ACCOUNTING FOR

ADAPTABILITY

Shóna Quigley

The Persuit of a Flexible Architecture Within Existing Structures:
A Design Strategy for Adaptability through Careful Retrofit and Extension

ACCOUNTING FOR ADAPTABILITY.

Bachelor of Architecture Thesis 2022/23

The Persuit of a Flexible Architecture Within Existing Structures:
A Design Strategy for Adaptability through Careful Retrofit and Extension

Shóna Quigley

ACKNOWL-EDGEMENTS.

I woud firstly like to thank all of the staff at SABE TUDublin for the support and guidance they have provided over the past 5 years, in particular Sarah Sheridan and Cian Deegan, without whom this project wouldn't have been possible. Your invaluable insight and expertise both enriched and pushed this thesis to a new potential. I would also like to thank Sima Rouholamin for her dedication and support throughout the year.

To Cora Carbajo, Ronan O' Connor and OC + C Architects, for giving me the most valuable year of experience I could ever have hoped for. The completetion of this thesis is direct result of the skills and confidence I gained during my time working at the office.

To my classmates, who have become life-long friends. Thank you for the past 5 years, I will miss you all as well as the vibrant buzz of the studio. I can't wait to see the great things you all go on to do.

Lastly, I would like to thank my family for their unwavered support throughout my architectural education (especially to my mother, who jokes she'll be up on stage at graduation getting my degree with me). I will never be able to thank you enough.

CONTENTS

AN INITIAL RESPONSE

"All buildings are predictions. All predictions are wrong"
(Brand, 1994)

The current movement of architectural design has been underpinned by sustainability and 'green' agendas, resulting in the vast transformation of a range of practices within the built environment. Architecture now employs a heightened level of consciousness in the consideration of materials, renewable energy, water, relationship with landscape and site etc. However, while many of these considerate practices occur in a building's initial design and construction, it is uncommon practice to consider the end-of-life scenarios of such buildings. This, in turn, has led to a range of unsustainable practices at the end-of-life stage. Standard construction and procurement practice favour the permanent use of materials, using techniques that prevent opportunities for these materials to be re-used or adapted. As emerging sustainability standards call for circular systems within our construction industry, our current methods cause materials to turn to waste and our buildings to fall to dereliction.

Dereliction and disrepair become prevalent when a building fails to accommodate the use required by its occupier. As our ideas for architecture and spaces continue to rapidly develop alongside society, technology, and demand, the less appropriate it becomes for the architect to design mono-programmatic spaces. The architect must now look to an architecture that preserves the life-cycle of a building, with future use and room for adaptation at the core of the design.

Almost no buildings adapt well. They're designed not to adapt; also budgeted and financed not to, constructed not to, administered not to, maintained not to, regulated, and taxed not to, even remodelled not to. But all buildings adapt anyway, however poorly, because the usages in an around them are constantly changing (Brand 1994)

Architecture often fails to successfully adapt as it is based on a series of assumptions set out by an architect, builder, developer, or client etc, of how a building may be used and does not reflect the infinite types of interaction with and within it that may occur over the lifetime of the building. Failing to acknowledge this variable has meant that our buildings often remain static objects that exist in isolation from time, development, and change. Our buildings have often become permanent objects, unreflecting of an ever-changing landscape and unable to keep up with the changing requirements of their user.

This thesis paper proposes an approach to flexibility within architecture that directly engages with user interaction. Such a proposal immediately calls into question the role of the architect and design. From here the question, 'How can architects better equip buildings for future adaptation and promote active flexible engagement between user and architecture without compromising the role of design?', can be asked. This paper will justify the need for newfound levels of collaboration between community and architecture in order to ensure overall sustainability, while simultaneously defending the importance of the architect in such collaboration.

"As an architect you design for the present, with an awareness of the past for a future which is essentially unknown." (Foster, 2015)

In order to facilitate a heightened level of understanding between an architecture and its user, it can be assumed that the use of simplified structure and assembly is an appropriate means of achieving accessibility amongst a varying range of users, many of which will lack the construction and design knowledge of the architect. It is the role of the architect to facilitate this accessibility, through the architectural systems and design approaches to be employed. Such practices and the pursuit for adaptability also align themselves in favour of a de-mountable architecture; the easier a building is to construct implies the easier it is to deconstruct, allowing the user the ability to adjust the programme as they require. The preservation of structures should therefore be promoted through engagement with the occupier, giving them control of the environment of which they inhabit.

The pursuit for an adaptable architecture will be supported by the investigation of the role of standardisation within architectural history. From here, the thesis paper will seek to challenge current building practices, in pursuit of a methodology of component-derived, demountable or a 'flexible' architecture. The paper will explore this idea through tectonic design strategies such as Design for Disassembly and Design for Future Adaptive Re-use to theories surrounding flexibility of use within architecture. It will also explore design principles and approaches undertaken by a range of architects and architectural practices that have sought to achieve such ideas within their design projects. An appropriate approach to the design project will be drawn from this research and shall be clearly outlined prior to deployment and testing within the Tolka Valley site.

The methods to be outlined by the paper aim to achieve sustainability from both an environmental and community perspective, in line with Sustainable Development Goals 13, Climate Action and 11, Sustainable Cities and Communities, respectively.

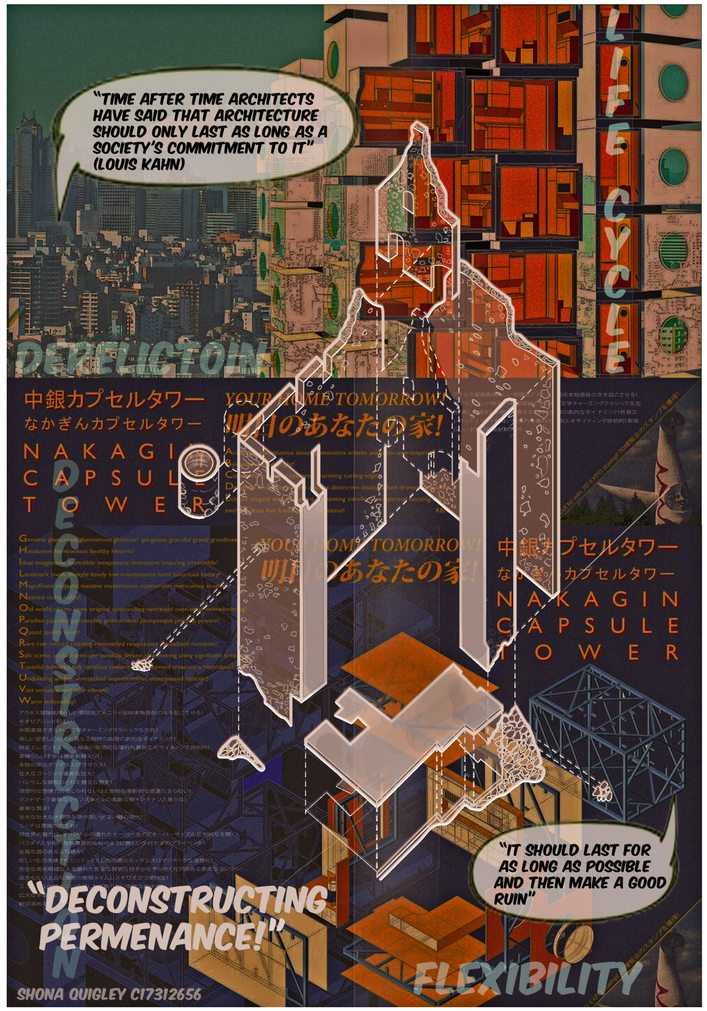
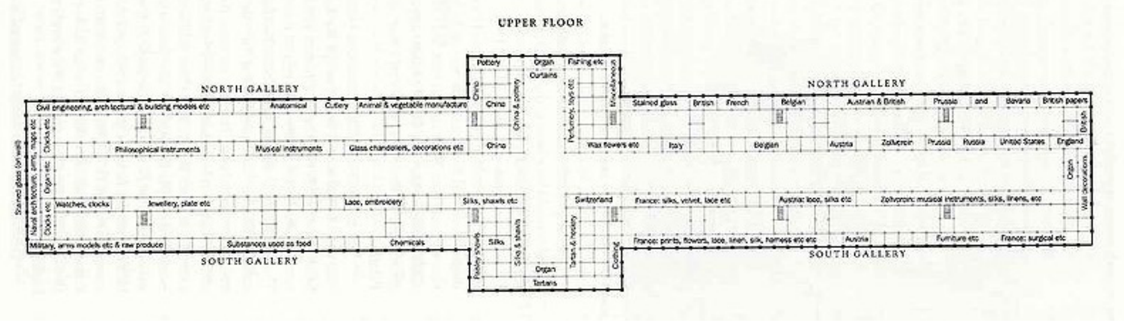


Fig. 1, Deconstructing Permenance, Collage, Author's Own

STANDARD PARTS, DISTINCTIVE USE

There are many existing practices and methods of design that have contributed to the idea of adaptability within the built environment. The emergence and development of approaches such as standardisation, prefabrication, and modularity, although design methods in their own right, often are employed in an overall scheme of adaptability. From here it is important to examine and understand their historic development and prominent periods of use.

The practicalities of a flexible architecture call for a certain level of 'open-ness' for adaptation to take place. Up until the first industrial revolution of the 19th century, the structural limitations of the existing common materials such as brick and stone created a built form of heaviness and permanence. The development of new materials such as steel and glass aided the development of industrial buildings, generating a new level of spatial freedom employing the use of gridded, repetitive, and light structures. Such ideas were prominently displayed in Sir Joseph Paxton's 1851 Crystal Palace . Paxton employed a modular system, which was based on the largest sheet of glass available at that time (10' x 49'). The design consisted of a series of repeated cast-iron beams and columns which were mirrored, multiplied and set at 90° angles from one another. Due to the simplicity of the proposal, all parts could be prefabricated and assembled into a self-supporting module. When the building's use, an exhibition in Hyde Park had ceased after six months, the structure was disassembled and re-erected elsewhere. The structure, due to its modular design, served as precedent for future prefabricated structures as well as temporary and de-mountable architecture. The Crystal Palace "foreshadowed industrialised building and the widespread use of cast iron and steel". (Gaber 2017)



WALTER GROPIUS & WEISSENHOF SIEDLUNG

Such methods of industrial building including prefabrication and mass production would influence many architects of the twentieth century, from Le Corbusier's modernist pursuit of the 'living machine' to Ernst Neufort's strive for time and cost efficiency within German WWII wartime construction. In 1927, architect Walter Gropius, founder of the Bauhaus, demonstrated the use of such 'industrialised' design strategies in a manner that aimed to "satisfy the public's desire for an individual designed house, by the multiple possibilities of combining interchangeable parts, without sacrificing the principles of mass production" (Mattsson, 2004). In his single unit house for the Weissenhof Siedlung scheme, Gropius utilized a module of 1 metre, which was repeated throughout the unit as well as a prefabricated panel system, which could be manufactured off-site, allowing for a more rapid construction. The house was Gropius' comment on how to build 'industrially'. However, the scheme was not 'limitless', as it had claimed to be.

"It hinted at endless possibilities of arranging the individual parts. Nevertheless, this system was not limitless. The walls could only be arranged in accordance to the designed grid system. The connections between the panels determined how they can be put together."

(Weimar Architecture, 2022)

While Gropius' use of standard, modifiable, components provided a newfound level of flexibility within architecture, the employment of a rigorous grid system restricted the building as a whole. The specific requirements of the user as well as overall interaction between user and architecture were limited to allowances of Groupius' predetermined grid.

Left: Fig. 2 Plan, Crystal Palace, Sir Joseph Paxton, 1851
Above: Fig 3. Weissenhof Siedlung, Walter Gropius, 1927

DE-MOUNTABLE ARCHITECTURE

& Understanding Buildings through Layers

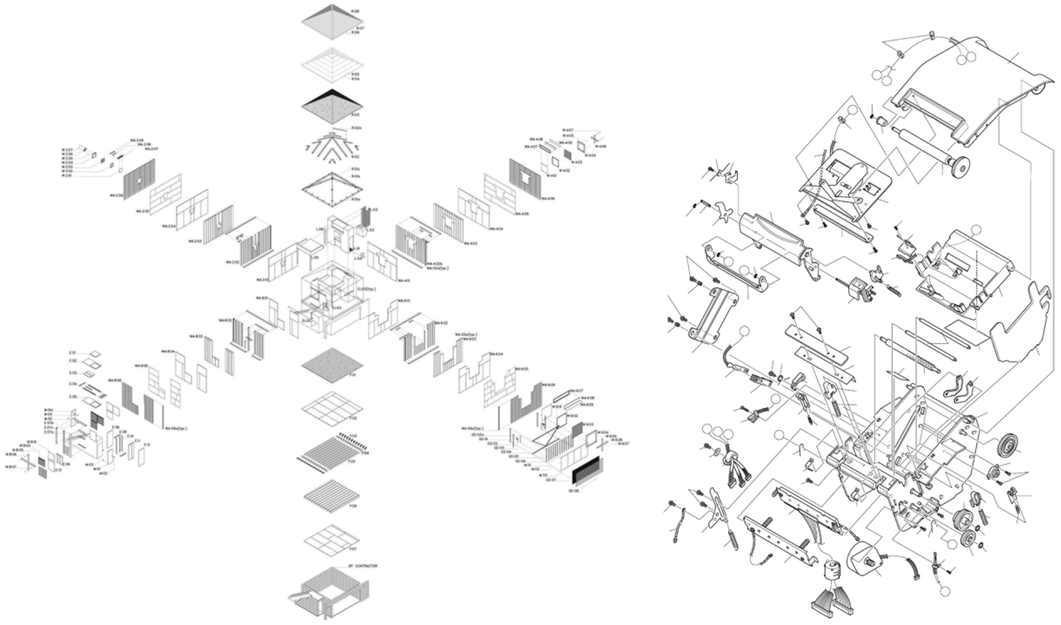


Fig. 4 Exploded Axonometric, Design for Disassembly,

Standardisation has been seemingly ever-present in the creation of architecture and within construction practices. However, while it appears standardisation has been used to facilitate building efficiency and design, it has not been used to its full potential when it comes to taking our structures apart again. A method in which such form of adaptability and de-mountable architecture can be explored is through the use of 'Design for Future Adaptive Re-use' and 'Design for Disassembly' principles.

The terminology of these strategies can be outlined and comprehended in the paper 'Architectural Design for Adaptability and Disassembly' by Paul W. Long. Under the subtitle 'Building Re-use, Component Re-use, Material Re-use, and Material Recycling', the author sets out a clear set of guidelines and definitions of concepts associated with 'Design for Adaptability and Deconstruction' (DFAD) . This umbrella term is broken down into the following:

Design for Future Adaptive Re-use (DFAR):

Involves the direct re-use, adaptation, or relocation of an existing building and/or its structure

Design for Deconstruction and Disassembly (DfD):

This term represents topics related to the re-use and recycling of building materials and components but excludes the building itself. This can be further broken down into:

a) Design for Deconstruction: The direct re-use and/or relocation of building components or assemblies within a new or existing building

b) Design for Disassembly: Involves the recycling of existing buildings into new materials and/or components i.e. recycled goods are used as raw material in the manufacturing of new products.

This is done to promote clarity and combat any confusion that has been previously present in the understanding of such concepts due to conflicting and diverse use of the terms. Here, the author distinguishes a hierarchy, making it clear how differing strategies can be used in parallel and to compliment another.

If an architect plans strictly for the future adaptive re-use of a building, she risks losing a significant portion of the building's embodied energy through renovations. Likewise, if a designer only plans for the future recycling of renovated materials, and/or the re-use of building components, he runs the risk of failing to rake advantage of the embodied energy inherent in the building's core and structure. (Long, 2014)

The paper argues that while the distinction of the terms is important for their understanding, the careful consideration of such strategies in conjunction with another suggests that “future buildings are well prepared to significantly reduce their negative long term environmental impact through the preservation of their embodied energy.” (Long, 2014)

By affording architecture the ability to be de-mounted, overall adaptability can more readily be achieved within both the constraints of the site or as an entirely new structure. For example, perhaps components are arranged as a school in one town, the population of school children in this area declines but grows in a neighbouring town. These components could be taken down, transported, and erected on the new site. Similarly, if the population demands a care home, perhaps the components are rearranged on a new site in a manner that is appropriate for this use. It is here that the life-cycle of the building is preserved by being adapted the needs of the user in that moment of time. It is entirely interchangeable.

UNDERSTANDING BUILDINGS THROUGH LAYERS

A subsequent key method in the design of flexible and de-mountable spaces is to examine the role of life-cycle within architecture. In his book, ‘How Buildings Learn- What Happens After They’re Built’, Stewart Brand sets out such a procedure using what he calls ‘Shearing Layers’. Similar to the beliefs of the 1960s Japanese Metabolists, Brand suggests the idea of building as ‘living organisms’, which have the ability to grow and evolve. This procedure involves the isolation of the different elements or ‘layers’ of a building in order to understand the varying life-cycle or ‘metabolic’ constraints of each individually to ensure the building’s overall flexibility. The principles set out by Brand’s ‘Shearing Layers’ diagram, which are derived from ideas set forth by architect Frank Duffy, are broken down by their respective metabolic rates into the following; Site , Structure , Skin , Services , Space Plan and Stuff .

The use of Brand’s diagram can serve as a useful tool in the pursuit of designing an adaptable architecture through the consideration of building parts in terms of life-cycle. This understanding is vital to ensure the overall preservation and sustainability of a structure and its parts. Through acceptance and acknowledgement that all buildings will adapt, whether designed to or not, the architect is facilitated to create structures that have the ability to respond to the changing needs of the user and developing demands caused by time.

> Buildings need to be three things at the same time. They’re a habitat for their occupants. They’re the property. At the same time, they’re also a part of the community. Buildings must fit their occupants and place they’re in. They must sit on the site that they’re built on. Buildings aren’t one thing. They themselves are a shearing layer between the wants and desires if the occupants and the desires of the community
>
> (Bogue, 2019)

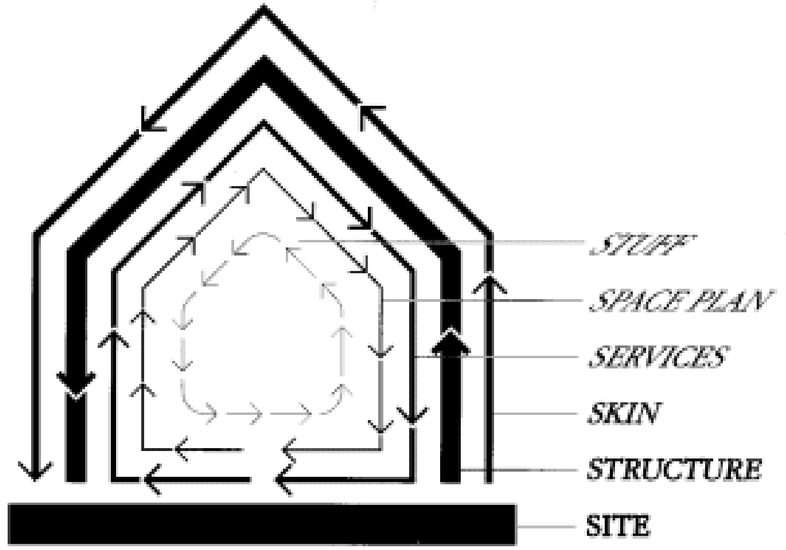


Fig. 5. Shearing Layers of Change, How Buildings Learn, Stewart Brand, 1994

THE VALUE & RE-USE OF MATERIALS

When contemplating de-mountable architecture as well as life-cycle, re-use and recycling, the consideration and value regarded for materials becomes prominent. At present, our building practices fail to consider materials beyond the life-cycle of the building in which they are employed. They become disposable, single use objects, turning to landfill once a building has reached the end of its life and/ or is demolished. Such practices are contributing to the large numbers of waste associated with the built environment with “construction and demolition waste (CDW) [accounting] for more than a third of all waste generated in the EU” (European Commission, 2020). The current treatment of materials is the result of a building industry that is constrained by cost, time, and resource efficiency. It is a mutual interest of involved parties to build as quickly, cheaply, and easily as possible, under what is usually an architectural aesthetic based on trends at that time. It is difficult to conceive the consideration of building materials beyond these parameters.

However, perhaps ‘radical thinking’ comes within a shift in the value we place on materials and the care with which they are treated with through construction. As outlined thus far, the needs of our buildings are constantly developing and changing. Perhaps instead of investing in the preservation of that specific building, we should be investing in the preservation of materials, so that they can be re-used and adapted as required, passing from one building to another. As outlined by Brand’s shearing layers of change, it is perhaps appropriate to consider the life-cycle of a certain material and how it can be preserved within our construction methods to be re-used to the full potential of the material’s life-cycle rather than that of the building.

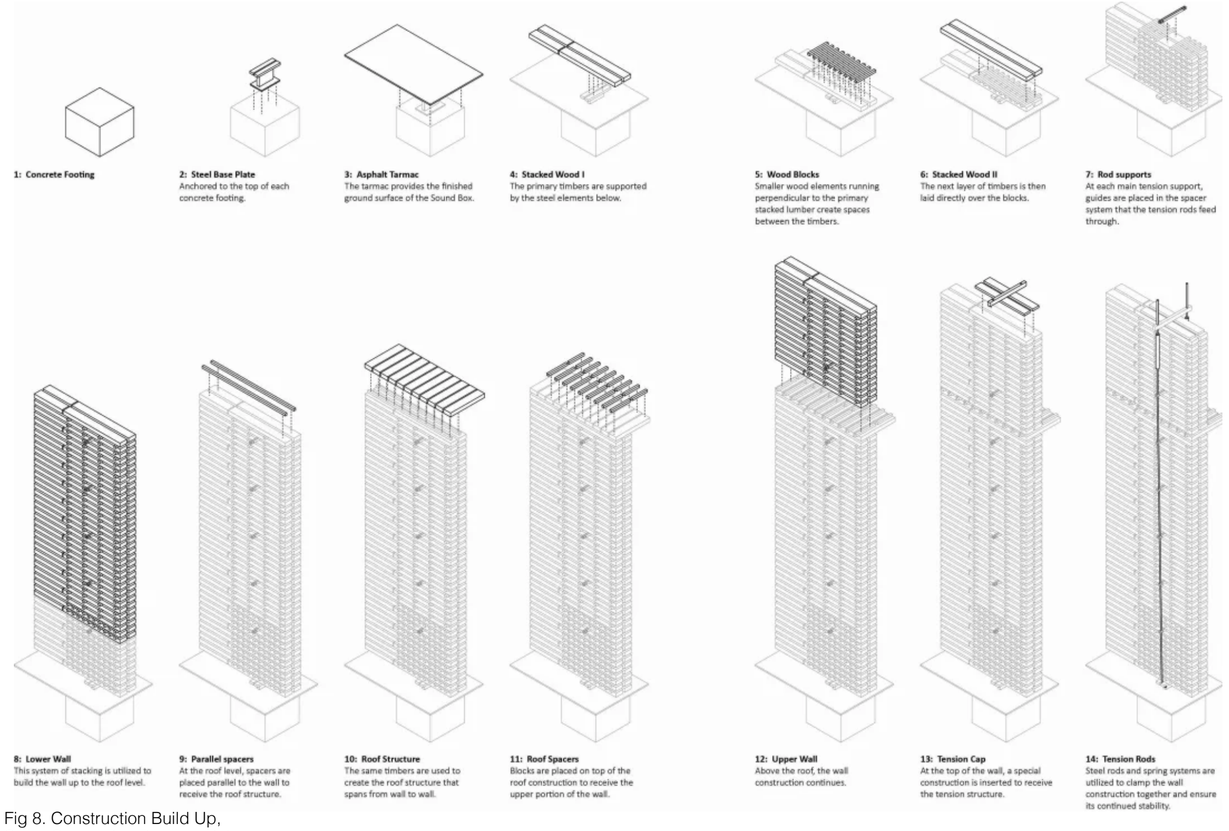
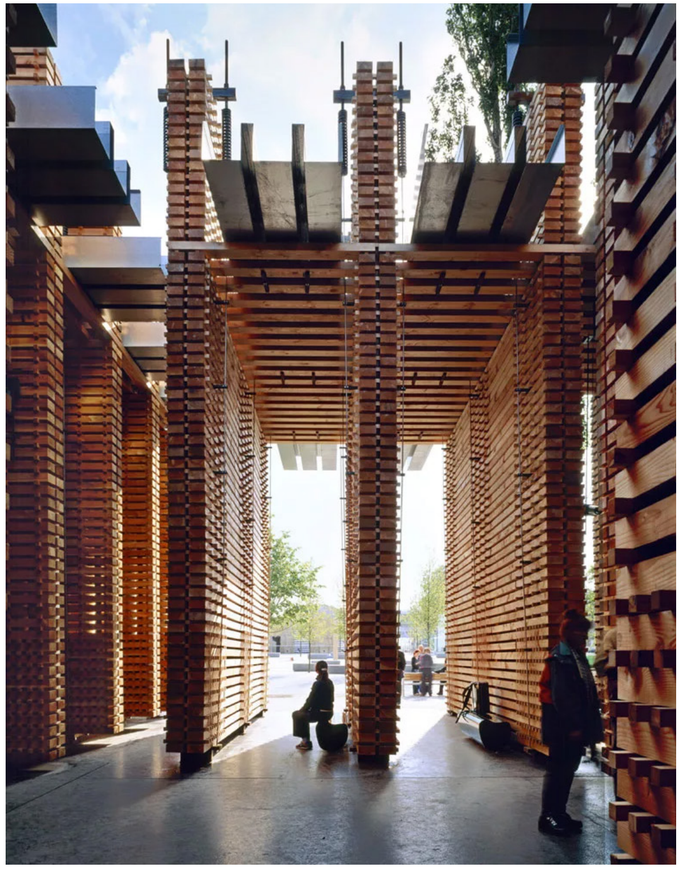


Fig 8. Construction Build Up, Swiss Sound Box Pavilion, Peter Zumthor, 2000



Every timber used in the Swiss Sound Box was unscathed by the construction process… the stacks were held together through friction resistance. The timbers were placed precisely in stacks using templates and scaffolding. After placement, the stacks were compressed using a system of stainless steel tension rods and steel springs. The tension systems were placed every 3 meters along the stacks and were anchored at the bottom to steel plates and at the top to a cap element that spanned across the wall. The springs were integral to the system as they allowed the compression system to maintain constant pressure despite the fact that the wood was constantly changing shape.

(CJS, 2016)

The temporary pavilion was made up of 40,000 timber beams forming 118 stacks to create walls. Care and protection of the material is seen in Zumthor's choice to use no permanent fixtures to hold the pieces together. Using methods of compression between the timber beams and walls which are connected by tension rods and steel springs, a non-invasive structure was formed. No bolts, screws or glue were used. This was done in order to preserve the timber beams, ensuring they were not damaged during their use, resulting in their capability for re-use following the deconstruction of the pavilion.

Such regard for materials can be exemplified by Peter Zumthor's Swiss Sound Box Pavilion entry to Expo 2000. The exposition took place in Hanover under the theme 'Man Nature and Technology'. Though designed between 1996-2000, the concept of sustainability through tectonic and value of materials employed by Zumthor's design remains relevant in current architectural conversations. The concept of the pavilion was to showcase Swiss culture, which is reflected in the choice of timber as the primary material for the structure.

The motive behind this method of flexibility is derived from the value that was placed on the material used. This method not only showcases a form of flexibility in the terms of tectonics, but the preservation and care for the timber. This not only meant that the processes of time on the material were uninterrupted by the structural system, but the pavilion itself could be taken apart and re-used, in turn, preserving its life-cycle and affording it the opportunity to be used to its full potential.

Left: Fig. 7 Swiss Sound Box Pavilion, Peter Zumthor, 2000

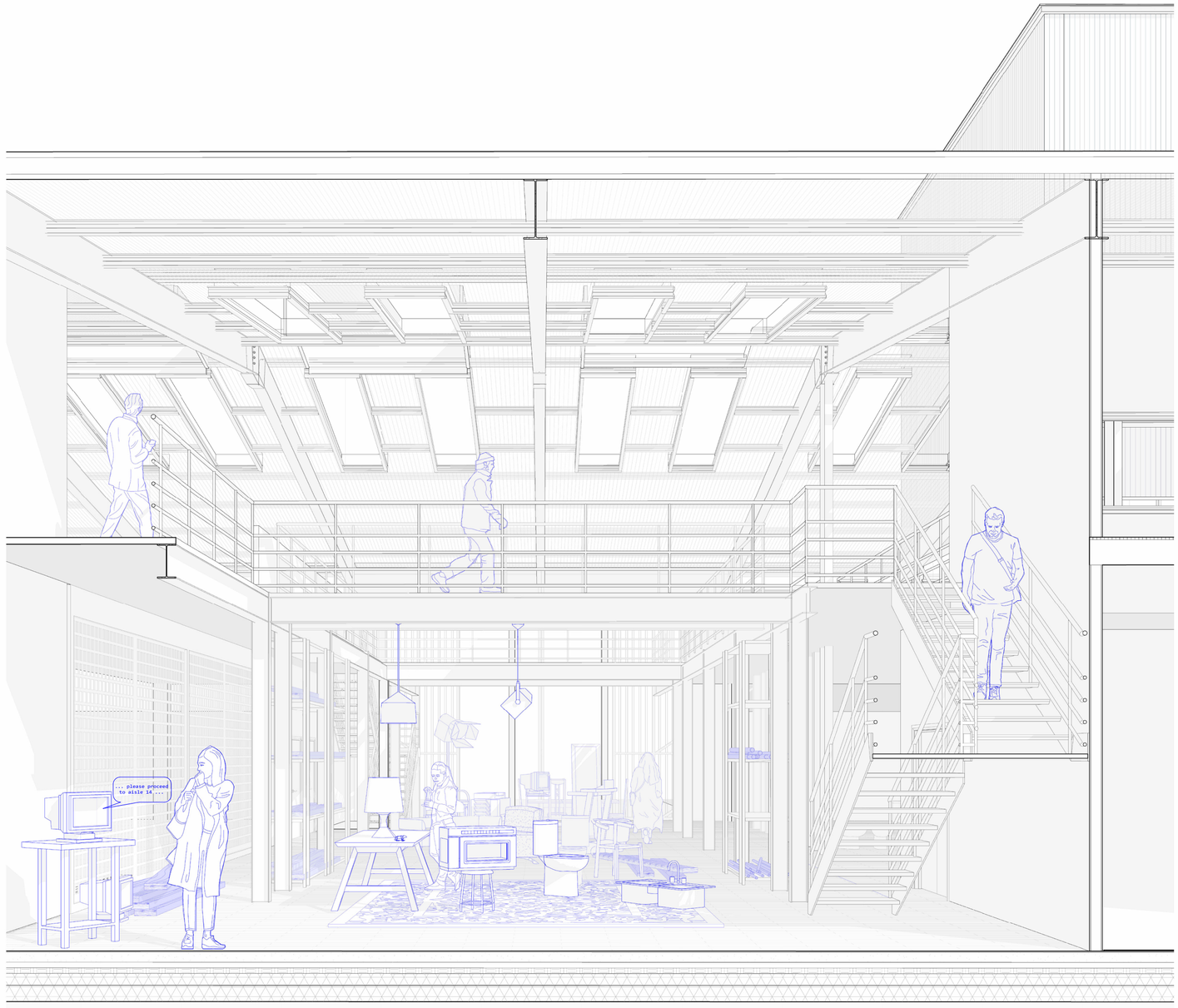
THE VALUE & RE-USE OF MATERIALS

Reclamation Realm

The group test thesis project brief is for a Material Reclamation Centre and Salvage Yard on the site of a former yeast factory in Finglas Business Park. The project proposes the re-use of the existing factory to store and sell reclaimed materials as well as the addition of new structures on the site which are constructed of reclaimed materials and components. The project identifies various granted planning permissions within the extents of the site. Many of these applications propose the demolition of existing structures to make way for new structures to be built in their place. The test project proposes to take these sites and carefully dismantle the present structures rather than demolishing them. The dismantled materials are stored the existing factory, now operating as Material Reclamation Centre, in parallel with their use in the construction of new surrounding structures. As mentioned, adaptability within this project is seen within the re-use of these structures, which have not yet reached end of life, but have outlived their original use. By recognising the value of such materials and structures, they have been afforded an opportunity to be used to the full capacity of their lifespan.

Language of the Tolka Valley has been carefully examined through the accurate cataloguing of existing structures in terms of their materials and components. The project identifies various granted planning permissions within the extents of the site. Many of these applications, situated in an industrial context, propose the demolition of existing factory and warehouse typologies in favour of the erection of new mid-rise residential units. It is here that the project has broken down the buildings into its components which have then been recorded.

Due to the prevalent industrial use of land within the site, the existing language is that of structural, gridded, and open architecture, with the prominent use of the portal frame structure, it is significant to note how these may inform the architecture to be created within the site. It is also significant to note how Ban's experimentation with industrial form could perhaps link back to the existing industrial conditions present throughout the site. In the pursuit of achieving an architecture of flexibility, reference to the existing typologies of the site could begin to inform a physical architecture.



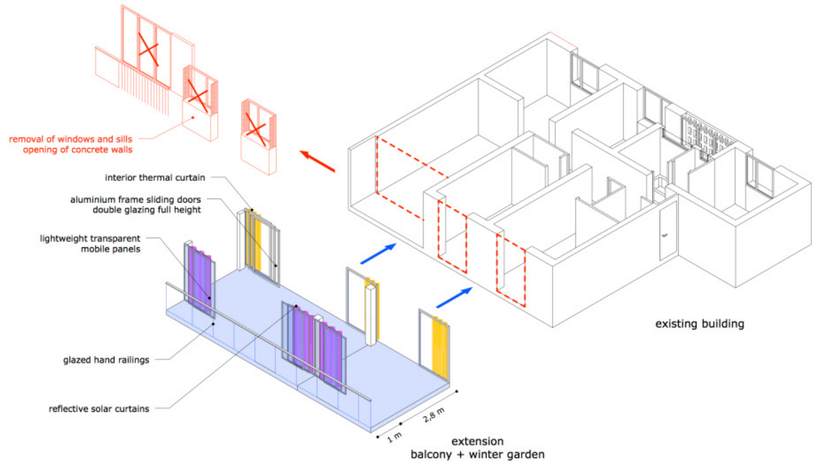
DESIGNING FOR UNPREDICTABLE OCCUPANCY

& Plasticity of Space

The use of adaptable or ‘open’ space becomes problematic in design where its use results in an architecture that is vague or un-bespoke therefore often questioning the role of design and the architect. A design approach that incorporates user-led adaptability without the compromise of design integrity can be seen within the architectural principles of the French practice Lacaton and Vassal. These principles are stated as ‘Espacio Libre’, ‘Transformación’, ‘Habiter’ or ‘Free Space’ , ‘Transformation’ and ‘Habiter’ , respectively. The practice aims to create sustainable spaces by programming opportunities for adaption and change to occur within. This is done through the equal amounts of use of programmed space vs. unprogrammed ‘free space’.

This extra space has no defined function. It is out of the programme. It exists in addition to the traditional or programmed spaces, and the combination of the two different spaces generates freedom, it allows for appropriation and creation. In all cases, the extra space expands the capacity for usage, it multiplies atmospheres, possibilities. It permits interferences and connections between private space and public space, creating spaces for mingling. It creates relationship. (Lacaton, Vassal, 2021, p157)

In the terms of Lacaton & Vassal, the challenge of the architect and the richness of the architecture is derived from the inhabitation of space by the user. The practice strives to offer generosity in an environment controlled by restrictions and budget, which often results in a limited architectural form. These principles build on the architectural aims of earlier modernists such as Gropius. Where Gropius intended to create adaptable spaces using a fixed standard grid, here buildings similarly take use of standard, basic and readily available materials and components but instead consciously use ‘free space’ to create unique, adaptable, and user-orientated architecture.



Previous: Fig. 8 .Perspective Section, Reclamation Realm, Group 1, Authors Own, 2022
Above: Fig 9. Axonometric, ‘Transformation’ Cite du Grand Parc, Lacaton & Vasal, 2016

CITÉ DU GRAND PARC

These principles are exemplified by the project ‘Cité du Grand Parc’, a housing scheme near Bordeaux, consisting of more than 4,000 dwellings. The original scheme had been built in the early 1960s and consisted of mostly social housing. Consistent with their ‘Make Do’ design principles, Lacaton & Vassal sought to regenerate the scheme through expansion rather than demolition.

“Never demolish, never subtract or replace, always add, transform and use, supplement, update, start off with the existing to do more and do better… our attitude is to ‘Make Do’”(Lacaton & Vassal, 2021)

A four-meter wide extension was added to the main façade of the complex, providing balconies and winter gardens to 530 dwellings. Through this addition “natural light, greater fluidity of use, better views and an additional living space” (Lacaton & Vassal, 2021, p132) were provided to each dwelling. Through the introduction of new layer of open space, the entire existing dwellings wereregenerated and together created greater opportunities for ranging uses and encounters to take place.

The more a place is a vessel of multiple and combined imaginations, the more we see it at somewhere stimulating to inhabit, a trigger for new relationships. The superimposition of two situations, temporalities or usages allows us to tip over into a third space. The project will then invent a new, more sustainable situation, enriched by all its preceding histories and strata.

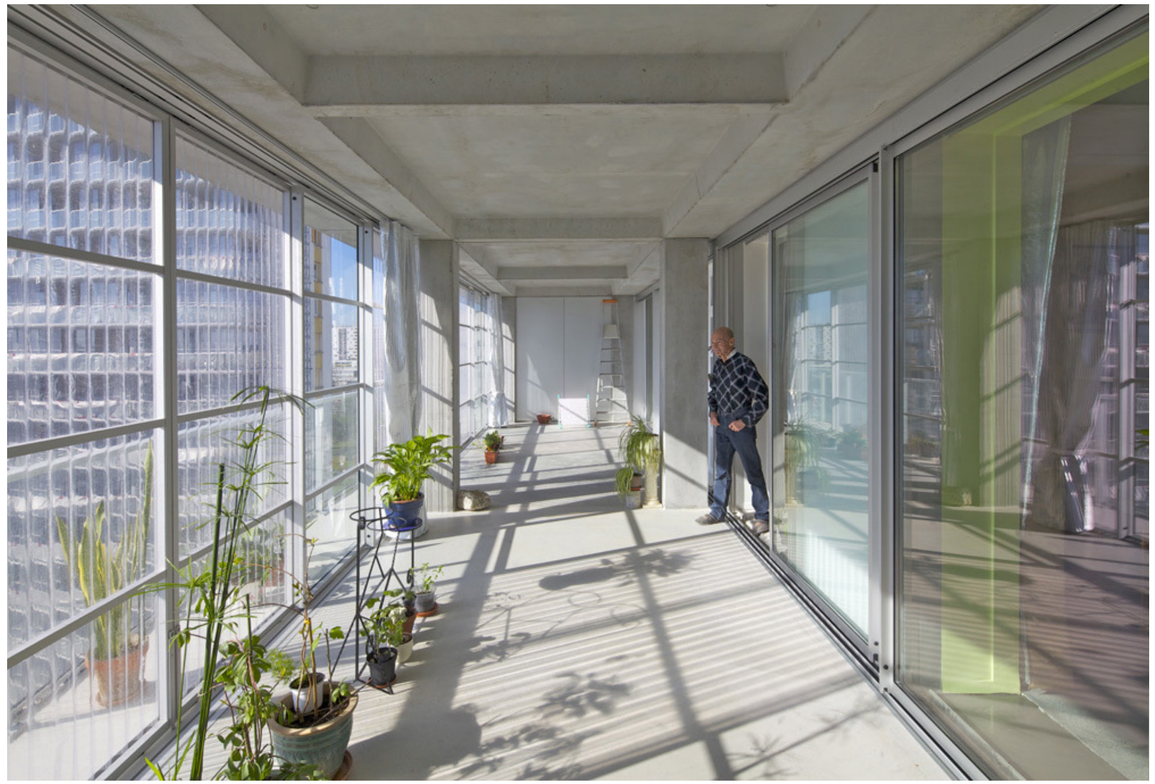
(Lacaton, Vassal, 2021)

“NEVER DEMOLISH, NEVER SUBTRACT OR REPLACE, ALWAYS ADD, TRANSFORM AND USE, SUPPLEMENT, UPDATE, START OFF WITH THE EXISTING TO DO MORE AND DO BETTER… OUR ATTITUDE IS TO ‘MAKE DO’”

(Lacaton & Vassal, 2021)

The balance between programmed and unprogrammed space could be the compromise and design challenge to be taken on by the architect, while affording the occupier freedom of use. Perhaps the integrity of design is found in achieving the balance of such spaces, between fixed and flexible, between closed and open. Practically speaking, it is unsuitable for service dependant spaces such as bathrooms, kitchens, and elevators to widely adapt given the fixed services they rely upon. Perhaps such spaces are constant, used to ground and familiarise the user through a flexible and changing landscape. Architecture is found in the judgement of these spaces and how they interact with one another. Through the use of inherently open spaces, a certain degree of flexibility is achieved within more programmed, designed areas, as they are constantly responding to the unlimited range of activities and interaction provided by ‘Free Space’.

Above: Fig 9. ‘Transformation’ Cite du Grand Parc, Lacaton & Vasal, 2016
Below: Fig 10. ‘Transformation’ Cite du Grand Parc, Lacaton & Vasal, 2016



DEFINING A STRATEGY FOR FLEXIBILTY

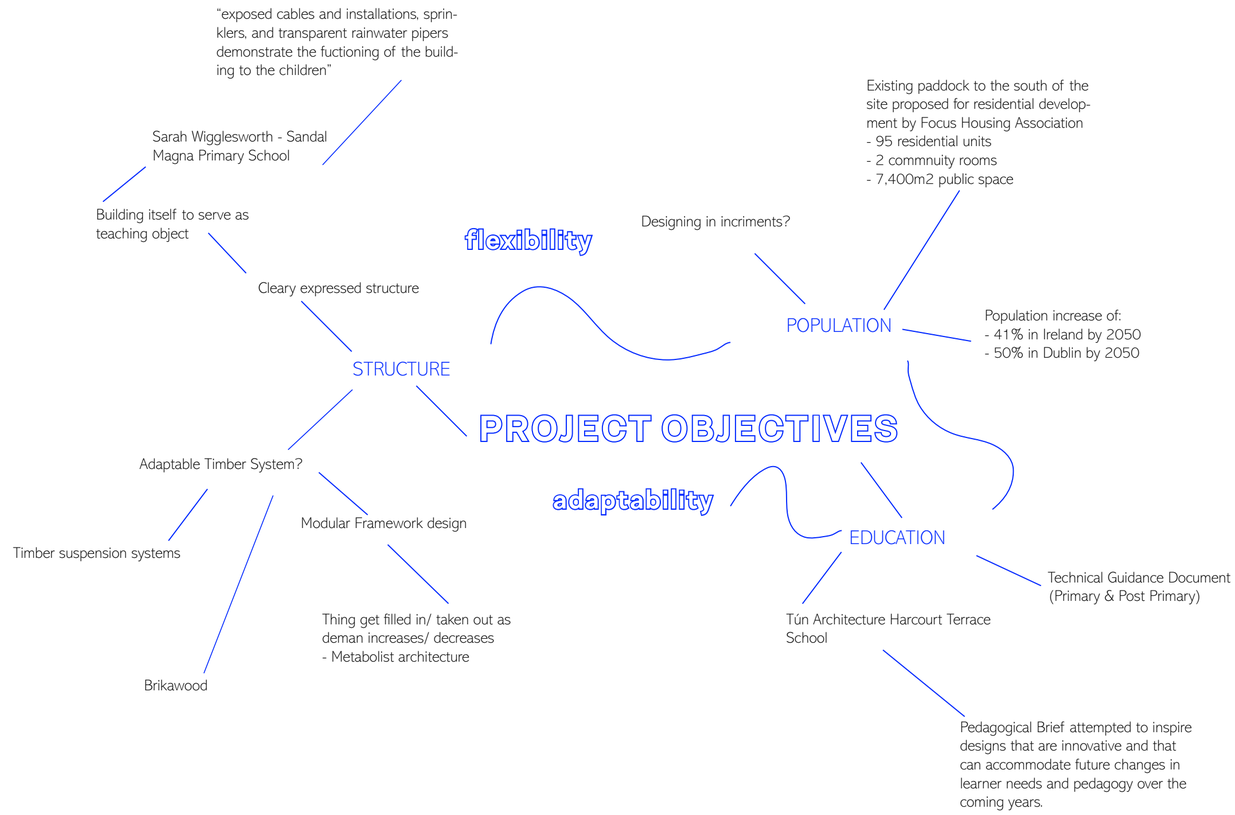
Within the architectural discourse, the terms ‘flexibility’ and ‘adaptability’ are broad and often non-specific. As seen in the ranging strategies of such concepts, terms such as ‘flexibility’ can refer to a range from moving walls to standardised parts, from demountable structures to self-build practices and from the balance of fixed and free to the consideration of buildings through metabolic layers. The term can describe ideas that range from a physical tectonic to a spatial phenomenology. With this in mind, it is important to clearly outline a method of flexibility, that has been derived from such concepts, in order to be tested and create an architecture that is explicit in its intentions.

The proposed means of achieving flexibility within the studio design project was undertaken on two scales; flexibility in how it is made (tectonic), and flexibility in how it is occupied and its relationship to the occupant (use).

Such use of adaptable tectonic can be exemplified by Peter Zumthor’s Swiss Sound Box Pavilion in Hanover. Through a heightened level of care for the materials used within the structure, they were awarded the capability to be adapted through re-use. While a tectonic flexibility could also refer to moveable parts as seen in the architecture of Shigeru Ban, perhaps it is more viable to invest in the life-cycle potential of our materials.

When we build, there is no truly accurate way to say for sure how long that building will stand in a particular site, in its specific intended use, as Brand states, “all buildings are predictions, all predictions are wrong.” By creating a method of tectonic adaptability, a building is given the opportunity to be regenerated when the materials, as well as its components have reached the end of their life. Similarly, if considered the other way around, the materials are given the opportunity to be re-used in a different structure. Using this method, control over how fixed or temporal a building may be based on it use, can be achieved.

Through the use of simple construction and expressed connections, an understanding of how a building has been put together is more readily accessible. From here, it can be argued that such method allows the user understanding of something that has been explicitly expressed to them. In turn, such understanding aims to promote a level of respect between the user and the architecture, with the beauty of the architecture generated.

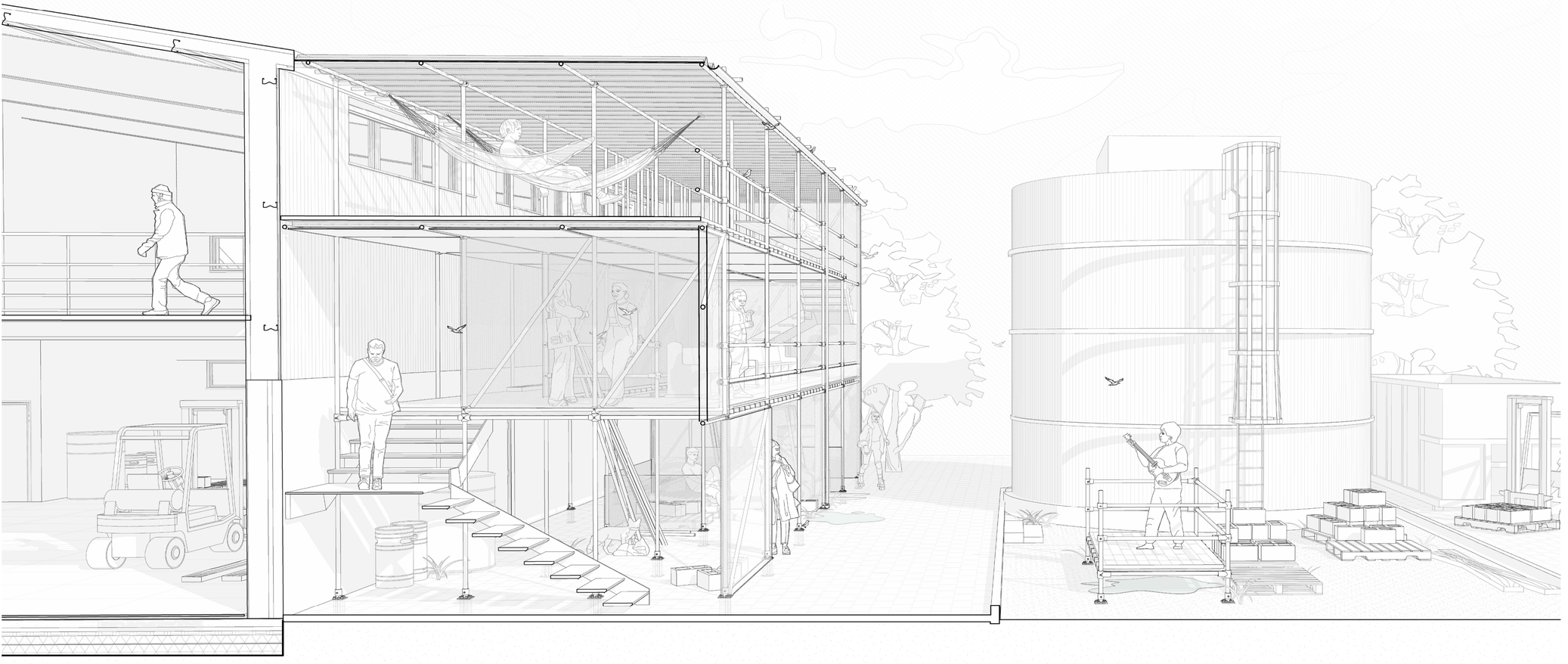


from its materials, components and tectonic. If the architect can demonstrate a level of care, placing a shift in the value we put on such parts, to not view them as disposable resources, but as versatile elements with wide capabilities. It is proposed that through such understanding, respect and care for the structure will be promoted, and a sense of resilience given to the community through their direct interaction and participation with the building.

From the research and evidence provided, it is clear that the achievement of a flexible architecture requires a balance of participation from both sides, the architect, and the community. This balance is exemplified in the principles of likes of Lacaton & Vassal, through the equal use of programmed space and free space, or in other terms, a balance between architect-led designed spaces and community-led flexible open spaces. The output of these sides working isolation from each other is the same; unusable space. The technical and design knowledge possessed by the architect is essential in the initial creation of functionality while the needs and requirements of the user is vital in the overall preservation and longevity. It is not a case of one or the other, but both.

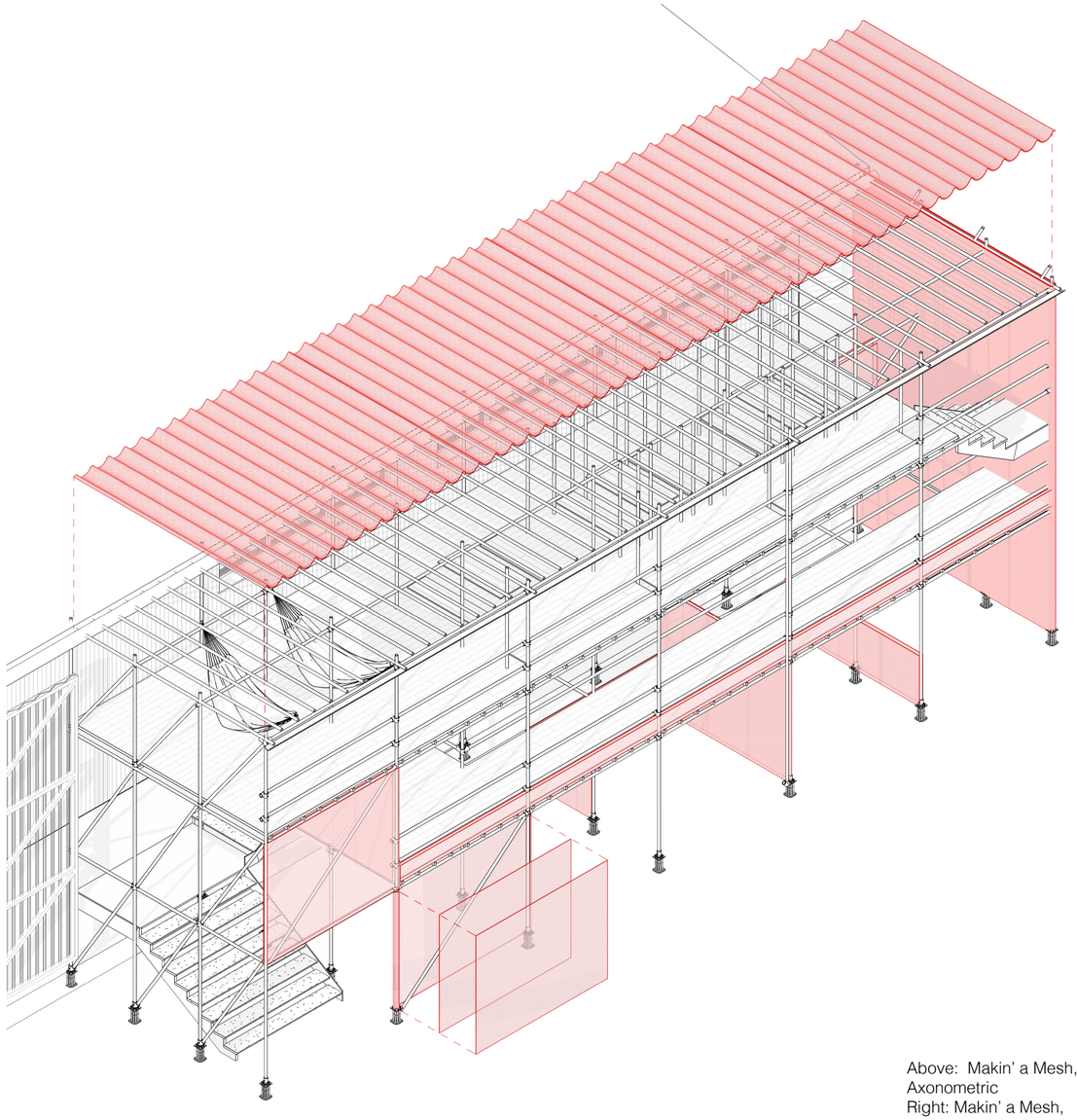
TESTING THE THESIS

‘Perfomance’



Following this, the individual test project proposed an inherently adaptable and demountable structure on the same site. The project proposes a structure of scaffolding and scaffolding mesh to create an ‘in-between’ buffer structure between the fixed, existing yeast factory and the open, proposed salvage yard. Similar to Zumthor’s lack of fixed connections, the system employs key clamps, affording the scaffolding the ability to be easily adapted or dismantled. These connections are clearly expressed in order to emphasize the manner in which they have been put together, once again aiming to facilitate an understanding with the everyday occupier.

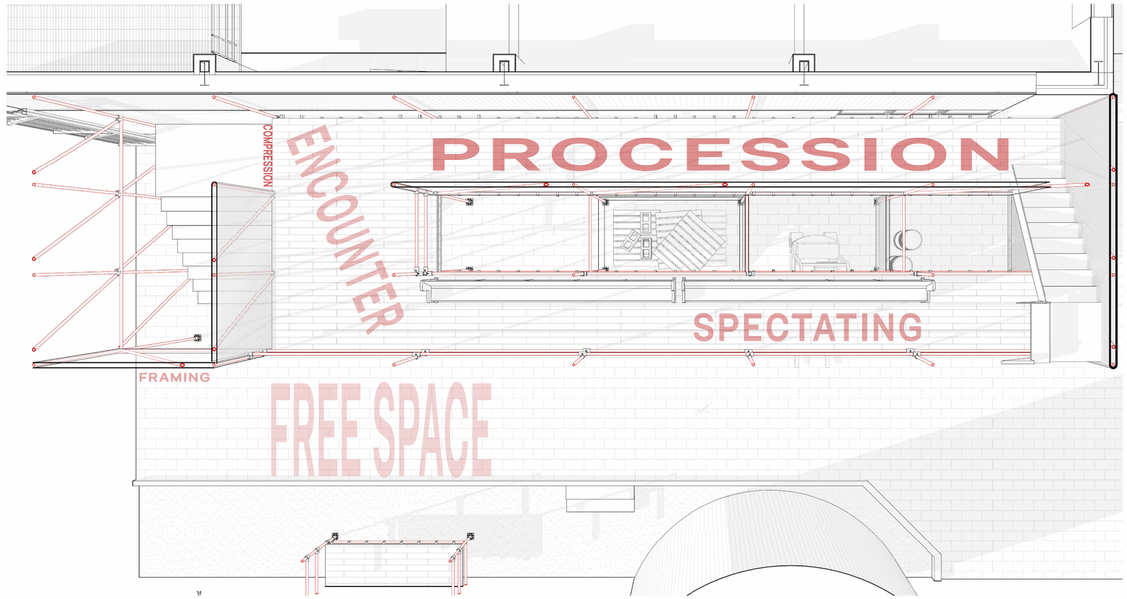
Left: Makin’ a Mesh,
Perspective Section



Above: Makin' a Mesh, Axonometric
Right: Makin' a Mesh, Perspective Plan

As well as the adaptable nature of the scaffolding, the use of the structure is also temporal and varied. By wrapping the scaffolding mesh in varied ways, a range of spaces and atmospheres are created using varying degrees of open or closed-ness. The structure can be used for further storage within the salvage yard as well as a realm for human and non-human occupation with protection and shelter provided by the mesh.

The ideas explored in both test projects begin to form the thinking of the proposed studio design project. Through the careful cataloguing, evaluation of available materials and their life-cycle status can be readily understood. It is through this process that the design project will identify an appropriate choice of materials and structure, reaffirming the idea of flexibility through re-use as seen in Zumthor's Swiss Sound Pavilion. The exploration of user adaptability through the idea of flexibility of space created by the relationship between fixed and open or 'free' space as referred to by Lacaton & Vassal will also form foundation for the studio design project.



THE SITE

The chosen site was St. Catherine's National School on the Ratoath Road, lying prominently within the Tolka Valley Region. The school is one of many within a small radius, serving a large population of young families and children within the area. However, despite such influx, the school is underpopulated, and stands in a dated, run-down state. The school was constructed in 1944 under Boyd-Barrett's generic school model for the OPW

By selecting an existing structure, the thesis sought to prove that an existing structure could be adapted to meet current requirements as well as any future requirements sought by the school The thesis also sought to recognise the carbon value of such existing structures. The school holds a 3000sqm floor area and is constructed of solid masonry structure. In order to instil radical thinking, the carbon value of these structures must be protected.

Right: St. Catherine's, Existing Site Plan

Entance Gate

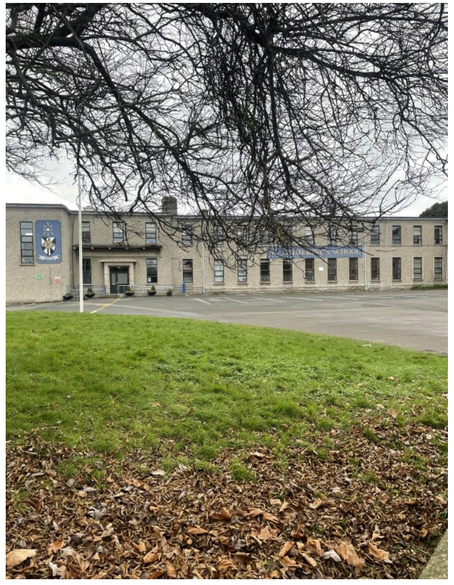
Rear Fencing

Existing Classroom

Pictures: St. Catherine's current conditions, all photos raken Author's own

Existing Windows

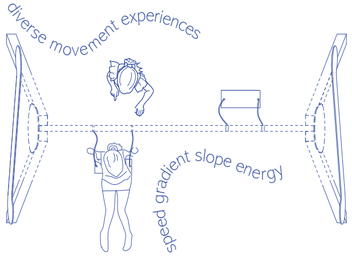
Existing Corridor

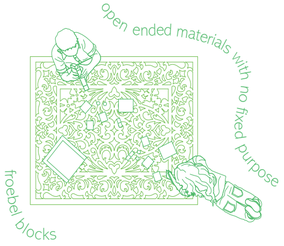


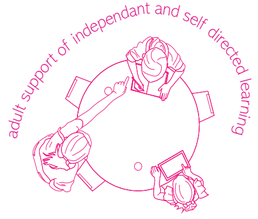
West View

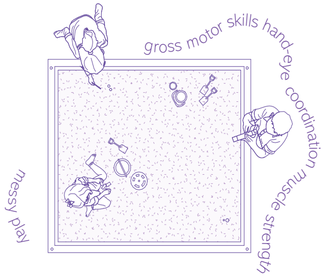
South View

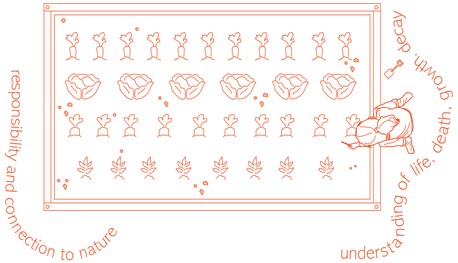
"KINDERGARTEN, A PEDAGOGICAL METHOD THAT ENCOURAGES A CHILD'S REALTIONSHIP AND UNDERSTANDING OF THE WORLD AROUND THEM, ESPECIALLY IN REGARDS TO THE NATURAL WORLD..."

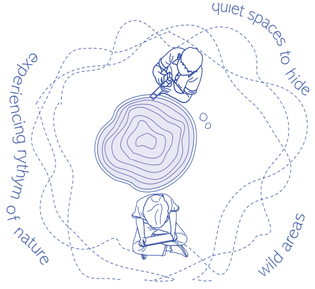












Above: Froebel Activities

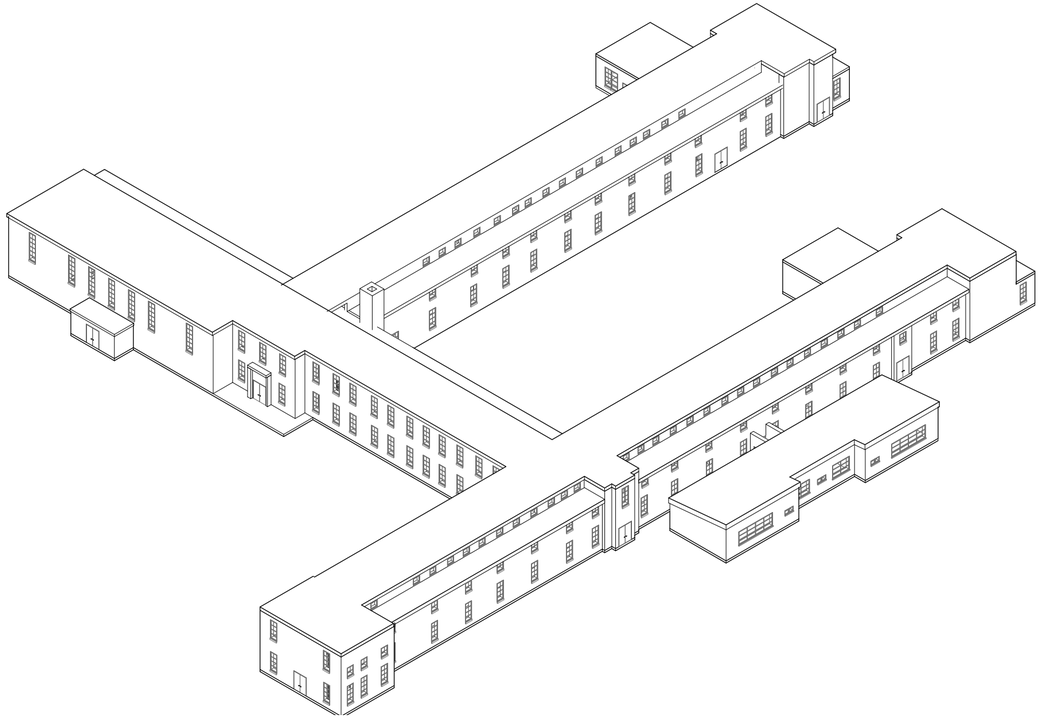
A FROEBELIAN APPROACH

Upon further research of the building and communication with the school, a better understanding and appropriate method for adaptability could be devised. The school adopts the Froebel method of learning and its practices, which are largely based on experiential learning. Friedrich Froebel was the inventor of Kindergarten, a pedagogical method that encourages a child's relationship and understanding of the world around them, especially in regards to the natural world.

Common practices within the school may include learning about the seasons of the year by going on nature walks and observing changes in the trees. Children may also learn about the cycle of life by growing plants and watching how it grows and withers over time. One of the first Froebel schools at Bad Blakenburg in Germany provided a plot for each of the students to sow their own seeds. These plots were surrounded by community gardens, in turn providing the school children of an understanding of their connection to society and the role they play within the community.

The idea of experiential learning was essential in the thesis proposal for the school, in order for building's inhabitants to better understand their environment, strengthening a relationship and care for the school that would aim to promote the upkeep of the school and prevent its fall into disuse.

THE EXISTING CONDITION



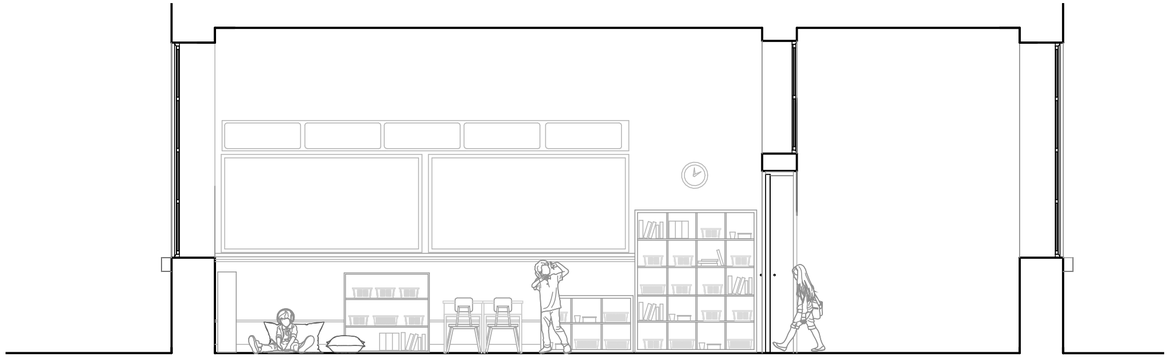
As the two-storey building stands it consists of two schools, a Junior mixed school on the bottom storey and Senior girls' school on the upper storey. The 1940's school model not only fails to adequately accommodate the school's progressive Froebelian teaching but has also become unsuitable in its practical use and alignment with current Building Regulations.

Above: Existing Site Plan
Left: Existing Axonometric

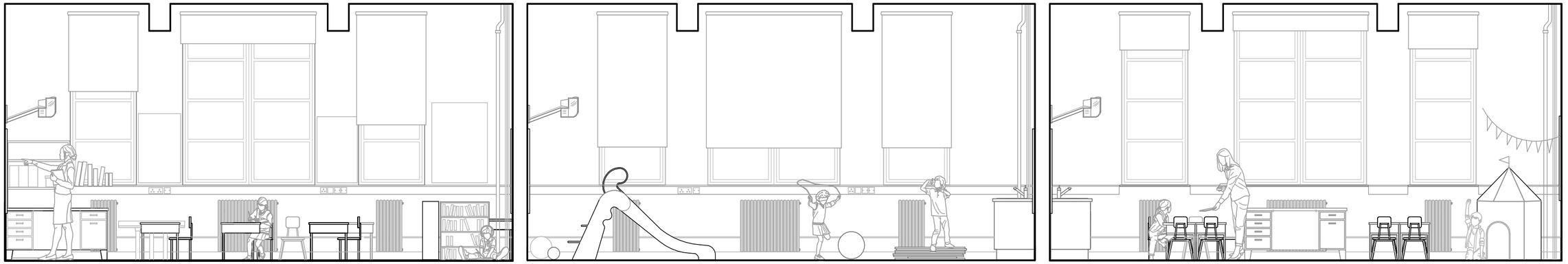
The school's status as a DEIS school further aims to improve the lives of its young but is restricted by its generic repeat layout and lack of diverse spaces that could be used during and outside of school hours that could be used to provide a wider scope of education and better equip students for varying aspects of life. St Catherine's is also attended by a large number of students with special needs. There are currently two classrooms dedicated for use by students with Autism (ASD classes), however, these classrooms were not purpose built and are problematic in their current layout as a result.

Due to the building's period of construction, there is currently no insulation within the structure, causing cold and damp throughout the building. This lack of comfortable space is further contributing to the school's current underpopulation and under-use. The Boyd-Barrett school model in its modernist approach, began to address issues of hygiene, locating bathrooms in blocks at the ends of corridors. While this was logical to address hygiene issues at the time, the practicality of having bathrooms served by a 60m corridor is that children must be accompanied to the bathroom in their class ground at scheduled times of the day. These corridors, while serve as a form of exercise for the children and have been utilised for occupational therapy, are undersubscribed as single loaded corridors, accounting for 20% of the buildings floor area, (double the regular standard of 10%) and serve as a potential fire hazard. Not only is this an inefficient use of space but is massively disruptive to class time and the flow of the school day. Furthermore, classroom sizes are also too small by current Building Regulation standards which require 80sqm with bathrooms inside the classroom vs the existing 50sqm.

The school as it stands in its underpopulated state has led past classroom to be repurposed for other uses such a gyms and libraries, with only 16 out of 20 classrooms being used for their intended purpose. These initial repurposes hint at ways the school could be adapted to better house these facilities.



Above: Existing Clasroom, Section



Above: Existing Clasrooms, Section

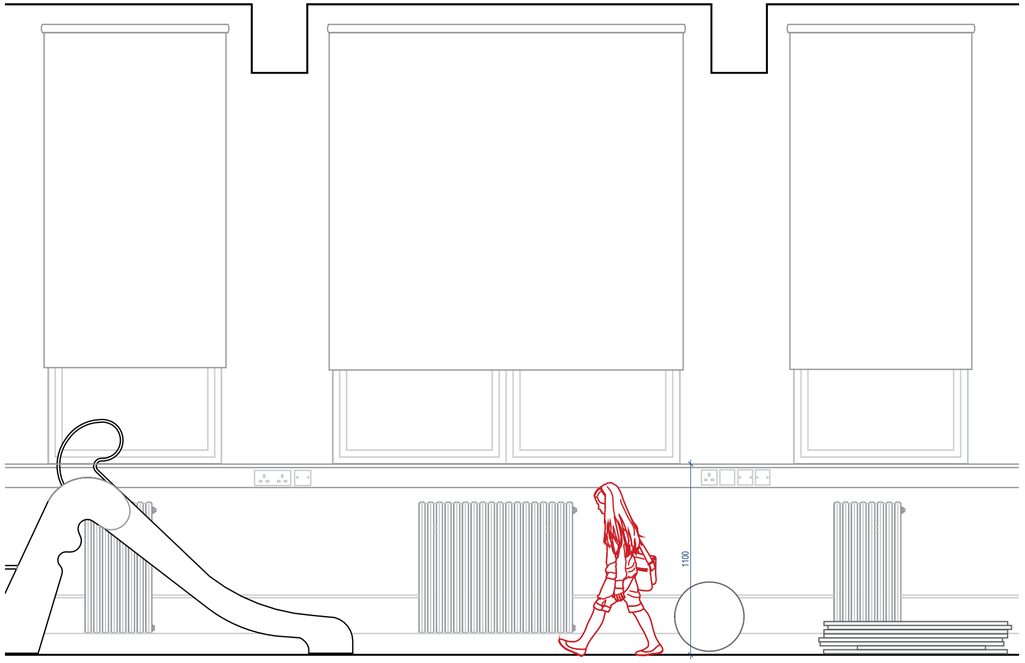
THE BRIEF

Through careful examination of the current context of the building, a clear brief was devised. The current undersized classrooms provide an opportunity for the redefinition of what a classroom might be and its adaptation into a modern context. From here the brief was proposed in two parts:

1. The current requirements: Match the 16 classrooms currently in use by the school and adapt the building so that it better reflects the Froebelian ethos.

2. The future requirement: Allow ‘free space’ so that the building can grow in line with population projections of young families and children within the Tolka Valley region while maintaining a Froebelian approach.

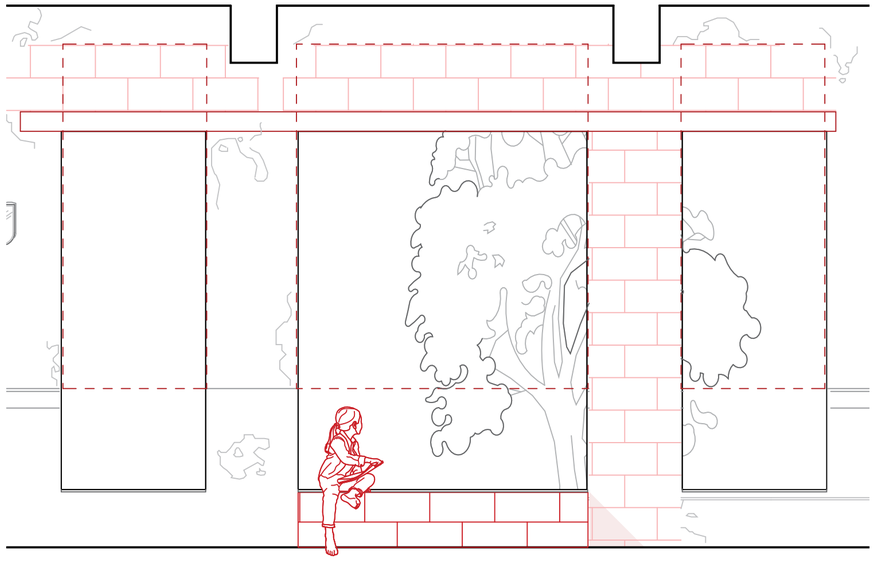
Left: Proposed Open Air Spaces, Render



EXISTING WINDOWS

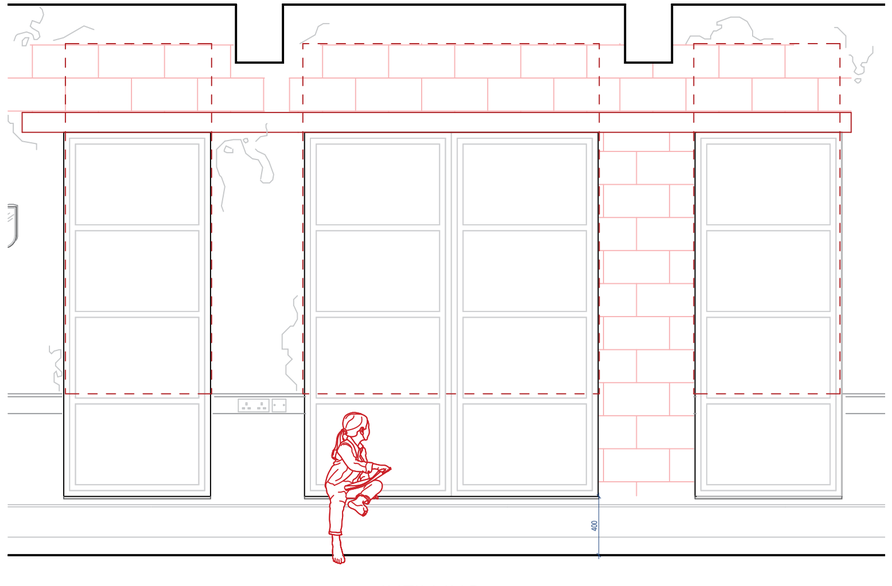
DERIVING AN ARCHITECUTRAL LANGUAGE.

Upon observation of the Boyd-Barrett model, some notable key features were identified. A recognition for health is seen in windows on either side of each classroom allowing for passive ventilation to flow through. The building also boasts impressive floor to ceiling heights of 3.75m and large windows, 2500mm in height, maximising light into south facing orientated classrooms. However, upon further inspection, it was noted that such windows are at a sill height of 1100mm. When considering the average age of a child in the school, taking a 7-year-old child as example, the average height of which 1090mm, most children are unable to see out of the windows. With a Froebelian approach in mind, an approach to better connect the building to nature is massively hindered by current sill heights.



DROPPING THE SILL

From here, the implication of dropping the sill height was explored. Dropping a window to a sill height to 400mm, although a minor move, creates a vastly different atmosphere. An existing wall thickness of 500mm also meant that the sill became a place for child to sit and look out. This move generated a language of cutting.



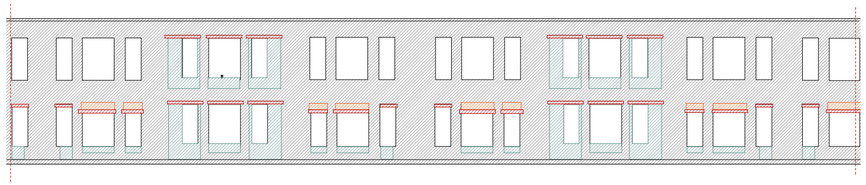
INFILLING

The idea of completely removing the window was then investigated. This move generated an idea about creating open air teaching spaces that addressed the role of Froebel within the design.

Honing back to the key idea of adaptability, the proportion of the window at its new sill height was maintained should the space ever have to be adapted back into a standard classroom. Propping the new opening with a lintel and using additional material to maintain the existing window dimension generated a language of infilling.

Previous, Above & Left:
Window Study

Below, Left & Next: Proposed
Cuts into Existing Fabric



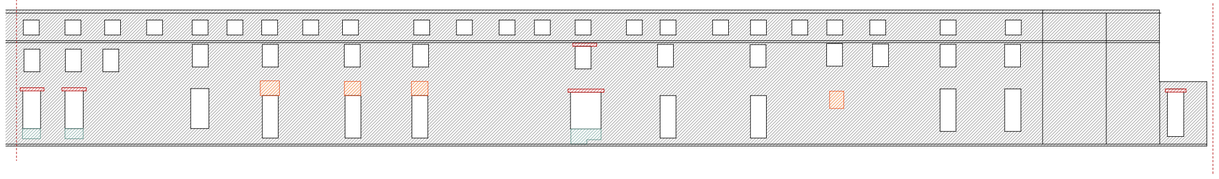
EXISTING

CUTTING

INFILL

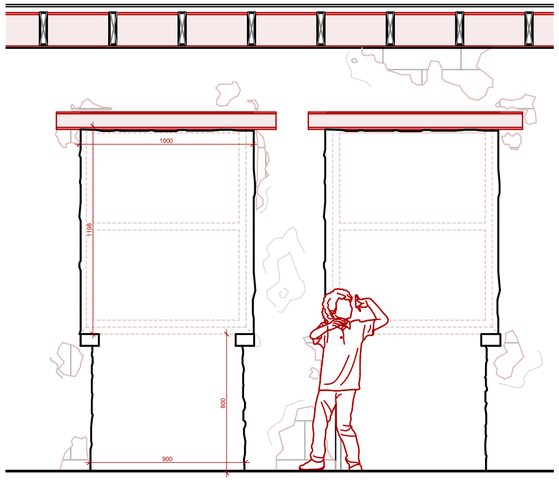
LINTEL

KEY ELEVATION: SOUTH

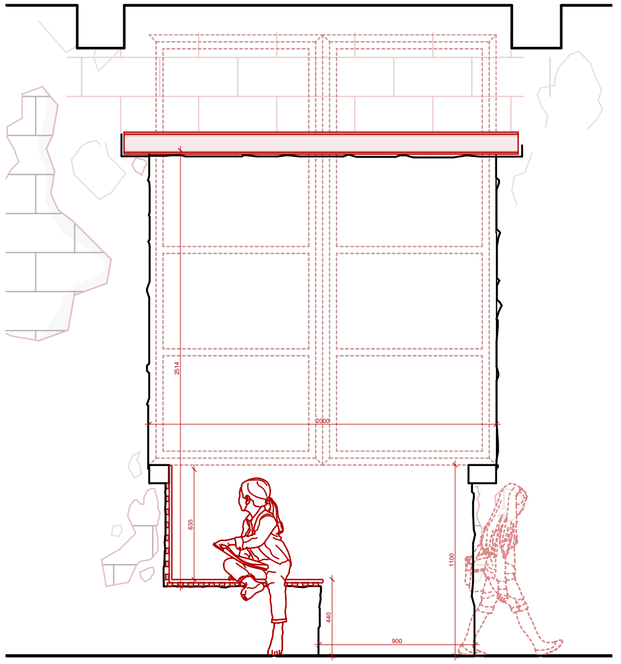


KEY ELEVATION: NORTH

PROPOSED GYM ELEVATION



CUTTING CONDITION A



CUTTING CONDITION B

Left: Proposed Site Plan

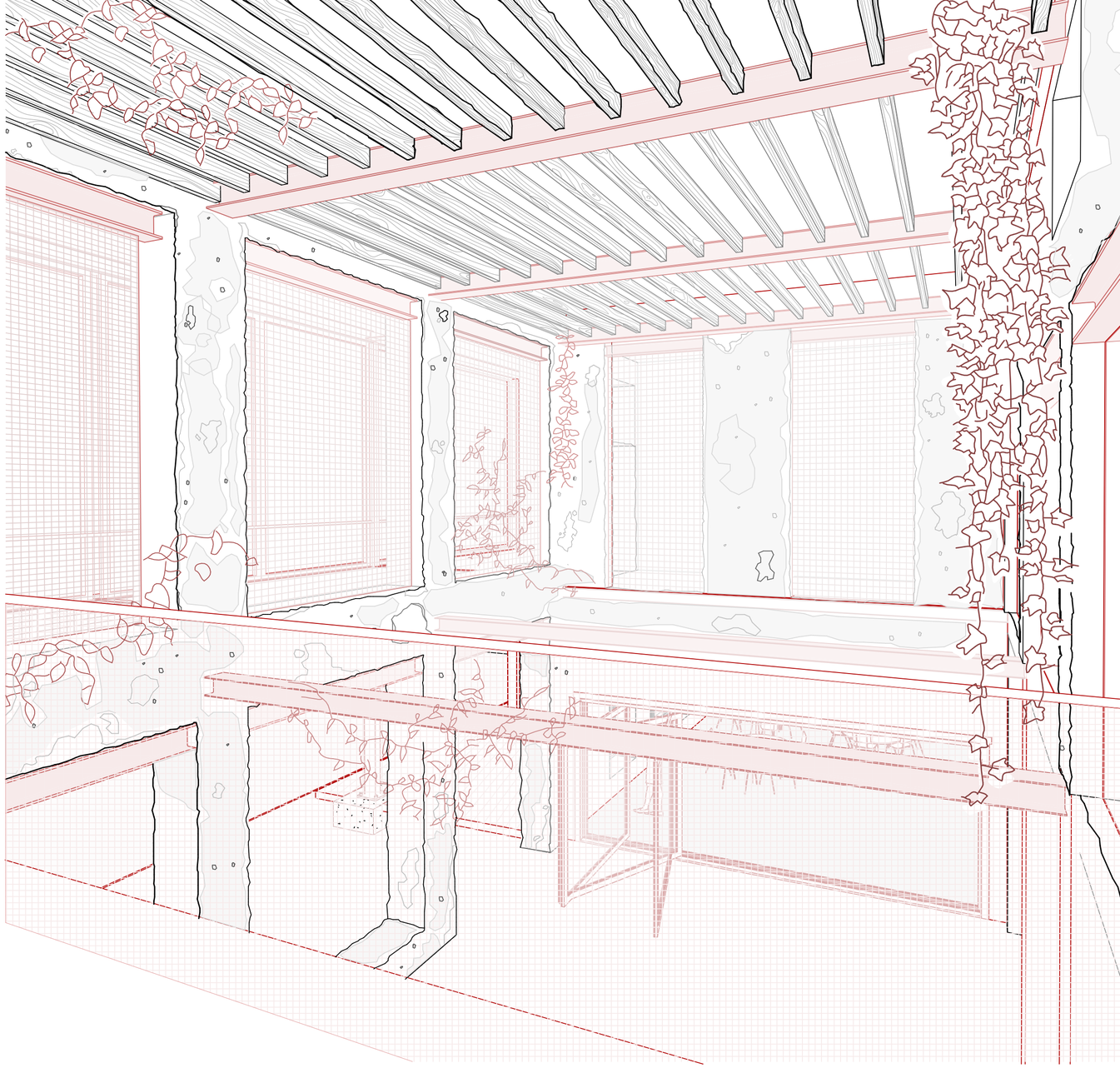
A SCHOOL FOR NOW AND THE FUTURE

“SPACES DISPLAYED LAYERS OF TIME AND BECAME PALIMPSESTS OF THE PROCESSES THEY HAD UNDERGONE.”

Through these exercises the character of the building proposal was largely informed, as layers of time became to form. Spaces became palimpsests of the processes they had undergone.

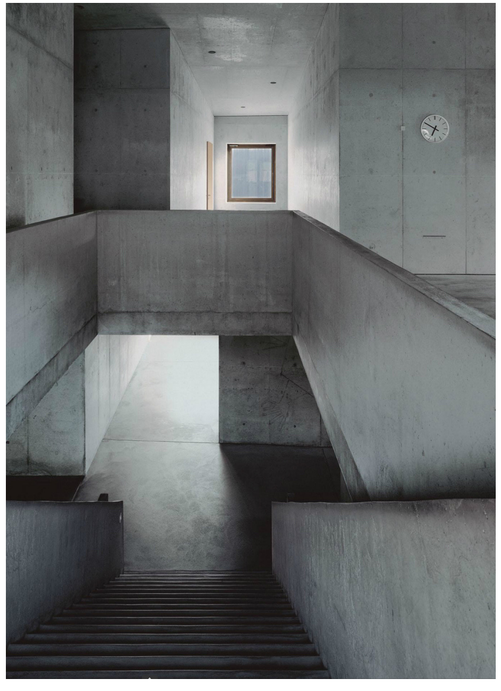
The character of the space created whilst completely removing the windows was further implemented by strategically cutting openings throughout the building to serve as open-air class spaces, redefining what a classroom is in a Froebelian context.

This character was carried through to the corridors. Removing windows created an open-air circulation to better promote health and to create an ambiguous, semi-open, in-between layer that connects the inside to the outside. By accepting these spaces as the cold, uninsulated areas they currently exist as, the space could be redefined in a richer and more efficient context, with the windows taken away to be stored and eventually reused in a more appropriate context.

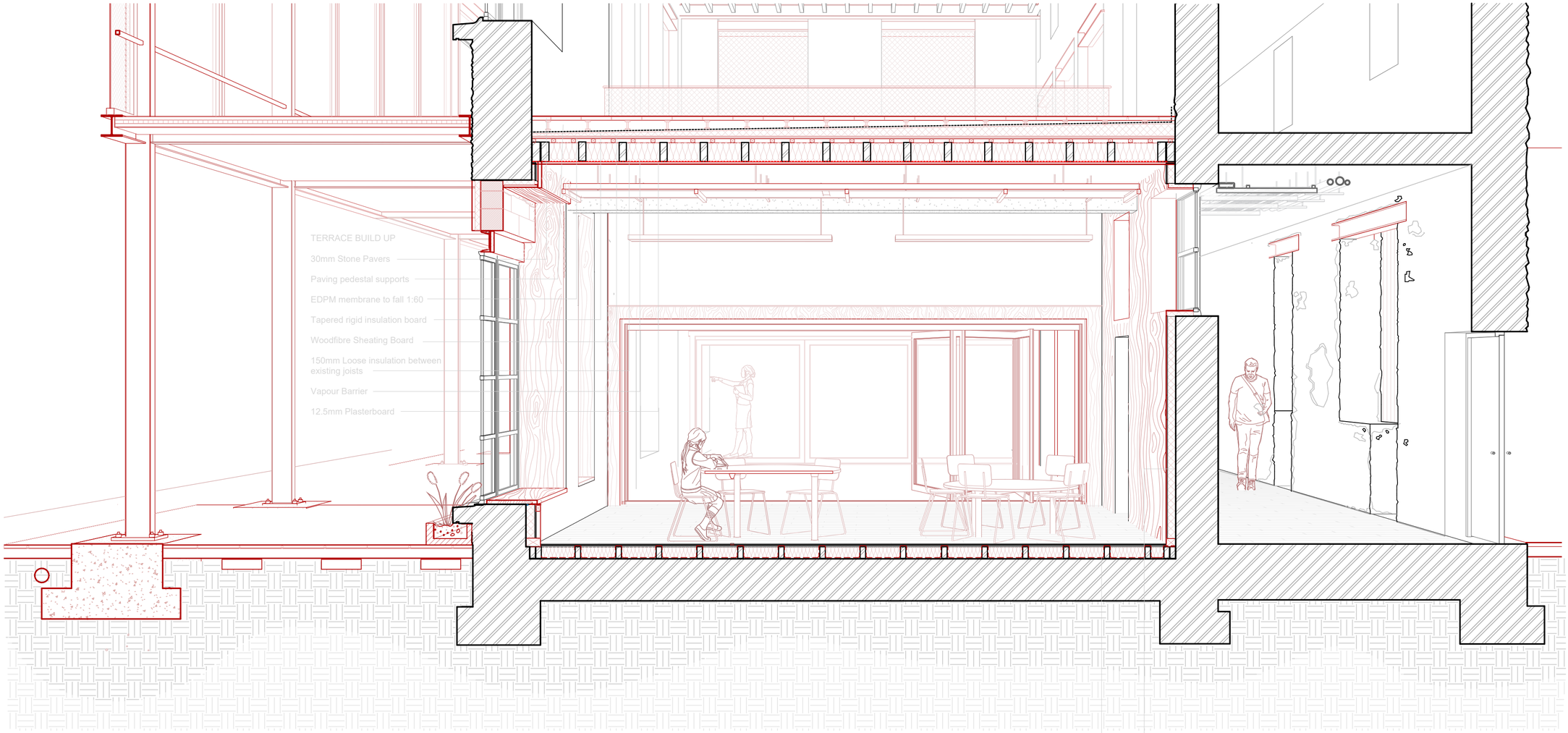


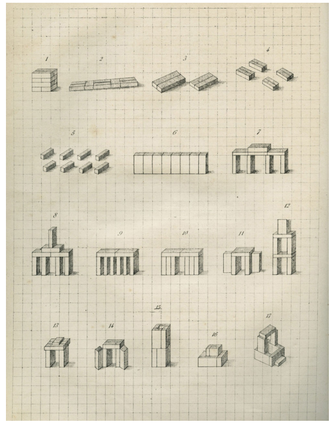
Left: Proposed Cutting to create open air spaces

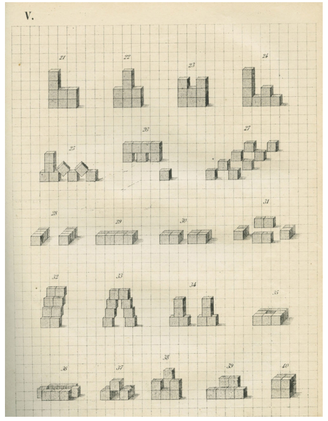
This strategy also allowed for a more efficient approach to the proposed retrofit of the existing spaces. Rather than wrapping the entire building in a mass of insulation, comfortable areas such as classrooms were identified and became lined, warm, safe spaces. This further contributed the new character of the building, creating a tension between the wrapped, sealed spaces and the imperfect open spaces as exemplified by Oligiati's school in Paspels, in which the classrooms were lined with timber to create warm spaces and the corridors left as the bare exposed concrete structure.

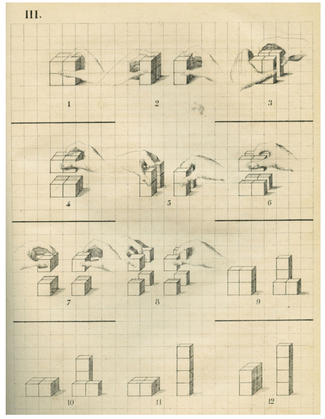


Above: Fig. 12. Classroom, School in Paspels, Valerio Olgiati, 1998
Above Left: Fig. 13 Corridor, School in Paspels, Valerio Olgiati, 1998 Left: Proposed additiona; lining to existing classrooms


TERRACE BUILD UP
30mm Stone Pavers
Paving pedestal supports
EDPM membrane to fall 1:60
Tapered rigid insulation board
Woodfibre Sheating Board
150mm Loose insulation between existing joists
Vapour Barrier
12.5mm Plasterboard
ADDITIONAL LININGS
100mm insulation added to existing walls
22mm Birch ply grade B/B
Loose netted insulation hung from existing joists





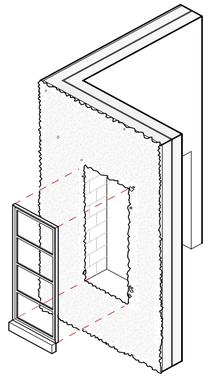


‘FROEBEL BLOCKS’

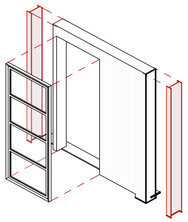
Referring back to Lacton & Vassal’s idea of ‘Free Space’, a system to accommodate any additional spaces for current and future requirements. Referring back to another key component of Froebel’s teachings known as Froebel blocks. These blocks are to be arranged by children with the use of a gridded table, allowing them to draw connections and create varying patterns using the familiar object of a wooden block. Froebel blocks hold a direct connection to modernist architectural practices, with influence over prominent architects such as Frank Llyod Wright.

Previous: Additional Linings,
Technical Perspective Section
Above: Fig. 14,15,16: Froebel Blocks
Right: Proposed Framework and
reuse of existing windows

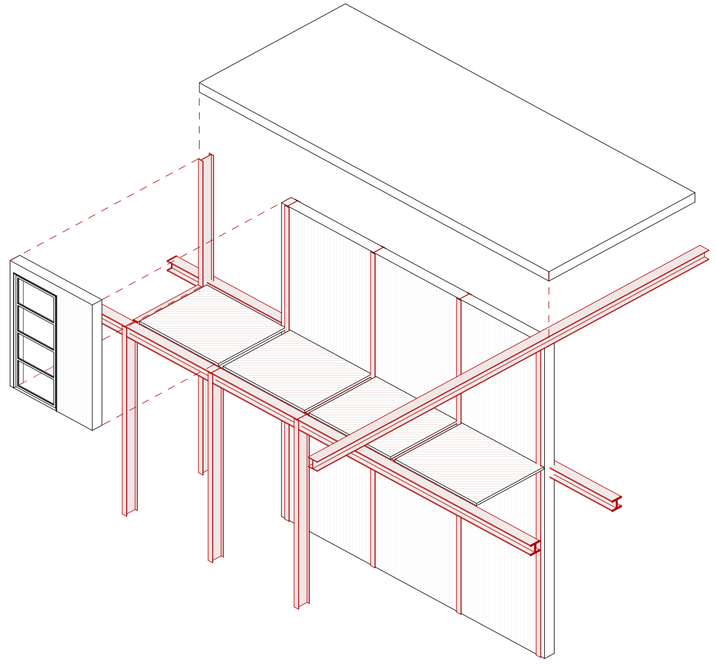
A FRAMEWORK FOR FLEXIBILITY



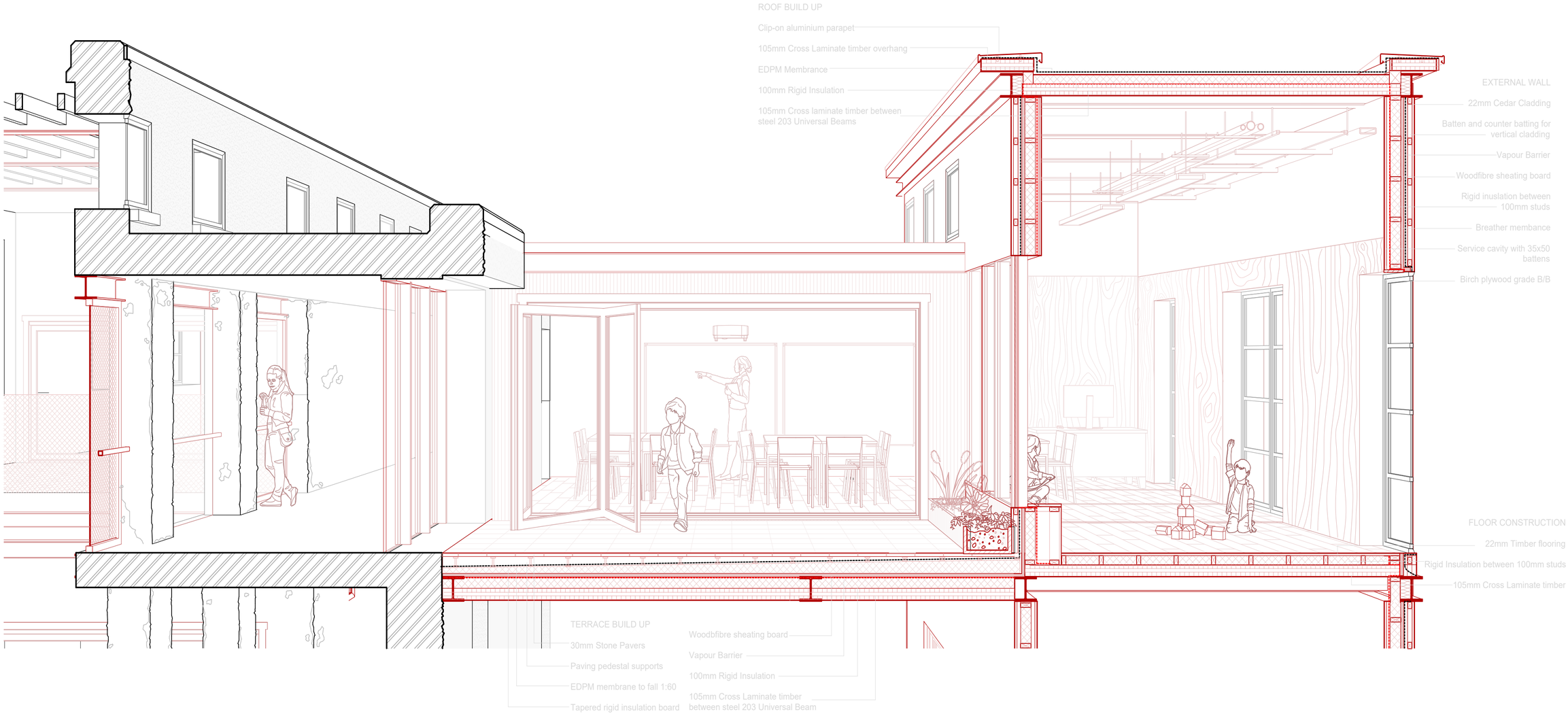
REMOVAL OF EXISTING WINDOWS



INSERTION OF EXISTIND WINDOWS INTO MODULAR PANELS



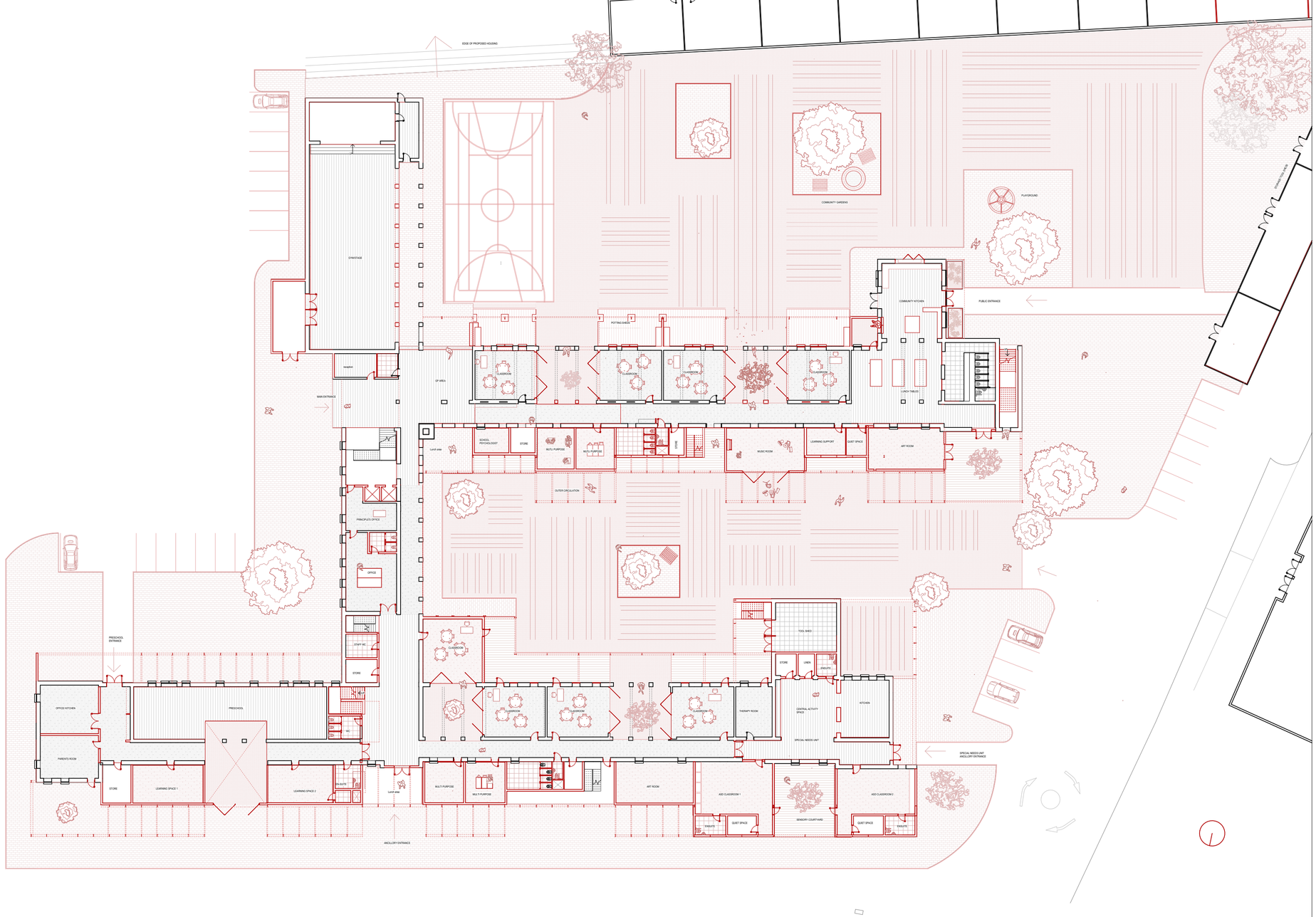
INSERTION INTO PROPOSED FRAMEWORK GENERATED BY MODULE OF EXISTING WINDOWS


ROOF BUILD UP
Clip-on aluminium parapet
105mm Cross Laminate timber overhang
EDPM Membrance
100mm Rigid Insulation
105mm Cross laminate timber between steel 203 Universal Beams
EXTERNAL WALL
22mm Cedar Cladding
Batten and counter batting for vertical cladding
Vapour Barrier
Woodfibre sheating board
Rigid inuslation between 100mm studs
Breather membance
Service cavity with 35x50 battens
Birch plywood grade B/B
FLOOR CONSTRUCTION
22mm Timber flooring
Rigid Insulation between 100mm studs
105mm Cross Laminate timber
TERRACE BUILD UP
30mm Stone Pavers
Paving pedestal supports
EDPM membrane to fall 1:60
Tapered rigid insulation board
Woodbfibre sheating board
Vapour Barrier
100mm Rigid Insulation
105mm Cross Laminate timber between steel 203 Universal Beam

By employing the use of the grid, numerous variations of spaces can begin to be formed within, aligning itself with a modular method of design. Reintroducing the idea of reuse of existing components, the grid system is based on the 2000mm dimension of the existing window width. This was done to allow for the windows removed from the corridor to be easily reused to set up any additional spaces. Anything that can be reused should be reused.

As per the Japanese Metabolism architects, the frame became a fixed component into which different spaces could be infilled. The infill of the frame acts as shearing layer, a more temporary component that can be replaced or changed to suit the requirements of the building or for materials to be replaced if they have reached the end-of-life stage. By adopting this method, the additional structure aims to maximise the overall lifespan of the building, allowing for its easy maintenance and adaptation.

Previous: Proposed Extension,
Technical Perspective Section
Left: Proposed Extension, Render

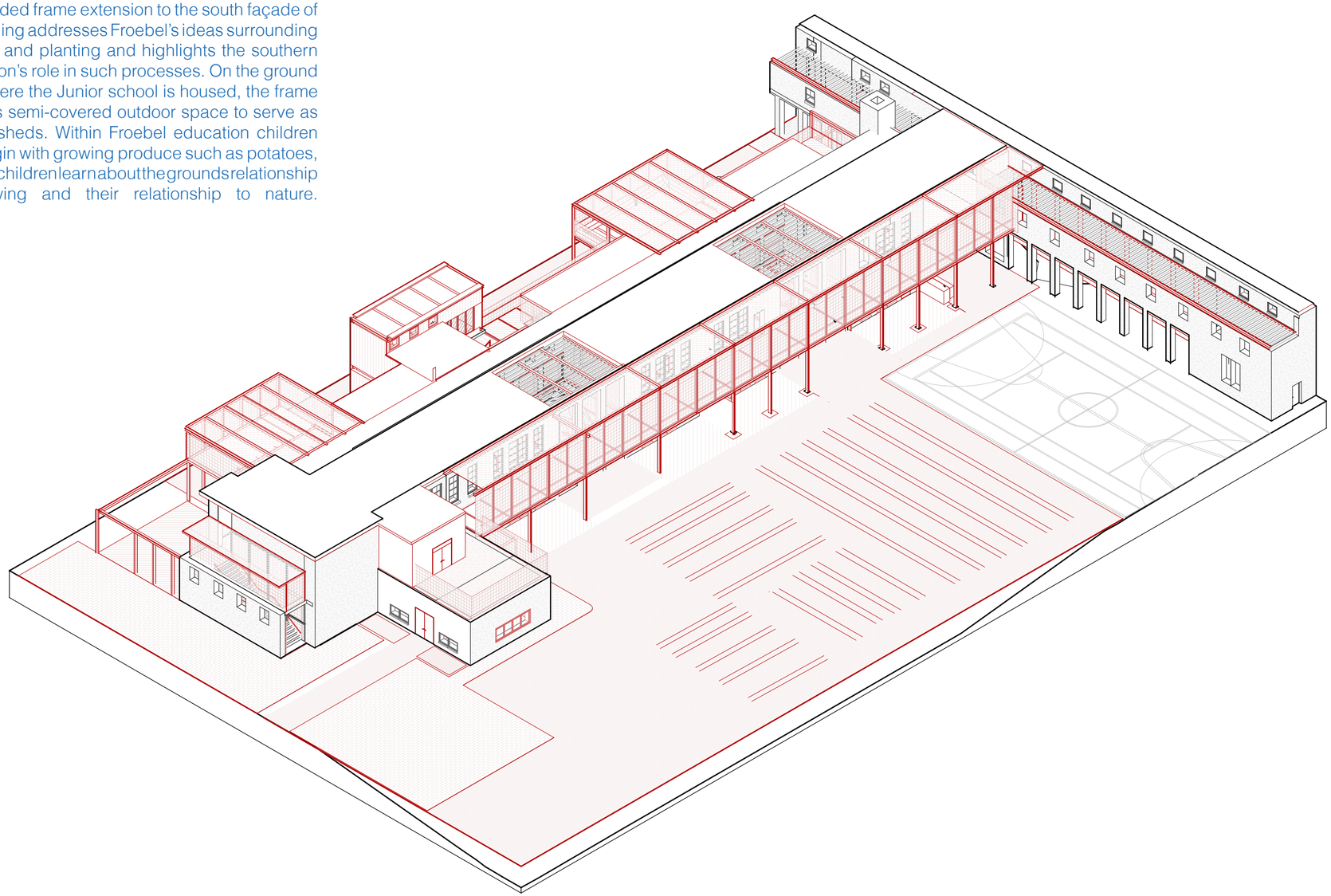


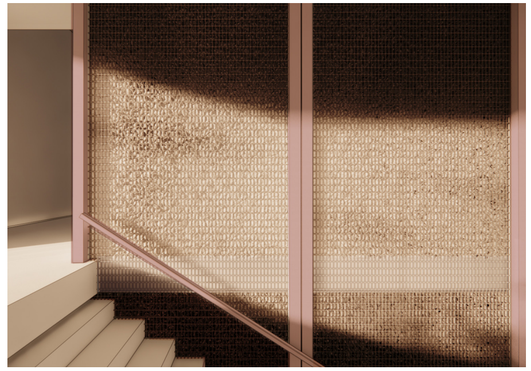
Left: Proposed GF Plan

Furthermore, employment of a gridded system allows for an incremental growth of the school as to not give the school an excess of what is required. This incremental approach allows so that construction could take place during the summer period, as to not disrupt the school period, as well as to address the realistic budget constraints of many schools in Ireland. The iterations of the plans investigated accommodate the classroom as its current two-stream 16 classroom form, with the empty frame acting as ‘free space’ for the students to use as lunch areas, to run around, to sit etc. The second iteration of the plan shows the school with the introduction of a third stream, in which the framed terraces are adapted into classrooms.

Left: Proposed Furture Extension GF Plan

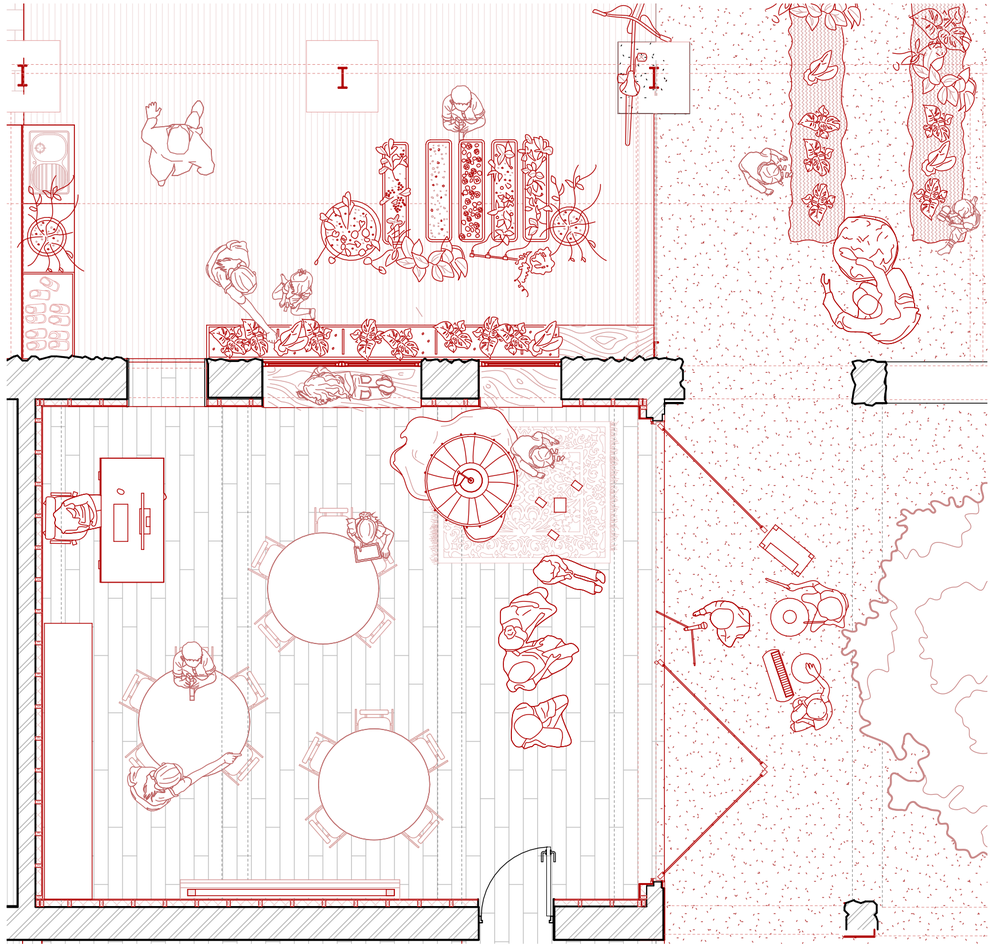
The gridded frame extension to the south façade of the building addresses Froebel's ideas surrounding growing and planting and highlights the southern orientation's role in such processes. On the ground floor, where the Junior school is housed, the frame provides semi-covered outdoor space to serve as potting sheds. Within Froebel education children may begin with growing produce such as potatoes, here the children learn about the grounds relationship to growing and their relationship to nature.



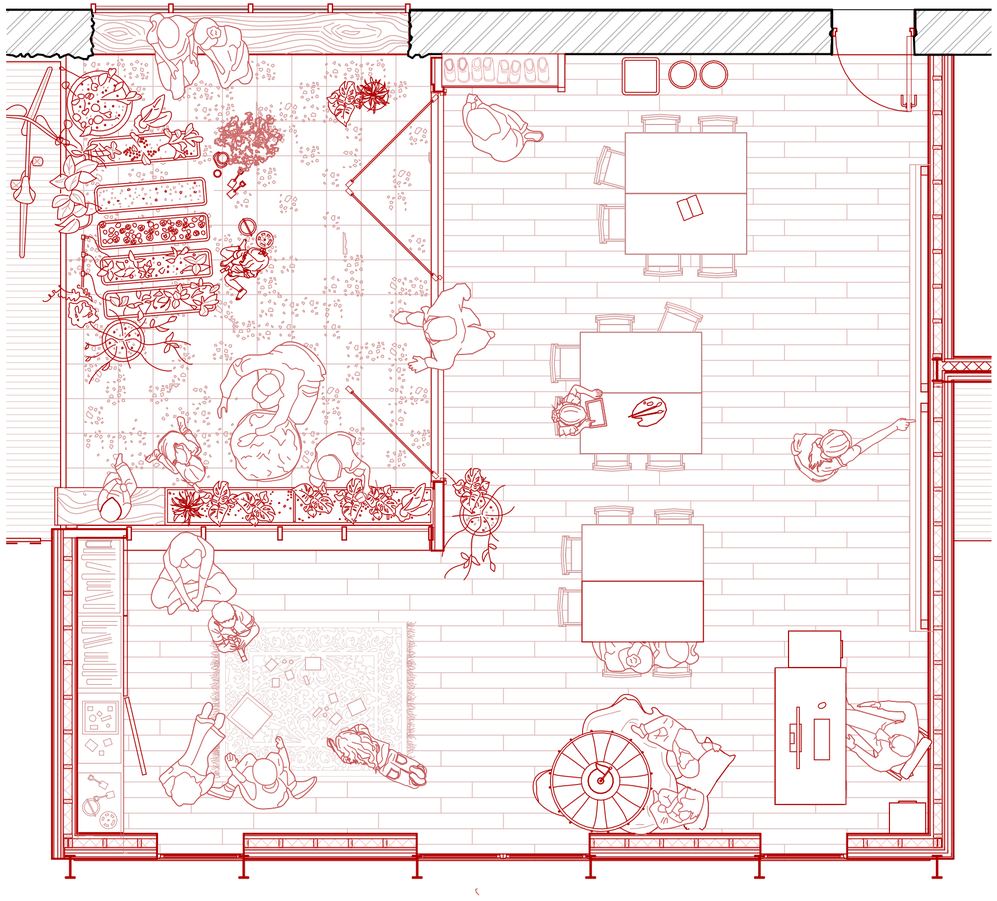


On the upper floor, where the Senior school is housed, the frame acts as a terrace for vertical growing. More complex crops such as peas are grown and supported by the terrace's mesh lining. It is here that the student now learns the buildings connection and relationship to growing and nature.

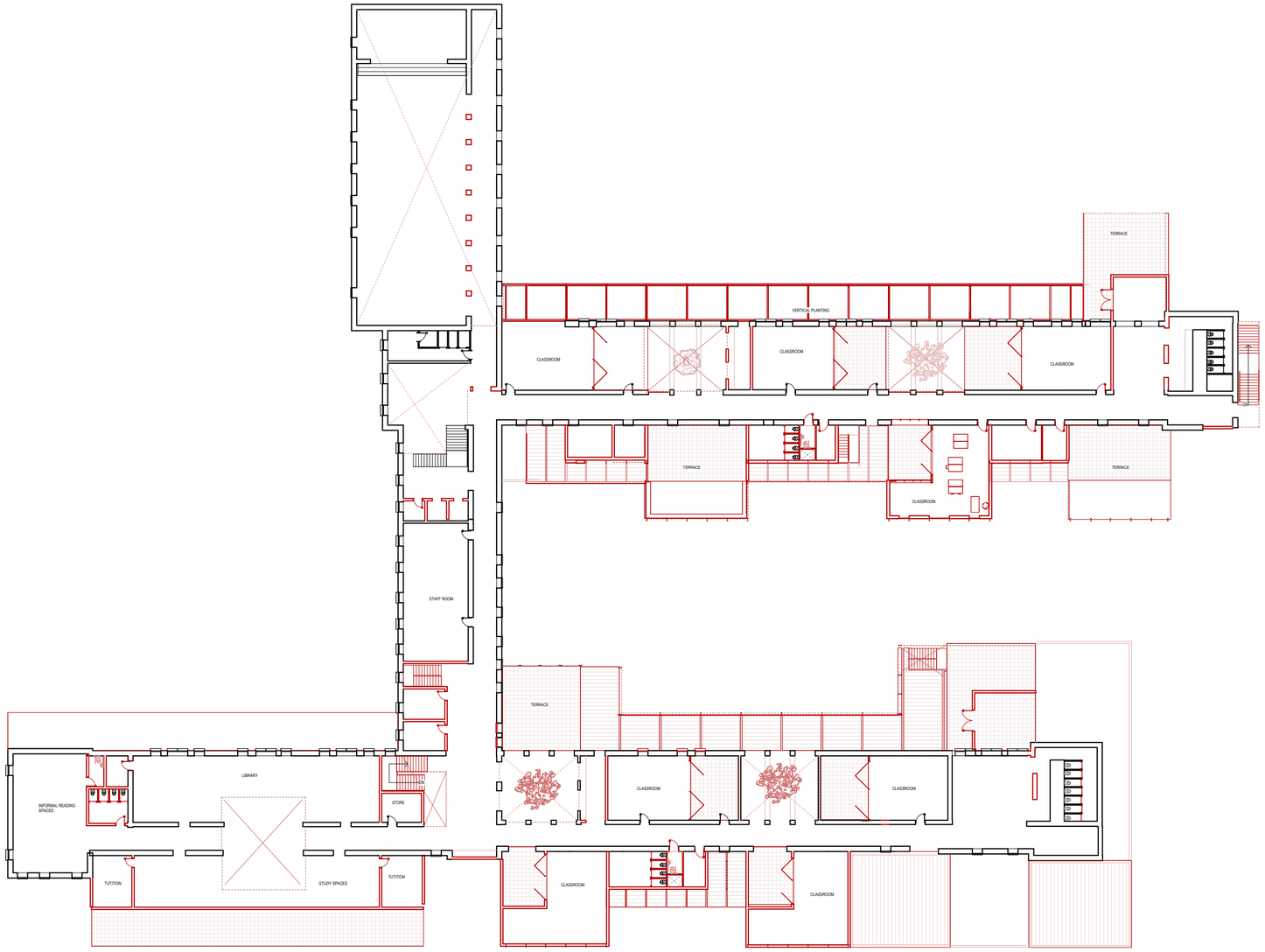
Left: Proposed Axonometric
Above: Proped Mesh Lining

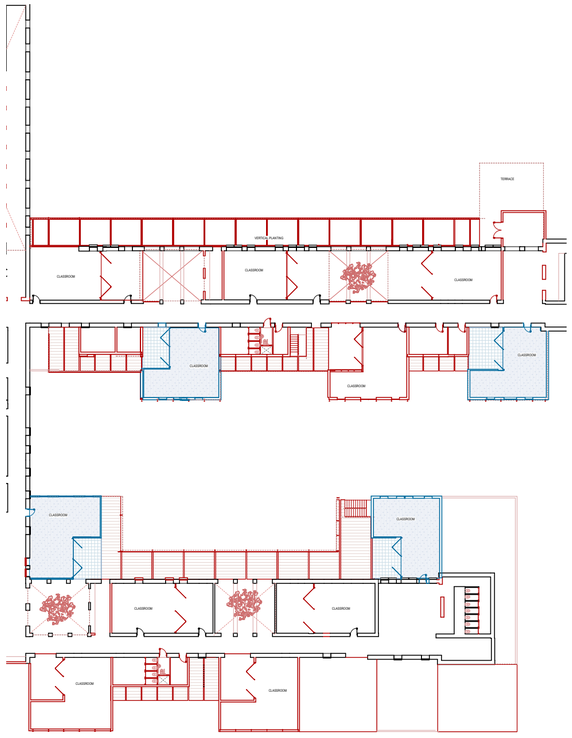


CLASSROOM TYPE A
‘RETROFIT’



CLASSROOM TYPE B
‘EXTENSION’





As reference to Terragni's Sant'Elia Nursery School in Como, in which different the different orientations of the façade served different purposes, the northern façade is differentiated from the south and is utilised as service spaces for bathrooms and storage, as well as less frequently populated rooms such as multi-purpose rooms, quiet rooms, art and music rooms.

Left: Proposed FF Plan
Above: Proposed Furture Extension
FF Plan

5 POINT STRATEGY FOR ADAPTABILITY

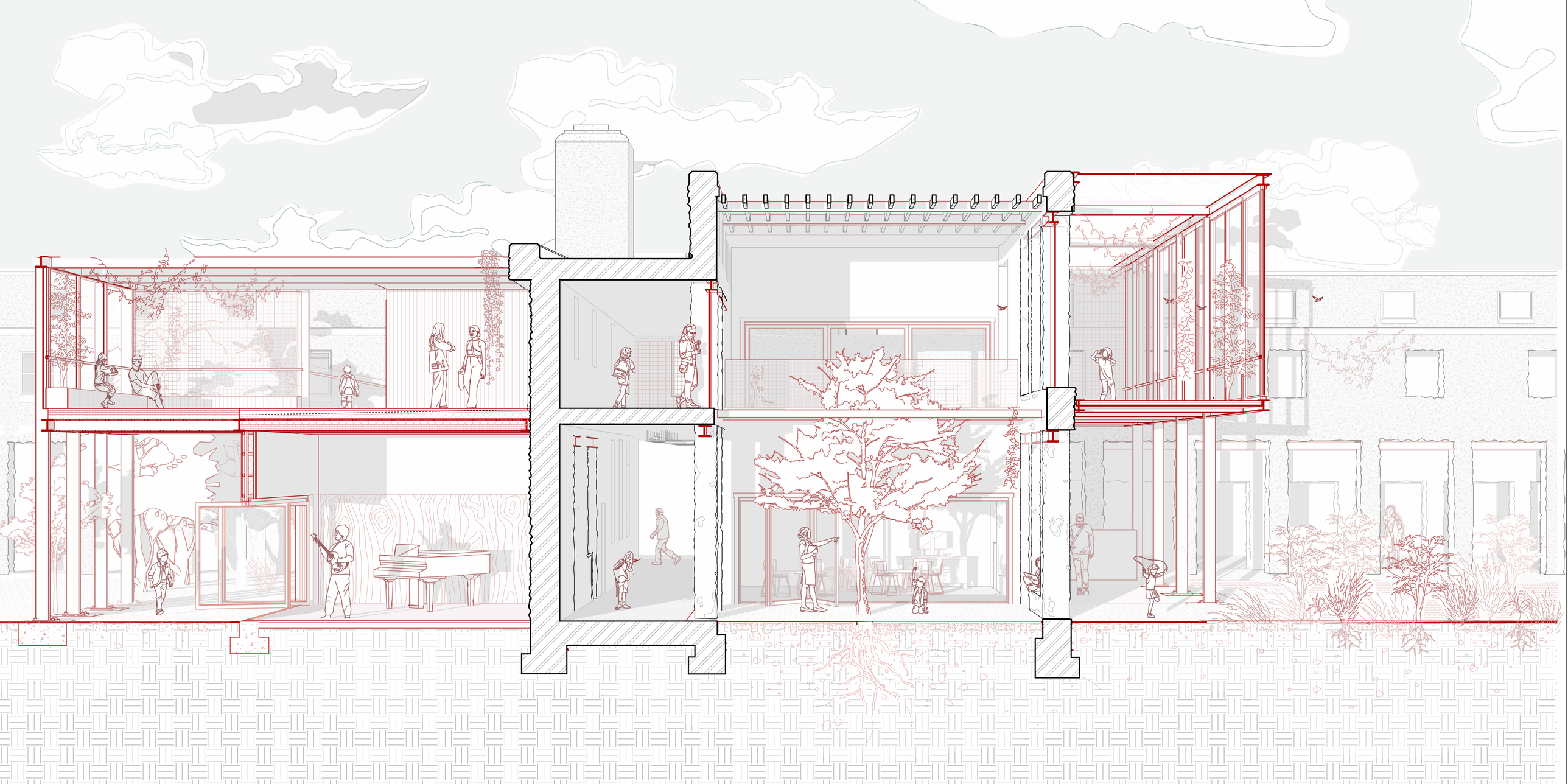
01. NEVER Demolish, use precised inventions of cutting and infilling

02. New Additions should reuse anything that can be reused

03. Make space by cutting and opening space

04. Use the ‘ Fixed’ to create the ‘Flexible’

05. No Falsehoods: The character of the space is a result of its processes

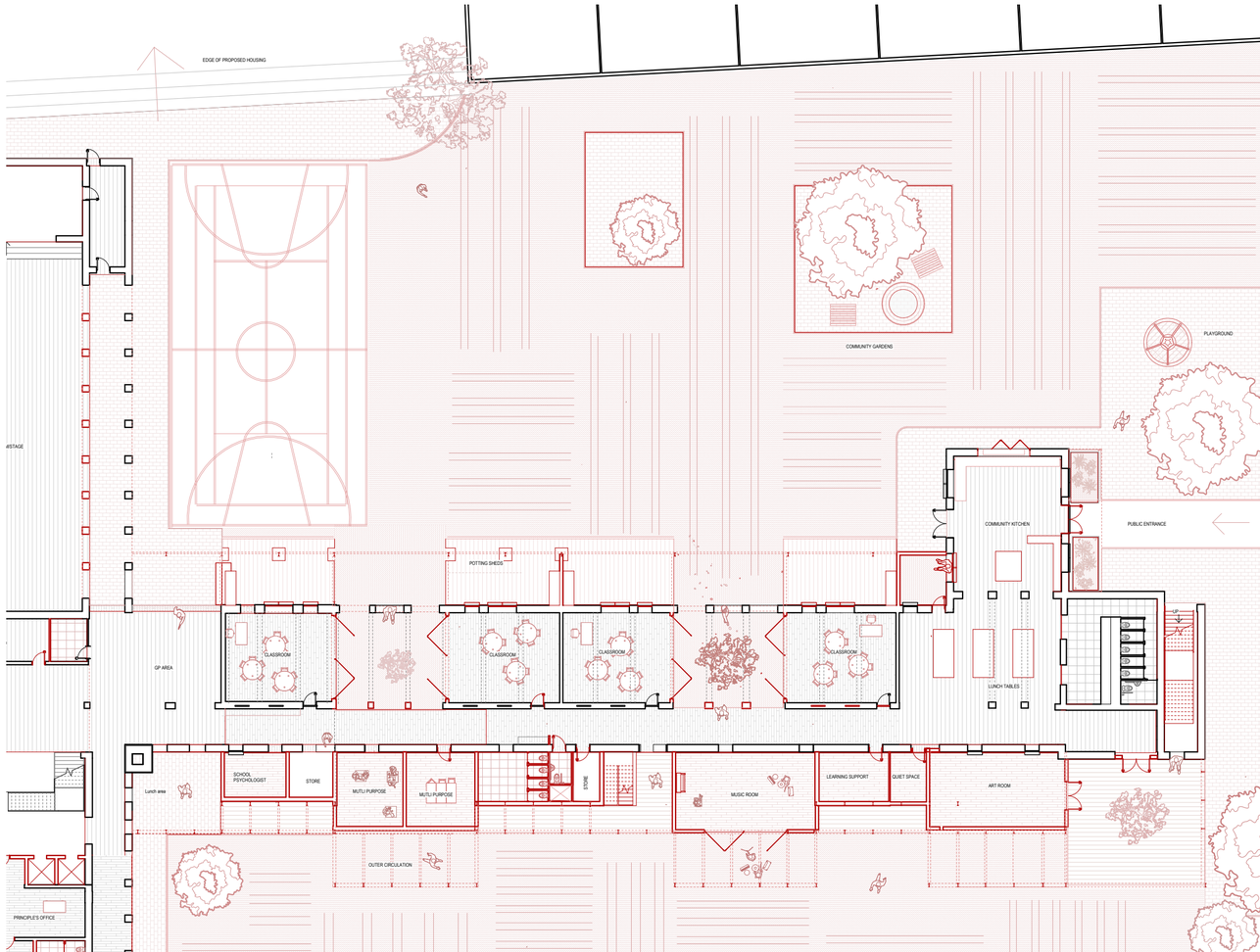


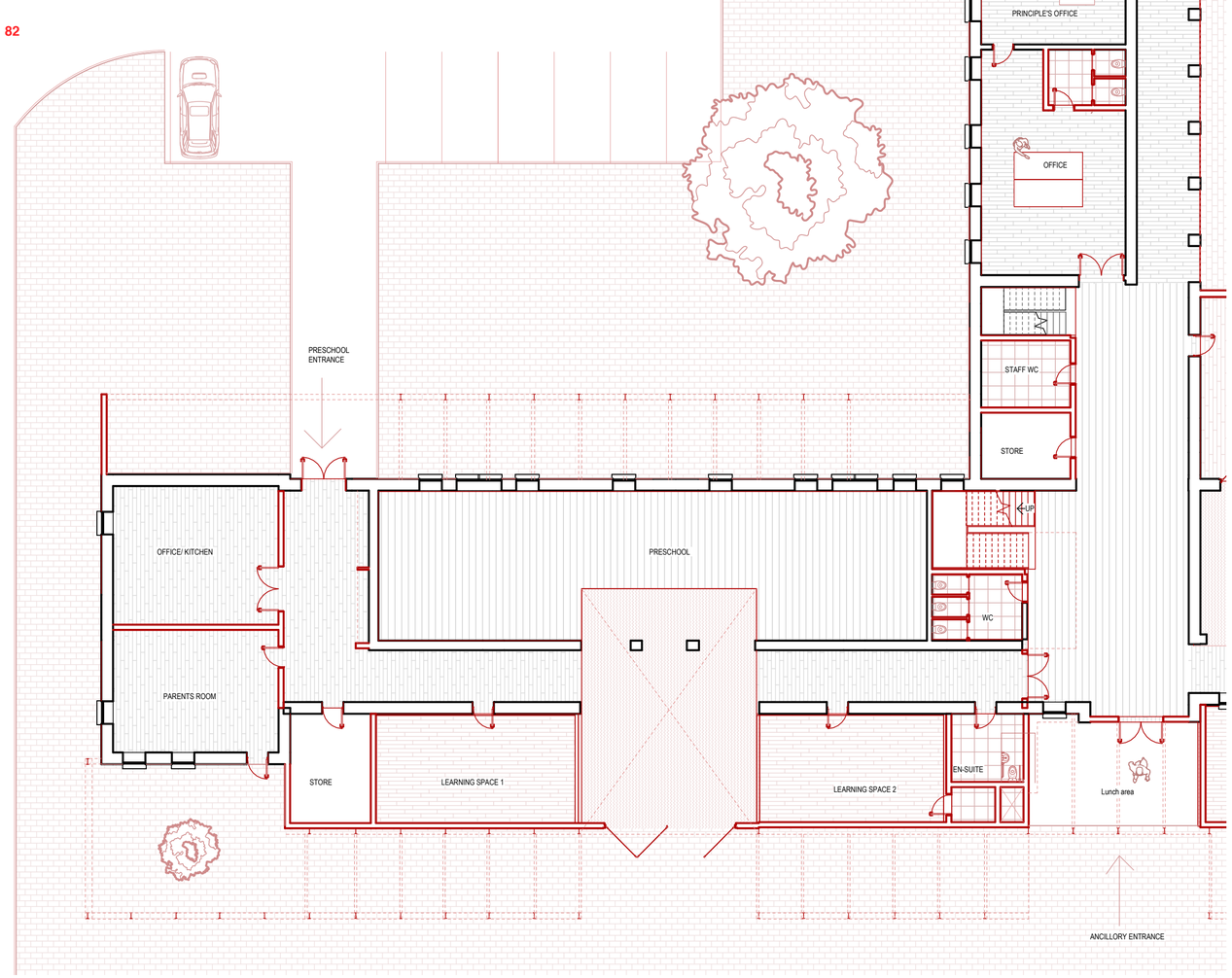
FLEXIBILITY OF USE

The design finally addresses introduces new flexibility of use, allowing for the school to be used outside of school hours. These areas are addressed at the nodes of the building. The existing gym is opened up to the back of the school so that it addresses a new sport's court. It is intended that students can use this court both during and after school hours. This node also addresses the granted proposal for 95 new dwellings to the south of the site for the use of these residents.

Furthermore, community plots are also lined on the periphery of the student plots for further use by local residents and parents. The next node is adapted into both a school and community kitchen, in which the produce grown can be made into meals to feed both students and the community, instilling a greater sense of resilience for all. Under the DEIS scheme, students are provided with meals during school time. This space could also be used for a breakfast club and for busy parents to feed their children before work.

Previous: Proposed Froebel Schoo,
Perspective Section
Right: Proposed Plan, Community
Plots, Kitchen and Hall

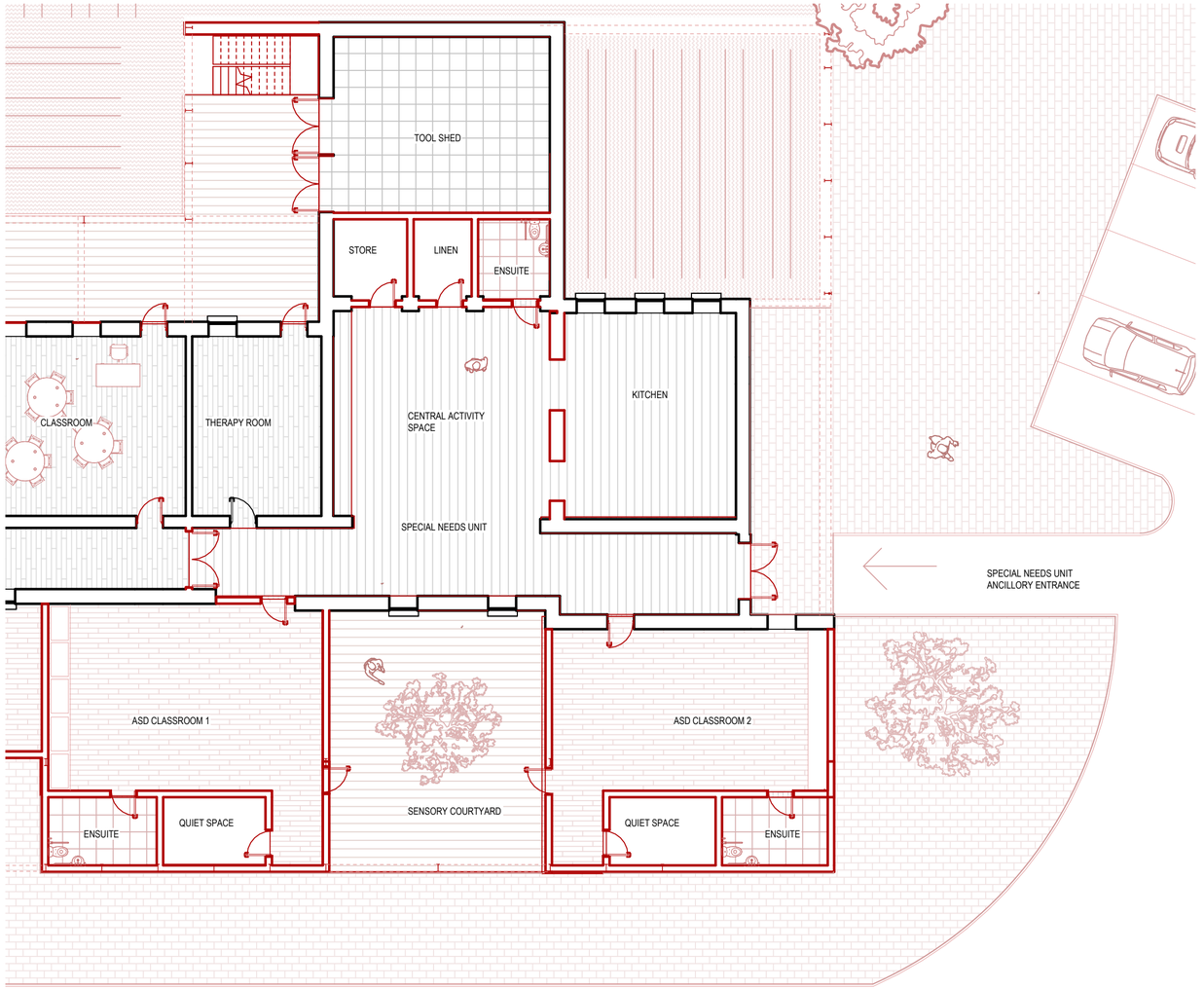




The existing nursery at the front of the school is kept slightly separate from the rest of the school, with the introduction of a new library space on the first floor. Opened for the least number of hours within the school, it is proposed that this space can be used by the community once the nursery has closed for the day, serving as study spaces or additional classrooms for the community.

Above: Proposed Plan, Nursery Block
Right: Proposed Plan, Special Needs Unit

Finally, the existing ASD classes are reformed to create a Special Needs Unit as a node. This block has specific ancillary rooms and services, a more and secluded area for student plots as well as a separate entrance for the unit via access from the quieter laneway within the convent grounds. This is done to create a less overwhelming environment for the students.



IN CONCLUSION

Through analysis of the research and evidence set forth by this paper, an appropriate method of adaptability to be tested within the studio design project was devised. A technical approach, as explored by the test project, was used to achieve flexibility at a tangible level within the site, incorporating understanding and analysis of the layers of change set forth by Brand. Simultaneously, the conscious consideration of an open space, susceptible to adaptation, worked to ensure the flexibility of use, together ensuring the overall preservation and sustainable use of our buildings.

Through careful observations of the existing structure of St. Catherines National School, a method of restraint and ‘doing less’ came to be. Despite this, a rich character emerged. Langauges of cutting and infilling, retrofit and extension, heavy and light, old and new were all formed. The final proposal was one that remained true to the reality of the existing school . Rather than covering up original features and replacing with a new sqeaky clean architecture, the proposal celebrates the building as a layer of history and time, which is explicity expressed throughout. A new layer provided to the building equips it with a new sense of resilience, providing the dated structure to be adapted to modern uses and beyond.

The answer to the question “how can architects better equip buildings for future adaptation and promote active flexible engagement between user and architecture without compromising the role of design?” is one of compromise and balance. Such balance is demonstrated in varying relationships, between fixed and temporal, between the architect and the user, though open and closed space as well as between theory and tectonic. It is through these relationships that a physical architecture, driven by adaptability, will be formed.

Above: Physical Model Front View
Right: Physical Model, Side View

REFERENCES

Brand, S. (1994), How Buildings Learn: what happens after they're built, Viking.

Bogue, R. (2019). Book Review-How Buildings Learn: What Happens After They're Built. [online] Thor Projects.
Retrieved 1 Jan 2023 at: https://thorprojects.com/blog/archive/2019/07/08/book-review-howbuildings-learn-what-happens-after-theyre-built/

CJS. (2016). 02 | Swiss Sound Box | Peter Zumthor. [online] Retrieved 2 Jan 2023 at: https://chadschwartz.com/iat/02-swiss-sound-box-peter-zumthor/

Ellis, C. (1987). Walter's Way, self-build schemes, Lewisham, London by the Segal method -
Architectural Review. [online] Architectural Review. Retrieved 30 Nov 2022 at: https://www.architecturalreview.com/buildings/walters-way-self-build-schemes-lewisham-london-by-the-segal-method

European Commission, Environment. (2020). Construction and demolition waste. [online] Retrieved 1 Jan. 2023 at: https://environment.ec.europa.eu/topics/waste-and-recycling/construction-and-demolitionwaste_en

Foster, N. (2015). Norman Foster: My green agenda for architecture, TED Talk. Retrieved 20 Nov.

2022 at https://www.ted.com/talks/norman_foster_my_green_agenda_for_architecture?language=en

Gaber, J (2017). History of Architecture – Industrial revolution (18th century) & Revival (1880 – 1940). John Gaber's Blog [online]. Retrieved 6 Nov. 2022 at:
https://johngaber.wordpress.com/2017/11/10/history-of-architecture-industrial-revolution-18th-centuryrevival-t1880-1940/

Lacaton, A & Vassal, J.P. (2021). Free space, Transformation, Habiter. Museo ICO.

Long, P.W. (2014). Architectural Design for Adaptability and Disassembly. [online] Retrieved 3 Oct.
2022 at: https://www.academia.edu/35804830/Architectural_Design_for_Adaptability_and_Disassemby

Mattsson, H. (2004). Another Architecture, Architecture and Consumption: Reyner Banham and the aesthetics of expendability. [online] Arkitektur och Konsumtion: Reyner Banham och utbytbarhetens estetik. Retrieved 5 Nov 2022 at:
https://www.academia.edu/19502735/Another_Architecture_Architecture_and_Consumption_Reyner_B anham_and_the_aesthetics_of_expendability?auto=download&email_work_card=download-paper

Merin, G. (2013). AD Classics: The Crystal Palace / Joseph Paxton. [online] ArchDaily. Retrieved 6 Nov.
2022 at: https://www.archdaily.com/397949/ad-classic-the-crystal-palace-joseph-paxton

Pavka, E. (2020). Shigeru Ban's Temporary Architecture is Made to Last. [online] Azure Magazine.
Retrieved 7 Nov at: https://www.azuremagazine.com/article/shigeru-ban-interview/

ThoughtCo. (2015). Japanese House Designs of Shigeru Ban. [online] ThoughtCo. Retrieved 7 Nov at https://www.thoughtco.com/interiors-japanese-houses-of-shigeru-ban-177319

Weimar Architecture. (2022). Weissenhof Siedlung. [online] Retrieved 6 Nov. 2022 at: https://weimararchitecture.weebly.com/weissenhof-siedlung.html

FIGURES

* ALL INCLUDED DRAWINGS AUTHOR'S OWN ORIGINAL

Fig 1. Quigley. S, Author's Own (2022) 'Deconstructing Permanence' [Cover].
Fig 2. Paxton. J. (1851) Crystal Palace.
Available at: https://www.archdaily.com/397949/ad-classic-the-crystal-palace-josephpaxton/51d479f7b3fc4b9e0f00019b-ad-classic-the-crystal-palace-joseph-paxton-image
Fig 3. Gropius. W, (1927) Weissenhof Siedlung,
Available at: https://weimararchitecture.weebly.com/weissenhof-siedlung.html
Fig 4. Cornell.edu. (2023). ARCH 4605/6605 Design for Disassembly | Cornell AAP. Available at: https://aap.cornell.edu/arch-46056605-design-disassembly
Fig 5. Brand, S. (1994), How Buildings Learn: what happens after they're built, Viking.
Fig 6. Zumthor, P. (2000), Swiss Sound Box Pavilion.
Available at: https://chadschwartz.com/iat/02-swiss-sound-box-peter-zumthor/
Fig 7. Zumthor, P. (2000), Swiss Sound Box Pavilion.
Available at: https://en.wikiarquitectura.com/building/swiss-sound-pavilion/
Fig 8. Quigley, S, Author's Own (2022) 'Reclamation Realm'.
Fig 9. Lacaton, A & Vassal, J.P. (2016) Cité du Grand Parc.
Available at: https://www.archdaily.com/915431/transformation-of-530-dwellings-lacatonand-vassal-plus-frederic-druot-plus-christophe-hutin-architecture
Fig 10. Lacaton, A & Vassal, J.P. (2016) Cité du Grand Parc.
Available at: https://www.lacatonvassal.com/index.php?idp=80
Fig 11. Lacaton, A & Vassal, J.P. (2016) Cité du Grand Parc.
Available at: https://www.theguardian.com/artanddesign/2019/may/12/grand-parcbordeaux-lacaton-vassal-mies-van-der-rohe-award
Fig. 12. Olgiati, V. (1998) School in Paspels
Available at: https://archello.com/story/49816/attachments/photos-videos/2
Fig. 13. Olgiati, V. (1998) School in Paspels
Available at: https://i.pinimg.com/originals/25/3f/8c/253f8ca56e28237bd69f4f7f6c0f5544.jpg
Fig. 14, 15, 16: Froebel Blocks
Available at: https://socks-studio.com/2021/03/08/understanding-reality-through-wooden-blocks-froebel-play-gifts/

BIBLIOGRAPHY

Austin, S. (2011). Understanding adaptability through layer dependencies. [online] Proceedings of the 18th International Conference on Engineering Design (ICED11), Vol. 10. Available at: https://www.academia.edu/2931661/UN DERSTANDING_ADAPTABILITY_THROUGH _LAYER_DEPENDENCIES?auto=download &email_work_card=download-paper [Accessed 3 Oct. 2022]

Banham, Reyner (1960). Stocktaking, Architectural Review, February 1960

Banham, Reyner. (1975)The Age of the M asters: A Personal View of Modern Architec ture. New York, Evanston, San Fransisco, L ondon: Harper & Row Publishers, p.29

Campos, I.D.D. & Bernardo, L.F.A. (2020). Architecture and Steel. Reflection and Analysis on the Use of Steel Structures (in Sight) as a Concept in the History of Architecture. Designs, [online] 4(3), p.30. doi:10.3390/designs4030030.

Modernist Architecture. (2010). Le Corbusier's 'Mass-Produced Buildings' (1924). [online] Available at: https://modernistarchitecture.wordpress.co m/2010/10/20/lecorbusier%E2%80%99s%E2%80%9Cmass-producedbuildings%E2%80%9D-1924/ [Accessed 24 Oct. 2022].

Ramesh, S. (2021). Onagawa Container by Shigeru Ban: Temporary Structures with Impactful Design - RTF | Rethinking The Future. [online] RTF | Rethinking The Future. Available at: https://www.rethinkingthefuture.com/case-studies/a4743onagawa-container-by-shigeru-bantemporary-structures-with-impactfuldesign/ [Accessed 7 Nov. 2022].

.Rossi, C. (2020). On Measuring Ancient Egyptian Architecture. The Journal of Egyptian Archaeology, [online] 106(1-2), pp.229–238. doi:10.1177/0307513320975782.

Strickland, M. (2010). TigerPrints Roman Building Materials, Construction Methods, and Architecture: The Identity of an Empire. [online] Available at: https://tigerprints.clemson.edu/cgi/viewcon tent.cgi?article=1909&context=all_theses.

The Journal of Architecture. (2015). From A4 paper to the Octametric brick: Ernst Neufert and the geo-politics of standardisation in Nazi Germany. [online] Available at: https://www.tandfonline.com/doi/full/10.1080/13602365.2015.1072232 [Accessed 24 Oct. 2022].

Wall, C. (2017). Standardization on Site: skill and the construction process in midtwentieth century Britain : WestminsterResearch. Westminster.ac.uk. [online] doi:Wall, C. 2017. Standardization on Site: skill and the construction process in mid-twentieth century Britain. Standard Architecture Symposium . Deutsches Architekturmuseum, Frankfurt am Main, Germany 19 - 22 Oct 2017.

Wall, C. (2015). Modular men: architects, labour and standardisation in mid-20th century Britain : WestminsterResearch. Westminster.ac.uk. [online] doi:Wall, C. 2015. Modular men: architects, labour and standardisation in mid-20th century Britain. in: Lloyd Thomas, K., Amhoff, T. and Beech, N. (ed.)

APPENDIX

01. Research Paper Additional Chapters

WALTER SEGAL & SELF-BUILD

Another modernist approach of affording individuality within design was explored by Walter Segal within the Self-Build Movement of the 19760's-70's. Segal was preoccupied with questions around empowerment, collaboration, and democratic design.
[Segal] reinvented building from first principles and reduced it to its simplest terms which led to the post and beam frame. His idea was that you would use readily available, inexpensive materials and you would use them in their bought sizes. (Architectural Review, 1987)

Segal's self-build principles favoured a new form of timber construction that employed the use of simple connections rather than that of more fixed construction methods such as bricklaying. Through self-build, the occupants of the building became familiar with the workings of the architecture, which enabled them to oversee the future maintenance of their homes, in turn ensuring the longevity of its lifetime.
In Segal's schemes, each household was entirely responsible for building its own house.

So families could proceed at their own speed and, on completion they are so thoroughly acquainted with every inch of the construction as to be able to remedy at once any defect that might occur… once the discipline of the frame and tartan grid (based on a module corresponding to standard material sizes to avoid cutting and wastage) have been understood, adjustments can be introduced at any time. (Architectural Review, 1987)

DISASTER RELIEF & TEMPORARY ARCHITECTURE

An example of Ban's temporary architecture is the Onagawa Container Housing. In 2011, the coast of Tohoku was struck with Japan's largest ever recorded earthquake. The disaster destroyed 70% of Onagawa's building and left approximately 10,000 residents homeless. The need for quick accommodation was met by a system of container housing set on a modular grid. Using the tsubo , Ban designed 3 plans using combined containers, one for single people and couples (6 tsubos), families of four (9 tsubos) and families of more than 4 respectively (12 tsubos). The construction of the project was completed within 5 months and has served as a precedent on housing high densities of people within a short timeframe. The cost of construction was cut due to the prefabricated nature of the containers and their quick assembly on site. It was proposed that after their use, they could be taken down, reassembled elsewhere, and re-used as a permanent structure.

Furthermore, many of the temporary accommodation schemes have been disassembled by the inhabitants and reassembled in their own towns and villages as their permanent homes.

For me, there is no difference between permanent and temporary structures. Some of the paper houses I made for victims of the earthquake in India became permanent because many of those people didn't have houses to begin with. After they went back to the village, they dismantled my houses and rebuilt them, so they became permanent. (Ban, 1994 qtd. in Pavka 2020)

FLEXIBLE SPACES & MOVEABLE COMPONENTS

Under this heading it is important to examine the early work and experimentation of Shigeru Ban. Industrial form and materials were the basis of many of these designs, with Ban employing prefabrication and modular techniques to create open spaces. In his 2000 project, 'Naked House', rooms were created as moveable modules set on casters, which were placed within the house's overall area of 139sq.m. These flexible modules were inspired by the 1960s Japanese Metabolism Movement and used a method sliding door/ walls meaning that the smaller, private modules could be connected to create bigger spaces. The house had the ability to change in accordance with the varying requirements of the occupant.

"This house is, indeed, a result of my vision of enjoyable and flexible living, which evolved from the client's own vision toward a living and a family life." (Ban qtd. in ThoughtCo., 2015)

Similarly, 1997's 'Nine Square Grid House' utilized ideas of the division of one bigger space into equal smaller ones using sliding walls. "The spatial composition combines the systems of two walls and a Universal Floor…these sliding doors allow a variety of spatial arrangements, adjustable to accommodate seasonal or functional needs." (Ban) . Grooves created on the floors and the ceiling allowed for the movement of partitions that could close off or open parts of the house's 108sq.m plan.

"I am very interested in flexibility, because in Japan we don't live in big spaces. So instead of just having the same space year-round, I think it is more useful to make the space flexible by having movable elements." (Ban qtd in ThoughtCo. 2015)

Within the theme of the paper, it is interesting to observe how Ban has used such ideas on varying levels of his architecture. From the flexible ability of schemes which allow them to be disassembled or reassembled, to the flexibility of space within the architecture itself, the output is that of resilience. The architecture is user-orientated and gives the occupant the opportunity to readily adapt the architecture to their needs. Ban employs his architecture with the freedom to change and adapt, instilling a sense of sustainability.

APPENDIX

02. Tracing Standardisation Timeline

Introduction: When examining the role of modular and simple construction in architecture it is helpful to outline the historic development of such methods. Below, standardisation in architecture and the built environment is traced through prominent periods of its use and stages of its development.

Ancient Egypt: Measurement used by the Ancient Egyptian civilisation is believed to have originally been based on the human body which was then standardised by the use of the cubit rod. The use of a cubit grid can be used to can detect patterns in Ancient Egypt architecture, thus proving the emergence of systems and standards within architectural design and construction.

Fig 1. Cubit Rod

Roman Empire: The rapid growth of the Roman Empire resulted in the requirement of prefabricated elements which was met by the development of standardised stone which would later lead to the creation of standardised brick.

> Three standard sizes of bricks were made by Roman manufacturers: lydium, 11.65" x 5.8", tetradoron, 11.65" x 11.65" (four hands), and pentadoron, 14.5" x 14.5" (five hands)… the pentadoron size brick was most useful in the construction of large buildings and city walls where large sections could be completed quickly. (Strickland, 2010)

This period saw the development of mass-produced, consistent materials which were u in a repeatable, standard method of construction.

The Industrial Revolution: This period saw a major turn in the advancement of technology and productivity. The development of materia was prominent at this time and saw the standardisation and mass production of the I of cast-iron, glass and steel. The newfound accessibility of these materials generated popularity of their use within the building industry. The structural potential of these materials revolutionised architectural design through size and function, with more larger spans and spaces as well as lighter structure now achievable. Architecture was no longer restricted to the sometimes 'claustrophobic' limitations of masonry and brick and now favoured a more 'open' form.

The Crystal Palace: Designed by Sir Joseph Paxton in 1851. Prior to its construction, a panel for the development had called for a temporary structure that would *"showcase th latest technologies and innovations from aro the world: The '*Great Exhibition of the Works Industry of all Nations.'" (Merin, 2013)

Paxton employed a modular system, which w based on the largest sheet of glass available that time (10' x 49'). The design consisted series of repeated cast-iron beams and colun which were mirrored, multiplied and set at 9(angles from one another. Due to the simplici of the proposal, all parts could be prefabricat and assembled into a self-supporting module When the exhibition in Hyde Park ended afte six months, the structure was disassembled and re-erected in Sydenham Hill. The structure, due to its modular design, served as precedent for future prefabricated structures as well as temporary and disassemble-able architecture. The Crystal Palace *"foreshadowed industrialized building and the widespread use of cast iron and steel".* (Gaber 2017)

Le Corbusier & Mass Produced Buildings 1924: *"Mass production demands a search for standards, and standards lead to perfection".* (Le Corbusier, 1924) Inspired by efficiency in the development of liners, airplanes and automobiles, Le Corbusier was interested in translating such practices into a new architecture. This architecture was to be a living 'machine' propelled by industry and mass-production rather than style and decoration. Such ideas marked the turn of the Modernist movement and a controversially different approach to architecture.

> In the early 20th century, mass production aimed to respond to the functional need to produce various components, to facilitate the daily lives of people and to increase the speed of construction of housing buildings. It is for this purpose that architects from the Modern Movement, such as Le Corbusier, associated the use of the "living machine" and mass production as a solution to solve the problem of the housing shortage at the time. (Campos and Bernardo, 2020)

Walter Gropius & Weissenhof Siedlung: This single-family house built in 1927 can be analysed as a precent to ideas and theories on standardisation and mass production that were to later follow. The house was designed based on a module of 1 metre, which was repeated throughout the unit. The system also employed Gropius' prefabricated panel system, which can be manufactured off-site, allowing for a more rapid construction. The house was Gropius' comment on how to build 'industrially'.

> The idea of industrializing housing construction can be realised by the repetition in each building of the same standardized component parts…it is thus possible, both commercially and technically, to satisfy the public's desire for an individual designed house, by the multiple possibilities of combining interchangeable parts, without sacrificing the principles of mass production," (Gropius, 1909)

Gropius' innovative use of a repetitive light steel frame provided a newfound level of flexibility within architecture, with easily modifiable parts. However, the scheme was not 'limitless', as it had claimed to be.

> It hinted at endless possibilities of arranging the individual parts. Nevertheless, this system was not limitless. The walls could only be arranged in accordance to the designed grid system. The connections between the panels determined how they can be put together. (Weimar Architecture, 2022)

Ernst Neufert & German Wartime Construction: Goering's 1936 Four Year Plan highlighted a shift in industry for wartime Germany, with a conversion plan put in place in for less vital labours to be turned into wartime industries in the event of heavy war activity. At this time, architect Ernst Neufert, who had assisted in the creation of the Bauhaus school in Dessau, was particularly interested in the use of standardisation in building components and types as a means of efficiency.

"In the Bau-Entwurfslehre I tried to distill and make readily accessible all the different standards sheets. In so doing, I observed almost daily the fact that there was no overarching system which united parts to one another and which made comprehension and systematisation easier." (Neufert)

In 1938, Neufert was enlisted by Albert Speer, Hitler's General Building Inspector (Generalbauinspektor für die Reichshauptstadt). Speer sought to use such the methods of systemisation Neufert was interested in to strengthen Germany's Four Year Plan. Neufert served as 'Consultant for Standards Questions' (Beauftragter für Normungsfragen) between 1942 and 1945. Students of the Bauhaus were also enrolled in a module named 'Schnellentwerfen' ('rapid design'), further strengthening the emerging architectural discourse.

The Octametric System: While under Speer, Neufert was tasked with the creation of social housing for Berlin. Prompted by Hitlers desire to have entire renovations of Berlin completed within twenty years, scarce available materials and resources, and the slave workforce that would be used to carry out the works as a means of cost saving, a new unit emerged, created by Neufert, coined the 'octametre'.

> The Octametric System was built on the premise that a grid system should dictate the dimensions of building components and building elements. Each module in the grid should measure 1/8 of a metre or 12.5 centimetres. Neufert suggested 'a complete world based on norms derived from the subdivision of the metre into eight basic modules of 12.5 centimetres, whence the notion of the "octametric" norm. (The Journal of Architecture, 2015)

The unit was based off the standard measurement brick. Using this way of measurement, Neufert believed doorways, windows and ceilings could be standardised, thus simplifying the tasks of architects and tradesmen alike. Though they were not built under Hitler, Neufert used the Octametric System to design housing schemes for Berlin and in 1950 it became an official DIN standard. Until the 1990s, octametric bricks were the only brick sizes readily available inside in Germany.

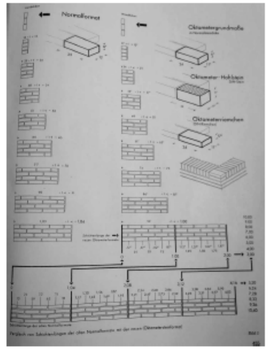


Fig 2. Ernst Neufert, 'Das Oktameter System'

Post WWII Britain: By the end of WWII, the United Kingdom saw shortages of both materials and labour. As a result, the British government promoted the industrialisation of construction practices. This thinking saw the breaking down of construction at a larger scale into its rational processes in the hope that opportunities to use standardised, prefabricated and interchangeable components would arise, thus driving down costs and combating the gaps in skilled labour required by traditional methods.

These ideas of standardisation were supported by ranging sides of architects, including those committed *"to the social enterprise of re-building a better Britain."* (Wall 2017) It was hoped that such processes would lead to better collaboration between architects and builders, which had been poor up to this point due to a lack of understanding between both practices.

Architects such as Mark Hartland Thomas had been fascinated by German wartime building practices. In 1946, investigation and interviewing of Ernst Neufert lead to the campaigning for Britain to implement a similar approach of standardisation.

1953 Modular Society: Such campaigning manifested itself in the formation of the Modular Society. Set up in 1953 by Mark Hartland Thomas, the creation of the society spawned from the desire to have architects at the helm of the design and production sides of construction. Marking a turn in 20th century Britain's building practices, the aims of the society, *"predicated on the conviction that building can be split into a series of simple, separate tasks, undertaken by a semi-skilled workforce, has since become the hegemonic understanding of the British construction process"* (Wall 2015)

Metabolism Architecture: This was a movement that emerged in post-war 1960s Japan in belief that architecture should reflect a society, politics and culture that was rapidly developing. One way these ideas manifested architecturally was in the use of megastructures that had modules inserted into them. An example of this was Nagakin Capsule Tower, designed by Kisho Kurokawa in 1972. The capsules inserted to the structure had a lifespan of 30 years and were intended to be removed and replaces to ensure the overall longevity of the megastructure.

Fig 3. Nagakin Capsule Tower

Reyner Banham & 'Une Architecture Autre'

In his 1960 book 'Theory and Design in the First Machine Age', architectural critic Peter Reyner Banham questioned the functionality of widely accepted modernist architecture and particularly the work of Gropius, who Banham believed was more concerned in creating an architecture that was only a visual and aesthetical representation of the machine age rather than a true representation of the developing technologies and materials and their implications within a physical architecture.

> "…it was no more an inherently economical style than any other. The true aim of the style had been, to quote Gropius' words about Bauhaus and its relation to the world of the Machine Age… *'to invent and create forms symbolising that world'*" (Banham, 1975)

Aligning himself with the futurist movement, Banham coined the term 'une architecture autre'

or 'another architecture' in an article entitled 'The New Brutalism', published by the Architectural Review in 1955. Where the likes of Gropius and Le Corbusier had been inspired by the automobile industry in the creation of standardised universal units, Banham believed in using standardised components which could be varied and repeated within units in other to establish differentiation and a more varied appearance within mass-produced buildings.

> If he / the consume / decides to go in for a mass produced, prefabricated house, he wants to select this from a catalogue and to purchase it ready made like his automobile. This attitude is now common among the general public throughout the western world. (Giedion, 1954)

Here we see Banham's interest in 'architecture as a service' and in 'une architecture autre' as a means of creating "fit environments for human activity". Banham was far more concerned with creating an architecture that could be varied on the requirements of the 'consumer' as was to be seen in the automobile and plastics industries as well as by the Japanese Metabolists movement's theories about 'capsules'.

> The operational lore of the architectural profession has assimilated prefabrication as a technique applied to fairly small repetitive components to be assembled on site. Such an arrangement leaves the determination of functional volumes still securely in the hands of architects, and the physical creation of those volumes in the hands of traditional-type site labour. (Banham, 1960)

CLASP: Banham's interest in mass production and 'another architecture' would go on to present itself in the form of CLASP, the Consortium of Local Authorities Special Programme, which was a collaboration of architects and engineers formed in the UK in 1957. The group contradicted tradition architectural practices in favour of more democratic approach. These practices were based on teamwork which meant *"that no individual was ultimately responsible for the design"*.(Mattsson 2004). The systems employed by CLASP resembled those of Gropius, which involved the assembling of standardised components.

> According to Banham, it was decided at an early stage that CLASP should be both visually and mechanically flexible, and that a large portion of important decisions about individual buildings should be made "far down in the design hierarchy" and beyond the control of those who made the original decisions about the system itself. (Mattsson 2004)

Shigeru Ban: Temporary Architecture & Moveable Elements: *"Whether a building is temporary or permanent depends on whether people love that building or not"* (Ban, 2008)

Shigeru Ban has become known for varying degree of flexibility within architecture, based on the use of standardised parts. An example of Ban's temporary architecture is the Onagawa Container Housing. A 2011 earthquake left Onagawa with the need for quick accommodation. This was met by a system of container housing set on a modular grid. Using the Japanese unit of tsubos (3.31sq.m), Ban designed 3 plans using combined containers, one for single people and couples (6 tsubos), families of four (9 tsubos) and families of more than 4 respectively (12 tsubos). The construction of the project was completed within 5 months and has served as a precedent on housing high densities of people within a short timeframe. The cost of construction was cut due to the prefabricated nature of the containers and their quick assembly on site. It was proposed that after their use, they could be taken down, reassembled elsewhere, and reused as a permanent structure.

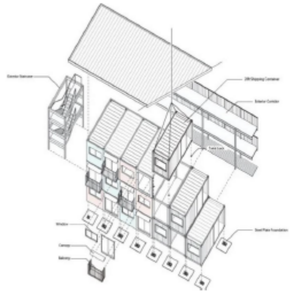


Fig. 4 Onagawa Container Housing, Shigeru Ban 2011

Industrial form and materials were the basis of many of Ban's earlier schemes and employed prefabrication and modular techniques to create open spaces. In his 2000 project, 'Naked House', rooms were created as moveable modules set on casters, which were placed within the house's overall area of 139sq.m. These flexible modules were inspired by the 1960s Japanese Metabolism Movement and used a method sliding door/walls meaning that the smaller, private modules could be connected to create bigger spaces. The house had the ability to change in accordance with the varying requirements of the occupant.

"This house is, indeed, a result of my vision of enjoyable and flexible living, which evolved from the client's own vision toward a living and a family life." (Ban)

Similarly, 1997's 'Nine Square Grid House' utilized ideas of the division of one bigger space into equal smaller ones using sliding walls. *"The spatial composition combines the systems of two walls and a Universal Floor…these sliding doors allow a variety of spatial arrangements, adjustable to accommodate seasonal or functional needs."* (Ban) . Grooves created on the floors and the ceiling allowed for the movement of partitions that could close off or open parts of the house's 108sq.m plan.

"I am very interested in flexibility, because in Japan we don't live in big spaces. So instead of just having the same space year-round, I think it is more useful to make the space flexible by having movable elements." (Ban)

Building Information Modelling (BIM): Recent developments in standardisation can be seen in the rise of BIM computer software. Such programmes are used within the automation of architectural design which is largely based on systems. Such workflows have allowed for greater collaboration between disciplines amongst the built environment and has created a new standard platform that can be shared amongst them.

Conclusion: Standardisation has been seemingly ever-present in the creation of architecture and within construction practices. However, while it appears standardisation has been used to facilitate building efficiency and design, it has not been used to its full potential when it comes to taking our structures apart again. This thesis proposed to investigate the reasons for this gap and how it can be combatted.

Bibliography:

1. Rossi, C. (2020). On Measuring Ancient Egyptian Architecture. *The Journal of Egyptian Archaeology*, [online] 106(1-2), pp.229–238. doi:10.1177/0307513320975782.
2. Strickland, M. (2010). *TigerPrints Roman Building Materials, Construction Methods, and Architecture: The Identity of an Empire.* [online] Available at: https://tigerprints.clemson.edu/cgi/viewcontent.cgi?article=1909&context=all_theses
3. Modernist Architecture. (2010). *Le Corbusier's 'Mass-Produced Buildings' (1924).* [online] Available at: https://modernistarchitecture.wordpress.com/2010/10/20/le-corbusier%E2%80%99s-%E2%80%9Cmass-produced-buildings%E2%80%9D-1924/ [Accessed 24 Oct. 2022].
4. Wall, C. (2017). Standardization on Site: skill and the construction process in mid-twentieth century Britain : WestminsterResearch. *Westminster.ac.uk*. [online] doi:Wall, C. 2017. Standardization on Site: skill and the construction process in mid-twentieth century Britain. Standard Architecture Symposium . Deutsches Architekturmuseum, Frankfurt am Main, Germany 19 - 22 Oct 2017.
5. Wall, C. (2015). Modular men: architects, labour and standardisation in mid 20th century Britain : WestminsterResearch. *Westminster.ac.uk*. [online] doi:Wall, C. 2015. Modular men: architects, labour and standardisation in mid 20th century Britain. in: Lloyd Thomas, K., Arnhoff, T. and Beech, N. (ed.) Industries of architecture London Routledge..
6. The Journal of Architecture. (2015). *From A4 paper to the Octametric brick: Ernst Neufert and the geo-politics of standardisation in Nazi Germany.* [online] Available at: https://www.tandfonline.com/doi/full/10.1080/13602365.2015.1072232 [Accessed 24 Oct. 2022].
7. Mattsson, H. (2004). *Another Architecture, Architecture and Consumption: Reyner Banham and the aesthetics of expendability.* [online] Arkitektur och Konsumtion: Reyner Banham och utbytbarhetens estetik. Available at: https://www.academia.edu/19502735/Another_Architecture_Architecture_and_Consumption_Reyner_Banham_and_the_aesthetics_of_expendability?auto=download&email_work_card=download-paper [Accessed 5 Nov. 2022].
8. John Gaber's Blog. (2017). *History of Architecture – Industrial revolution (18th century) & Revival (1880 – 1940).* [online] Available at: https://johngaber.wordpress.com/2017/11/10/history-of-architecture-industrial-revolution-18th-century-revival-t1880-1940/ [Accessed 6 Nov. 2022].
9. Campos, I.D.D. and Bernardo, L.F.A. (2020). Architecture and Steel. Reflection and Analysis on the Use of Steel Structures (in Sight) as a Concept in the History of Architecture. *Designs*, [online] 4(3), p.30. doi:10.3390/designs4030030.
10. Weimar Architecture. (2022). *Weissenhof Siedlung.* [online] Available at: https://weimararchitecture.weebly.com/weissenhof-siedlung.html [Accessed 6 Nov. 2022].
11. Merin, G. (2013). *AD Classics: The Crystal Palace / Joseph Paxton.* [online] ArchDaily. Available at: https://www.archdaily.com/397949/ad-classic-the-crystal-palace-joseph-paxton [Accessed 6 Nov. 2022].
12. Banham, Reyner. (1975) *The Age of the Masters: A Personal View of Modern Architecture.* New York, Evanston, San Fransisco, London: Harper & Row Publishers, p.29
13. Banham, Reyner (1960). *Stocktaking,* Architectural Review, February 1960
14. Barton, C., Gans, D. & Palmer, R. 2018, "Beyond Temporary: Prototypes for Resilient Communities", *Architectural design*, vol. 88, no. 4, pp. 78-85
15. Ramesh, S. (2021). *Onagawa Container by Shigeru Ban: Temporary Structures with Impactful Design - RTF | Rethinking The Future.* [online] RTF | Rethinking The Future. Available at: https://www.re-thinkingthefuture.com/case-studies/a4743-onagawa-container-by-shigeru-ban-temporary-structures-with-impactful-design/ [Accessed 7 Nov. 2022].
16. Pavka, E. (2020). *Shigeru Ban's Temporary Architecture is Made to Last.* [online] Azure Magazine. Available at: https://www.azuremagazine.com/article/shigeru-ban-interview/ [Accessed 7 Nov. 2022].
17. Thoughtcodotcom(2015). *Japanese House Designs of Shigeru Ban.* [online] ThoughtCo. Available at: https://www.thoughtco.com/interiors-japanese-houses-of-shigeru-ban-177319 [Accessed 7 Nov. 2022].