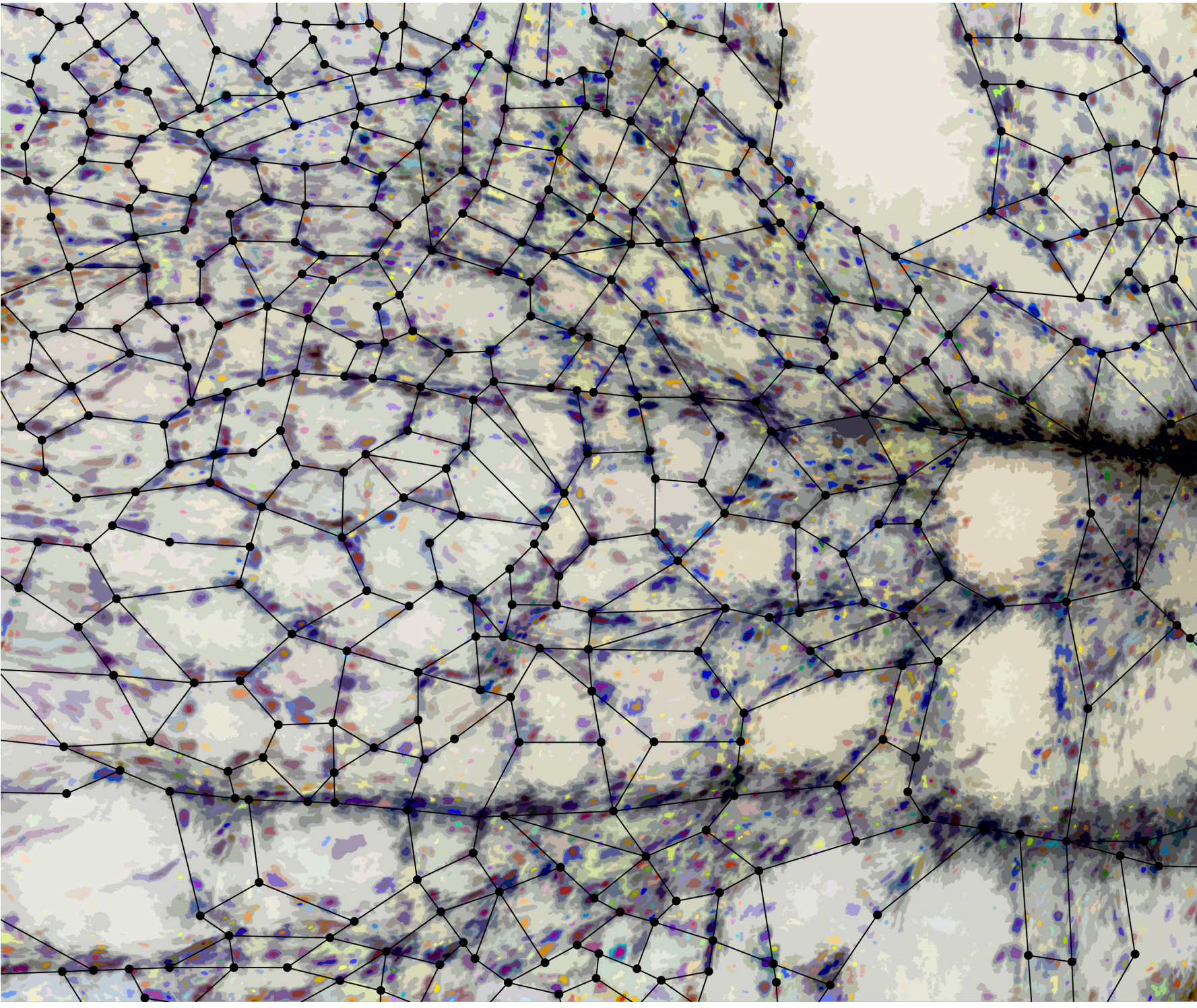




Co-Lab: Experimental Materials, Environments and Architecture

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This document is submitted in partial fulfilment for the degree: Master of Architecture (Professional) at the University of the Witwatersrand, Johannesburg, South Africa, 2020.

Declaration

I, Chantal Maria Rycroft (1098100) am a student registered for the course Master of Architecture (Professional) in the year 2020. I hereby declare the following: I am aware that plagiarism (the use of someone else's work without permission and/or without acknowledging the original sources) is wrong. I confirm that the work submitted for assessment for the above course is my own unaided work except where I have stated explicitly otherwise. I have followed the required conventions in referencing thoughts, ideas, and visual materials of others. For this purpose, I have referred to the Graduate School of Engineering and the Built Environment style guide. I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my unaided work or that I have failed to acknowledge the source of the ideas or words in my own work.

Aknowledgements

I would like to dedicate this work to my parents, thank you for all your love and support. To my mother, thank you for your constant encouragement and reassurance.

Signature:



Date: 27/07/2020

Abstract

Digital and virtual tools and technologies enable remote learning and working. The adoption of such methods of operation by tertiary education institutions in South Africa, up to now, for the most part, has been slow and gradual for various reasons. Some universities did not possess the necessary funds to establish such methods. There was also the issue of students' lack of access. The Covid-19 pandemic and national lockdown, however, have necessitated and accelerated the adoption of remote education and research practices by South Africa's higher education sector. A return to previous methods of operation seems unlikely as people have experienced something that seems more relevant to a future marked by increasing digitalisation (Habib, Kupe, Phakeng, 2020). Mamokgethi Phakeng, the vice-chancellor of the University of Cape Town, Tawana Kupe, the vice-chancellor of the University of Pretoria, and Adam Habib, the vice-chancellor of the University of the Witwatersrand, all predict that local universities will embrace a hybrid, or blended form of operation going forward, one that incorporates both contact and online strategies (Habib, Kupe, Phakeng, 2020). This research report re-imagines university architecture in light of evolving functional and spatial requirements and proposes the design of a high-tech, multi-disciplinary Centre for research and development at Wits University.

Activities at the proposed Centre would focus on the application and development of digital fabrication and material technologies and the prototyping of useful and sustainable products and processes. Such explorations hold particular interest in the realms architecture, art, science and engineering. A shared and multi-disciplinary space would integrate a wide array of skills and expertise and bring together diverse areas of interest and inquiry. Imperative to sustainable production is material and energy efficiency. These are increasingly important considerations in architectural design. Through research and development, we can potentially realise environmentally-friendly solutions to how we build and what we build with, in support of a sustainable and circular economy.

The proposed Centre would not only accommodate Wits University staff and students but would also incorporate a broader community of professionals and entrepreneurs. Such an inclusive environment would support networking and the formation of connections and associations. Access to specialised amenities and resources in a social and inspiring space could motivate participation, concentrate University education and research operations and encourage collaboration, experimentation and invention.

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1.1. Introduction

Often in the working world, individuals with different skills sets and knowledge bases need to work together. The design of a building, for example, is never a solo endeavour. It requires a whole team of professionals, including engineers, architects, planners, and other specialist consultants. Different professionals contribute different expertise and perspectives to a building project. Good co-ordination and collaboration are necessary to achieve the best possible outcome in response to a client's brief. Unfortunately, although synergy between members of different fields is important in the occupational sector, multi-disciplinary association at Wits University is not overtly encouraged. A rounded university experience should promote multi-disciplinary interaction, at both undergraduate and postgraduate levels (Ludwig Hansen Architects and Urban Designers, 2015). Increased interactions between researchers and students from different faculties and schools could improve teamwork skills, stimulate new ways of thinking and engender reciprocity. There is also opportunity to incorporate a broader community in University activities, share access to University resources and encourage association between not only scholars of different disciplines but individuals of different working backgrounds and levels of experience as well. A collective and stimulating environment could bring together diverse areas of interest and exploration and foster knowledge exchange and collaboration.

In light of the Covid-19 pandemic and national lockdown, Wits has transitioned to a period of remote learning and working that will likely have a long-lasting influence. Spatially, this implies a reduced need for central and dedicated teaching and working facilities going forward, as these operations can largely be conducted from remote locations. Future spatial development at Wits will likely focus instead on the provision of specialised amenities and resources, like laboratories and archives, that support research and education.

This research report conceptualizes a new high-tech, multi-disciplinary and community inclusive centre at Wits University for research and development (R&D) focused on the application, localisation and advancement of Fourth Industrial Revolution technologies, specifically digital fabrication tools and advanced, smart and bio material technologies. Researchers, students and interested community members would have the opportunity to engage with and apply these technologies in the design and development of useful and sustainable products and processes. Imperative to sustainable production is energy and material efficiency. The Council for Scientific and Industrial Research (CSIR) is an example of a local multi-disciplinary research and development organisation that innovates and localises technologies for the purpose of accelerating socio-economic prosperity in South Africa (CSIR,

2020). A focus of the CSIR is the utilisation of Fourth Industrial Revolution technologies in the development of innovative products and manufacturing processes. The efforts of the CSIR are geared towards strengthening resource efficiency and cleaner production for sustainable industrialisation (CSIR, 2020). Issues of material and energy efficiency are also imperative in architectural production and are further discussed in this report under the headings **1.7. Adaptive Architectural Surfaces**, **1.9. Material and Structural Efficiency** and **1.11. Assembly and Disassembly**.

The purpose of this research is to establish a design methodology for functional, programmatic, performative and mechanical requirements. Methods of enquiry include consultations with Wits academic staff members and the analysis of secondary sources. Staff members consulted include lecturers and professors knowledgeable in the fields of architecture and engineering and in the areas of material science, computational design and digital fabrication.

1.2. The University of the Witwatersrand

The University of the Witwatersrand is situated in the city of Johannesburg, South Africa, a vibrant commercial and economic hub on the African continent. The University began its origin as the African School of Mines which was formally established in Kimberley in 1896 (University of the Witwatersrand, 2020, *About*). The institution transferred to Eloff Street in the Johannesburg CBD in 1904, becoming the Transvaal Technical Institute. It was subsequently rebranded as the Transvaal University College in 1906, the South African School of Mines and Technology in 1910 and University College, Johannesburg in 1920. In 1922, the institution gained full university status and was officially inaugurated as the University of the Witwatersrand. Construction of a new campus on a site at Milner Park, donated to the University by the Johannesburg Municipality, began at this time. The University moved into the first completed teaching buildings at Milner Park in 1923 (Fig 1). At this early stage, Wits had 6 faculties, Art, Science, Medicine, Engineering, Law and Commerce, 37 departments, 73 members of academic staff and approximately 1000 students.

From 1947 to the 1980s the University experienced a period of considerable growth. Rapidly increasing student numbers necessitated the expansion of University facilities and Wits grounds were extended with the acquisition of new land in Braamfontein and Parktown. The University



Figure 1. The University of the Witwatersrand Milner Park Campus looking south, 1930s.



Figure 2. Aerial view showing Wits University West Campus in the right foreground, East Campus in the middleground and Braamfontein in background, 1984.



Figure 3. Wits East Campus today with Braamfontein in the background.

procured the Milner Park showgrounds, to the west of the previously established campus on the opposite side of the M1 highway, from the Witwatersrand Agricultural Society in 1984 (Fig 2). AMIC deck was build in 1989 over the M1 highway to link the East and West University Campuses.

Important to the identity of Wits University is its history of political and civic activism. In the past, Wits was strongly opposed to the apartheid regime. From its inception, the University has maintained a policy of openness and non-discrimination on racial or any other grounds. This position was tested when the apartheid government passed the Extension of the University Education Act in 1959 which enforced racial segregation in tertiary education institutions. Although ‘non-white’ students were permitted to attend the University after a special permit was granted to them by the Minister of State, social mixing between students on campus was prohibited. Wits community at large protested strongly against this and other apartheid policies (Fig 4). These protests were sustained as civil liberties were withdrawn and peaceful opposition to apartheid was suppressed. As a result, the University suffered serious consequences, including the banning, detention and deportation of staff and students as well as the invasion of riot police to disrupt protest meetings on campus. Tension between the University and the state government continued up until 1994 when apartheid was abolished in the country. Far more recently, from 2015 to 2016, members of Wits student body were involved in the

#FeesMustFall protest movement, which demanded free, decolonised and quality education for all and an end to outsourcing at South African universities (Fig 5). Today, Wits staff and students remain outspoken and active in addressing prevalent issues in society, including gender-based violence and disability rights.

Presently, and more than ever before, the university promotes an open culture that is inclusive and equitable. Pertinent to this research report is the notion of openness, however, herein it is suggested that its meaning be expanded to incorporate knowledge exchange through open collaboration between schools, faculties and the working community. Public engagement and increased association between different fields of study are imperatives of the University.

Over the years Wits has become internationally recognised for academic excellence and extensive research activities. Today, it is one of the top two leading universities in the country and on the continent. The University is further committed to growing its stature as a world-class, competitive, tertiary education institution and gateway to research engagement and educational achievement in Africa. Essential to the University's mission is the continuous upgrade, improvement and expansion of its facilities to support growing staff and student bodies as well as diverse and cutting-edge areas of investigation.

Figure 4. Wits protested the imposition of apartheid at universities, 1959 (Extension of University Education Act).



Figure 5. Wits students in #FeesMustFall demonstration, 2016.



The Johannesburg Region and Immediate Context of Wits University

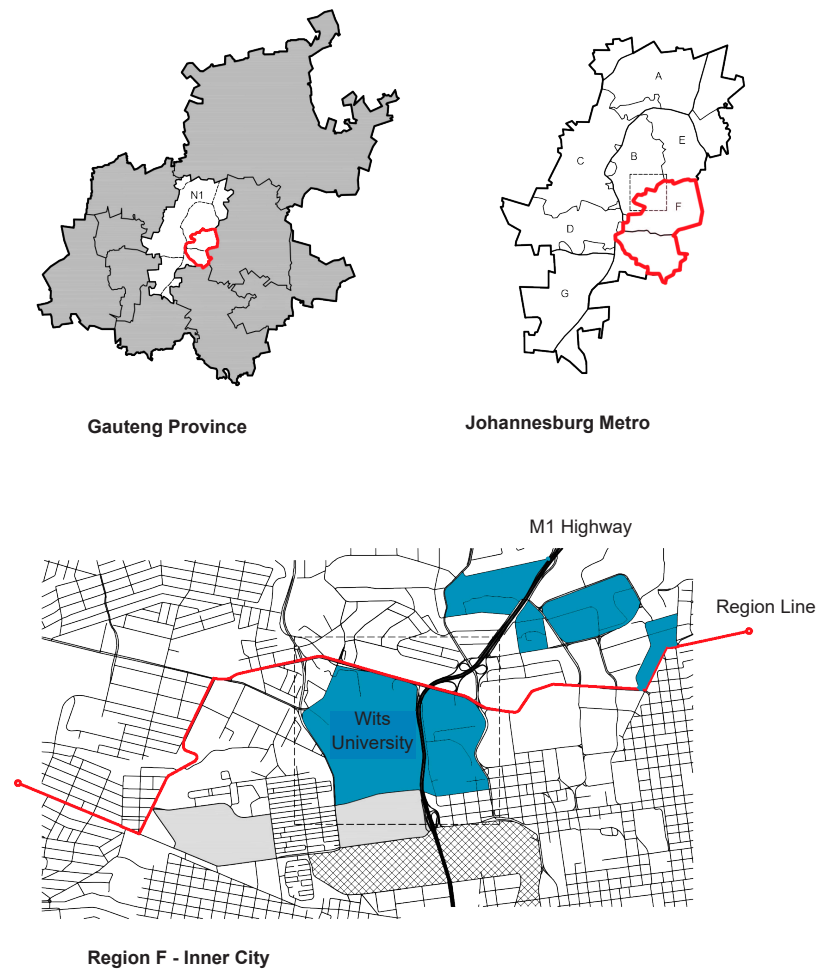


Figure 6. (above) and Figure 7. (right). Wits University is located in the heart of Johannesburg at the boundary between the suburbs of Parktown and Braamfontein. In spite of previous deterioration and neglect, Braamfontein has recently seen substantial renewal under the authority of the 'Braamfontein Management District' and is now a lively and energetic space filled with students and young people who crowd to the cafes, restaurants, bars, theatres and galleries located in the area. It is a civic and cultural focal point in the city. Parktown was one of the first residential suburbs north of the inner city. It is presently the location of several secondary schools as well as Wits Medical, Education and Business Schools.



The Urban and Natural Setting of Wits University



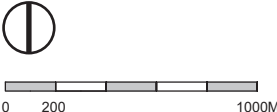
Figure 8. (top left) - Broad Land Use

- Education
- Business
- Cemetery
- Industrial
- Institution
- Municipal
- Open Space
- Residential
- S.A.R
- Special
- Government
- Public

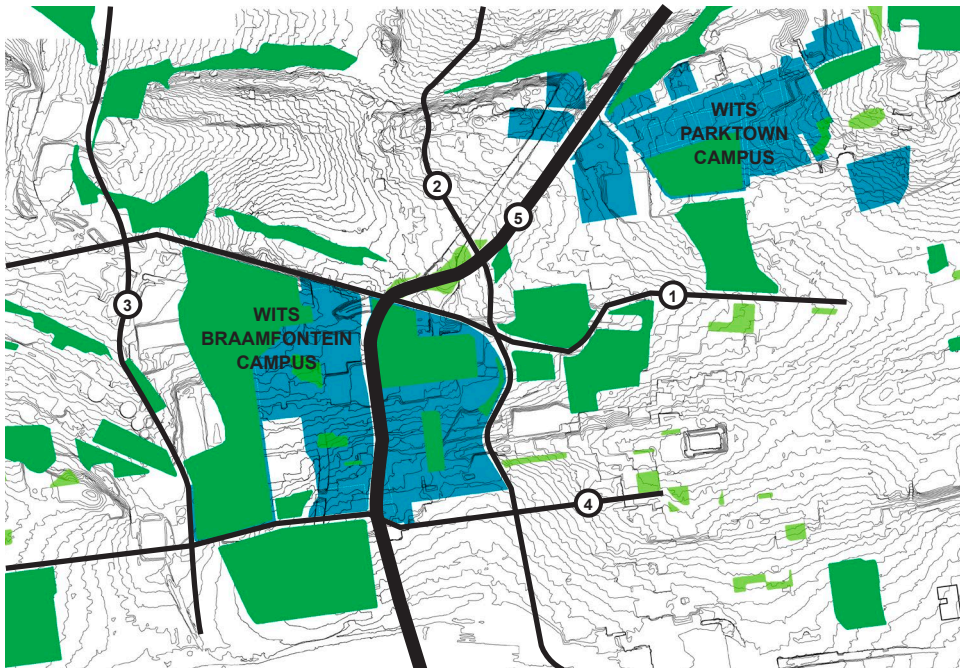
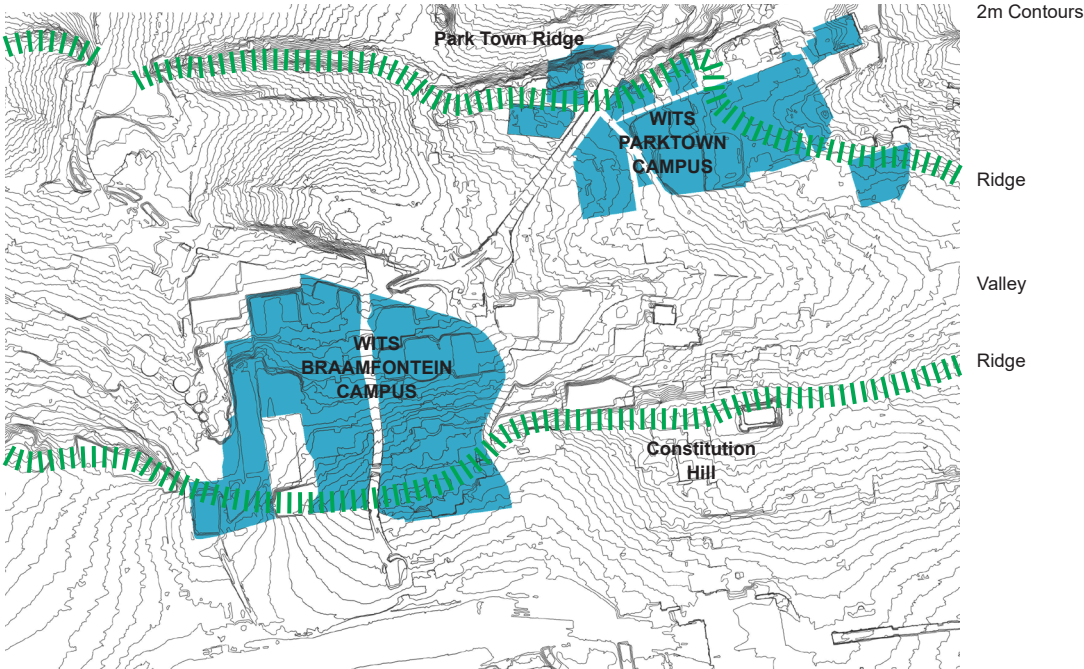
Figure 9. (top right) - Natural Features

Figure 10. (bottom right) - Greenary

- 1 - Empire Road
- 2 - Jan Smuts Avenue
- 3 - Annet Road
- 4 - Enoch Sontonga Avenue
- 5 - M1



These maps illustrate the urban and natural context of Wits University. The University's campuses sit in the valley between Parktown Ridge and Constitution Hill. They are located in a primarily commercial and educational district with residential properties situated further away to the north, east and west. The railway and CBD are located to the south of Braamfontein campus. Braamfontein campus is divided into east and west by the M1 highway and is bordered on all four sides by main roads. A wide green buffer to the west of Braamfontein campus separates it from the Gas Works.



Site Location, Wits University East Campus

Figure 11. (left) - Site Location, Wits East Campus



The site selected for this project incorporates a parking lot and old abandoned asbestos building (the old architecture workshop) situated on Braamfontein East Campus.

Site Data	
Property	University of the Witwatersrand, East Campus, Braamfontein, Johannesburg.
Owner	University of the Witwatersrand, Johannesburg
ERF	401/53-IR
Area	340 963.57m ²
Zoning	Educational.
Primary land use rights	Institutions, places of instruction, social halls, religious purposes.
Secondary land use rights	Medical consulting rooms, dwelling units, residential buildings, sport and recreation clubs, public or private parking areas.
Proposed building programme	New centre for research and development. This programme complies with the property land use rights as it supports Wits academic and research functions.
Proposed building classification	A3 (place of instruction), C2 (library), C1 (exhibition hall), D4 (plant room), G1 (offices), B3 (low risk commercial service), J3 (low risk storage), E3 (other institutional - residential)

Site Rights and Constraints	
Coverage	Allowable coverage is 70%, acutal coverage is 23%. The proposed new building will not cause the actual coverage to exceed the allowable coverage so long as its footprint is less than or equal to 47% of the site area (160 252.88m ²).
FAR	Allowable FAR is 2.1, estimated FAR is 1.2. The proposed new building will not cause the FAR to exceed the allowable FAR so long as its floor area is less than or equal to 0.9 x the site area (306 867.21m ²).
Height zone	H0
Height restrictions	3 storeys. This restriction can most likely be contended as several existing buildings on the property exceed this limit.
Building lines	0m on all boundaries.
Parking requirements	0.4 space/student, according to the South African Parking Standards, 1979-1980
Contours	The topography of the site slopes down towards the north.
Aesthetics	The materials and aesthetic of proposed new building should fit in with the materials and aesthetic of the existing buildings on the campus.

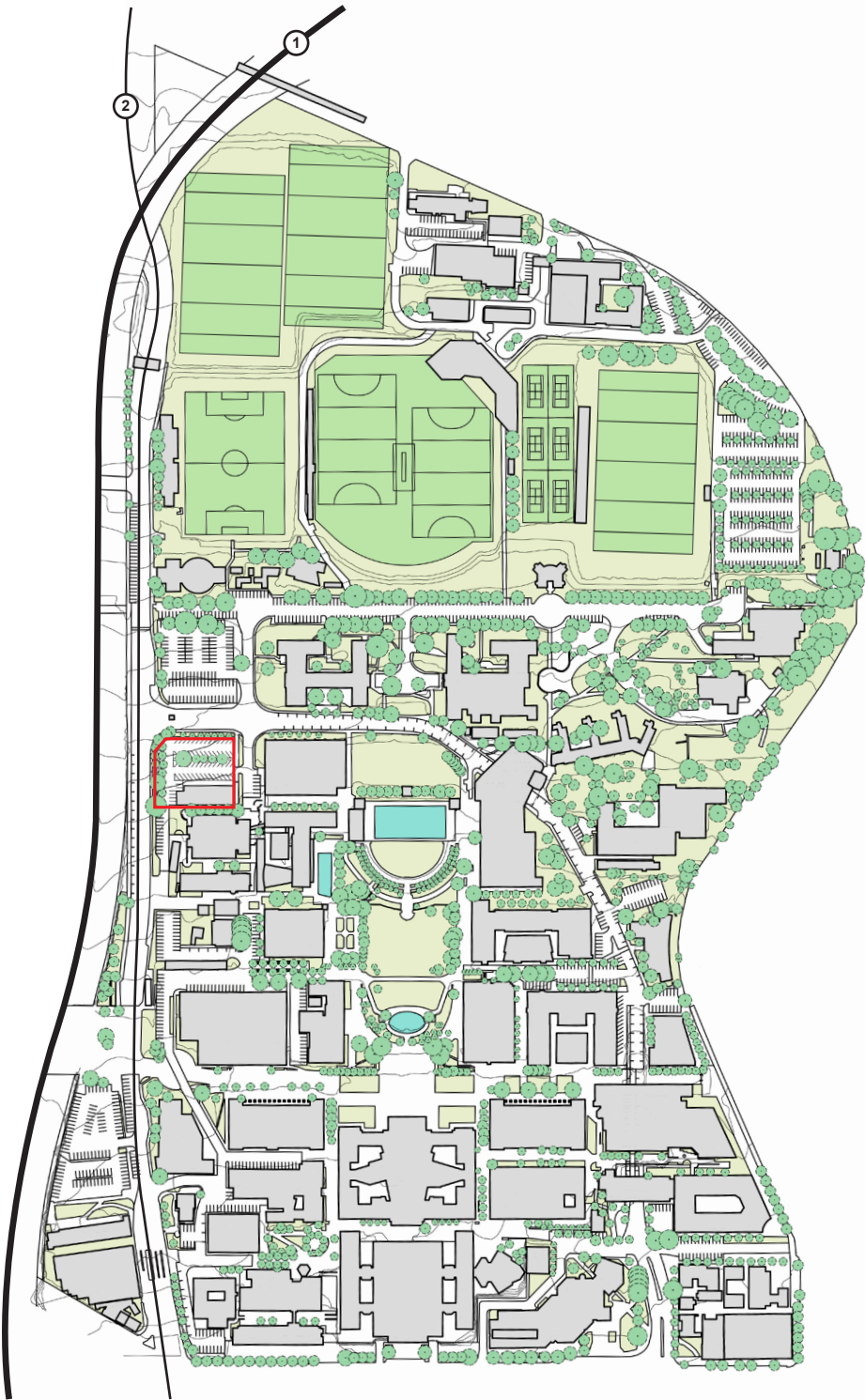




Figure 12. Photograph of the selected site showing the old architecture workshop looking south west.

1.3. Remote Learning and Working and the Post-Covid Picture

As a result of the Covid-19 pandemic and national lockdown, Wits has transitioned to a period of remote learning and working. The University campus has sat mostly empty for, at the time of this writing, approximately five months, while education and research operations have continued. This move has been enabled by modern information and communications technology and raises questions about the possible decentralization of various University functions going forward. This would have significant spatial implications.

There was an adjustment period as Wits moved to remote learning and working which required training, testing and troubleshooting online communication. University teaching staff have also had to adapt coursework and requirements and prepare new course material, including guides, lecture recordings and lecture slides. Being able to reuse this material, while making any necessary updates in the future, could subsequently lessen lecturers' course loads (Habib, Kupe, Phakeng, 2020). Students can access course material online at any time and at their own convenience. Lecturers communicate with students online, providing direction and guidance and publishing notices, announcements and feedback on coursework. If students have any course-related queries, they

can contact lecturers or tutors directly, request private online meetings or post questions on a course forum. Staff and students have also been given remote server access to use software licensed by the University necessary for their work and studies. Wits IT support staff are available to help those experiencing any technical difficulties.

Although the exact consequences of the necessitated shift to remote learning and working are not yet clear, it is unlikely that Wits will ever return to 'how things were before'. The effectiveness of the established online methods so far suggests that they could be maintained, or partially maintained, going forward (Habib, Kupe, Phakeng, 2020).

According to Adam Habib, the Vice-Chancellor of the University of the Witwatersrand, as stated in an interview with The Conversation Africa, anecdotal evidence is indicating that students are performing better in online learning environments as compared to face-to-face, suggesting a need to adapt teaching methods going forward. According to Habib, Mamokgethi Phakeng, the vice-chancellor of the University of Cape Town, and Tawana Kupe, the vice-chancellor of the University of Pretoria, in the time ahead we will see a strong shift to a hybrid, or blended, model of teaching at South African universities that incorporates options for both

local and global transmission to proximate or remote students (Habib, Kupe, Phakeng, 2020).

Online learning presents several advantages. Firstly, holding lectures online increases the number of students able to attend and enrol in certain courses without the University needing to provide and maintain large dedicated teaching venues. Lecture halls are notoriously inefficient as they are limited in their usage and largely inflexible. Such uneconomical spaces could be reconstituted to increase the serviceability of existing buildings on campus. Future development and renovation at Wits University will likely focus on the provision of useful amenities and resources, like libraries and archives, and the creation of highly operative spaces that support multiple functions and constant usage.

Secondly, increased student enrollment would bring more income to the institution and help finance infrastructure development and operational expenses, and thirdly, improved tuition efficiencies would free human capacity to allow for greater focus on research activities, which is a priority of the University. Finally, online learning presents opportunities to develop more flexible study programmes and increase prospects for part-time study and lifelong learning. Lifelong learning is the on-going pursue of knowledge throughout ones life for personal or professional reasons. It typically refers to the learning that takes place throughout and as part of ones career. A wide array of flexible, short and part-time online courses

would establish a basis for interested working individuals to increase their knowledge and skills and thereby increase their employability for future job opportunities.

Traditional face-to-face learning also has its benefits. Face-to-face interactions make communication easier, smoother and more informal and in-person association between students encourages peer-learning, healthy competition and the development of social relationships. Places on campus that support working, learning and meeting, therefore, still remain necessary. Provision must also be made for students who do not have access to the internet, computer equipment or software and for those individuals who may prefer to sometimes or all the time work away from home.

1.4. A Centre for Prototyping and Materials Research

Proposed in this research report is the design of a multi-disciplinary centre for research and development at Wits University focused on prototyping and the application and development of material and digital fabrication technologies. Multi-disciplinary spaces facilitate spontaneous encounters, networking and knowledge exchange. A wide array of knowledge and expertise becomes available in multi-disciplinary environments representing a metaphorical marketplace for finding information and exchanging ideas. In the case that remote learning and working is continued at Wits, such inspiring conditions may entice staff and students to spend more time on campus. The proposed facility will also offer exclusive amenities and resources, including fabrication, materials and computer labs and a materials library, as well as meeting rooms, student working areas, seminar rooms and offices for University staff.

1.4.1. Materials Research at Wits University

Material studies is a promising field full of variety and potential. Advancements in material studies expand the possibilities of material performance and application. The designer, or researcher, acts as the intermediary between materials and ideas. They resolve what materials, and, by extension, what means of fabrication, would best realise the object of their imagination.

Many researchers and research groups at Wits work with materials, in materials science, materials engineering and materials application. Materials research groups formally established within the University include the Material Physics Research Institute (MPRI), the DSI-NRF Centre of Excellence in Strong Materials (CoE-SM), the Materials for Energy Research Group (MERG) and the newly formed African Research Universities Alliance Centre of Excellence in Materials, Energy and Nanotechnology (ARUA CoE-MEN). In the near future, the University intends to establish a Wits Institute of Materials to bring together all those working in materials, to better support and represent them, to improve connections, increase research efficiencies and attract funding (University of the Witwatersrand, 2020, *Wits Institute for Materials*). A large, broad grouping of Wits Materials community would support resource sharing, knowledge exchange and multi-disciplinary cooperation.

The Institute of Materials would engage several research areas, those that would be accommodated at the Centre proposed in this report include advanced materials, smart materials, biomaterials and nanotechnology (University of the Witwatersrand, 2020, *Wits Institute for Materials*). Advanced materials are materials with engineered and improved properties created through the development of specialised synthesis and

processing technology, smart materials are materials that possess specific properties that can be changed in a controlled manner in response to external stimuli and biomaterials are materials capable of interfacing with biological systems. Nanotechnology involves the manipulation and restructuring of matter at an atomic level to create new materials or enhance material properties, such as strength and durability. Material labs at the proposed Centre would support the preparation of material samples and characterisation of material properties and behaviours. Use of the material labs would not only be available to Wits research staff and post graduate students but would also be granted to the wider academic community and qualified professionals for a fee. Public access to these facilities could foster collaborative interactions, and enable the University community to expand its connectivity.

1.4.2. Materials Research and Architecture

Architecture contributes to material studies through its pursuit of technologies that enable complex formal and performative objectives, as described by associate professor of design at Harvard Graduate School of Architecture Thomas Schroepfer (Schroepfer, 2011). In practice, architectural projects that aspire to use materials in innovative ways may face several obstacles. Firstly, few clients are interested in funding architectural investigations inessential to the realisation of their commission. Secondly, many contractors are unwilling to take on the risk

of unconventional construction without significant added cost and, thirdly, regulations may not provide systematic support for exploratory material practices. Academic investigations present a freer means for material innovation in architecture (Schroepfer, 2011).

The proposed Centre would support creative exploration in the application of digital fabrication and advanced and smart material technologies in architecture. Such speculative investigations fall into the category of experimental architecture research. Experimental architecture is concerned with the development of conceptual projects that aim to disrupt conventions and influence change within the architectural profession (Armstrong, 2019). This form of research practice has previously been referred to as ‘paper architecture’. The term ‘experimental architecture’ was first introduced into architectural discourse by Peter Cook in 1970 (Armstrong, 2019). Experimentation relies on testing and prototyping as a means of discovery. It is in the nature of experiments to sometimes fail or produce unforeseen or unwanted results. No matter how we prepare, there are always things unknown and uncontrollable. We can learn something new even through unexpected outcomes. Experiments reveal different aspects of a situation that enable different approaches that may lead to other findings. According to Rachel Armstrong, a professor of experimental architecture at Newcastle University, alternative architectural paradigms can be developed by redefining the materials, tools and limits of the field through experimental practices (Armstrong, 2019). Academic

pursuits in experimental architecture could invent new building solutions and contribute to material application, experimentation and study. Ideas and technologies developed as a result of experimental architecture research may find applicability in practice or even in other industries. Experimental investigations in the application of digital fabrication and advanced and smart material technologies in architecture could also act as a basis for engaging broader architectural themes, including purpose, permanency, environmental performance, adaptability and context.

A variety of disciplines may be integrated in experimental architecture research practices. LabStudio, co-founded by architects Jenny E. Sabin and Peter Lloyd Jones in 2006, is an example of a research group that adopts interdisciplinary approaches to experimental architecture (Sabin & Jones, 2018). The group is established at Cornell University, the University of Pennsylvania and Stanford University. Simply put in *LabStudio: Design Research between Architecture and Biology*, “the studio and the lab investigate the intersections of architecture and science and apply insights and theories from biology and mathematics to the design, fabrication, and production of material structures” (Sabin & Jones, 2018). The group’s work integrates material and digital complexity through prototypical design experiments that interpret dynamic practices and models from different disciplines to generate adaptive architecture and material assemblies. The lab and the studio become platforms that facilitate knowledge exchange and joint research efforts. By incorporating

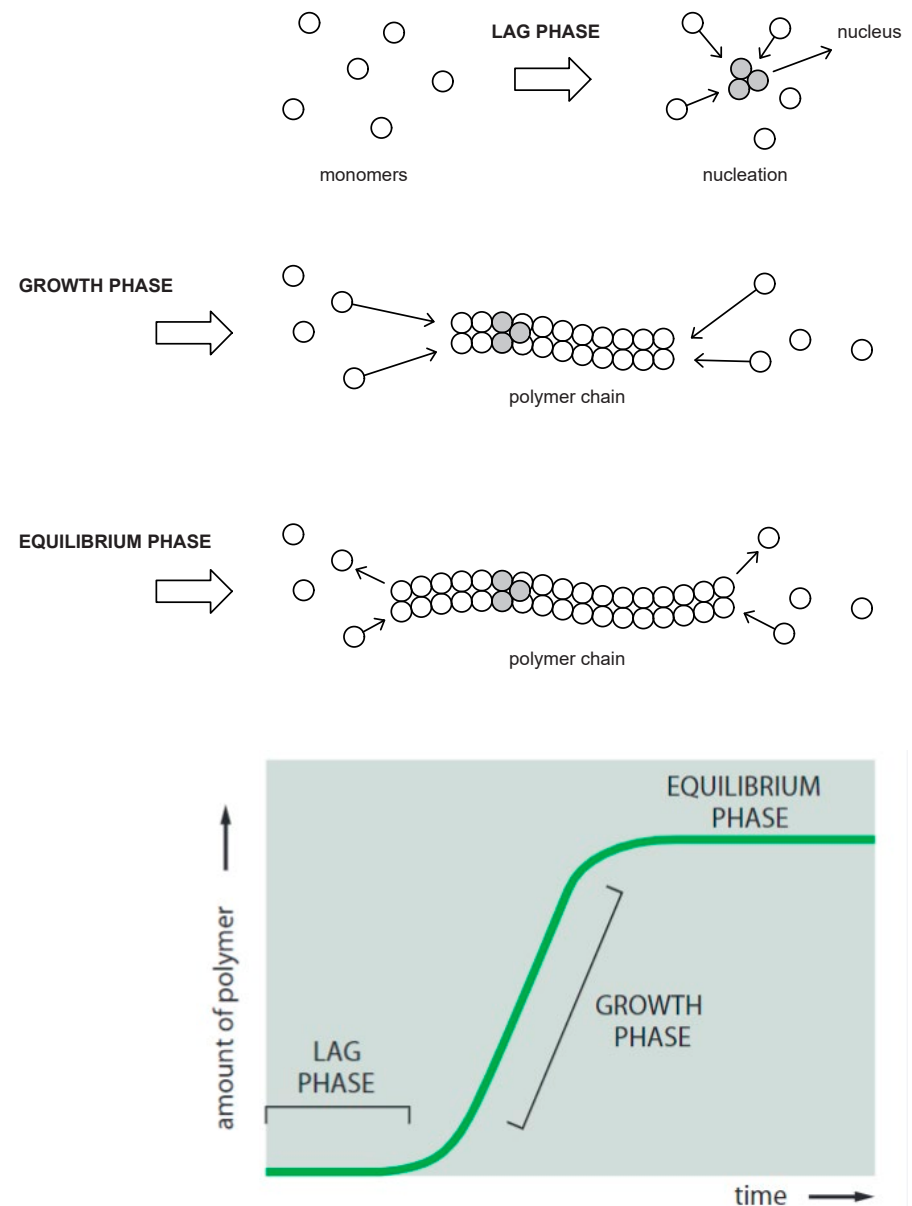


Figure 13. (bottom) and Figure 14. (top). The phases of polymerisation.



Figure 15. LabStudio,
Case Study: Actin
Polymerisation: Models
for Self-Assembly,
Final Prototype
variegated assembly.

the knowledge of other disciplines in experimental architecture initiatives, new and creative concepts, processes and solutions are developed that benefit all participants involved.

An example of one such experiment by the group is a case study in actin polymerisation as a model for self-assembly (Sabin & Jones, 2018) (Fig 15). Actin is a protein found essentially in all animal cells. In the process of polymerisation, actin monomers (molecules that can undergo polymerisation) assemble to form filaments or polymer chains. This process takes place over three phases: lag, growth and equilibrium. The lag phase relates to nucleation when the first few monomers stick together to form a stable configuration that becomes the nucleus for polymerisation. The growth phase is characterised by the addition of monomers to the polymer. The equilibrium phase, commonly known as “treadmilling”, occurs when the net flux of monomers to and from the filament stabilises and the polymer retains a constant length (Fig 13 and 14). Through various means of modelling and simulation, the group aimed to understand these behaviours and investigate how they could be interpreted at a larger scale in the development of new and non-standard modes and methods for assembly. As a result of this investigation, the group developed a series of component prototypes. These elements had directionality, polarity and connectivity, they could aggregate to form structures and stick together using magnets. The group does not aim to apply this system on an architectural scale but supposes that a certain

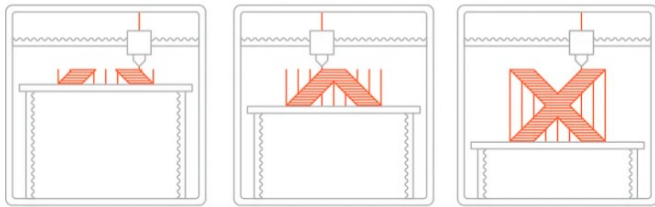


Figure 16. (above) - 3D Printing Process: Material Extrusion

Material extrusion is the 3D printing process whereby thermoplastic filament is pushed through a heated nozzle and deposited along a predetermined path in successive layers to form a solid object.

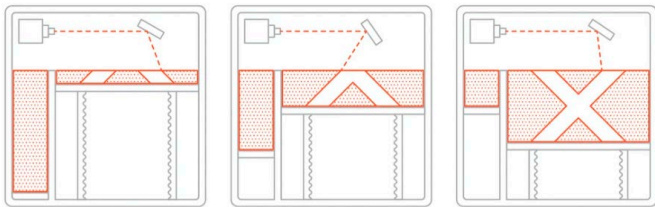


Figure 17. (above) - 3D Printing Process: SLS (Selective Laser Sintering)

In this 3D printing process a thermal energy source selectively induces fusion between powder particles inside a build area to form a solid object.

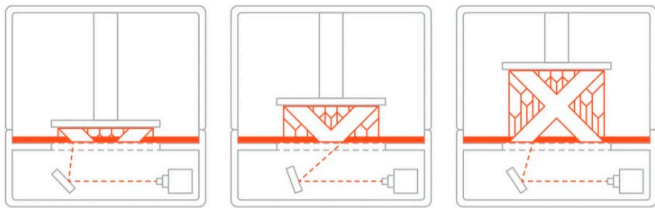


Figure 18. (above) - 3D Printing Process: SLA (Stereolithography)

In SLA 3D printing a light source selectively cures a photopolymer resin in a vat.

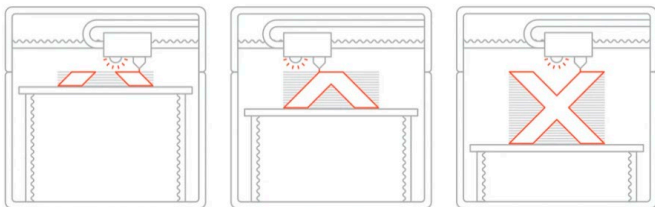


Figure 19. (above) - 3D Printing Process: Material Jetting

Material jetting works in a similar way to an inkjet printer where tiny droplets of a material are deposited on a build surface and cured but instead of only printing a single layer, multiple layers are built up on top of each other to form a solid object.

understanding of cellular behaviour may engender a quality of “cellness” in architectural design. They believe that the tools, methods and models generated through their research endeavours can support alternative strategies in architecture and promote new ways of thinking in design and science.

1.4.3. Prototyping

Prototyping is a system of investigation and invention essential to research and development. It involves acquiring knowledge through making operations and embodies processes for further thinking and working through (Armstrong, 2019). Rapid prototyping is the fast fabrication of a physical model, part or assembly using computational design and digital fabrication technologies. Through digital fabrication, computational space is linked to the material world, effectively breaking down distinctions between processes of design and production. Computation codifies design into a set of instructions for digital fabrication. Through digital fabrication, virtual models are translated into physical space. The designer mediates between the digital and physical realms.

3-D printing, laser cutting, CNC-milling (computer numerical control milling) and robotic assembly are digital fabrication technologies that support rapid prototyping (Sabin & Jones, 2018). 3-D printing is a means of additive manufacturing and lends itself to the creation of individual

and continuous component parts or fibrous assemblages. Different types of 3-D printing technologies include, for example, material extrusion (Fig 16), SLS (Selective Laser Sintering) (Fig 17), SLA (Stereolithography) (Fig 18), and material jetting (Fig 19). Robotic assembly refers to fabrication via the use of industrial robot arms (Fig 20 and 21). The operation, or movement, of these machines, can be programmed by the user. End effectors, devices that attach to the end of a robot arm, can be selected, changed or customised depending on the robot's required function (Fig 22). CNC-milling is a means of subtractive manufacturing in which a rotating cutting tool progressively removes material from a workpiece to produce a product and laser cutting is the process by which a laser is used to cut pieces out of or engrave on a flat material surface. These controllable processes allow for quick and easy fabrication and a high level of quality and precision.

Robot House is a programme at the Southern California Institute of Architecture that supports fabrication via robotic assembly (Testa, 2017) (Fig 23). It is a design and simulation lab, an animation studio and a movement and prototyping platform. The programme advocates learning and creative experimentation in the use of industrial robot arms beyond simply applying them for fast and precise production. The programme also explores how developments in robotics might redefine design practice in the future. Computer softwares developed in-house enable visual programming and animation-based motion control, real-time motion

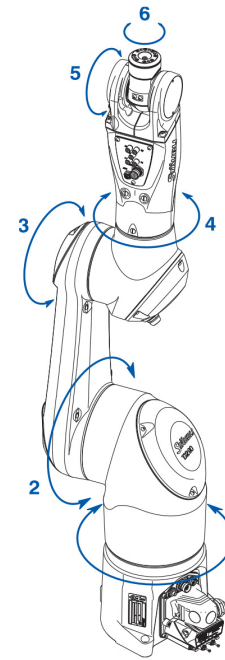


Figure 20. (above) and Figure 21. (left). Six axis industrial robot.

Figure 22. (right). Robotic end effectors, top to bottom, 3 pronged gripper, 2 pronged gripper, extruder nozzle.



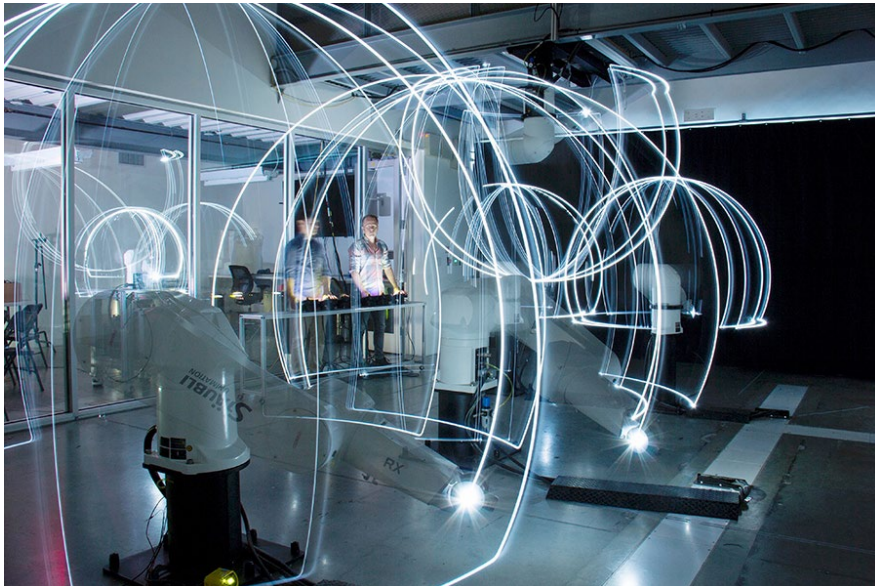


Figure 23. Robot House, Southern California Institute of Architecture, multi-robot choreography.



Figure 24. Robotic Fabrication Laboratory, ETH Zurich.

control, object-orientated programming and multi-robot choreography. Robot House has six robot arms, all with six-axes and fully spherical ranges of motion. These robots are positioned to create a complex shaping environment. The software and machinery are instruments, creative mediums, used by students for prototyping and representing their designs through experimental processes. Conceptual, digital, robotic and physical workspaces operate in parallel and creative workflows span across these realms. Robot House gives us an idea of the mechanical requirements and potential of a university facility for fabrication via robotic assembly.

The Robotic Fabrication Laboratory (RFL) at ETH Zurich is a large scale digital construction environment that supports research in the field of robotic fabrication in construction and architecture (Gramazio Kohler Research, ETH Zurich, 2016) (Fig 24). In the lab, four six-axes robots with fully spherical ranges of motion are mounted to overhead running gantry ways and can be moved in the x, y and z directions. The total shaping environment created is 45x17x6m and allows for the construction of large scale architectural projects and construction experiments. The RFL platform is also open to use by other disciplines and provides the necessary means for conducting research projects that rely on digitally controlled spatial applications.

Both hand and digital competencies can be integrated into prototyping processes. The designer must determine what means of fabrication are

best suited to the scale, intention and realisation of their design. The formation of complex assemblies may also require the use of multiple different fabrication techniques. Virtual models can be used to simulate and describe a feasible way to make and assemble prototypes using the desired tools and materials. The proposed Centre would support multiple means of fabrication and include in its programme wood and metal workshops as well as digital fabrication labs for 3-D printing, laser cutting, CNC milling and robotic assembly. As material, computation and fabrication technologies become more and more sophisticated, more and more opportunities arise for investigating and inventing design solutions.

The Made In Workshop (MIW) in Fontainebleau, Randburg, is an example of a local makers space that integrates options for both digital and traditional fabrication methods (Made-in Workshop, 2020). The shared workshop provides access to facilities for laser-cutting, 3D-printing, CNC-milling and metalwork for members to innovate and experiment in designing and manufacturing a project, product or idea. It offers members the opportunity to work in a collaborative environment and connect with other members, gain inspiration and share advice. After receiving training on how to use the tools and machinery available in the workshop, members can book or “hire” equipment as they need it. MIW also offers access to fully licensed CAD software and uncapped internet. The space allows small scale manufacturers to upgrade their manufacturing capabilities without having to incur heavy fixed financial costs. A similar

model would be implemented at the Centre proposed in this report, whereby makers, designers and entrepreneurs would be allowed to access the university facility after completing a training course and for a fee. Professional artisans employed at the proposed Centre would be available to provide advice and assist users with the operation of heavy machinery, in line with Wits’ health and safety policies.

The University of Johannesburg’s Experimental Fabrication Laboratories provides another precedent for this project. These labs also support research and development and prototyping. They are open to any department at the University and offer facilities including laser cutting, 3D printing, woodworking, CNC-milling, a lighting studio, a VR studio and a printer room (The University of Johannesburg, 2019). To use the labs, students and researchers must attend an orientation, after which they can book an available time slot to use the specialised equipment and spaces.

Material experimentation, selection and application are essential aspects of prototyping. Materials libraries present a broad range of material possibilities and raise awareness of new commercially available, innovative and sustainable material products. Typically, materials libraries, like Material ConneXion, MateriO, the Swiss Material Archive and the Harvard University Material Library, offer access to online material databases and physical material collections as well as provide consultancy services (Fig 25 and 27). Users can search and find detailed material information and specifications online, browse physical samples

and request advice on material options from experts. The Harvard University Material Library works in parallel with the curriculum of the Graduate School for Design, allowing students to experiment with materials and develop expertise which they carry forward with them into practice (Schroepfer, 2011). Research conducted within the school's seminars and design studios feeds back into the material collection, making it an institutional archive of material trends and critical thought. A materials library would support prototyping activities, allow students to engage with material technologies and could be expanded by materials research at the proposed Centre. Open access to the materials library would be available to the public although consultancy services would be charged for.

Networking and multi-disciplinary association in a creative space could bring together common interests and encourage the formation of collaborative business arrangements and joint research endeavours. Large funding opportunities are available for collaborative research efforts that engage real-world problems and develop commercially viable products (University of the Witwatersrand, 2020). Crowdfunding also becomes an option when addressing socially relevant issues or market demand. Successfully attracting finances for student bursaries, innovation, project running costs and equipment would lead to increased student throughput, research output and return on investment (University of the Witwatersrand, 2020).

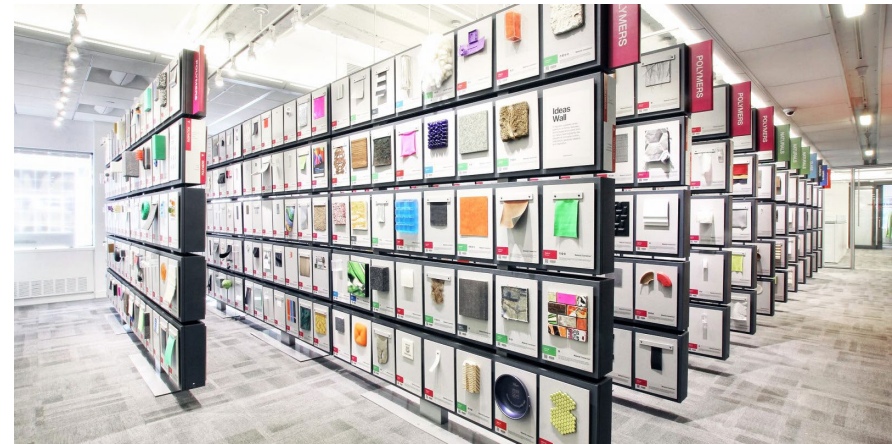


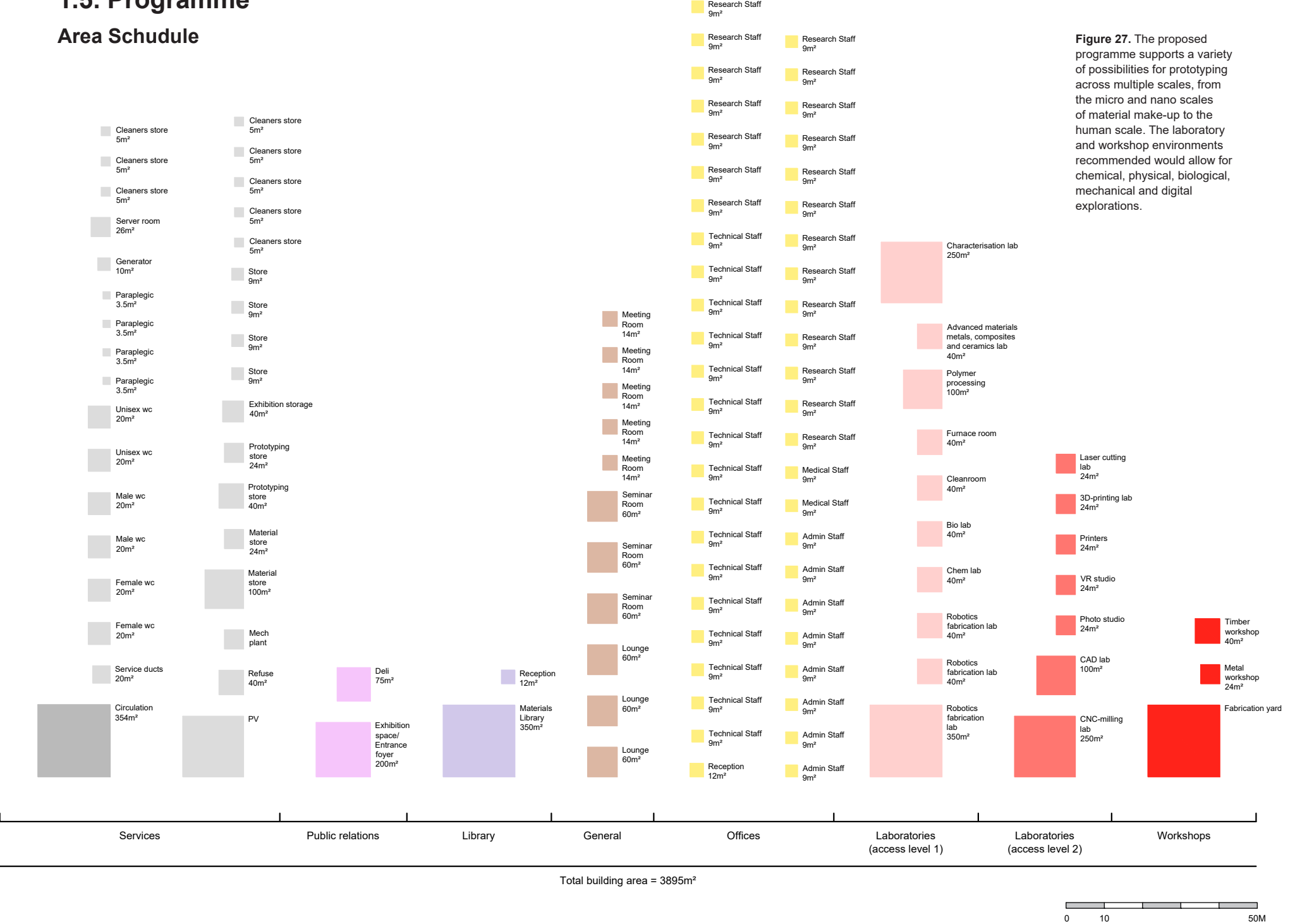
Figure 25. Material ConneXion, material sample library, New York.



Figure 26. Material ConneXion, material tabular.

1.5. Programme

Area Schudule



Spatial Repatonships

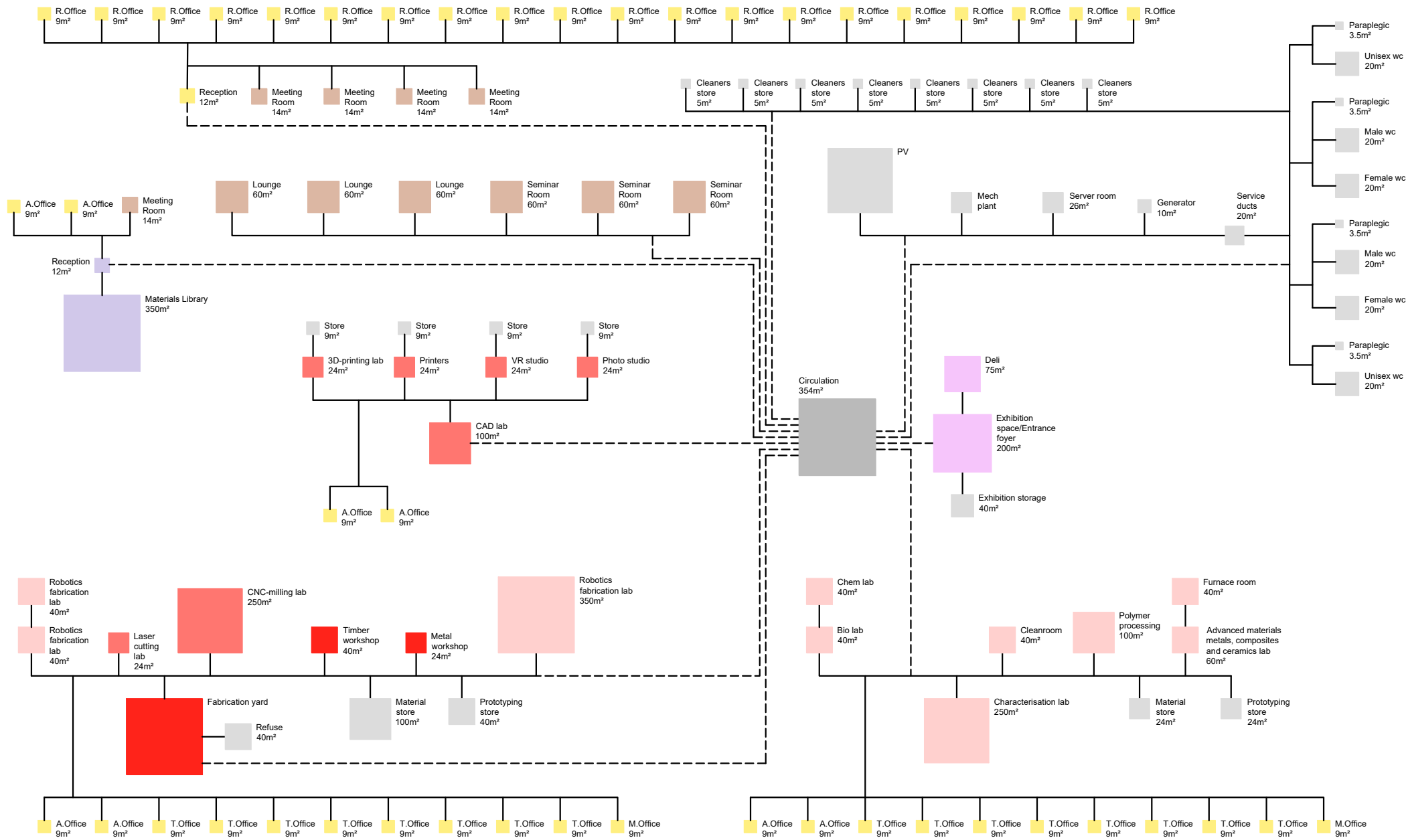


Figure 28. The above diagram illustrates planned spatial connections and groupings.



User Groups

Faculty of Engineering and the Built Environment
School of Architecture
School of Civil and Environmental Engineering
School of Chemical and Metallurgical Engineering
School of Electrical and Information Engineering
School of Mechanical Industrial and Aeronautical Engineering

Faculty of Humanities
School of Arts

Faculty of Science
School of Computer Science and Applied Mathematics (Robotics)
School of Geosciences (Paleontology)
School of Physics (Materials Physics)

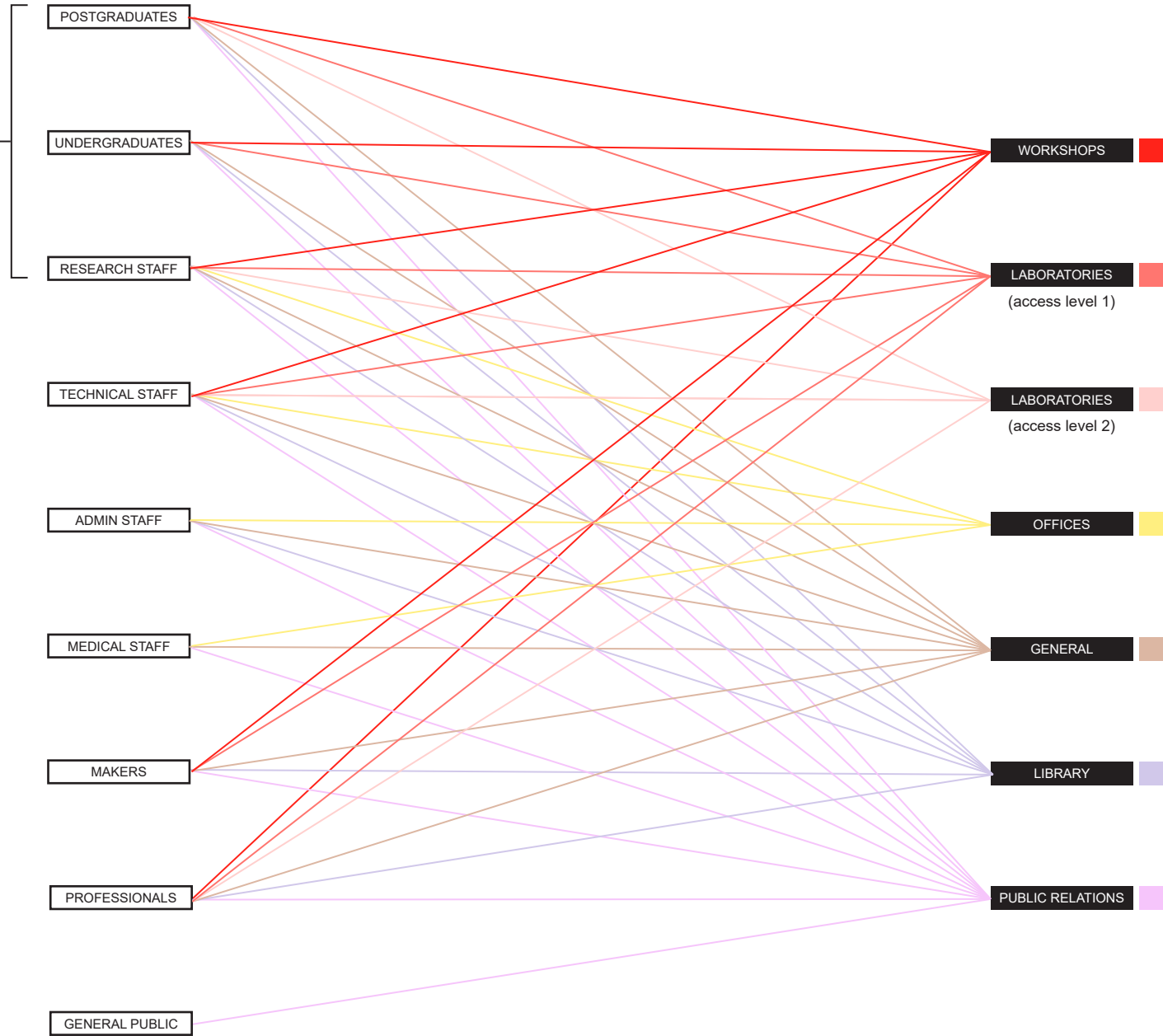


Figure 29. The proposed building would integrate the above mentioned users in its programme.

1.6. Refractography Experiment: Surface Properties of Materials

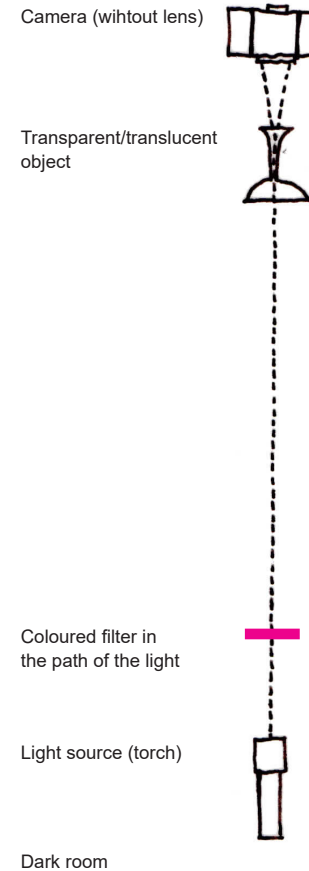
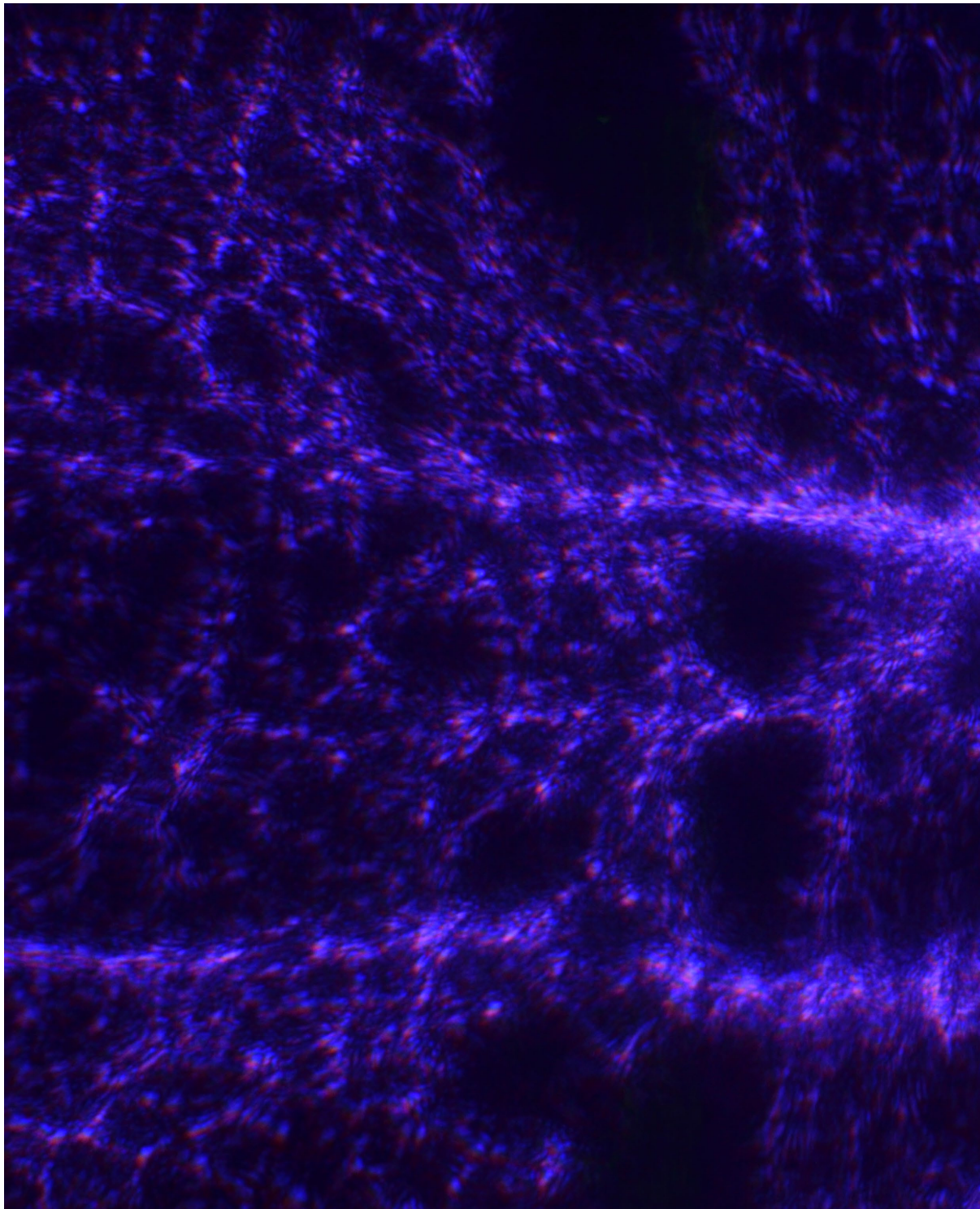


Figure 30. (above). Refractography setup.

Figure 31. (left). Refractograph.

This experiment comprised a series of refractographs, which are images of patterns formed when light reflects and refracts through a transparent object. Different shaped glasses of varying opacities and different coloured filters were used to produce different lighting effects. The material surface becomes a platform for artistic expression in terms of how it interacts with light.

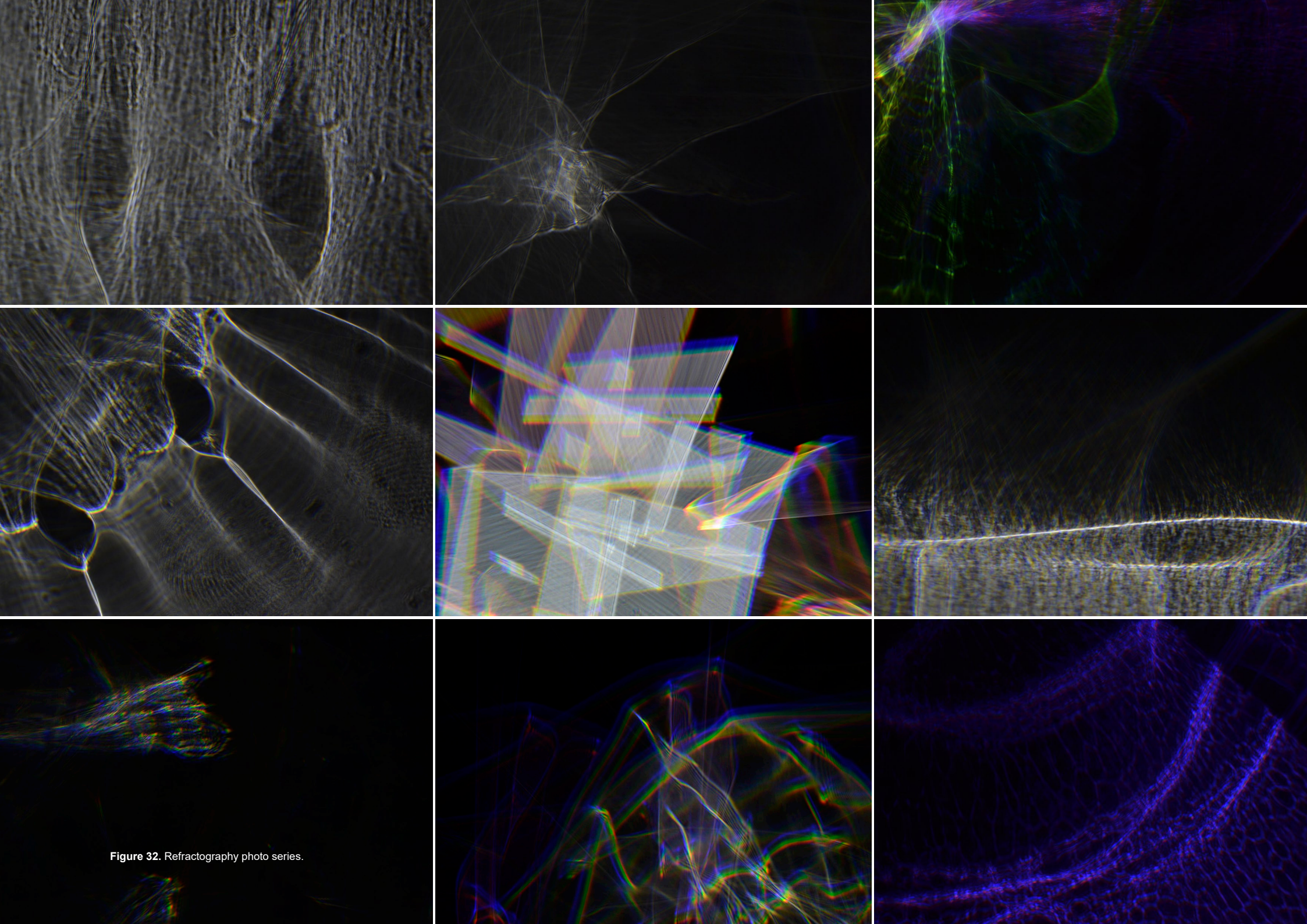


Figure 32. Refractography photo series.

1.6. Adaptive Architectural Surfaces

Environmental consideration in architectural practice is an increasingly imperative international cause. Fundamental to sustainable building is energy efficiency and support for a circular material economy.

Currently, South African energy supply is dominated by fossil fuels. South Africa's National Development Plan (NDP) prioritizes transition to a low carbon economy and the provision of affordable, accessible and reliable clean energy to all (The Presidency: National Planning Commission, 2012). Essential to achieving this goal is the increased use of renewable energies and the promotion of energy efficiency. The adoption of energy-efficient technologies in building can significantly reduce energy demand and consumption.

Building operations account for the highest levels of energy usage in building lifecycles (Khatib (ed.), 2016). For Jamal Khatib, professor of civil engineering, this is mainly attributed to the use of HVAC systems (Khatib (ed.), 2016). How a building skin manages light, heat and fluctuating weather conditions directly contributes to the energy performance of a facility and the creation of a comfortable internal environment. Dynamic material systems and technologies can be applied to the design of adaptive facades that mediate light and temperature, respond effectively to environmental changes and reduce operational

energy demands. Experimental architecture approaches to the issue of sustainability can produce new concepts for the creation of a truly ecological architecture, an architecture that is in constant feedback and interaction with its surrounding environment (Menges (guest ed.), 2020).

1.6.1. Smart Materials and Dynamic Details

Any discussion about the detail is inevitably about the smallest particle of architecture per se (Castle (guest ed.), 2014). The detail is the smallest architectural element that can be imbued with meaning. Sensors, microcontrollers, actuators and information technologies are transforming architectural details into networked and programmable systems with embedded behaviours and responses that function on an invisible level (Castle (guest ed.), 2014). If the essential purpose of architecture is to design the human experience, then the faculty of the architect expands considerably when they have the opportunity to utilise invisible technologies that only make themselves known performatively by their response to the environment and their effect on people (Castle (guest ed.), 2014). In the project, Epiphyte Chamber, by the Living Architecture Systems Group, sensors, microcontrollers and actuators are used in the development of a prototypical system designed to react to human presence, movement and action in the creation of an interactive and

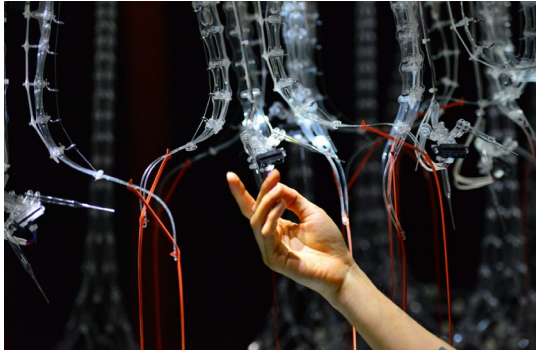


Figure 33. Epipyte Chamber, Living Architecture Systems Group.

empathic environment (Living Architecture Systems Group, 2013) (Fig 33). In this case, responsive technologies are used to enhance the user's spatial experience. Added functionality and performance at an invisible level presupposes a new meaningful minimum for architectural design (Castle (guest ed.), 2014).

Smart materials deploy chemical or mechanical devices active within the material to make certain behavioural characteristics possible. This includes property-changing, energy-exchanging or matter-exchanging behaviours. Within the material, one phenomenon is converted into another phenomenon in response to an input. An interesting example of smart material behaviour encountered as being of particular relevance to architecture is the hygroscopic nature of conifer cones (Menges (guest ed.), 2020). Hygroscopicity refers to a material's ability to take in moisture from the atmosphere when dry and release moisture to the atmosphere when wet, thereby maintaining a moisture content in equilibrium with the surrounding relative humidity (Menges (guest ed.), 2020). The scales of a conifer cone open to release seeds when dried and close when wetted. Inspired by this behaviour, the Department for Form Generation and Materialisation at HFG Offenbach and the Institute for Computational Design (ICD) at the University of Stuttgart developed a humidity-responsive veneer-composite element that took advantage of the hygroscopic properties innate to wooden material (Menges (guest ed.), 2020) (Fig 34 and 35). Like the scales of a conifer cone, the veneer-composite element could open or close in response to

an increase or decrease in relative humidity. The element's behaviour could be customised or 'programmed' by adjusting the parameters of its construction. When open, a system of combined elements could allow for natural ventilation and, when closed, protect against the rain, with the ability to sense, actuate and respond to weather dynamics embedded within the material components themselves.

The Homeostatic Facade System developed by Decker Yeadon, an architecture office based in New York, presents another example of smart material technology applied in the design of an environmentally responsive architectural surface (University of Washington Conversation, 2013) (Fig 36 and 37). The prototypical system is low energy, sensor-regulated and self-actuating. It comprises an engineered ribbon inside the cavity of a double-glazed window. The ribbon is made from an electroactive polymer which is a material capable of changing in shape or size when stimulated by an electrical field. A silver coating on the electroactive polymer distributes a charge across its surface causing it to expand and close to provide shading and protect against solar heat gain. This adaptive system was inspired by the compression of human muscles and the ability of organisms to regulate their internal environment, including their temperature.

1.6.2. Biomimicry and Synthetic Biology

Environmentally responsive and adaptive behaviours are fundamental

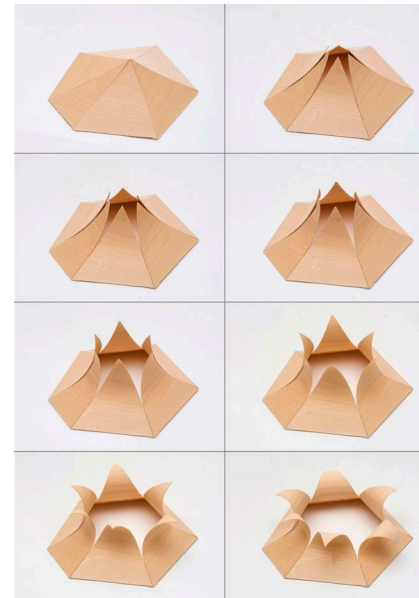
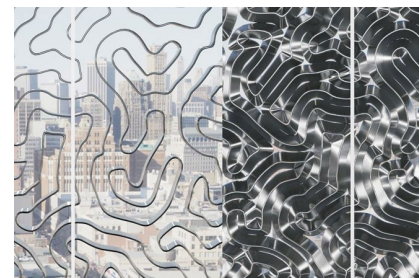
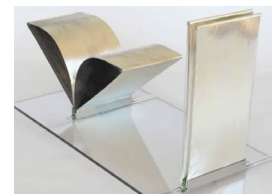


Figure 34. (top right). Conifer cone, open and closed, section and elevation.

Figure 35. (top left). Responsive Surface Structure II, Department for Form Generation and Materialisation at HFG Offenbach and the Institute for Computational Design (ICD) at the University of Stuttgart.

Figure 36. (bottom left) and Figure 37. (middle). Homeostatic Facade System, Decker Yeadon.



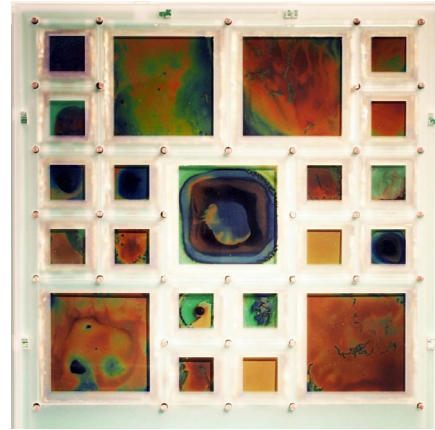
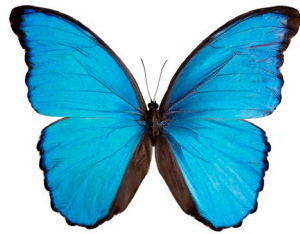


Figure 38. (top left). Blue Morpho butterfly.

Figure 39. (top right). eSkin, LabStudio.

Figure 40. (bottom left) and Figure 41. (bottom right). Vespers Series III Mask, Mediated Matter Group.



to living systems. Structures and processes found in nature, developed over millions of years of evolution, embody efficient and sophisticated solutions that perpetually inspire design and technological advancement. Architecture has always looked to nature for inspiration. In a general sense, we can refer to nature-inspired design as biomimicry (Sabin & Jones, 2018). Biomimicry takes cues from natural models to enhance formal, structural or other performance-based outcomes.

LabStudio investigates biologically informed design through the representation of complex datasets and the experimental prototyping and digital fabrication of speculative material systems (Sabin & Jones, 2018). Together the lab and studio develop tools, methodologies and models that translate biological behaviours into the realms of architecture and material manifestation. Design solutions are generated as a result of experimental, process-based research practices conducted in a shared and collaborative environment.

eSkin is an example of a prototypical smart material technology developed by the group inspired by the structural colour of Blue Morpho butterfly wings and hummingbird's feathers (Sabin & Jones, 2018) (Fig 38 and 39). Structural colour refers to colour produced as a result of an optical effect as opposed to pigmentation. Nanostructured surfaces trap and reflect out a specific wavelength of light that is perceived as colouration. Changes in the pattern and geometry of such a nanostructured surface would effect changes in colour, opacity and transparency. The group aimed to translate

this material behaviour to the design of a dynamic and colour-changing sun-shading system. To achieve the desired material effect at the human scale, the group used a nanoparticle solution that exhibited structural colour adaption in relation to a variable voltage. The application of an electrical charge to the solution altered its particle arrangement leading to a change in colour appearance.

Synthetic biology involves the design of new biological systems and the redesign of systems already found in nature. Where biomimicry is nature-inspired design, synthetic biology is design-inspired nature (Mediated Matter Group, 2020). Biosynthetic approaches in architecture integrate biological behaviours with material and detail systems to generate models and prototypes that are at once natural and artificial (Sabin & Jones, 2018).

Hybrid living materials (HLMs) are biosynthetic material composites that combine living and non-living matter. An example of this is Mediated Matter Group's Vespers Series III (Mediated Matter Group, 2020, *Vespers Series III...*) (Fig 40 and 41). Mediated Matter Group is a cross-disciplinary research group at MIT that draws inspiration from nature and biology in the application and development of design fabrication tools and technologies. In their Vespers Series III, objects, masks, are 3D-printed with embedded chemical signals that direct microorganisms, biologically engineered bacteria, spray-coated on their surfaces to produce pigments. The process used allows for strict control of designed

and biologically derived properties, creating a pre-programmable, responsive material surface. This technique could potentially be applied to the patterned production of bioactive compounds in personalised drug delivery devices (Mediated Matter Group, n.d., *Mediated Matter Project...*). HLM's are part of an emerging class of materials that aim to expand the ways in which living cells can be functionalised to generate new material properties (Mediated Matter Group, n.d., *Mediated Matter Project...*). Such technologies could one day be applied in the design of environmentally responsive architectural skins. Theoretically, bio-engineered and bio-hybrid materials could transform buildings into living organisms, metabolisms, that sustain inhabitants and integrate into local ecosystems (Armstrong, 2019). *Experimental Architecture: Designing the Unknown*, presents a vision of the future where cities can be programmed to change states, evolve and eventually act and learn as living organisms, where all of these performances are embedded in their material properties (Armstrong, 2019). Approaches to experimental architecture with material intentions could promote the emergence of such alternative theories.

Synthetic biology operates between nature and technology, where mechanisms inherit the qualities of organisms and vice versa. This approach supports the creation of architectures that interface with natural systems and encourages the development of hybrid built and natural environments that sustain dynamic ecosystems.

1.8. Bottle Experiment: Mechanical Properties of Materials

Figure 42. (right). Bottle Experiment photo series.

Figure 43. (bottom left). Bottle Experiment final form.

The malleability of plastic allows it to be reshaped by applying pressure. In this experiment a metal wire was used to change the form of a plastic bottle by applying a tensile force. This demonstrates how different materials can act on each other to evoke new qualities. How materials handle forces can also result in a transformative effect.



1. Pour boiling water into plastic bottle



2. Tie metal wire around bottle and tighten



3. Tie second metal wire around bottle and tighten



4. Pour water out of bottle



5. Allow plastic to cool and harden



6. Remove wires



7. Final form



Figure 44. Human bone, cross section showing microstructure.

1.9. Material and Structural Efficiency

“No material is without form and no form exists without materialization”
 - Menges (guest ed.), 2012, *Material Computation: Higher Integration in Morphogenetic Design*

Elegant form and efficient function so often go hand in hand in the living world (Menges (guest ed.), 2020). It is through homeostasis – the continual striving for a good fit, or stable equilibrium, between living things and their external conditions – that this beautiful coherency emerges (Menges (guest ed.), 2020). Consider bone as an example (Fig 44). Bones are remarkably well-designed structures capable of supporting static and dynamic loads under often unpredictable conditions. Bone is a living and dynamic structure that is constantly remodelling itself. Cells within the bone monitor strain and redistribute material mass, building up bone here, taking it away there, until every place in the bone is bearing the same amount of strain, the bone is optimally bearing its load (Menges (guest ed.), 2020). Homeostasis is accommodated at the point where structure and function are optimized (Menges (guest ed.), 2020). In a sense, as described in *Material Computation* by J Scott Turner, an American physiologist, “Bones are well-designed because they want to be well designed, they know when their design falls short, and they take active steps to remedy the shortcomings”.

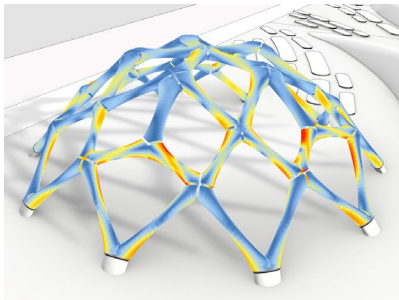
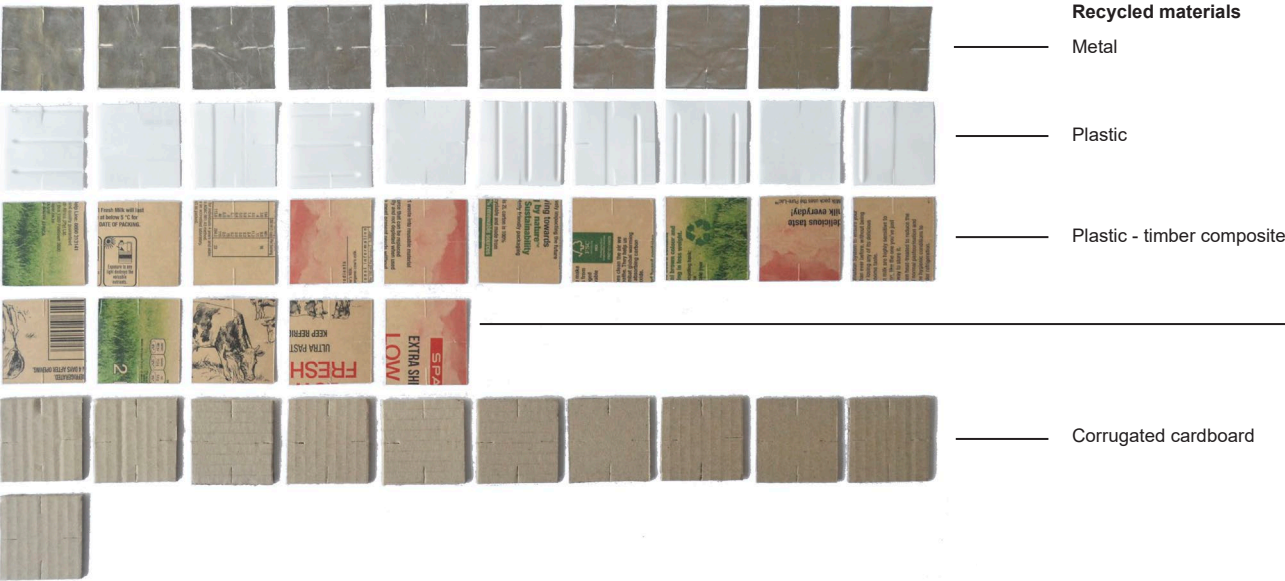


Figure 45. (top), Figure 46. (middle), Figure 47. (bottom). The BUGA Fibre Pavilion, Institute for Computational Design (ICD) and the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart.

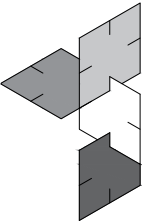
Nature's strategies can inspire form generation in architecture driven by maximum performance with minimal resources through local property variation, or anisotropy (Menges (guest ed.), 2020). Anisotropy is the ability of a material structure to exhibit different physical properties along different axes. In biology, most load-bearing structures, like bone, are fibre-composites that exhibit finely-tuned and locally varied material distributions that enable unrivalled structural performance and material efficiency. Computation allows for the simulation of material application and improved structural performance in the production of built form.

Experimental architecture projects present a means by which to investigate and develop alternative, sustainable and efficient material and structural solutions. The BUGA Fibre Pavilion by the Institute for Computational Design (ICD) and the Institute of Building Structures and Structural Design (ITKE) at the University of Stuttgart combined cutting edge computational and digital fabrication technologies in the development of a building system inspired by structural systems found in nature (University of Stuttgart: Institute for Computational Design and Construction, 2019) (Fig 45, 46 and 47). In this project, fibre-composite building components were manufactured using a technique in which fibrous filaments were wound between two rotating scaffoldings by a robot. Translucent glass fibres were used to form a lattice onto which black carbon-fibres were placed where they are structurally needed. These components were used in the construction of a large dome, were highly effective and exceptionally lightweight. Their unique architectural expression also contributed to the creation of an extraordinary spatial experience.

1.10. Recycled Materials Experiment: Joining of Materials



Materials are cut into squares with slits on all 4 sides to allow them to be joined together in different ways to form larger structures and to be taken apart.



Example of 4 squares joined together. This system allows different materials to interact with each other, to be assembled and to be disassembled.

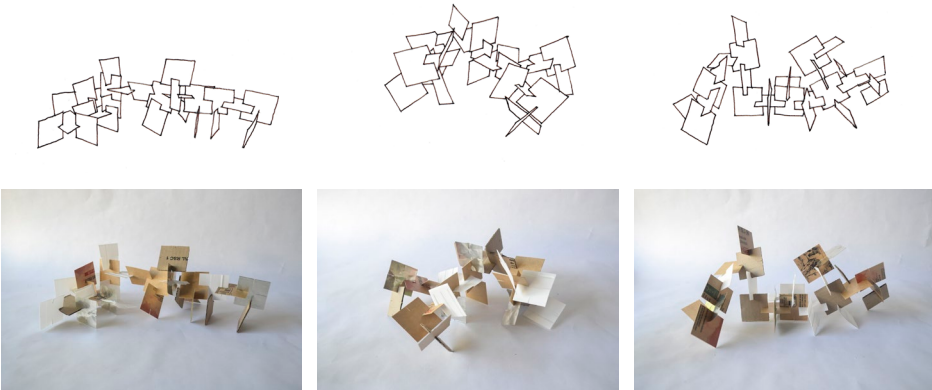


Figure 48. (above). Cards made from recycled materials and material joining system.

Figure 49. (left). Material assemblies.

This experiment used recycled materials in the creation of a system that allowed different material elements to be joined together in different ways. Disassemblable material systems allow building components to be reused after deconstruction or renovation which is supportive of a circular material economy.

1.8. Assembly and Disassembly

A circular economy aims to eliminate waste and recover resources through recycling and reuse. The South African economy is at present unsustainably resource-intensive (The Presidency: National Planning Commission, 2012). In favour of more sustainable consumption and production patterns, the National Development Plan (NDP) anticipates the absolute reduction of the total volume of waste disposed to landfill each year through increased recycling and the development of green products, processes, technologies, and services (The Presidency: National Planning Commission, 2012). Recycling and reusing building components and retrofitting or renovation, as opposed to redevelopment, are sustainable approaches in building industry that support this intention.

Recycling or reusing materials in construction can decrease the need for raw material extraction and limit the waste stream burden. Recycling materials via low energy preparations also offers a means for reducing the amount of energy spent in material processing in general. Energy-saving strategies and the use of recycled or reused materials can help reduce the ecological footprint of the built environment.

Buildings represents a substantial material and carbon investment. Preserving or adapting built form is generally more resource and energy-efficient than redevelopment. Pre-planning a design in ease of adaption

or reuse can lessen the level of intervention required in the refurbishment of an existing building to meet emerging needs (Lifschutz, A. (guest ed.), 2017).

Rotor is a Brussels-based cooperative design practice that investigates material studies and reuse strategies with a focus on sustainability and ecology (RotorDC, 2020). Services offered by Rotor include identifying the reusable elements of an existing building, scouting for suitable reclaimed elements for a project, providing specifications for integrated reuse strategies, and designing projects to maximise the incorporation of reclaimed elements. The company also creates exhibitions and uses reclaimed elements in interior design projects. Rotor Deconstruction/ Consulting is a spin-off division of Rotor that promotes and facilitates the reuse of construction materials in large-scale projects with the intention of supporting a resource-efficient materials economy (Rotor, About us...). The reuse value of an element depends on various criteria including; market demand, condition, extraction processes and reintegration processes. Salvage reduces the volume of demolition waste and yields good quality building products with a negligible environmental impact.

‘Deconstruction’ was a specialised studio hosted by the Faculty of Architecture and the Built Environment at TU Delft in 2017 (Devlieger et al., 2017). The Faculty brought in Lionel Devlieger and Maarten Gielen

from Rotor as visiting professors. The studio aimed to conceptually ‘deconstruct’ buildings marked for demolition and to identify components available for reuse in radical redesign projects. An exhibition was held at the studio’s conclusion. Rotor’s work and the Deconstruction studio demonstrate the potential of circular material strategies in sustainable design. In the built environment there is opportunity to create an exchange between assembly and disassembly, addition and subtraction. Material resources can be recovered from and reincorporated into the built environment. The architectural profession should engage subtractive and reintegration systems and support closed material loops. Experimental architecture that aims to develop materials and building systems which are sensitive to environmental change and weather fluctuations can provide solutions to help reduce operational energy requirements.

Designing for deconstruction, or disassembly anticipates and plans for the eventual recycling and reuse of materials in the case of renovation or at the end of a building’s lifecycle. Disassembly allows a whole to be broken down into its constituent elements so that they can be combined anew (Castle (guest ed.), 2014). Disassembly processes are intrinsically linked to the materials and methods of construction used (Beorkrem, 2018). Some materials and joining methods lend themselves more easily to being taken apart again. It is the responsibility of the architect to coordinate the relationship between materiality and construction from the point of conception to deconstruction (Beorkrem, 2018).

To create efficient material and (dis)assembly systems design thinking must be aligned with knowledge of material properties (Brownell (ed.), 2010). Using fewer materials to account for multiple performances and simplifying material joints can make construction and deconstruction more convenient.

The potential application of digital fabrication technology in building practice could present novel possibilities for addressing construction challenges in the face of energy expenditure, waste generation, and environmental impact (Menges (guest ed.), 2020). Such possibilities could be engaged by experimental architecture projects. In South Africa, however, construction automation could result in job losses and increased unemployment where the unemployment rate of the country is already of great concern. How then might digital fabrication find appropriate application in the building industry in South Africa? The most promising possibility seems to lie in prefabrication. Prefabrication supports the use of digital fabrication technologies in a factory setting while still requiring on-site labour for assembly. Prefabrication also presents an opportunity for architects to engage with the design of (dis)assembly systems.

Prefabrication and the use of modular building elements are examples of techniques that simplify assembly processes and increase construction efficiency. These techniques enable better sequencing in the construction process, reduce building delivery times and construction costs relative

to traditional construction methods, and create safer on-site working environments (World Economic Forum, 2016). Customisation and versatility in prefabrication are made possible and more affordable by the use of digital fabrication technologies. An extreme example of this is DFAB House, a building project initiated by the National Centre of Competence in Research (NCCR) Digital Fabrication in 2014, and opened in 2019, which was predominantly built using digital fabrication techniques, including bespoke digital prefabrication (DFAB House, 2020) (Fig 47 and 48).

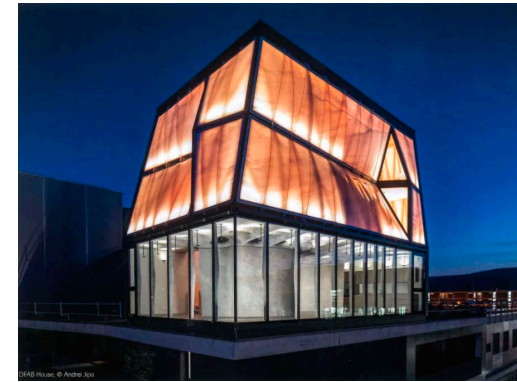
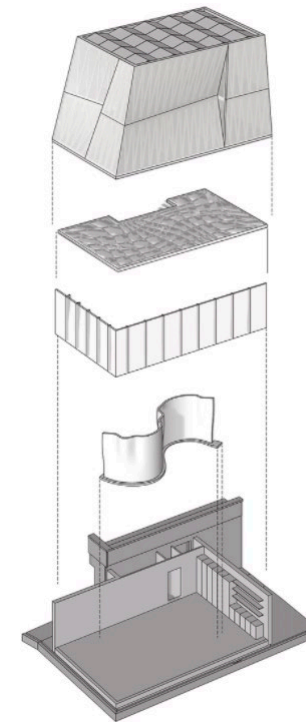


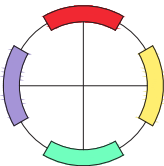
Figure 50. (top) and Figure 51. (bottom). DFAB House, National Centre of Competence in Research (NCCR) Digital Fabrication.



Conclusion

In the context of a shift to a blended model of learning and changing University spatial development requirements, this research report speculates a high-tech, multi-disciplinary research and development Centre at Wits and a university architecture that is inclusive of a broader community and intent on diversifying knowledge bases, forming connections and making discoveries. The proposed Centre would supply a wide range of laboratory environments for the construction of material and component prototypes. Such facilities would offer support for experimental architecture research practices. Architectural experiments offer ways of navigating sustainable and ecological issues (Armstrong, 2019). Through experimental architecture, alternative solutions are developed that enrich debate about how to approach the environment and sustainable challenges facing our world (Armstrong, 2019). In general, our ability to alter the conditions of the present and influence our chances for the future depends on our capacity for innovation and our ability to bring different forms of knowledge together in order to do things differently (World Economic Forum, 2016).

2.1. Design Process



Brief 1 BRIEF - the first phase of the design process establishes the brief for the project, including the project users, programme, site, aims and significance as discussed in the previous chapter. The brief is open to change as the project develops.	Analysis 2 ANALYSIS - in the second phase, research is conducted pertaining to the conceptualization and planning of the project which informs design decision-making. This includes site and precedent analyses.	Concepts 3 CONCEPTS - the third phase of the design process focuses on the development of relevant design concepts motivated by the project objectives.	Development 4 DEVELOP - in the fourth phase, the design is increasingly resolved through an iterative process of trial, evaluation and revision.
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CHAPTER 1

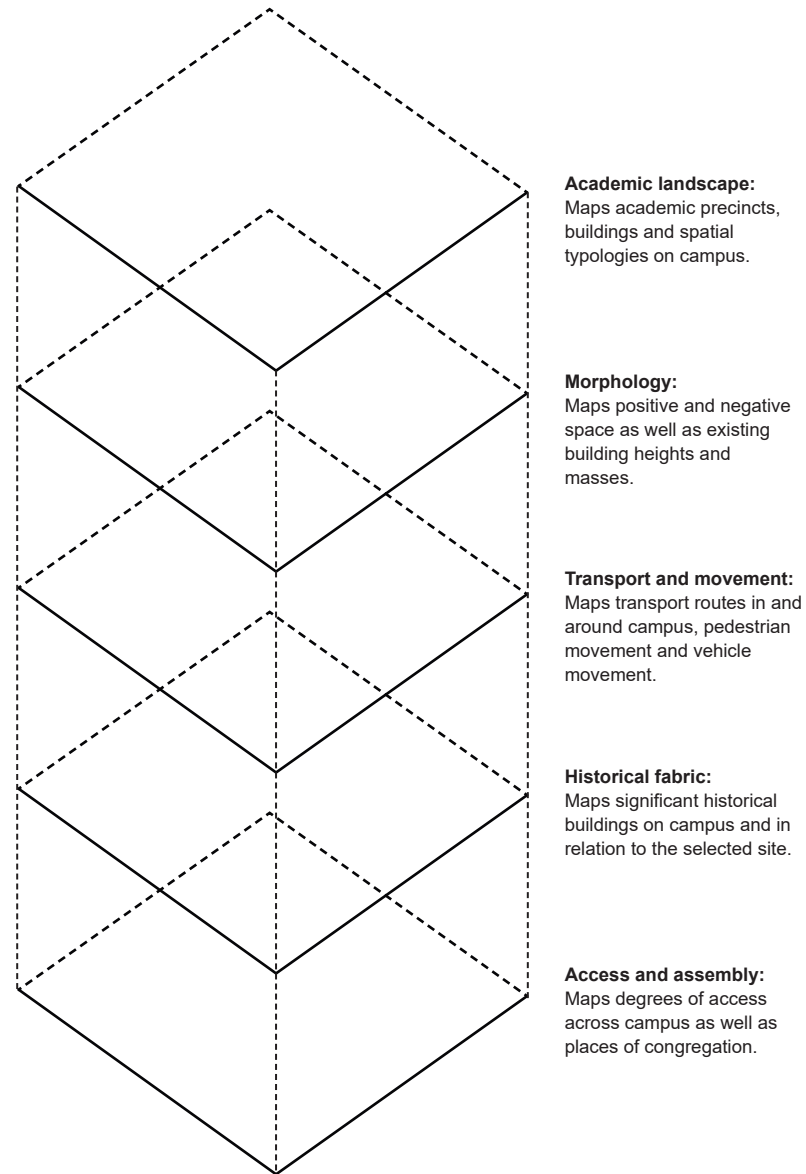
CHAPTER 2

2.2. Site Analysis

In this chapter, the existing landscape of Wits University is mapped and described through a series of filters, including:

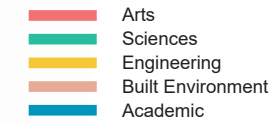
These analyses provide a picture of existing conditions on campus.

Also presented in this chapter are the factors determining site choice, photo essays of the selected site and relevant site informants.



Academic Landscape: Wits University Precincts

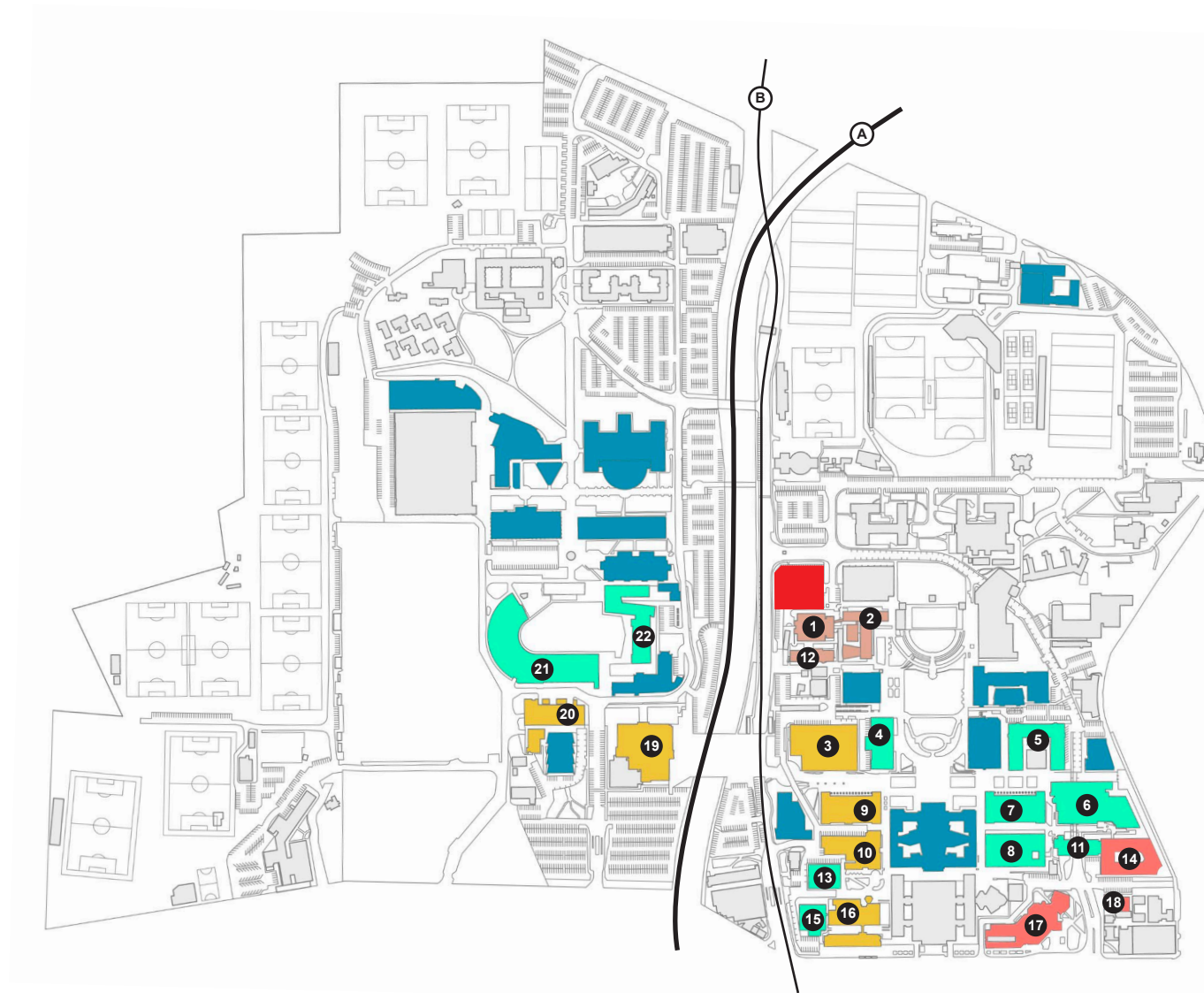
Figure 52. Precincts.



A - M1 Highway
B - Yale Road

- 1 - John Moffat Ex.
- 2 - John Moffat
- 3 - North West Engineering
- 4 - Geo-Science
- 5 - Biology
- 6 - Oppenheimer Life Sciences
- 7 - Physics
- 8 - Humphrey Raikes
- 9 - South West Engineering
- 10 - Hillman Building
- 11 - Gate House
- 12 - Construction Management Bldg.
- 13 - Bernard Price
- 14 - Wits School of Arts
- 15 - Paleoscience Centre
- 16 - Richard Ward
- 17 - Wits Theatre
- 18 - The Nunnery
- 19 - Chamber of Mines
- 20 - Genmin Laboratories
- 21 - Wits Science Stadium
- 22 - Maths and Science Building

The selected site for this project forms part of the precinct for Engineering and the Built Environment located along Yale Road.



Academic Landscape: Spatial Typologies

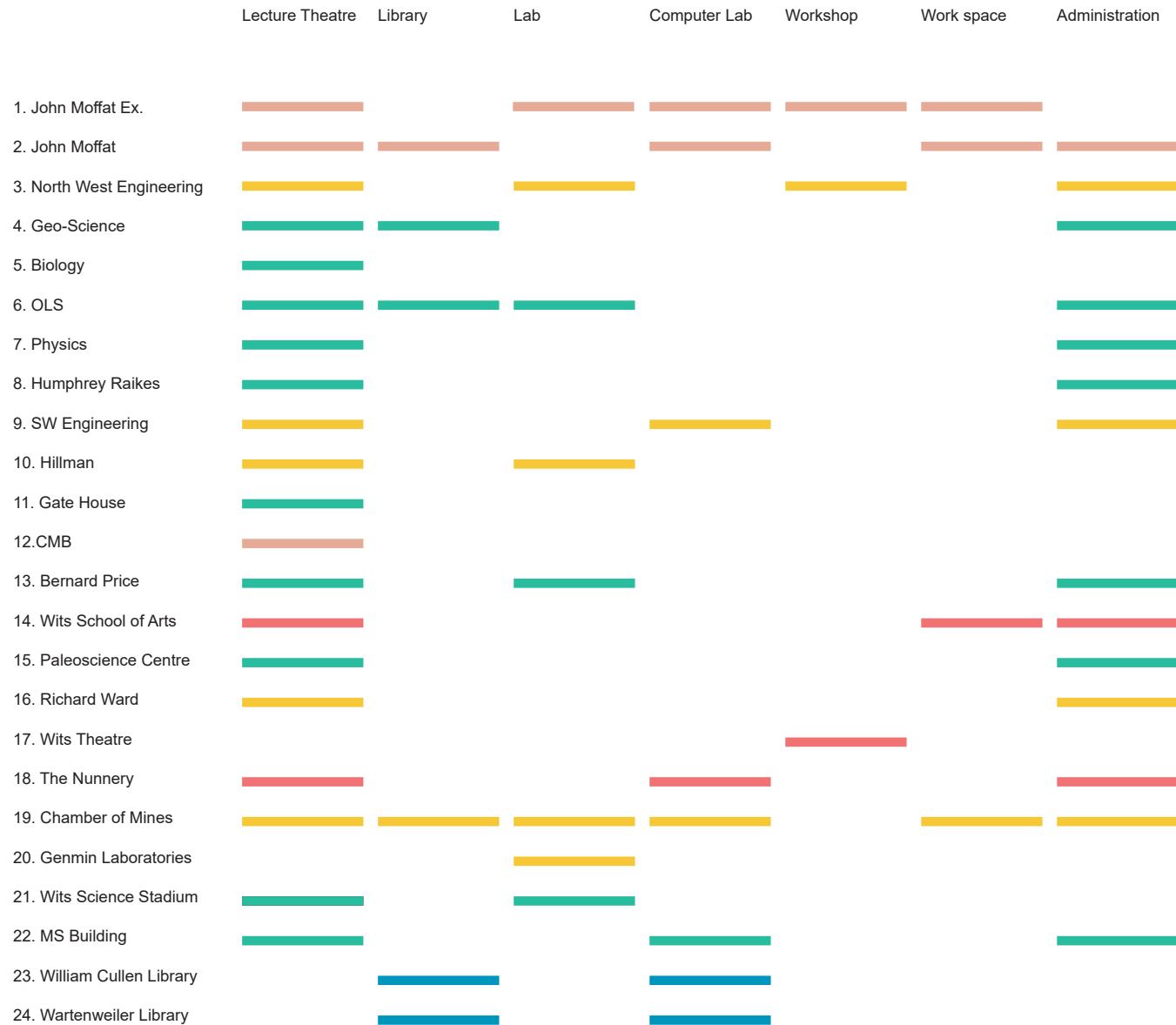
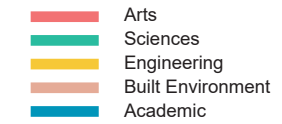


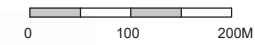
Figure 53. Spatial Typologies.



This diagramme illustrates the various spatial typologies associated with the academic buildings on campus. Lecture Theatre and Administration are the favoured spatial typologies.

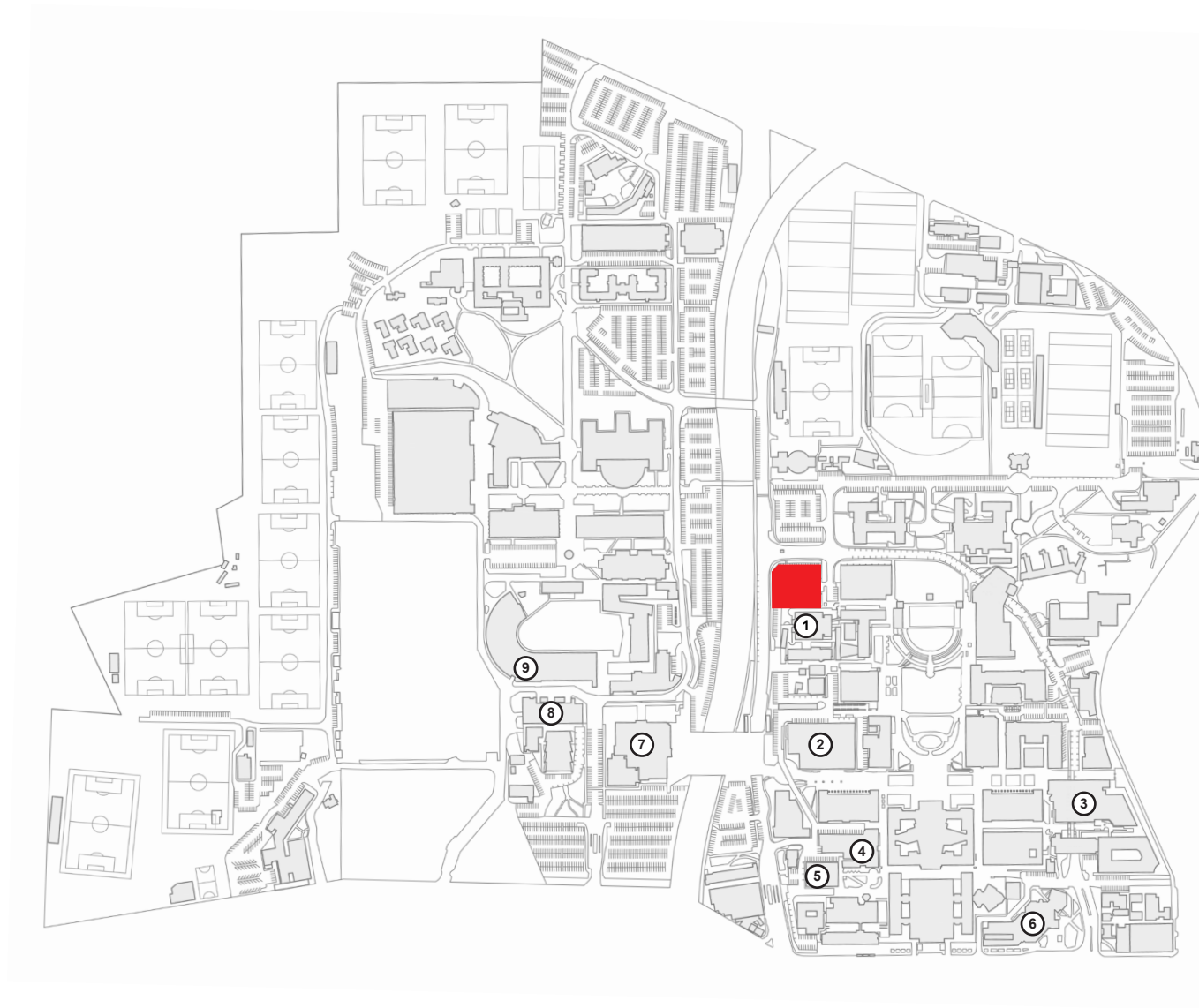
Academic Landscape: Labs on Campus

Figure 54. Existing labs.



- 1 - Architecture fabrication lab
- 2 - Mechanical, industrial and aeronautical engineering labs
- 3 - Life science labs
- 4 - Civil engineering workshops and testing labs
- 5 - Geochemistry lab
- 6 - Set construction
- 7 - Electrical engineering lab and digi-mine lab
- 8 - Electrical engineering lab
- 9 - Chemistry and physics labs

Mapped here are the existing labs and workshops on campus. The close proximity of the selected site to the existing School of Architecture Fabrication Labs creates an opportunity to form a connection between these labs and the programme proposed in this report.



Morphology

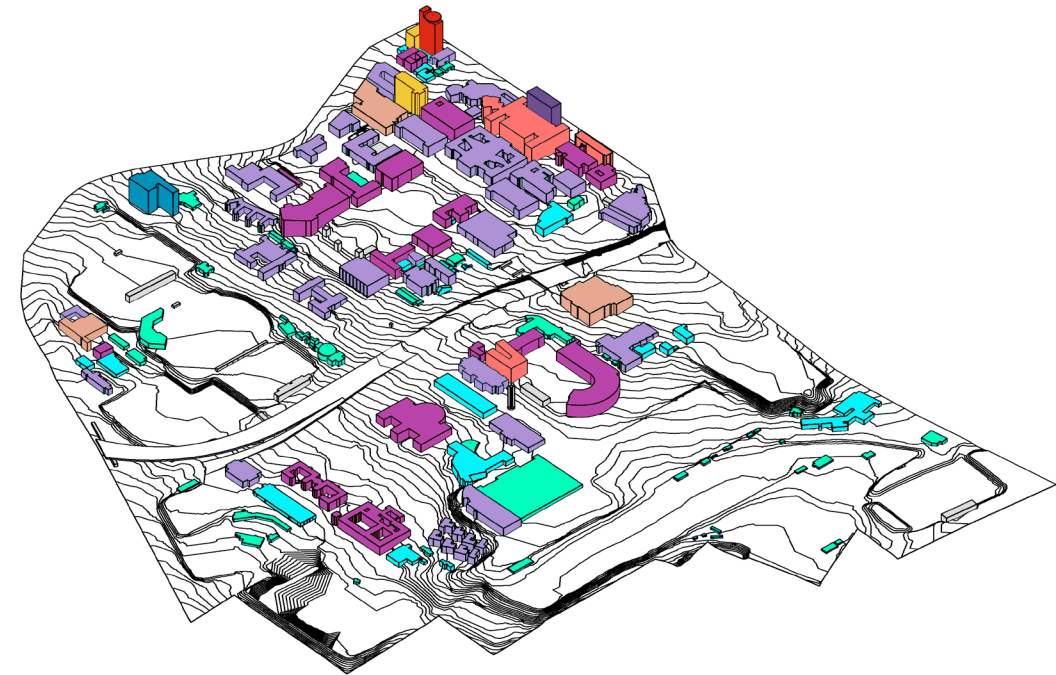


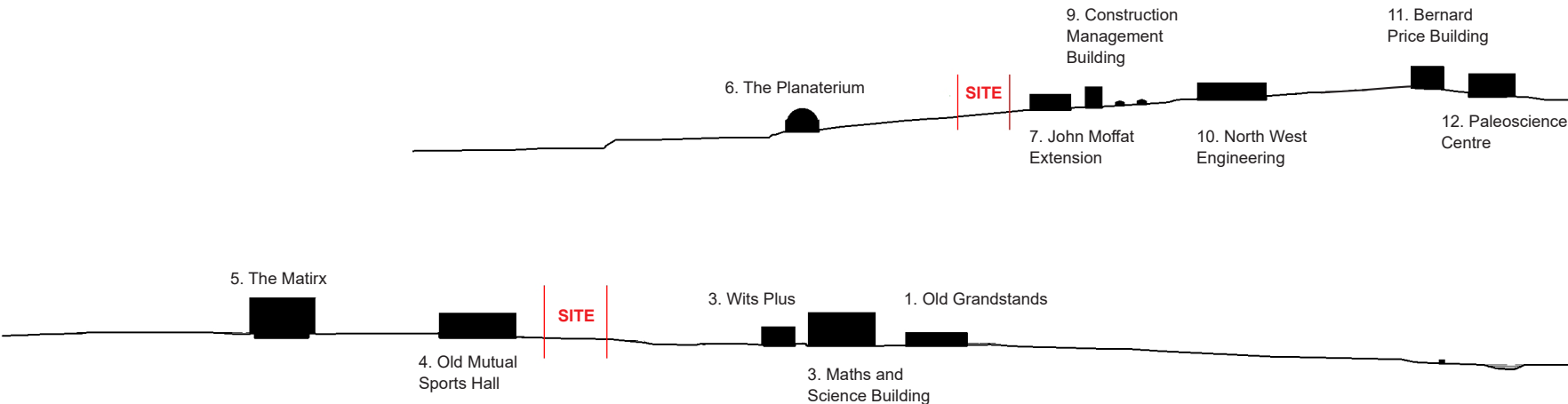
Figure 55. Building Heights.
NTS

- 1 storey
- 2 storeys
- 3 storeys
- 4 storeys
- 5 storeys
- 6 storeys
- 10 storeys
- 13 storeys
- 14 storeys
- 20 storeys

Figure 56. (top). Section AA.
Figure 57. (bottom). Section BB.



Figure 58. Figure-ground.



Transport and Movement



Figure 59. (top left). Transport.

- BRT
- - -●- - - Metro bus route
- ...●... Wits bus route
- ... Predominant
- - - Pedestrian route
- - - Cycle route
- Visiting bus stop

Figure 60. (top right). Vehicle Movement.

- Vehicle entrance
- Restricted access
- Parking
- Dead end
- Vehicle route
- - - Service route

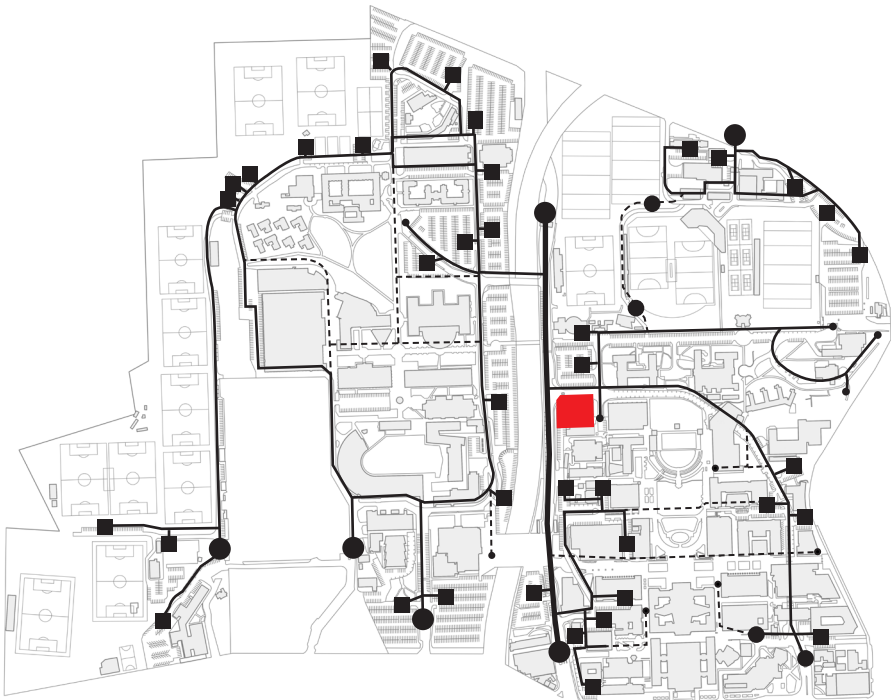


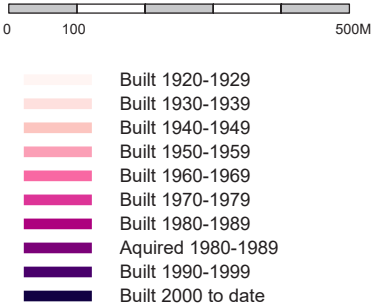
Figure 61. (right). Pedestrian Movement.

- Main access point
- Pedestrian access
- - - Primary pedestrian route
- Secondary pedestrian route



Historic Fabric

Figure 62. (right). Wits Development History.



6. The Planetarium
Built 1960-1969 (Fig. 65.)



Figure 63. Section AA.
NTS

SITE

7. John Moffat Ext.
Built 1990-1999 (Fig. 66.)



8. Yale Telescope
Built 1920-1929
(Fig. 67.)

8. Construction
Management Building
Built 2000 to date
(Fig. 68.)



9. North West Engineering
Built 1920-1929 (Fig. 69.)



10. Bernard Price
Built 1970-1979 (Fig. 70.)



11. Paleoscience Centre
Built 1950-1959 (Fig. 71.)

2. Maths and Science Building
Built 2000 to date (Fig. 75.)

Figure 64. Section BB.
NTS



5. The Matrix
Built 1960-1969 (Fig. 72.)



4. Old Mutual Sports Hall
Built 1970-1979 (Fig. 73.)

SITE



3. Wits Plus (Fig. 74.)



1. The Old Grandstands
Built 1970-1979 (Fig. 76.)

Access and Assembly

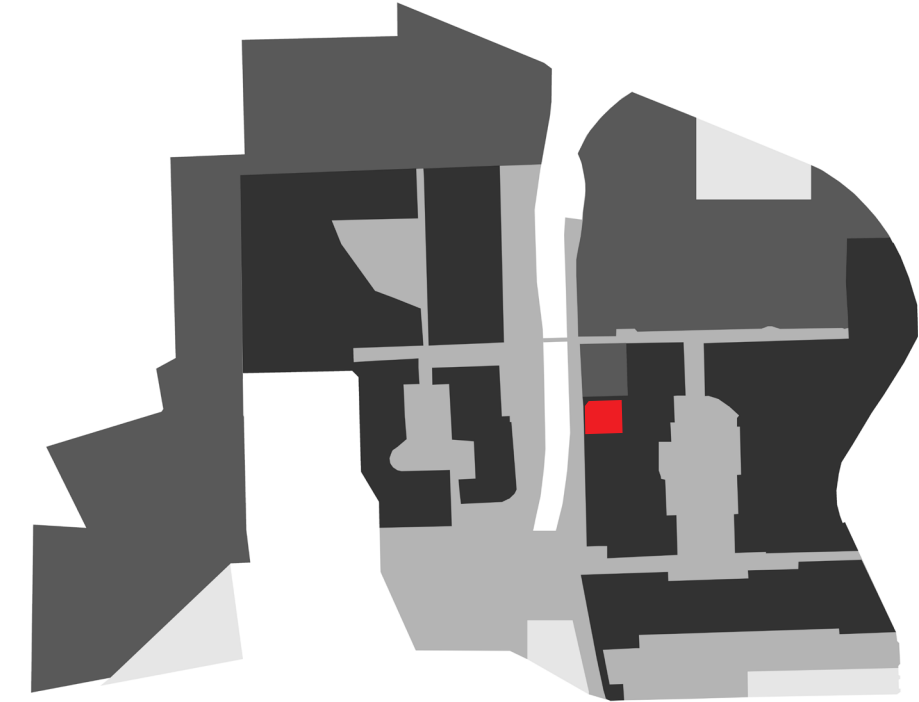


Figure 77. (top left). Gradations of Access

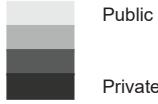
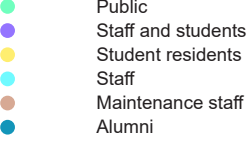


Figure 78. (top right). Pedestrian Congregation

Figure 79. (right). Access



Factors Determining Site Choice

Figure 80. Plan showing site and surrounding context.



1 - Prominent corner:

The site is located on a prominent corner along Yale Rd.

2 - Views:

The downward sloping terrain to the north of the site allows for spectacular views.

3 - Proximity to visitors parking:

Visitors parking is located across the road from the site. Members of the public visiting the proposed centre could make use of this parking area.

4 - Service access:

The service lane located to the east of the site would allow for material deliveries to and waste removal from the proposed centre.

5 - Proximity to FAB LABS:

Proximity of the site to the existing School of Architecture Fabrication Labs creates an opportunity for connection.

1 - Dalrymple House

2 - Old Mutual Sports Hall

3 - Visitors Parking

4 - John Moffat Building

5 - John Moffat Extension

6 - Construction Management Building

7 - Yale Telescope

8 - William Cullen Library

9 - North West Engineering

10 - Geo-science Building

11 - Amic Deck

12 - Library Lawns

13 - Swimming Pool

14 - Basketball and Volleyball Courts

15 - Amphitheatre

16 - Old workshop to be demolished

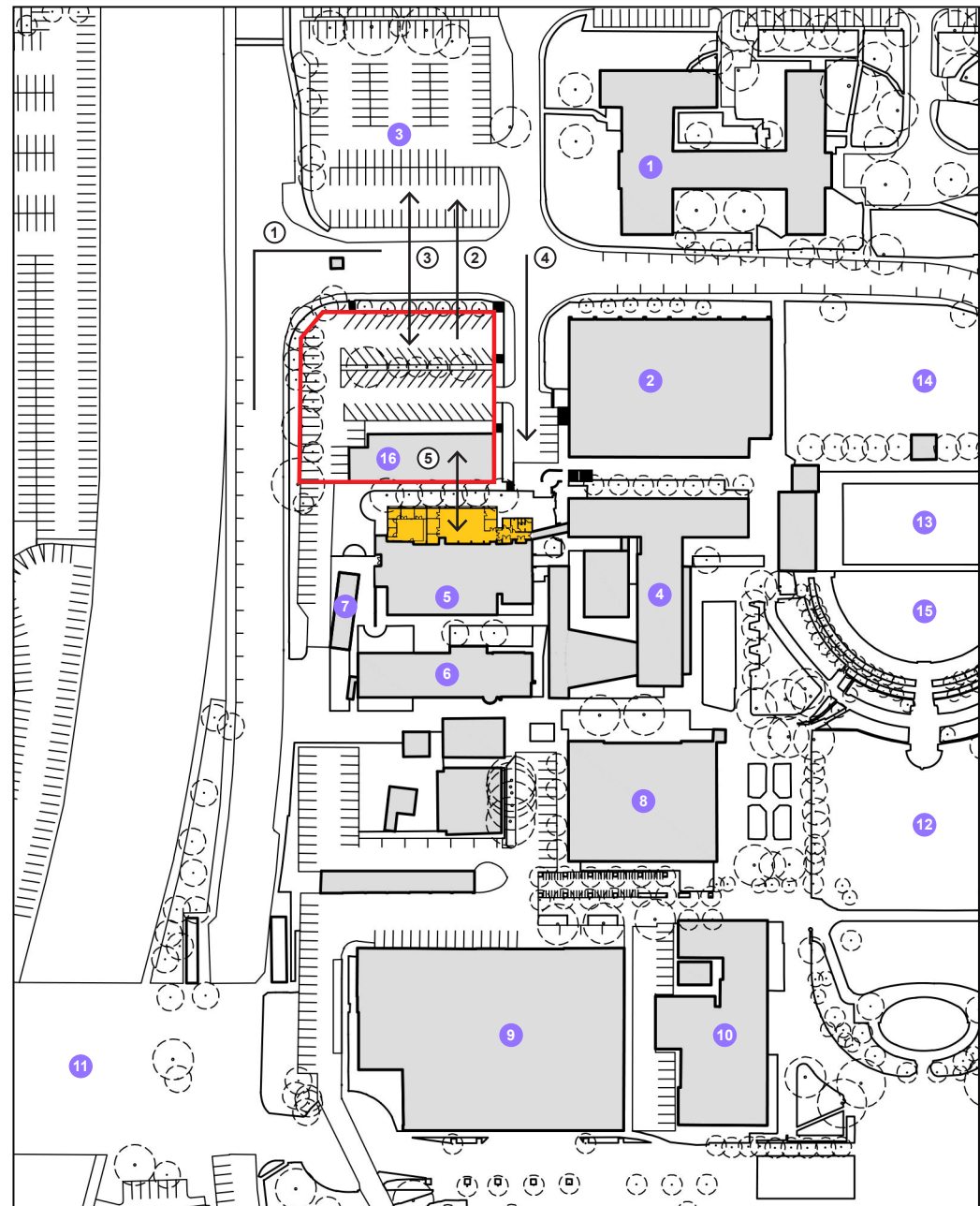


Figure 81. Aerial view showing site and surrounding context.



Photo Essays

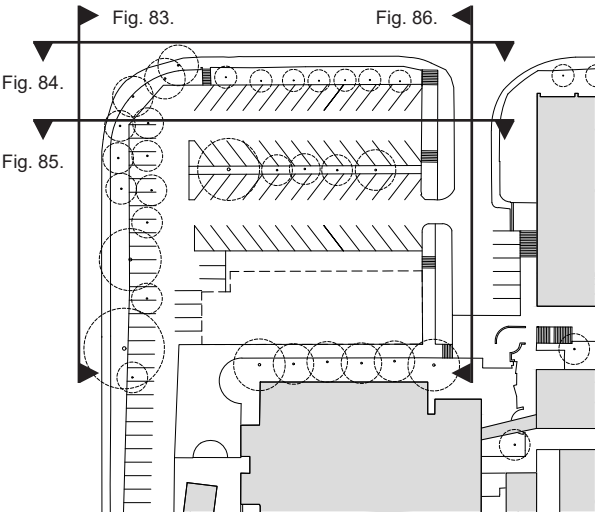


Figure 82. (left). Reference plan.

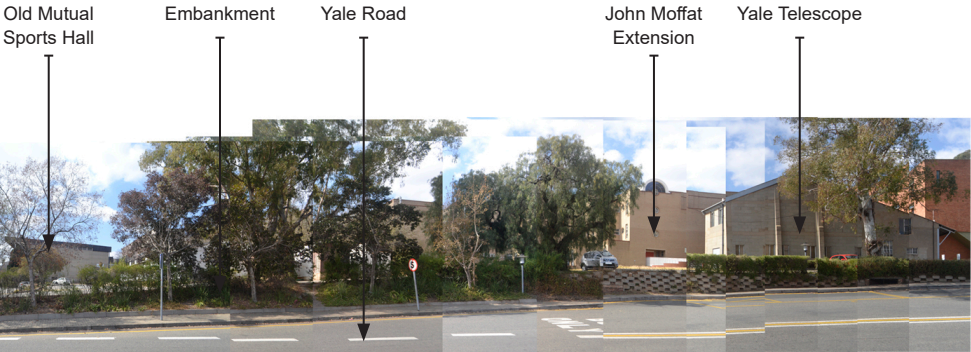
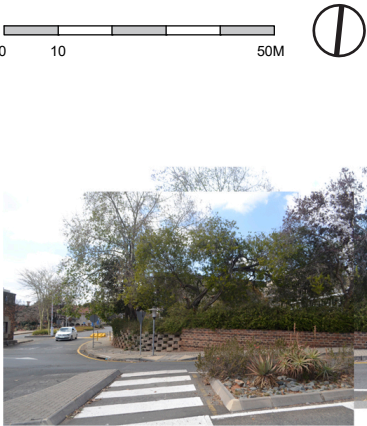


Fig. 83.

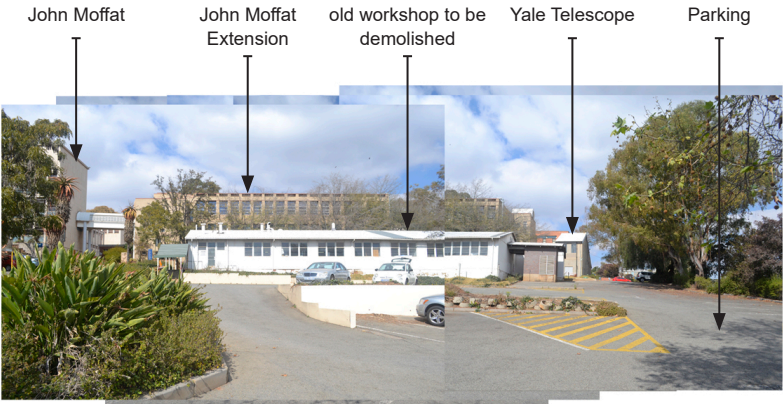


Fig. 85.

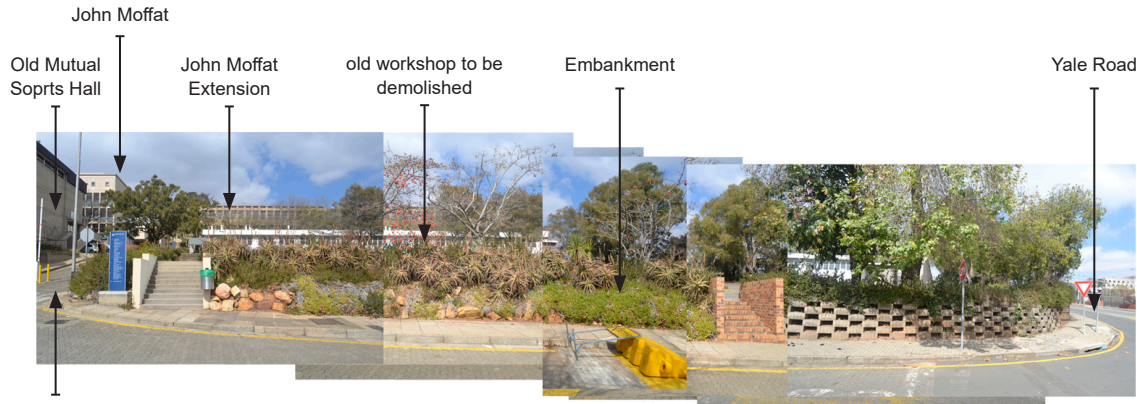


Fig. 84.



Fig. 86.



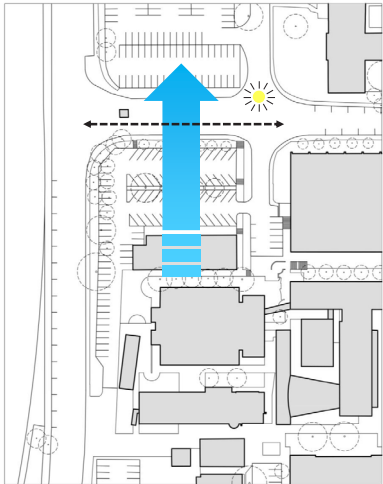


Figure 87. Views and orientation.

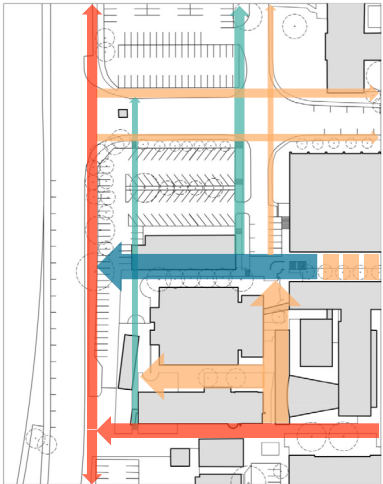


Figure 88. Pedestrian walkways.

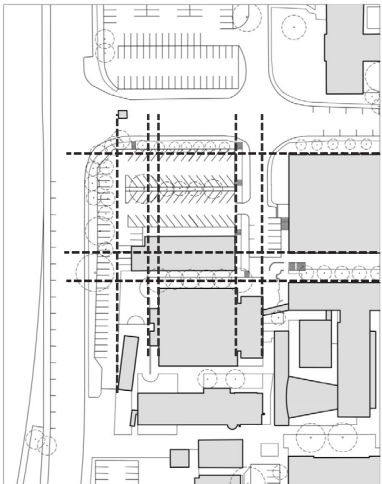


Figure 89. Building edges.

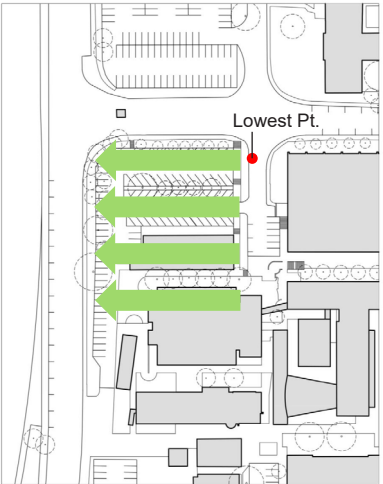


Figure 90. Terraces.

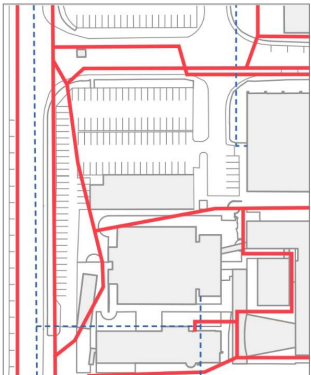


Figure 91. Stormwater and gas

- Stormwater
- - - Gas

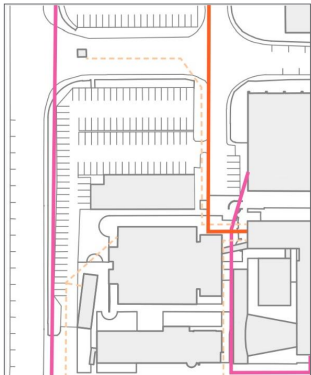


Figure 92. Electricity and Telkom.

- Telkom
- Electricity high voltage
- - - Electricity low voltage

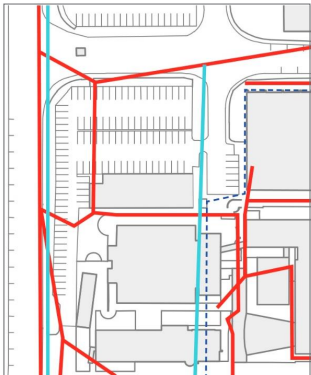


Figure 93. Sewer and water.

- Sewer
- Drinking water
- - - Water

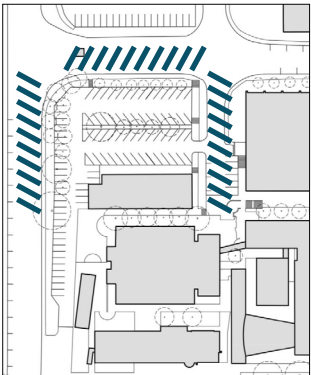


Figure 94. Hard edges.



2.3. Precedent Analysis

Project: Institut Du Monde Arabe, 1987

Location: Paris, France

Architects: Jean Nouvel, Architecture-Studio, Pierre Soria and Gilbert Lezenes

Key features: Adaptive facade

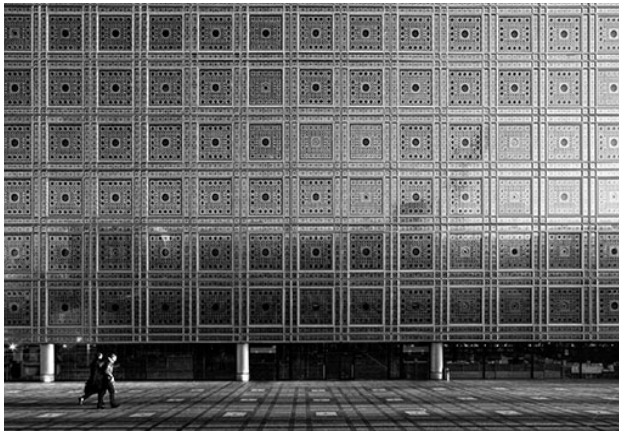


Figure 95. Institut Du Monde Arabe, Jean Nouvel, Architecture-Studio, Pierre Soria and Gilbert Lezenes.

The main feature and innovative element of Institut Du Monde Arabe is its incredibly intricate and beautiful south facing facade (Winstanley, 2010). This responsive metallic brise soleil was inspired by the mashrabiyya, a traditional lattice work screen used in Middle Eastern architecture for ventilation, sun protection and privacy. The system uses light sensitive diaphragms to control light transmission and to mitigate solar heat gain. Shifting geometric patterns form on the facade as aperture sizes increase or decrease. This causes dramatic change to the building's exterior appearance.

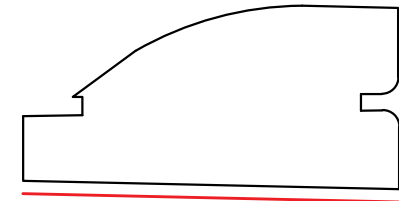


Figure 96. Plan.

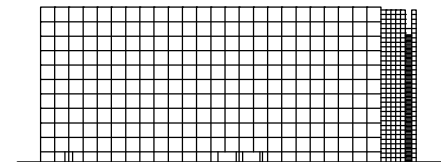


Figure 97. South elevation.

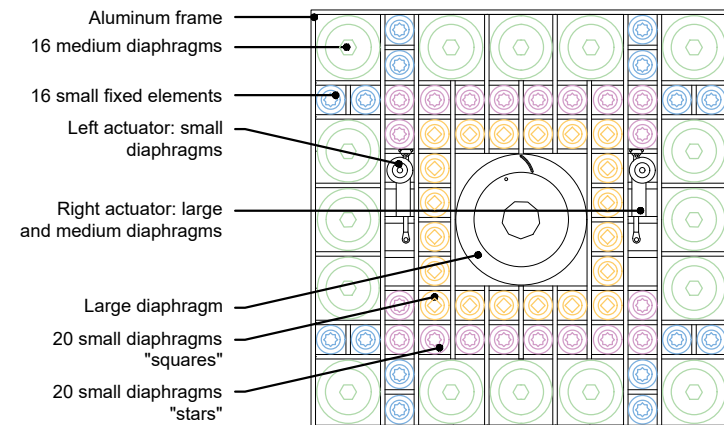


Figure 98. Metallic brise soleil panel.

Project: Anthony Timberlands Centre Design Competition, 2020

Location: Arkansas, US

Architects: Dorte Mandrup

Key features: Structure and programme



Figure 99. Dorte Mandrup, Anthony Timberlands Centre Design Competition Entry.

Dorte Mandrup was one of the six shortlisted firms for the design competition for the future Anthony Timberlands Center for Design and Materials Innovation at the University of Arkansas (Harrouk, 2020). The centre will form part of the Fay Jones School of Architecture and Design and will support the school's new postgraduate programme in timber and wood design. The centre will house the school's existing and expanding design-build program and multiple fabrication technologies laboratories. The centre will also have staff offices, classrooms, seminar spaces, studios and conference rooms. This building typology is similar to the building typology proposed in this research report. The proposed conceptual design

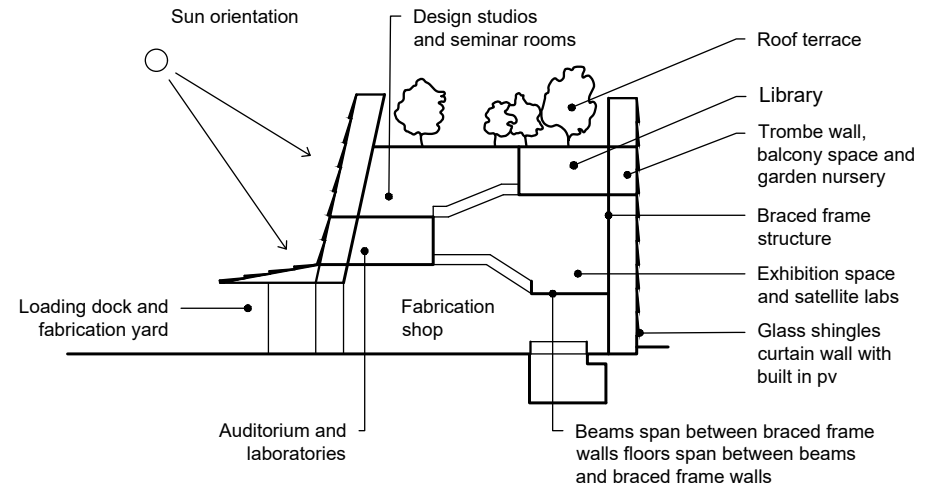
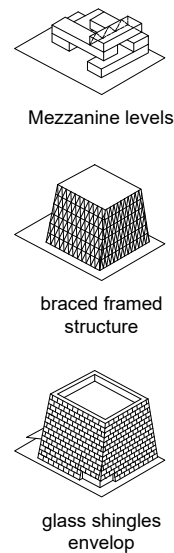


Figure 100. (above right). Sectional analysis.

Figure 101. (above left). Conceptual diagrams.

for the Anthony Timberland Centre by Dorte Mandrup uses a braced frame timber structure to allow clear spans. Inside the building, beams span between the structural surfaces and support mezzanine floor levels. According to Dorte Mandrup, this system of support allows the floor levels to be easily renovated if necessary. The building is enclosed by a curtain wall made up of glass shingles with integrated photovoltaics. The space generated between the structure and enclosure acts as a trombe wall and creates a balcony space that can be used as a garden nursery. The roof also hosts a few trees, supporting the topic of timber design.

Project: Croatian Pavilion at the Venice Biennale, 2010

Location: Venice, Italy

Architects: Saša Begović, Marko Dabrović, Igor Franić, Tanja Grozdanić, Petar Mišković, Silvije Novak, Veljko Oluić, Helena Paver Njirić, Lea Pelivan, Toma Plejić, Goran Rako, Saša Randić, Idis Turato, Pero Vuković and Tonči Žarnić

Key features: Light and materials



Figure 102. Croatia Pavilion at the Venice Biennale, 2010.

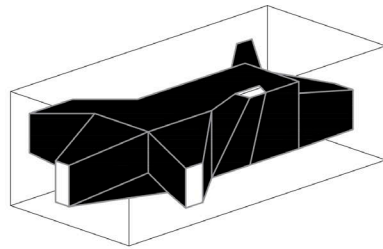


Figure 103. Void form axonometric.

The 2010 Croatian Pavilion at the Venice Biennale was inspired by the idea of a mirage (Beorkrem, 2018). The installation was constructed on a 10mx20m barge at the Kraljevica ship yard, employing local contractors, and was towed across the Adriatic to Venice. The construction consists of 42 layers of steel mesh, typically used for re-inforced concrete slabs, welded to vertical rods at set vertical intervals. A void form with a series of view cones is carved out of the structure and shaped by varying the horizontal contours. The different densities of steel mesh create different transparencies, resulting in a moiré effect. The materiality and phenomenological expression of the pavilion create a unique user experience.

Project: Media Centre building at the Massachusetts Institute of Technology, 2009

Location: Massachusetts, US

Architects: Maki and Associates

Key features: Programme



Figure 104. MIT Media Centre, Maki and Associates.

The Media Centre building at the Massachusetts Institute of Technology supports trans-disciplinary research culture (MIT, 2009). The Centre supports technological innovation, design and the arts at MIT. Research teams at the centre work on projects ranging from biomechanics and personal robots to city science and responsive materials. Within the building, seven flexible laboratories are arranged around a central atrium criss-crossed by ramps and staircases. Offices are clustered around the labs. The airy glass and metal framework allow for abundant natural light and views into and across all the laboratory spaces, create an internal absence of openness, embodying the cross-disciplinary work conducted at the Centre.

Project: New Lab, Research and Manufacturing Centre, 2016

Location: Brooklyn, US

Architects: Marvel Architects

Key features: Programme

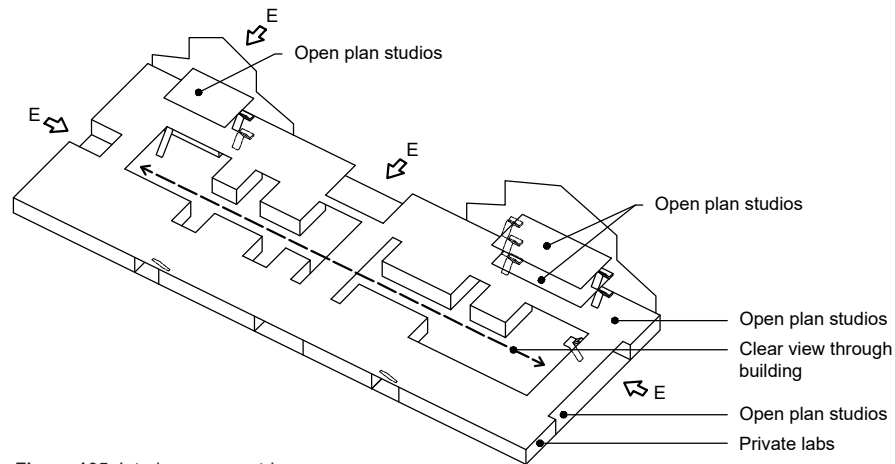


Figure 105. Interior axonometric.

This development project converted an old hanger for ship manufacture in the Brooklyn Navy Yard into a new lab, research and manufacturing centre (Maggiore, 2019). The historic structure was preserved and only the building interior was renovated. The centre provides facilities for institutions, designers, fabricators, manufacturers, scientists and engineers, creating a collaborative space for innovation and education. The building programme includes communal meeting areas, studios, prototyping labs and an event and exhibition space. This building typology is similar to the building typology proposed in this research report.

Project: Anthony Timberlands Centre Design Competition, 2020

Location: Arkansas, US

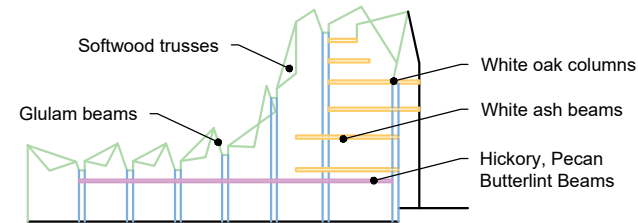
Architects: Grafton Architects

Key features: Building as a tool for teaching



Figure 106. (top left). Grafton Architects, Anthony Timberlands Centre Design Competition Entry.

Figure 107. (bottom left). The building was intended as a teaching tool, making use of a variety of different timbers and showcasing their qualities and strengths.



Grafton Architects was selected as the winning firm to design the Anthony Timberlands Centre for Design and Materials Innovation, a new applied research facility for wood and timber design that would form part of the Fay Jones School of Architecture at the University of Arkansas (Harrouk, 2020). The firm's entry for the competition showcased the versatility of timber as both structure and envelope and featured a cascading canopy roof. The building itself was intended as a teaching tool, displaying the strength and quality of the various timbers used.

Project: Media-TIC/78, 2011

Location: Barcelona, Spain

Architects: Enric Ruiz-Geli

Key features: Adaptive facade and structure



Figure 108. Media-TIC/78, Enric Ruiz-Geli.

The Media-TIC/78 building is a communication and information technology hub set in the science and technology district of 22@Barcelona built in 2010. CAD and CAM digital systems were used in the design process (Ruiz-Geli, 2010). The design objective for this building was for it to generate and use energy efficiently. This is achieved through the use of ETFE (ethylene tetrafluoroethylene) facade systems that control light transmission and mitigate solar heat gain and through photovoltaic modules installed on the roof. ETFE is an efficient building material which is light, insulative, durable and performs well under high temperatures. The south-east building facade is clad with a triangular configuration of inflatable ETFE cushions. Shading

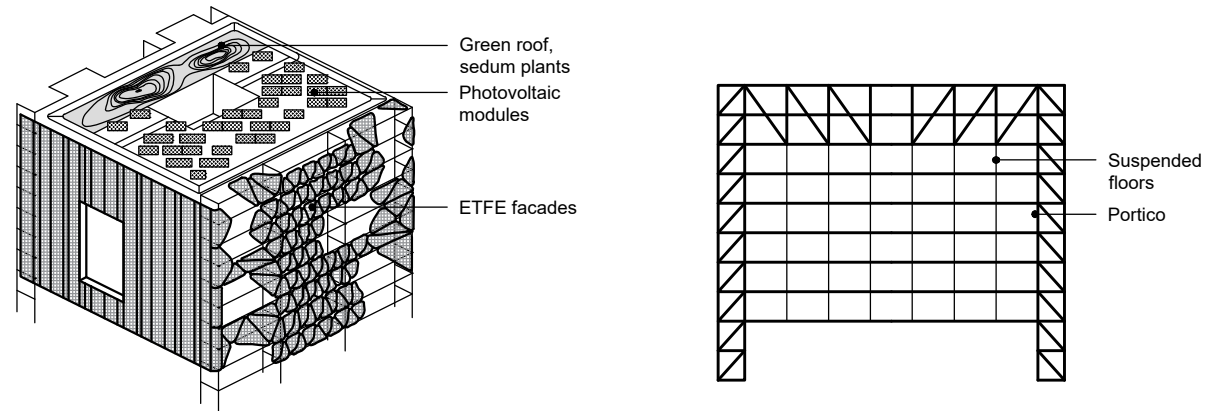


Figure 109. (above right). Sutstructural system.

Figure 110. (above left). Green building systems.

is provided by means of a pneumatic system. The cushions expand to gain solar energy, and contract to protect and shade. Each cushion is individually operated by a light sensor. On the south west facade, sun shading is achieved via a system which injects fog into tall and narrow ETFE cushions. The building structure is a metal structural frame consisting four porticoes from which the floor structures of the building are hung.

Project: Fun Palace, 1964

Location: London, England

Architects: Cedric Price

Key features: Structure and adaptability

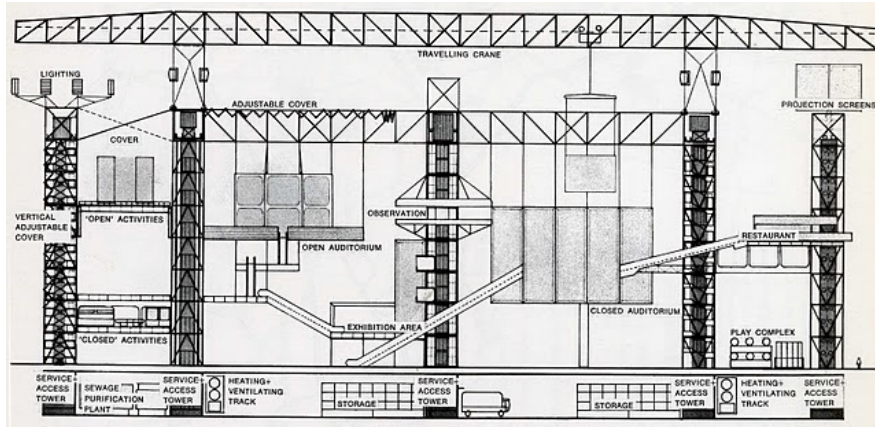


Figure 111. Fun Palace, Cedric Price.

The Fun Palace was a conceptual architectural project by Cedric Price commissioned by avant-garde theatre producer Joan Littlewood in 1964 (Glynn, 2005). The design comprised an exposed steel structure that supported a flexible and diverse programme. It was imagined that users would be able to assemble and rearrange the interior of the building themselves to match their needs and desires. The internal spatial layout would be altered by using travelling gantry cranes to move prefabricated building elements around and into place. This speculative design provided a precedent for the Centre Pompidou in Paris.

Project: Centre Pompidou, 1977

Location: Paris, France

Architects: Renzo Piano, Richard Rogers

Key features: Structure



Figure 112. Centre Pompidou, Renzo Piano and Richard Rogers.

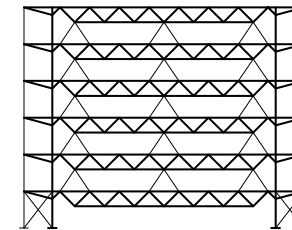
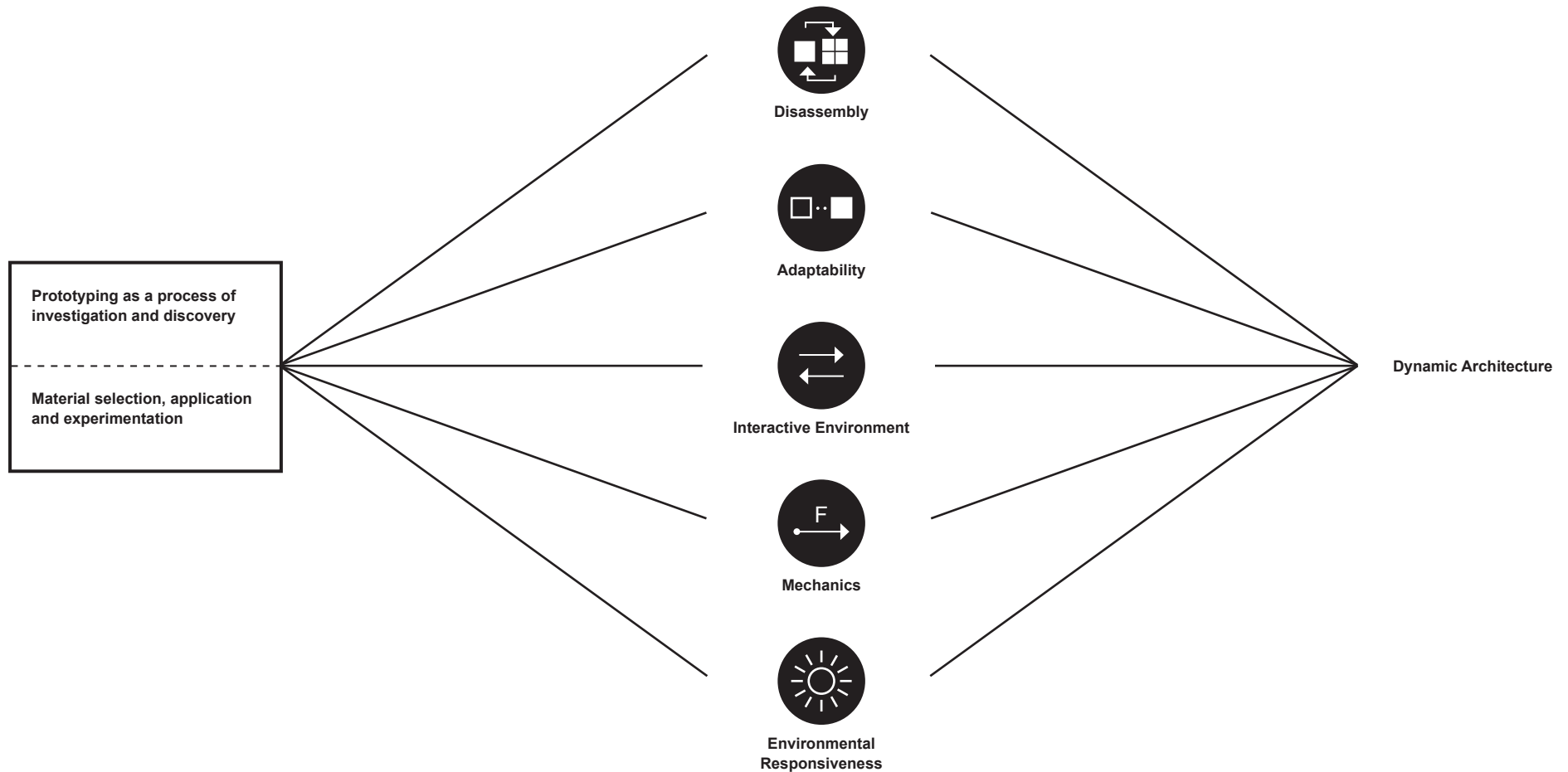


Figure 113. Structural system.

The Centre Pompidou exposes building services and structure usually concealed, turning architecture inside-out. This cultural centre is structured using a cast steel x-braced frame system and a system of cast steel trusses. The building structure used many custom fabricated elements, such as garabettes, which facilitated the connection between trusses and the main structural columns (Perez, 2011). The building structure of the Centre Pompidou is relevant to my project because it allows for long clear spans and uses custom parts and improved material sections.

2.4. Design Concepts

Research conducted during the course of this project focused on 1. prototyping as a process of investigation and discovery as well as 2. material selection, application and experimentation subsequent to sustainable objectives. This translated to the concepts of adaptability, disassembly, interactivity, environmental responsiveness and mechanics and motion which were applied in the creation of a dynamic architecture. The main features of my design which adapted these concepts included the **building structure, envelope and courtyard**.



2.5. Design Development

Massing

Figure 114. Site massing model

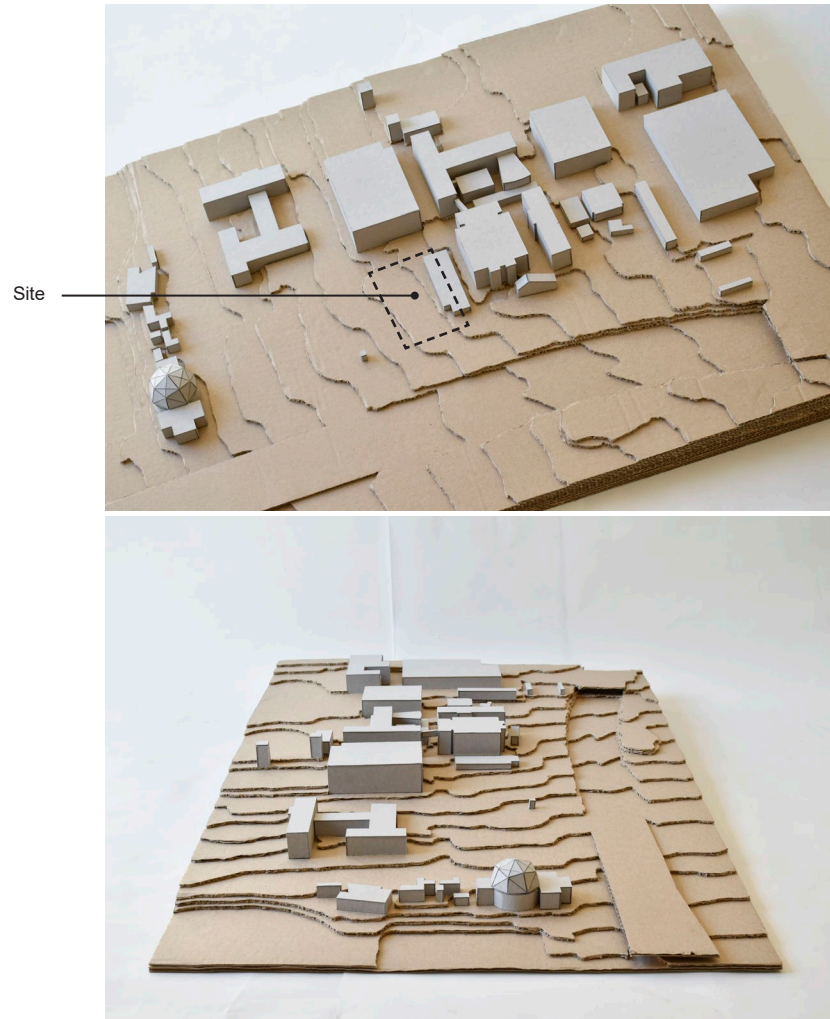


Figure 115. Early massing model experiments

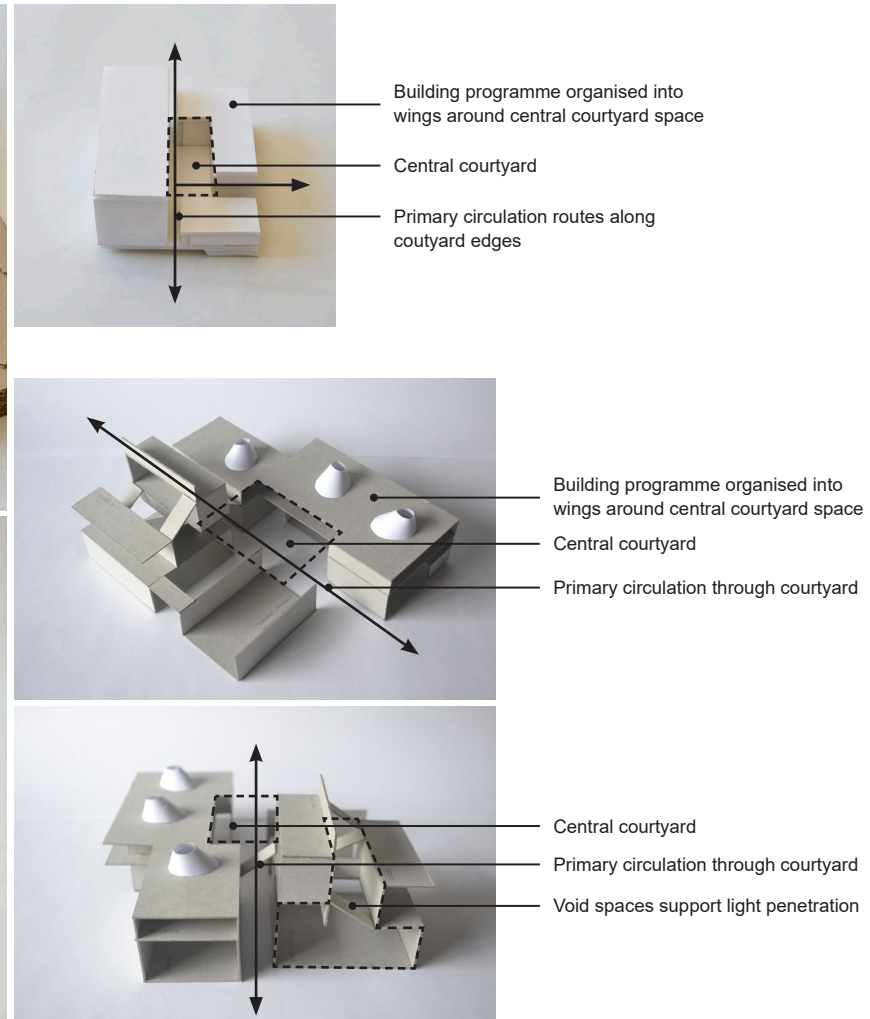
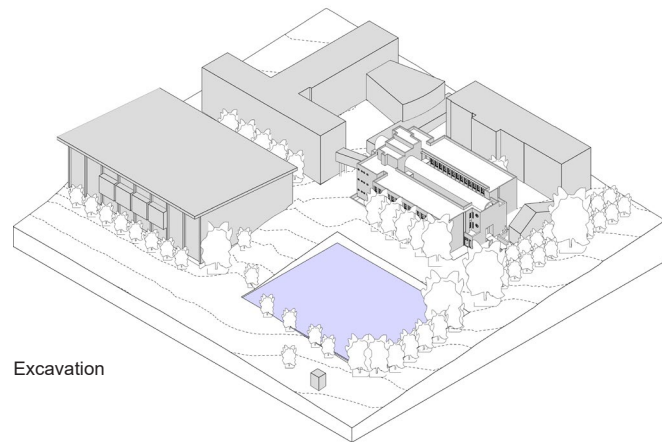
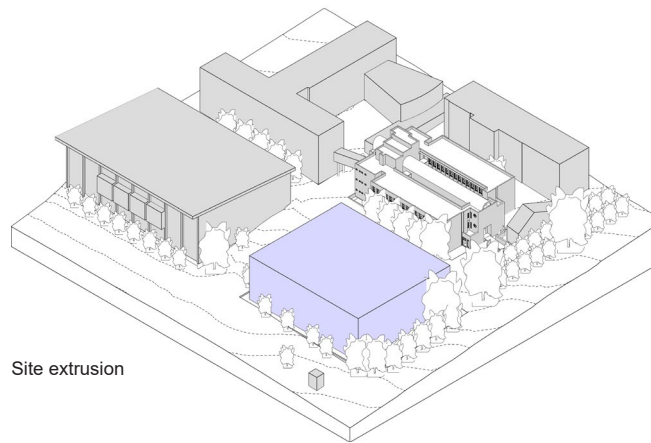


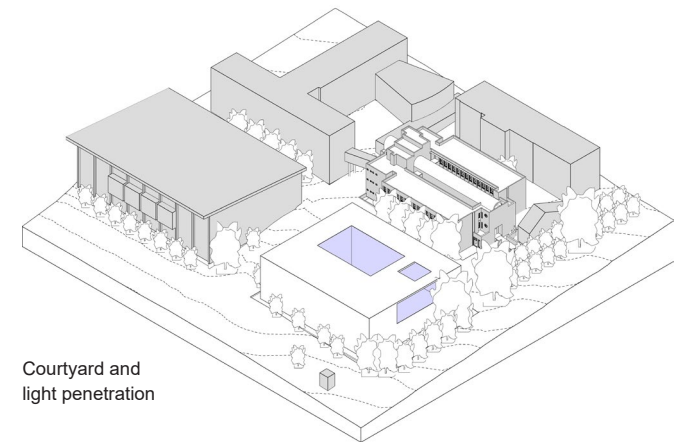
Figure 116. Massing analysis



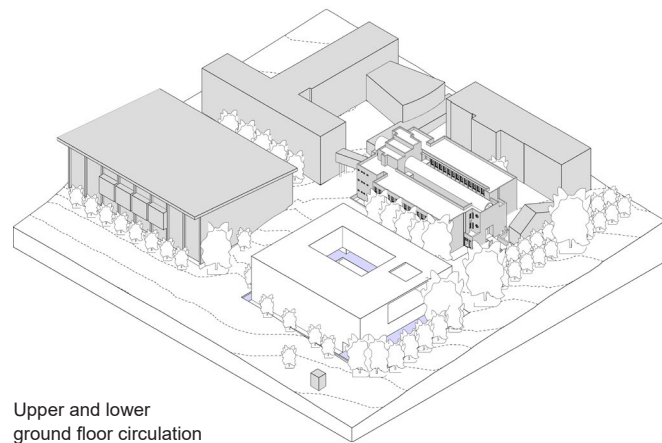
Excavation



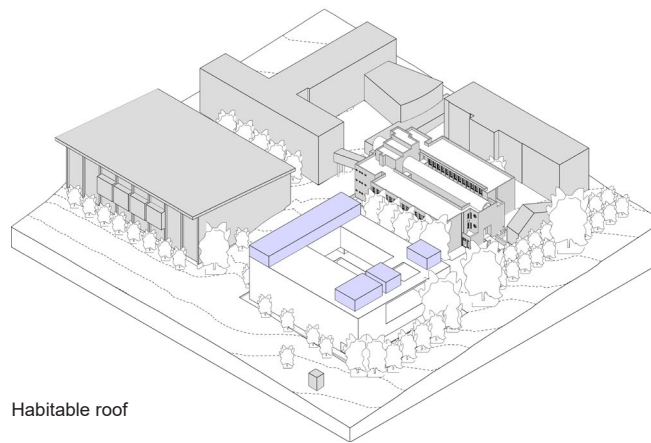
Site extrusion



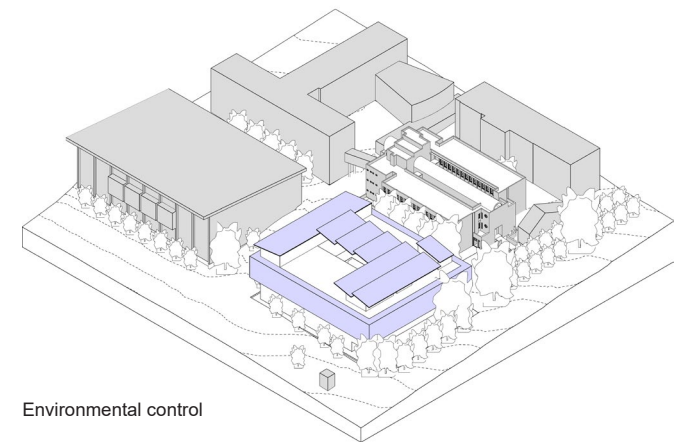
Courtyard and
light penetration



Upper and lower
ground floor circulation



Habitable roof



Environmental control



Structure

Figure 117. Early model experiments exploring material and structural efficiency

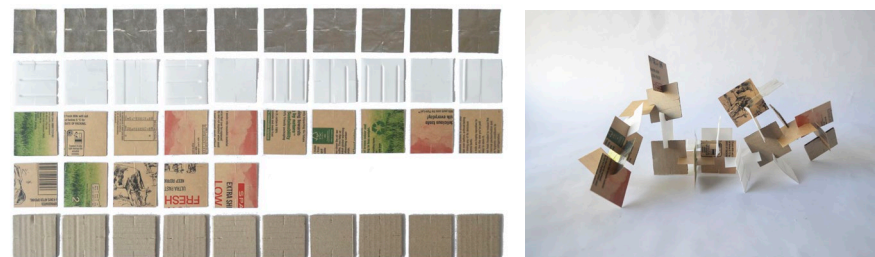
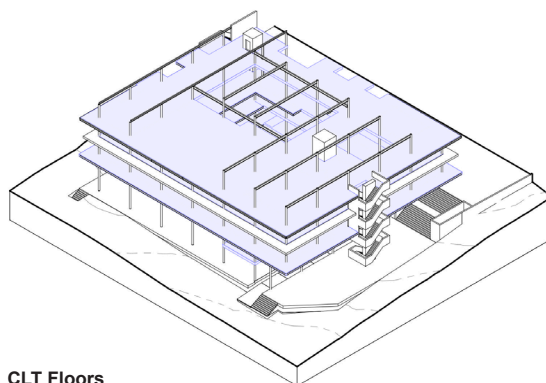
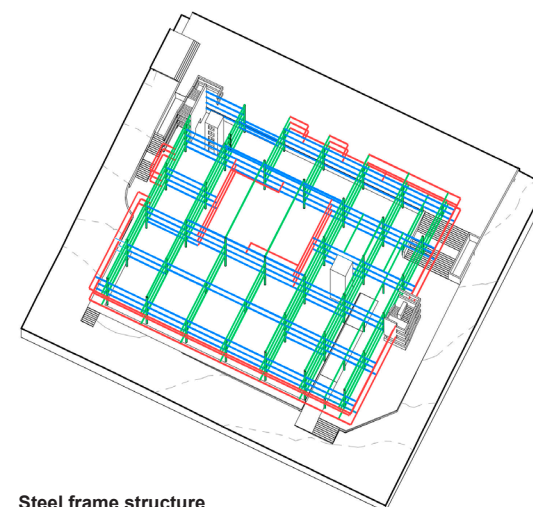


Figure 118. (above). The concept of disassembly was explored early on in the design process through an experiment that used recycled materials in the creation of a system that allowed different elements to be joined together in different ways and taken apart again.

Figure 119. (below left). and **Figure 120. (below right).** Concrete lift cores, concrete fire stairs and steel framing comprise the main structural elements of this design. The steel frame structure works on a 7710mm x 7710mm square grid and overhangs on the first, second and third floors. Structural steel sections can be reused or recycled after deconstruction. CLT slabs were used for the building's floors. This material was specifically chosen for its sustainable properties and for its ability to be easily renovated.



CLT Floors



Steel frame structure



Envelope and Courtyard

Figure 121. Early model experiments exploring the desired lighting effect which later inspired the use of polycarbonate sheeting as a cladding material



Figure 122. (right). Another experiment which comprised a series of refractographs considered the way light interacts with material surfaces. This prompted consideration of light penetration through the building envelope and the creation of a dynamic roof and adaptive façade system which saw multiple iterations.

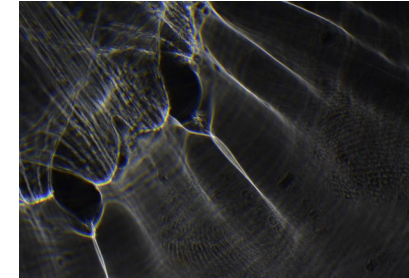


Figure 123 (below left). The final design for the façade provides sun shading and allows architectural researchers to incorporate their own prototypes on the face of the building. The façade becomes a space in itself, possessing a form, supporting building operations and facilitating movement and circulation.

Figure 124. (below right). Central to the building is a covered courtyard with a gantry way above. The courtyard is imagined as a animated space that accommodates construction activities and facilitates the movement of people and materials throughout the building.

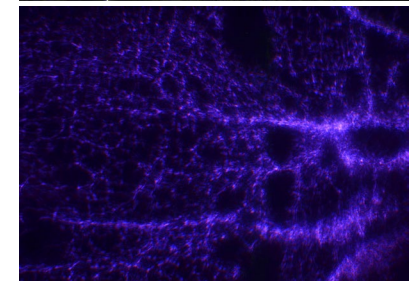
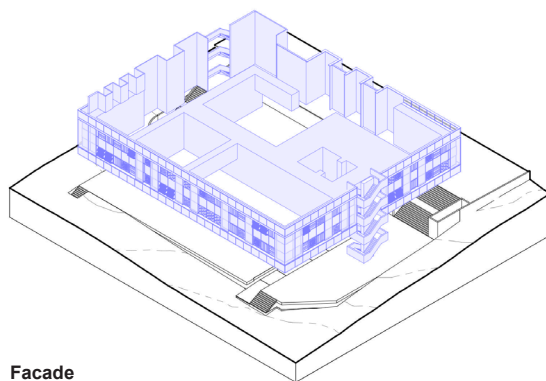
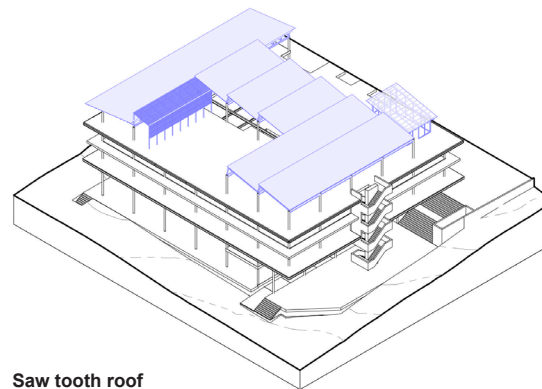


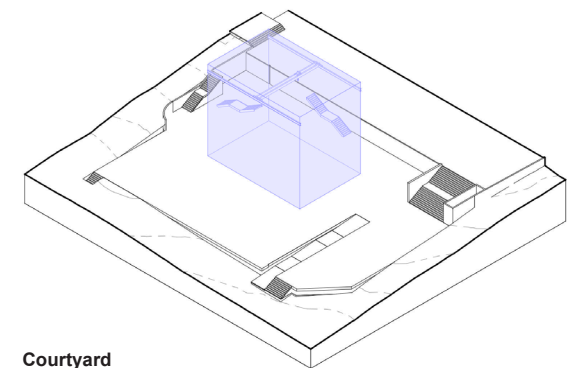
Figure 125. (below middle). An open saw tooth roof above the courtyard provides shade and protection from the rain, while allowing for natural ventilation and heat expulsion, creating a comfortable outdoor environment to build and work in.



Facade



Saw tooth roof



Courtyard

Envelope Iterations

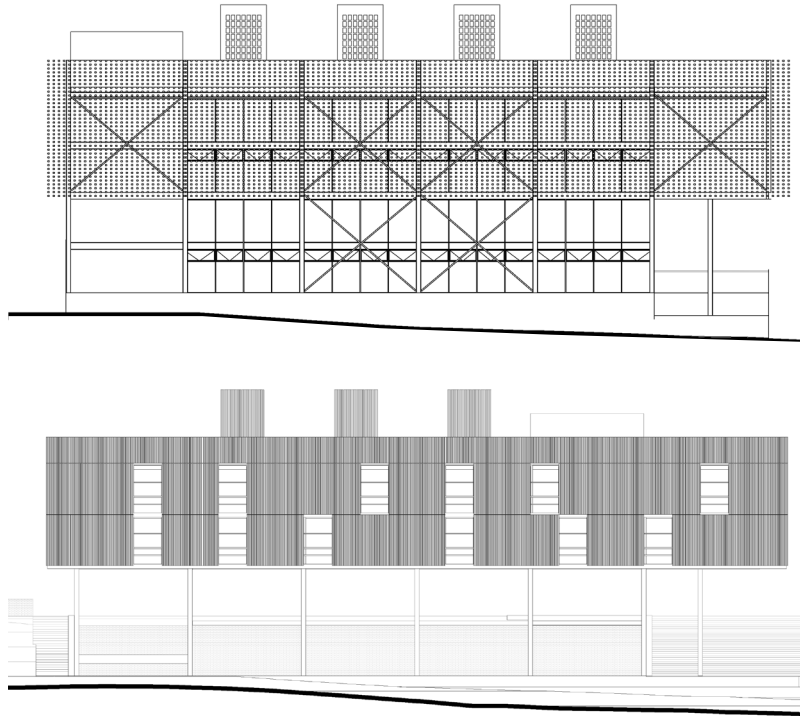


Figure 129. (above). The third facade design used large manually openable sliding panels and a grid support system to allow architectural researchers to incorporate their own prototypes on the face of the building. While adaptable and useful, this facade system did not achieve the desired lighting effect.

Fig.126. (left) and Fig. 127. (right). The first interpretation of the building envelop used a floating brick screen to create a moire effect. This facade design, however, was static, solid and heavy, and was not adaptable or useful in any way.

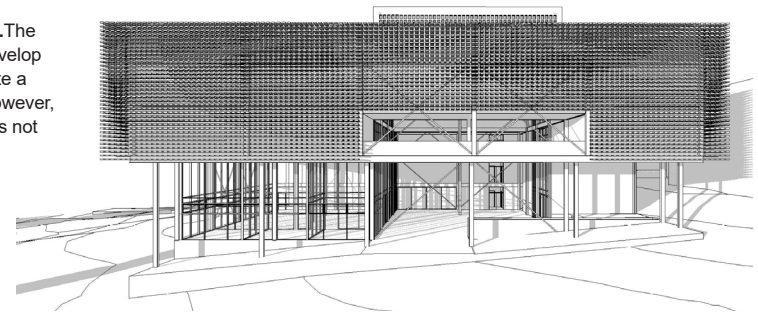


Figure 128. (below). The second facade design used a tight grid of mechanically automated panels to create a similar lighting effect to that of the first design. These panels would open and close automatically in response to the changing position of the sun. While adaptable, this facade system was not useful to the building users.

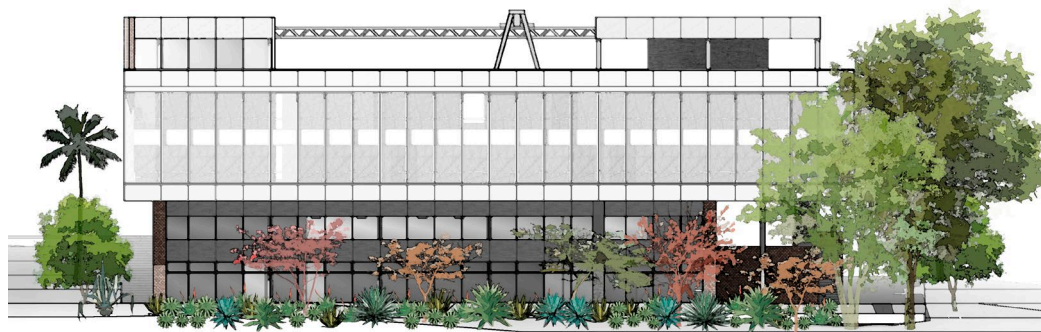
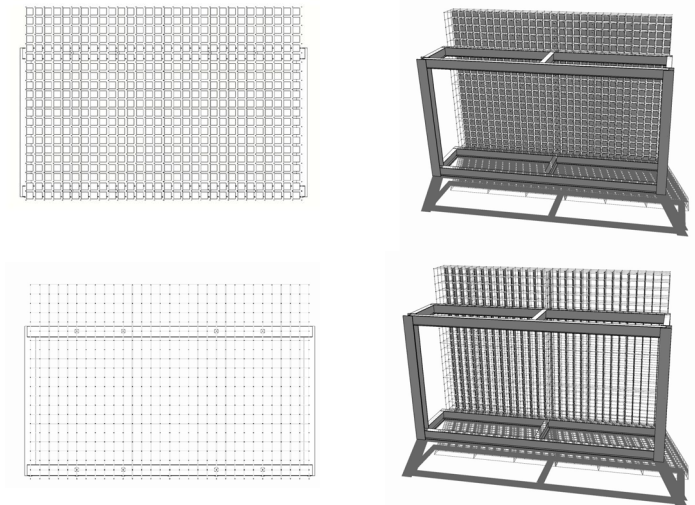


Figure 130. (left) The final design of the building envelop used a similar system of operation to the third design but with polycarbonate panels, creating a soft and ghostly lighting effect. While different from the lighting effect originally intended, this design proved more practical, affordable and useful.

Facade Detail

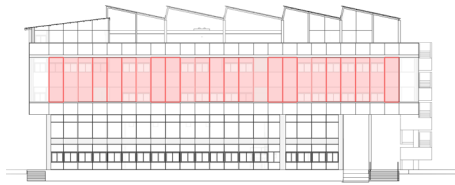


Figure 131. Sliding panels



Figure 132. Grid support system to allow architectural researchers to incorporate their own prototypes on the face of the building.

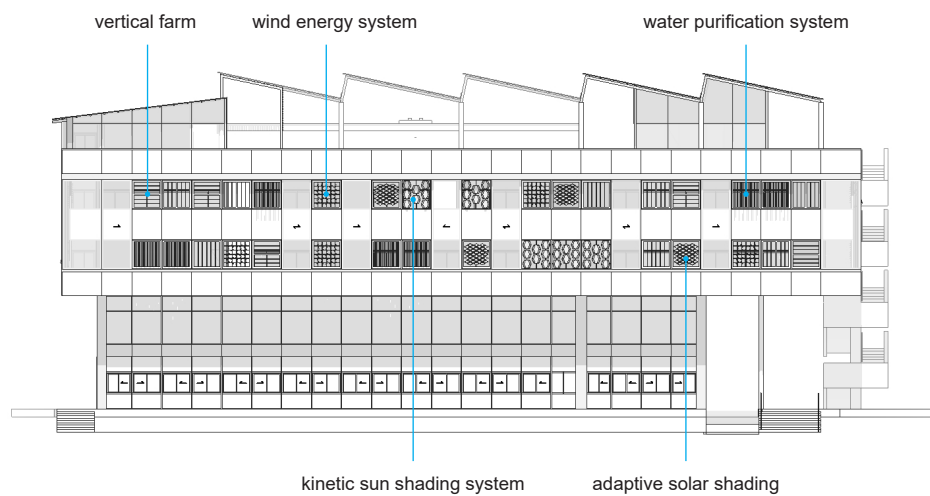


Figure 133. Example of different prototypes integrated into the north building facade.

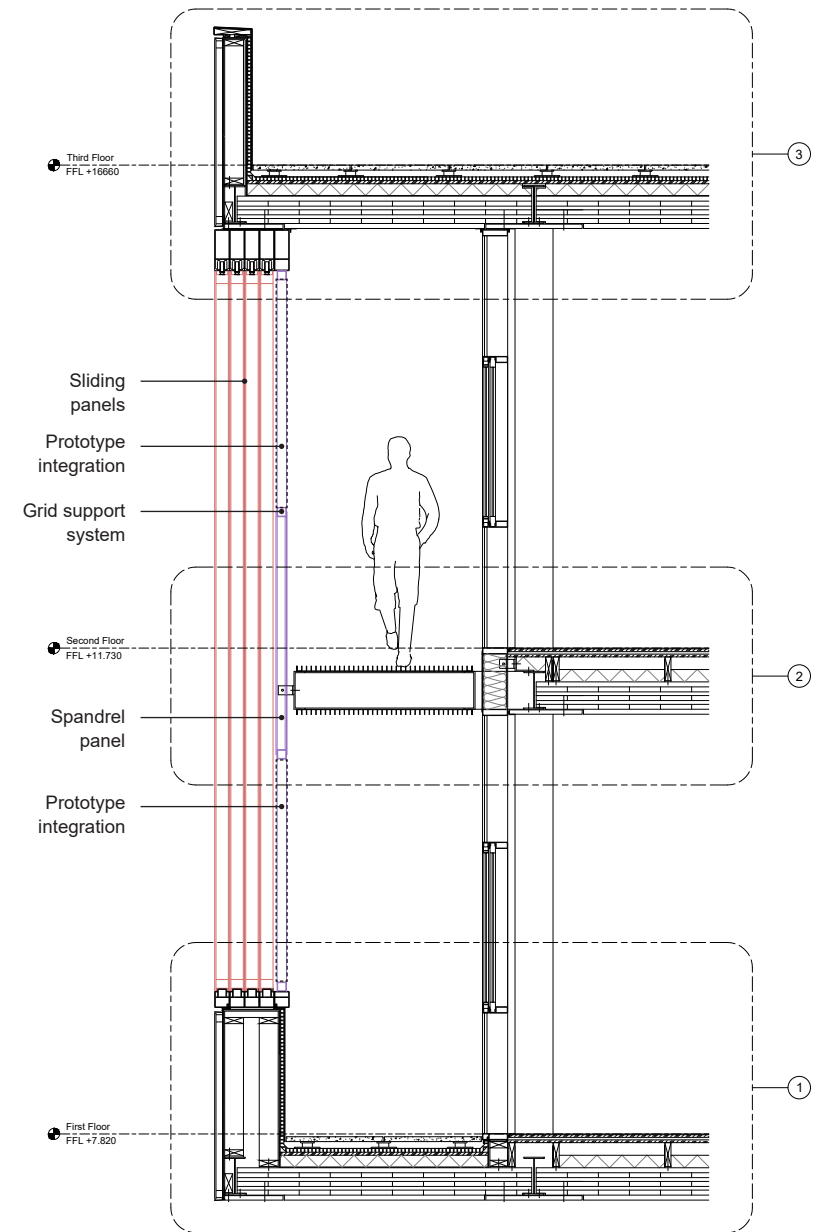


Figure 134. Perimeter Section

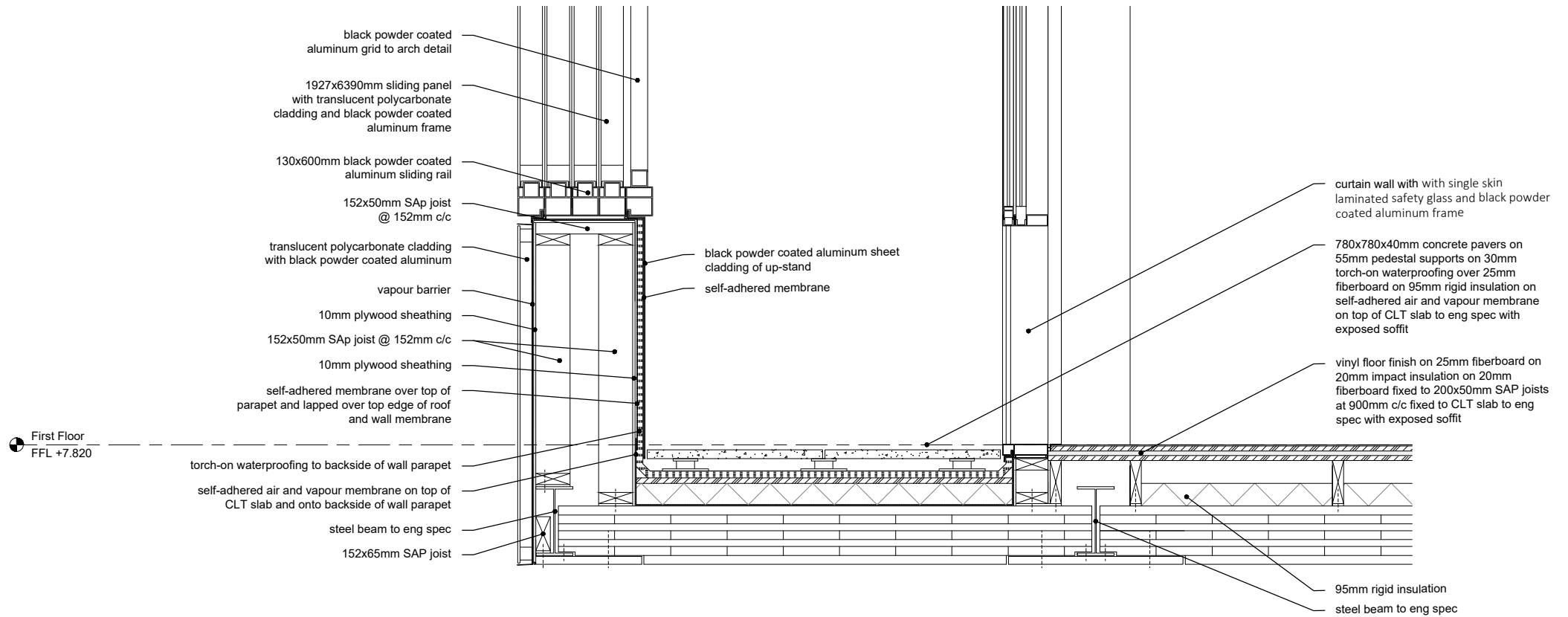


Figure 135. Detail 1 Scale 1:25

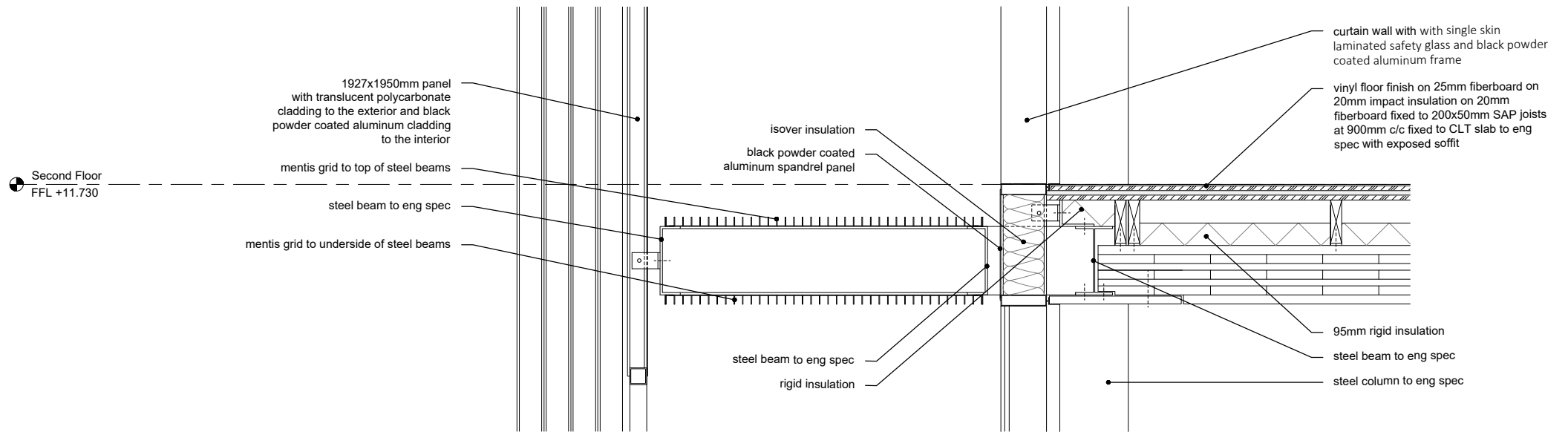


Figure 136. Detail 2 Scale 1:25

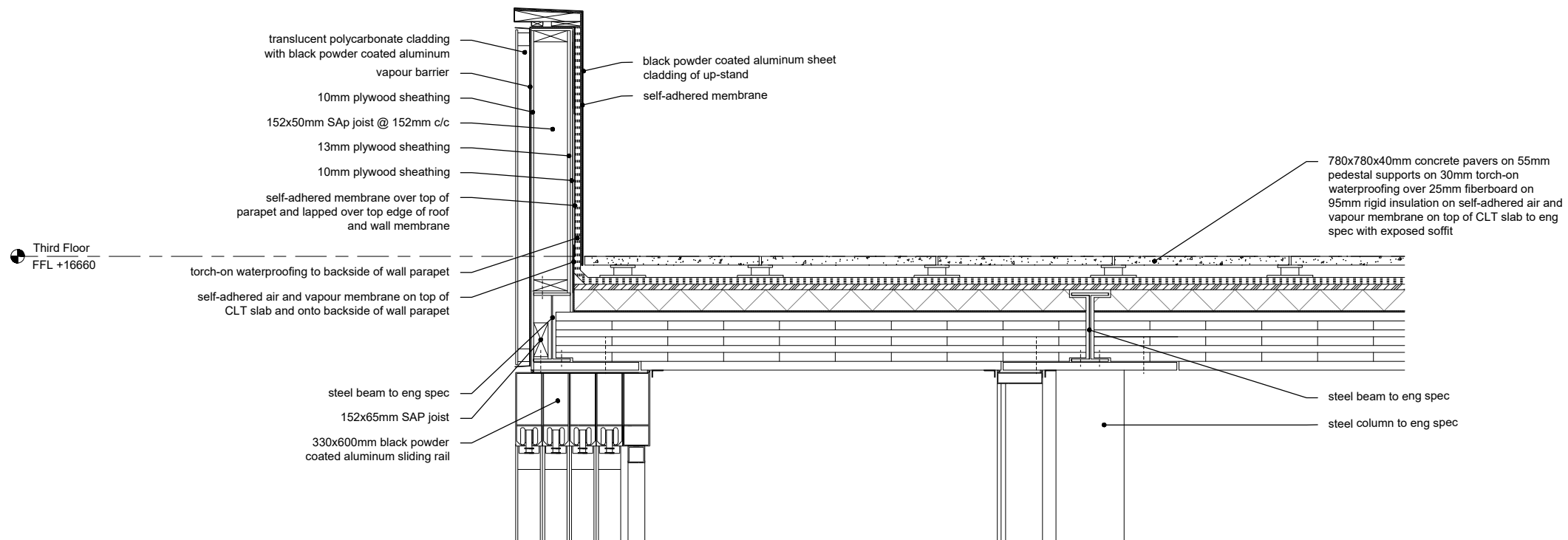


Figure 137. Detail 3 Scale 1:25

Design Rationale

Third Floor

Second Floor

First Floor

Ground Floor B

Ground Floor A

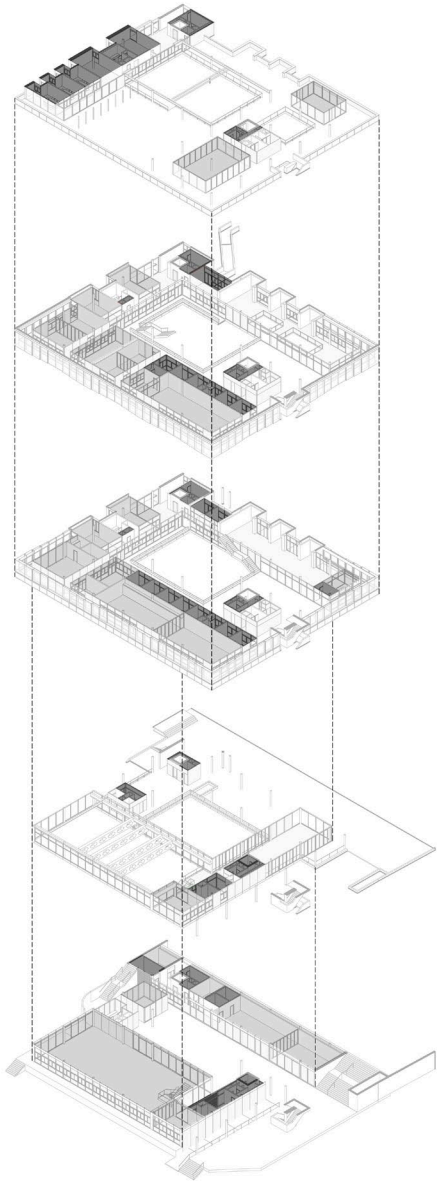


Figure 138. Spatial Organisation

- Fabrication laboratory
- Materials research laboratory
- Digital laboratory
- Materials library
- Offices
- Public relations
- General
- Services

Figure 139. Public/Private

- Public
- Semi-Public
- Private



Third Floor

Second Floor

First Floor

Ground Floor B

Ground Floor A

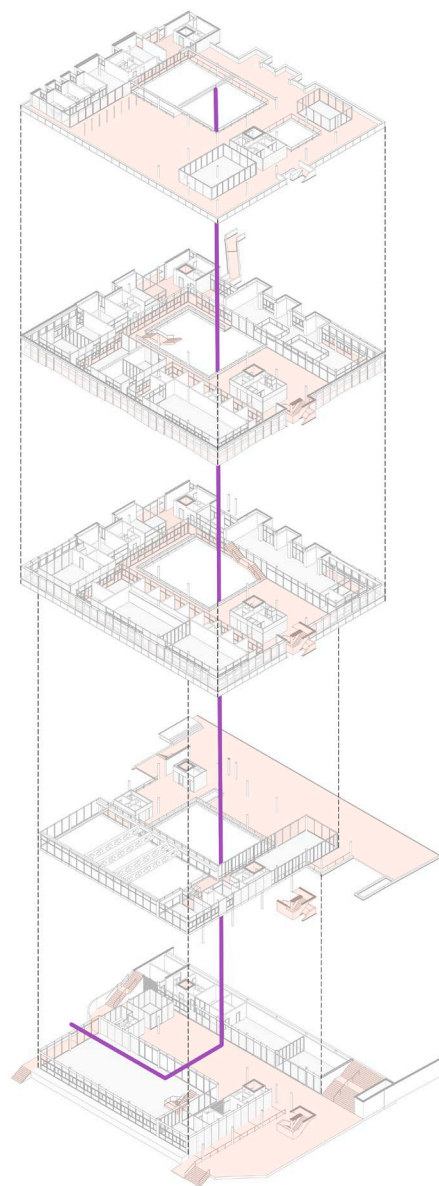
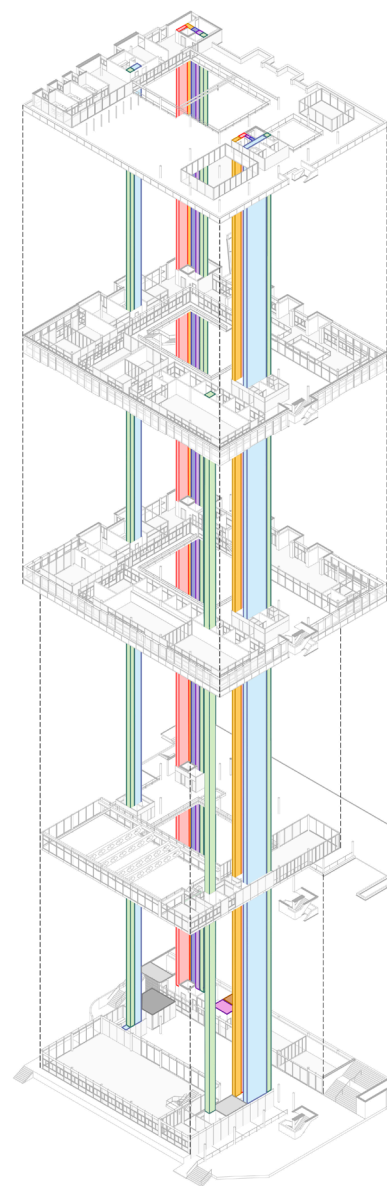


Figure 140. Movement

- Circulation area
- Movement of materials

Figure 141. Building services

- Water/drainage
- HAVAC
- Fire
- Electrical
- Data
- Security
- Mechanical plant
- Refuse
- UPS Store
- Server room



2.6. Final Drawings

Figure 142. Context Plan

- 1 - John Moffat Building
- 2 - John Moffat Ext. A
- 3 - Old Mutual Sports Hall
- 4 - Construction Management Building
- 5 - Yale Telescope
- 6 - Dalrymple House
- 7 - Visitors parking
- 8 - John Moffat Ext. B to be demolished
- 9 - Staff parking to be removed
- 10 - Old workshop to be demolished
- 11 - New avenue of trees

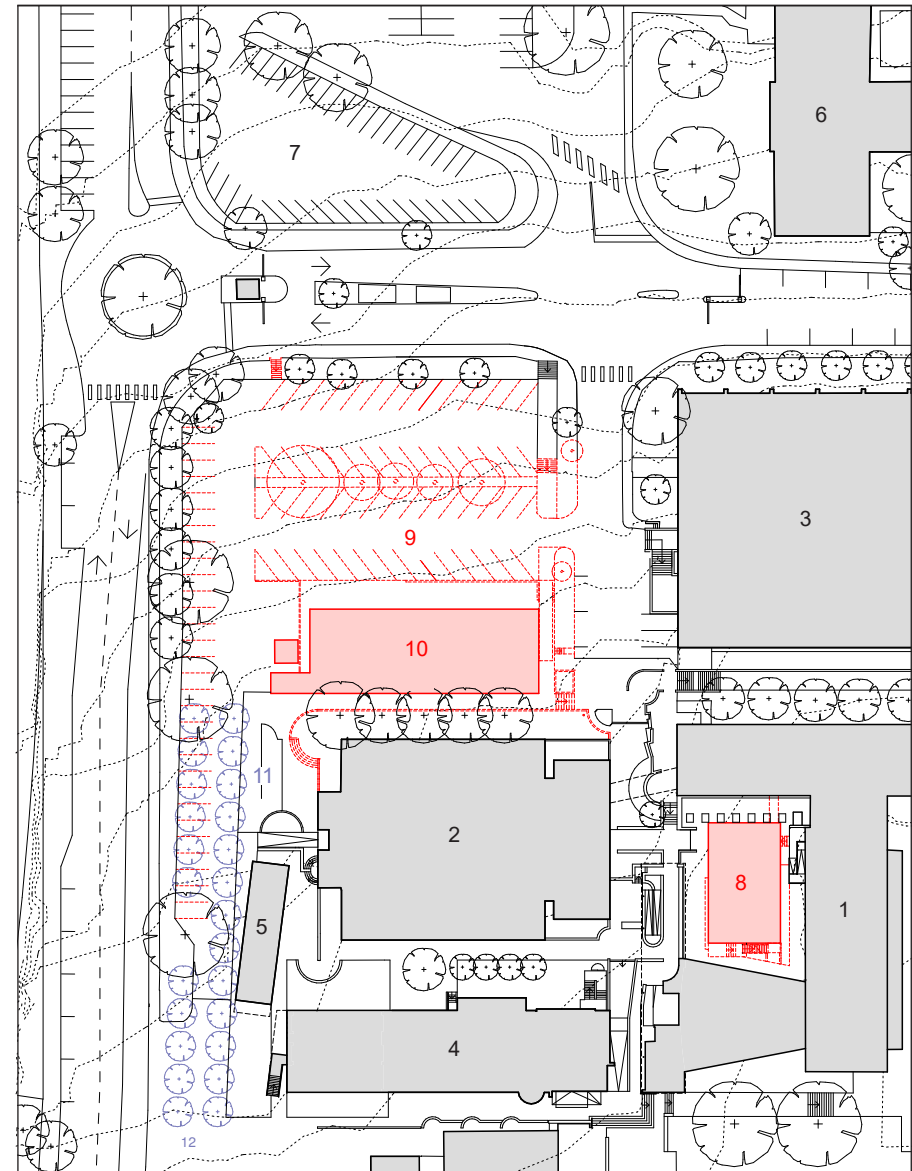
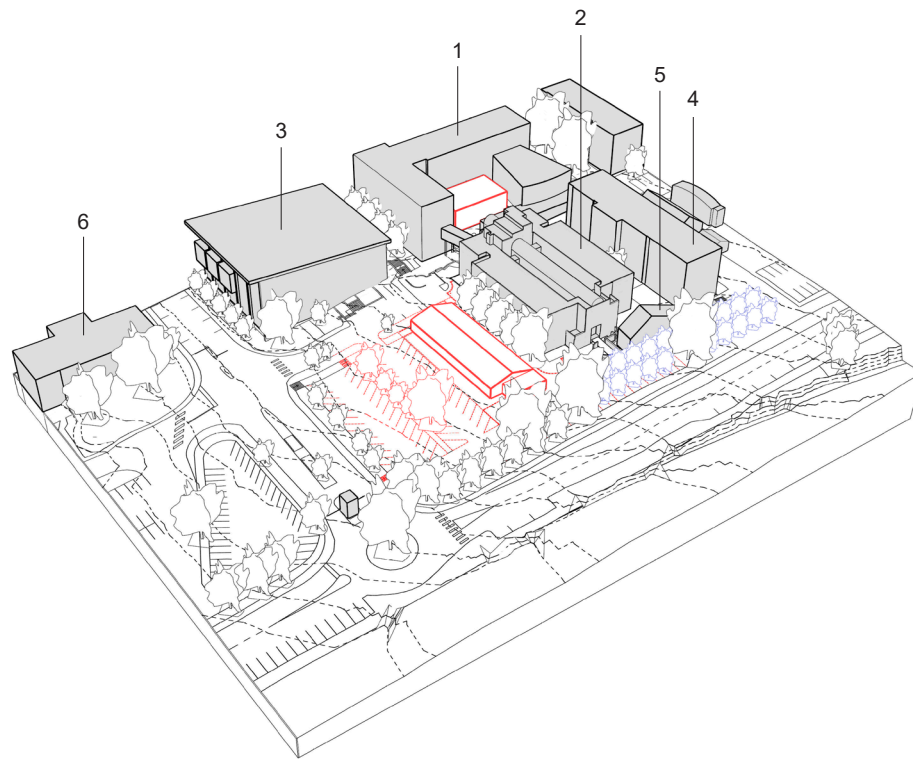
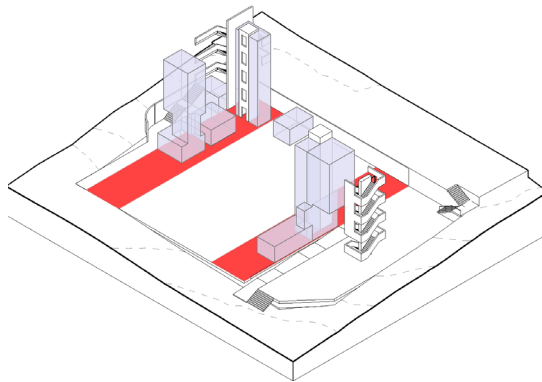
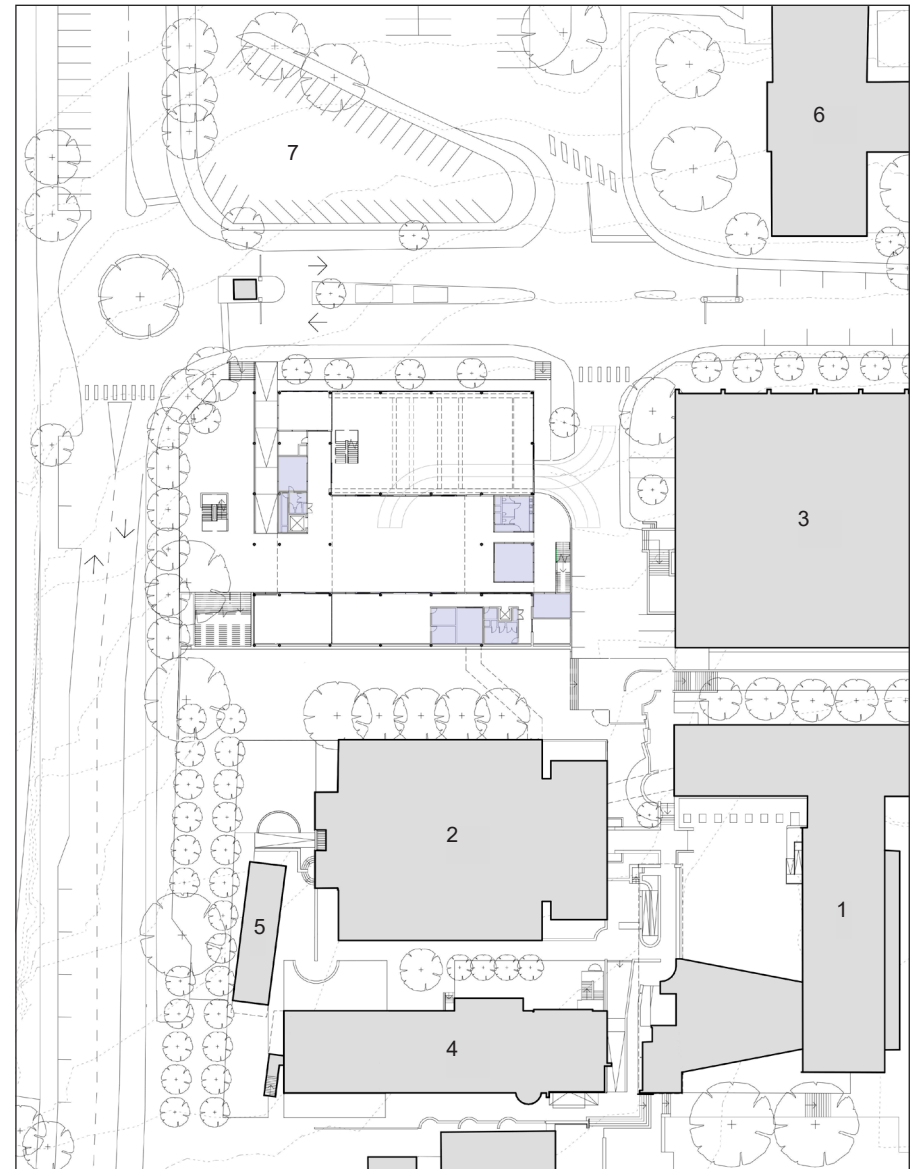


Figure 143. Site Plan

- 1 - John Moffat Building
- 2 - John Moffat Ext. A
- 3 - Old Mutual Sports Hall
- 4 - Construction Management Building
- 5 - Yale Telescope
- 6 - Dalrymple House
- 7 - Visitors parking



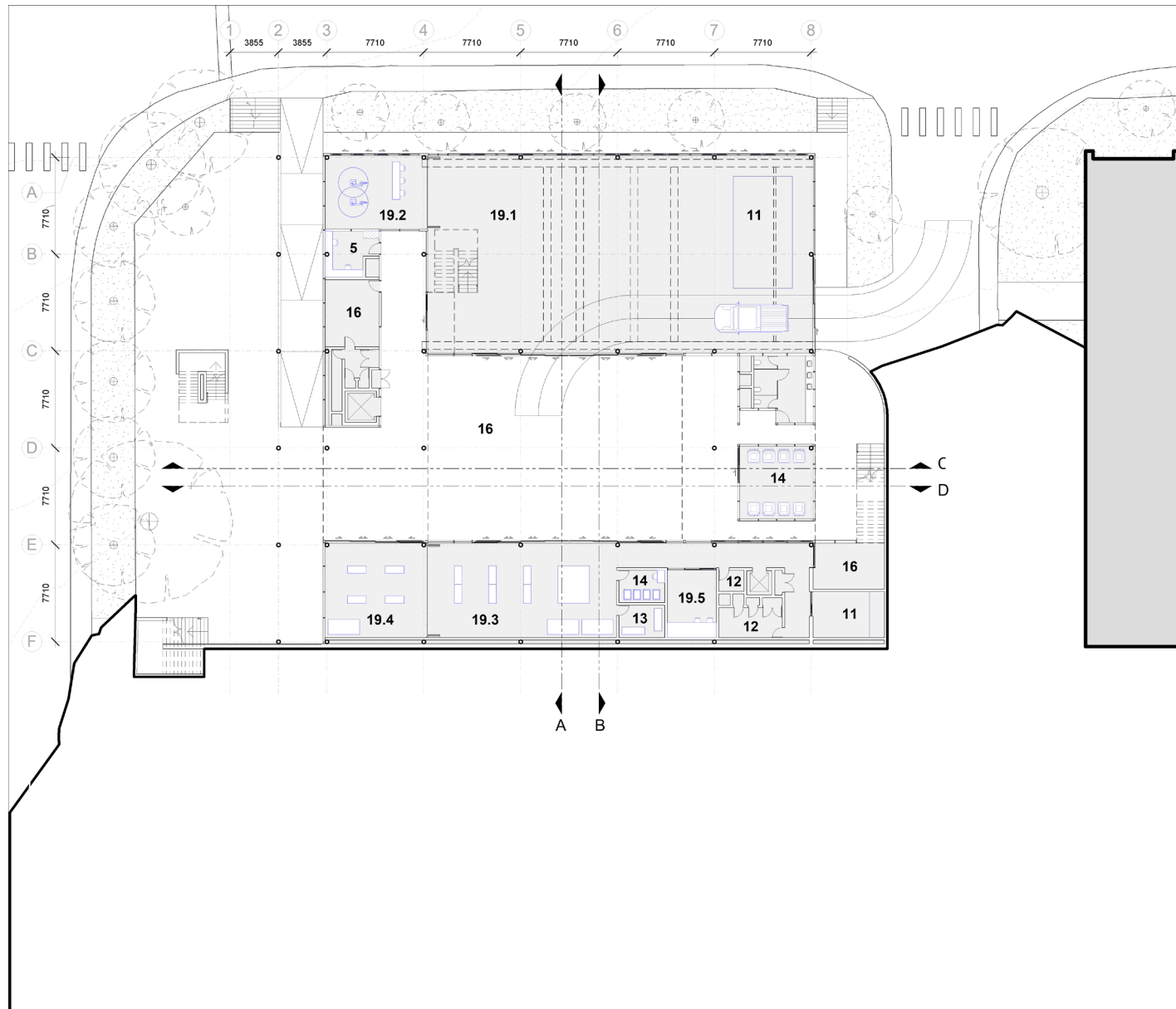
Building services located along the east and west edges of the site



0 5 m 10 m



Figure 144. Ground Floor Plan A



1. Seminar room
2. Lounge
3. Office
4. Open plan office
5. Security office
6. Meeting room
7. Reception
8. Deli
9. Exhibition space
10. Materials library
11. Materials store
12. Store room
13. UPS store
14. Server room
15. Refuse
16. Mechanical plant
17. Fabrication yard
18. Build space
19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse
21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer

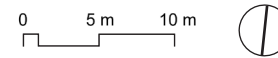
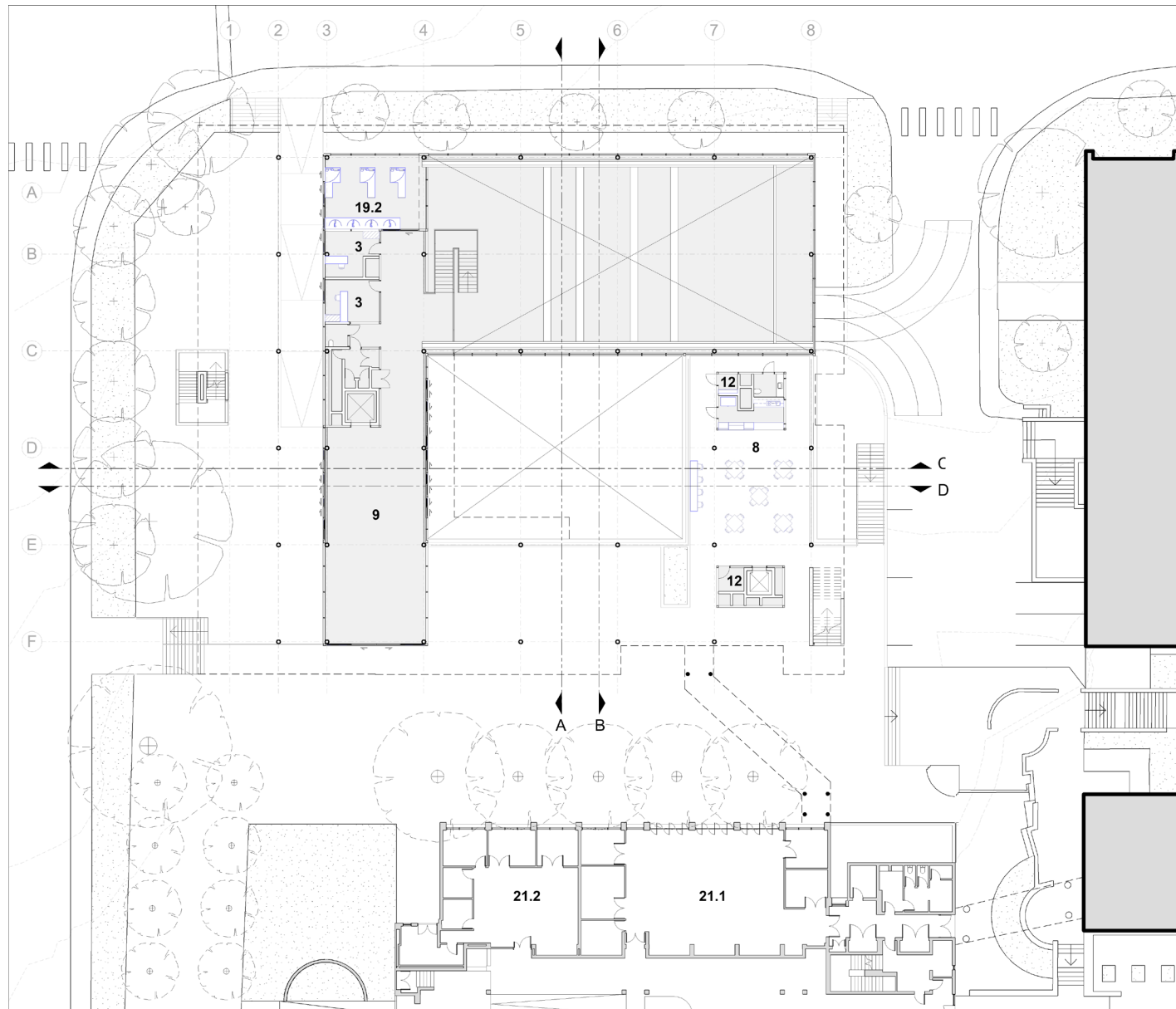


Figure 145. Ground Floor Plan B

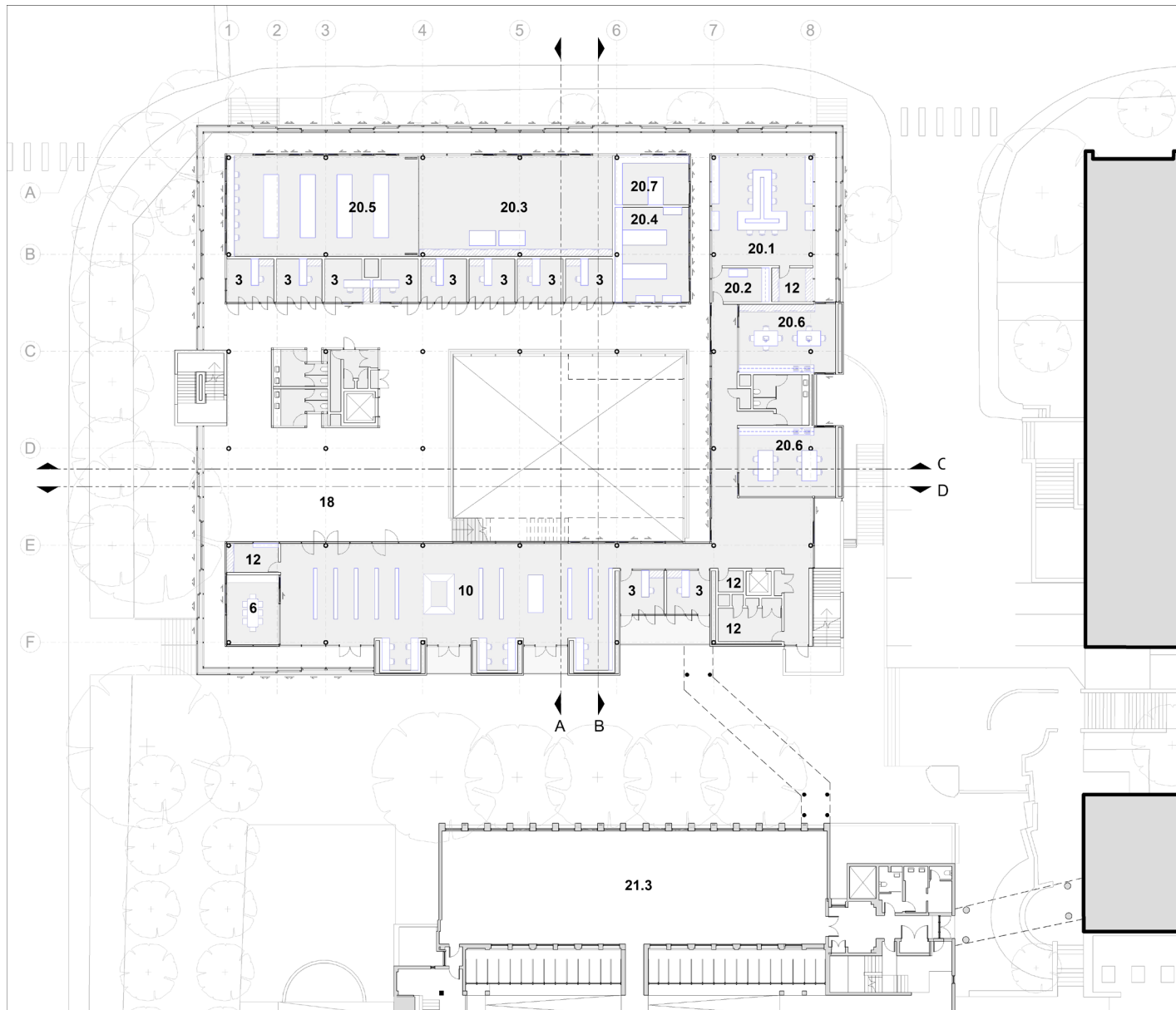


1. Seminar room
2. Lounge
3. Office
4. Open plan office
5. Security office
6. Meeting room
7. Reception
8. Deli
9. Exhibition space
10. Materials library
11. Materials store
12. Store room
13. UPS store
14. Server room
15. Refuse
16. Mechanical plant
17. Fabrication yard
18. Build space
19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse
21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer

0 5 m 10 m



Figure 146. First Floor Plan



1. Seminar room
2. Lounge
3. Office
4. Open plan office
5. Security office
6. Meeting room
7. Reception
8. Deli
9. Exhibition space
10. Materials library
11. Materials store
12. Store room
13. UPS store
14. Server room
15. Refuse
16. Mechanical plant
17. Fabrication yard
18. Build space
19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse
21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer

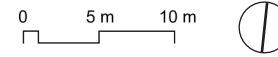
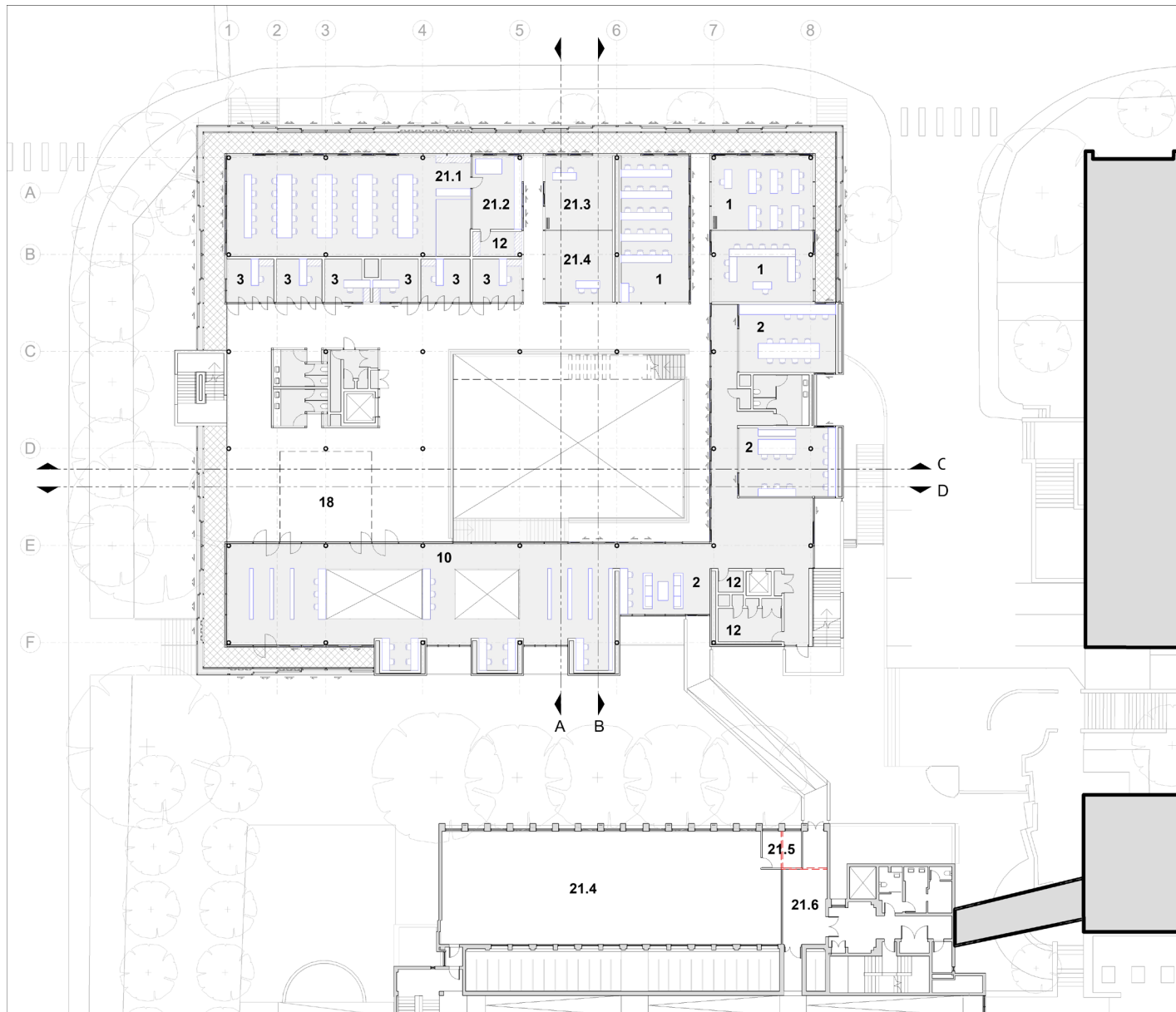


Figure 147. Second Floor Plan



- 1. Seminar room
- 2. Lounge
- 3. Office
- 4. Open plan office
- 5. Security office
- 6. Meeting room
- 7. Reception
- 8. Deli
- 9. Exhibition space
- 10. Materials library
- 11. Materials store
- 12. Store room
- 13. UPS store
- 14. Server room
- 15. Refuse
- 16. Mechanical plant
- 17. Fabrication yard
- 18. Build space
- 19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
- 20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse
- 21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
- 22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer

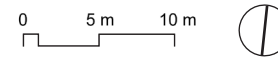
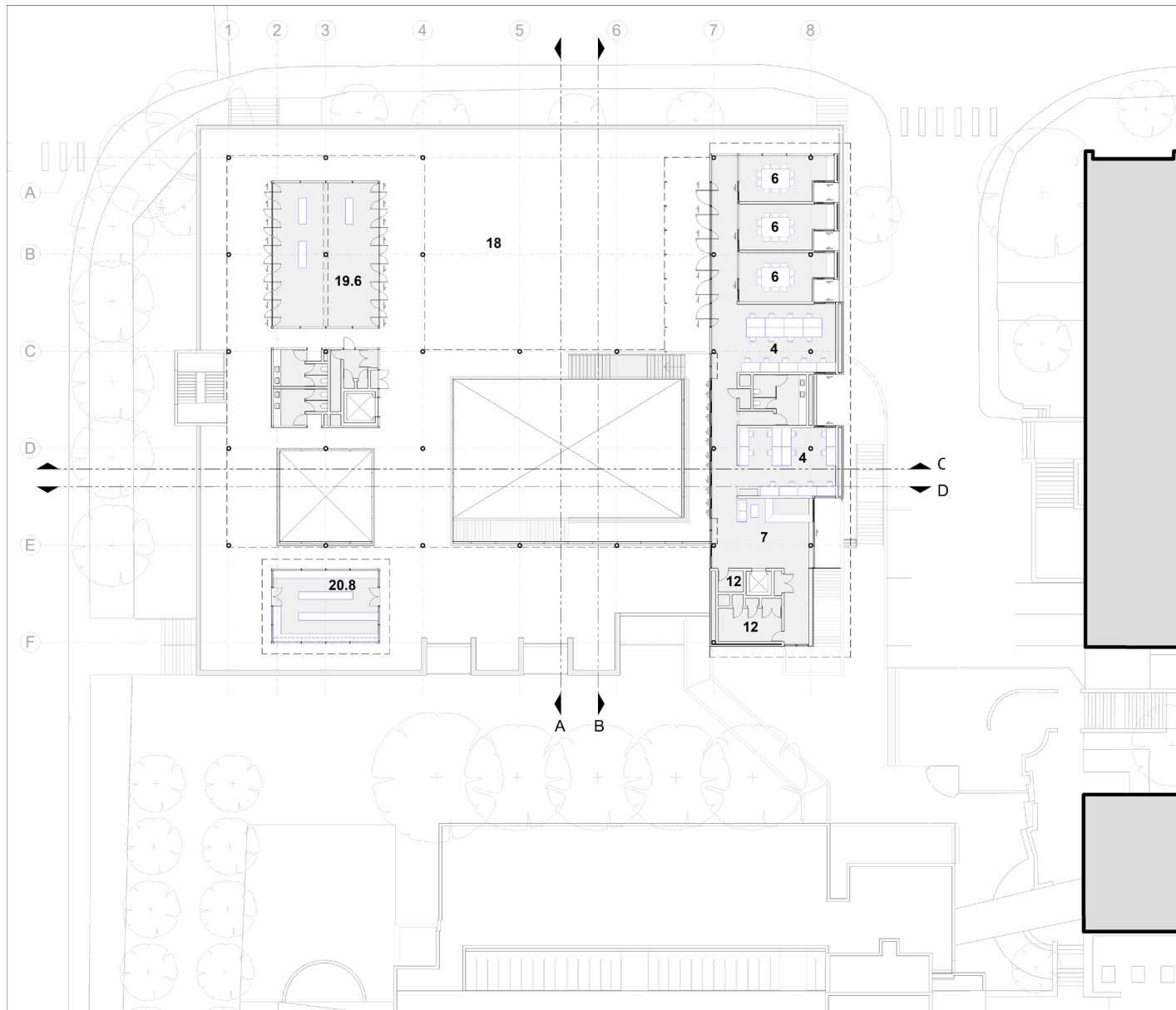


Figure 149. Thrid Floor Plan



1. Seminar room
2. Lounge
3. Office
4. Open plan office
5. Security office
6. Meeting room
7. Reception
8. Deli
9. Exhibition space
10. Materials library
11. Materials store
12. Store room
13. UPS store
14. Server room
15. Refuse
16. Mechanical plant
17. Fabrication yard
18. Build space
19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse
21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer

0 5 m 10 m

1. Seminar room
2. Lounge
3. Office
4. Open plan office
5. Security office
6. Meeting room
7. Reception
8. Deli
9. Exhibition space
10. Materials library
11. Materials store
12. Store room
13. UPS store
14. Server room
15. Refuse
16. Mechanical plant
17. Fabrication yard
18. Build space

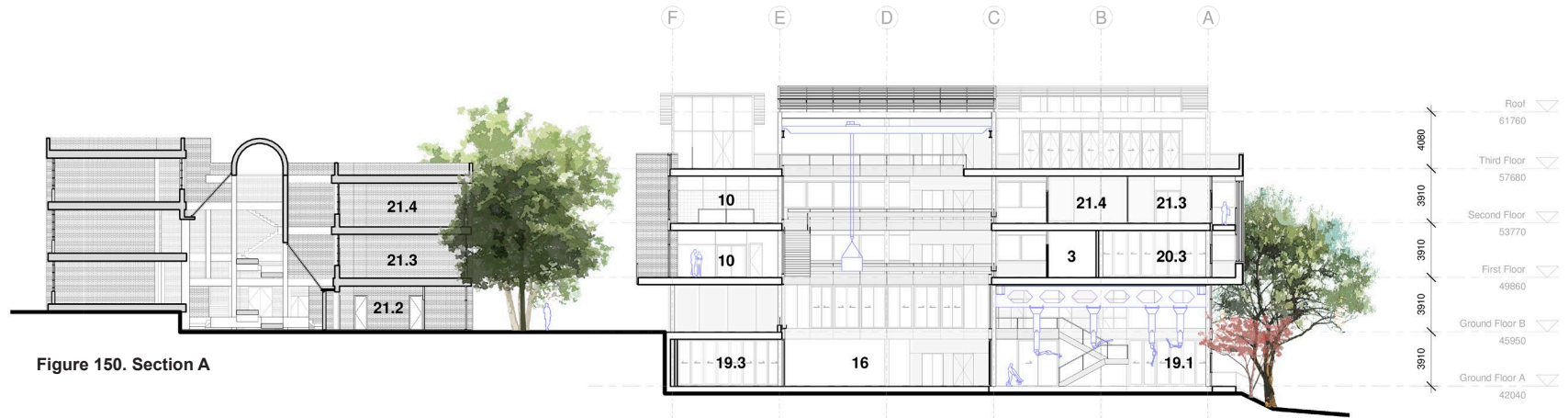


Figure 150. Section A

19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse
21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer

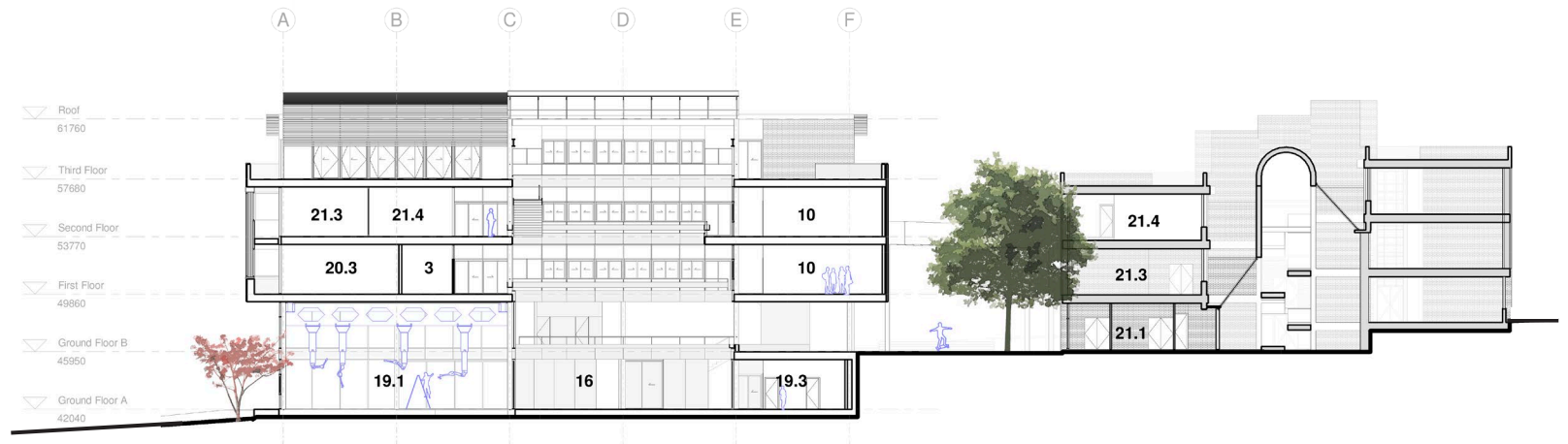
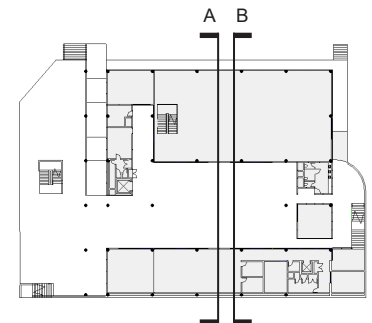


Figure 151. Section B



0 5 m 10 m

1. Seminar room
2. Lounge
3. Office
4. Open plan office
5. Security office
6. Meeting room
7. Reception
8. Deli
9. Exhibition space
10. Materials library
11. Materials store
12. Store room
13. UPS store
14. Server room
15. Refuse
16. Mechanical plant
17. Fabrication yard
18. Build space



Figure 152. Section C

19. Fabrication laboratory
 - 19.1. Large robot shaping environment
 - 19.2. Small robot shaping environment
 - 19.3. CNC-milling and metal workshop
 - 19.4. Timber workshop
 - 19.5. Laser-cutting workshop
 - 19.6. General workshop
20. Materials research laboratory
 - 20.1. Cleanroom
 - 20.2. Ante room
 - 20.3. Polymer processing plant
 - 20.4. Advanced materials lab
 - 20.5. Characterisation lab
 - 20.6. Wet lab
 - 20.7. Furnace room
 - 20.8. Greenhouse

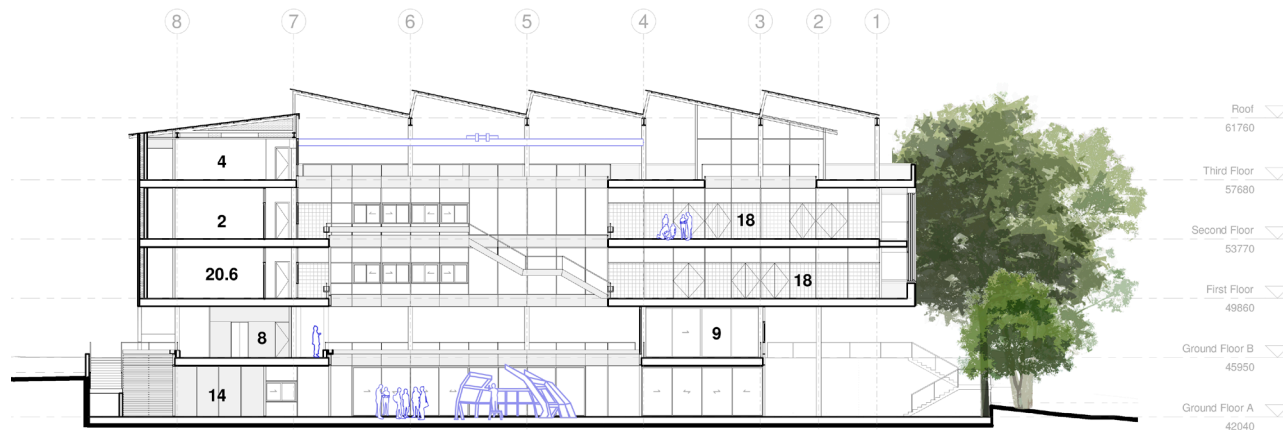
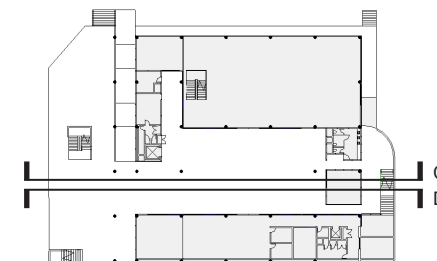
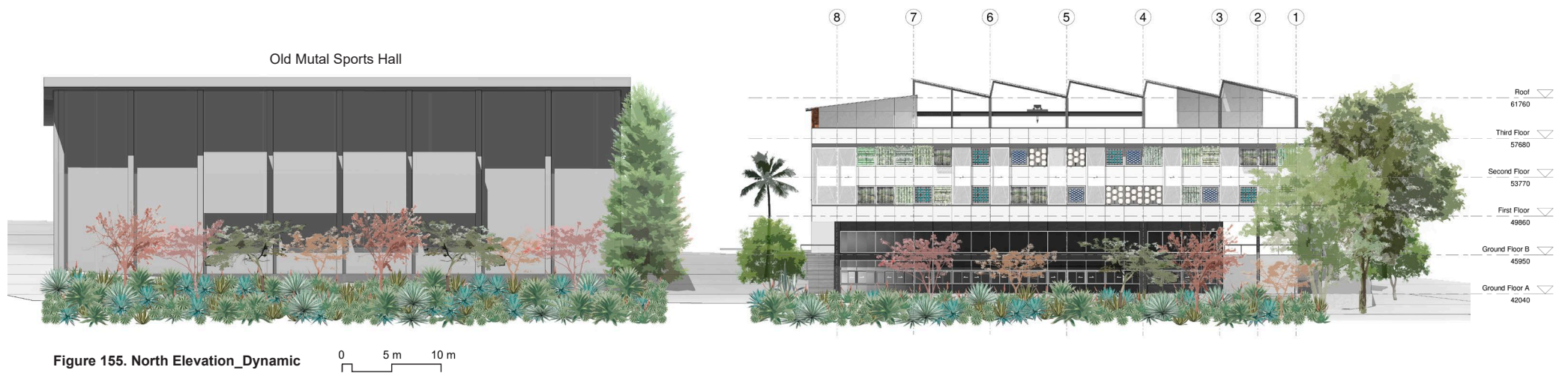
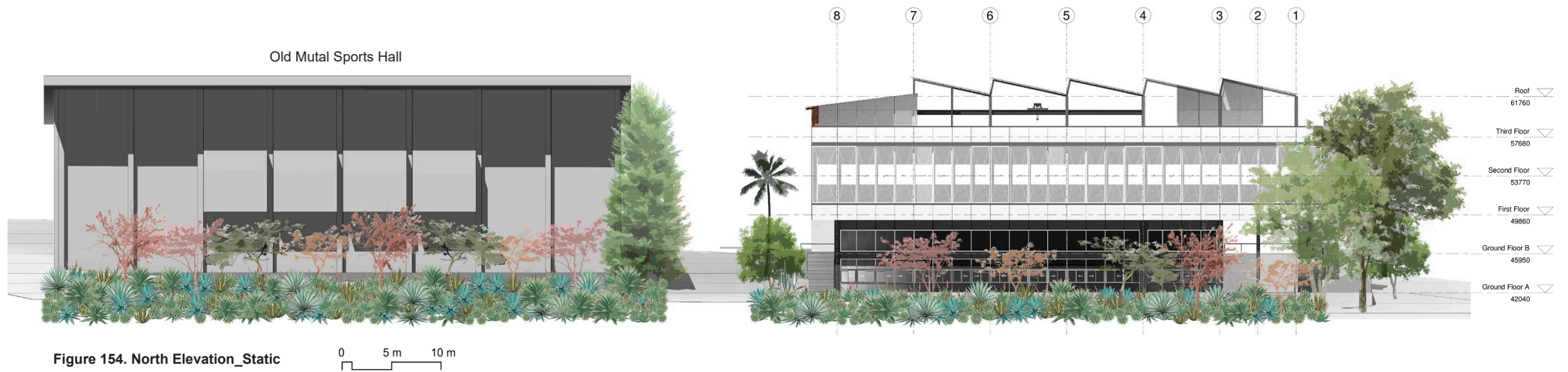


Figure 153. Section D

21. Digital laboratory
 - 21.1. CAD lab
 - 21.2. 3D printing lab
 - 21.3. Photo studio
 - 21.4. VFX studio
22. John Moffat Ext.
 - 22.1. Timber workshop
 - 22.2. FAB Lab
 - 22.3. First year studio
 - 22.4. CAD lab
 - 22.5. IT office
 - 22.6. Foyer





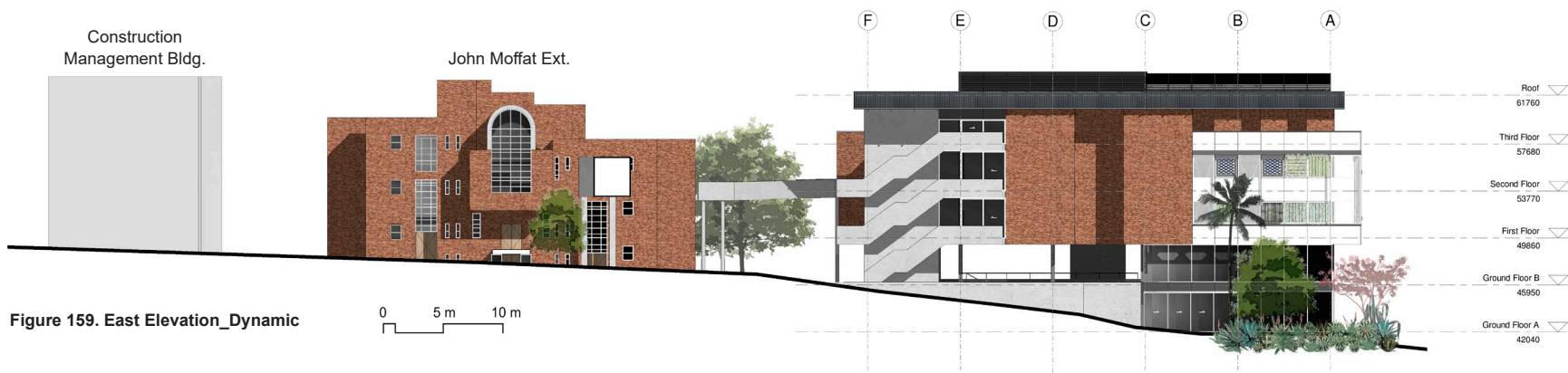
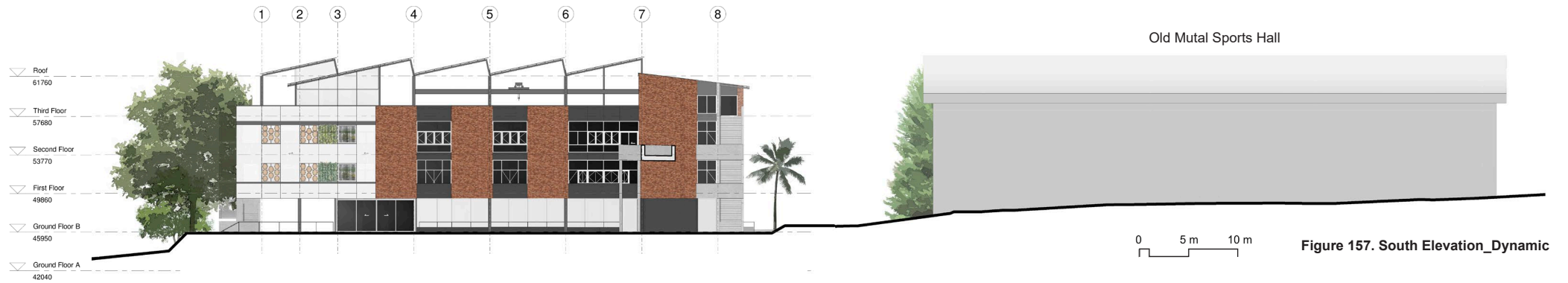


Figure 160. (bottom right) . Perspective View_ Pedestrian Walkway

Figure 161. (bottom left). Perspective View_Internal Courtyard

Figure 162. (top). Perspective View_South Facade

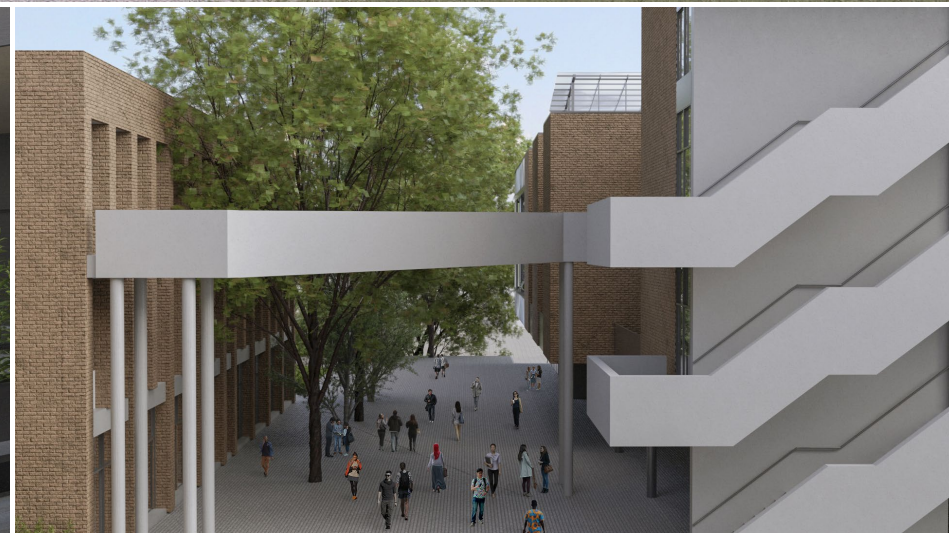




Figure 163. Perspective View_West Facade

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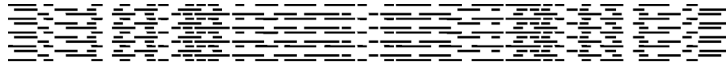
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**SCHOOL OF ARCHITECTURE AND PLANNING
HUMAN RESEARCH ETHICS COMMITTEE**

CLEARANCE CERTIFICATE
PROTOCOL NUMBER: SOAP08/03/2020

PROJECT TITLE: Prototyping Theatre: Design Development and Materials Research Centre at the University of the Witwatersrand

INVESTIGATOR/S: CHANTAL MARIA RYCROFT (Student No:1098100)

SCHOOL: Architecture and Planning

DEGREE PROGRAMME: Master of Architecture Professional (MArch Prof)

DATE CONSIDERED: 09 May 2020

EXPIRY DATE: 09 May 2021

DECISION OF THE COMMITTEE: Approved

CHAIRPERSON
(Dr Brian Boshoff)

DATE: (Signed electronically under lockdown: 10.5.20).

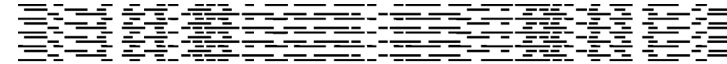
cc: Supervisor/s: Hilton Judin

DECLARATION OF INVESTIGATORS

I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to endure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee.

School of Architecture & Planning
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Private Bag 3 Wits 2050
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Signature

Date



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Consent Form

Prototyping Theatre: Design Development and Materials Research Centre at the University of the Witwatersrand

Chantal Maria Rycroft (1098100)

I agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I acknowledge that my participation may not remain anonymous by mention of my professional position.

YES

NO

I agree that the researcher may use quotes in her research report.

YES

NO

I agree that the conversation may be audio recorded.

YES

NO



..... (signature)

29/07/2020
..... (date)

Consent Form

Prototyping Theatre: Design Development and Materials Research Centre at the University of the Witwatersrand

Chantal Maria Rycroft (1098100)

I agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I acknowledge that my participation may not remain anonymous by mention of my professional position.

YES

NO

I agree that the researcher may use quotes in her research report.

YES

NO

I agree that the conversation may be audio recorded.

YES

NO

..... (signature)
2020.07.21 (date)

Consent Form

Prototyping Theatre: Centre at the University of the Witwatersrand for Design Development and Materials Research

Chantal Maria Rycroft (1098100)

I agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I acknowledge that my participation may not remain anonymous by mention of my professional position.

☒ YES

NO

I agree that the researcher may use quotes in her research report.

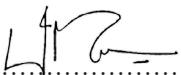
☒ YES

NO

I agree that the conversation may be audio recorded.

☒ YES

NO


..... (signature)
27 May 2020
..... (date)

Consent Form

Prototyping Theatre: Centre at the University of the Witwatersrand for Design Development and Materials Research

Chantal Maria Rycroft (1098100)

I agree to participate in this research project. The research has been explained to me and I understand what my participation will involve. I agree to the following:

(Please circle the relevant options below).

I acknowledge that my participation may not remain anonymous by mention of my professional position.

☒ YES

NO

I agree that the researcher may use quotes in her research report.

☒ YES

NO

I agree that the conversation may be audio recorded.

☒ YES

NO



..... (signature)

3 June 2020 (date)



Reference: Ms Olga Ndlovu
E-mail: olga.ndlovu@wits.ac.za

14 September 2020
Person No: 1098100
TAA

Miss CM Rycroft
Po Box 1120
Pinegowrie
Randburg
2123
South Africa

Dear Miss Chantal Rycroft

Master of Architecture (Professional): Change of title of research

I am pleased to inform you that the following change in the title of your Research Report for the degree of **Master of Architecture (Professional)** has been approved:

From: **Prototyping Theatre: Design Development and Materials Research Centre at the University of the Witwatersrand.**
To: **Co-Lab: Experimental Materials, Environments and Architecture.**

Yours sincerely

A handwritten signature in black ink, appearing to read 'Yaseen Stoffberg'.

Mr Yaseen Stoffberg
Faculty Registrar
Faculty of Engineering and the Built Environment