reduced to playing a part in a whole rather than informing the whole.

The interest in fashion and textile design, then, has come about because these disciplines still work directly with materials, there is no digital tool in the design process that replaces the direct investigation of material and form, and they test techniques directly with fabric to develop ways of creating a garment.

The PhD starts with small physical tests using singular materials that work inform a larger set of ideas. This sometimes lengthy process has been necessary, as the work travels from the scale of fashion and textile design to architecture. Through this process I have uncovered new knowledge that sits in the moments between the disciplines. A nascent logic emerges through this experimentation and constant testing of physical and digital trials. Kwinter describes technique as the engagement of real logics present in the human or non-human environment and their conversion into potential – specifically, into apprehensible, formative potential. Technique then, is design from within, embedded in the outcome, or matter.

This PhD and my practice has been influenced by the unique architecture culture that exists in Melbourne including contact with practices such as Lyons, Studio Bird, ARM, Edmond and Corrigan. These practices have a unique perspective on material, giving priority of the idea over detail which has helped to shape the my practice that were seeded in my undergraduate and masters degrees. Leon Van Schaik talks about Lyons where “they frequently enter into a world in which buildings appear to be ‘things’ – industrial products that could be plucked off a shelf,” or commenting on the Box Hill Institute ‘things’ – industrial products that could be plucked off a shelf,” or commenting on the Box Hill Institute. “It is important to note where" It is important to note where...
1. Speculations
In The Field
SPECULATIONS IN THE FIELD

There is a rich history of architectural practitioners who have contributed to knowledge around working with specific material sets or structural logic in relation to tensile structures employing fabric, or advances around the modeling of complex forms. I have found that there is a gap in knowledge around approaches that seek to develop form, structure, and skin simultaneously where there is no hierarchy of importance and all are used dynamically to inform each other.

The lineage of practices that relate to this PhD fall in line with Mies van der Rohe's legacy of structural expression over pure rationalisation of structure as seen in the Seagram building, where external columns are used when visually required rather than when only load paths demand, in order to communicate something about the structural system used. This is in contrast to practices such as Greg Lynn's advanced parametric form making or Shukhov's tensile structures because these practices do not consider material simultaneously with form or structure, and the expression is embedded with the structural or digital logic only.

From the early interest I had around material qualities, I have fleshed out practices and practitioners who have approached architecture and/or garments in ways that inform my work through the uncovering of new techniques, and boundaries that define the core interests of my practice. The seminal publications, works, practices and designers discussed in this section frame the material discourse, a term I use to distill the large field of work that focuses on materials as they relate to my interests in architecture.

The practitioners and practices included then, are ones who have introduced me to relevant aspects of the material discourse; worked to express the character of a material; experimented with new techniques on existing material sets; used digital fabrication as a way to reconsider materials; envisaged architecture with new materials; used materials to create the poetic; used recycled materials; or collaborated with textile design. I do not include the many publications that catalogue materials for use in architecture without any contribution to built form or physical experiments. I do include practices and practitioners from disciplines other than architecture, such as fashion and textile design, as their approaches and techniques are intertwined in the development of my practice. These include Hussein Chalayan, Issey Miyake, Comme Des Garçon and Iris Van Herpen. I separate the practitioners I have worked with directly from the ones I refer to via publication or exhibition only. This is because the collaboration I seek is about developing new territory between the disciplines, rather than being influenced by their work from a distance. For example, Jenny Underwood's independent textile work does not directly influence my approach, but rather her grasp of technique and ability to work across scales with me to develop a common language, that I then applied to architecture.

EARLY EXPOSURE TO MATERIAL AS A FOCUS

Toshiko Mori was the Dean of Architecture at the Harvard GSD and a practicing architect when she curated and edited an exhibition and subsequent publication titled Material Immaterial, Architecture, Design and Materials Millennium Matters in 2001. This publication was a reaction against the digital model and its lack of investigation around impact, effect, or result. The stated intent of the exhibition/publication was to "re-look at and making how this was always the domain of architects, that there needed to be a re-look at how we make things and acknowledging that new technologies allow us to reclaim this lost territory...By understanding materials' basic properties, pushing their limits for greater performance and at the same time being aware of their aesthetic values and psychological effects, an essential design role can be regained and expanded." This publication, together with a seminar I took with Toshiko Mori and Dai Fujiwara (then the textile designer for Issey Miyake and co-creator of the "APOC – A Piece Of Cloth"), exposed me to a collaborative way of working across non-architectural design disciplines. This approach allowed for an alternative perspective around fabrication and technique. The sensibility of playing with fabric, a non-architectural or non-structural material, was intriguing to me, laying the direction for my practice and PhD.

During this seminar we were exposed to intricacy and pattern through the APOC range of clothing. Each garment was digitally knitted, constructed from self-knotting thread patterns that allowed the wearer to customise each purchase by cutting away at the pattern without unraveling the garment. The wearer could turn a dress into a T-shirt, scarf, skirt, socks or gloves. The embedding of pattern and structure within the garment reduced waste and the need for hems or seams, and was functional as well as beautiful, demonstrating a novel way of integrating material, structure and pattern.

Springing from this seminar, I produced a series of ‘Paint On Structure’ models that worked to give an illusion of a self-supporting thin piece of fabric by using glue to stiffen areas of the fabric. The glue would act as the structure in the same way a beam or column would. These experiments gave alternative ways of thinking about structure and material, such that the structure becomes indistinguishable from the material. This also expanded my interest into the Floppy range of materials and away from typical architectural palettes that require a separate frame.

These Floppy materials generally refer to fabric but can also refer to any material that fails when there is not enough support. When investigating the Floppy, I found a need to look beyond architecture in order to source techniques and approaches from disciplines well versed in these materials, namely fashion and textiles. These disciplines have knowledge of working with Floppy materials and have developed techniques to manipulate them. By selecting a Floppy material palette, the challenge for me was to communicate material qualities without rendering them as decorative only. This meant asking questions such as: How can the material character be protected from the process of architectural fabrication?, or How can we communicate the illusion of the material standing up by itself?, or How can the tactile nature of the fabric be included in the fabrication?. The early work grounded the direction of my practice, where there was a focus on working with singular material palettes in order

1.05 Laminate experiments

1.06 Laminate experiments

1.07 Laminate chaise lounge

Leanne Zilka - Paint on Structure. Application of Super glue onto linen to create rigidity and enclosure.
to develop knowledge around how to express their qualities. These qualities disappear when applied to a substrate or are incorporated into a structural system. This is why I looked at materials that have been separated from their system, as is the case with veneers that are adhered to MDF (medium density fibreboard) or plywood.

My focus on a material approach is also influenced by the proliferation of new fabrication techniques, and tools that allow for the digital model to be realised at an architectural scale. These advances have contributed to the shift we are now seeing in the way we design cities and buildings that, up till now, have been solely driven by the invention of steel and concrete. Through advanced digital tools, including digital modeling and fabrication, we can now design and build with materials that have not been included in the architectural palette, IE: Floppy materials.

**PRACTICES THAT EXPERIMENT WITH NEW TECHNIQUES ON EXISTING MATERIAL PALETTES**

Nader Tehrani and Monica Ponce De Leon, when they were practicing together under the name Office dA, were featured in the “Immaterial Ultramaterial, Architecture Design and Materials” publication and exhibition by Toshiko Mori. Office dA worked with singular material palettes, which included the familiar brick, timber veneer, timber siding, and block work; and explored ways of working with materials that gave expression without overtly expressing a separate structural system. One of their installations applied tailoring techniques such as darting and fusing as a way to give timber veneers form and strength. They used the term “2d-3d”, which was adapted from fashion as a way to describe taking sheet material and applying a process or technique to convert it to 3d. Where Issey Miyake was inspiring because of the intricacy of a functional pattern embedded in a garment, Office dA worked to give structure and form to materials familiar to architecture. Brick would drape like fabric to form skin, timber siding would twist to give light to an interior, and block work would incrementally rotate to create transparency. Using material as the starting point and privileging it over other considerations such as site, orientation or cultural reference defined Office dA’s practice, and was also important in the early approaches of my practice.

I spent time working with materials such as laminates, thin aluminum sheets and timber veneers, typically used with substrates, in order to extend the application of these materials. Patterns and forms were tested with the sole goal of making these sheet materials stand up using only themselves with no separate structure. The patterns tested were ones that used lots of material, such as cross hatching laminate, or cellular structures, creating strength through the sheer amount of material. This created a network or field of structure.
Herzog and de Meuron, who were also teaching at the GSD when I attended, are another key practice in this material discourse. They state that “We try to enhance the material, physical appearance of architecture and explore the border regions of the material condition. It is here that ordinary undetected qualities are often revealed. What embodies weight? What constitutes brightness? What is a wall, what is light? These concepts all bespeak our perception of the physical world on a conceptual, spiritual level. And this is precisely the level we want to reach, to target in our architecture: the conceptual level of perception.” Herzog and de Meuron look at the way materials express or can express other forces around them, such as gravity or weathering, in order to reveal something more or unknown about the material. This way of considering material gives the material discourse a polemic to the high detail precedent present in my architectural education, where weathering of any sort was not tolerated and neither was material changing over time.

Herzog and de Meuron work on communicating a material limit – a point where rocks are restrained from falling (Prada Concept); or when concrete might become ruin (Ricola); or when the weight of a building is being held up by a thin slice of metal (Caixa Forum). The Ricola storage building in Mulhouse exposes the exterior concrete wall to the weather, so it reveals its robustness and ability to withstand the elements. The concrete wall is purposely exposed to weathering to express the weight, strength and longevity of the concrete. The concept for a Prada pedestrian shelter also works to enhance the material, physical appearance of architecture.

In addition to Peter Testa, there were Industrial designers whose work resonated with me. These largely Dutch designers used new materials to create objects that again played with our intuition around material weight and purpose. Marcel Wanders’ Rope Chair, was rope dipped into resin, giving the impression of a Floppy structure that is rigid to sit on. The Carbon fibre chair he co-designed with Bertjan Pot used woven carbon fibre, creating an impossibly light weight chair that shocks when lifted. Both of these create juxtaposition between the Floppy and the rigid that we (as architects) are not familiar with. These works broadened my approach, material palette and reference base to include non-architecture practitioners, framing early design studio teaching and early projects which included terms such as ‘brick curtain’, ‘soft laminate’, ‘fibre columns’, ‘pleated room’, ‘pleated tent’, and ‘pleated pavilion’.

### PRACTITIONERS THAT WORK WITH NEW MATERIALS

**Extreme Textiles:** Designing for High Performance was an exhibition curated by Matilda McQuaid at the Cooper Hewitt Gallery in New York in 2005, displaying textiles from a wide array of disciplines as artifacts isolated from their use. These artifacts included items such as carbon fibre I-beams, glass fibre sail cloth, and hi tech camouflage garments. When isolated in a gallery, attention was drawn to their aesthetics and composition rather than their function and purpose. This publications and exhibitions questioned how to build and design with them as they were unfamiliar to the material palettes we as architects were used to dealing with.

We could now dream of weaving a building, with high strength low weight carbon fibres as Peter Testa displayed with his carbon fibre towers. Carbon fibre has a very high strength to weight ratio that makes it possible to use much smaller quantities than steel or timber. The towers proposed by Peter Testa were woven, resulting in a building that combined structure and skin while being transparent. This allowed for pedestrian circulation to become a giant beam snaking through the building. The various loads become patterns that are either a fine scale or a larger grid, depending on the stresses and loads it needed to accommodate. Despite the cost implications and the fact that buildings of this scale have not been built in carbon fibre, the idea around a woven building made of an intricate network of carbon resonated with my increasing sensibility about fabric and textiles, showing a delicate and fragile aesthetic that brought the possibility of applying fashion and textile techniques to architecture.
The digital materialists are an important inclusion in the material discourse, providing another perspective around material manipulation and fabrication within architecture. With new materials and techniques came practitioners who used new fabrication technologies as a way to further push material limits and re-orientate our relationship to material. These technologies allowed for intricate patterns to be fabricated faster and cheaper than before. The early pioneer of robotic fabrication was Matthias Kohler from Gramazio Kohler who ran a workshop at RMIT University with architecture students and practitioners.

Gramazio Kohler worked with materials such as brick in a way that allowed for incremental intricate shifts in the brickwork not possible by hand. Gramazio Kohler were not interested in creating things that looked like Office dA’s brick curtain, but rather in pushing the limits of a material’s capacity to create something that surpassed traditional views of the material. In “Digital Materiality in Architecture” Kohler describes the way a material is used in fabrication can connect us to the material, with the material intrinsically linked to the technique used to manipulate it, influencing the way the material is perceived. For example, brick is stacked by one hand lifting the brick into place and the other hand grouting for adherence. According to Kohler, once the brick is freed from the limitation of the hand and the accuracy and strength of the robot is applied, the perception of the brick changes to something more dynamic and responsive, able to take on forms not seen before. The brick placement is no longer dictated by what the hand can do but rather what can be imagined digitally. Kohler demonstrates how we can change the perception of materials simply by changing the technique used to manipulate them. Brick in this case is no longer simply a unit within a whole, but one that can provide intricacy and drive the form.

Robotic fabrication also allows for a direct relationship between conceptual model and fabrication, a process that previously involved reducing complex form into simplified components to be assembled by hand, compromising the form to accommodate the material system. The digital fabrication practitioners see a faster and more expensive way of pursuing the construction of complex form. Iwamoto and Scott edited a book titled “Digital Fabricationscht”. The book documents large scale installations that employ various fabrication techniques and demonstrate the variety of ways the digital model becomes a realised project. Extending the ideas from the Toshiko Mori edited book “Immaterial Ultramaterial, Architecture, Design and Materials” publication, “Digital Fabrication” was done in the early days of digital fabrication, when laser cutters were only just becoming widely available in design schools. The full scale fabrications showed me that the intricacy seen in fabrics could be scaled up to an architectural scale. Part of my process includes the translation between idea, digital model and constructed project, where the material condition works to inform the fabrication idea.

POETIC MATERIALISTS
I include the Poetic Materialists, a name I use, because this group use materials as the key driver in delivering their vision of architecture. I understand the Poetic to mean when the whole vision of a project reaches a point where it addresses all aspects of a building “program, site, materials and construction”. This group can be explained through Sean Godsell and Kerstin Thompson, who seek to create atmospheres using the materials. For example, Sean Godsell’s St Andrews Beach House shows a mono material use that relies on its inherent transparency to create views out as well as interior lighting effects. Godsell is interested in the reality of the construction to make it appear as if the space is formed out of the material. I work to communicate something about the material condition and make this condition an active participant rather than a passive one that is manipulated according to the vision of the space.

Poetic Materialists have been a significant group for me to polemicise against. I too employ mono-material palettes that do all the work from structure, skin to architecture. However I differ from this group in that I am not interested in the atmospherics but rather the architectural object, which is produced after putting the material to reveal its condition then using this to make it stand up. So I fold, pleat, dart and seam smaller samples of the material, then using this to make it appear as if the space is formed out of the one material.

I work to communicate something about the material condition and make this condition an active participant rather than a passive one that is manipulated according to the vision of the space.
ARCHITECTURE AND TEXTILES

The work of this group was a revelation to my practice, as I was seduced by the aesthetic possibilities for architecture. Sheila Kennedy from KVA (Kennedy Voilich Architects) is the key figure here. She is a practitioner and educator based at MIT but was teaching at the GSD when I attended. I saw her studio teaching and viewed processes and techniques she taught around working with technology embedded flexible materials. The material that I found most fascinating was the film and fibre based electroluminescent materials and their application to architecture. This provided the grounding for my work with the Glow materials, discussed later on. Kennedy worked with the fibre based electroluminescent materials as a way to tackle the problem of access to light in remote communities. Electro luminescent materials are produced in fine fibre form and require small amounts of energy to illuminate them. The materials were attractive to Kennedy because they could be incorporated into traditional textile making, providing an easy manufacturing solution for these isolated communities.

The electroluminescent tapestry Kennedy designed was a beautiful solution to embedding technologies into space, and drove the beginning of my practice where I focused on collecting a range of techniques that could be used with fibres. Another project by KVA was the Soft House. The walls of this speculative house were to be constructed of textiles embedded with power and data, and were flexible in their arrangement where they could be moved and drawn like a curtain. This work seeded my interest in Floppy materials as it gave the effect of ephemerality and tactility, effects that can only be simulated with conventional sheet materials. Kennedy published and taught from the standpoint of responsive materials and their technological benefits to being able to harvest energy more efficiently. I was seduced by the aesthetics apparent in this way of working.

ARCHITECTURE AND TEXTILES

The work of this group was a revelation to my practice, as I was seduced by the aesthetic possibilities for architecture. Sheila Kennedy from KVA (Kennedy Voilich Architects) is the key figure here. She is a practitioner and educator based at MIT but was teaching at the GSD when I attended. I saw her studio teaching and viewed processes and techniques she taught around working with technology embedded flexible materials. The material that I found most fascinating was the film and fibre based electroluminescent materials and their application to architecture. This provided the grounding for my work with the Glow materials, discussed later on. Kennedy worked with the fibre based electroluminescent materials as a way to tackle the problem of access to light in remote communities. Electro luminescent materials are produced in fine fibre form and require small amounts of energy to illuminate them. The materials were attractive to Kennedy because they could be incorporated into traditional textile making, providing an easy manufacturing solution for these isolated communities.

The electroluminescent tapestry Kennedy designed was a beautiful solution to embedding technologies into space, and drove the beginning of my practice where I focused on collecting a range of techniques that could be used with fibres. Another project by KVA was the Soft House. The walls of this speculative house were to be constructed of textiles embedded with power and data, and were flexible in their arrangement where they could be moved and drawn like a curtain. This work seeded my interest in Floppy materials as it gave the effect of ephemerality and tactility, effects that can only be simulated with conventional sheet materials. Kennedy published and taught from the standpoint of responsive materials and their technological benefits to being able to harvest energy more efficiently. I was seduced by the aesthetics apparent in this way of working.

RECYCLED MATERIALISTS

Recycled materialists are of interest because of the priority they place on their selected material palette to communicate an idea. Their work seeks to express the recycled nature of the materials, rather than hide this history. Early on in my practice, I was working with offcuts of waste materials, usually because laminates and veneers were not available without a substrate. Suppliers would only allow me access to damaged, end of the line materials that were going to be thrown away as waste.

Architectural practices such as Phooey Architects and Six Degrees create spaces from the materials they have collected. These material collections are often accumulated and stored in warehouses or are discovered on site. They seek to advertise the recycled nature of their materials, looking to express their aesthetic as part of the design. There is investigation around ways of working with the waste materials, for example where new systems are created to accommodate the material, but this group does not want to disguise them or obscure their origins. The material conforms to the design, adapting to the demands of the architect. They do no make recycled steel perform in ways we are not used to nor develop a way of working with the material that subverts is structural nature, rather the materials simply adapt to the different functions. Phooey, an architectural practice based in Melbourne, uses recycled materials as an advertisement around waste and reuse trends seen in other industries, offering alternative ways of designing with found materials. They choose to expose the raw recycled materials as a way to draw attention to reuse, allowing architecture to participate in the larger global concern for environmental responsibility. To me, the material’s qualities or conditions are of secondary importance in this work and the way form is generated is not driven by the material.
FASHION AND TEXTILES
While the PhD and contribution to knowledge lies in the realm of architecture, I include fashion and textile designers in my community of practice, as their techniques have assisted in the conceptual framework of my practice when working with the Floppy. Fashion and textile design excel at creating illusion and effect with the body where fashion pattern manuals detail how to make different pleat patterns for different effects: a Double Pleat is described as “when the pleats are opened out, they have a visual effect of depth due to the different layers”, while a Fluted Pleat is “...used to uniformly join a large amount of cloth to a smaller base without making the fabric more voluminous”; and a Plissé Pleats has a “...final effect of flawed natural beauty.” Like architects, fashion and textile designers work to translate ideas into finished garments and this translation travels through simulations and sampling or croquis. Croquis is a term used in fashion and textile design that derives from the word ‘sketch’, where the ‘sketching’ is done through the act of making samples that are trialled on the body or as small samples that test pattern, shape and construction, calico and toile. This is similar to the way architects develop ideas around form, structure and materials. The fashion and textile designers I have worked with directly include S!X fashion led by Denise Sprynskj and Peter Boyd and Jenny underwood, a textile design academic at RMIT University. Each discipline has a way of working that has taken time to understand as well as shed misconceptions around. The direct engagement with fashion and textile designers is woven into the way I practice and has allowed me to develop a practice that looks to materials or non-architectural starting points to develop ideas around producing architecture.

I describe three fashion designers whose work falls between space and the body, and who bridge these differing scales. Hussein Chalayan, Iris Van Herpen and Rei Kawakubo, work separately but can be grouped together as they work between the body and space and/or employ architectural tools and techniques to develop their garments. Their connection to space is anchored back to the shape of the body, exposing moments of where the body sits in relation to their garments. This shift between the two scales was pivotal in assisting the resolution of intricacy and architecture in my practice, where there are seemingly irreconcilable scales.

HUSSEIN CHALAYAN AND SCALE
Chalayan collaborates with engineers and architects, applying their knowledge of structural and formal language to the design of his garments. He sees all objects, structures, and architecture as externalisations of the body. Chalayan’s pivotal collections happened around early 2000, and his perspective of the body and architecture are integrally linked. This has helped me to shift scales from body to building, where clothing defines the intimate zone around the body and architecture defines a much larger one. The jump in scale between fashion and architecture has been a central concern in the development of my practice as concepts that work at the scale of the body cannot be easily enlarged to the scale of a building. Likewise, building scaled concepts struggle to shrink down to the scale of the body. This scale shift between fashion and architecture often results in something that ‘looks like’ the other but loses all material connection or behaviour as soon as the scale increases. Typically the results are based on images rather than the discovery of the processes used in the image. Chalayan sees the built environment and the body as all connected and not as separate entities. His garments can often become shelters or pieces of furniture where he collapses skirts into tables, or expands them into a canopy. There is a dialogue between the individual garment and the space it occupies, and the construction works to hide the mechanism or the structures that allow for this garment to become shelter. Here the garment is the architecture and the architecture is the garment. This way of thinking about scale, garment and space informed some of the early experiments with laminate and other fragile materials as well as working on hiding rather than expressing the structure.
COMME DES GARCONS (REI KAWAKUBO)

Comme des Garcons - lead by Rei Kawakubo, works with the silhouette and the space between garment and body. Kawakubo uses these spaces to exaggerate and emphasise parts of the body. In Kawakubo’s Bump collection, the exaggeration in the garment works to reconstruct proportions of the body, re-thinking the relationship of the shoulder to the waist and the waistline to the hem, without taking any notice of the underlying body. Kawakubo’s garment patterns rarely correspond to natural body proportions and fabrics are often draped or wrapped around the body with sleeves, collars, pockets and fastenings in unusual positions. Kawakubo believes that architecture and fashion have a great deal in common; where like architecture fashion is a construction of space.

IRIS VAN HERPEN AND INTRICACY

Iris Van Herpen works with parametric modeling and advanced manufacturing techniques typically used in architecture. Van Herpen collaborates with architects such as Daniel Widrig, Isaie Bloch, and Jolan Van Der Wiel, who are at the forefront of digital fabrication and material invention. Many of the patterns created in Van Herpen’s work come from the digital model rather than the manual manipulation of calicos or toiles typically used in fashion design, where the designer works with cotton calico fabric on a mannequin or body in order to develop form, structure and construction. The work, done in collaboration with Isaiie Bloch, produced a pleated torso structure that allowed for pattern and structure to interconnect with each other. This garment is a 3D printed object, bypassing the traditional toile process. By using the digital model and 3D printing it, the design stays as a rigid structure that is quite foreign to typical garments that move with the body, here the garment expresses form over movement.
ESTABLISHING THE PRACTICE AND THE PHD – TESTING TO DETERMINE A GAP IN KNOWLEDGE

It is important to reflect on the range of projects undertaken that tested the PhD and where it might make a contribution to knowledge. These segues functioned to define the boundaries of the PhD and the core of my practice. They were either experiments that tested assumptions around material, structure and form, diverted into other directions to test the boundaries of the PhD, or design studio teaching that contributed to the methodology of my practice. These projects include the Brick Curtain House, Timber Slat Screen, Pre-Fab, and the Hawthorn Brick House.

ON TRACK PROJECTS

BRICK CURTAIN HOUSE

Experimenting with the concept of using the stacked brick to mimic a curtain as seen in the unbuilt Casa De La Roca house by Office dA, I worked on The Brick Curtain House. The Brick Curtain House was an extension to an existing exposed brick Edwardian detached dwelling, that used a single skin of hit/miss brick pattern designed to look like a brick wall that had been drawn apart as a way to link the new extension to the old Edwardian brick construction. I set out to design a brick wall that looked like it was being drawn open to reveal the living areas, where the folds would become the vertical supports for the single skin wall. When working with an engineer, it was clear that the single skin wall would need additional continuous vertical support in the form of steel columns to ensure wind loads could be resisted. These steel columns were placed at rear of the wall folds, concealed from the main view. This hiding of the columns gave the illusion of a single skin brick wall that was rigid due to the folds. At the beginning of the PhD I wasn’t sure whether I should include this project, as it seemed like a failure due to the use of columns that made the folds in the wall merely decorative. The Casa De La Roca house delicately connects the brick wall to the roof beam as if it were a track where the folds in the curtain crease more at the edge of the curtain, reinforcing the illusion that brick skin is as light as fabric. Upon reflection, the decisions made to firstly use the columns for support and to continue with the single skin despite its lack of strength works to give the effect of a folding wall. The structural purity is of less importance than the communication around experiencing effect.
TIMBER SLAT SCREEN
The Timber Slat Screen was a second smaller project that learned from the Brick Curtain house, showing a path towards the Pleat investigation discussed further on in the PhD. This was a small timber screen that used standard timber sections. The screen begins as a vertical double layered wall that registers the pushing of the table and chairs. This pushing creates a spatial niche for the furniture, where the timber pieces move to accommodate the force. The clarity gained from the Brick Curtain House and the fact that a single skin was not sufficient is rectified here as a double skin that hides the bracing between the skins. Here form, effect and material are working together in a way that tested the idea of using enough material initially to accommodate any effect that I was going to test, whether that is push/pull, fold, pleat, stretch etc. In this way, it provided the precursor for the Pleat projects.

HAWTHORN BRICK HOUSE
When playing with materials and effect, the main goal was to produce form which developed in unexpected ways, or ways that were not always predictable from the outset. In the Hawthorn Brick House, I experimented again with developing form through effect, but not from a material starting point, rather manipulating an envelope that was an abstract volume determined through the program and site qualities, not a stack of timber slats, or a pile of bricks or a pleated fabric. The envelope was warped and lofted to make it respond to site/program.

The lack of material specificity resulted in a house that did not develop new knowledge for the PhD. It did however reveal that working with a material and effect and not envelope, volume and effect was important. By omitting the material condition of the brick in the design process, the outcomes are divorced from the process.
1.35. Leanne Zilka - Sketch Hawthorn Brick House
Simple extrusion from ground to first floor. The vertical lines represent fine steel structure to follow curves.

1.36. Leanne Zilka - Sketch Hawthorn Brick House
Idea is to make skin conform to changes in shape.

1.37. Leanne Zilka - Sketch Hawthorn Brick House
Simple extrusion from ground to first floor lofts between discrepancies in floor plate area.

1.38. Leanne Zilka - Sketch Hawthorn Brick House
Skin study

1.39. Leanne Zilka - Sketch Hawthorn Brick House
Skin study – metal threads protruding from openings

1.40. Leanne Zilka - Sketch Hawthorn Brick House
Skin study with brick

1.41. Leanne Zilka - Sketch Hawthorn Brick House
Skin study with brick and openings
OFF TRACK PROJECTS
These projects describe some of the misdirections taken during the PhD, which while not relevant to the final conclusions, worked to flesh out where the practice lies. The PhD started with a focus around material systems. Prefabricated systems were explored in order to find an application for the research. The prefab investigation occurred just after the textile experiments with students, and I was concerned that the length of time needed for these ideas to generate architecture might mean the knowledge would not be able to applied in practice, but rather stay within the confines of the PhD. From these concerns I decided to investigate the use of pre-made systems to see if this direction might free up the material investigation and redirect to expand my spatial knowledge.

PREFAB
The Pre-Fab studies were based on a prefabricated wet area unit that was built within a custom made shipping container, delivered to site where the remaining house would be constructed around it. This system is used to reduce time and cost on the most labour-intensive part of a dwelling.

Several projects were tested using these Pre-Fab wet area modules, to determine how a material system could be integrated spatially. The result was a series of accommodation types that used the Pre-Fab unit as the anchor point for the program to revolve around. Where the textile design work resulted in a relationship between body, space and material, the prefab work sought to mimic this by developing a relationship between prefab, program and exterior envelope. The results of these prefab projects failed to produce new knowledge around materials and their relationship to form, as the system was not able to be altered and so there could be no specific material exploration.
2. Floppy Logic
Developing an understanding of the Floppy by working with fashion & textiles

I have coined the term ‘Floppy’ to describe the quality in material that requires extraneous support to produce architecture. Floppy generally refers to fabric, but can also refer to any material that fails when there is not enough support, as is the case with sheet materials when the span between supports exceeds a certain length. During the PhD I have worked to define and redefine the term Floppy, to assist in distilling the large body of work in the material field, the material palette and the relevant techniques. I have been drawn to the aesthetic and tactile nature of fabrics or sheet materials where I work to bring their conditions into architecture. From this I have discovered novel ways to judge material behaviours, and techniques to create form. Working with the Floppy range of materials requires exploration around the material’s condition and how these materials behave when manipulated. The Floppy allows for invention because of its unfamiliarity to architecture, where rigidity is a priority.

A primary way of working with the Floppy was through simple models made by hand that either worked with a pattern, such as pleat, or material, such as laminate. By physically testing each idea with the material, I could see how incremental shifts affected the material. This accumulation of knowledge contributed to my aesthetic development which now allows for decisions without the need to repeat the earlier tests.

The pursuit of the Floppy and the expansion of approaches that can be used to develop the Floppy required collaboration with fashion and textile design in order to observe and understand new ways of working with materials that are not in the realm of my architectural knowledge. This section looks at the work done directly with fashion and textile design and shows the emerging logic developed over several projects, culminating in a set of limits. These boundaries help define where working with fashion and textile is helpful; where it fails; and how it has been used as a way to conceive the merging between structure, skin and space. Throughout the PhD I have sought to establish a way of working with these disciplines in order to learn and then apply the knowledge to architecture.

The processes described in this chapter have framed my practice and allowed me to judge when these processes produce space and when they cannot. The translation from a Floppy textile to a rigid structure requires the textile croquis, to be constantly visualised as space, then edited back as a textile, then re-envisioned as a space. There were many failures in developing this way of working, largely because either the textile sample was not scalable, or did not produce much more than a curtain or window covering.

There are two main ways in which I see failure occurring. Firstly, where there is too much extraneous structure required, resulting in a fabric that becomes decorative only and/or a superficial skin. Secondly, when the experiments produce a naïve understanding of fashion and textile design, and words and or images are the only collaborative point. For example a ‘pleated surface’ that may be a folded sheet of material fixed to a separate frame for support, where the folding only functions as decoration. Or ‘draping concrete’, where a mold is built out of timber or foam and then concrete is poured and set. There is no connection to the idea of drape (the hanging of cloth from the body) other than the visual effect.

The relationship between architecture and textiles has had a long history in architectural discourse, but there is always a separation between architecture and textiles: one (textile) is always submissive to the other (architecture); the architecture stands without the need for the textile but the textile always needs the architecture. In “Undisturbed”, Beatriz Colomina talks about SANAA’s installation in the Mies Barcelona Pavilion, as a reminder that the “Barcelona pavilion comes from curtains, from a soft material. The beginnings of architecture were textile”. It is a Semperian idea of architecture, adopted by Loos who wrote: “The general task is to provide a warm and livable space. Carpets are warm and livable. He decides for this reason to spread one carpet on the floor and to hang up four to form the four walls. But you cannot build a house out of carpets. Both the carpet on the floor and the tapestry on the wall require a structural frame to hold them in the correct place. To invent this frame is the architect’s second task”. This PhD rethinks this relationship between building and textiles, asking: Can you translate the material conditions in textiles to architecture?

Annie Albers, artist, industrial designer, educator, and textile designer, looked at textiles as similar to buildings despite the vast difference in scale. Both she says, construct a whole from separate parts that retain their identity, which is very different from working with metal, or clay where parts are absorbed into an entity.
RESEARCH LED DESIGN STUDIO TEACHING

My Practice has developed and defined itself through the incorporation of strategies and techniques from fashion and textiles initially developed in the design studio teaching. This early testing has been an integral part of developing the techniques, strategies and knowledge around working with these diverse disciplines. Research led design studio teaching is where assumptions around other disciplines were overcome, ways of working with the Floppy range of materials developed, application of these ideas and tests with architecture occurred, and the application of textile technologies in the fabrication of full size prototypes occurred. I have found the research led design studio teaching allows for the discovery of common ground between the disciplines and a space to exchange ideas and techniques, through direct discussion rather than the distant one that occurs when the collaboration is text or image based only.

The decision on what to base a design studio around comes directly out of questions and problems I deal with in practice. For example there are moments at any stage of a project where I am unclear of how to progress or what direction will work. The design studio teaching gives a place for the discussion centred around the artefacts produced, rather than discussion alone. These ideas are nascent in text or discussion but revealed through the material experiments.

The teaching is situated at RMIT University in the School of Architecture and Design and collaborates with the schools of Fashion and Textile Design. The teaching is organised in small cohorts of architecture and textile design students, or architecture and fashion design students, with input from other disciplines, such as aerospace engineering, who have expertise in working with non-standard fibre based structures. This discipline combination work to test ideas, develop physical samples and then propose larger architectural propositions.

At the beginning of the design studio teaching, students are given minimal constraints in order to allow for a common ground to be discovered between the students. Once an idea is initiated, which could be a textile student bringing in a small croquis, or a fashion student showing some of their previous work, the architecture student works to spatialise the idea. Due to the Floppy nature of the textile samples, this can involve a suspension of the physical sample from a frame; a digital model mimicking the sample; or sketches around possibilities for architecture. The textile student revisits the croquis or creates something entirely new, to a scale that again can be spatialised by the architecture student. This process is repeated until there is a direction that has the potential to produce architecture and is done over several weeks, with the textile or fashion practitioners and myself editing the work and providing options for students to pursue. I look for the potential of a croquis to accommodate structure skin and enclosure. I have reduced the constraints as a way to free up experimentation and allow for more risk taking around aesthetics, form and structure. Once these appear, students can go on to address other complexities needed to produce architecture. Running studios where the brief, program, site and other constraints are given early on in the process, fragments the explorations, and results in projects that do not fully utilise the skill sets of the other disciplines. Fashion, textile and engineering disciplines do not have the skill set nor the interest to discuss program or site.

From the textile collaboration, working iteratively with the small textile croquis to architecture scale allows for a clear way to understand what works and what fails, as the small models replicate larger issues. This is where interest in the material condition has developed, where behaviours are understood and how the collaborations lend themselves to scaling from small handheld models to larger architecture.

The following description of working with fashion versus textile design gives an insight into the exploration taken to develop a working collaborative model. I have searched for a meaningful relationship between architecture and fashion and textile design because I have been aware of previous projects, both my own and others'. I found when assumptions around other disciplines were made that are naive or uninformed, there is no possibility of discovery in the territory between the disciplines.
WORKING WITH FASHION DESIGN

My experience of working with fashion design students and practitioners reveals perhaps the most significant gap between how fashion design develops garments and my naive assumptions around where the priorities lie in this process.

Fashion design is a diverse field in itself, as is architecture. Each practitioner or student has a range of interests that are manifested in the garment, rather than my assumption, that the garments manifest the idea or the technique drives the idea. This incorrect assumption was most likely because of:

1. My initial exposure to fashion designers where technique was the key driver. These include figures such as Issey Miyake and his Pleats Please and APOC range; or Iris Van Herpen and her laser cut and digital print garments. These fashion designers talk specifically about technique first, and it is clear that the innovation within their practice is around the manipulation of materials.

2. The hacking of fashion and textile terminology by architects. Architects such as Office dA have used fashion terms to give alternative ways to think about fabrication, as seen in the darted timber veneer installation in the Material Ultramaterial publication and exhibition26. For Office dA, the dart is a way of connecting delicate veneer pieces to each other to produce an undulating surface, however when discussing this term with fashion practitioners, there is a much richer understanding of dart when dealing with form as it relates to the body.

I worked with Denise Sprynskyj and Peter Boyd from S!X fashion label and RMIT Fashion Design in a collaborative design studio. Their practice is described as having an interest in revisiting existing garments and then altering them, picking them apart and reworking them in a new way that may reveal something about the structure, material and design. This information is then used in the development of new garments27. While the techniques they use are critical to the realisation of the garments, in the design studio teaching they were tacit rather than explicit.

Technique with Denise and Peter was discussed separately from other complex ideas around garments, and I think they assumed the same around architecture – that our groups of architecture students could separate technique from other interests. The studio therefore progressed without the small scale fabric investigation I was interested in pursuing, and while the projects were interesting and had a high level of conceptual thinking, the exchange did not satisfy my need for experimentation with fashion techniques.

The most successful pairing of students in these studios was between Pia Interlandi, a fashion design student who was interested in pursuing biodegradable fabrics; and Linda Valentic, an architecture student. Their process began with Pia Interlandi presenting some of her work on dissolvable fabrics that were light weight, ephemeral and through the disintegration process produced intricate patterns. These dis-solvable fabrics had no inherent structure, so manipulating them, through folding for example, did not work, as they were destroyed by applying too much heat or water. The pair took a piece of the semi-dissolved material and 3D scanned it to convert the patterns and appearance into a digital model. The material could not be drawn in any other way due to its random pattern and delicacy. The results of this scanning produced a highly triangulated volume that was then manipulated by the architect into a space. Because of the intricate triangles, building a physical model was almost impossible without some digital assistance so Pepakura, an origami program that converts 3D volumes into a 2D folded pattern, was used to assist in the 3D physical models. The combination of working with the raw material, 3D scanning technology and the Pepakura program allowed for some of the complexity of the fabric to be kept during the dramatic increase in scale required to go from body to building. It also showed that many approaches need to be tested in order to convert the material scale to a building scale, and that the architectural parameters around structure skin and enclosure can be introduced incrementally.
WORKING WITH TEXTILE DESIGN

I began to work with textile design after the collaborations with fashion design. The experience with fashion reinforced my initial instinct around technique being the central driver in the desire to collaborate with disciplines who understand ways of working with Floppy. Through discussions around technique with Jenny Underwood and her fellow RMIT textile design practitioner Esther Paleologos, it became clear that we shared similar curiosities around each other’s respective disciplines. In addition to this was the fact that Jenny Underwood completed a PhD titled The Design of 3D Shape Knitted Preenorm® which looked at expanding the use of 3D knitting technologies to create complex form for uses in the aerospace industry and building componentry. Jenny’s understanding of 3D form meant that discussions around space and fabrication would be possible. The productive work done with textile design is largely due to Jenny’s ability to jump in scale between the two disciplines, and her understanding of the knit fabrication technologies, which I am aware may not be possible with other textile designers.

Students in textile design at RMIT are split into technique based groupings such as knitting, weaving or print making. The collaboration with such diverse techniques gave the architecture students a rich palette of approaches to choose from. In the early groupings, textile design students would initiate experiments with knitting or printmaking as a way to provoke discussion. Architecture students would then work with these croquis, suspending them from a frame, or stretching them between their hands to test for form and enclosure. Once a common idea was agreed upon, the architecture students would work digitally to develop a set of forms based on their interpretation of these tests. The textile design students would work to develop the pattern and structure further to assist the visualisation of architecture, and clarify the idea further.

In the early stages of the collaboration there was no scale to the croquis made, but there were discussions around what the patterns represent (structure, openings, material change); how these studies might be envisaged as architecture; and what would need to happen to make the croquis stand independently. This would mean adjusting the patterns, giving them a hierarchy of structure and/or changing the material used.

One exemplar pairing was between Vanja Joffer (architecture student) and Danielle Thiris (textile design student – knitting), who worked together on Danielle’s knitted croquis to produce a set of ‘Y’ shaped structures that were stiffened and linked together with fine fibres. This process incrementally scaled the delicate knitted croquis to larger sized structures that could be stretched between frames. Once in a frame, clarity around floor, wall, and how the textile could create an enclosure emerged, and due to the fineness of the textile became a transparent network of material. This model was studied to clarify the different conditions that were working to create the form, as there were a variety of elements that were bifurcated, contained one knitted pattern, changed dimension over the length of the knit, and were denser in parts and more open in other parts. This categorisation assisted in the design of a full enclosure at the conclusion.

Another couple, Dominque Hall (architecture student) and Courtney King (textile design student – print making) explored patterns. In this pairing, the architecture student digitally generated graphic patterns which were then converted into a fabric print by the textile design student. The print was composed of a fine nylon and puff paint (a paint that becomes 3 dimensional when heat is applied). The fabric substrate is then peeled away, revealing an intricate structure. Aerospace engineering students were invited to give input around how to make the croquis stand up, where they looked for a hierarchy in the patterns around load paths, narrowing the discussion to basic structural elements of cantilever and column. This allowed for the designers to scan their models for these same structural patterns, as a way to ensure their tests were embedded with these principles.
The design studio teaching with textile design produced possibilities for architecture, which included:

1. Understanding that textile design allows for space to be constructed with a very fine structure but more frequency than typical materials used in architecture. Textiles are made up of large amounts of networked fibres, where each fibre is necessary for the whole to exist. If you were to take away a single thread, creating separation in the fabric, this network would start to fail. By working with lots of structure that is very fine, there is integration between skin, structure and enclosure. This differs from the conventional architectural language that separates structural elements like column and beam from the skin, and focuses on the creation of large spans between structures, resulting in a separation between space and structure.

2. Textiles contain a hierarchy of structure. Whole garments, such as a knitted sweater, use a change in pattern to deal with connection or a shift between forms. For example, if you unfold a knitted garment, the pattern serves a function, a sleeve transitioning from arm to shoulder will have a different pattern at this junction, or a sock which is constructed of 2 tubes (leg and foot) turn a complex corner at the heel and the toe; it is the pattern or redirection of a knit at the seam that creates the complex form.

3. Fabrication. Textile design and the development of ideas is directly linked to the technology used. A manual or digital knit is used to explain an idea. There are no digital simulations of garments that mimic how they will behave on the body, rather the textile designer uses physical trials or croquis to experiment. The limitation of the technology impacts the progress of the idea. For example it was frustrating working with weaving, because unlike a knit it is essentially a flat piece of fabric that can cope with different 2D patterns and perhaps colour shift, but is not able to take on a third dimension needed to produce architecture. Weaving cannot take on form in the same way as a knit can be made into a tube for example. This realization occurred in the studio and discovering that a 3D weaving machine was only able to give a fabric a thickness and not a form.

4. Scale. Textile and fashion design do not refer to scale in the same way that architecture does. Textile and fashion design might talk about the scale of a pattern or thread, but rarely do they work at scale separate to the final outcome of the intended garment. So a garment is tested through croquis or toiles which are made from cheaper, non-precious materials. Architecture, on the other hand, always works at a scale less than the final building scale, relying on the digital or physical model to simulate the final outcome. Architects have the ability to discuss full scale impacts from smaller scaled models, so when discussing croquis with the textile designers the architects need to constantly clarify what scale they are visualizing when presented with the croquis. During the design studio, the architects needed to be taught to ensure that they were talking about the outcomes.
2.23 Vanja Joffer and Danielle Thiris. Knitted components of an architectural space. These croquis are designed as beams, columns and struts.

2.24 Erin Metcalf. Textile experiment showing how a textile might become spatial.

2.25 Erin Metcalf. Textile experiment showing how a textile might become spatial.

2.26 Joey Azman. Digital image showing a textile space. Fine structure and lots of it.

2.27 Joey Azman. Digital image showing a textile space. Fine structure and lots of it.
2.28 Glow installation with lights on. Installed in the Design Hub RMIT

2.29 Glow installation with lights off. Installed in the Design Hub RMIT
The first project that worked with the plastic surfaces did not project large amounts of light but illuminated aesthetically beautiful, lightweight and functional. The light qualities of the electro- and photo luminescent materials, electroluminescent materials as a way to assist communities that are not able to connect to an energy grid and need systems to use small amounts of energy. While Kennedy's work experimented with fibre based versions of the material, her research was largely focused on the Glow material applicable to architecture, and initially made to provide visual guidance for egress and evacuation in buildings. I was interested in experimenting with the Glow materials after seeing the work produced by Sheila Kennedy and her work with electroluminescent materials. Unlike photo luminescent materials, electroluminescent materials are not passive and require low amounts of energy to power them. Kennedy used electroluminescent materials as a way to assist communities that are not able to connect to an energy grid and need systems that use small amounts of energy. While Kennedy’s work experimented with fibre based versions of the material, her research was largely focused on the plastic flexible sheet that could be embedded in small industrial objects. The fibre based version of the electroluminescent material was only used in a textile installation, but I felt there was great potential in textile based technologies, as they are not passive and require low amounts of energy to power them. The Glow materials was somewhat of a diversion in the PhD but was necessary in order to understand how these non-standard materials can be used. The behaviours were difficult to understand, because there was no data around light levels, and so trial and error was the only way to use the material successfully. This unknown light quality made it difficult to design with, and so the PhD segued into developing scientific studies designed to measure light levels.

A scientific study into perception and light levels emitted from this material was designed. The material was never going to behave in the same way that conventional lighting behaves. So I needed to understand light levels and how the eye sees, in order to incorporate perception when using the material and its low level of light. Michelle Addington discusses how “the eye does not recognize any of these stimuli in absolute terms, only in relationship to other stimuli in the field of view. Like the rest of the neurological system, the eye is insensitive to constancy, and cannot differentiate between a steady high light level and a steady low light level. We can only determine light levels comparatively. A surface with low light level will appear dark if placed next to a surface with a higher light level.” In other words, the eye sees through contrast and not through light levels alone, and we only need very low levels of light to see, provided there is enough contrast. The minimum threshold of light level is quantified as 0.3 foot candles and once this threshold has been passed, the eye sees through contrast of a ratio of 3 to 1. This means that the more similar the light levels are to the objects or space, the more light needs to be used to create this level of contrast.

In order to quantify these light levels emitted from the Glow materials, a study was conceived in collaboration with Professor Mainwaring that tested when the glow levels from the photo luminescent material matched the levels from a standard light. Two black boxes were made: one contained the Glow material and one contained an artificial light covered with a green tinted filter to mimic the colour of the Glow material. A subject (person) would be invited into a blackened space and we would slowly increase the light level of the artificial light until the subject perceived the light levels as being the same or similar. This information was recorded, and we gained a consensus around the lux levels (light measurement) of the glow. In addition to this study, I also placed large boards, which had stripes of the plastic and paint versions of the Glow in the Graham Street Underpass in Port Melbourne. This was done to understand if the material was perceivable in dark public spaces, and which material was the most visible. By trialling this material and using the design studio teaching again to think about how this material could be deployed, I understood that the material relied on:

- The use of pattern to give a level of contrast between the material and the dark spaces;
- Navigation around a space lit by the Glow materials, requiring ‘reading’ the boundaries of the space rather than seeing the whole space.
2.30 Lindy Hayter - Glow plastic experiments

2.31 KVA - Portable Light Project using electroluminescent materials

2.32 KVA - Give Back Curtain. Woven textile using electroluminescent thread

2.33 Photo luminescent thread
2.34 Glow Lantern Installation at the Frankfurt Opera Plaza, at night. Surrounding light made the glow of the lantern imperceptible.

2.35 Glow Lantern Installation at the Frankfurt Opera Plaza. - During the day.

2.36 Glow Lantern Installation at the Frankfurt Opera Plaza. - At night.
2.37 Photo luminescent Powder in Blue. This is an image of the raw polymer prior to it going into a substrate such as plastic film, fibre or paint.

2.38 Panels mounted under Graham Street overpass in Port Melbourne to test the light quality of the luminescent paint and plastic.

2.39 Perception tests. Two black boxes: the left housing standard artificial light with dimmer, the right has Glow material.

2.40 Perception tests. Two black boxes comparing the light levels between the artificial light on the left and the Glow material on the right.
PATTERN OBSERVATIONS
Dealing with the Glow material and understanding its lighting limitations led to a further investigation around perception and pattern. I looked at optical artists who experimented with perception and illusion as a way to deal with the limited amounts of Glow materials. A graphic pattern using the Glow material could work to create illusion within a space, as well as informing an individual around its limits and how to navigate through such a space. Artists included Victor Vasarely, Bridget Riley, Josef and Annie Albers, and later on Felice Varini. Their work demonstrated a way to incorporate pattern into space in the form of illusion or effect. A series of studies were done that focused on pattern and architecture, as a way to find more common ground between architecture and textile design. Jenny and I then applied a pattern logic to the immersive textile we were designing, that had a mix of Glow and non-Glow fibres.

Architects are well versed in deciphering patterns as they relate to space. Sanford Kwinter explains the significance of pattern by explaining that: “Implicit in this world view is the presupposition that the structure of the world is a product of interwoven patterns”. Kwinter continues by describing pattern as “the means through which the world at once communicates and materially interacts with itself. Pattern is at once the empirical and the abstract.”

There is something fundamental in the way we look for pattern in order to understand things, for example we read depth of space based on the patterns of structure in it.

The discovery of using pattern as a tool to develop links between structure and space came about from the simple need to use the Glow materials sparingly. From this utilitarian need, and the fact that knitted garments are essentially a network of patterns, came the investigation into other patterns that could be used to create structure and form. Other patterns such as origami folds and fashion and textile techniques such as pleating were subsequently investigated in later projects discussed in the Pleat section.
TEXTILES AS ENCLOSURE

Designing textile structures that are immersive, or able to create architecture, lay in finding the middle ground between architecture and textile design. Finding this middle ground was important because, based on the previous experience, when either discipline dominated, failure occurred due to the naive assumptions around the other discipline.

Jenny and I used the techniques developed in the design studio teaching, that were based around working with small croquis then manipulating them until we mutually agreed on a direction. This way of working meant that we were able to incrementally scale the design to form architecture, and test the textile fabrication tools to ensure the ideas could be made. The tests started with dense knits that were manipulated through twisting or plaiting knitted strips that were then digitally modeled in a space to visualise the spatial impact. None of these early tests were successful, as they seemed too craft-like, rather than expressing a system that could become architecture. The breakthrough came when we looked at producing tubes that had more transparency and a readable pattern, over the tightly knitted strips of fabric.

Once the tube construction and pattern was decided upon the Shima Seki digital knitting machines were used to mass produce these custom tubes, making the production of the numerous textile tubes possible. Hand knitting was not possible for such a large installation. The Shima Seki machines are limited in that they are designed to mass produce garments from pre-set templates that include gloves, jumpers/sweaters, pants, hats and socks. The sizes of these templates can change, but not the preset forms. The challenge lay in working within the constraints of this technology while visualising an immersive architecture.

Issey Miyake’s APOC range, mentioned previously in the PhD, uses this same technology, as does the Flyknit installation for Nike by Jenny Sabin (this was completed after the Glow installation but demonstrates the same constraints of working with digital knitting technologies and the limited templates). These practitioners both take part of the available template and change the pattern of the knit.

The Glow installation used tensioned knitted tubes as the basis for a ‘colonade’ of Glow. In order to manufacture the numerous tubes, we altered the template so that it produced a series of sleeves as columns, scripting a slightly different pattern in each tube. The architectural idea was a fibre colonnade embedded with glow, where the Glow would intensify at eye level, then fade away as it transitioned to ceiling and or floor. The intensification at eye level was decided as it allowed for the contrast needed for the eye to perceive the Glow material. This decision was based on the previous investigation around perception and how the eye sees through contrast rather than through light levels alone. As the space between the knitted tube colonnades became narrower, the glow material would be reduced, as less would be needed to navigate through the space. As the colonnade of tubes grew further apart, creating a wider path, the Glow material would increase. The resulting space was of a patterned glow that reflected the compression, and decompression, of the path between the columns. The colonnade was tensioned between the ceiling and the floor using embroidery hoops that were clamped at either end of the tubes. With the lights on, the knitted structure was an ephemeral light fabric that was easy to touch, and when the lights were off, only the green Glow sections of the columns were visible, giving the illusion of a floating green image suspended in space.

The Glow exploration was one that took the material condition of the Glow and designed a space to exploit this behaviour. This contrasts to an approach that creates a space first and then requires the Glow to conform to it, as was tested in the Alte Oper Lanterns. The following images document this process and show how knowledge around the material slowly developed into a space that accommodated the limitation of the material.
2.50 Leanne Zilka. Placing the small croquis in a spatial configuration, with lights on(top) and lights off(bottom). The croquis are simply lining the wall and ceiling.

2.51 Leanne Zilka (Top and bottom). Testing 'patches' of Glow on a metal grid. Left: lights on. Right: lights off

2.52 Leanne Zilka (Top and bottom). Testing metal grid with more glow material. Left: lights on. Right: lights off
2.53 More spatial testing. Lots of fibres, picking up on some of the discoveries from the Design studio teaching.

2.54 More spatial testing. Lots of fibres, converging to allow for an intense moment of Glow.

2.55 Glow visualised with lights off.

2.56 Folding Glow plastic sample to increase intensity of Glow effect.
2.58 Knitted tests. Developing pattern

2.59 Knitted tests. Developing pattern

2.60 Knitted tests. Developing form as a reaction to the flat croquis

2.61 Knitted tests. Developing form through twisting

2.62 The previous knitted tests were too flat and craft-like. The intricacy of the thread was re-investigated

2.63 Thread based investigations, pursuing intricacy and transparency. Glow thread introduced to give pattern

2.64 Further thread based investigations

2.65 Larger knitted panels with different knit patterns tested. These were done to understand scale of pattern

2.66 Knitted panels become more transparent as translucent thread is incorporated. The solid thread represents the low material

2.67 Closer view of the knitted patterns

2.68 Moire effect with the knitted croquis
2.69 Glow knitted croquis, to test pattern with the glow fibres. Geometry of line work difficult to control.

2.70 Glow knitted croquis. Articulation of pattern unclear.

2.71 Glow knitted croquis. Contrast between glow and non-glow is clear in this croquis.

2.72 Digitally modeled croquis. Strips of fabric. Images show lights-on, lights-off effects of the glow material.

2.73 Knitted croquis showing the glow thread position contrasting with a transparent thread, creating the illusion of a ‘floating’ glow.

2.74 Prototyped knitted tubes embedded with Glow.

2.75 Trial install in-situ. Tubes measured to ensure stretching of fabric would work.

2.76 Close-up photo of tube with Glow stripe. Earlier croquis that tested moire effect used.
2.77 Shima Seki knitting machine loaded with Glow Thread

2.78 Shima Seki knitting machine digital templates

2.79 Shima Seki knitting machine digital templates, process of fabrication

2.80 Shima Seki knitting machine digital templates, showing process of fabrication

2.81 Unfolded sweater as shown in the Shima Seki knitting machine digital templates. Patterns show the seams between sleeve and body etc.

2.82 Shima Seki digital image of the Glow knitted tubes
2.83 Digital visualisation of Glow installation. Tubes become colonnades in the space.

2.84 Digital visualisation of Glow installation. Perspective of Glow Tubes

2.85 Physical installation trial

2.86 Plan sketch showing a space that compresses and de-compresses depending on the placement of the Glow materials.
2.87 Digital visualisation of Glow installation. Perspective shows the Glow material increasing as the tubes come closer together.

2.88 Digital visualisation of Glow installation
2.89 (left) and 2.77 (right) Installation of Glow Tubes
2.90 Digital visualisation of final Glow installation

2.91 Plan and elevations of Glow tube placement in the Design Hub
MATERIAL LIMITS – LESSONS FROM GLOW

There were many things learned from the Glow work.

1. The initial light study showed me that the way we view is through contrast rather than purely on light levels alone. This finding gave me an understanding around working with photo luminescent materials and their particular characteristics that can be distilled for use in architecture.

2. Glow is unlike artificial lighting, where a grid of lighting works together to eliminate any darkness. Glow works discretely, to illuminate only the necessary path, and requires the use of peripheral vision to read the limits of the space. There is more a navigation through space, with Glow providing guidance, rather than a whole space being illuminated.

3. When working with new materials, or materials that are not typically used in architecture, there is missing information around their performance that we cannot assume, as we are unfamiliar with the material. These materials are unlike timber, steel and concrete, for example, where we understand the principles that make them stand up, we understand load paths and develop an instinct around what looks right and what looks wrong structurally. These principles are not able to be used when presented with new materials. Instead, further research around a material’s behaviours is required before we can design with it. This need also puts the architect into a position where they are working outside of their knowledge base.

3. The fibre form of the material is not part of the typical architectural material palette (eg sheet, masonry, steel, concrete) and requires the establishment of a way of working in order to use this material in architecture.

4. Adjusting the distance between the body and the material determines how recognisable the fibres are. Too far apart and they become decorative, and too close together and they are avoided. The intricacy of the fibres can only be ‘read’ at a certain distance.

The Glow project allowed for the negotiation between the body, material and space. Kengo Kuma’s publication, Studies In Organic, discusses relationships: “the question is, if architecture cannot be autonomous and can only exist as relationships, then how are the relationships to be designed?” He continues by saying that he is interested in designing “relationships between architecture and the external world through particles. I could not stand to see concrete buildings that are heavy, indivisible masses. For a long time I framed the question as a matter of dual opposition, that is mass versus particles, concrete versus wood. However, when I thought about it, simply breaking up things into fine pieces was not necessarily the answer. In every environment, there is a certain size of particle that is pleasant; our bodies are not comfortable with a particle that is larger or smaller than that…. the body, matter and the environment repeatedly engages in a dialogue until certain dimensions are achieved.” This negotiation between person and material explains the process of taking a garment scaled croquis or smaller, and increasing its scale so that it can become architecture without eliminating the qualities of the fibre.

Materials can transform into something beyond their intended design or typical use. For example fine vertical web-forgé looks harsh and industrial up close, but when placed further away seems soft, almost fabric like, as is the case with the interior spaces of Sean Godsell’s Design Hub building. Another example in this building is the rectangular form composed of galvanised steel frame with circular glass inserts, which is readable up close and further away; the materials are not disguised to look like something else but are expressed as themselves. This contrasts with the discs on the Selfridges store in Birmingham by Future Systems, which are more ambiguous because of the custom fabricated discs that divorce themselves from any familiar treatment of aluminium and the amorphous form of the skin, viewed at a distance that reinforces the ambiguity of the material as it dissolves into form.
3. Pleat
This section discusses a series of projects that revolve around the Pleat, a fashion and textile technique I have explored to develop an understanding around where fashion, textile design can be used to develop architecture, and how the differences in these approaches can be used to develop an architecture that considers material, structure, skin and form at the same time and not a separate processes. Through the design and fabrication explorations of the Pleat, I have applied the lessons learned from the previous collaborations with fashion and textile design, discarded peripheral directions, and established a way of operating for future projects. The projects discussed in this chapter include the Pleat Pod, Pleat Pavilion and Pleatent. These projects have used the process of developing smaller tests or croquis developed through the collaborations to inform the larger architectural propositions of the Pleat projects. The images in this section document the processes taken, problems encountered and resolutions in order to communicate the benefits and possibilities of working in the space between fashion, textile design and architecture.

PLEAT VS FOLD

The differences between the pleat and the fold are important to distinguish, as it is the investigation of these differences that illustrate how fashion and textile design consider pattern, form and structure together and how architecture considers them separately. I compare these two terms because I see Fold as a common and familiar term within architecture and Pleat as its equivalent in fashion and textile design. By looking at the way each discipline considers these techniques, I reveal new territory that lies between the disciplines where there is a rich source of information and approach.

A pleat is a type of fold formed by doubling fabric back upon itself and securing it in place, and is a composition of a set of repeated folds. The pleat is commonly used in clothing and upholstery to gather a wide piece of fabric around a circumference. Pleats are categorized as pressed, that is, ironed or otherwise heat-set into a sharp crease; or unpressed, falling in soft rounded folds. I understand a Pleat to be a combination of pattern and form that involves many folds.

I define a Fold as the act of folding a material back onto itself to create structural stability or visual effect from a sheet of material. I assume that fold in architecture is predictable and controllable, where the act of folding works to strengthen a material and disguise material sizes, giving the appearance of a continuous skin. A fold in architecture does not communicate a material condition, for example how flexible a piece of steel or aluminium is, because once the steel or aluminium goes through the folding process it is fixed to supporting structure and does not move. The fold also does not reveal the if the material is aluminium or steel or the thickness or weight of the material, or how far the material can be pushed before it fails, rather we use it to for effect. The pleat, on the other hand, refers to a fabric that gathers in strategic areas on the body, it is not a continuous treatment but is used at points around the body, for example at the waist of a skirt, allowing the fabric to fall, responding to the hips and then legs. The pleat is dependent on the weight, flexibility, and thickness of the material used, the ‘springing’ points of the pleat, and the form it is attached to.

The functional difference between the pleat and the fold helps to explain the way architecture and fashion deal with form. By working between fashion, textile design and architecture, I see that form in architecture is used to enclose program; address context; express a materiality; and deal with climate and site, where there is an external reason driving the formation of the material. The scale used when developing architecture means there is often a disconnect between the generation of the form (done at a variety of scales with different materials) and its materialisation. That is, the material is
The designers that I mention earlier in the PhD are further referenced here to demonstrate the different ways pleating can be considered. From Chalayan’s Table-Skirt, where he attempts to bridge between body and space, to Issey Miyake’s fine pleated materials that blur the form of the body, to Iris Van Herpen’s use of intricacy to exaggerate form.
PLEATPOD

The PleatPod deals with pleating as a way to create pattern and structure. It began as a competition entry for a meeting pavilion commissioned by RMIT University. The brief for the meeting pavilion asked for 22m² of enclosed space for meetings to go into an open plan office. There needed to be some acoustic attenuation, visual privacy and compliance with the relevant building codes. The site was the RMIT Design Hub, Melbourne designed by Sean Godsell.

The PleatPod marks a turning point in the PhD as the explorations used knowledge gained throughout the collaborations on the previous projects. The many iterations of the Pleatpod worked to clarify what is important to my way of working and where the priorities of my design sensibility lie.

The first submission of the meeting pavilion was called, the KnitPav, and picked up where the glow and textile collaborations with Jenny Underwood ended. Still interested in textile design, I now understood that fabric needs significant structural assistance for it to succeed at an architectural scale and that this ‘assistance’ needs to happen at the same time as the concept is developing. Furthermore I also knew I was not interested in only applying fashion and textile terminology to architecture but finding a direct connection between the qualities of fabric, textiles and architecture. There is a fine balance between ‘freezing’ materials, (rendering them so they no longer possess the qualities of the material, only the appearance) and providing support to simply assist materials which still allow its qualities to remain. I am interested in the way a material behaves where there is discovery through the manipulation and testing on the material directly.

The KnitPav (knitted pavilion) was envisioned as a structured curtain that would hang from a track embedded in the ceiling. Users would be able to wrap the curtain around an interior meeting space when needed and then pack it away, and due to this flexibility, the KnitPav could take on many configurations. This was a direct response to the brief for a solution to open plan offices that require privacy for meetings. The idea for a curtain was still linked to my experience of working with textile design in the previous Glow work, but I also understood the structural limitations of fabric and the need for a support system. The Glow project had tensioned tubes attached to embroidery frames, relying on tension to give form to the textiles.

The KnitPav would have an embedded structure between the fabric to give form and stiffness as it hangs from a ceiling track in the same way a garment hangs off a body. It was to be constructed from an acoustic felt with Glow seams articulating the pattern on the interior. The acoustic nature of the curtain was to act in the same way as stage curtains line walls of theatres for sound insulation.

The embedded frame was inspired by a corset. A structure independent of the garment used to constrain the body and articulate a desired body shape. The corset is constructed of many fine elements to reduce overall weight and allows for many fixing points for the garment to connect to. These intricate structures work to create an illusion around the form of the body47. In this way the KnitPav alludes to an architecture that is supported by a material in the same way that Rei Kawakubo changes’ the form of the body through padding.

Once the KnitPav was shortlisted a process of exploration around how to create it began. The competition images describe an operable curtain that has a form, folding in an origami-like way. At this stage of the competition the pattern was decorative only.

Exploring how fabric could have an embedded structure that also gave it form, began with paper folding. This exploration gave me understanding of what a fold can do to a Floppy piece of paper and how the act of folding can create more rigidity in the paper. Pleating was referenced here as it was a way to expand the potential of the fold to create form.

At this stage of the investigation, I was grappling with scale and how to navigate between the small paper models that were no bigger than A4 or A3 sized sheets of paper. Scaling from paper to architecture asked questions around how to develop form using the technique of pleating without a body for support.

How can we translate the material condition between the different scales? How do you increase the scale of the pattern so that it is not only decorative? Which aspect of the initial design concept is robust enough to cope with the jump in scale? How do you ensure form follows these scale increases?

Using folded paper as a way to investigate patterns was useful as it was clear when the pattern strengthened the paper and when it make the paper weaker. These explorations also tested aesthetics, spatial potential and how the folds would stop at ground and ceiling. When scaling up, material limitations needed to be considered. Not only the limitations of the size of the fabric or sheet material but also its thickness. As the paper samples increased in size so too did the thickness of the material. This was necessary because the material and technique are linked, i.e.: if the paper is too thick the pattern becomes obsolete as the inherent strength of the paper takes over and vice versa, if the paper is too thin the folding becomes only decorative.

The Pleat experiments show, that by understanding the effect of pattern on material, as structural language can develop that integrates stability with pattern and thus pattern can express a load path. The column and cantilever were basic structural principles I used to assess the likelihood that a pattern would create rigidity in the paper. Initially this stability was given through the addition of structure such as sticks to act as columns or doubling up parts of the paper to add strength so it could cantilever. These extra bits of structure were then absorbed into the pattern through longer folds, double folds or shifts in pattern.

Once the logic of fold and structure became clear, the scale of the tests increased. The half scale model showed stability and was then used to test the operability of the panelised pleat. The curving of the form becomes clear and the ‘feet’ look like there is a way to create stability without hanging it off a track or creating a separate structural system.
3.04 Leanne Zilka, Bruce Oakley. Final rendered image of the PleatPod prior to fabrication.
After the work done on the initial KnitPav, the competition required more refinement of the concept around buildability. The name shifted from KnitPav to PleatPod as we were using the pleat increasingly to provide structural support, departing from a solution that would be hung from a track. Working with the pleat pattern made the PleatPod look like a garment that would wrap around a space (an invisible body).

The challenge of how to create a fabric that did not simply hang but held its own weight. The frame became a corset of fine crisscrossed timber that would be hinged at each frame intersection. The fine-ness of the frame would hide the structure between two layers of fabric giving the illusion of a curtain and the glow elements became diamond shape knitted inserts attached to the interior. By focusing on the structure of the ‘curtain’ I was rendering the ceiling track obsolete as it was undermining the fabric by making it look decorative only.

While dealing with scale, pattern, and structure the form of the PleatPod was constantly adjusted and assessed visually to absorb these changes. Even the most incremental shift impacted on the form. Some of the pleated trials gave too much enclosure and others not enough, some options looked less like a pleated enclosure and more like a tent, hitting the ground heavily. The digital model was used to visualise the form and the physical trials tested material conditions, structural stability and pattern. The final form was decided upon when I saw enough variety in the pattern that made the PleatPod look as if it was fixed in motion, or seemed to be in mid-fold. While the reality of creating a fully flexible form was becoming increasingly difficult, working with the idea of a flexible enclosure allowed for the form to shift and change easily. Operability became a technique used to develop the form. The geometry of the final form alluded to a folded architecture, bringing back the lessons from fashion, where the form of the body dictates the behavior of the pleat. The accentuation of the body occurs by expanding a pleat pattern. The ‘body’ in the case of the PleatPod was invisible but was still driving the manipulation of the pleats.

To ensure stability, the final form was given to structural engineers for modeling. The 3d prints gave me confidence that the whole system would stand once assembled but as we were fabricating, over 50% of the elements were unable to stand independently. The engineer studied the form, and material and concluded that the PleatPod would stand once the whole structure was complete. Highlighting the elements that were not able to stand independently and the ones that were stable. The stable panels gave strength to the unstable panels in the same way a cantilever works. The compressed pleats acted as columns and beams supporting the more open pleats. In addition to this the circular form of the plan of the PleatPod allowed for the additional support from the geometry.

Materially, we shifted from only using acoustic board to creating a composite material of MDF, acoustic board and acoustic felt. Only using the acoustic board failed as it sagged over time and its rigidity could not be guaranteed. A more stable board would need to be incorporated to withstand impact from users as well as sag from the acoustic material. The composite panel had MDF sandwiched to an acoustic sheet. This panel would then be dressed or covered with fabric, to give the illusion of a pure fabric structure. At this stage there was confidence in the geometry and the logic of the structure to progress without full scale tests. The 5 axis CNC machine was used to cut out the mitered triangles that were then glued together.

The flexible components were assigned to the entry only, again providing an illusion that the whole structure could be compressed and expanded.
3.08 Rendered images of KnitPav.
KnitPav in open position

3.09 Rendered images of KnitPav.
KnitPav in closed position
HINGE

Working with the idea of an operable curtain drove the initial design of the KnitPav then the PleatPod. The folds in the early paper models were seen as hinges, so when increasing scale this is where the exploration of a hinge remained. Jenny Underwood assisted in developing the connection between paper, fabric and then MDF panels so that the PleatPod would look like a seamless object, folding and unfolding. Jenny's understanding around embedding hinges seen in knitted garments, (the way a sock turns from ankle to foot through a change in the knitted pattern at the junction) was used and resulted in a range of options to create a discrete operability. This was the logic applied to connections between elements in the PleatPod in order to develop a seamless architecture that would hide the composite of materials and connections used and express the form with minimal interference, in the same way that sewing is hidden in garments.

The initial hinging experiments worked with cardboard and masking tape as a way to understand the stresses on the folds when numerous pieces are joined together. As the scale increased there was instability caused by a twisting of the elements. The material scale needed to be in proportion to the scale of the final PleatPod otherwise there would be discrepancy in the behaviours of hinge vs material.

Once the form and hinge system seemed resolved enough we then increased the scale and tested the system with acoustic board and felt. As the acoustic board was made up of 2 layers there was thought around slicing through one layer of the board and using the other layer as the flexible hinge. Part of the PleatPod were made a full scale to test the hinge further.

The trials of the flexible hinge consistently failed and the decision was made to abandon the flexible direction, as it became apparent that it was impossible to reconcile the form with the need for flexibility. The intricate folds and illusion of the structure being a continuous folded piece of material became more important than pursuing operability.

In order to make the PleatPod operable the form would need to be less curved to balance the motion of moving the pleats. The exploration into flexibility while useful in developing form, ultimately conflicted with the form.

The final PleatPod was constructed of, what I called columns that were each made up of eight triangles mitred together. The centre of gravity of the columns changed depending on their shape so the more open or vertical the columns the lower the center of gravity and the less stable the column. When the connections were tested for flexibility the top of some of the columns began to swing and became too difficult and heavy to fold.

Further reflection on the decision to abandon operability has revealed another aspect to my way of working. That is, the iterations have always been made as flexible tests, as this allows me to understand where the impact of even the slightest shift in the form occurs. When I expanded or compressed the folded paper too much the form would not be self-supporting or require too much material. Each movement informing the whole. By using the flexible model there has been an efficient way of viewing the consequences of small shifts on form, structure and skin.

The following pages document the development of the PleatPod from its early stages as an operable curtain (KnitPav), through to a resolved space constructed from a composite of materials. The negotiations between scales and the use of small tests to inform the larger architecture are also shown. The following images illustrate the explorations of the key issues discussed in the Pleat section. These are split into the following:

1. PLEAT - finding the pattern that produced stability and form allowing for the increase in scale.
2. MATERIAL TESTS - documentation of the process of working with the acoustic material only and the shift to using a composite of materials.
3. FORM - the development of visual judgement (aesthetics) around enclosure. The form has developed from the material explorations.
4. CONNECTION AND HINGE - the difficulties, and conflicts between form and the operable.

3.10 Initial experimentation with paper folding. This pattern had a high level of flexibility allowing for a variety of forms. There is a natural curve that is occurring the geometry of the folds is not changing, rather the cellular pattern is causing the paper to curl. The pattern produces an arch. This pattern ultimately failed as each fold is offset from the next, breaking the path of the load (as shown with the arrows)
3.11 Shifted pattern to reduce curling of paper and provide more rigidity in the paper

3.11 Scale of pattern tested to understand curving opportunities

3.12 Scale of pattern tested to understand curving opportunities

3.13 Scale of pattern tested further to understand form making opportunities. The pattern is able to be compressed to allow for a change in direction of the form
3.14 Earlier play with the geometry of the pattern becomes more purposeful here. The folds are now scaled to form an enclosure.

3.15 Flexible frame hinged at intersections developed, to give the structure flexibility.

3.16 Geometry and pattern of folds studied. The smaller the pattern the greater the curve.

3.17 Previous scale of folds too small, creating the need for additional support. This trial shows larger cells in the fold giving the structure more stability.

3.18 Inverted view of image.

3.19 Enlarged part of the folded paper to study the material size limits once scale of material increased.

3.20 Interior view of fold.
3.21 Folds become wall and enclosure. This model was presented in the second phase of the competition and is now titled Pleat Pod.

3.22 Flexible timber frame. 1:5 scale

3.23 Flexible timber frame with fabric skin attached. 1:5 scale
3.24 Corset structure. 'Cage Crinoline'

3.25 Axonometric of KnitPav

- Track fixed to ceiling
- Flexible frame
- Glow inserts
- Fabric Cover
- Furniture layout
- Plan
3.26 Removing the frame progressively. Isolating the critical support required. Here it is the vertical paddle pop sticks attached to the paper folds.

3.27 Testing form with the paper models. Reinforcing the paper with timber pieces glued to the paper.

3.28 Longer folds reduce the vertical curvature and allow for longer seams to act as columns. There are no timber supports here.

3.29 Support is now absorbed into the pattern of the folds. Challenge is to ensure the structure stays upright without the need for additional support.
3.30 Folded pattern now expresses column and cantilever as a way to create enclosure and stability

3.31 Folded pattern incorporates a folded footing, where structure could be weighted down, without need to penetrate the floor

3.32 Demonstration of self supporting folds being weighted down at ground

3.33 An option to secure the base of the PleatPod to the floor by folding back the column and then fixing this to the floor

3.34 Footing detail. Wedge shaped insert to be added to the structure to create stability

3.35 Doubling up on the skins so create a larger footing

3.36 Once the paper folded models were tested for geometry, work was done to test a fabric solution. Here fabric was sandwiched together with interfacing to stiffen the fabric. Timber was also used to reinforce the columns
3.37 Scale increase. Studies were done to create a material that would look like fabric but still stand up. Acoustic fabric was sandwiched around pieces of MDF; this resulted in too much pressure at the joints so acoustic board was trialled.

3.38 Acoustic board with fabric hinges trialled. This stood up and held the geometry at 1:5 scale.

3.39 The acoustic board with fabric hinge 1:5 trial was scaled up to 1:2. Stable result.

3.40 The acoustic board with fabric hinge 1:2 trial was scaled up to 1:1. Material sagging.

3.41 Interior view of the 1:1 trial.
3.42 PleatPod proposal. Closed position

3.43 PleatPod proposal. Open position
3.44 Form studies of the PleatPod. This model was rejected as curve of the form only happened at floor and ceiling.

3.45 Form studies of the PleatPod. Sketch showing the segments of the PleatPod. Curve too dramatic.

3.46 Digital model of sketch in image 3.45
3.47 Form studies done in fabric. This version shows ground, pod junction too flat and the pod looks more like a teepee or tent.

3.48 Form studies done in fabric. In this version the above form is folded out into a ‘wall’ configuration.

3.49 Form studies done in fabric. In this version the floor, pod junction is improved and this is the form pursued.
3.50 Adjustments to the digital model made from understandings gained in the physical trials. The tests were around amount of curve in the walls, floor and ceiling junction.

3.51 Adjustments to the digital model made from understandings gained in the physical trials.
3.52 Idea around entry where a separate screen would be provided.

3.53 Sketch discussing the curve at the ceiling.

3.54 More sketches around curvature of pod.

3.55 3d prints of the form were also used to give a clearer understanding of the form. These helped understand stability. The above 2 models show a uniform pleated panel that seems never ending, as if it is a long piece of material that is bought in lengths. I was looking for a form that expressed the size of the enclosure and was customised to that space.

3.56 3d prints of the form. Here the configuration became a wall. The initial idea of a flexible pleated system that could move and respond to the user’s needs drove the compression and expansion expression of the final PleatPod. The compressed moments gave the Pod more stability.
3.57 The final form which had a combination of compressed and expanded elements. When the elements were compressed there was more enclosure from above. This model had 40 columns and was too big.

3.58 40 columns reduced to 34 columns. This was the model we proceeded with to full scale fabrication.

3.59 Plan view showing the compressed elements supporting the outward/inward leaning elements.

3.60 Digital model was sent to Bollinger Grohman to test stability. The highlighted elements shown here would rotate inwards. These elements were the flexible opening.

3.61 The highlighted elements shown here would rotate outwards.

3.62 The highlighted elements shown here would rotate inwards.
3.63 Diagram showing the final composite panel system. MDF panel sandwiched between 2 layers of acoustic material.

3.64 Single column or unit pieces after being cut. MDF and acoustic board were glued together and then cut as one to ensure the angles of both board were exactly the same.

3.65 Single column or unit - showing the unstable columns (left) and the stable columns (right). Engineers models matched this.

3.66 Exterior view of the first full scale prototype. This shows the curve and the articulated elements. These units did not stand on their own, which was predicted by the structural modeling shown earlier.

3.67 Interior view of the first full scale prototype.
3.68 Prototype with fabric covering showing clear structural path, column and cantilever

3.69 Process of covering the MDF core

3.70 Interior of prototype
3.71 Initial trial showing the connections between columns. At this stage there is no consideration of material thickness, nor changes in the geometry. Tabs on either side would be fixed together.

3.72 Basic hinge detail. Showing a pivot point for 4 panels.

3.73 Partial masking tape used on a 1:20 model. This was a fail as the structure is warping from the weight of the cantilever.

3.74 Two operations of the same hinge. Simple hinge on the left and overlap for fixing the shape on the right. The left option would be operable and the right version would assist in fixing the curtain in place once deployed.

3.75 A more complex hinge subsequently developed. This had 2 layers of card. The geometries converge at a central point of each column.
3.76 The hinge system applied to a fully flexible Pod. This allows for manipulation of the pattern where some elements are compressed and others expanded.

3.77 Interior view compressed (above) and expanded operations (left).

3.78 Freezing the flexible units once the Pod was deployed. Here a prop is inelegantly inserted at the top of the pod.

3.79 Prop at the base of the structure.
3.80 Slicing the acoustic board stopping at the felt. Using the felt as a hinge

3.81 Fabric tape as hinge. (2015)

3.82 Mimicking a hinge with timber rod inserted to provide a pivot for the 2 panels

3.83 Assembly of pieces used to create fabric hinge

3.84 Cross cutting acoustic board

3.85 Cross cutting acoustic board

3.86 Double layer of acoustic board showing complex hinge joint

3.87 Separating the systems. Placing acoustic board between two layers of fabric

3.88 Complex hinge - translated from the cardboard trials to acoustic board/fabric

3.89 Connection between columns. Trial of biscuit joint where an allen key kicks out a clip that locks the pieces together. This was considered as a way to allow the PleatPod to be relocated
3.90 Full flexibility was not pursued, rather a zone of flexible columns at entry was pursued.

3.91 Vinyl hinge on MDF. Failed as MDF was too heavy for the hinge.

3.92 Weight of MDF and size of Pod made folding panels difficult. Concealed wheels at the base were used to help operability. The panels did not vertically stack, the form of the Pod made movement irregular so wheels moved at an acute angle.

3.93 Piano hinge was investigated and was able to cope with the weight of the board.

3.94 Opening and closing the column required 2 people as the column went from stable when closed (above) to unstable when open (right).
3.95 To reduce the weight of the board milling material out of the MDF was trialled. This worked to lighten the boards but revealed that the geometry was the problem when folding and unfolding.

3.96 Re-trial of full scale column with piano hinge and milled material. This also failed as there was swinging at the top of the columns.

3.97 Replacement of the top panels and replace with fabric tested to reduce weight of material.

3.98 Removal of the top panels and replace with fabric tested to reduce weight of material.

3.99 Further investigations around the folding and unfolding of the entry columns revealed a problem with the top pieces not being able to fold easily. These pieces (indicated in red) needed to be treated like a webbing so that they would not lock against each other in the process of folding. These pieces were exaggerated, pleated to test form.
PLEAT PAVILION

The Pleat Pavilion was an entry into the NGV Summer Pavilion competition to be built in the Grollo Courtyard of the National Gallery of Victoria. The design was a pleated structure to be made out of external sunshade materials typically used as tensile structures for external use. The pleats would form cone-like forms to be constructed from a linear length of fabric using Pleat techniques developed during the PleatPod investigation. The whole canopy would be made from a continuous length of fabric, expressed through the furling and unfurling of the cone shaped forms in the same way that the PleatPod was a concertina of a folds.

The pleated fabric would begin as a simple fold on ground and then gain complexity and intricacy as it became canopy, hovering over the public space. Two oversized columns at the rear of the courtyard would support the structures allowing them to look as if they were floating.

From the PleatPod paper folding iterations that travelled from pattern and then into form, I fast tracked this process using digital tools only, as I knew which patterns could work and which would fail. The knowledge from the PleatPod gave the following rules that I applied to the Pleat Pavilion:

1. Only certain patterns are able to be used to create strength in Floppy materials, others are decorative only and require large amounts of separate structure.
2. The scale of the pleated patterns need to vary to produce a furling and unfurling effect. This ‘freezing’ of the action of furling allows for a clearer reading of what the patterns is doing and how it is formed from the simple folding of fabric.
3. The pattern should give form rather than adjust to a predetermined form, as this renders the pattern superficial and non-essential.

From these rules, I began the design of the Pleat Pavilion. The inspiration for the entry came from the work done by fashion designer Iris Van Herpen and architect Daniel Widrig, who designed a 3d printed garment titled 'Crystalisation'. The forms of this garment were complex pleats that reacted to the shapes of the body. For me the beauty of this piece lay in the intricacy achieved, alluding to softness despite the hard polymer it was constructed from. Crystalization challenged some ideas around the translation from digital image to physical tests to full scale project. I questioned if the Pleat Pavilion could simply be 3d printed, bypassing the prototyping and material testing. Iris Van Herpen's 3d printed garment develops from directly from digital model to fabrication without the incremental toiles typically used by a fashion designer to test form, drape etc. Crystalization remains a hard polyamide digital print worn as if it is a piece of armor, freezing a material moment and while it is a beautiful image, it remains just that, an image and does not have a materiality, as its material is a prototype in the same way that a toile, (an early version of a garment) is made to test form and construction but is not intended to be the final garment.

The ability of pattern to take on complex form and the repetition of a single element that shifts depending on the form or space it needs to respond to, created the form of the pleated swirls in the Pleat Pavilion. This is similar to the PleatPod in that there is an invisible body that is driving the form, removed once it is deployed or installed. The materiality is important to the outcome of the Pavilion, it would be satisfying if it was cast in concrete or folded in steel, as the effect of complex folded fabric would be lost.

3.103 'Crystalisation' collection by Iris Van Herpen with Daniel Widrig. Inspired the design of the Pleat Pavilion through the furling and unfurling of the structure

3.102 Initial sketches showing the furling and unfurling of the structure
3.104 Pleat Pavilion.
NGV Summer Pavilion Entry
3.106 The Pleat Pavilion is constructed out of this one coil of pleated fabric that is rotated and repeated to create an illusion of an a endlessly furling and unfurling pavilion, all from one roll of fabric.

3.107 Colour used to emphasise the pleat pattern
3.108 Diagram of the Pleat Pavilion process of going from a flat piece of material to a curved form
PLEAT PAVILION TESTING

After the competition I undertook some studies to see if the digital model would match the outcomes of physical trials. Working again with a fashion designer the manually constructed pleats performed very differently to the digital model, that had no materiality. The weight of the fabric tests altered the pleated pattern in ways that could not be predicted manually. From this I understood that there needs to be an understanding of the material condition when working from a material to architecture process.

DIGITAL TESTS

The digital tests used parametric modeling to develop intricate folds that could respond to various random forms. The challenge was getting the script to respond to the form in a way that mimicked how it might behave if it was a folded piece of paper. Here I relied on the knowledge and experience of working with folded paper to assess the digital models. The tests presented a range of success, where there is a negotiation between form and pattern. When the pattern is too light there is the inclination to provide separate support through additional folds that then render the pattern as decorative only.

Referring to the rules mentioned previously these experiments show that firstly the pattern is not able to be used to create strength in Floppy materials (non-continuous folds which would fail), secondly the scale of the pleated pattern varies so the objects look like they are in the process of furling and unfurling. Lastly the pattern does not give the form but rather adapts to form.

PHYSICAL TESTS

After the digital tests, the physical tests were done with a synthetic mesh that performed similarly to paper. The synthetic mesh had inherent stiffness and once folded, held the fold and form tests. This stiffness made the material perform differently to the cotton fabric which had no inherent strength and the behavior was less predictable. The observations around working with fabric firstly showed when folded the folds do not hold a crisp geometry. When the scale of folds exceeds the materials inherent strength, curling of the material occurs. Secondly form can only be created by stretching apart sections between compressed sections, and not whole sections. The form can only be clear if the pleats are gathered in moments. Thirdly the furling and unfurling needs to be supported at every shift in pattern.

3.109 Early tests to develop form of the Pleat Pavilion units. This pattern is more decorative and would not work to create strength in the material

3.110 This Pleat is being driven by the form rather than the pleat dictating the form. Intricacy is good but form is random

3.111 Form is overriding the potential of the pattern

3.112 Pleating compressing at base is starting to register the forces at play here

3.113 The folds are too intricate and small, and again are not influencing the overall form, rather acting as decoration

3.114 Alternative angle of above image
3.115 More pattern tests, applying a form to the pattern, vs pattern to a form. This page and opposite.
3.116 Physical trials with mesh material that behaves like paper were done to understand relationship between pattern, material and form.

3.117 Physical trials with cotton fabric with no inherent structure, to understand pleating effects.
PLEATENT

The Pleatent (Pleat + Tent) was another competition entered to test the ideas around pleating and fabric behaviours. The annual competition asked for a low cost shelter that could be easily erected in Socrates Park New York City for a sculpture festival. There were size and budget constraints which limited the size of the structure. I proposed a structure that would allow the exterior fabrics to react to the winds, billowing within the constraints of the steel frame. Referring again to Iris Van Herpen’s garments, specifically the pleated garments in the 2016 collection titled Seijaku, where the garment is constructed of a pleated fabric that is fixed in points to ensure the pleat pattern remains while the body moves.

MODELING THE UNPREDICTABLE

Expanding on the work done in the Pleat Pavilion, as I wanted to explore material behaviours similar to billowing fabrics, or pleats in motion. The physical tests on fabric done for the Pleat Pavilion showed that the pleat expands but will revert back to the compressed pleat if part of the pleat is fixed in points. The Pleatent constrained the pleats at some points and then loosened at others so the fabric could move freely. Three frames would be used that were independent of each other but undulate towards each other. The smaller the distance between the steel structural tubes the more drape occurs in the fabric. Conversely, the greater the distance between the steel structures, the more tension on the pleats. The wind would pick up the non-tensioned fabric and billow the fabric and the billowing was constrained by the tensioned pleats. This exercise assisted in understanding more about material behaviours and ways to create architecture that could work with material conditions.
3.121 Form finding with Pleat pattern in digital model. Knowledge from PleatPod and Pleat Pavilion transferred here.

3.122 Testing form, frame and pattern.
Conclusion
The projects contained in the PhD have explored the territory between architecture, fashion and textile design. Collectively the research has covered more than the less materials prior to their application to a substrate or structural system, looking to fashion and textile design to understand how they work with sheet fabrics to create 3d garments, developing architectural applications from the discovery of selected fashion and textile design techniques, documenting the narrow zone that exists between fashion, textile design and architecture through the projects, and finally developing an architecture that utilizes the principles embedded in fashion and textile design to synthesize structures that simultaneously develop structure, form and skin.

The floppy has been the focus of the research as it represents a material at its most vulnerable, where it has no function, form or structure. This material condition allows for clarity around a material behaviour when selected techniques are applied, it has also allowed for the investigation into specific materials after they have been separated from their role in prefabricated construction systems, stripping away the engineering and allowing the material to fail and react. The PhD explores, the limitations and opportunities embedded in specific fashion and textile techniques, the application of these techniques to develop materials and reworkings of birds ideas, from the beginning of a project, the application to a substrate or structural system, looking to fashion and textile who have developed techniques to manipulate a flat sheet of material into form and pattern.

The exploration undertaken through the projects contained in the PhD have worked to flesh out ways of working in the territory between architecture, fashion and textile design. There have been attempts at looking at material qualities only, specifically sheet materials, which give a limited insight into the way fashion and textile work and it has been through the adoption of specific techniques typical in these disciplines but foreign to architecture that reveal a richness in knowledge. This is where the PhD makes its most significant contribution.

When focusing on materials, architecture has answers, techniques and approaches well tested to deal with a familiar range that typically includes timber, steel, glass, brick and concrete. The new knowledge in this thesis has occurred when I (the architect) adopt the techniques from fashion and textile design and then apply these to the architectural materials. Architecture can be like fashion and textile who have developed techniques to manipulate a flat sheet of material into form and pattern.

The path taken to understand how fashion and textile design use terminology such as drape, pleat, croquis etc is a contribution of this PhD and I have devoted time to experiment directly with both fashion and textile disciplines in order to develop a deeper understanding of these approaches. Early in the PhD I grouped fashion and textile design together, where I assumed that both worked in the same way. When working directly with these disciplines, however, I came to the realisation that they operated differently and independent of each other. I found that fashion manipulates form through techniques, such as Pleat, to distort the figure of the body. The Pleat, allows structure, form and fabric to come together seamlessly, giving the illusion of a continuous piece of fabric that can be as voluminous as needed, simply by increasing the pleat size, or fixing points in the pleat. Textile design on the other hand, is able to translate scale from small croquis or tests, to architecture, through the understanding how the join or connection between materials can extend the illusion or effect developed through the fashion technique. I understood that fashion design can be used to produce form and that textile design can be used to assist in the realisation or fabrication of this form. In this way I (the architect) took the role of the fashion designer, working directly with textile design to realise the architecture. By clarifying each disciplines role in the projects through discussion around the croquis, I explain where each disciplines strength lie and how this contributes and broadens the material discourse.

The exploration of the pleat technique revealed structural clarity around how lots of structure but fine structure can be used to develop an architecture that can fuse the development of structure form and skin where each is developed simultaneously in the same way that a pleated skirt falls off the body and reacts to the combined forces of gravity and shape of the body.

While the individual processes of folding or stacking etc, are not new approaches to material fabrication it is the accumulation of the tests and their simultaneous consideration of structure, form and skin that brings a novel approach to the development of architecture. From this Floppy logic, a discovery of a way of working that has emerged that is applied more clearly as the projects have progressed in the PhD, each iteration using knowledge from the previous iterations that becomes embedded in my aesthetic judgment, or visual knowledge.

Working with fashion and textile design has allowed for the exploration and development of the aesthetics of fine-ness and intricacy in addition to understanding the functional and performative qualities of the materials. For example, the use of architectural materials (Glow), for example, had two qualities that needed to be understood in order to make things with them. The Glow qualities as well as their fibre and plastic substrates. Investigating one worked
to inform the other. The light qualities of the Glow material required an optimal distance between body and material and the fibres were tactile and intricate which would only be perceived if close to the body, resulting in a space that could be brushed past and touched. When dealing with new materials or using materials in non-standard ways, a dual investigation into function, performance and aesthetics is needed as these make up the material condition I look for.

From my experience as an architect, when we work with design disciplines other than our own, there is typically a distance between them. Either the collaboration is a defined scope of work the design practitioner is employed to do, or each discipline views the other via their images and artefacts. For example draple, defined as the act of placing a piece of fabric over a form, allows for a range of conceptual ideas around form to be generated. By draping, fabric hits points on the body and lofts (where a loft is the creation of a surface by stretching a surface between two points) between them resulting in the appearance of deformation of the body. This is an informed understanding around draple as understood by fashion and textile design. When this term is used to develop effects with poured concrete I see a naivety around the meaning of drape. The work in this PhD is in direct discourse with fashion and textile design in order to understand these terminologies and their possibilities for architecture. The knowledge gained from the collaborations has been used to pursue an architecture that fuses structure, skin and form. Defining the Floppy allowed for a way to select materials from the infinite choice available. After many trials, I found that materials that had no inherent structural qualities required more testing as there was not a lineage of precedent in architecture to draw from. This lack of precedent and way of working with the Floppy also allowed for rich discussion with fashion and textile design as we both had to develop a vision to produce architecture. Using our ‘discipline instinct’ to guide towards a common ground. This discovery of a common ground between the disciplines allowed for architecture to adopt the techniques used in fashion and textile design to give form, pattern, intricacy and structure to the Floppy materials.

A further clarification occurred when I compared two terms, Pleat and Fold, to unearth the key differences between technique in architecture and its parallel in fashion and textile design. Fold is a common and familiar term within architecture, and Pleat is its equivalent in fashion and textile design. I used the differences in the definitions to develop architecture that absorbs both meanings. By looking at the way each discipline considers these techniques, I understood that it is the combination of pattern, form and effect embedded in a term such as Pleat that makes it better able to produce form than Fold. I found Fold in architecture refers to the singular act of one fold, where Pleat was a network of folds that work together to produce a whole garment. Therefore Fold was more restrictive and Pleat opened up more possibilities because of the way it could manipulate Floppy materials with the fixed form of the body.

The differences between the Pleat and the Fold allowed me to investigate ways to create form in architecture led by material exploration, bringing a closer relationship between the generation of form and its materialization. Fashion and textile design, deal directly with a fixed set of forms, the body. The body is comprised of, head, shoulders, neck, arms, hips legs etc. and over time fashion and textile design have developed many techniques to manipulate this set of fixed set forms. By isolating these forms and understanding that architecture can also be considered as comprising of sets of forms, I could apply the knowledge from fashion and textile design to architecture. I understood the potential of the different techniques used by fashion and textile design to manipulate form.

I have observed that textiles are a network of lots of fine structures, where each fibre is necessary for the whole to exist. If you take away a single thread this network would start to fail and create a separation in the fabric. This micro focus of the structure of a textile, informed my way of looking at lots of structure that can also become skin and form. The PleatPod uses many pleats to create stability and rigidity in the form, where each fold is providing some structural support, but it is unclear where the hierarchy of support lies. This approach differs from contemporary architectural language that separates column and beam from skin and seems to prefer large spans between structures.

Textiles also contain a hierarchy of pattern. Whole garments, such as a knitted sweater, use a change in pattern to deal with connection between forms (arm to shoulder or leg to hip), allowing different forms to connect to create a whole. The PhD documents the way textile designs work in connecting forms, in ways that do not seek to celebrate this junction that is a typical approach I see in architecture, but rather works to seamlessly connect different elements through a change in pattern. The Glow and Pleat projects in the PhD seek to create this seamlessness in the different functions (Glow vs non-Glow materials) or different structural stresses (compressed vs uncompressed Pleats in the PleatPod, Pleatent).

**MATERIAL SELECTION**

Curating the relevant figures in the Material discourse was important in setting the direction of the PhD, raising gaps in knowledge. I gave priority to the practices who investigated ideas through physical trials, as it showed evidence of their approach, while also revealing opportunities for investigation. Some of these practices work across disciplines, developing architecture that uses techniques external to it, others had a bias towards sheet materials that included laminates, veneers, and aluminium, assisting in the focus on the Floppy. Only after testing these materials and understanding the flexibility of the Floppy arise, that is, a set of materials that can the tactile nature of the fabric be included in the material? How do you use only the material to create verticality and enclosure? What do you need to do to the material to remain the need for extraneous structure? Where does the material fail? And does this failure offer an opportunity to know more about the material?

Working with fabric and textiles requires thought around how to communicate material qualities without rendering them as decorative only, adding more questions such as: How can the ‘fabric-ness’ be protected from the process of architectural fabrication?, or how can we communicate the illusion of the material standing up by itself? How can the tactile nature of the fabric be included in the fabrication? In order to answer these questions, singular materials, with no added support systems was focused on, allowing me to see the strengths and weaknesses of the materials and how they behaved.

The satisfaction of making a Floppy material stand up without the help of elaborate structural systems, as shown with the early Paint On Structure explorations, broadened the material research from sheet materials to fabric and textile. Through working with these Floppy materials a logic was revealed (Floppy Logic) that was then applied to the Pleat projects. When working with fabric and textiles, I saw that there was little lineage in architecture that produced enclosure other than the tensile structures made with shade cloth materials. My approach to these materials, extends conventional ways of working with fabrics and textiles and demonstrates an approach that develops architecture from a material starting point. The exploration undertaken through the projects
The Glow project assisted in the development of a way of working by firstly asking key questions. How can the material stand up unassisted? How can the materials inherent qualities give a structural solution? These questions give a starting point for the project but do not need to be constrained to the strategy of folding, for example, where everything needs to be a fold, these ideas or tests help to develop an understanding of the material condition. The Brick Curtain House initially seemed to be a failure because the brick did not stand up unassisted, and the folds in the wall were not enough to allow for vertical stability without the need for columns. The same happened with the Pleat Pod where the initial idea to construct the whole object out of fabric covered acoustic board failed as the board material was not designed to take any load nor span any distance without support. These projects work to communicate a material condition. The brick unit is expressed as a set of individual components that can be arranged in a way that gives transparency, form and a visible structural logic. The PleatPod is a way of making sheet material stand up through one technique, a pleat.

**FORM**

The merging of effect and form developed through the Pleat experiments, showed ways of producing form through the discovery of the qualities found in fabric, textiles and garments and their use of pattern to communicate something about structure, material and skin. By working with non-structural materials such as the Flocky range of textiles and fabrics, solutions are required to replace the structural function of the body with other means to create enclosure.

The figurative Pleat in the PleatPod displays the act of shaping the composite materials of MDF, acoustic insulation and acoustic fabric into a particular form. The PleatPod and the Pleat Pavilion, while using techniques from fashion and textile, work to create an object that looks like it is a folded piece of paper or an enlarged part of a pleated skirt that can move or is in the middle of a movement. There has been great effort to hide anything that could reveal the composite nature of the PleatPod (separate triangles glued together then covered). There is no expression of joint; no revealing of the many complex components, no separate supports and it does not move. The Pleat Pod wants you to see it as a thin piece of material about to be folded away, without it functioning in this way. The Pleat investigation was a way to transform materials into a structure that could provide enclosure through the expression of a material condition.

In architecture we use a variety of construction systems to make materials conform to an architectural intent where the character or behaviours of these materials are dictated by the system used. This PhD separates the system from the material, exploring how, for example, a veneer behaves when separated from its substrate, or how sunshade fabric behaves when not in tension, or how low materials give off light, informing the material discourse through the demonstration of the physical trials and constructed projects.

Through the process of developing the PleatPod from digital model to architecture, I discovered that making architecture that moves, directly conflicts with form. To make the PleatPod open and close requires giving priority to the mechanisms of movement over form, where the pursuit of one requires a compromise of the other. The outcome of the PleatPod is one that removes this compromise and pursues form over direct garment making. To pursue form over movement became clear towards the end of the project, when full scale fabrication was well underway. The opening and closing of the structure did not work in the 1:2 scaled trials and it was thought that 1:1 scale trials were needed to ensure the mechanical fixings were simulated accurately. Through these trials it became apparent that the pleats needed to be vertical and not curved, which would have turned the PleatPod into formless curtain.

**ISSUES OF SCALE**

There is a difference in the way fashion, textile design and architecture work. Fashion works at 1:1 or full scale and architecture works anywhere from 1:5 for detail to 1:10,000 for larger urban scales. A garment or components of a garment are not scaled during development, rather croquis and calligos made of cheaper materials, are used to test fabrication and form as it relates to the body. Architecture must work at a scale smaller than the final building scale, and relies on smaller scaled models to develop the envelope of the building, materiality and detail. Decisions are made in architecture at a smaller scale than the final building. The architect develops an understanding around the full scale impact of the decisions made during the smaller scale development, and is trained to visualise the final outcome. When I worked with contained in the PhD have worked to flesh out ways of working in the territory between architecture, fashion and textile design. There have been attempts at working in the territory between only specifically	 sheet materials, which give a limited insight into the way fashion and textile design work and it has been through the adoption of specific techniques typical in these disciplines but foreign to architecture that reveals a richness in knowledge that is where this PhD makes its most significant contribution.

When focusing on materials, architecture has answers, techniques and approaches well tested to deal with a familiar range that typically includes timber, steel, glass, brick and concrete. The new knowledge in this thesis has occurred when I (the architect) adopted the techniques from fashion and textile design and then applied these to the architectural palette of materials. Fashion and textile techniques have been developed to manipulate a flat sheet of material into form and pattern.

The exploration of the pleat technique revealed structural clarity around how lots of structure but fine structure can be used to develop an architecture that can fuse the development of structure form and skin where each is developed simultaneously in the skin where each is developed simultaneously in the component, no separate supports and it does not require a compromise of the other. The outcome of the PleatPod is one that removes this compromise and pursues form over direct garment making. To pursue form over movement became clear towards the end of the project, when full scale fabrication was well underway. The opening and closing of the structure did not work in the 1:2 scaled trials and it was thought that 1:1 scale trials were needed to ensure the mechanical fixings were simulated accurately. Through these trials it became apparent that the pleats needed to be vertical and not curved, which would have turned the PleatPod into formless curtain.

**PROBLEMS OF WORKING WITH NEW MATERIALS**

Fabrics, textiles and functional materials, are not part of the typical architectural material palette, and require the establishment of a way of working as well as building up knowledge around these materials if they are to be used in architecture. The Glow work, allowed me to demonstrate how a non-architectural material can be used to develop architecture, by understanding their limitations and the way they behave. The Glow project became a negotiation between the body, material and architecture, where the relationship between body and material was used to create a new relationship between space and material. Understanding the maximum distance between the body and the material determines how recognizable the fibres are. Too far apart and they become decorative, too close together and they invade space.

When working with new materials, or materials not typically used in architecture, there is missing information around their performance and behaviour needed when using them in fabrication. There are also few precedents to fill this gap in knowledge. When we work with timber, steel, concrete, for example, we understand the principles that make them stand up, or their load paths. We develop an understanding that looks right to what looks wrong. These principles are not able to be used when presented with new materials such as fibre or fabrics and require segues into research around material behaviours before designing architecture with them. This need also puts the architect into a position where they are working outside of their knowledge base and developing architecture becomes difficult when there are so many unknowns. These unknowns lack of precedent has allowed this PhD to contribute to knowledge by filling in some of these gaps around specific material behaviours but more importantly the techniques and approaches that will allow others to work with non-architectural materials and techniques.

The early work of the PhD assisted in the development of a way of working by firstly asking key questions. How can the material stand up unassisted? How can the materials inherent qualities give a structural solution? These questions give a starting point for the project but do not need to be constrained to the strategy of folding, for example, where everything needs to be a fold, these ideas or tests help to develop an understanding of the material condition. The Brick Curtain House initially seemed to be a failure because the brick did not stand up unassisted, and the folds in the wall were not enough to allow for vertical stability without the need for columns. The same happened with the Pleat Pod where the initial idea to construct the whole object out of fabric covered acoustic
fashion and textile design, scale was always clarified to ensure no confusion around what I might view as being a 1:50 scale when the fashion and or textile designer viewed it as a 1:1 scale. This was a significant clarification in the research because when testing fabrication and material ideas, the materials used needed to reflect the scale of the intended outcome as well as the variety of scales used to test all aspects of the project. The interest in fashion and textile design came from the viewing of garments, which were at the scale of the body. When trying to increase from garment scale to building scale, there is a danger of losing the intricacy, tactility, form, seen in these garments. This observation came about after many tests that tried to use garment scaled patterns or techniques at an architectural scale, and failed. This observation also reinforced my drive to create architecture out of fashion and textile techniques that did not render these techniques as decorative only.

Scale creates a relationship between pattern and material. Intricate patterns applied to materials change the behavior of the material. For example perforating a sheet material weakens the sheet. The exploration on the pleat technique showed that when the folded pattern was too small the sheet became too weak to stand up. To work out the correct scale to material relationship we incrementally increased the scale and/or changed the material thickness until the pattern and material became stable. These observations around scale and material informed the Pleat Pavilion and Pleatent and will allow for future collaborations to begin projects with this knowledge in place.

FABRICATION

Through the PhD, I have learned to use fabrication as another tool to translate fashion and textile design ideas into architecture. Fabrication requires clarity of idea in order to successfully make things. Resolving issues of flexibility or operability occurred during the full scale fabrication phase of the PleatPod as it was not possible to physically simulate the behaviour of the materials in motion and the effect the form would have on this. The full scale fabrication tests exposed the material behaviour that was not able to be accurately modeled digitally. The smaller models seemed to fold up easily, but when fabricating we came across resistance between movement and form and unseen issues around the way the triangulated composition at the top was slipping and not folding.

Furthermore, textile design and the development of ideas is directly linked to the technology used. Textile design works directly with the physical croquis. For example a knitted sample is used to explain ideas around pattern and is fabricated with a knitting machine. This means that the limitation of the technology impacts directly on the idea. If it can’t be made then it can’t be developed, there is no prototypes involved with textile manufacturing, the garment is not tested in different non-standard materials and at different scales to determine its success as a whole garment. Working with certain techniques such as weaving, which has a rich history digitally was restricted by the mechanical capabilities of the weaving machines. These machines are not able to do anything other than a flat weave. While we as architects and play infinitely with digital visualisations, textile design needs to be tethered to the fabrication technology, as was the case with the Glow tubes.

The increasing accuracy of digital fabrication technology allows for a closer relationship between the disciplines of architecture, textile and fashion design because the intricacy, can now be closely translated. This PhD demonstrates how to go from textile croquis through to architectural scale space. The intricacy and accuracy present at the textile croquis scale is able to be mimicked through the accuracy of the 5 Axis CNC (Computer Numerically Controlled) machines. This is also the case for large scaled knitted textiles that can be manufactured using the digital knitting machines. These advanced fabrication technologies allow for the translation from idea to physical outcome to be increasing direct, reducing the need to alter the idea to suit the fabrication technology. There is no need to think about how to express or interfere with a join because the join can now be seamless, with almost no tolerance required between them.

This PhD has developed a way of practicing that looks to reveal the material condition rather than bring a condition to the material. The catalogue of techniques and understanding of techniques developed from working with fashion and textile design allows architecture to develop from a material beginning. Material systems that are applied to a design are limited by constraints of the system rather than the constraints of the materials. By working directly with Floppy materials new ways of developing form and effect are explored.

FUTURE THINKING

While I discussed the material discourse and its key contributors as it relates to my research, there is the possibility for future research to place the current digital fabrication, and modelling tools that are proliferating and shaping our buildings and our cities, in the broader context of the practice of architecture. The advance of material development in architecture, has driven shifts in architectural expression, throughout history. We know the early shelters made from thatch or mud brick had limited spans, and the form of these dwellings were shaped by utilitarian needs to shed water, provide air flow or keep the heat in. Over time, new materials were developed and engineered. Kiln fired brick, concrete, steel and glass, allowed larger spans, taller buildings, and more adventurous forms appeared.

We are now situated in the middle of another set of advances involving technique driven ways of considering materials. Through advanced digital tools, including digital modeling and fabrication, we can investigate Floppy materials, and study the multidisciplinary techniques that can translate the qualities of the Floppy into architecture. This shift allows us to look at the Floppy with knowledge from the disciplines who have mastered techniques to manipulate the Floppy. It also opens up other discipline techniques who been developed in parallel to architecture as a source of new knowledge to be applied to architecture.

Loos’ assertion that ‘you cannot build a house out of carpets, as these require a structural frame to hold them in the correct place’17, was referenced earlier. But through the work done in this PhD and the adoption of terms, techniques and approaches from fashion and textile design, I believe you can make a house out of carpet – if you understand the condition of the carpet prior to developing it as architecture.
2. Ibid
3. Ibid
6. These practitioners include the large body of published work that catalogue new and existing materials without any demonstration on how they can be used.
8. Ibid
23. Ibid
30. Ibid p 3
33. Ibid
37. BOHNEBERGER, S from Bollinger Grohman. engineering firm located in Melbourne. Bohnenberger completed the digital structural simulation of the PleatPod to text for stability.
Croquis – derives from the word ‘sketch’, in fashion and textiles this sketching is done through the act of making samples that are trialled on the body in the case of fashion or as small samples that test pattern, shape and construction in the case of textiles.

Calico – an unbleached cotton often used by fashion to model form and construction of a garment prior to fabrication with final fabric selections.

Dart – folds that come to a point to provide shape.

Drape – the act of placing a piece of fabric over a form without manipulating the fabric first.

Fabrication – the full scale or 1:1 realisation of architectural concepts and ideas.

Fabric – used when talking about materials used in fashion specifically at the scale of a body.

Fold – the act of folding a material back onto itself to create structural stability or visual effect out of a sheet of material.

Floppy – defined as something that is soft and flexible, and in the context of this PhD refers to a set of materials that require extraneous support to produce an enclosure. Floppy generally refers to fabric but can also refers to any material that fails when there is not enough support, as is the case with sheet materials when the span between supports exceeds a certain length.

Glow – refers to Photo Luminescent materials and/or projects that use this material. Photo Luminescent materials absorb light and then release it. Typically absorbed during daylight and then given off at night.

Hem – fold back and sew down an edge.

Interfacing – is a textile used on the unseen or “wrong” side of fabrics to make an area of a garment more rigid.

Intricate – having a lot of small parts or details that are arranged in a complicated way and are therefore difficult to produce. This term also refers to an aesthetic that intricate constructions have.

Loft – the creation of a surface by stretching a surface between two points.

Materialist – practitioners in architecture that work with materials the starting point to develop architectural space.

Pleat – a pleat is a type of fold formed by doubling fabric back upon itself and securing it in place. It is commonly used in clothing and upholstery to gather a wide piece of fabric around a circumference. Pleats are categorized as pressed, that is, ironed or otherwise heat-set into a sharp crease, or unpressed, falling in soft rounded folds.

Seam – a line where two pieces of material are joined together.

Textile – textile is used when talking about materials used on a larger building scale.

Upholster – cover walls or furniture with fabric.

1.02 Practice Path Diagram. Image by Leanne Zilka

1.03 Paint On Structure. Photo by Leanne Zilka (2001)

1.04 Ibid

1.05 Laminate experiments by RMIT Student Oscar Sainsbury, Shann Ching Pei Yong, Timothy Heron. Photo by Leanne Zilka (2010)

1.06 Laminate experiments by RMIT Student Jonathan Barzel. Photo by Leanne Zilka (2010)

1.07 Chaise lounge made from Laminate by students Jonathan Barzel, Bronwyn Litera, Mathilde Lucas, Ashini Kutulange. Photo by Leanne Zilka (2010)


material-spotlight-carbon-fibre (2009)


1.18 Ibid


1.21 Pia Interlandi and Linda Valentic - architectural proposal Photo Pia Interlandi (2010)


1.28 Ibid


1.30 Leanne Zilka - Brick Curtain House. (2005)

1.31 Ibid

1.32 Ibid

1.33 Leanne Zilka - Timber Slat Screen. (2014)

1.34 Ibid

1.35 Leanne Zilka - Sketch Hawthorn Brick House (2015)

1.36 Ibid

1.37 Ibid

1.38 Digital render. Dane Zane (2015)

1.39 Ibid

1.40 Ibid

1.41 Ibid

1.42 Leanne Zilka and Simon Whibley - Stacked Vacationer Model. Photo Leanne Zilka (2013)

1.43 Ibid

1.44 Ibid

1.45 Leanne Zilka Hybrid House Prototype. Photo Leanne Zilka (2013)

1.46 Ibid


2.01 Jenny Underwood. The Design of 3d Shape Knitted Preform. PhD, RMIT. (2009)

2.02 Esther Paleologos, Framework shown in the 1st Tomworth Textile Triennial. (2011)


2.04 Ibid

2.05 Pia Interlandi - Dissolvable fabric (2010)


2.07 Pia Interlandi and Linda Valentice - Pekakura folded form. Photo Pia Interlandi (2010)

2.08 Danielle Thiris and Vanja Joffer - Knitted Croquis. Photo Vanja Joffer (2011)

2.09 Ibid

2.10 Ibid

2.11 Ibid

2.12 Ibid

2.13 Ibid

2.14 Dominique Hall and Courtney King - Computer generated pattern. (2013)

2.15 Ibid

2.16 Ibid

2.17 Ibid

2.18 Ibid

2.19 Ibid


2.21 Ibid

2.22 Ibid


2.25 Ibid


2.27 Ibid

2.28 Ibid

2.29 Ibid

2.30 Lindy Hayter - Plastic sheet embedded with Glow material. (2014)
2.33 Photoluminescent Thread. Photo David Mainwaring (2010)
2.34 Glow Lantern Installation at the Frankurt Opera Plaza. Photo Sascha Bohnenberger (2010)
2.35 ibid
2.36 ibid
2.37 Photo luminescent powder in blue. Photo David Mainwaring. (2010)
2.38 Panels mounted under Graham street overpass in Port Melbourne. Photo Leanne Zilka (2011)
2.39 Perception tests. Photo Leanne Zilka (2011)
2.40 ibid
2.50 Photoshop images. Images by Leanne Zilka (2013)
2.51 Ibid
2.52 Ibid
2.53 Digital model. Images by Leanne Zilka (2013)
2.54 Ibid
2.55 Ibid
2.56 Glow plastic sample. Photo by Leanne Zilka. (2013)
2.57 Knitted tests. Photo by Jenny Underwood (2013)
2.58 Ibid
2.59 Ibid
2.60 Ibid
2.61 Ibid
2.62 Thread testing. Photo by Leanne Zilka. (2013)
2.64 Ibid
2.66 Ibid
2.67 Ibid
2.68 Ibid
2.70 Ibid
2.71 Ibid
2.72 Digitally modelled croquis. Image by Leanne Zilka (2013)
2.74 Ibid
2.75 Trial of glow installation. Photo by Leanne Zilka (2013)
2.76 Ibid
2.77 Shima Seki knitting machine loaded with Glow Thread. Photo Leanne Zilka (2013)
2.83 Digital Model. Image by Leanne Zilka (2013)
2.84 Ibid
2.85 Physical installation trial. Photo by Leanne Zilka (2013)
2.86 Plan Sketch. Image by Leanne Zilka (2013)
2.87 Digital model. Images by Leanne Zilka (2013)
2.88 Digital model. Images by Jun Kit Chan (2013)
2.89 Installation of Glow Tubes. Photo by Shannon McGrath (2013)
2.90 Digital images by Jun Kit Chan (2013)
2.91 Orthographic plan and elevations by Leanne Zilka (2013)
2.92 Glow installation. Still from video made by Julien de-Sainte-Croix (2013)
3.03 Pleat tests. Photo by Leanne Zilka (2015)
3.04 Digital rendered model. Image by Bruce Oakley and Matt Liu (2016)
3.05 Rendered section. Image by Leanne Zilka
3.09 Ibid
3.10 Paper fold tests. Photos by Leanne Zilka
3.11 Ibid
3.12 Ibid
3.13 Ibid
3.14 Ibid
3.15 Ibid
3.16 Ibid
3.17 Ibid
3.18 Ibid
3.19 Ibid
3.20 Ibid
3.21 Ibid
3.25 Axonometric of KnitPav (2015)
3.27 Ibid
3.28 Ibid
3.29 Ibid
3.30 Ibid
3.31 Ibid
3.32 Ibid
3.33 Ibid
3.34 Ibid
3.38 Ibid
3.40 Ibid
3.41 Ibid
3.43 Ibid
3.44 Ibid
3.46 Digital model by Muhammad Shah and Mery Hermita Samosir (2015)
3.48 Ibid
3.49 Ibid
3.50 Digital model by Muhammad Shah and Mery Hermita Samosir (2015)
3.51 Ibid
3.52 Ibid
3.54 Ibid
3.56 Ibid
3.58 Ibid
3.59 Ibid
3.60 Digital model testing structural integrity by Bollinger Grohman. (2016)
3.61 Ibid
3.64 Construction of PleatPod. Photos by Leanne Zilka (2016)
3.65 Ibid
3.66 Ibid
3.67 Ibid
3.68 Ibid
3.69 Ibid
3.70 Ibid
3.73 Ibid. Photo by Leanne Zilka
3.74 Ibid
3.75 Ibid
3.76 Ibid
3.77 Ibid
3.78 Ibid
3.79 Ibid
3.81 Ibid
3.82 Ibid
3.83 Ibid
3.84 Ibid
3.85 Ibid
3.86 Ibid
3.87 Ibid
3.88 Ibid
3.89 MDF with Biscuit join. Photo by Leanne Zilka (2016)
3.90 Digital model by Muhammad Shah and Mery Hermita Samosir (2016)
3.91 MDF tests. Photo by Leanne Zilka (2016)
3.94 3.95 MDF, Acoustic board, brass hinges. Photo by Leanne Zilka (2016)
3.96 Ibid
3.97 Cardboard, fabric 1.5 scaled model. Photo by Leanne Zilka (2016)
3.98 MDF, Acoustic board, brass hinges. Photo by Leanne Zilka (2016)
3.99 Digital Model by Bruce Oakley. (2016)
3.100 Photo by John Gollings (2017)
3.101 Ibid
3.102 Sketch by Leanne Zilka (2016)
3.109 Digital model by Vince Lai (2016)
3.110 Ibid
3.111 Ibid
3.112 Ibid
3.113 Ibid
3.114 Ibid
3.115 Digital model by Mery Hermita Samosir (2016)
3.116 Fabric trials done with Danielle Abury (2016)
3.117 Ibid
3.118 Digital Model by Bruce Oakley (2016)
3.119 Ibid
3.121 Digital Model by Vincent Lai. (2016)
3.122 Digital model by Bruce Oakley (2016)


EISENMAN, P. 1999. Diagram Diaries, Thames and Hudson.


SOMOL, R.E. 1999. Dummy text or the diagrammatic basis of contemporary architecture in "Diagram Diaries". UK: Thames and Hudson.


