DfMA Guidelines

School Infrastructure NSW

Revision 4 - 10/12/20

WOODS BAGOT

NSW GOVERNMENT Education

Revisions

Revision	Date(dd/mm/yy)	Description
1	11/11/20	First Issue
2	26/11/20	Issued for Review
3	10/12/20	Industry Release

Contents

1 Principles

1.1 Glossary

DfMA	Design for Manufacture and Assembly	The design of a product and it's parts for ease of manufacture and ease of assembly on site
SINSW	School Infrastructure New South Wales	The government agency within the Department for Education NSW
EFSG	Education Facilities Standards and Guideline	
SELU	Special Education Learning Unit	
SLEC	School Learning Environments and Change	
HB	Home Base	
GLS	General Learning Space	
PAA	Practical Activities Area	
SLS	Shared Learning Space with Practical Activities Area	
COLA	Covered Open Learning Area	
NCC	National Construction Code of Australia	
BCA	Building Code of Australia	
DTS	Deemed to Satisfy	A type of performance requirement under BCA
CLT	Cross Laminated Timber	
GLULAM	Glued Laminated Timber	
LVL	Laminated Veneer Lumber	
CPTED	Crime Prevention Through Environmental Design	
BASE OPTION		The base option is a work example to test the system
RCP	Reflected Ceiling Plan	
FFL	Finished Floor Level	
SSL	Structural Slab Level	
WWR	Window to Wall Ratio	

1.1 Glossary

FECA	Fully Enclosed Covered Area	Includes all spaces that are enclosed with a roof, a façade and a floor slab. Including internal stairs, engineering, plant and circulation
UCA	Unenclosed Covered Area	Includes all spaces that have a roof and a slab but are unenclosed (without a façade). This includes circulation and COLA spaces that are bounded by balustrades or perforated mesh.
GFA	Gross Floor Area	Combines the area of UCA and FECA
COLA	Covered Outdoor Learning Area	
UFA	Useable Floor Area	Teaching spaces and support spaces and include homebases, storage, general learning spaces, labs, workshops, libraries etc but exclude circulation, engineering, outdoor space, toilets, plant, etc
Efficiency		The result of UFA divided by GFA and expressed as a percentage. The higher the percentage, the better the building efficiency.

1.2 Purpose of the Guidelines

School Infrastructure NSW (SINSW) and Woods Bagot in conjunction with a team of consultants, are developing a new set of guidelines to enable the application of DfMA (Design for Manufacture and Assembly) construction methodologies to schools across the state.

These construction methods include either volumetric construction or 'kit-of-parts' component-based structures. The primary target for the kit-of-parts construction is the use of Cross Laminated Timber (CLT) as a sustainable, healthy and modular material. However, this doesn't preclude the ability to implement traditional materials such as steel and concrete or a hybrid mix.

These guidelines are intended to describe the drivers, principles, system and performance criteria of the DfMA System for the purpose of designing and constructing schools in New South Wales.

The guidelines are intended to be used by architects, professional consultants, manufacturing contractors and assembly contractors. They comply with the current EFSG and should be read in conjunction with the EFSG.

The guidelines have been developed through a rigorous stakeholder engagement process with School Infrastructure and Department of Education groups. A Technical Working Group was formed to input into the guidelines as included the following stakeholders:

- DfMA Project Team
- Asset Management Unit (AMU)
- Design Advisory Team
- School Learning Environments and Change (SLEC)
- Sustainability Group

The consultant team

Architecture and Interiors
Woods Bagot

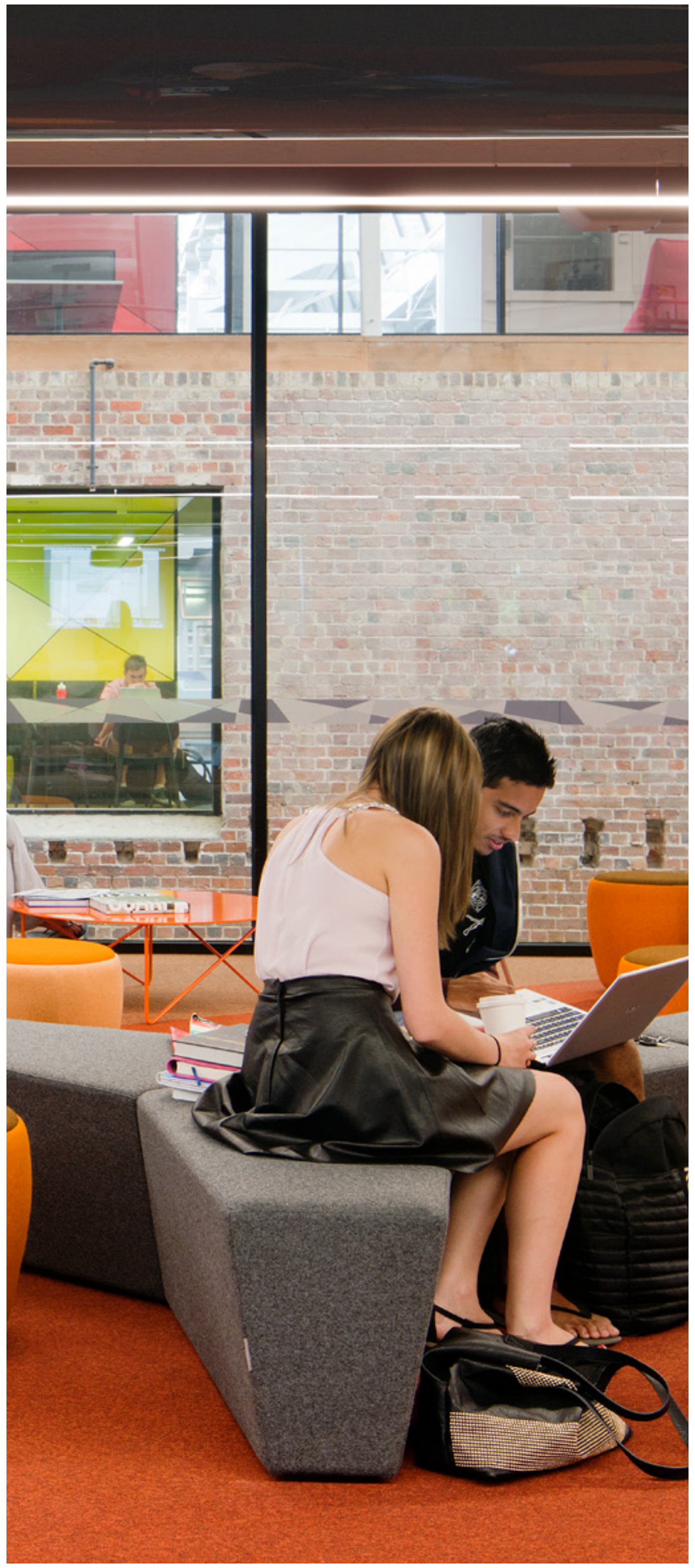
Structural Engineering
Taylor Thomson Whitting (TTW)

Sustainability, Acoustics, Services, Façade Engineering
Mott Macdonald

Fire Engineering
Holmes Fire

Building Code of Australia
Blackett, Maguire and Goldsmith

Costing
MBM



1.3 The DfMA Vision

A generational vision to transform the operation and construction of schools has presented itself as a result of a rapidly growing population in NSW and the need to build schools quickly to meet this demand. It coincides with an evolution toward co-teaching which required more flexibility in spaces.

The need

This opportunity presents itself as a product of significant population growth and aging school assets. The challenge the NSW government face, is to meet its obligation to provide a school place for every child. This means significant investment in school infrastructure via expansion, upgrade and new school projects and to deliver these to keep up with demand while offering a standard of schooling.

The Opportunity

In meeting this challenge, School Infrastructure NSW have an unprecedented opportunity to support principles of pedagogy, sustainability and construction technology.

The opportunity to apply a repetition and repeatability to 80% of the design of a school, enables the design and delivery of a school which balances:

- Utilisation of all spaces for flexible, informal or formal learning
- Optimum sustainability performance of the learning environments, driving down energy consumptions and emissions whilst improving the quality of the air, natural ventilation and daylight into the classrooms; and
- Lowering the on-going operational, running and construction costs such that capital can be recycled into maintenance and more projects.

Standardising the design of school, including the learning environments and building components, enables a Design for Manufacture and Assembly efficiency which in turn, enables more schools to be constructed to meet the growing demand. It all begins however, with a standardised, repeatable design and product.

Pedagogy

The role of schooling is in rapid change following recent social and technological upheaval. In the past a teacher would be mainly imparting knowledge. Today, with the free availability of knowledge, the aim is to provide guidance on use of this knowledge and to harness skills in critical thinking, problem solving, collaboration skills as well as the more traditional skills in numeracy and literacy.

We are already seeing the adoption of co-teaching and open learning, where multiple class groups learn together. In the future, it is predicted that the curriculum will shift towards a more cross disciplinary mode of learning. In meeting the challenge of DfMA schools, the spaces created will need to enable this type of pedagogy, as well as traditional modes and future flexibility

1.3 The DfMA Vision

Changing EFSG

In order to enable DfMA, parts of the existing Education Facilities Standards and Guidelines (EFSG) will need to adapt. A new standardised classroom size planned around a grid framework enables the standardisation of spaces and components to enable DfMA. With pedagogy and user wellness at the heart of every decision, this means larger classrooms than is currently employed to enable a more varied method of learning modes. This will enable a variety of furniture settings to utilise the use of both traditional and activity-based learning methods. The classrooms are typically grouped together as hubs with sliding large-format doors to enable flexible open plan co-teaching methods as well as traditional.

Future flexibility

The standardisation of rooms on a grid system also enables the future flexibility to convert primary schools to high schools, and general learning spaces to specialist spaces without the need for costly and time consuming refurbishments. This future proofs the ability to also steer education towards a future of cross disciplinary learning methods and even more open space learning if that direction prevails.

Affordability

The larger classrooms are offset through more efficiently planned buildings with less wasted circulation. Cost is further recovered through the use of self-finishing materials and the use of standardised componentry and the minimisation of wet-trades on sites. This equates to the same or lower construction cost per square metre than current practices.

Whole-of-life costs are reduced through the use of careful site-planning, orientation to maximise solar gain in winter and solar shading in summer. Natural ventilation and daylight penetration is promoted through narrow floor plates and will reduce the need for expensive running costs in the long term.

A new DfMA industry

The DfMA system aims to result in faster construction of schools to meet the demand of a growing NSW population, while providing schools to enable changing learning methods, equity across the state with healthier buildings that utilise our natural resources and address climate change. The schools will be safer to construct with a higher degree of quality control and safety standards and will help to trigger an industry shift in construction methods. It will harness state-sourced materials and draw on local labour to build a new DfMA construction industry pushing towards the biggest shift in construction practice in the last 100 years.

1.4 Key Benefits

The NSW Schools DfMA System has been created to reap some key benefits across a variety of criteria.

Improved Sustainability

- DfMA manufacturing and assembly reduces Co2 emissions, material and water waste.

Improved Health, Safety & Productivity

- DfMA improves mental health, site safety & construction productivity
- Manufacturing of building parts creates jobs in safe environments and on-site assembly requires less interfaces.
- Increased building efficiency: larger teaching spaces, more outdoor space, less circulation.

Opportunities to Reduce Cost

Design standardisation and repetition reduces cost.

The objective is that a portfolio application of DfMA, particularly kit of parts, will reduce the cost of construction by 20%.

Easy to use performance guidelines that set simple rules and allow for innovation.

Please refer Sections 1.16 and 4.7 Cost for detailed analysis and supporting documentation.

Design Efficiencies

Following the DfMA Planning System Guidelines, School designs can achieve:

- 10% greater building efficiency (UFA/GFA)
- 10% increases in UFA

The above is accomplished while retaining consistent GFA to that of pre-DfMA school designs.

Please refer to the associated case-studies in section 4.8.

1.4 Key Benefits

Design Flexibility

- The DfMA Planning System accommodates all required Primary and High Schools space types within the 9m framework.
- Interchangeability is thus optimised facilitating future growth and expansion (or vice versa) as briefing requirements adapt and change over time.

Planning Module Kit of Parts Consistency and Flexibility

The DfMA Planning System Guidelines comprises a kit of parts of space types which can be configured to suit differing contextual environments, education and operational objectives. Whilst there is a consistent DfMA Planning module, there is flexibility in the arrangement and orientation of the module, the connections of circulation spaces and configuration of collaboration spaces.

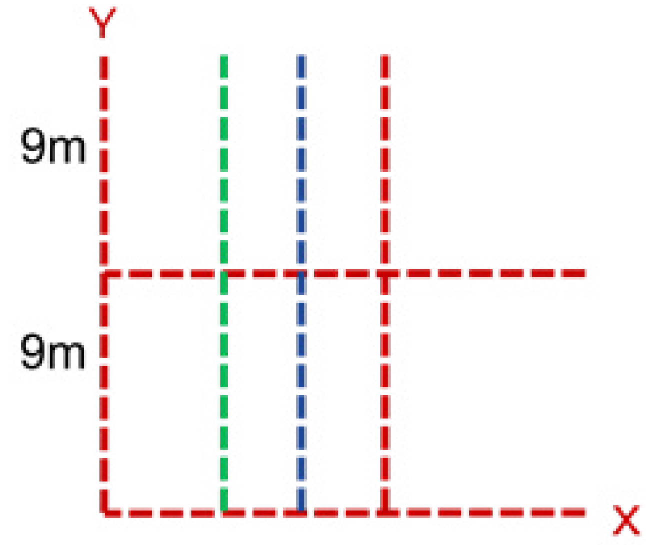
Structural Grid Flexibility

A standardised approach to design remains a consistent and constant theme to successfully enable DfMA. However, over the course of the year, through extensive consultation with educators and stakeholders, the initial 9m x 9m has evolved.

The 9m dimension remains constant but has evolved into 9m + 9m (referred to as 'train tracks') which provides a consistent depth to buildings. Learning spaces in classrooms has been redistributed from over-sized 81m2 classrooms to 67m2 classrooms and larger, consolidated centrally located practical and shared activity / collaboration spaces. A 67m2 dedicated classroom is closer to the current EFSG standard and now includes built-in storage.

When tested on typical wing layouts for more complex learning environments such as specialist spaces in High Schools, a 9m x 7.5m dimension was found to be an ideal fit. The 7.5m dimension could be sub-divided further to a dimension of 3.75m to enable volumetric DfMA. The more simple spaces, commonly found in Primary Schools, can still accommodate a 9m x 9m dimension thus providing ultimate structural system flexibility.

It is important the planning grid module dimensions - which are the same for Homebases, GLS's, specialists and SELU - remain the same to ensure consistency of product and repurposing of future use. Structural grid systems can be tested throughout the design stage with the most efficient structural grid solution agreed as part of finalising the construction contract.



1. 9m x 3.75m (volumetric)
2. 9m x 7.5m
3. 9m x 9m

1.4 Key Benefits

Time Savings

- DfMA construction is 30% faster
- Early investment in design standardisation allows for on-site time savings.

Minimised Impact on Operations

DfMA reduces disruption to school operations

Off-site manufacturing and on-site assembly requires less trades on site and generates less noise, dust, traffic and disruption

Enable an interchangeable module for all primary, high school and special education teaching spaces.

Enables state-wide spatial and social equity.

Upskills the Workforce

DfMA affords opportunities for local upskilling

Manufacturing facilitates new jobs, training and upskilling

Establish demand to grow NSW manufacturing capacity

Drive lower construction costs per sqm over time.

1.5 Innovation and Evolution

Innovation by both the design community and the contractor industry is encouraged to create continued learning and development of this pioneering system. Creativity and variance is encouraged and desirable to avoid sterile, cooker-cutter schools while balancing the need to provide n equal level of education no matter the location in the state.

These guidelines are intended to demonstrate the vision behind the system, its key drivers and the beginnings of a standardisation of spaces and componentry. The design and construction industry are intended to challenge the guidelines and provide feedback where the guidelines can be adapted over time to apply lessons-learned and innovations.

The guidelines are intended to create equity across the state – education should be experienced in a similar way regarding spatial and qualitative standards of building performance and pedagogy. However, the flip side of equity is variance and individuality. Designers are encouraged to find the balance to create schools that are of their place and to serve the community they represent. Schools should form a source of pride for their staff, students, parent and community. The guidelines will adapt as this challenge unfolds.

1.6 Overarching Principles

Each decision along the development of the DfMA system has been informed by these overarching principles. They address the NSW need to meet its obligation to meet the school place demand, while addressing key societal issues of wellness, sustainability and the ability to deliver new typologies in the construction industry in NSW.

Pedagogy First

- Enable flexibility and best possible teaching outcomes, now and in the future.
- Increased building efficiency: larger teaching spaces, more outdoor space, less circulation

Equity

- Consistency across all schools
- Ability to deliver the same level of education, design, layout and joinery across the state

Prioritise Resilience & Wellness

- Adapt for a changing climate
- Change the focus to the wellness and best possible teaching and learning environment for student and teacher.

Kit of Parts

- A single universal education planning grid
- Interchangeable module for all primary, high school and special education teaching spaces.
- Enables state-wide spatial and social equity.
- School building as a learning opportunity.

Investment & Infrastructure

- Enable all construction methods from off-site volumetric to conventional to secure quality and program, and maximise use of budget.
- Establish demand to grow NSW manufacturing capacity
- Drive lower construction costs per sqm.

Whole of Life Thinking

- Shift the discussion on capital cost to encompass whole-of-life cost, flexibility, durability and maintenance.
- Put in place easy to use performance guidelines that set simple rules and allow for innovation.

1.7 Delivering DfMA

DfMA can be delivered in two Assembly Methods:

Component Kit of Parts

- A component 'kit of parts' in which the building elements including floor panels, walls, portal frames, roof trusses etc. are manufactured off-site, transported to site as building components and assembled as a 'kit of parts', on site.
- Component 'kit of parts' is suited to all sites, particularly sites with access restrictions and for school buildings up to 6 storeys.

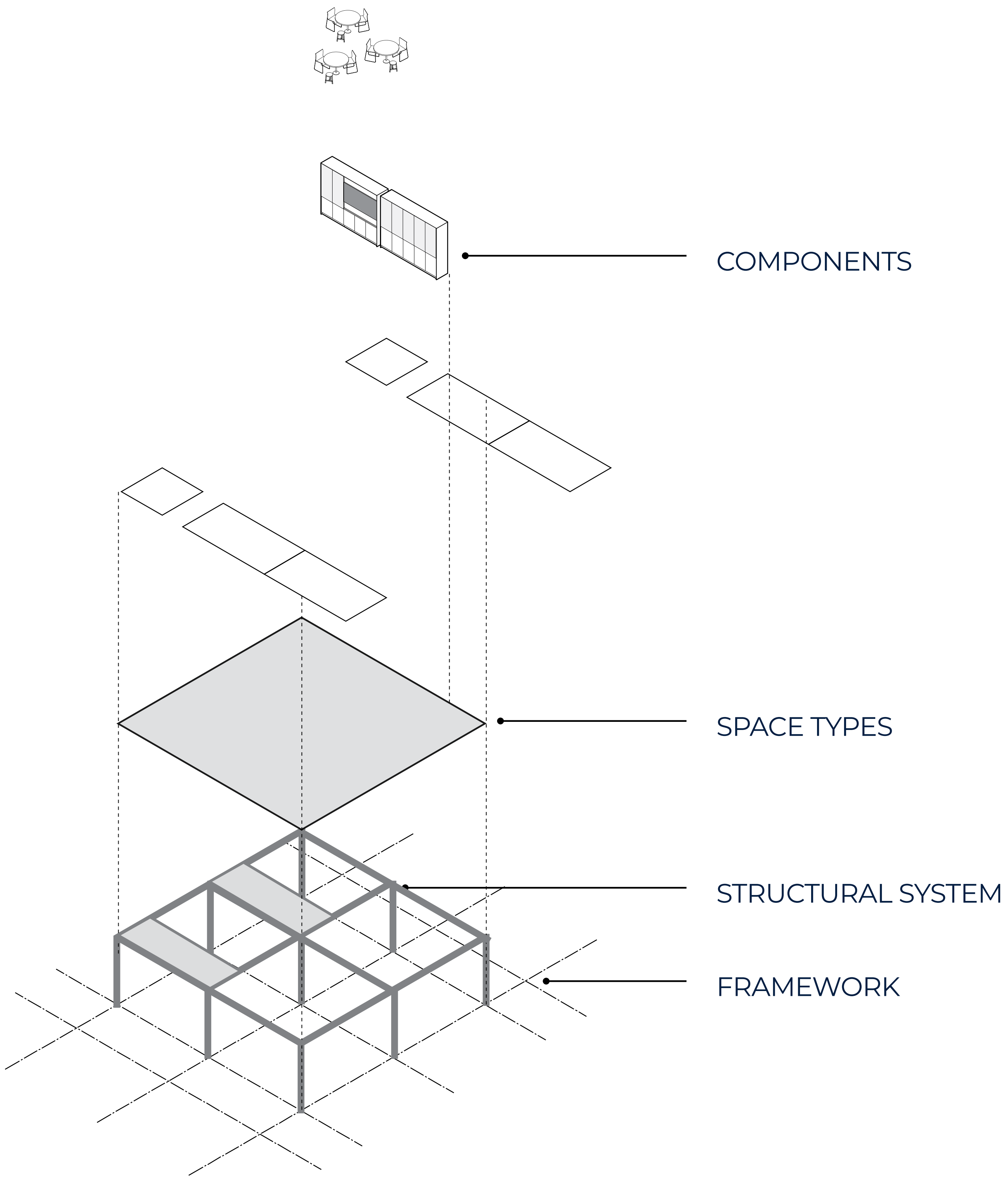
Volumetric

- Volumetric in which it is manufactured off-site, assembled in a factory, transported to site and craned into location as a complete module.
- Volumetric DfMA is well suited to easily accessed sites and regional locations for school and ancillary buildings up to 3 storeys

The practical implementation of DfMA includes:

- Eliminate wet trades
- Prioritise off-site manufacturing for every component
- Ensure structural systems support efficient assembly and disassembly
- Ensure designs are fit for purpose (fire, acoustics and vibration compliance)
- Ensure structural systems support different services and mixed mode
- Prioritise well-being and health benefits in material selection
- Ensure every material is working at its optimum efficiency
- Ensure designs support flexibility of choice for structural systems

1.8 The DfMA System



The NSW Schools DfMA System comprises various parts that work in synergy with each other and allow each project to use the system to meet varying spatial and programmatic needs.

The system aims to standardise certain aspects of spatial planning and componentry but allows each project to be creative to assemble an architecture of its place and to meet its needs.

The system comprises:

Framework

The framework to enable a standardised layout that is future flexible to easily convert spaces to different uses

Structural System

The beams, columns, floor system i.e. Timber frame, concrete, steel, volumetric or hybrid

Space types

The classrooms, support spaces, practical activities areas, specialist spaces etc

Components

Façade, walkway, roof, stairs, joinery, finishes, furniture

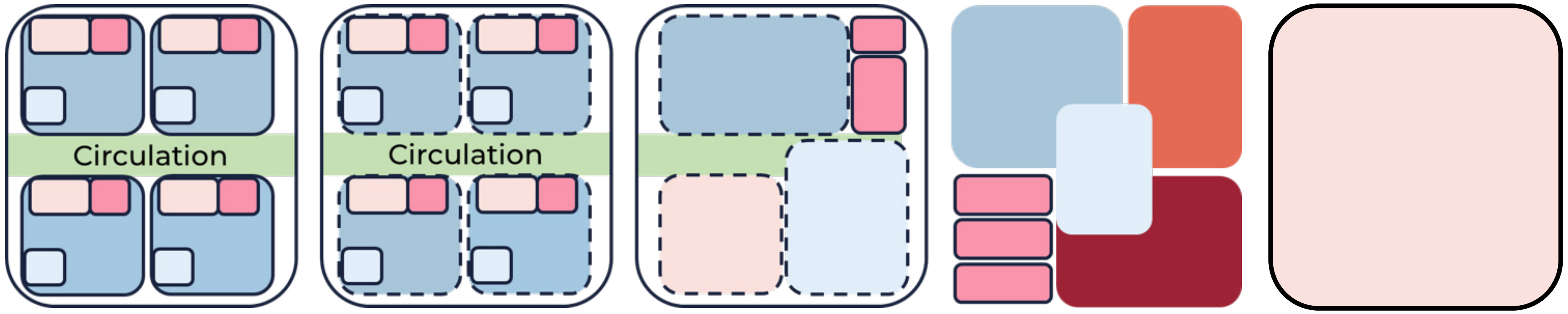
1.9 Pedagogy

Technology has enabled a shift in how we learn. Classrooms are seeing the need to become more of a 'problem-solving' environment where students can learn in a wide variety of learning modes – from traditional, explicit learning to various forms of activity-based and individual learning.

The role of schooling is in rapid change following recent social and technological upheaval. In the past a teacher would be mainly imparting knowledge. Today, with the free availability of knowledge, the aim is to provide guidance on use of this knowledge and to harness skills in critical thinking, problem solving, collaboration skills as well as the more traditional skills in numeracy and literacy.

We are already seeing the adoption of co-teaching and open learning, where multiple class groups learn together. In the future, it is predicted that the curriculum will shift towards a more cross disciplinary mode of learning. In meeting the challenge of DfMA schools, the spaces created will need to enable this type of pedagogy, as well as traditional modes and future flexibility.

The School Infrastructure NSW DfMA System provides the ability to teach in a variety of learning modes and is adaptable to flex between traditional enclosed classrooms and open learning modes.



Enclosed	Connected	Combined	Communal	Open
Learning spaces that operate independently	Learning spaces with flexible connections	Learning spaces with flexible connections and combined allocations	Learning spaces with combined allocations and less distinct separation	An ambiguous and flexible space that can be modified to suit a need

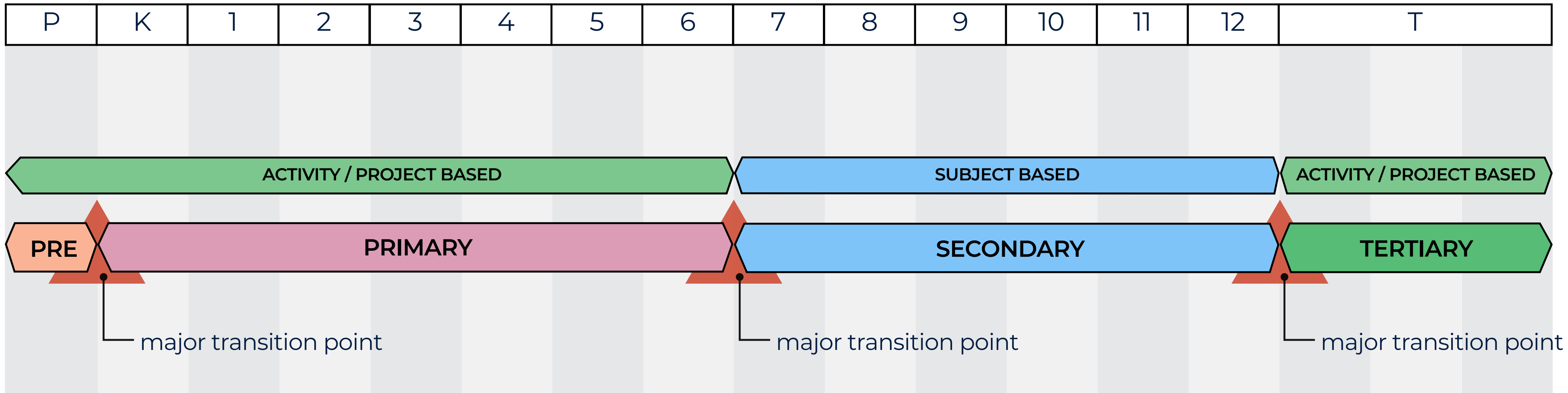
1.9 Pedagogy

Learning modes across a person's life-span currently has an anomaly during high school years where activity-based learning ceases and is replaced with traditional learning methods.

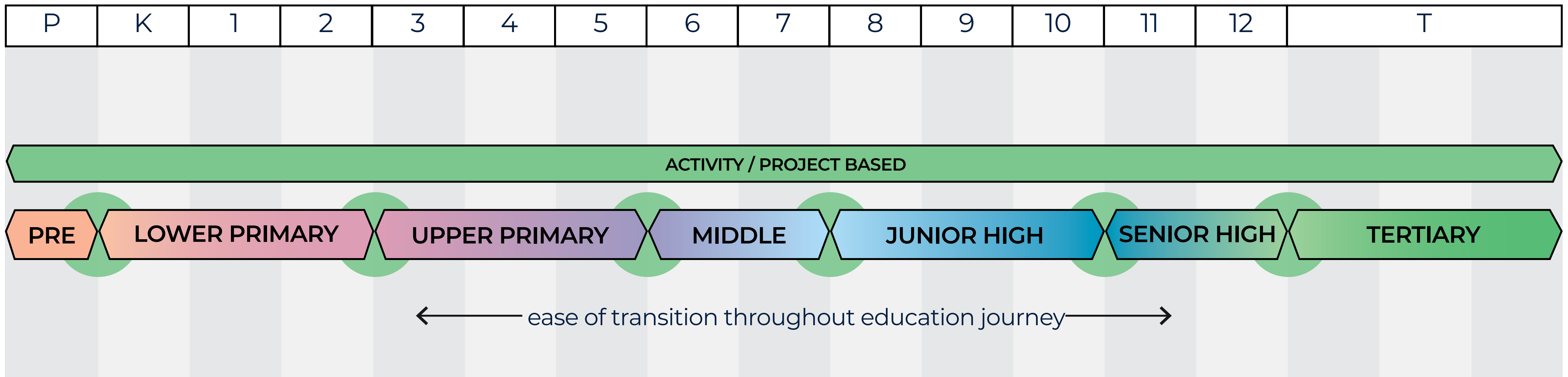
Currently, activity-based blended learning typically occurs in pre-school and primary school years. The curriculum in high schools and the stock of school spaces is geared towards traditional classrooms. The blended learning then typically returns in tertiary education and in the workplace.

The School Infrastructure NSW DfMA System provides the ability to transition high schools to a more activity-based learning method over time and unifies the spatial framework between high schools and primary schools. This also allows for flexibility to easily convert primary schools to high schools in the future.

A further benefit to providing similar learning environments across a life-span is the aiding of smooth transitions between the current major transition points at the beginning of primary school, high school and tertiary education.



Current Learning Stages



Potential Future Learning Stages

1.10 Adaptability and Future Flexibility

Spaces have been designed to both adapt on a daily basis between different learning modes and to be future-flexible for ease of transformation between, say primary schools and high schools, or between general learning and specialist spaces.

The planning framework, which is built around a standardised grid, enables the standardisation of spaces. This is desirable in order to future-proof schools to be able to adapt to inevitable change. There is a high likelihood that the current young population attending primary school will lead to a greater demand for high schools in coming years.

Similarly, the possible shift to cross-disciplinary curriculum in the future, could mean a more diverse teaching space that is more akin to an office workplace – with open plan, collaboration rooms and shared specialist spaces.

The DfMA system has been designed to allow minimal structural and infrastructure intervention to make such conversions. Spaces have been left as obstruction-free as possible, and spaces planned around the framework and the planning grid.

On a daily basis, the spaces can flex between enclosed classrooms and open plan co-teaching modes. This is done through large-format sliding doors and shared Practical Activity Areas and Shared Learning spaces.

Primary School

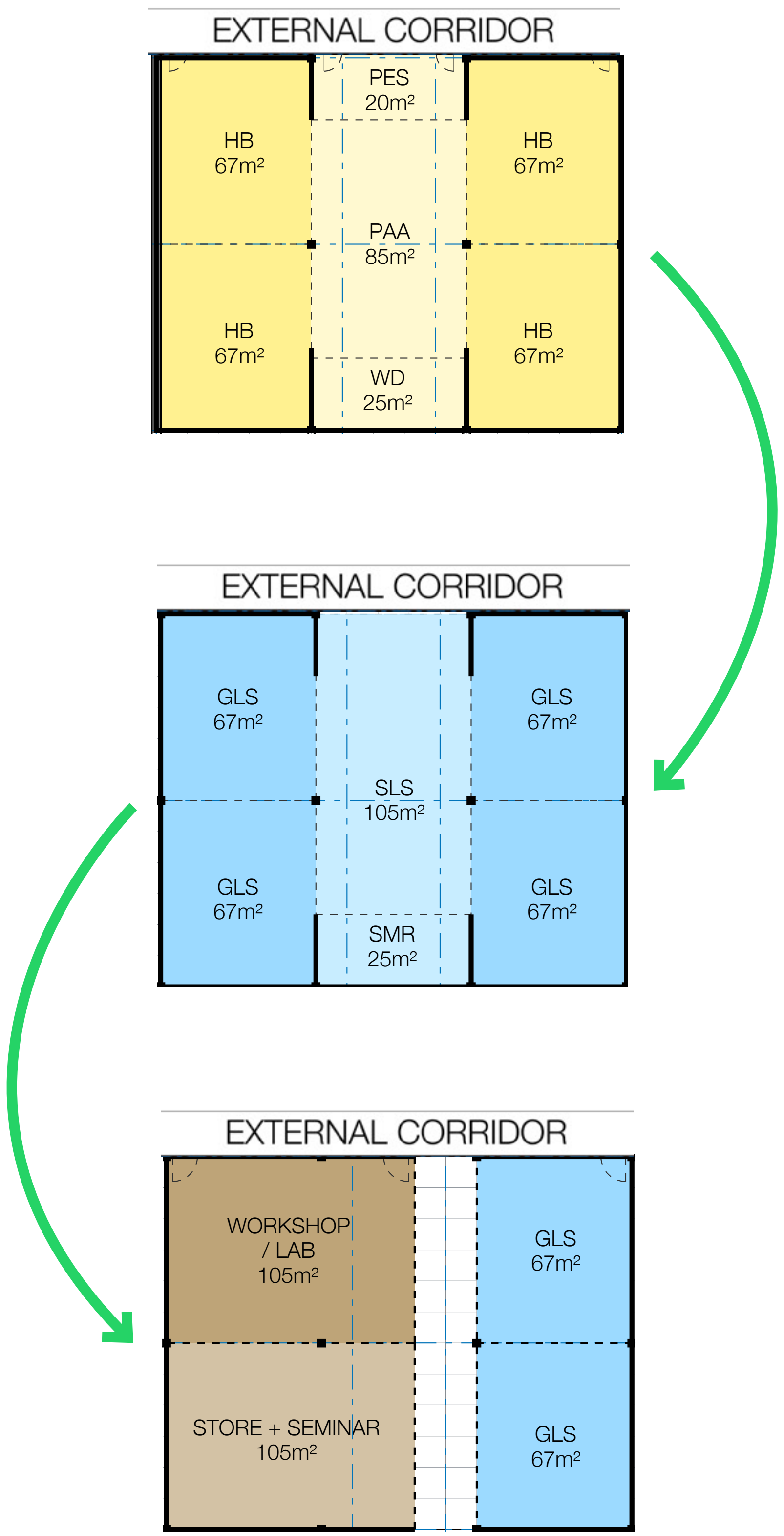
Primary school homebase cluster with practical activities area and withdrawal rooms.

High School

High school general learning space cluster with a shared learning space and seminar room.

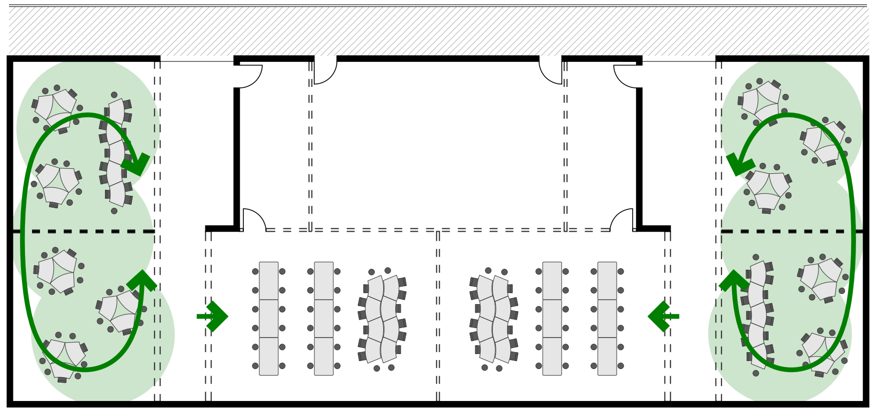
Specialist

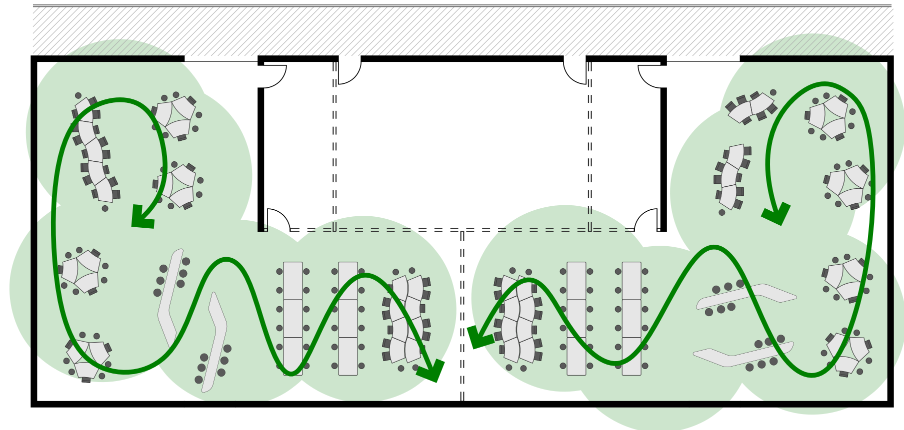
High school workshop or lab with adjoined store/seminar space and additional general learning spaces

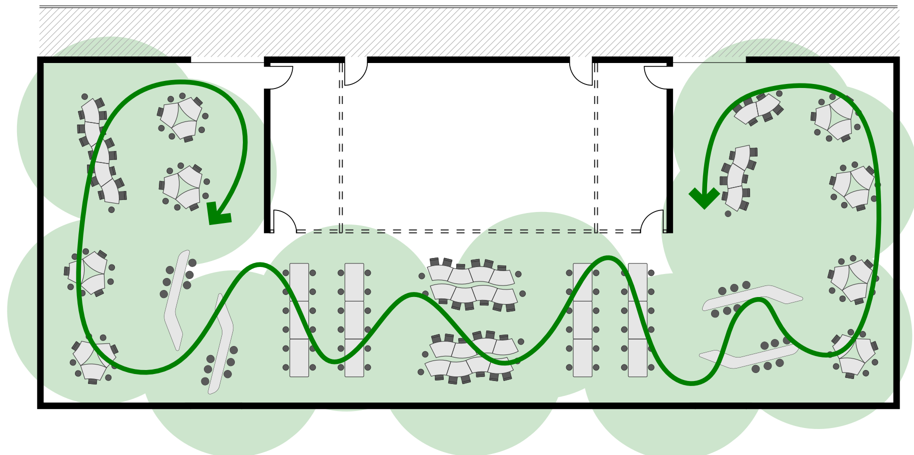


1.11 Change Management

Change management, which will require a period of time where new pedagogies are tested can be implemented over time with the possibility of open shared learning spaces featuring in future schools. Or conversely, a return to traditional formats. The DfMA has both eventualities and any mix enabled.







1.12 Sustainability

The Dept of Education (DOE) continues to set itself innovative and ambitious Sustainability objectives across all aspects of its services.
The objectives of the NSW Schools DfMA System Guidelines has been developed with these in mind to facilitate and contribute to the DOE achieving these objectives.

Sustainability Pillars of The Department of Education (DOE)

The DOE has established the following Four (4) pillars in establishing its vision and key Sustainability performance targets:

1. Climate Action – Net Zero Emissions
2. Give Back More Than We Take
3. Unlocking Individual Potential
4. Resilience

For further detailed information in relation to above pillars and the DOE strategy, please refer to the DOE's strategy paper which is a separate document to this Guideline.

The following elaborates on select key objectives of these DOE pillars and outlines how they have been addressed within this DfMA strategy.

Please refer to Section 4.1 which substantiates below in much greater detail.

Climate Action – Net Zero Emissions

The DOE proposes strong action to both decelerate and support adaptation to climate change.

This includes reducing and/or eliminating carbon emissions, building higher performing buildings and creating energy on-site.

A whole-life-cycle approach to carbon reduction is envisioned and this inherently informs the design standards established in this guideline.

Specifically, the DOE is targeting Net Zero Carbon emissions as follows:

- Operational carbon emissions to be Net-Zero by 2030
- Embodied carbon emissions to be Net-Zero by 2040

DfMA addresses this by:

- Supporting clear strategies and infrastructure for integration of Photo-voltaics (PV) on new buildings and future retrofit applications;
- External walkways, building depths and orientations which shade, control and promote both natural light and ventilation;
- Material selections such as mass timber and their inherent sustainability benefits compared to concrete and steel.
- Acknowledging that future innovative materials (i.e. geopolymer or other 'green' concrete(s)) are to be considered within this DfMA strategy as they develop and become available.

Give Back More Than We Take

Water consumption, waste and clean energy are to be managed and monitored to optimise the health and wellbeing of the communities and sites that house and support NSW Schools.

DfMA addresses this by:

- Reducing up-front waste during school construction;
- Plant can be upgraded, replaced, modified or removed with minimal impact on school function, other construction assemblies and finishes;
- Planning and layering of functional spaces coupled with varying degrees of permeability (UCA vs FECA) promote passive design principles and reduced mechanical ventilation;

Unlocking Individual Potential

Respect for the environment ultimately has beneficial impacts on the health and wellbeing of the people it nurtures. Fundamental to the DOE's vision is to create a built educational environment that has positive impact on the health and wellbeing of students and teachers, ultimately strengthening the larger community it supports.

DfMA addresses this by:

- Biophilic design which provides building-wide connection with the outdoors;
- spatial layering to filter environmental impacts on internal functional areas;
- Standardised designs applied portfolio-wide to unlock opportunity for further innovations recognised by Green Star and other relevant

1.12 Sustainability

tools of assessment. Thus enabling NSW Schools to be at the forefront of impactful innovation across its entire pipeline.

Resilience

Clearly our future will expose us to both hotter and colder temperatures as well as depletions of natural resources due to both climatic and urban impacts.

As experienced with COVID-19, the requirements of our communities will also change and be challenged from time to time.

NSW Schools are in a position to not only address critical social infrastructural requirements over time, they must also be future-proofed and support change.

Schools will need to address adaptation of space usage, technology and flexibility in accommodating future needs and demands and will be required to adapt to growth or reduction.

DfMA addresses this by:

- Planning modules that suit multiple uses; both for school environments as well as other uses;
- Primary and High School spaces are interchangeable;
- Clear consistent structural grid(s) capable of accommodating varying functions (ie. Health, Commercial, Residential);
- Generous floor-to-floor dimensions, again, capable of absorbing changing functional requirements, joint-uses and services;
- The ability for NSW Schools to share their core amenities with the community and/or other schools. The ability to up/down-size to suit community requirements.
- Componentry can be shared with other schools. While one school may be dis-assembled, it's structure and componentry could be utilised at another which is being expanded.

Performance Requirements

To achieve these objectives, a series of Performance Results and Requirements are proposed in Section 4.1.

1.13 Construction

The DfMA System recognises the need to provide a fast construction method which challenges the current construction practices and provides options for kit-of-parts or volumetric type constructions as well as traditional.

The planning framework and space types enable any construction methodology to be employed from timber, steel, concrete, volumetric or a hybrid of all of the these methods. The most environmentally sustainable system is the timber frame method that uses Cross Laminated Timber slabs and shear walls with glulam beams and columns.

Construction needs to adapt to climate change challenges, greater consideration of safety and faster, more quality-controlled buildings.

DfMA can be delivered as a kit-of-parts or volumetric methodology. These typologies shift effort from majority of trades on site to predominantly off-site manufacture. This enables standardisation of components.

Construction processes and management will adapt to include both manufacturing contractors and assembly contractors. Emphasis will be on highly detailed design prior to site availability and a reduced time on site.

Disassembly is enabled through favouring bolted connections over welded and glued connections. This enables the re-use of componentry and ease of upgrade and conversion.

1.14 End of Life/Dissasembly

The sustainability and climate targets call for a consideration of end-of-life processes. Disassembly, reuse, recycling and waste, should be considered for each component. For the structure, this can mean favouring bolted connections over welded and glued connections. The examples provided have aimed to avoid services penetrations through the beams to enable re-use. The ability to easily disassemble, means that upgrades and conversions to schools, or even re-use of school sites can happen speedily and with minimal impact on waste.

Materials selected for componentry are best prioritised to aim for disassembly and re-use in the first instance, or second preference would be for recycling and last priority for safe, non-carbon emitting disposal. This target has a preference for minimising sealants, adhesives and permanent fixings in favour of mechanical fixings and non-glued gaskets for ease of disassembly and recycling.

1.15 Maintenance and Safety

The DfMA system has been devised to create spaces and componentry to minimise ongoing maintenance costs and provide safe environments for students of all ages.

Maintenance

Maintenance of schools is a significant investment and the DfMA system has made selection of materials to minimise costs while balancing the need for safe, effective learning spaces, and the creation of buildings for their community.

- Hard wearing resilient finishes
- Avoidance of timber in external areas
- Avoidance of many, complex moving parts
- Minimising of paints and requirement of re-finishing
- Ease of replacing parts
- Self-finishing multi-functional surfaces such as whiteboards and pinboards

Safety

Schools are places where behaviour issues are often encountered and recognition of this leads to safety measures required within the componentry and spaces designed in the DfMA. Requirements must also meet the EFSG, good Safety on Design and CPTED principals. In addition the safety and security units, typically part of the Technical Stakeholders Group, provide review and guidance. The spaces and componentry in the DfMA System have considered these aspects, although each school project will require engagement and compliance in addition to these guidelines:

- Prevent falling from height
- Prevent bullying and anti-social behaviour through spaces with good supervision
- Prevent entrapment
- Prevent climbability

1.16 Cost

The DfMA System considers cost savings through greater efficiency, less wastage, less time on site and simpler approach to finishes. Whole-of-life costs are also balanced and considered as a whole approach to cost.

Cost effectiveness is high on the priority list for schools in balance with speed of construction, equity, sustainability, wellness, safety and maintenance.

Efficiency

The DfMA System aims to increase building efficiency and utilise secondary circulation to double up as usable space. For example, the external walkway efficiently delivers a means of access and egress, and the Practical Activity Areas and Shared Learning Spaces act as access for incoming and outgoing movement, and usable during class time.

Storage has been incorporated within the classrooms to save on wasted circulation space.

Through these measures the actual usable space of each classroom is increased, which is important to enable activity-based learning, but without the overall increase in GFA.

Lower construction cost rate

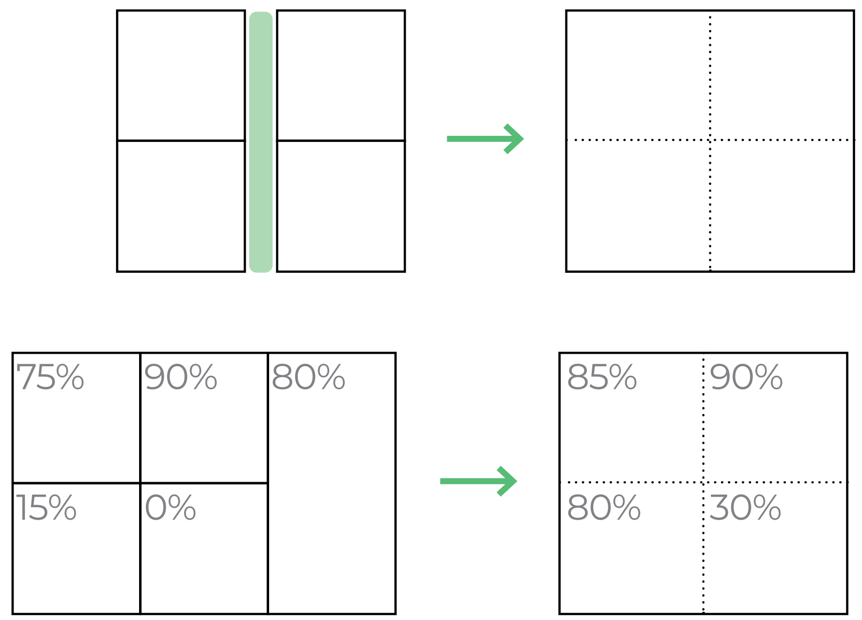
The rate per square metre is lowered through implementation of self-finishing, multi-functional componentry. For example, wet trades are eliminated, timber structural members are inherently fire protected, finishes consist of whiteboards and component-based, ceilings are exposed CLT slabs etc. The lower construction rate can offset any usable floor area increases.

Whole of Life

The application of sustainability measure, good passive design and lower maintenance costs lead to lower whole of life costs with reduced energy consumption. This long term vision can help to offset costs associated with starting up and upscaling the new impending DfMA construction industry.

Future Timetabling

An initial study has found that classroom utilisation is on average at 62% in a high school, meaning that classrooms are theoretically empty 38% of the time. Through a review of timetabling, not part of this scope, further cost savings could be explored through building less classrooms and more closely timetabled in conjunction with a review of the curriculum.



1.16 Cost

Please refer Section 4.7 Cost for detailed analysis and supporting documentation referred to in this section.

Case-Studies

Case-Studies were conducted by MBM on the following Schools with data provided by SINSW.

MBM's research and estimating does assume that Building Contractors and suppliers are operating in a market where they can achieve scale and repeatability.

All costs included:

- Builder's Works (works to Building Structure Only, excl. Landscaping, out-buildings, etc).
- Main Contractor Preliminaries
- Main Contractor Margin
- Professional Fees

DfMA elemental cost plans were conducted on a number of active projects as "Case-Studies" in order to assess and compare DfMA Delivery and Cost Options. The findings of these cost plans and the methodology underpinning the development of the elemental cost plans, assumptions and inclusions were reviewed and endorsed by the SINSW.

(Refer Section 4.7 Cost for further supporting detail and comparison tables for each case-study)

Delivery and Costing Options:

- Traditional Construction and Delivery
- DfMA Volumetric Construction and Delivery
- DfMA Component (Kit-of-Parts) Construction and Delivery

Schools subject to detailed costing analysis were as follows:

- Googong PS
- Marsden Park HS
- Westmead South PS (Stage 2)
- Hawkesbury Centre of Excellence
- Richmond STEM

The following were the results:

- Traditional Build costs are typically averaging $4,500/m2.
- DfMA Volumetric cost comparisons of the same designs tend to be cost neutral and or nominally greater cost than those of Traditional delivery.
- DfMA Component (Kit-of-Parts) are yielding costs of $3,554/m2 equating up to 14% Savings when compared to Traditional delivery.

In addition to these cost savings, the standardisation of the design which utilises an access walkway which provides circulation external to the classroom spaces, results in the reallocation of the proportion of FECA versus UCA. Thus converting this circulation space to a less expensive and more functional access walkway, yielding savings of approximately $1,745 per m2.

The following summarises the analysis of the Five (5) case-studies, indicating a consistent result where DfMA Kit-of-Parts Delivery Methodologies resulted in a rate of ~$3,554/m2, thus providing a cost savings of 14% compared to Traditional construction.

		Googong		Marsden Park HS		Westmead PS (Stage 2)		Hawkesbury		Richmond	
		Cost	Cost/m2	Cost	Cost/m2	Cost	Cost/m2	Cost	Cost/m2	Cost	Cost/m2
Construction Costs *(New build only, excluding external works, landscaping)*		$ 27,887,641	$ 3,076	$ 65,806,994	$ 2,788	$ 8,128,771	$ 2,846	$ 13,605,420	$ 2,495	$ 3,083,930	$ 2,739
Main Contractor Preliminaries	14%	$ 3,904,270	$ 431	$ 9,212,979	$ 390	$ 1,138,028	$ 398	$ 1,904,759	$ 349	$ 431,750	$ 383
Main Contractor Overhead & Profit	4%	$ 1,115,506	$ 123	$ 2,632,280	$ 112	$ 325,151	$ 114	$ 544,217	$ 100	$ 123,357	$ 110
Subtotal		$ 32,907,416	$ 3,630	$ 77,652,253	$ 3,290	$ 9,591,950	$ 3,358	$ 16,054,396	$ 2,944	$ 3,639,037	$ 3,232
Consultant Fees	8%	$ 2,632,593	$ 290	$ 6,212,180	$ 263	$ 767,356	$ 269	$ 1,284,352	$ 236	$ 291,123	$ 259
TOTAL		$ 35,540,010	$ 3,921	$ 83,864,433	$ 3,554	$ 10,359,306	$ 3,627	$ 17,338,748	$ 3,180	$ 3,930,160	$ 3,490

1.16 Cost

Cost Summary and Savings – DfMA Kit-of Parts (The Clear Winner)

In summary:

- Traditional = ~$4,500/sqm
- DfMA Volumetric = ~$4,500/sqm
- DfMA Component (Kit-of-Parts) = ~$3,554/m2 equating up to 14% Savings
- Externalising circulation saves $1,745/m2 (FECA converted to UCA).

Future Cost Savings

It is MBM's opinion that a longer term analysis and further wholesale adoption by the sector, will provoke further cost reductions and at the same time improve programme efficiencies. The combination of these factors has the potential to deliver a 20% saving on construction costs and between 30% to 50% savings on project programmes.

The below section discusses some of the potential areas of focus for time related cost savings.

Consultants and Design

There is clearly a learning curve as designers become familiar with the manufacturing process.

MBM believes that once the standardised design principles are established, savings of around 15% in design time could be achieved.

Substructure

Given that prefabricated classrooms and building component elements are designed to be lightweight for transportation, this can reduce the size and complexity of the concrete slab as well as foundations. This knock on effect will produce some time and cost savings. In addition, manufacturing can take place in parallel with early site works (including slabs and foundations) unlike the linear timeline of a traditional project delivery.

Efficiencies from the Manufacturing Process

As standardisation is established in the market place and the product becomes well known to the supply chain, the manufacturing process has the potential to increase the output of building components (such as façade panels, beams, columns etc) such that the productivity of on-site construction assembly is significantly increased.

An increase in the production efficiency and supply of precision manufactured building components, into the market, at less cost, enables faster (and safer) on-site construction productivity. The project cost savings enable a client to recycle capital and reinvest into more projects. This has the potential to create a positive cycle of increased construction productivity and project capacity for all industry participants, particularly manufacturers and construction contractors.

Life Cycle Cost Analysis

An important key component of life cycle cost analysis is determined by cost and quality of materials and workmanship.

There are some reasonable grounds, in MBM's opinion, to support the theory that work taking place in a quality controlled environment, will produce a higher level of quality and workmanship and therefore the likelihood of embedded or superficial defects, and ultimately maintenance cost, is reduced significantly.

In addition, the reduced time on site and lessened exposure to inclement weather, would also dramatically reduce weather sourced defects.

It is MBM's opinion that, with an increasing number of projects adopting off-site manufacturing and prefabrication, a more positive result for all of industry and particularly project cost savings, can be realised.

2 Planning

2.1 Planning System

The planning system takes into consideration research into pedagogy, viability and buildability. This will ensure that all aspects of the system are balanced to offer standardisation, enable flexibility for future pedagogy and maintain areas that do not greatly exceed the current EFSG schedule of areas.

The planning system is composed of two elements; a framework and standardised space types.

The Framework

The planning system is based on a fixed planning and structural framework with internal flexibility

- A fixed grid ensures speed and ease for the design phase as planning and structure are integrated into the grid, allowing a focus on usability, internal flexibility and facade design.
- The standardised planning framework is aligned with the building structure which therefore, enables a 'long life' to the structure and a 'loose fit' to the interior fit-out. Thus the interior fit-out can be adapted over time as required.
- Utilising furniture choices and sliding walls to enable flexibility of room types allows for changing pedagogy and multiple learning environments.
- Providing consistency and clarity of the end product will result in consistent design and building standards which, over time, result in a reduction in cost and time as the design and construction industry develops a greater understanding of the SINSW 'product'.

Standardised Space Types

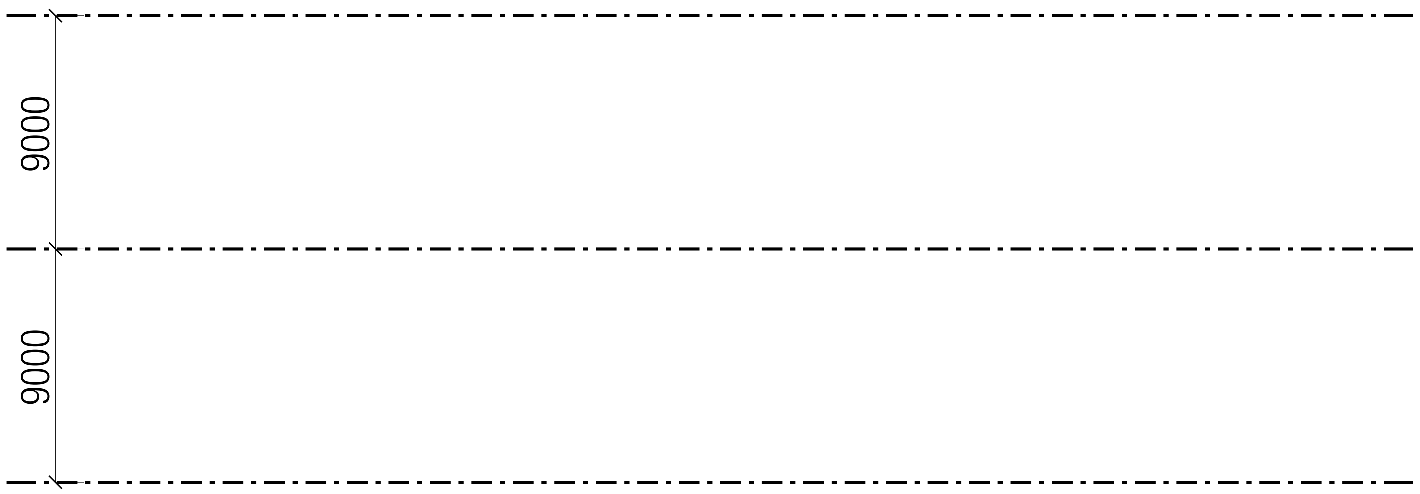
The existing EFSG schedule of areas is converted into standardised space types to fit within the framework.

- Adhering to the current EFSG enables equality and immediate roll-out.
- Flexibility between activity based and traditional learning is maintained.
- The standardised spaces are based on SLEC's four tiers of Zones, Hubs, Neighbourhoods and Schools in order to organise spaces based on functional relationships
- Classrooms are standardised between primary and high school to enable adaptability.

2.2 The Framework

9m Framework

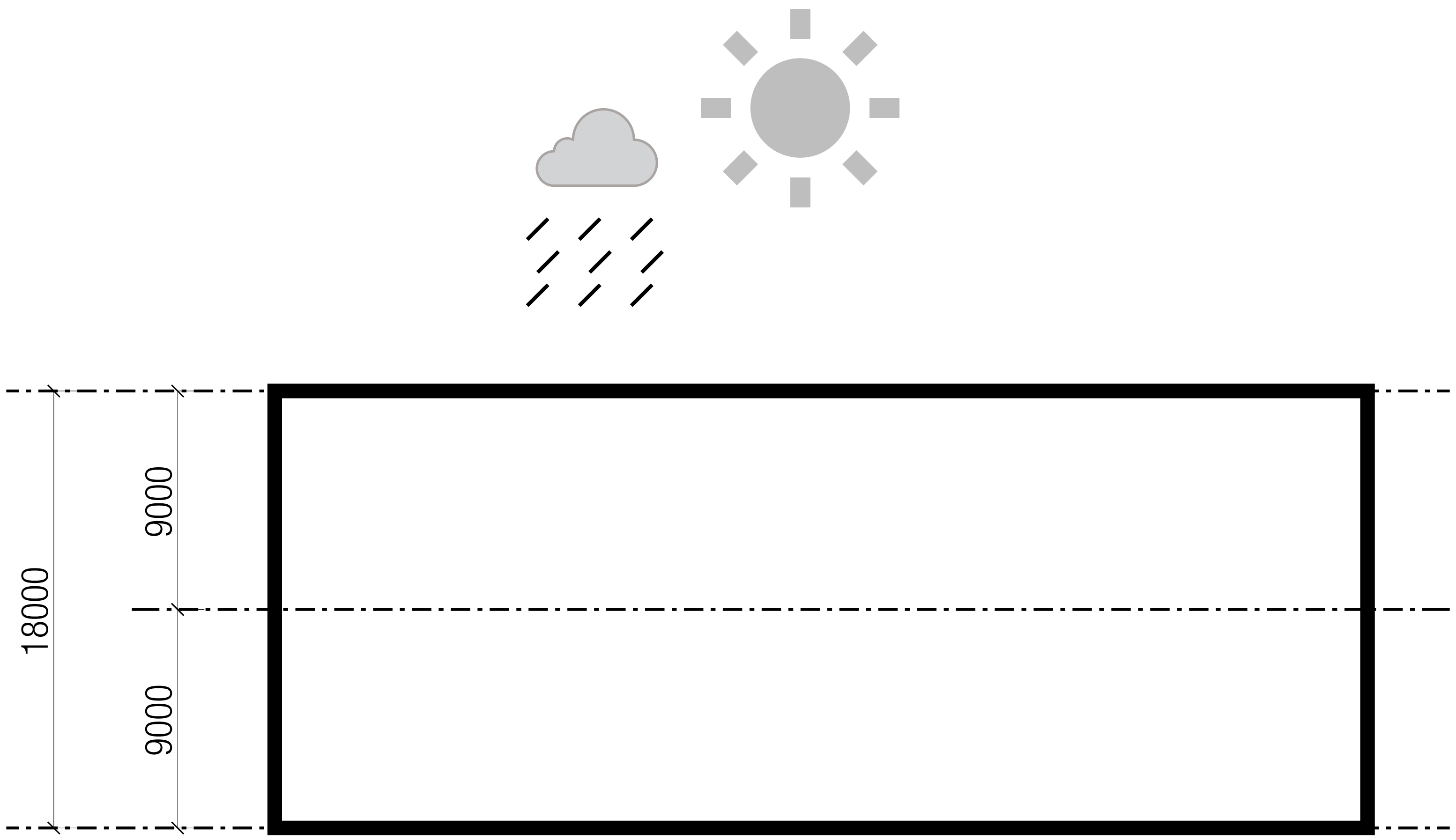
- A consistent 9m framework across all schools sets up the site, ready to receive the educational modules required for each school.
- The 9m framework can be broken down, rotated and dispersed in order to suit site conditions, topography and setbacks.



2.2 The Framework

Facade

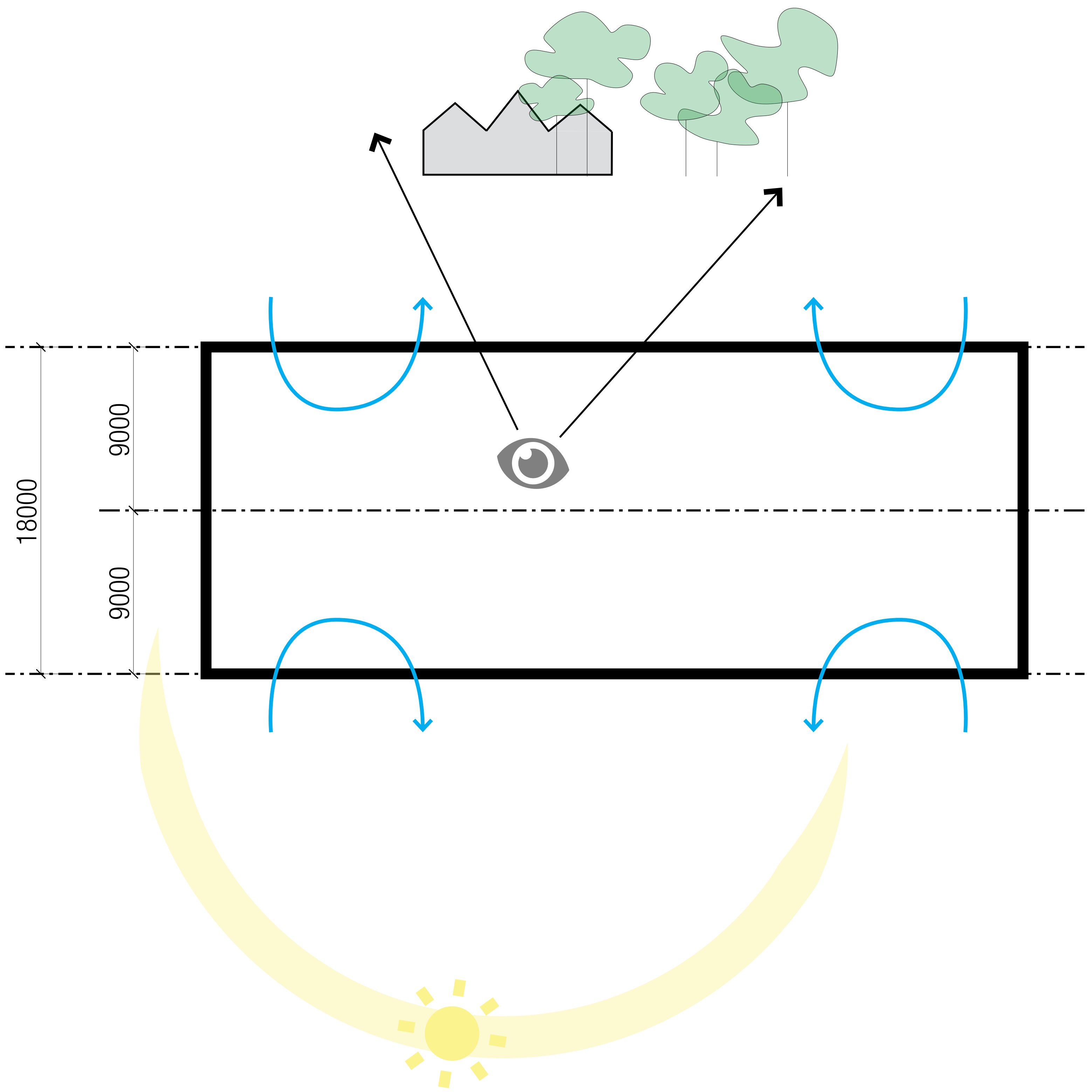
- The facade encloses the 9m grid to create a volume that can be internally manipulated while the exterior remains the same.
- Creating a facade system that sits on the grid allows a consistent system to be generated.



2.2 The Framework

Environment

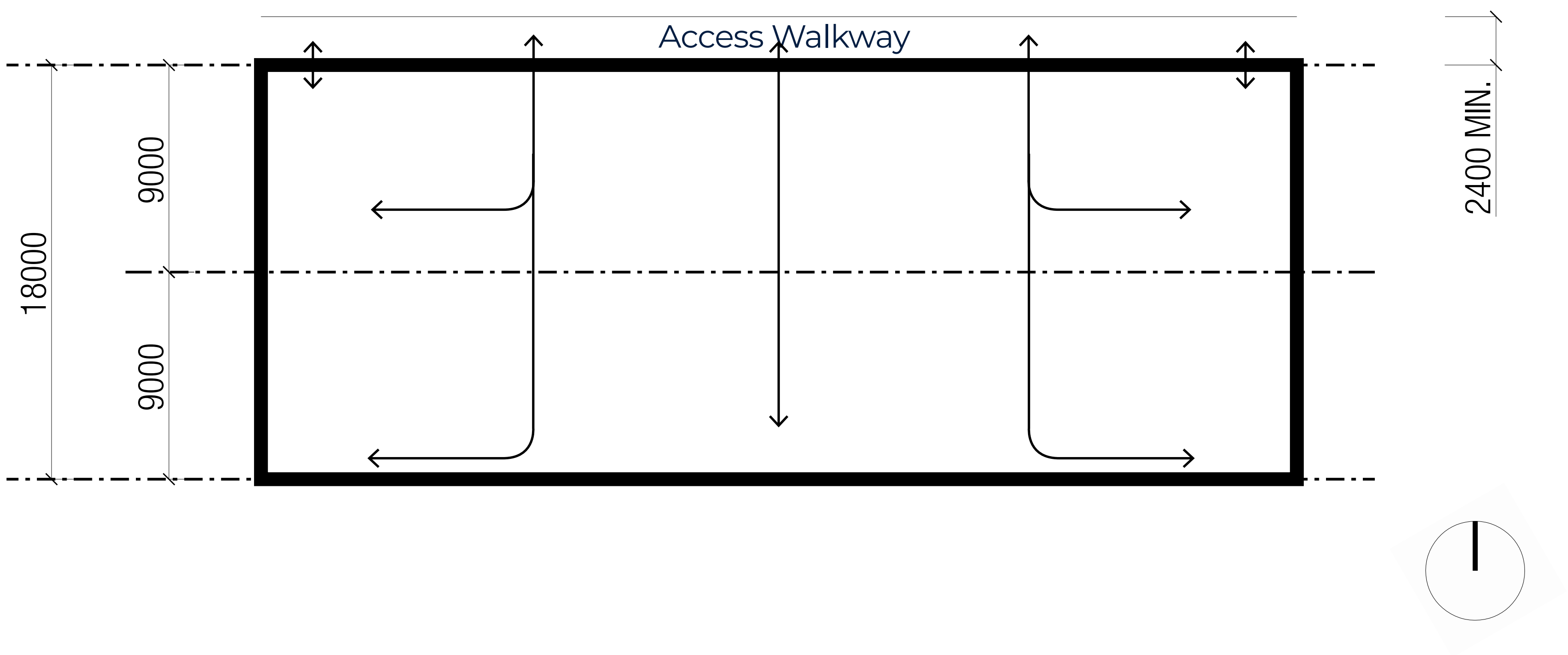
- A consistent building depth of 18m enables engagement with surrounding views, allows natural light to penetrate and natural ventilation throughout.
- Orienting the DfMA design appropriate to its climate and conditions allows better control of environmental factors.
- Orienting the DfMA design according to its cultural context, topographic and built form results better planning outcomes.



2.2 The Framework

Access Walkway

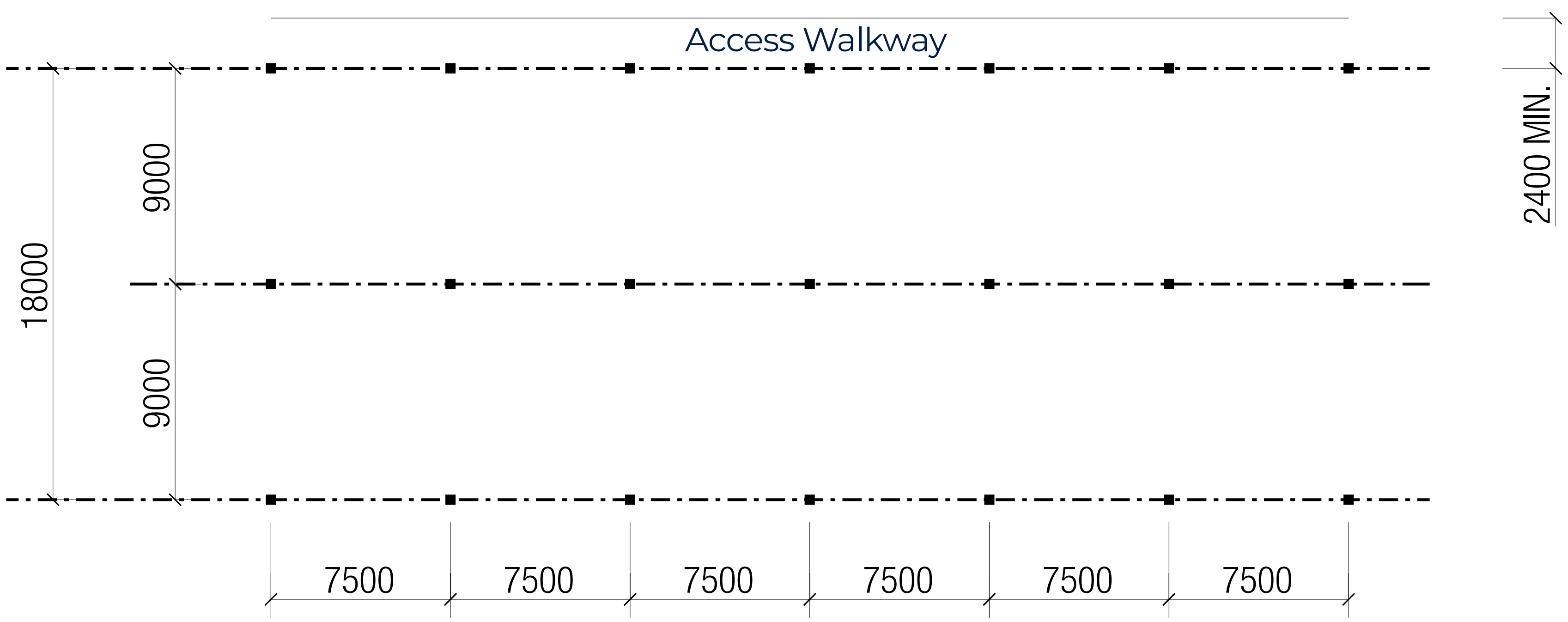
- All space types can be accessed from the external corridor while also maintaining engagement with the environment
- Fire egress can be easily controlled as the building depth is 18m, less than the DTS required maximum 20m to a point of choice.



2.2 The Framework

Structural Grid

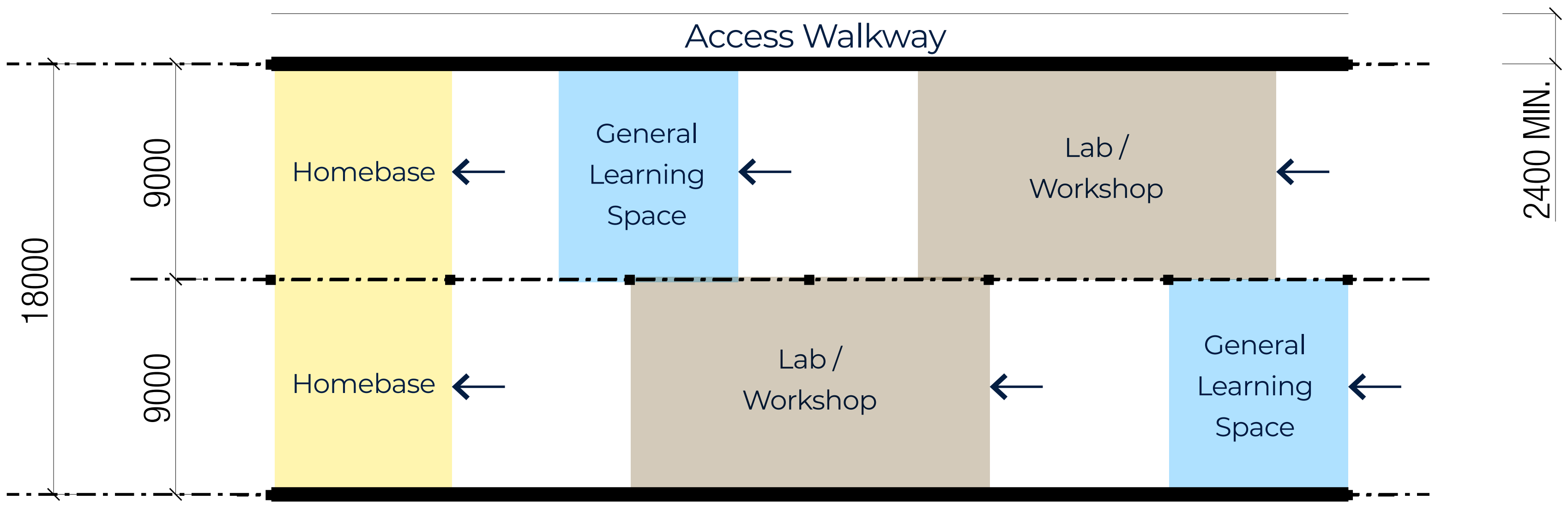
- A series of common structural systems have been considered and can be used to deliver these guidelines.
- A 9m x 7.5m column layout is ideal for construction, and aligns with the 9m framework.
- Other structural solutions can also work on the system, including 9m x 9m.



2.2 The Framework

Standardised Space Types

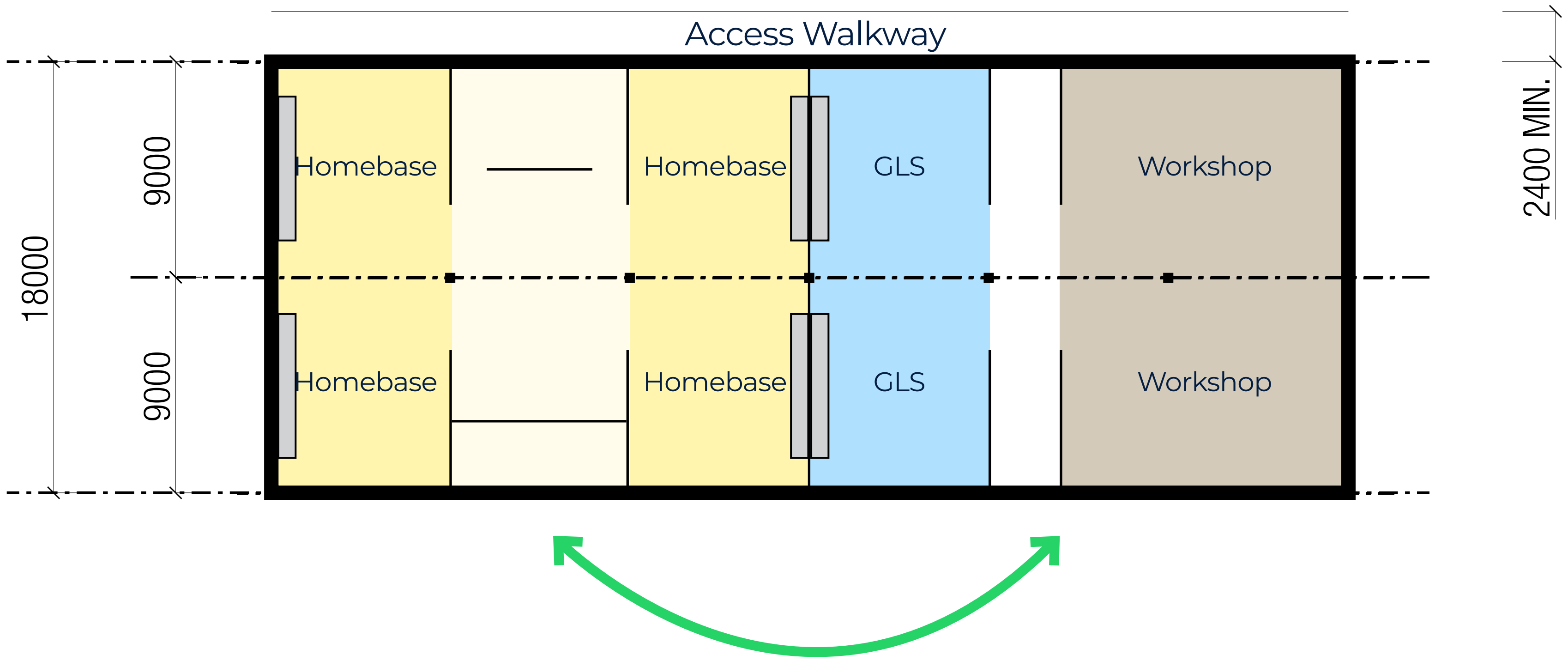
- The existing EFSG Schedule of Accommodation identifies different space types required. The planning system has standardised these space types to fit within the 9m framework.
- Al space types can be arranged within the 9m framework as required.
- By standardising space types, future flexibility is enabled as spaces can be interchanged and replaced as pedagogy and school requirements change over time.



2.2 The Framework

Internal Walls and Joinery

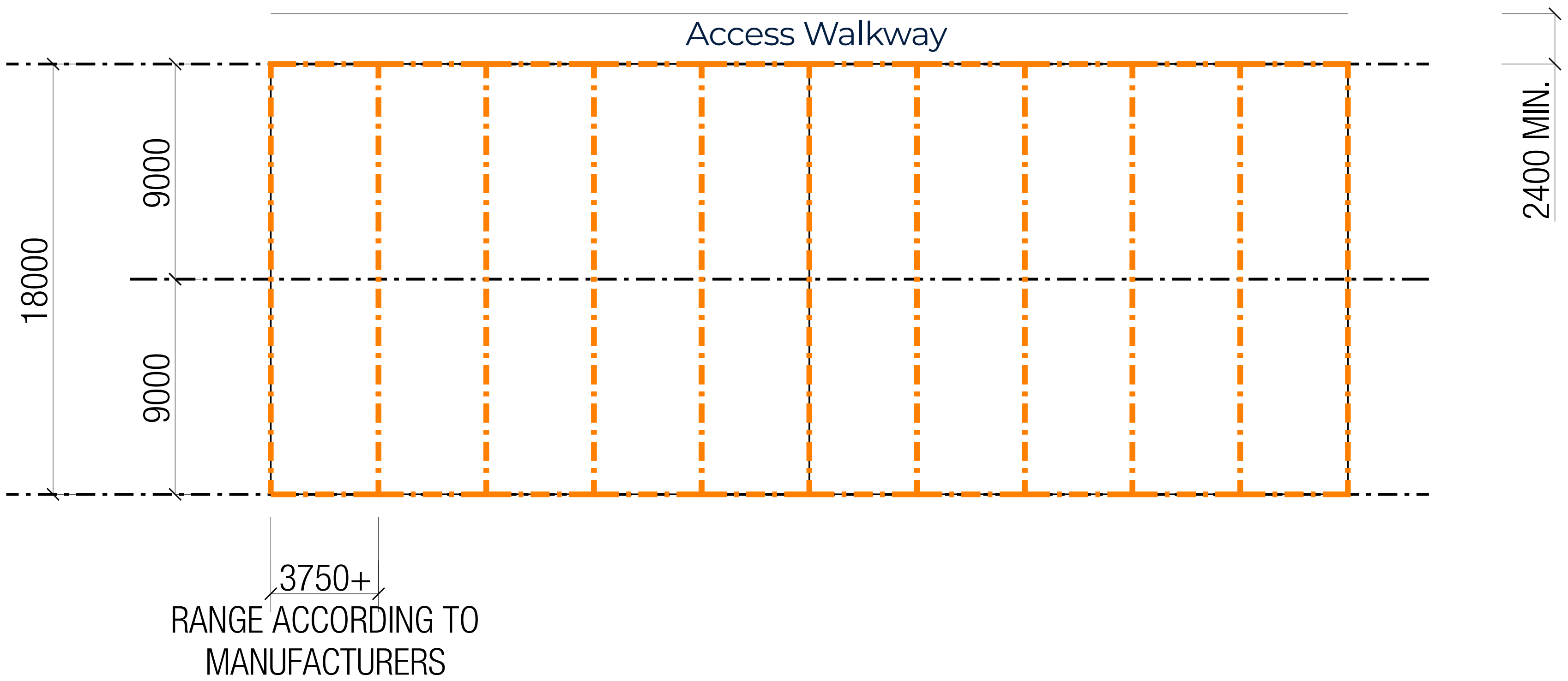
- The fixed facade location at the edge of the 9m framework allows internal walls and joinery to be placed anywhere on the 1.5m planning to identify different space types.
- Future flexibility is enabled with the ability to easily remove and replace internal walls to suit the new space type area requirements.
- Joinery can also be disassembled and replaced to suit new space type requirements.
- Future flexibility is enabled by standardising all space types to sit on the 9m framework.



2.2 The Framework

Volumetric Layout

- Using Volumetric construction breaks the grid into modules with a desirable size for manufacture and transportation.
- Maintaining a consistent framework between construction methods means equity between schools.



2.2 The Framework

4.2m Vertical Framework

- A standard height of 4.2m is required per level to accommodate all common types of structural materials and to incorporate all services and standard details. Further details are provided in chapter 3 components and chapter 4 structure performance, services performance sections.

- A minimum internal height of 2.7m is required for all learning spaces

- A majority of schools in NSW are between 1 - 3 storeys, making them Class A buildings. The site should be planned so as to maintain this standard.

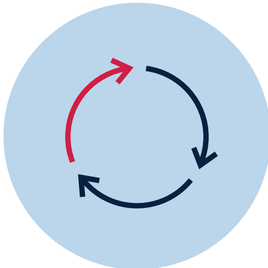
2.3 Standardised Space Types

The Standardised Space Type Principles

Pedagogy First

Equity

Flexibility



Modularity

2.3 Standardised Space Types

Space Type Requirements

- Each school contains required space types.
- The EFSG Schedule of Areas lists space types required and the number of spaces needed.
- The numbers required per space type are based on either the Stream or Core size.

Learning Spaces

- The Standardised Space Types are based on the current EFSG Schedule of Areas.
- The learning spaces have been grouped into hubs in order to collect spaces together that have specific proximity requirements.
- By creating standardised hubs that can be placed on the 9m framework and 1.5m planning grid, schools can be designed efficiently, quickly and enable future flexibility.

Other Spaces

- Other space types are required for both primary and high school. The units contained in the space types to the right have been grouped.
- The other spaces contain units that are flexible depending on the required areas as per the EFSG Schedule of Areas.
- The layouts in the document for these areas are suggestions only, as the spaces are flexible depending on site requirements.

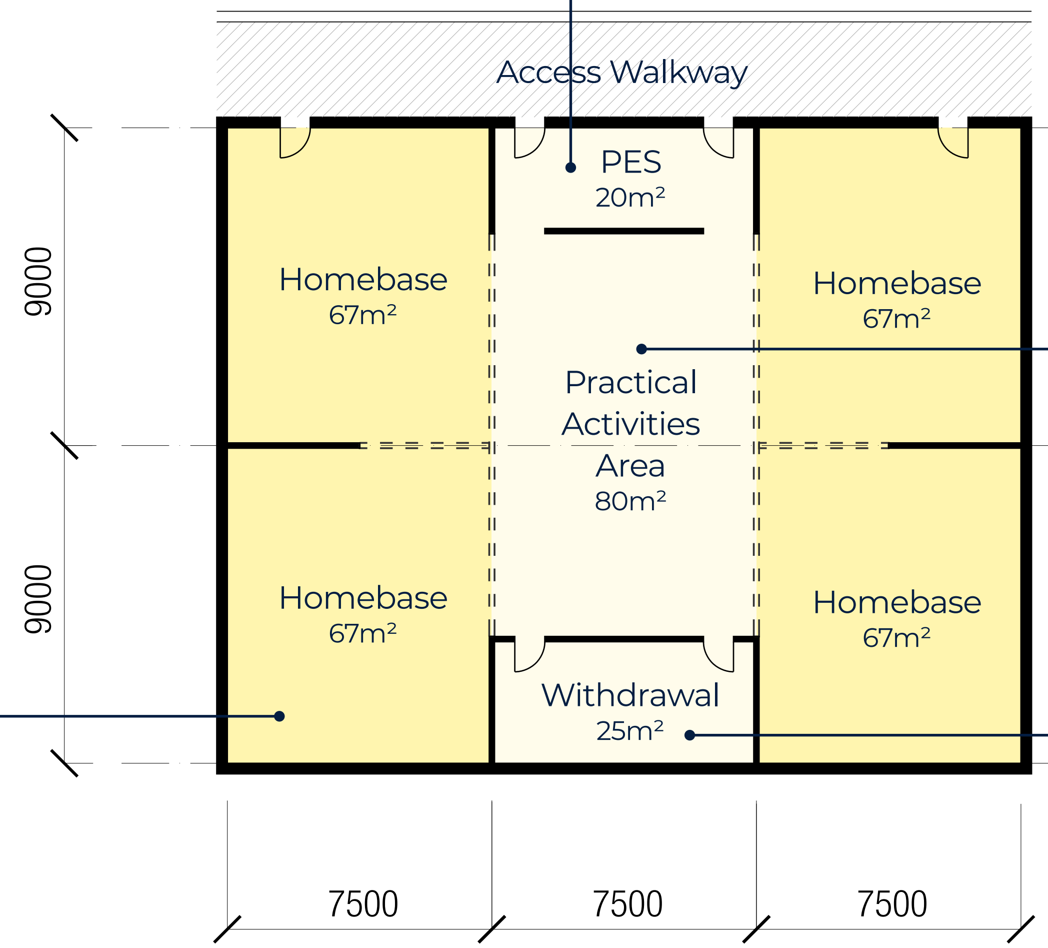
	Primary School	High School
Learning Spaces	Homebase Shared Practical Activities Area / Personal Effects Storage / Withdrawal Room	GLS Shared Learning Space / Seminar Room / Lecture Workshop / Lab Specialist unit specific stores and supporting spaces.
Other Spaces	Sports & Performance Unit / Canteen Unit / Covered Outdoor Space / OSHC Library Unit / Special Programs Unit (Primary School) Staff Unit / Administration Unit Student Amenities / Storage Unit / Comms	

2.3 Standardised Space Types

Standardised Hub of 4 - EFSG Space Requirements

- Homebases, GLS and SELU classrooms have been standardised into a hub of 4 for stackability, adaptability, equality.
- The hub of four has been created to incorporate all spaces required in the EFSG schedule of areas.
- The spaces included in the hub of 4 can be interchanged depending on the project specific requirements and brief.

The EFSG asks for 3m² of Personal Effects Storage per Homebase. The Hub of 4 creates a zone for PES that can be interchanged with an air lock in colder zones.



Homebase Room Area Layout

The EFSG requires 17m² for a Practical Activities Area for each Homebase. The Hub of 4 creates a central PAA zone that has the ability to open up between the 4 Homebases and adapt to different learning and teaching modes.

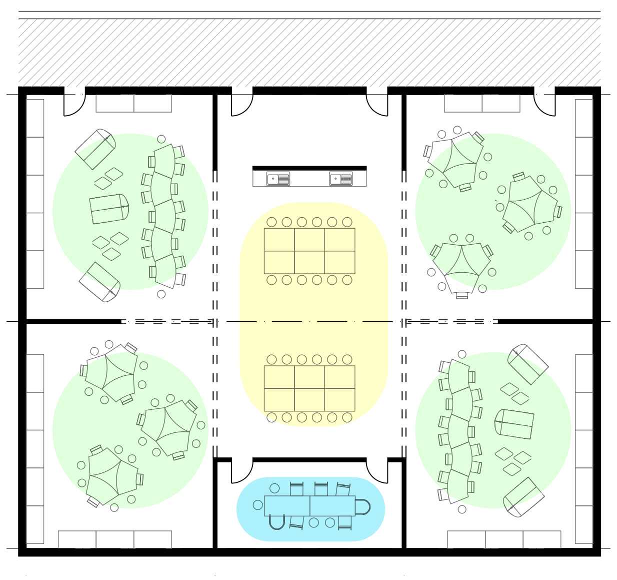
The EFSG requires 12m² for a shared Withdrawal Room between two Homebases. The Hub of 4 creates a Withdrawal Room for 4 Homebases which can be interchanged with a High School seminar room, a specialist store room or an outdoor space.

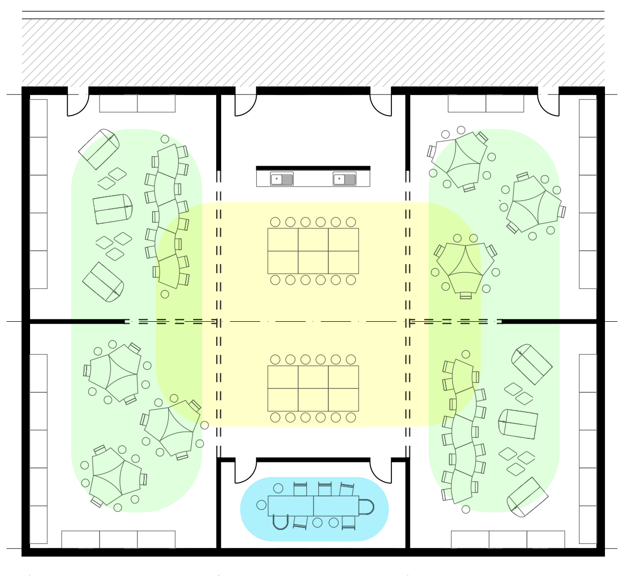
The EFSG requires 60m² for a Homebase and 6m²for store. The areas have been combined with storage being integrated into the storage elements. The Homebase and storage can be interchanged with a GLS or a Special Education Learning Classroom.

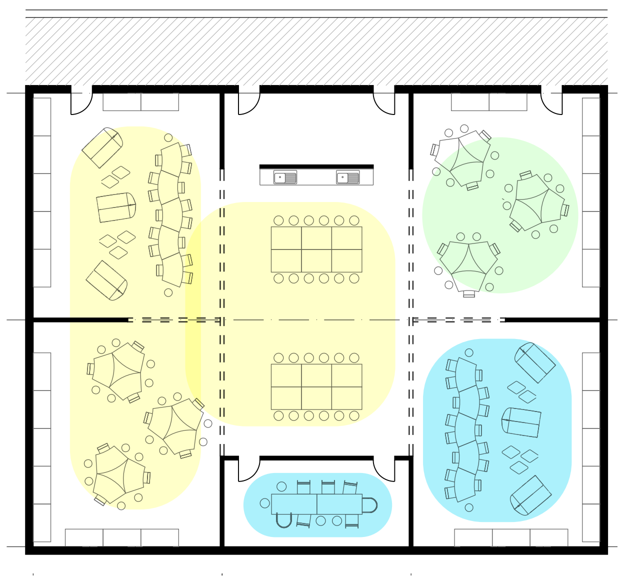
2.3 Standardised Space Types

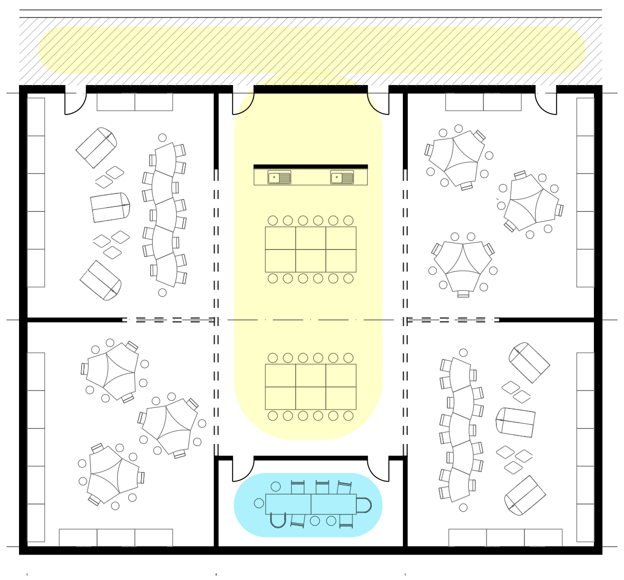
Standardised Hub of 4 - Flexible Pedagogy

- The Hub of 4 allows multiple learning modes to be activated.
- The adjustable walls through out and the different sized spaces allow the space to be customized.









Instructed Learning

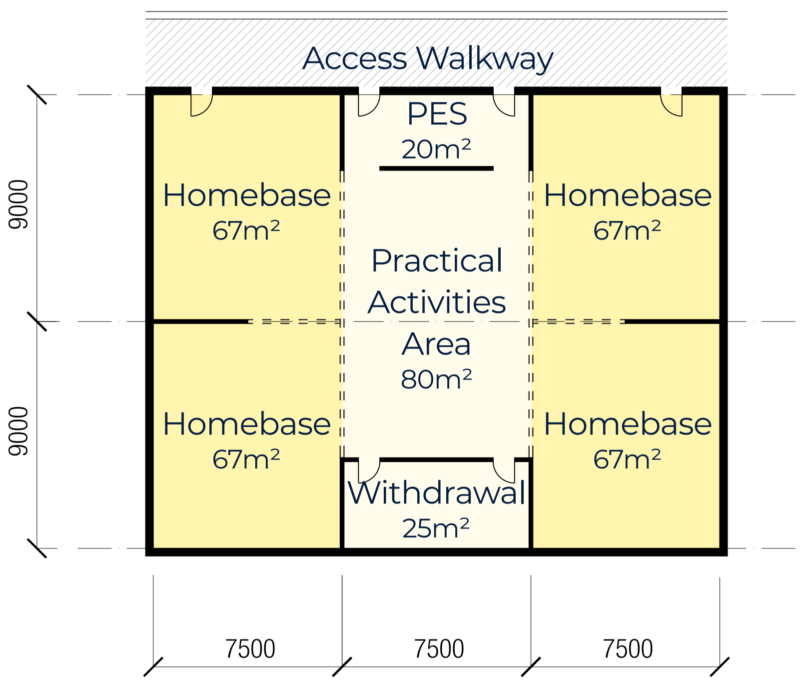
Active Learning

Focussed Learning

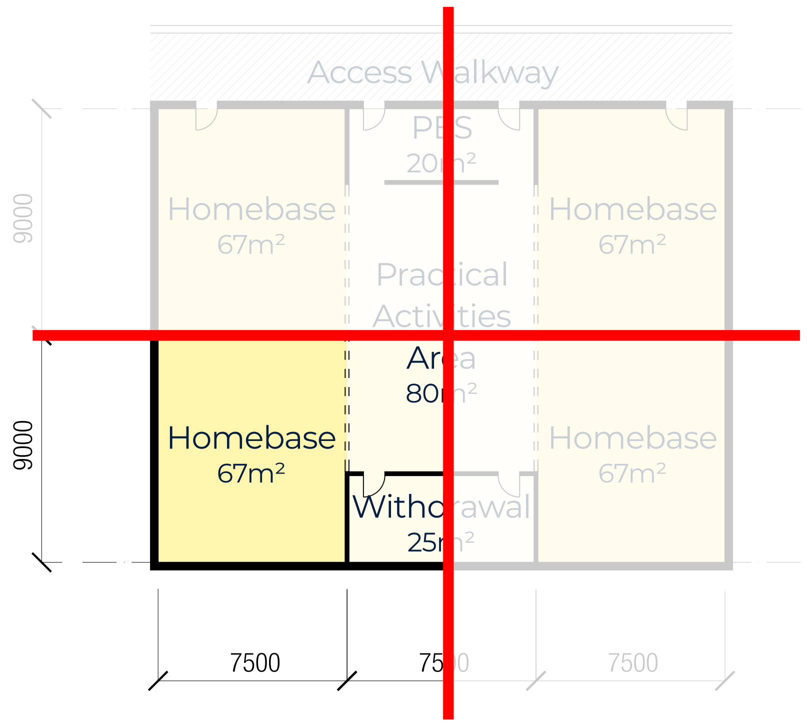
2.3 Standardised Space Types

Linear Hub

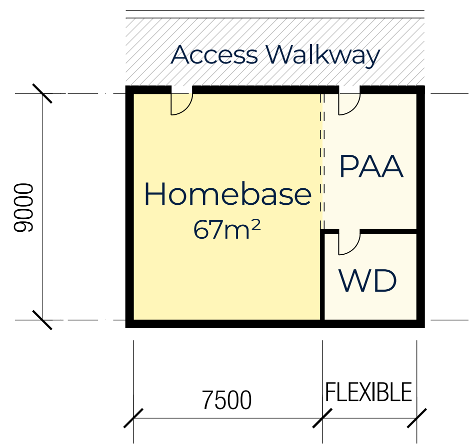
- In some circumstances the hub of 4 may not be appropriate due to site conditions, or when doing an infill project where a specific number of learning spaces are required. The linear hub can be used for these projects.



Homebase Hub Area Layout



Subdivide the Hub of 4

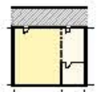
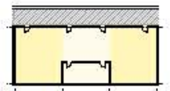
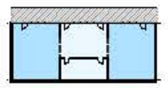
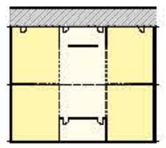
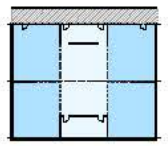
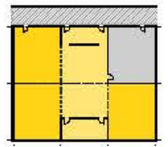


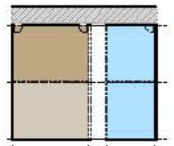
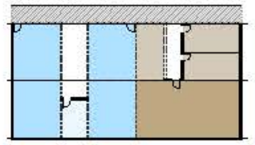
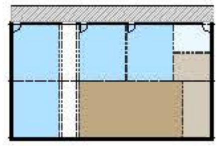
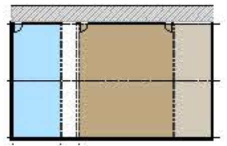
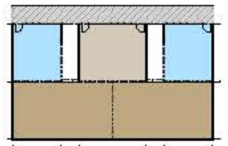
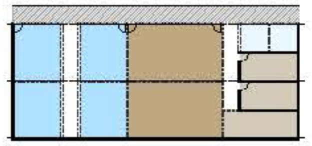
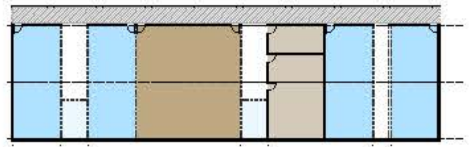
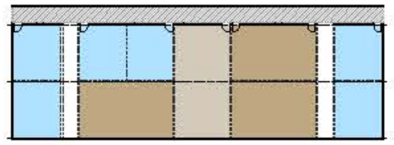
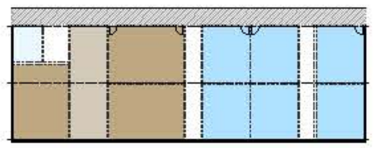
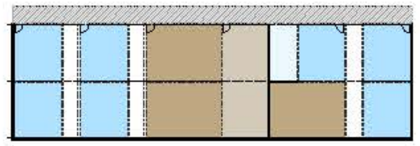
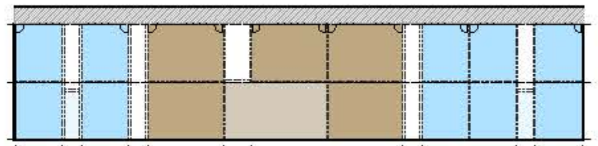
1 x Linear HB Room Area Layout

2.3 Standardised Space Types

Hub Menu

The Hub Menu contains all the standardised hub types that fit onto the 9m framework to satisfy all the learning space requirements for primary and high school.

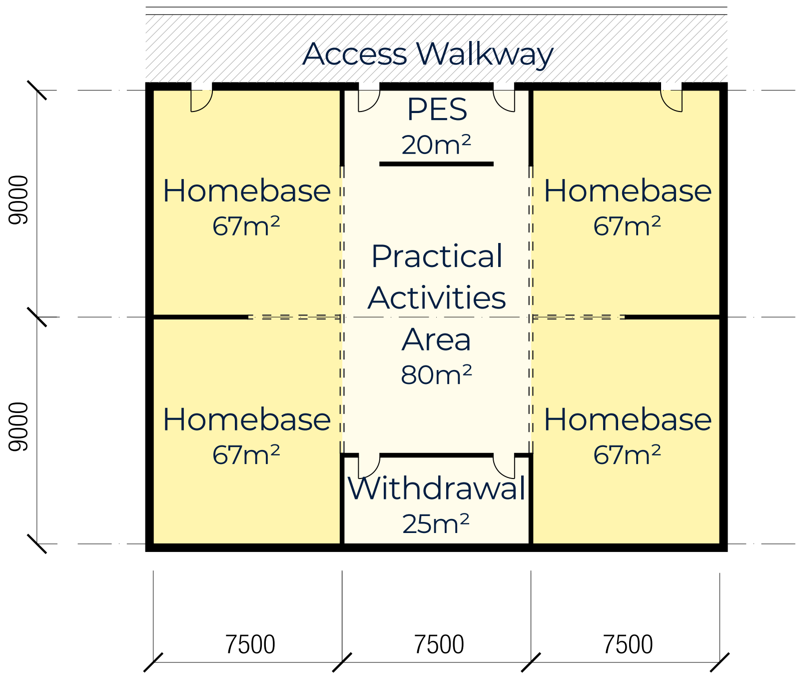
Classroom Hubs			
Hub of 1			
Hub of 2			
Hub of 4			

High School Specialist Hubs		
1 Lab & 2 Classrooms		
1 Lab & 4 Classrooms		
2 Labs & 2 Classrooms		
2 Labs & 4 Classrooms		
2 Labs & 8 Classrooms		
3 Labs & 6 Classrooms		
3 Labs & 7 Classrooms		
5 Labs & 10 Classrooms		

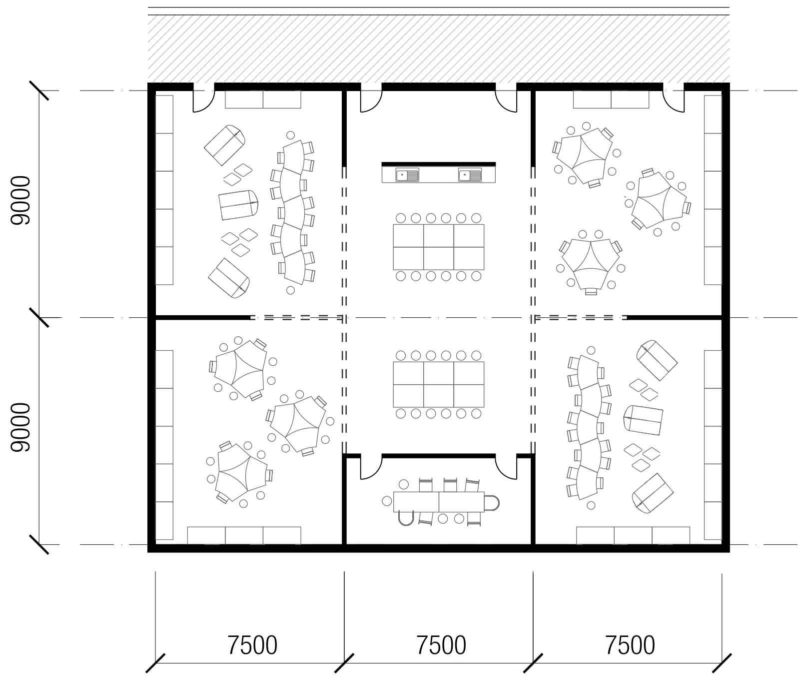
2.3 Standardised Space Types

Homebase Hub of 4

- 4 Homebases
- Shared Practical Activities Area
- Shared Withdrawal Room
- Personal Effects Storage



Homebase Room Area Layout



Homebase Furniture Layout

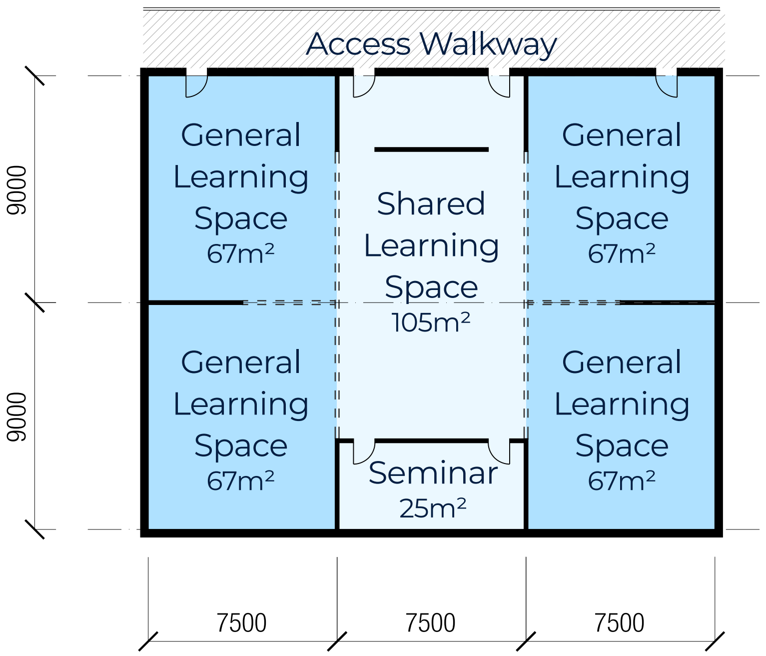
PES Personal Effects Storage
Homebase (Classroom)
Support Space
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

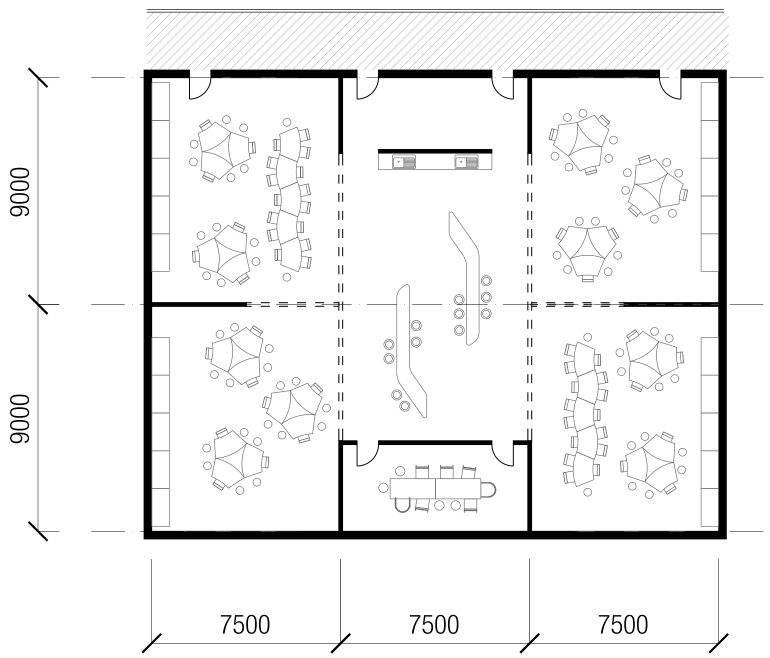
2.3 Standardised Space Types

GLS Hub of 4

- 4 GLS
- Shared Learning Space
- Shared Seminar Room



GLS Room Area Layout



GLS Furniture Layout

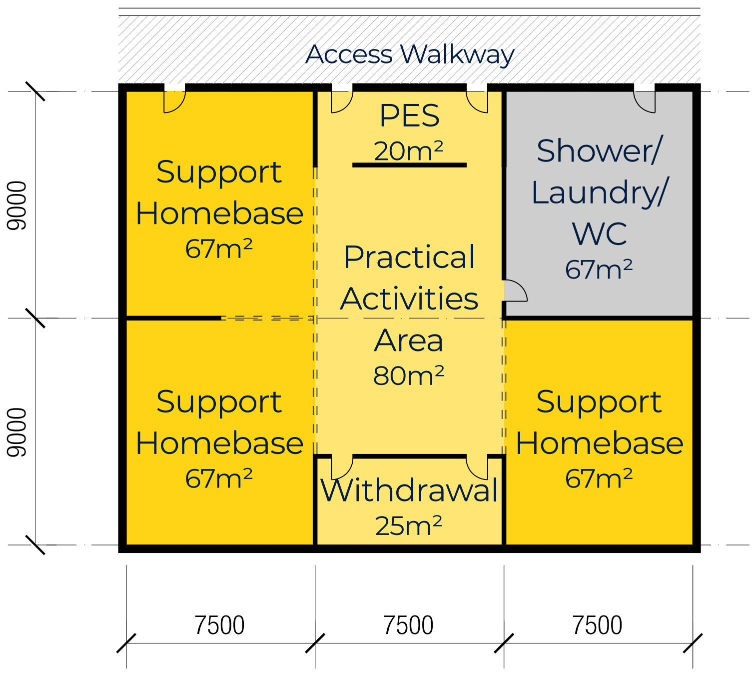
General Learning Spaces
Support Spaces
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

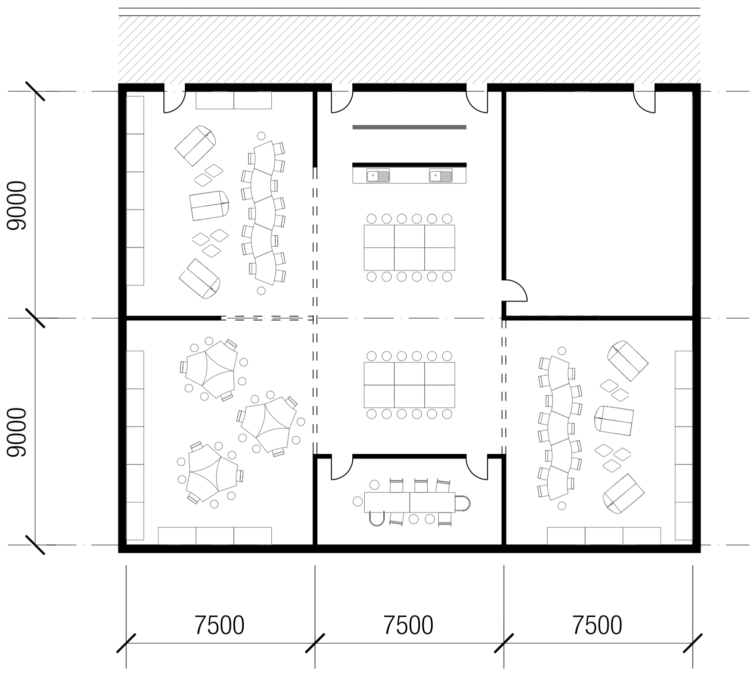
2.3 Standardised Space Types

SELU Hub of 4

- The SELU module uses the standardised hub of 4 to maintain equity across learning spaces, and also allow future flexibility.
- The SELU hub contains a WC and shower zone in place of a learning space to provide the unit with direct access.



SELU Room Area Layout



SELU Furniture Layout

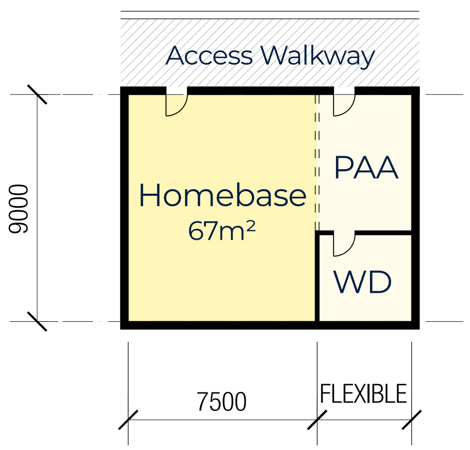
WC	Water Closet
PES	Personal Effects Storage
(yellow)	Support Homebase (Classroom)
(light yellow)	Support Space
- - - -	Grid
▬▬	Fixed Wall
------	Adjustable Wall

1:300 @ A3

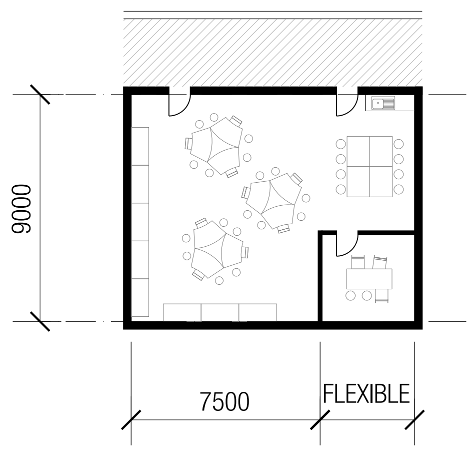
2.3 Standardised Space Types

Linear Learning Hub

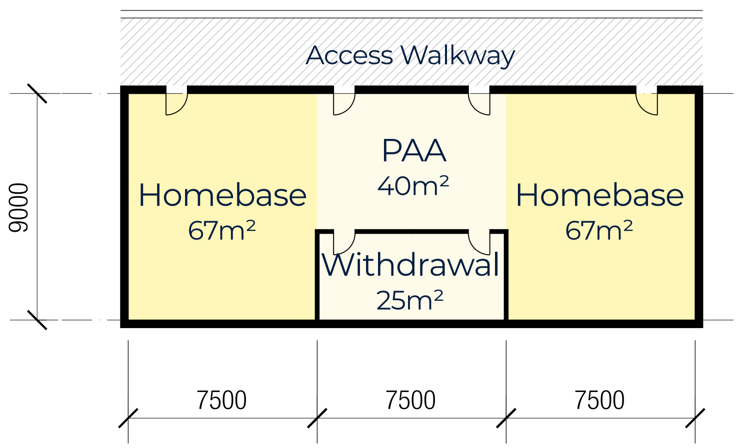
- The modules of 1 and 2 learning spaces with accompanying support spaces, can be mirrored and duplicated to form any amount of learning spaces.



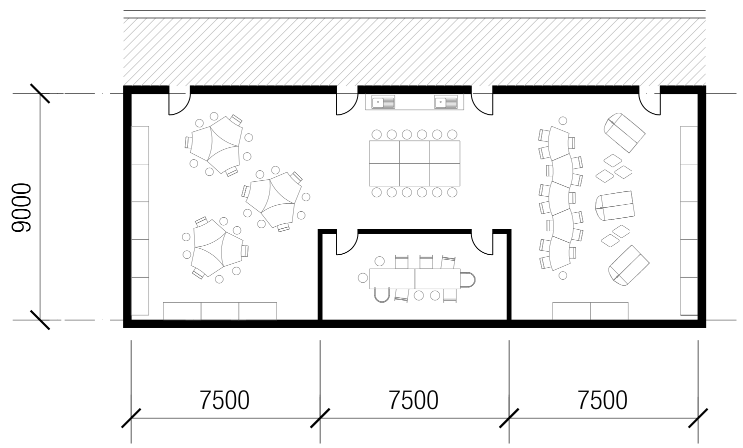
1 x Linear HB Room Area Layout



1 x Linear HB Furniture Layout



2 x Linear HB Room Area Layout



2 x Linear HB Furniture Layout

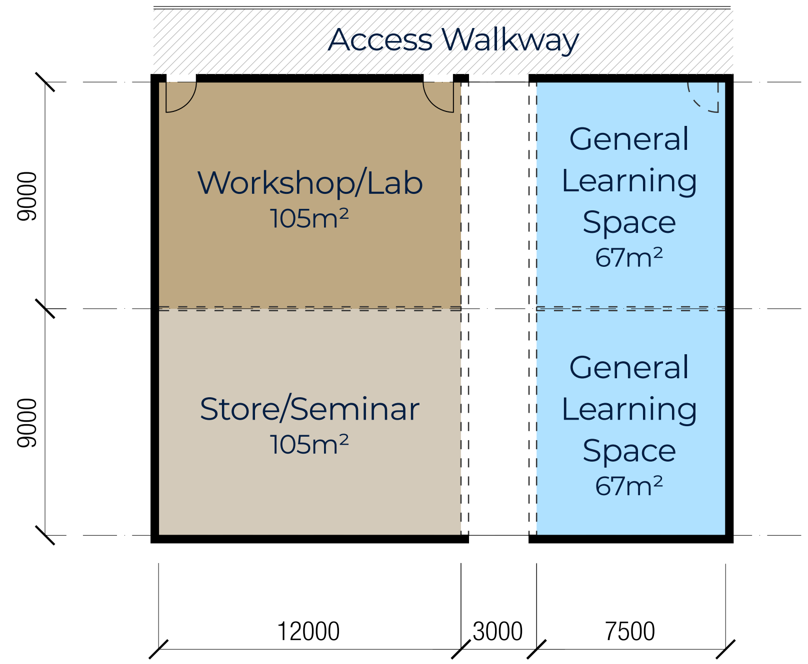
WD	Withdrawal Room
PAA	Practical Activities Area
	Homebase (Classroom)
	Support Space
----	Grid
	Fixed Wall
------	Adjustable Wall

1:300 @ A3

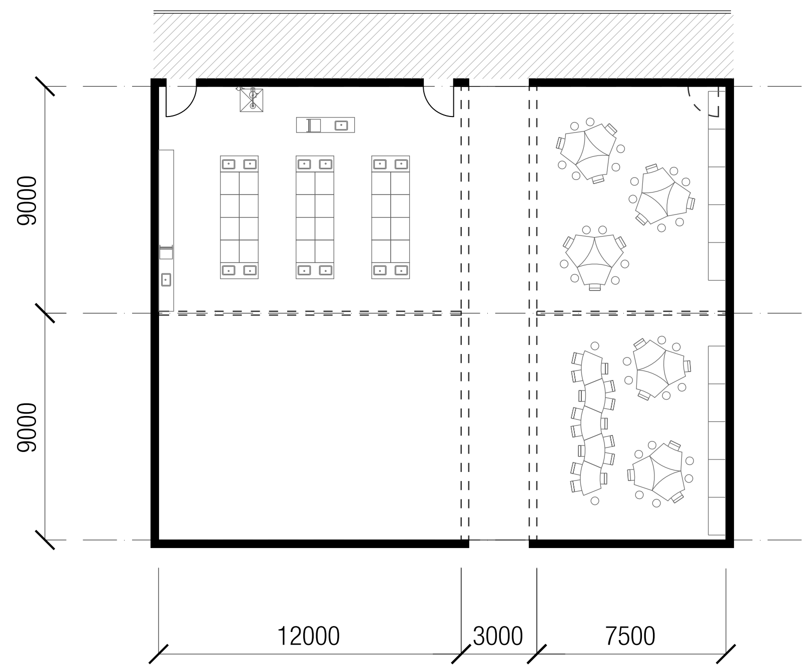
2.3 Standardised Space Types

Specialist Space Type

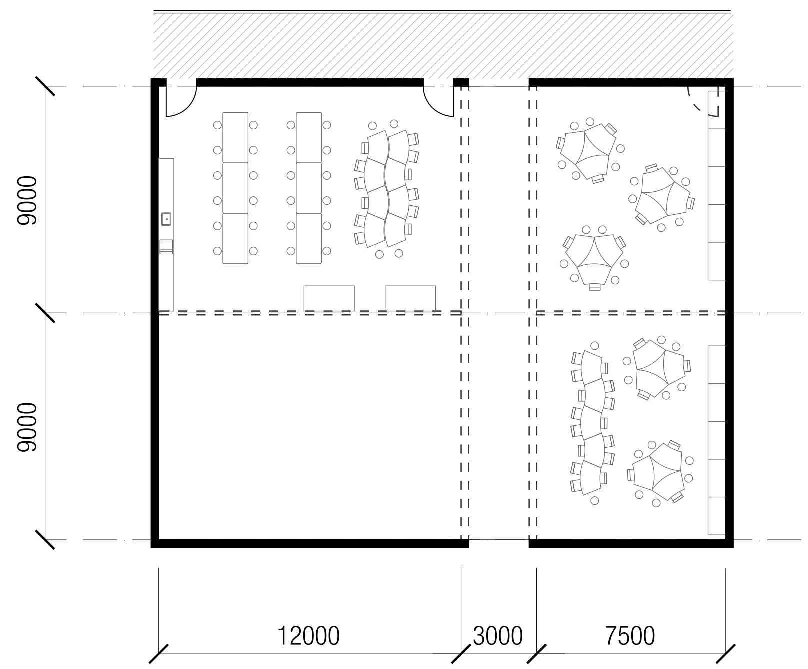
- 2 x General Learning Spaces
- 1 x Specialist Workshop/Lab



Single Specialist Room Area Layout



Single Science Furniture Layout



Single Visual Arts Furniture Layout

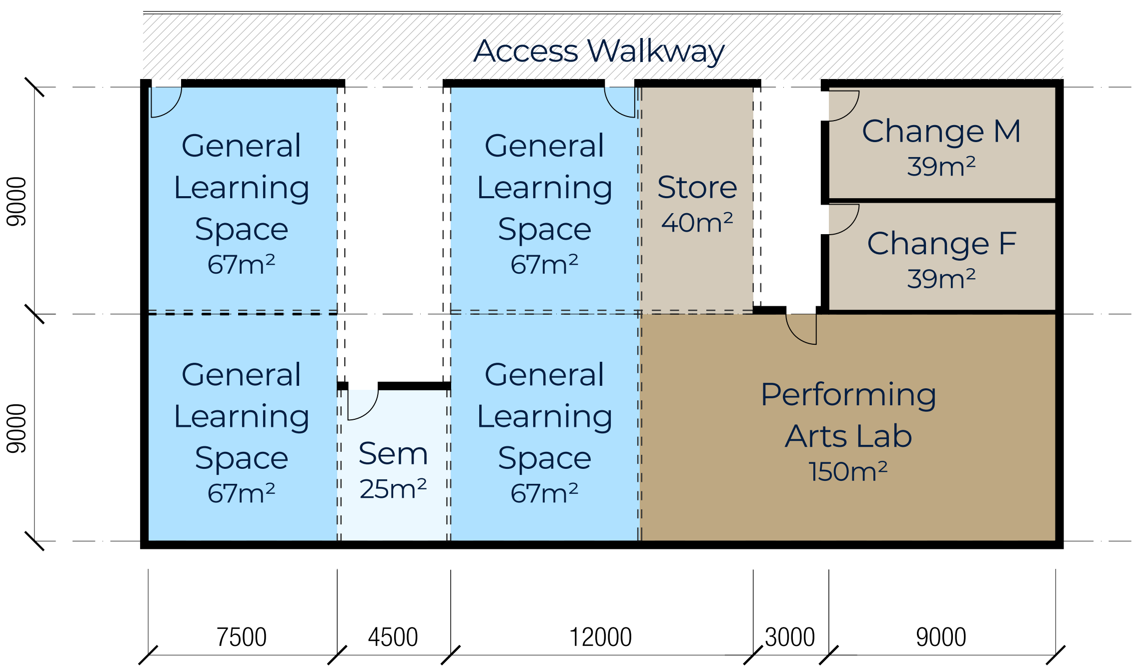
General Learning Space (Classroom)
Workshop/Lab
Store/Seminar Room
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 1 x Performing Arts Lab



Performing Arts Room Area Layout

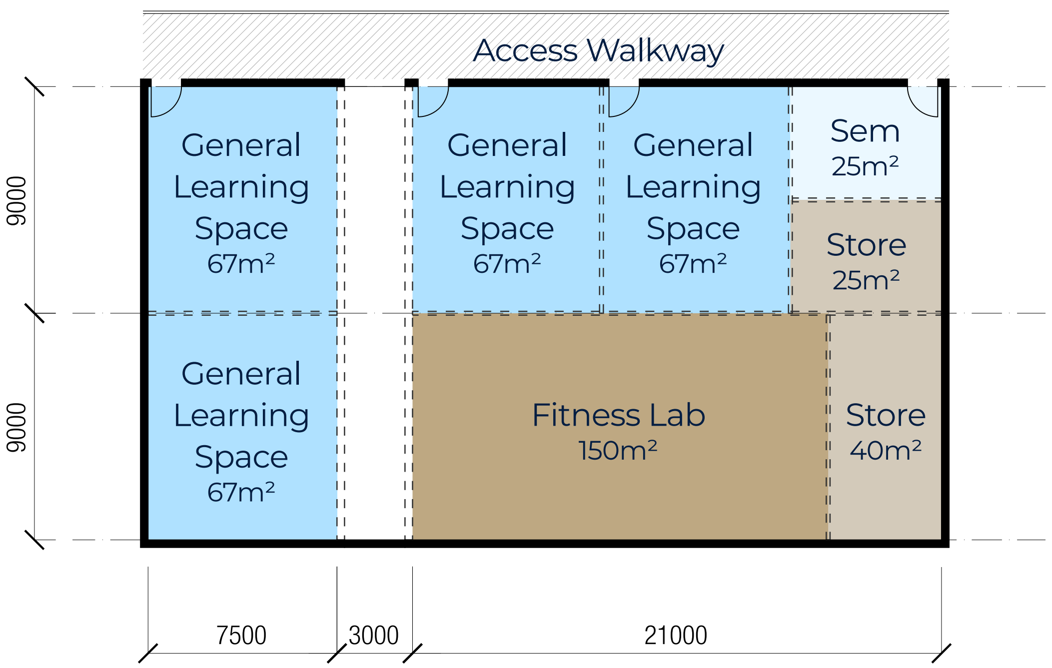
Sem	Seminar Room
	General Learning Space (Classroom)
	Workshop/Lab
	Store/Change Room
	Seminar Room
----	Grid
	Fixed Wall
------	Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 1 x Fitness Lab



Fitness Room Area Layout

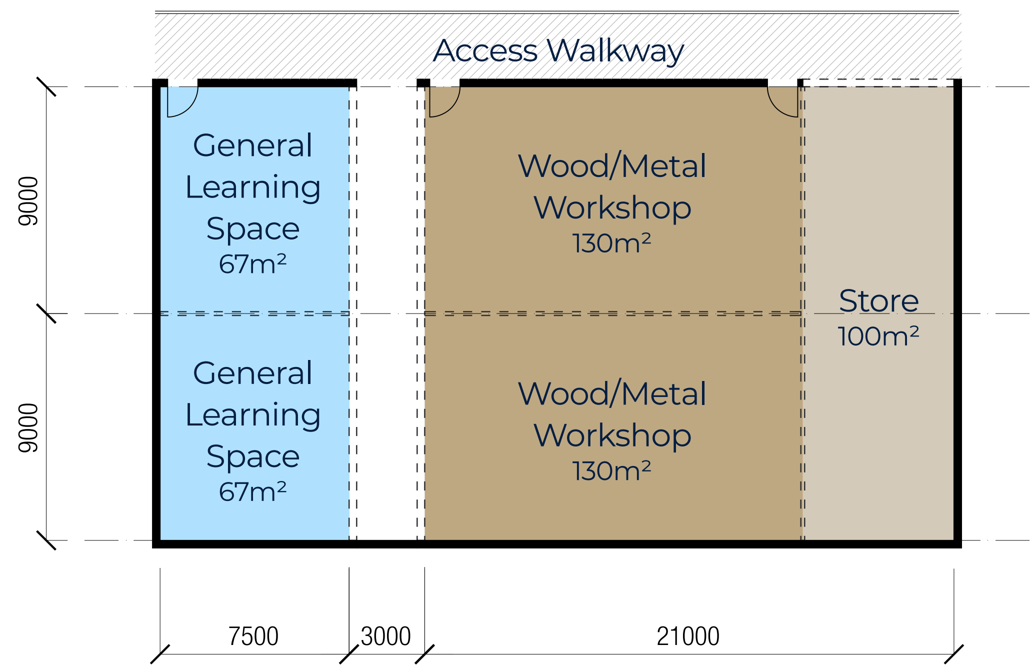
Sem	Seminar Room
	General Learning Space (Classroom)
	Workshop/Lab
	Store/Prep Room
	Seminar Room
----	Grid
	Fixed Wall
------	Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 2 x General Learning Spaces
- 2 x Workshop



Wood/Metal Workshop Room Area Layout

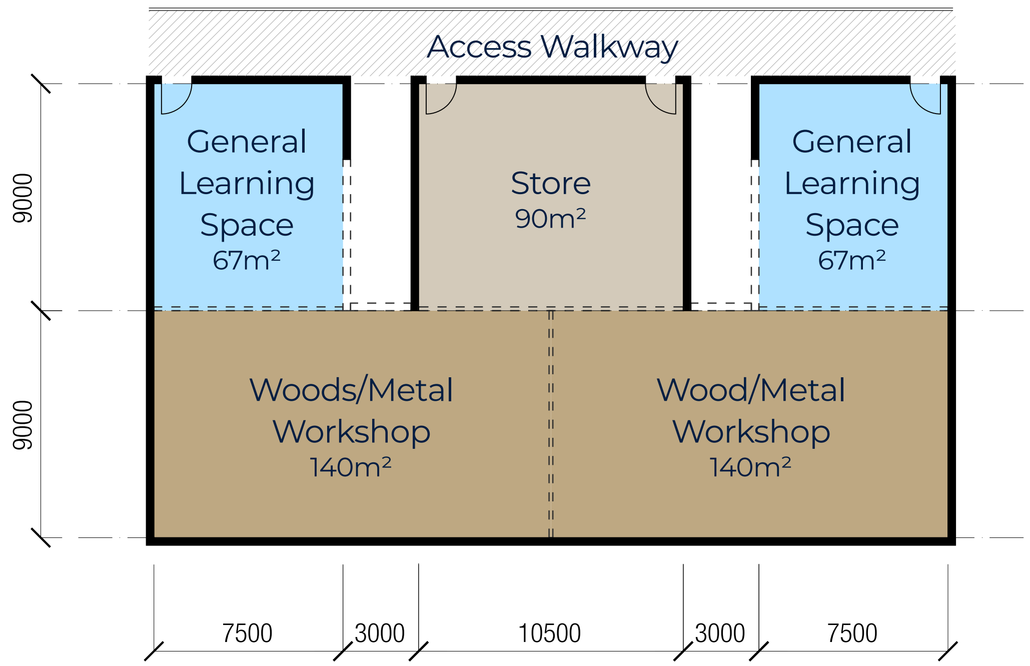
	General Learning Space (Classroom)
	Workshop/Lab
	Store/Prep Room
----	Grid
▬	Fixed Wall
------	Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 2 x General Learning Spaces
- 2 x Workshop



Wood/Metal Workshop Room Area Layout

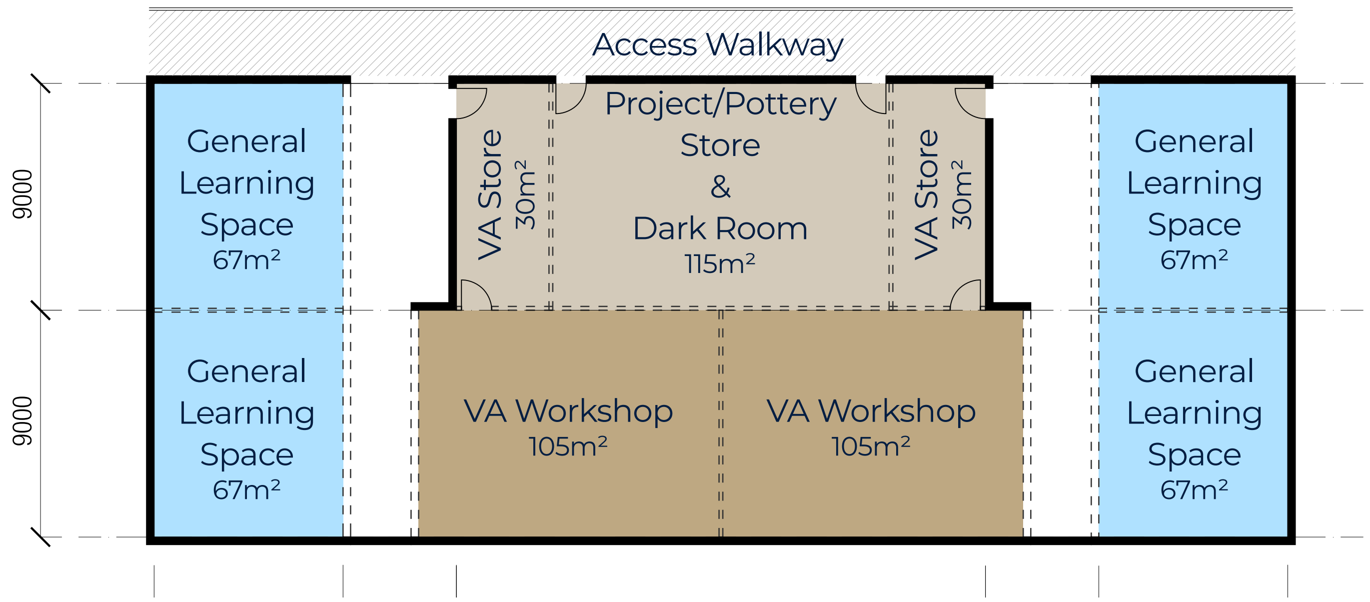
General Learning Space (Classroom)
Workshop/Lab
Store/Prep Room
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 2x Visual Arts Workshops



Visual Arts Room Area Layout

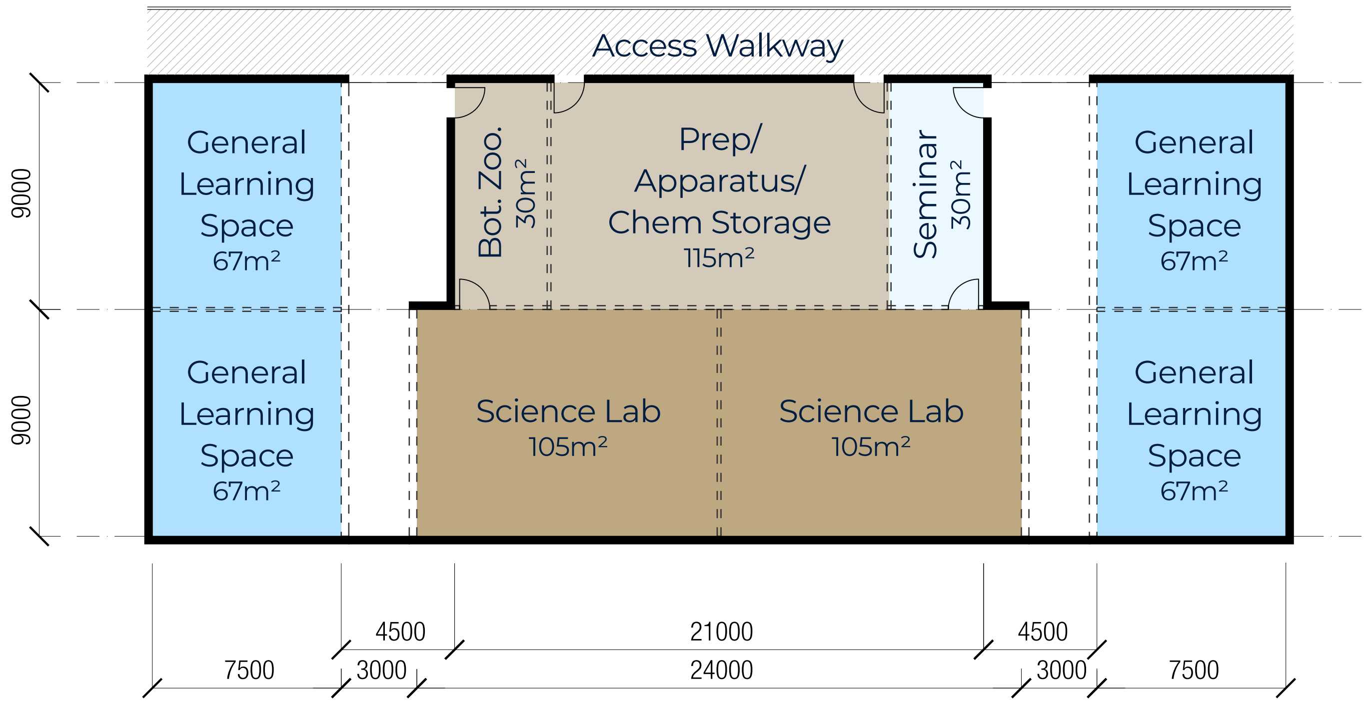
VA	Visual Arts
(light blue)	General Learning Space (Classroom)
(brown)	Workshop/Lab
(beige)	Store/Seminar Room
----	Grid
(thick line)	Fixed Wall
------	Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 2 x Science Labs



Science Room Area Layout

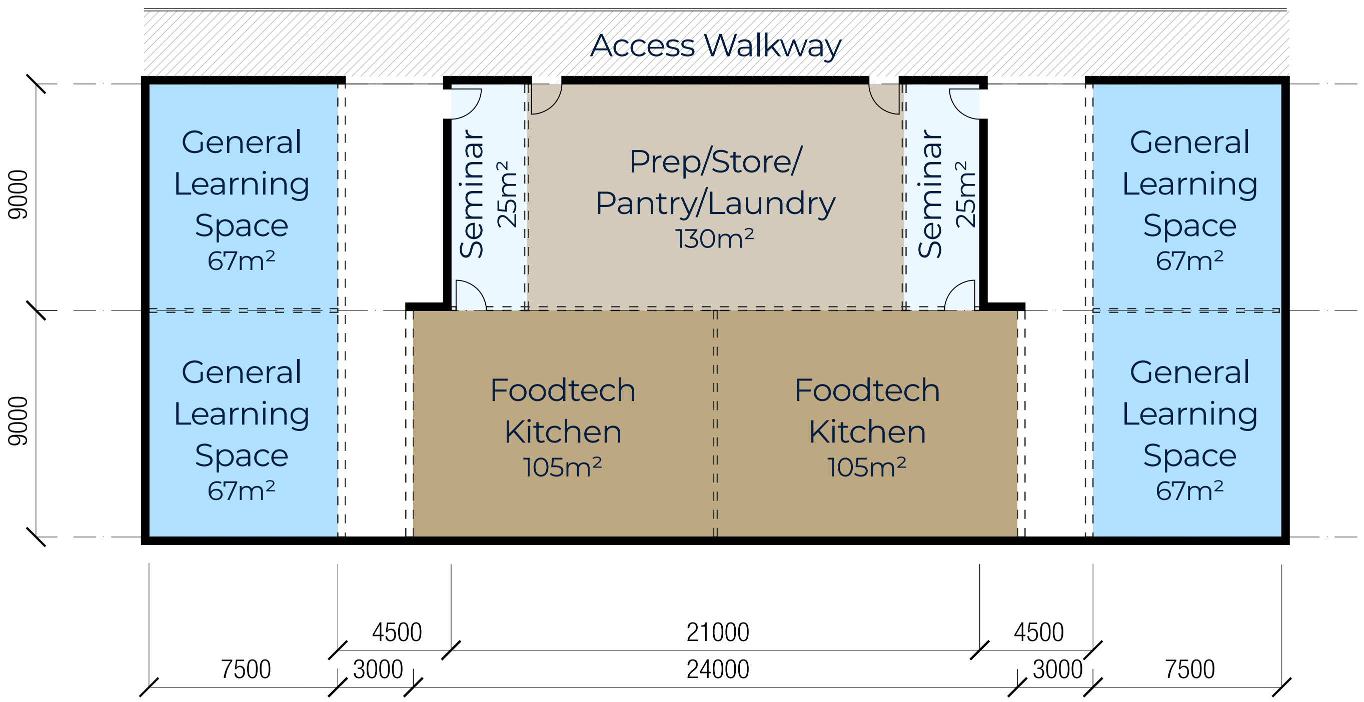
- General Learning Space (Classroom)
- Workshop/Lab
- Store/Prep Room
- Seminar Room
- Grid
- Fixed Wall
- Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 2 x Foodtech Kitchens



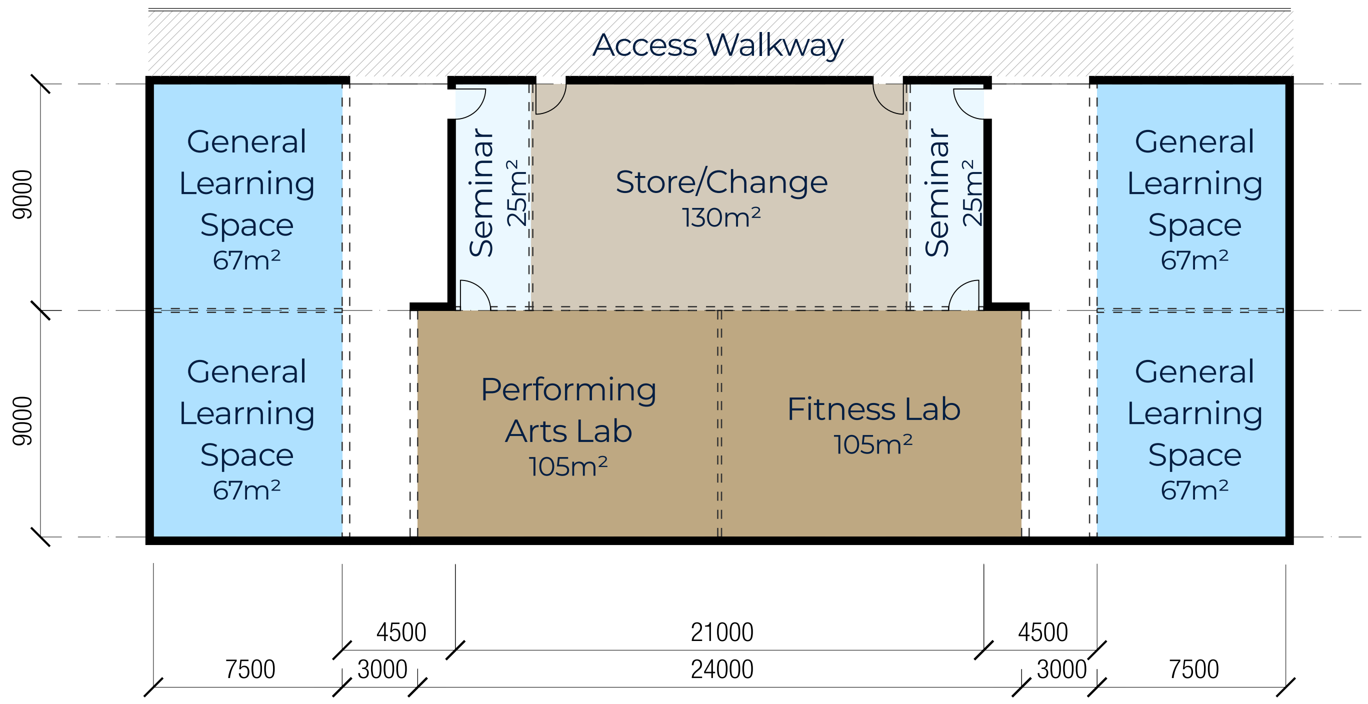
Foodtech Room Area Layout

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 1 x Performing Arts Lab
- 1 x Fitness Lab



Performing Arts/Fitness Room Area Layout

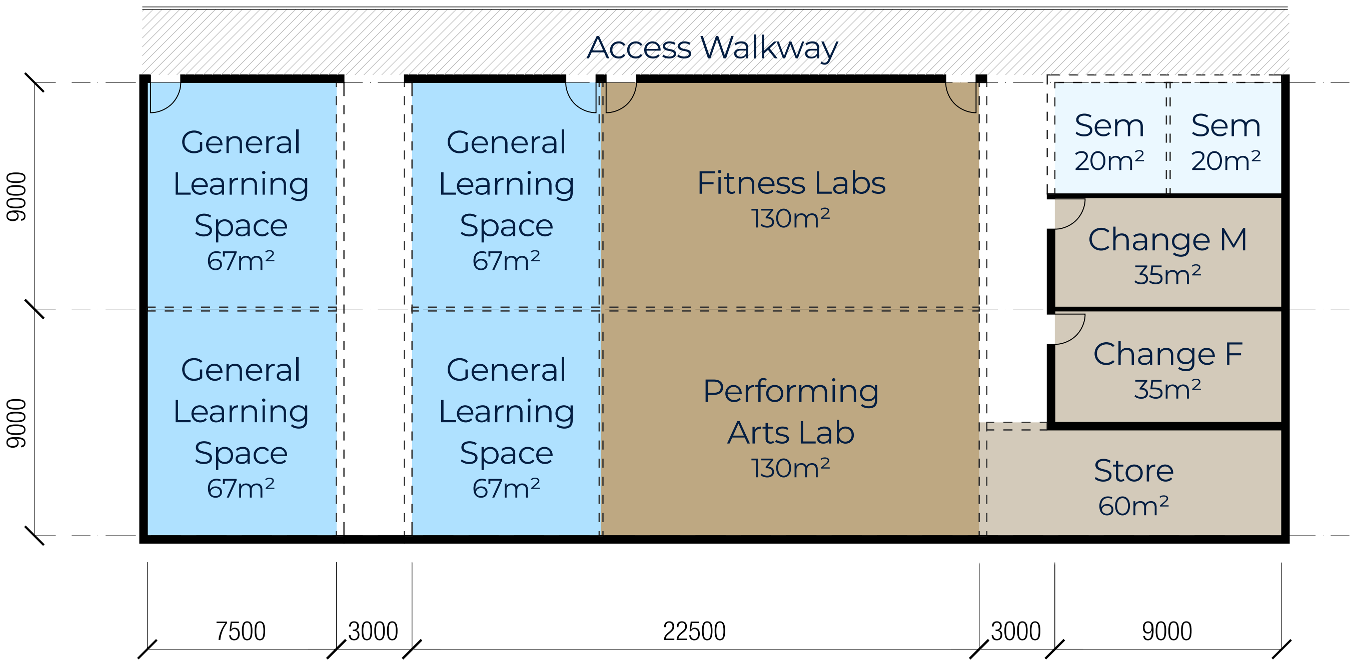
General Learning Space (Classroom)
Workshop/Lab
Store/Change Room
Seminar Room
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 4 x General Learning Spaces
- 1 x Performing Arts Lab
- 1 x Fitness Lab



Performing Arts/Fitness Room Area Layout

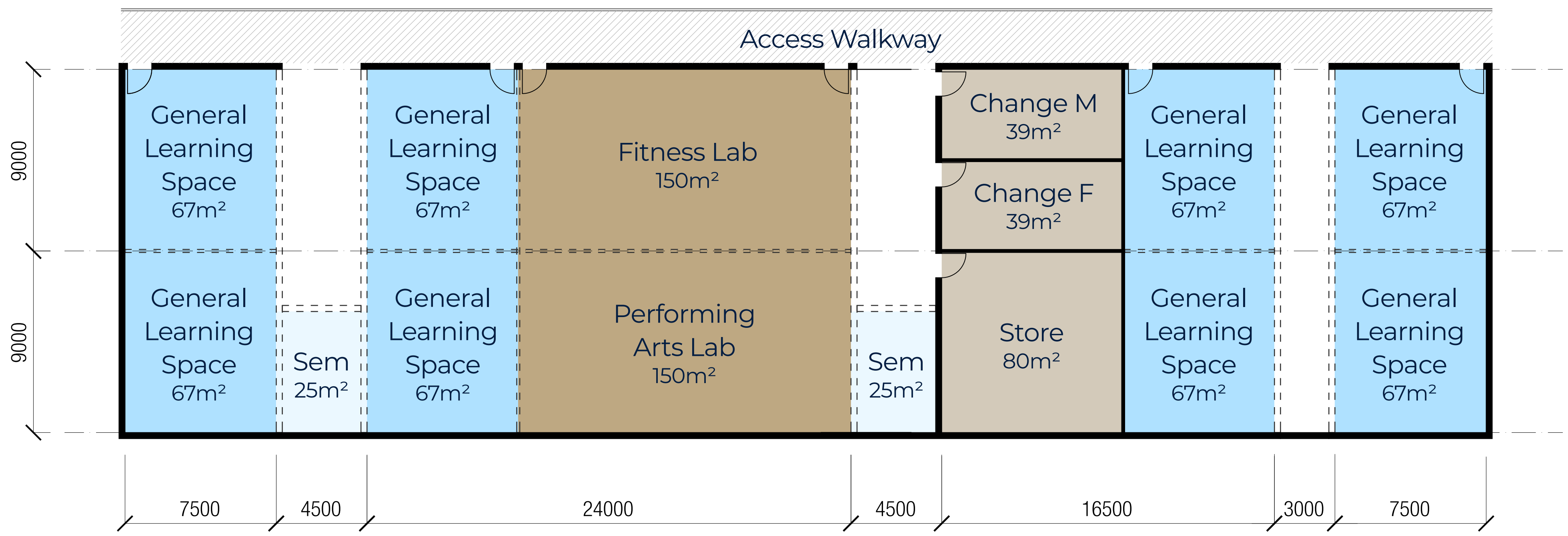
Sem Seminar Room
General Learning Space (Classroom)
Workshop/Lab
Store/Change Room
Seminar Room
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 8 x General Learning Spaces
- 1 x Performing Arts Lab
- 1 x Fitness Lab



Performing Arts/Fitness Room Area Layout

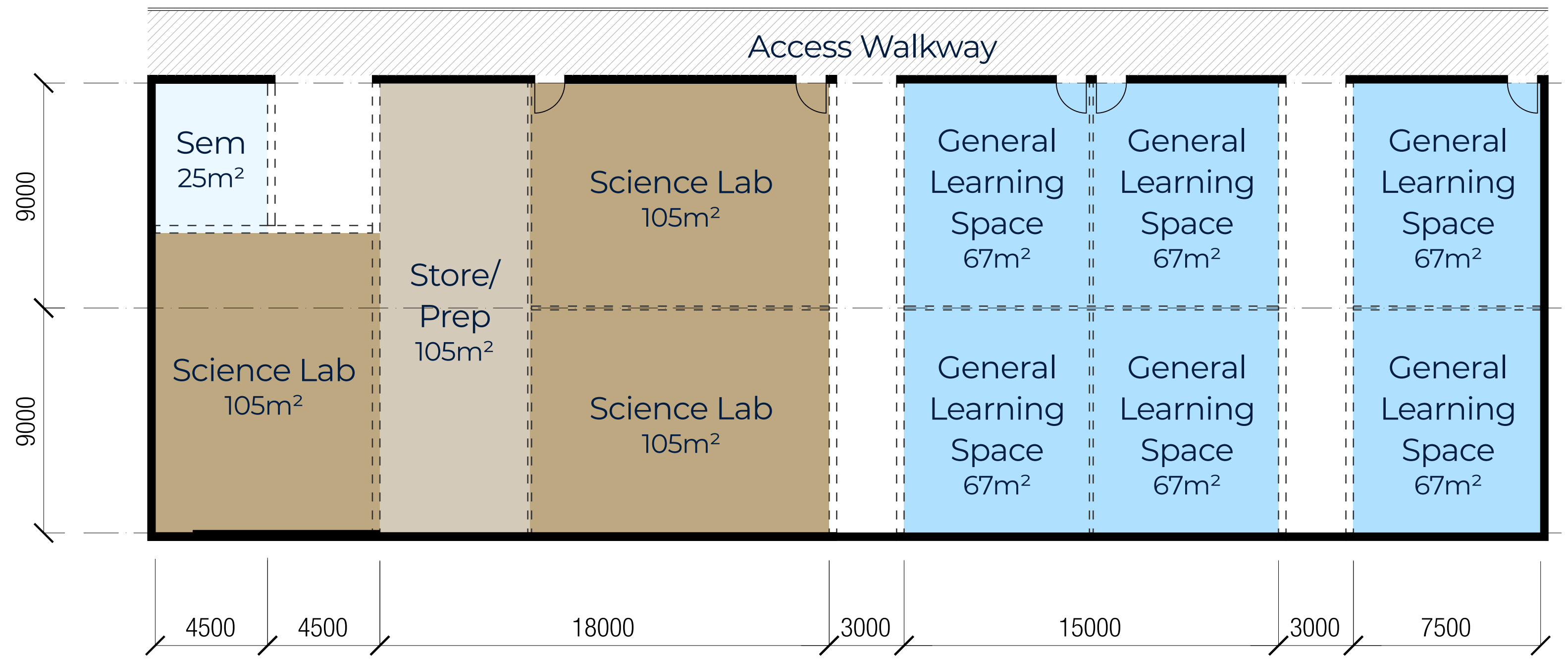
Sem	Seminar Room
(light blue)	General Learning Space (Classroom)
(brown)	Workshop/Lab
(beige)	Store/Change Room
(pale blue)	Seminar Room
----	Grid
(thick line)	Fixed Wall
------	Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 6 x General Learning Spaces
- 3 x Science Labs



Science Room Area Layout

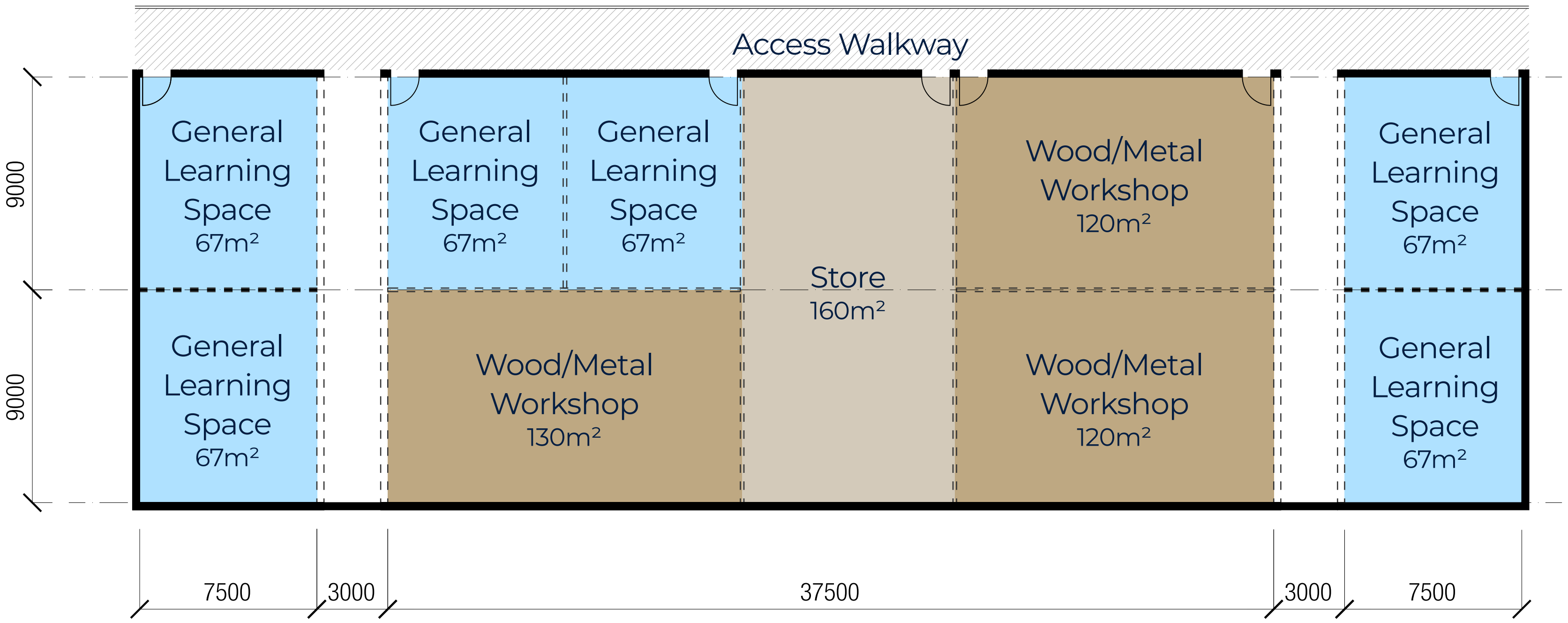
Sem	Seminar Room
	General Learning Space (Classroom)
	Workshop/Lab
	Store/Prep Room
	Seminar Room
- - - -	Grid
▬▬	Fixed Wall
------	Adjustable Wall

1:300 @ A3

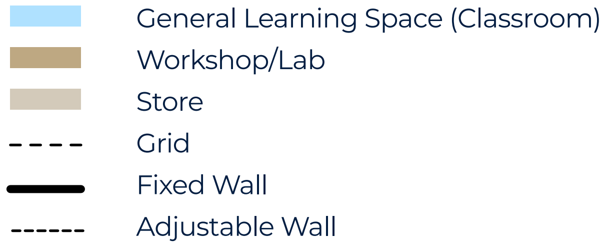
2.3 Standardised Space Types

Specialist Space Type

- 6 x General Learning Spaces
- 3 x Wood/Metal Workshops



Wood/Metal Workshop Room Area Layout

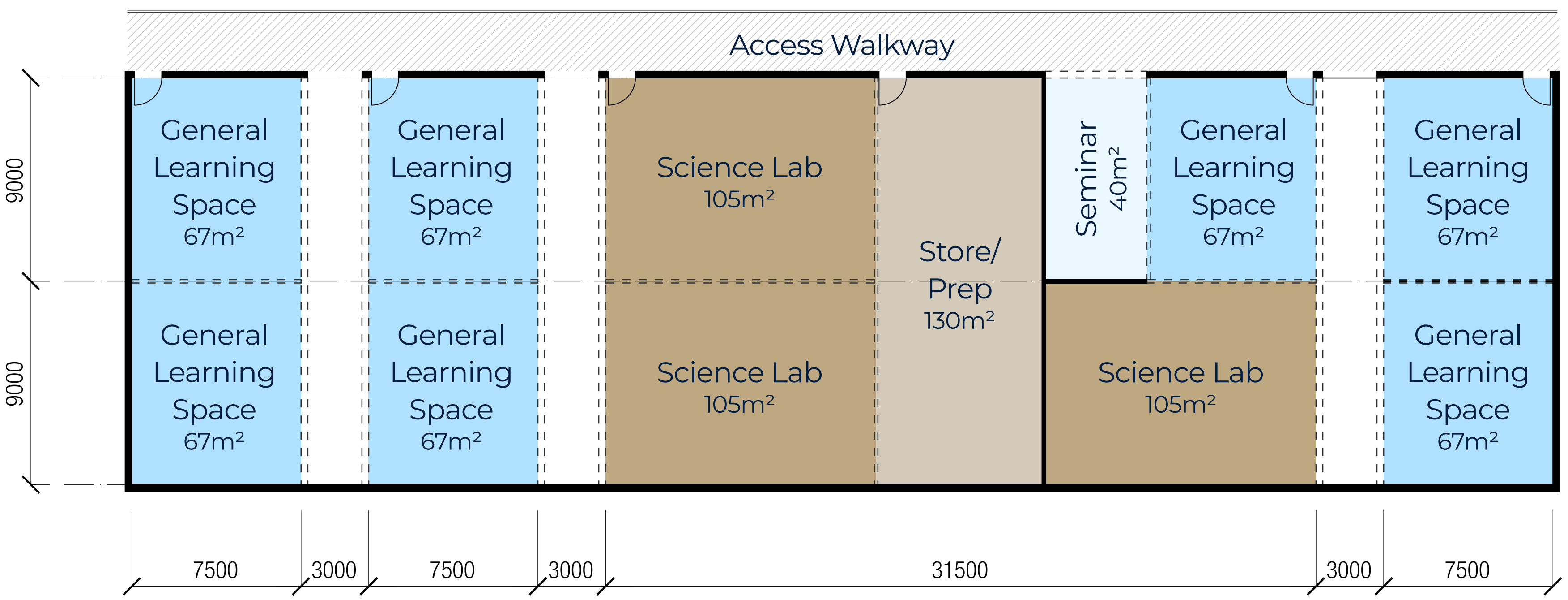


1:300 @ A3

2.3 Standardised Space Types

Specialist Space Type

- 7 x General Learning Spaces
- 3 x Science Labs

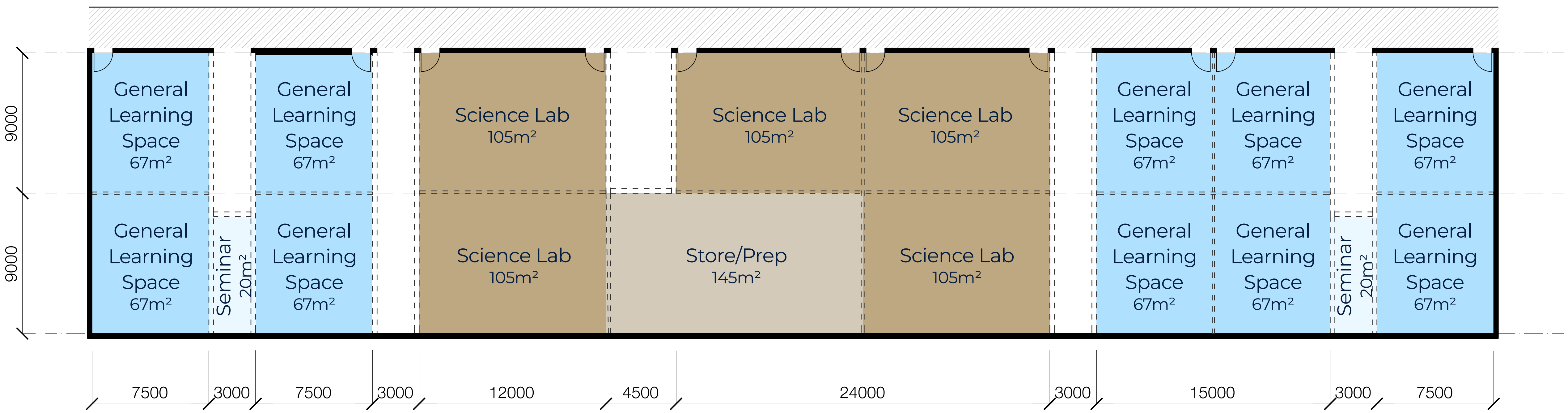


Science Room Area Layout

Sem Seminar Room
General Learning Space (Classroom)
Workshop/Lab
Store/Support Space
Seminar Room
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types



Science Room Area Layout

Specialist Space Type

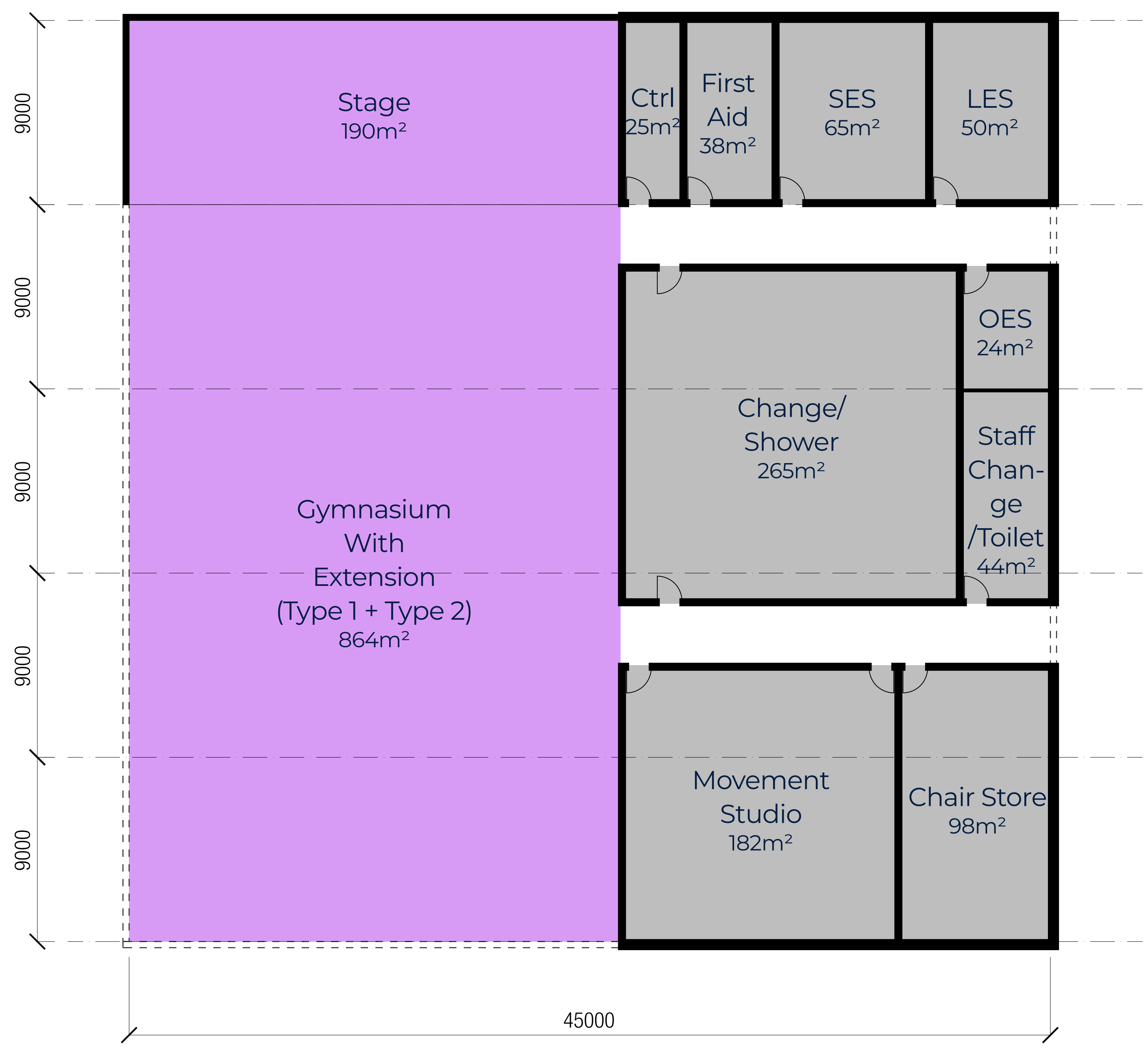
- 10 x General Learning Spaces
- 5 x Science Labs

General Learning Space (Classroom)
Workshop/Lab
Store/Prep Room
Seminar Room
Planning Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Hall Space Type



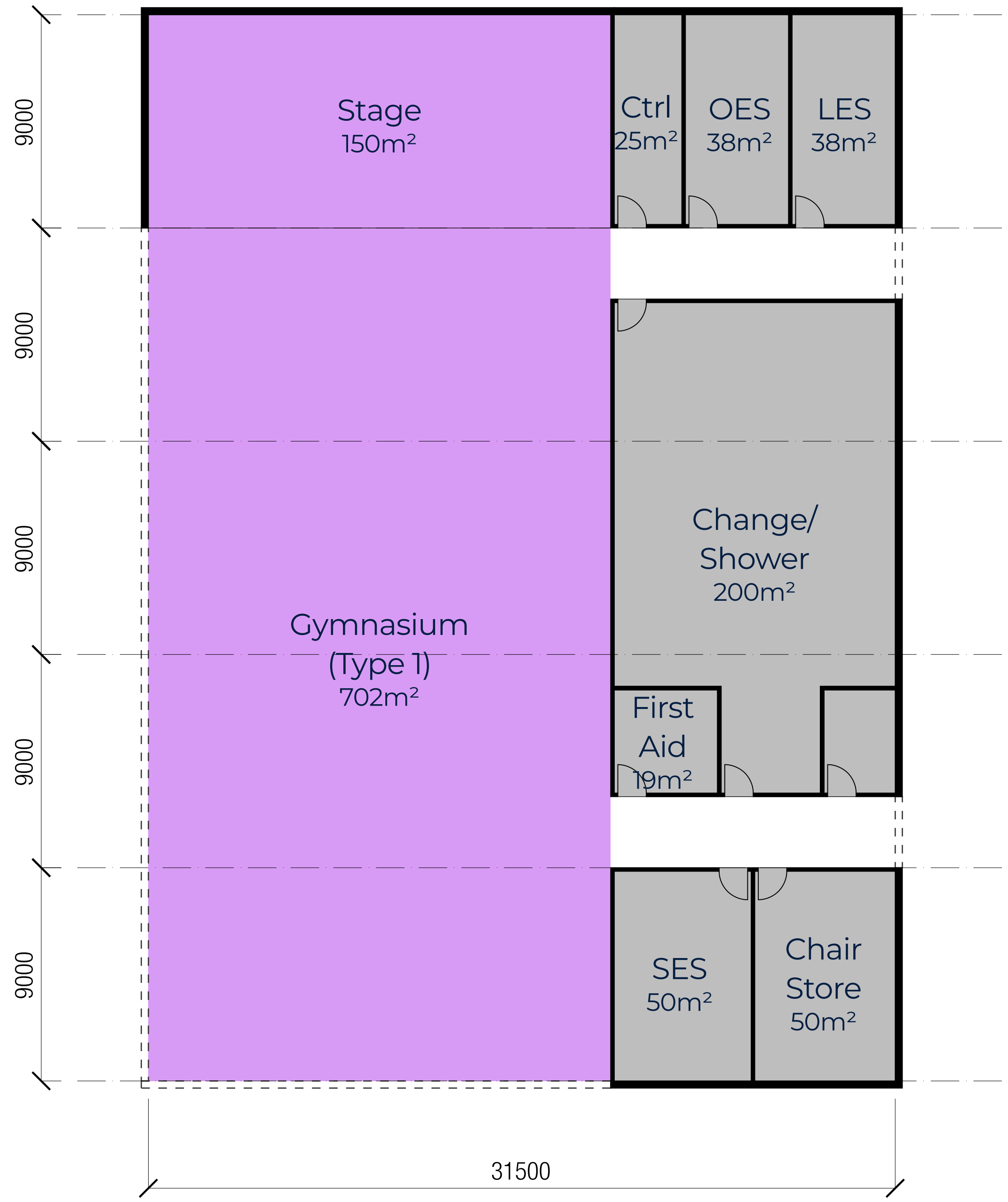
LES	Large Equipment Store
SES	Sport Equipment Store
OES	Outdoor Equipment Store
Ctrl	Control
	Hall & Performance Spaces
	Storage/Change/Wet Areas
----	Grid
	Fixed Wall
------	Adjustable Wall

1:300 @ A3

Hall/Movement Room Area Layout

2.3 Standardised Space Types

Hall Space Type



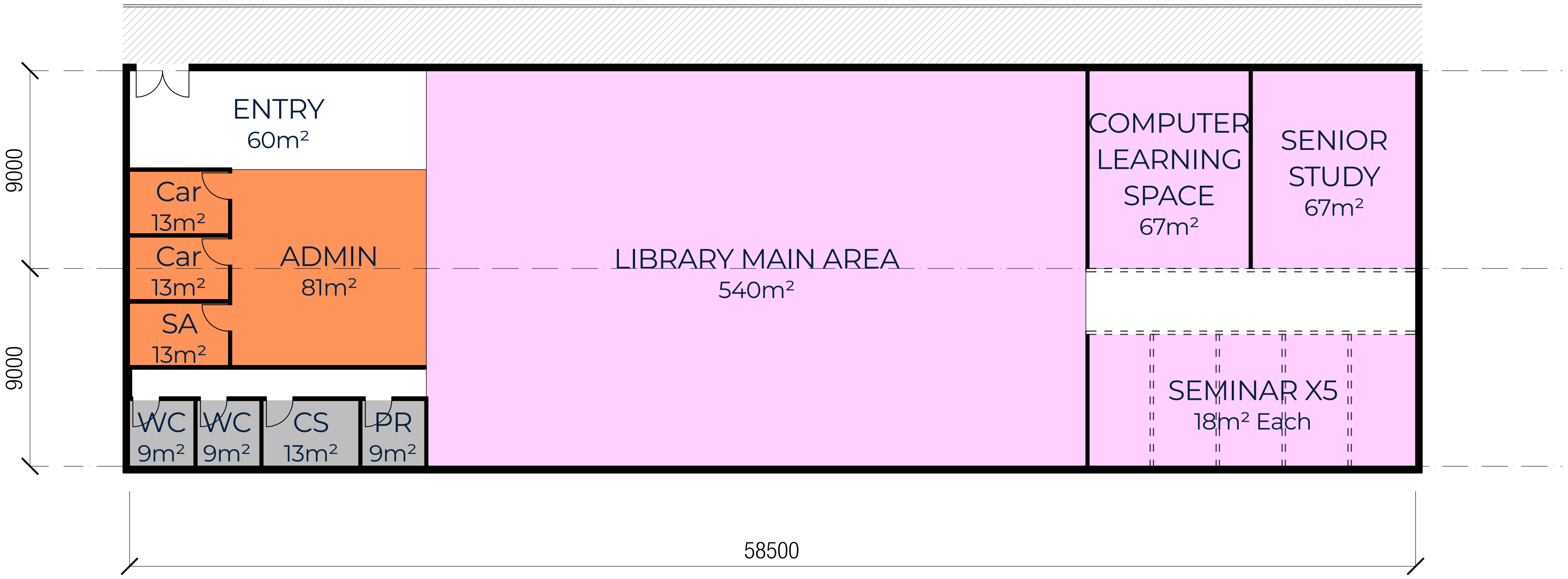
LES Large Equipment Store
SES Sport Equipment Store
OES Outdoor Equipment Store
Ctrl Control
Hall & Performance Spaces
Storage/Change/Wet Areas
Grid
Fixed Wall
Adjustable Wall

1:300 @ A3

Hall/Movement Room Area Layout

2.3 Standardised Space Types

Library Space Type



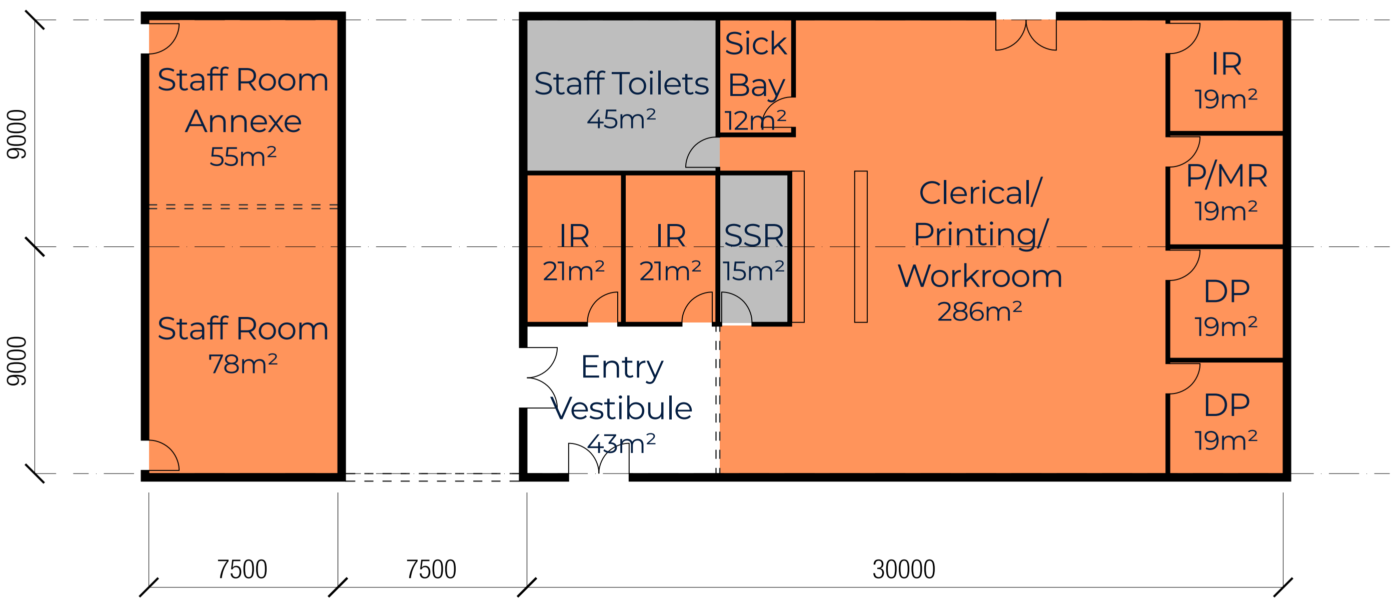
Library Room Area Layout

Car	Career
SA	Systems Administration
CS	Computer Storage
PR	Print Room
	Library Learning Areas
	Administration
	Storage/Wet Areas
----	Grid
	Fixed Wall
------	Adjustable Wall

1:300 @ A3

2.3 Standardised Space Types

Administration Space Type



Administration Room Area Layout

IR	Interview Room
DP	Deputy Principle
P/MR	Principle/Meeting Room
SSR	Security Storage Room
(orange)	Administration
(grey)	Storage/Wet Areas
----	Grid
▬	Fixed Wall
------	Adjustable Wall

1:300 @ A3

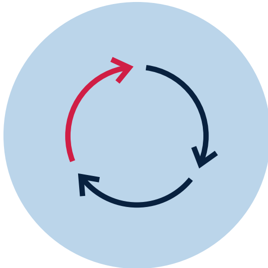
2.4 Masterplanning

The Masterplanning Principles:

Site Specific Design

Environment

Infrastructure



Whole of Life Thinking

2.4 Masterplanning

Starting Point

Site Analysis

Secure a thorough contextual analysis of the Site with an emphasis on the school year & school day.

As a minimum, to include:

- Solar Access
- Wind
- Temperature
- Overshadowing (in + outside of Site)
- Overlooking (to + from Site)
- Visual Amenity
- Acoustic (in + outside of Site)
- Ecological
- Topographical
- Transport and Access

Brief

- What and how much accommodation is required?
- How many learning units or hubs are required?

2.4 Masterplanning

Site Opportunities & Constraints

Playground

Contiguous Space

Maximise contiguous space for safety and ease of surveillance.

Topography

Preserve existing topography and ecology where possible.

Neighbouring Context

Consider relationship to neighbouring context, overlooking, acoustic and overshadowing. (See A-i)

Space

- Consider opportunity of access to play space out of school hours.
- Presumption that a minimum 10m² playground per student should be provided.

Building

How many storeys?

- Test how many levels are required to meet brief and pedagogy outcomes.
- Stack hubs for a contiguous structure and services to benefit cost/program/flexibility of internal layout and accommodate for changes through time.

Orientation

Orientate with the external circulation corridor facing north to provide summer shading while also having opportunity to harness benefits of winter sun to preheat/warm space.

Aspect

Quality of aspect, long views and access to nature to be considered.

Community & Context

Urban Context

Understand local urban context, consider impact of proposals (bulk, scale, materials etc.) on local street context and wider urban setting.

Neighbourhood Value

Balance and adherence to the prevailing context with the role of new school and its social and cultural value to a neighbourhood.

Overshadowing

Consider overshadowing to context, both outside and within the Site. Calibrate with respect to amenity, use and existing condition.

Entrance & Transport

Safety

Facilitate safe and free flowing movement of vehicles. Drop off zone should be adequately designed for safe access to school.

Separation

Depending on school program, it is recommended High school, primary school, SSP and kindergarten to have its own entrance.

Communal Hall + Gym

Communal hall/gym to be at grade to allow direct level inclusive access for all. Location of communal hall/gym to be easily accessible for both school and community, and to be adjacent to a secure main entry, canteen, OSHC and dedicated WC.

2.4 Masterplanning

Planning & Components

Scale

Consider the viewpoint: height, eye level & accessibility of each year group user.

Stairs

External stairs mounted off the external circulation corridor should be of a DTS spacing.

Passive surveillance and anti-bullying to be considered for all stairs and circulation spaces.

Core

Contains lifts, toilets, services rooms, cleaners rooms etc. Core design can be varied according to schools needs. Distance from classrooms to toilets to be minimised through design of core locations.

COLA

COLA should be open to allow free movement of air.

COLA to be protected / orientated to respond to prevailing wind condition.

Learning Spaces

For the Hub of 4, learning spaces are accessed either from the PAA or the external circulation corridor.

COLAs can be interspersed throughout the building to provide outdoor teaching spaces and access to learning spaces.

Specialist Spaces

Wood & Metal: Should be located on the ground floor or service areas for loading of materials.

Fitness and Performing Arts: Should be clustered together, located away from the general learning spaces or provide engineered solutions to reduce noise/vibration impacts.

Library

Library can be located adjacent to COLA space which gives it room/space to expand for outdoor learning.

Staff & Admin

Staff and reception to be located adjacent to secure main entry.

2.5 Example School Layouts

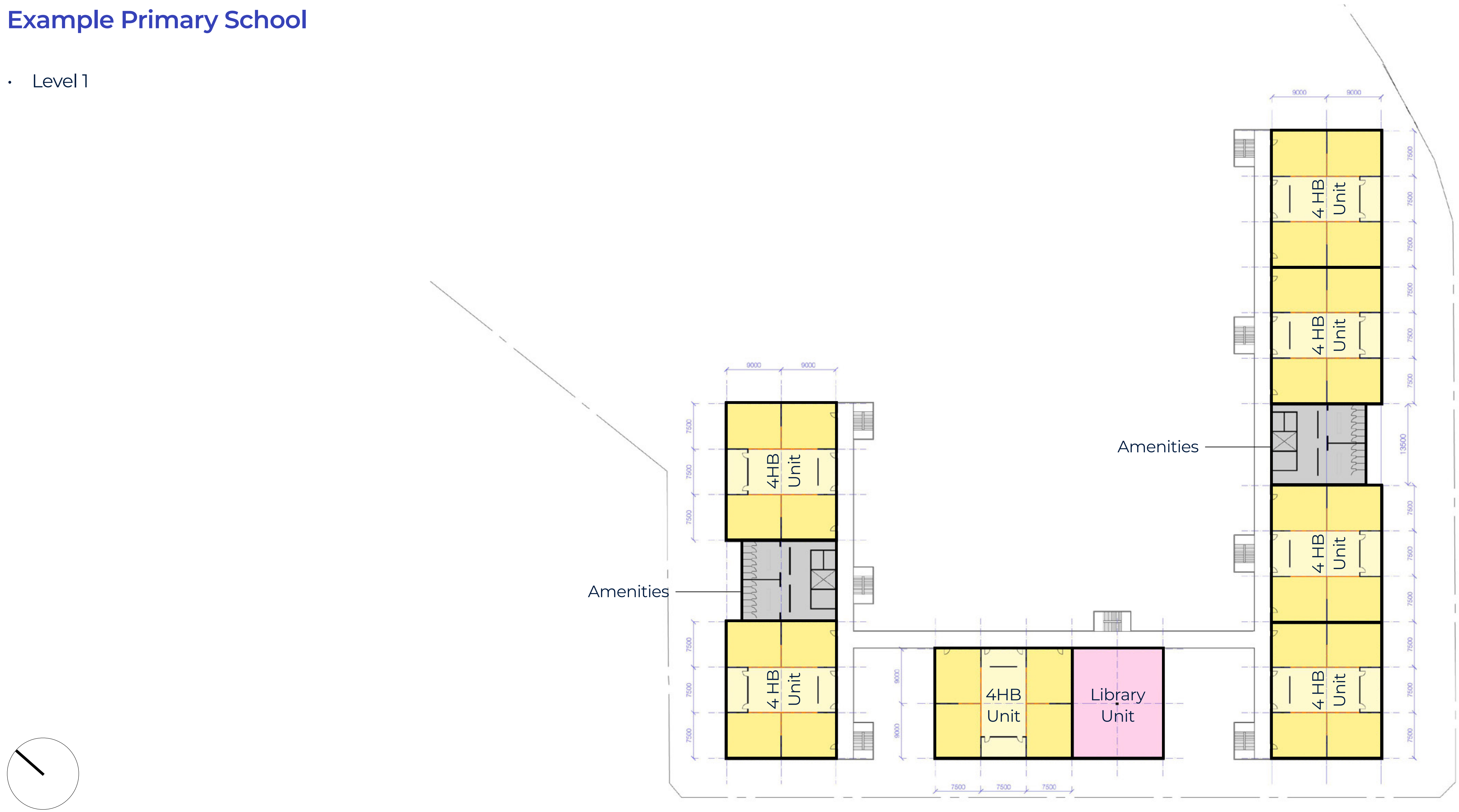
Example Primary School

- Level Ground

2.5 Example School Layouts

Example Primary School

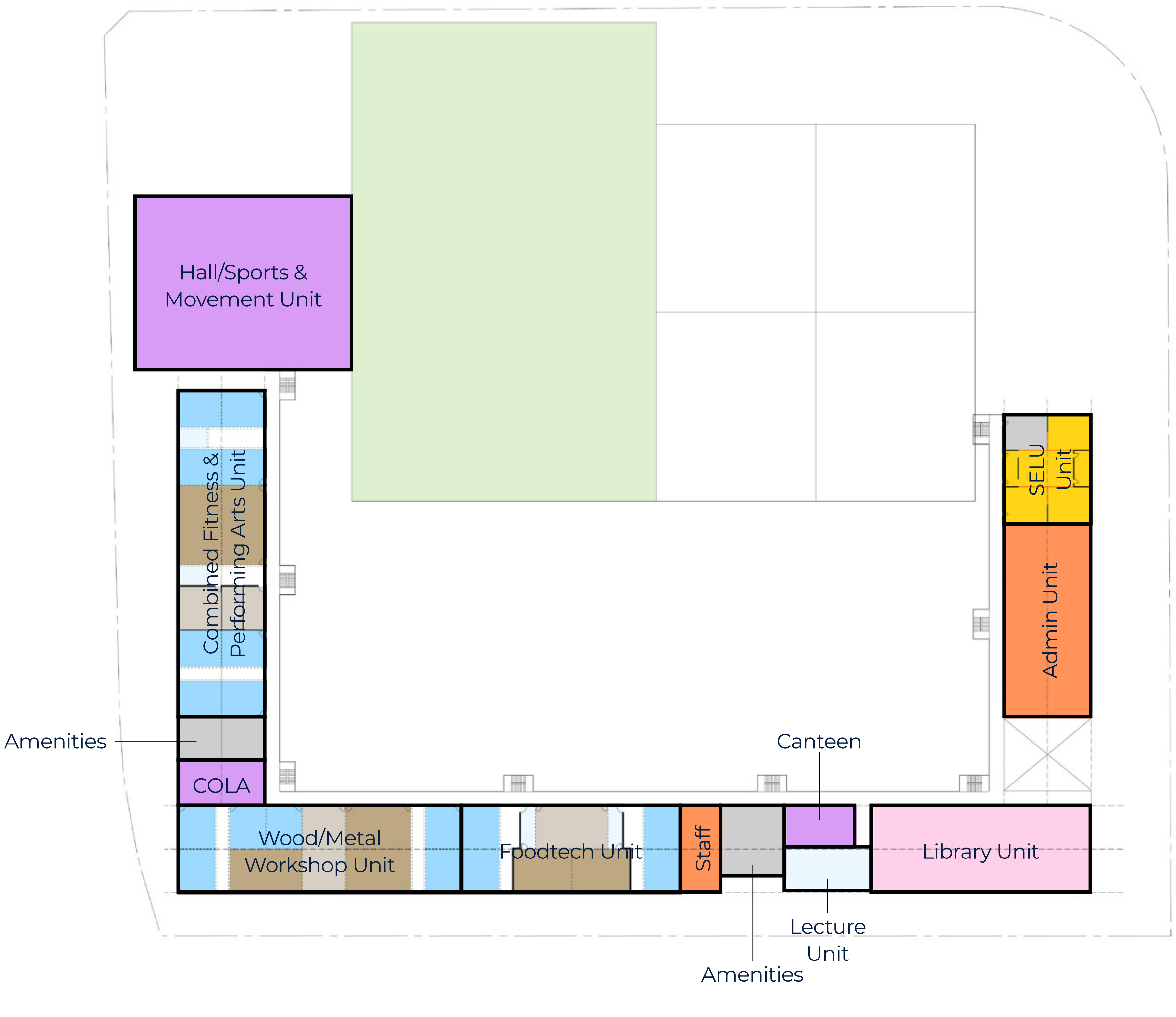
- Level 1



2.5 Example School Layouts

Example High School

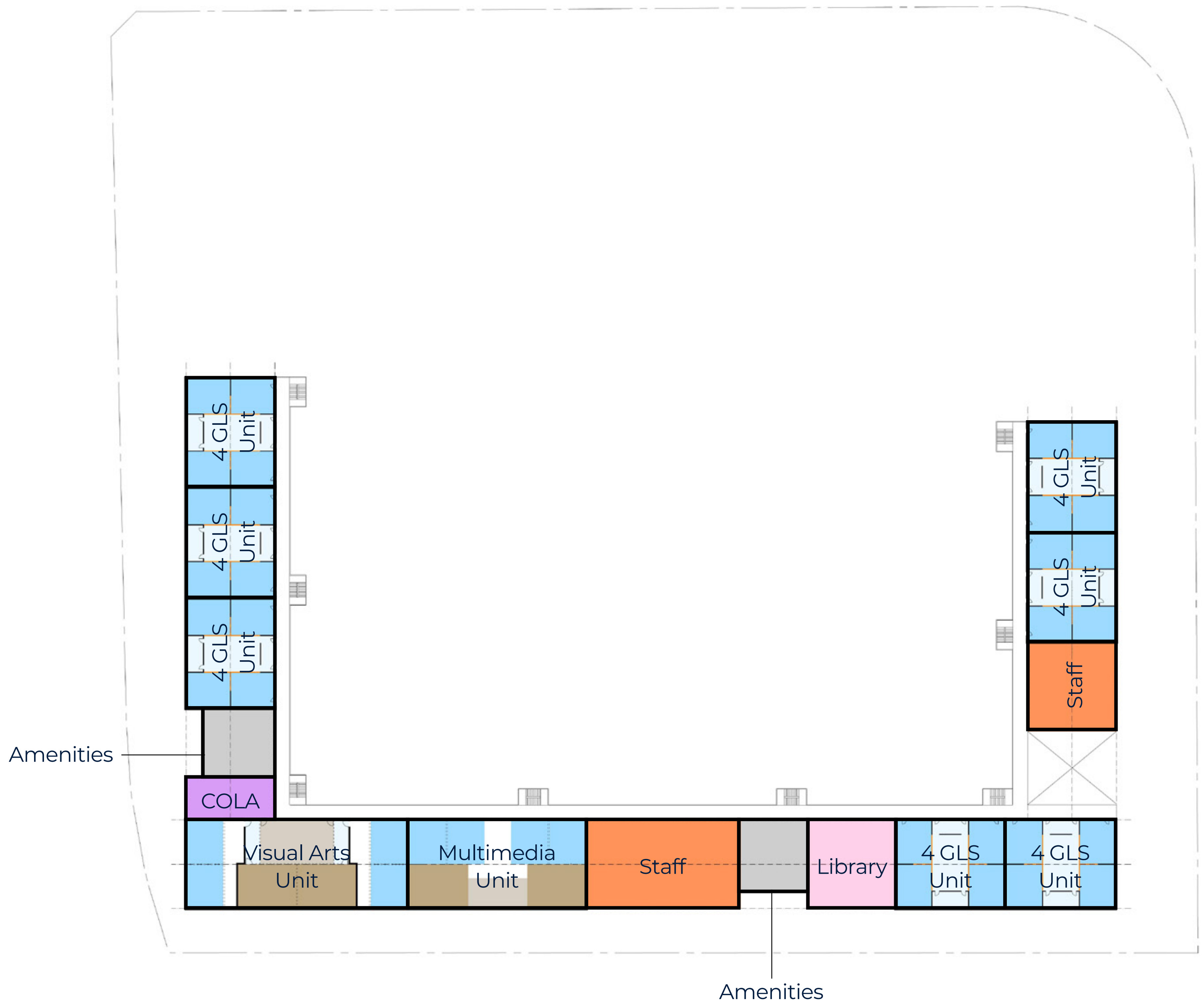
- Level Ground



2.5 Example School Layouts

Example High School

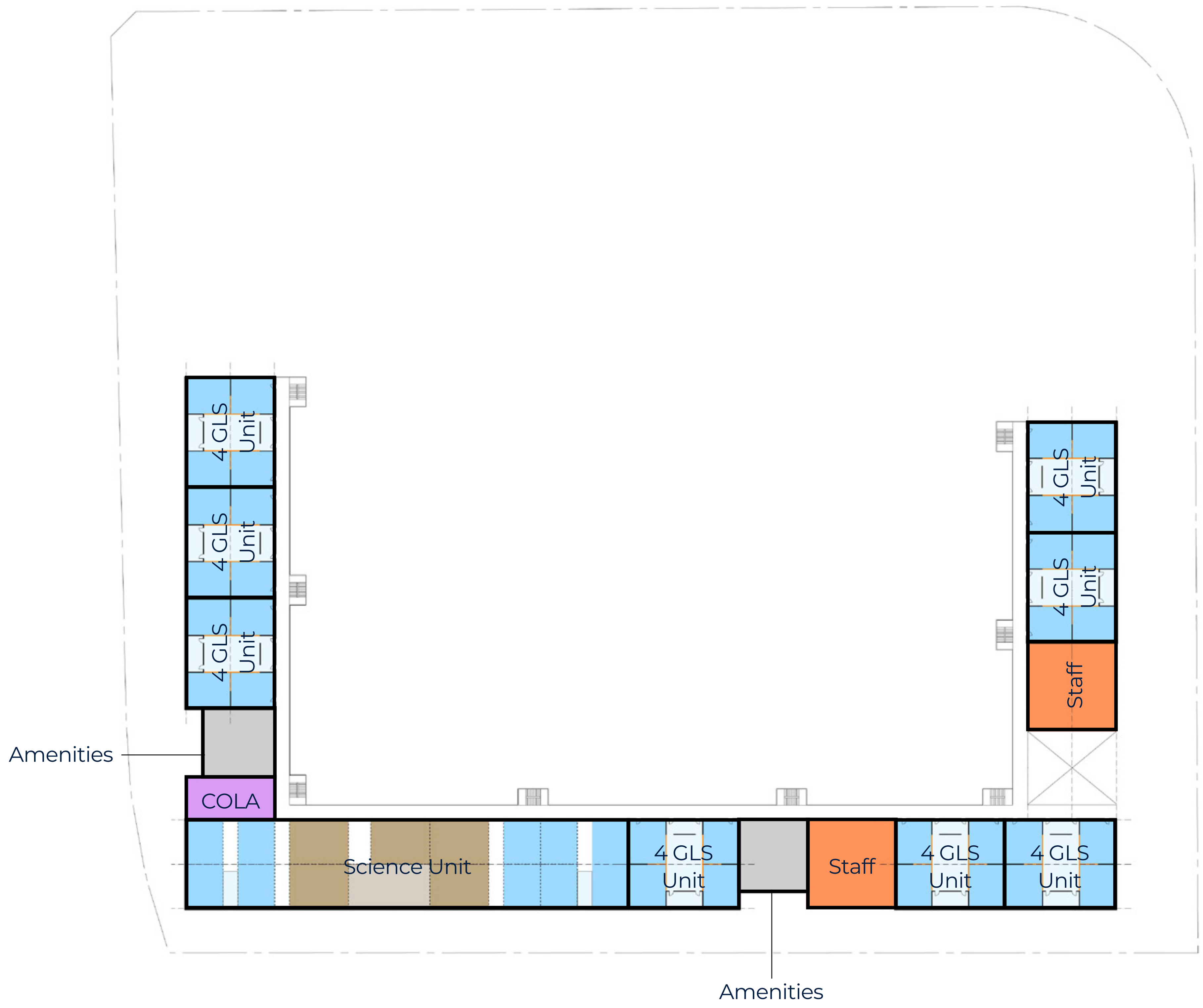
- Level 1



2.5 Example School Layouts

Example High School

- Lever 2



3 Components

3.1 The Components

The DfMA Components Principles

Design Standardisation

- Implement a standardised approach to the design of schools
- Develop a series of industry standards for school design
- Enable innovation through the standardised system
- Encourage use of local NSW construction industry
- Easy to maintain system
- Multiple construction types available.

Modularity and Customisation

- Modularity enables standardised assembly and disassembly
- Space types can be interchanged to suit brief and site specific requirements over time
- Creates a system that allows flexibility
- Demountable System
- Creates an equal standard of facilities across the state

Sustainability

- System designed to cater for a changing climate
- Sustainability factors have been integrated within each component
- Embodied energy
- Reduce waste by optimising material module sizes

Whole of Life Thinking

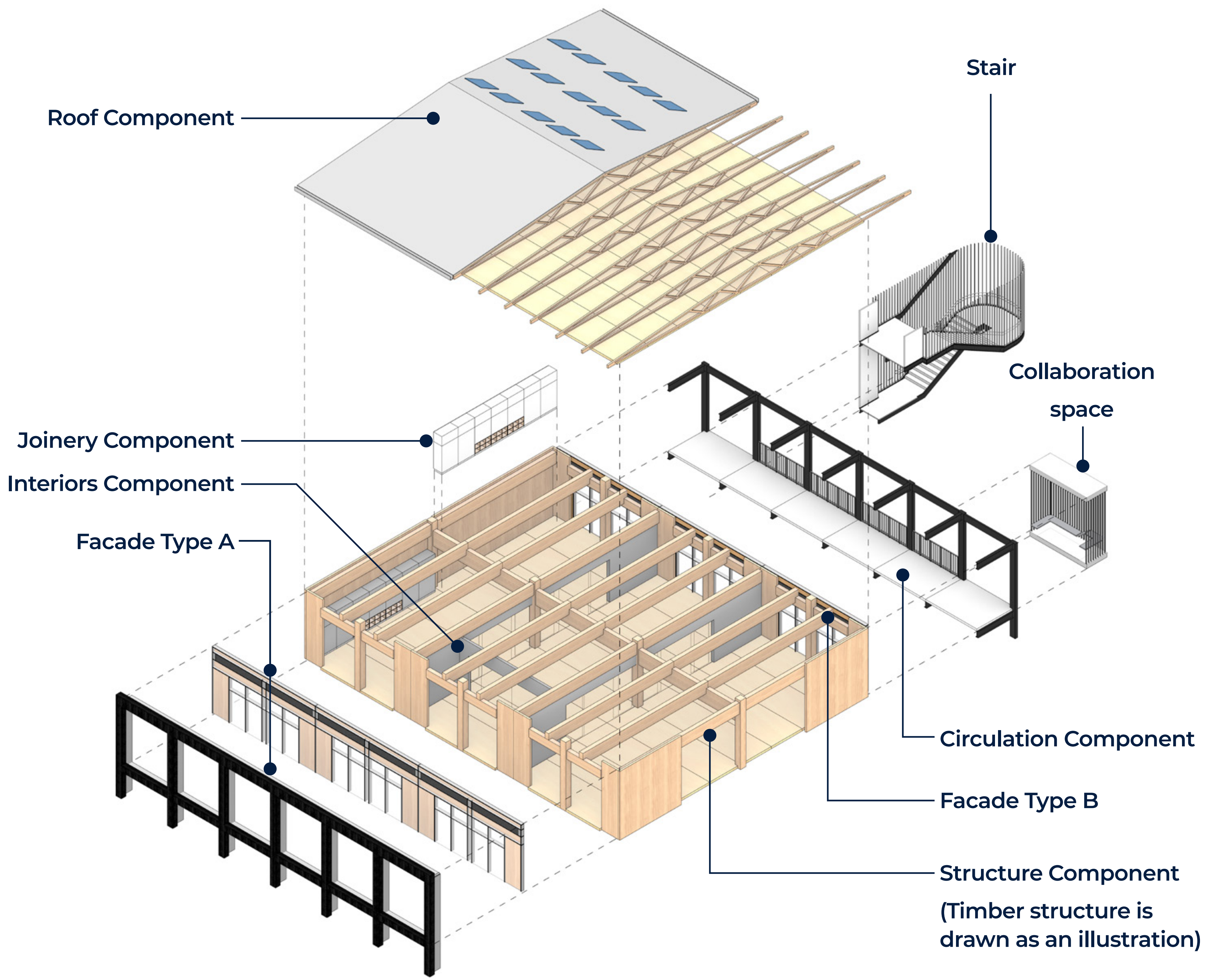
- Shift the discussion on capital cost to encompass whole-of-life cost, flexibility, durability and maintenance.
- Put in place easy to use component guidelines that set simple rules and allow for innovation.
- Standardisation that facilitates reuse.

3.1 The Components

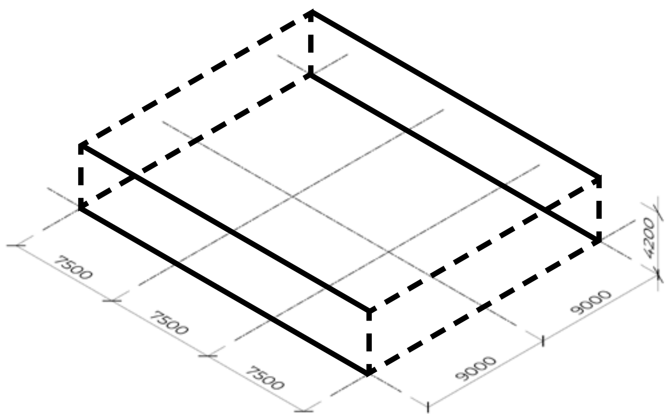
The component system has been created to enable DfMA, ease of maintenance and provide for future flexibility.

The axonometric diagram illustrates the components in the system.

The timber structure shown in the diagram is an example of many other possible structural framing/ slab systems.

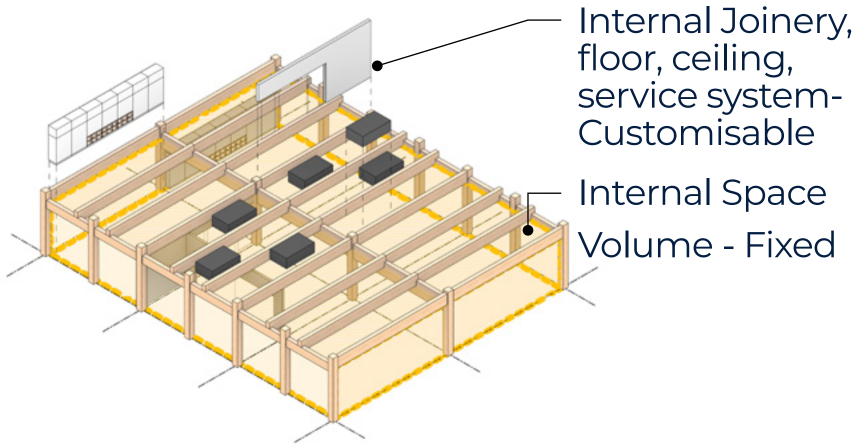


3.1 The Components



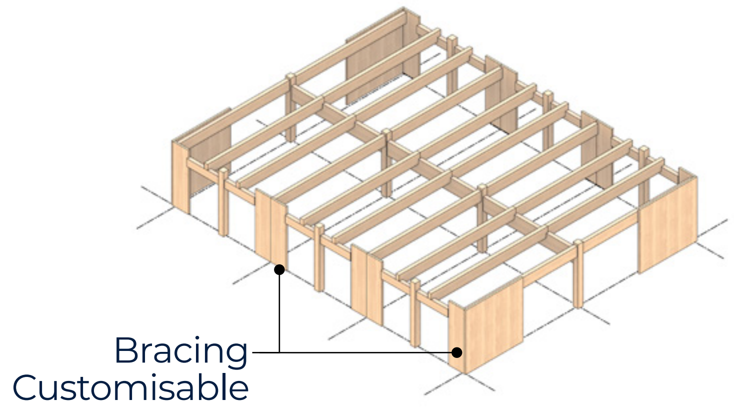
Framework & Structural Grid

A fixed system - All structural elements to work with the outlined structural grid; All functional space to fit within the framework envelope.



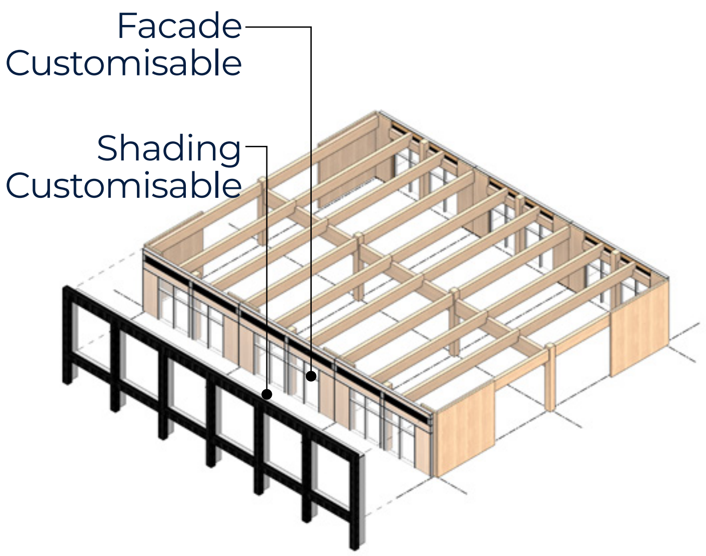
Internal Space Volume

The internal space volume is contained within the framework envelope with a minimum height of 2.7m. All movable parts, joinery and services etc. can be designed and tailored to specific spatial requirements. Refer to Internal Components, Services and joinery components for further details.



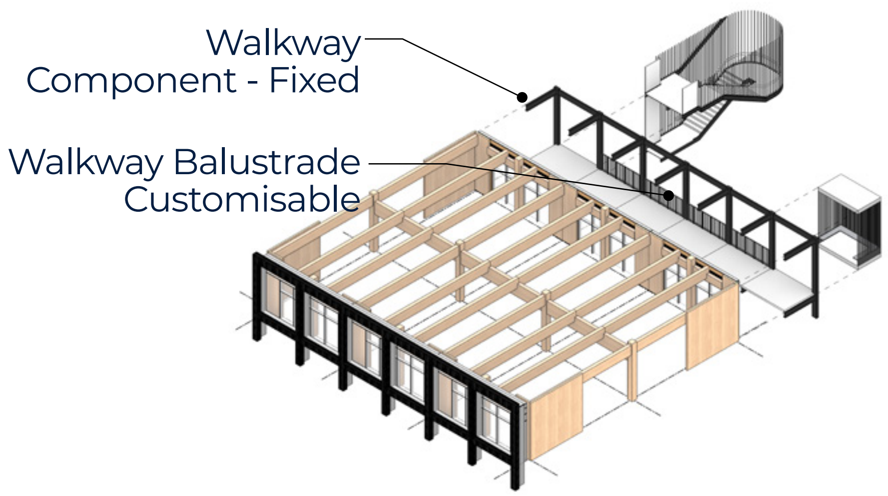
Bracing

The bracing system is a site and project specific system, scale of built-form, location of core elements, bracing materials can all influence the final outcome of the bracing system of a project. Refer to the bracing section for further details.



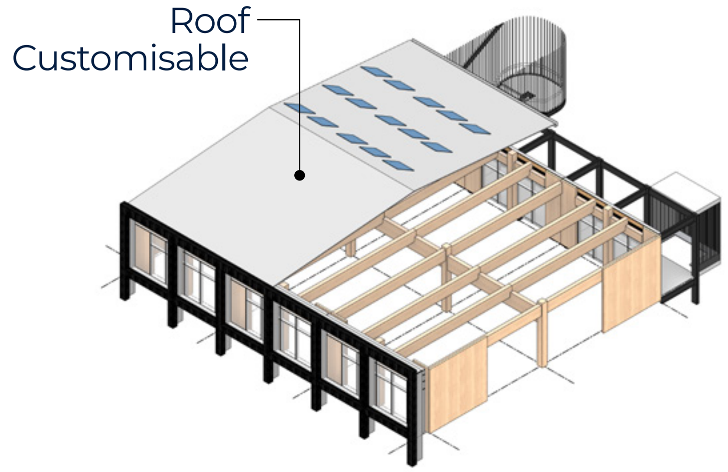
External Facade and Shading

The site context, orientation, climatic zones will all influence the final facade and shading outcome. Window wall ratio, shading ratio and ventilation ratio have to be met for every project. Refer to facade component chapter and chapter 4 ESD for further details.



Access Walkway and Balustrade

The access walkway is a fixed component which provides access to teaching spaces and amenities. Site context, orientation, climatic zones will all influence the design outcome of the balustrade for the access walkway. Refer to circulation-balustrade section for further details.



Roof

The roof is a site and project specific design component. Site context, orientation, climatic zones will all influence the final roof outcome. Refer to the roof component section for further details.

3.2 Structure

The DfMA Structure Components have been designed and detailed with the following principles:

Constructibility

- Eliminate wet trades on site
- Ease of construction
- Ease of assembly and disassembly
- Reduces vehicular movements and traffic congestion.
- Waste can be easily managed in a factory.

Adaptability

- Design is fit for purpose
- Equality of spaces integrated within structural framework
- Optimised space with raised quality
- Demountable

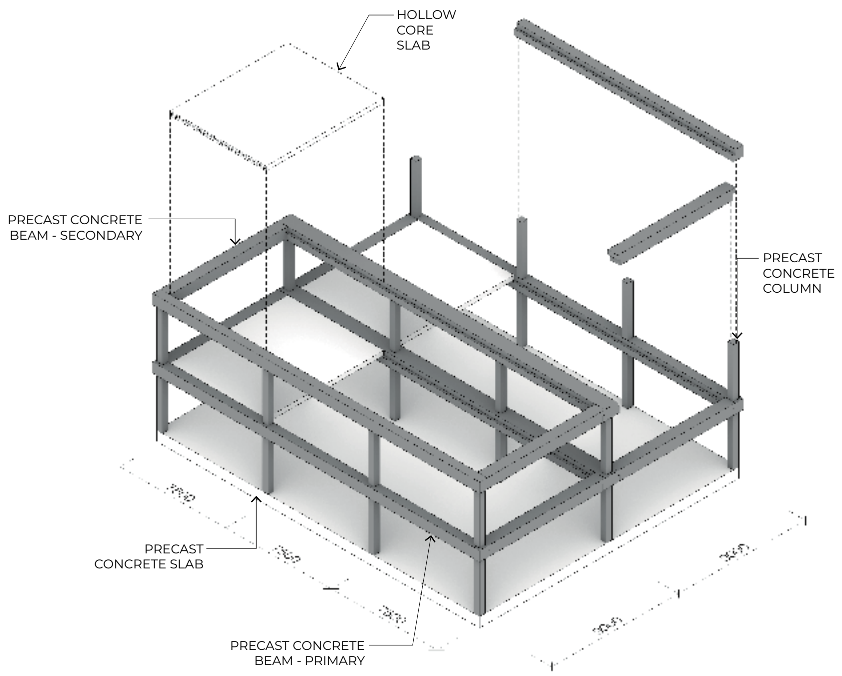
Maintenance

- Enable all construction methods from off-site volumetric to conventional to secure quality and program, and maximise use of budget.
- Establish demand to grow NSW manufacturing capacity.
- Drive lower construction costs per sqm through standardisation.
- Pre-finished materials to be used where possible.

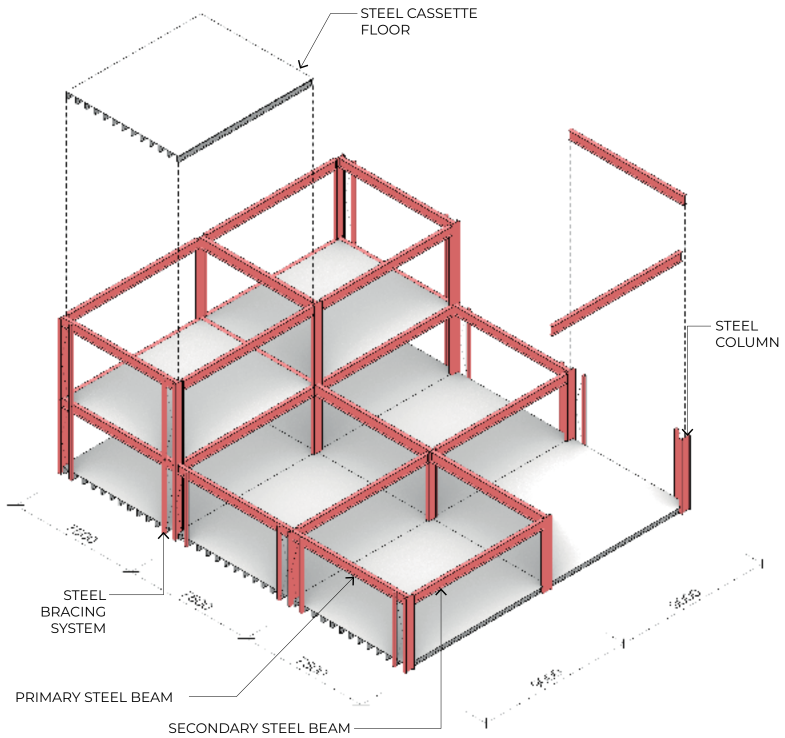
Sustainability

- Capital cost to encompass whole-of-life cost, flexibility, durability and maintenance.
- Put in place easy to use performance guidelines that set simple rules and allow for innovation.
- Building for beyond design life. Structure is base for many generations.

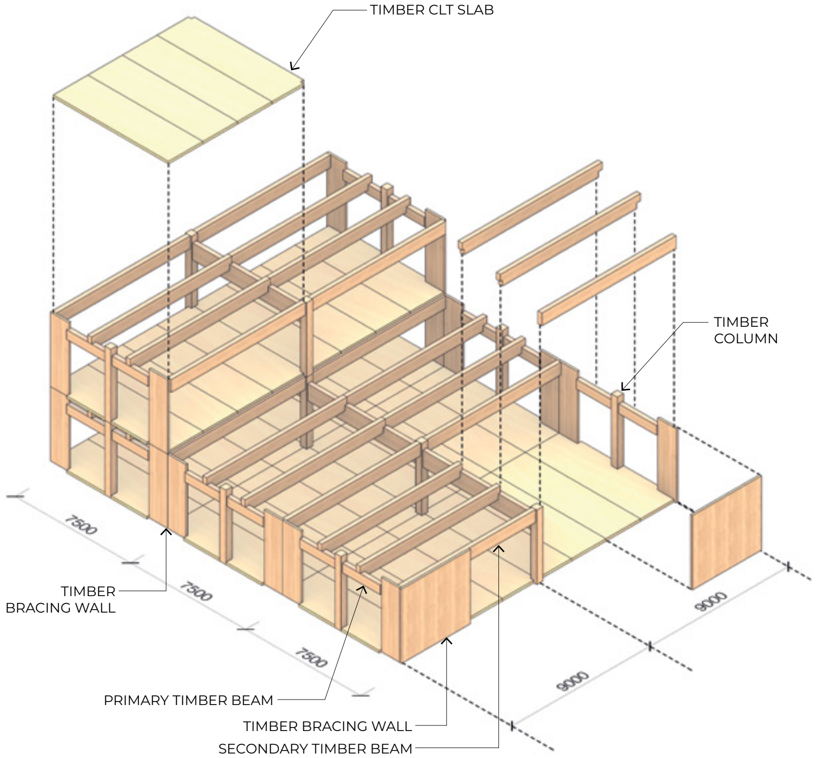
3.2 Structure



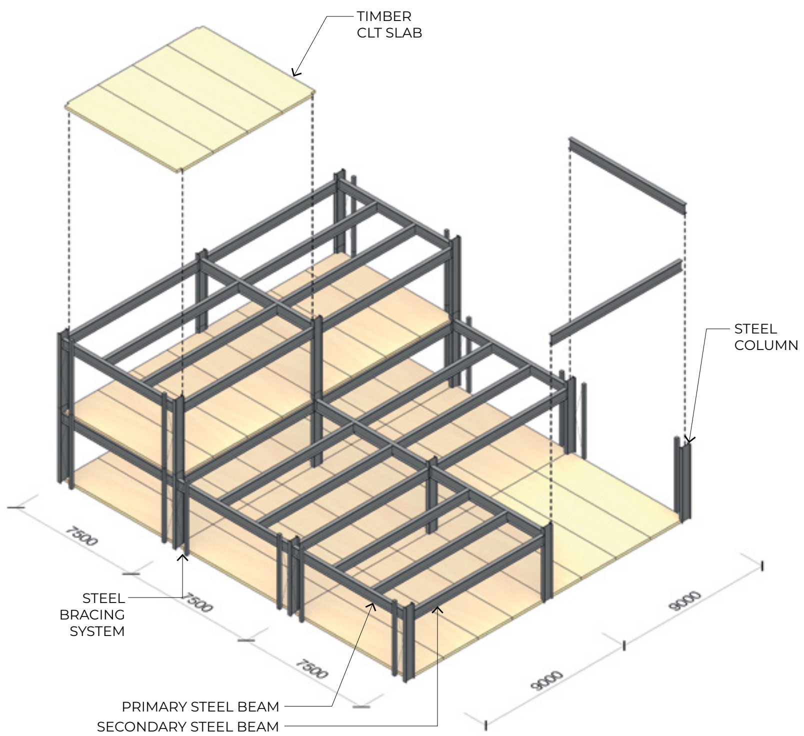
Concrete System



Steel System



Timber System



Hybrid System
(One Example of Many Possible Types)

3.3 Timber Structure

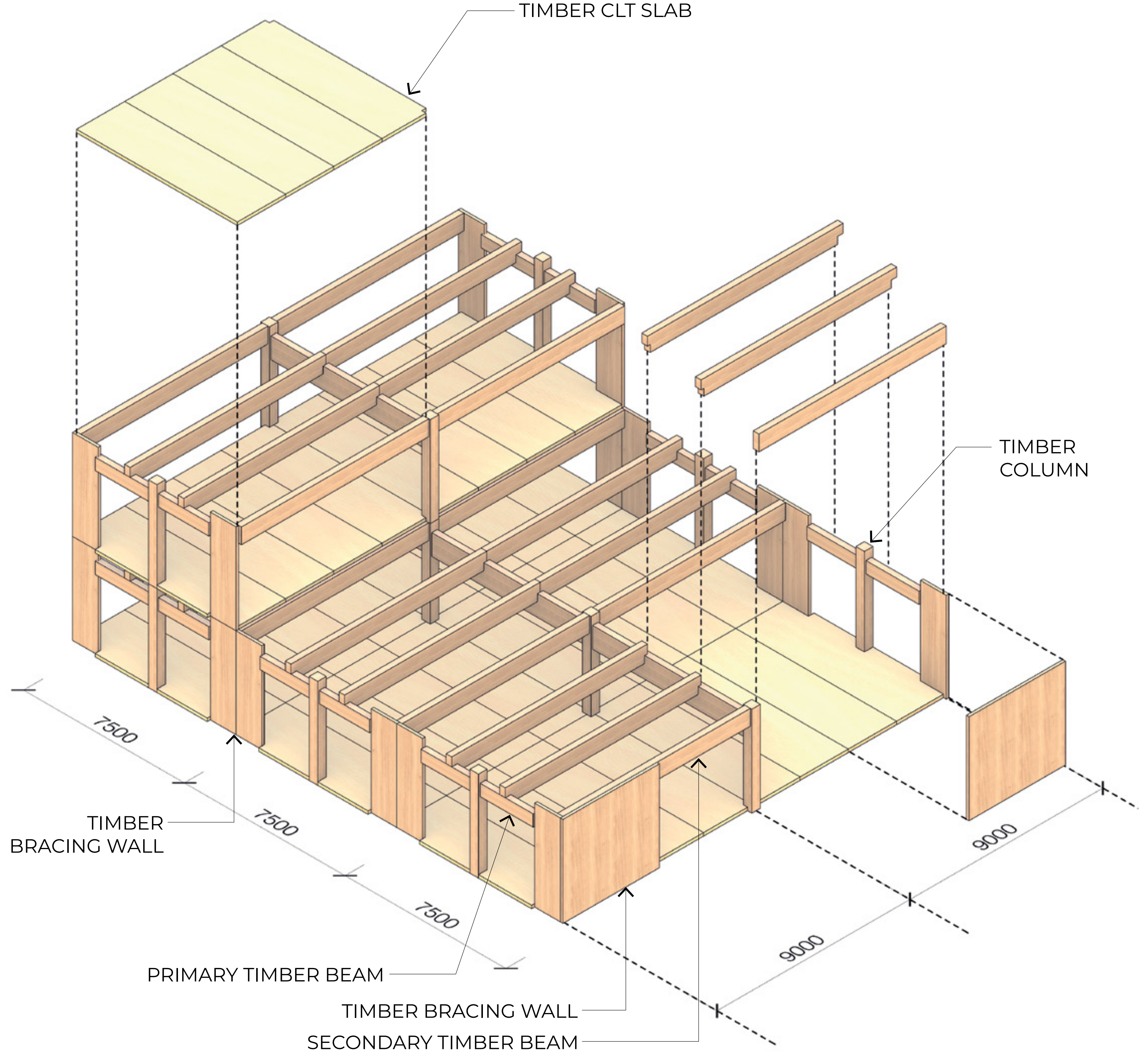
Timber System

The timber structure system is a construction method using mass timber construction, the following items should be considered while selecting timbers for a project:

- Use Australian timbers. The labelling difference of structural timber members between Europe and Australia needs to be considered and factored in all engineering calculations.
- Choose a mature Australia mass timber construction system, i.e. glulam or LVL for framing and CLT for slabs. The base timber structure option uses glulam rather than LVL as the glulam beams/columns have a purer and more appealing look compared to LVL. Additionally LVL is produced in a fixed depth, this can result in more material waste as it could require the need to trim timber members to size. The LVL system with an industrial look could still be suitable for certain projects and it can be an option to explore according to project brief and context.

The base timber system option is composed of the following:

- Timber Columns spaced at 7.5m apart on the framework set up by the planning system.
- Primary timber beams spaced 9m apart on the 9m framework
- Secondary timber beams spaced 2.5m apart
- Timber bracing walls on the facade
- CLT slabs sitting on the secondary timber beams



Timber Framing System - Axonometric Diagram

3.3 Timber Structure

Timber System

The RCP to the right details the structural component sizes for the full timber system.

Disclaimer:

- All structural element sizes are indicative only, they are high level figures for the purpose of this report.
- The column size is designed for a 3 storey building

Timber Framing System - Kit of Parts:

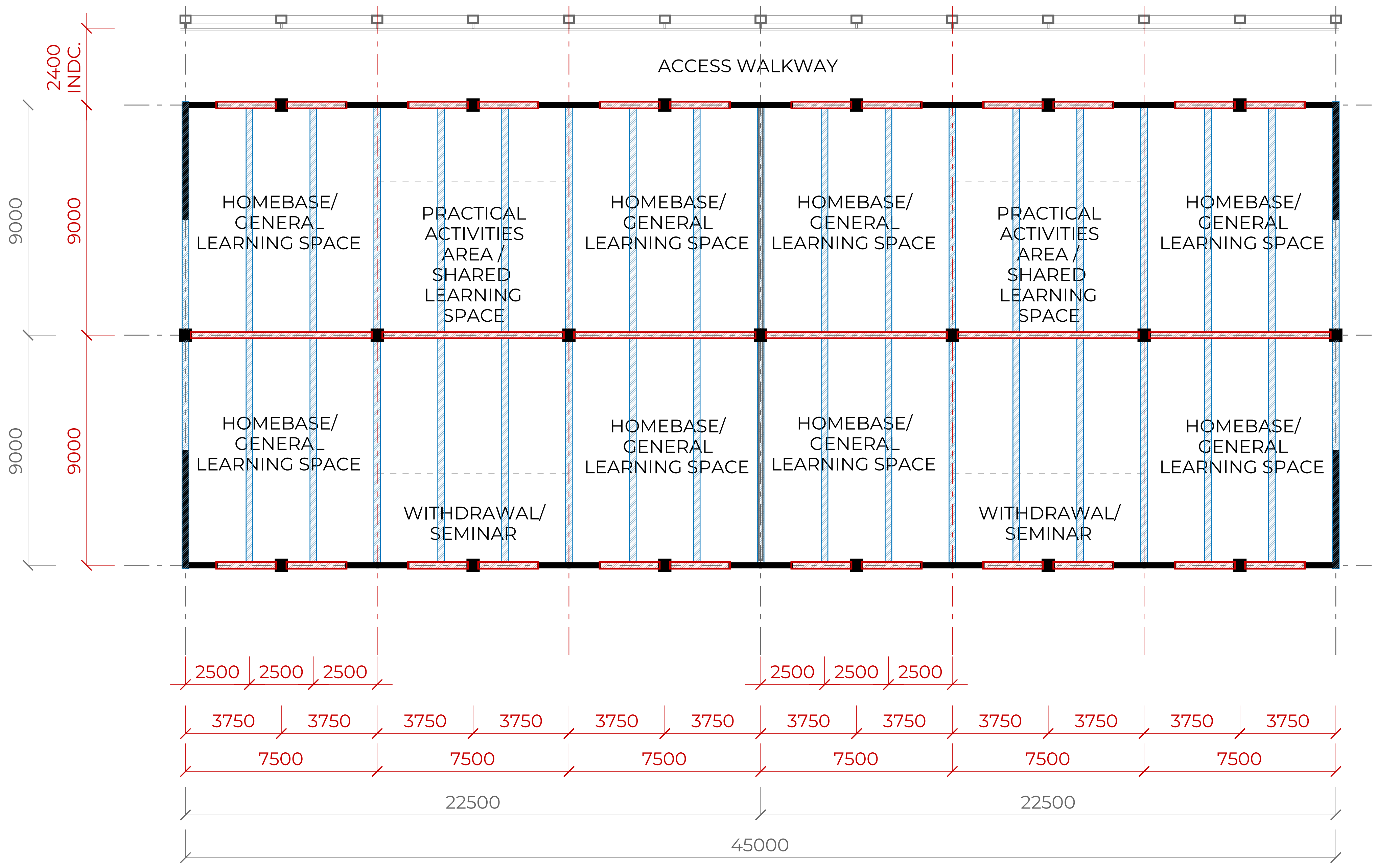
Primary Beam Internal - 260 x 960 GL13 or 390 x 760 GL13

Primary Beam External - 260 x 540 GL13

Secondary Beam - 260 x 680 GL13

Square Timber Column - 400 x 400 square

*GL13 - Glulam Grade ; Unit of element size: mm



RCP - Full Timber Framing System

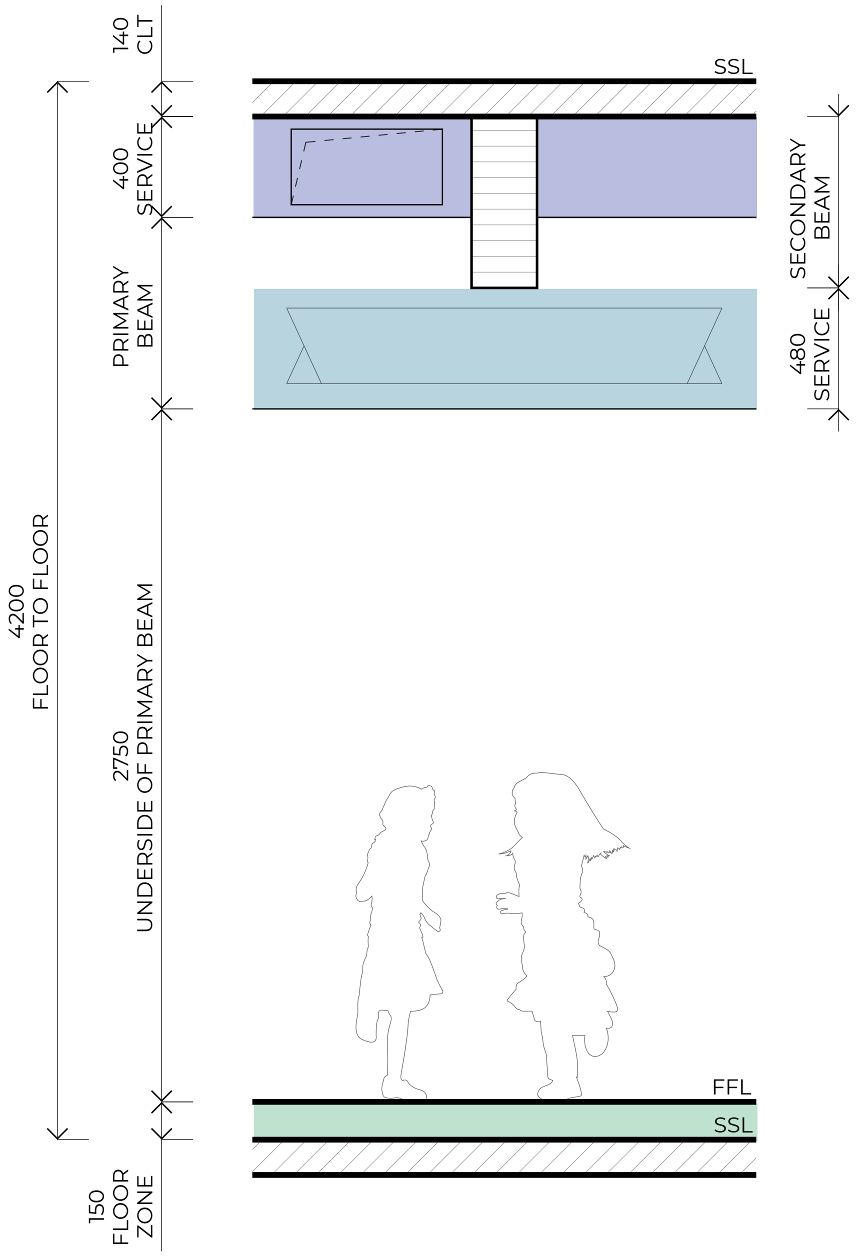
3.3 Timber Structure

Structural / Services Zones

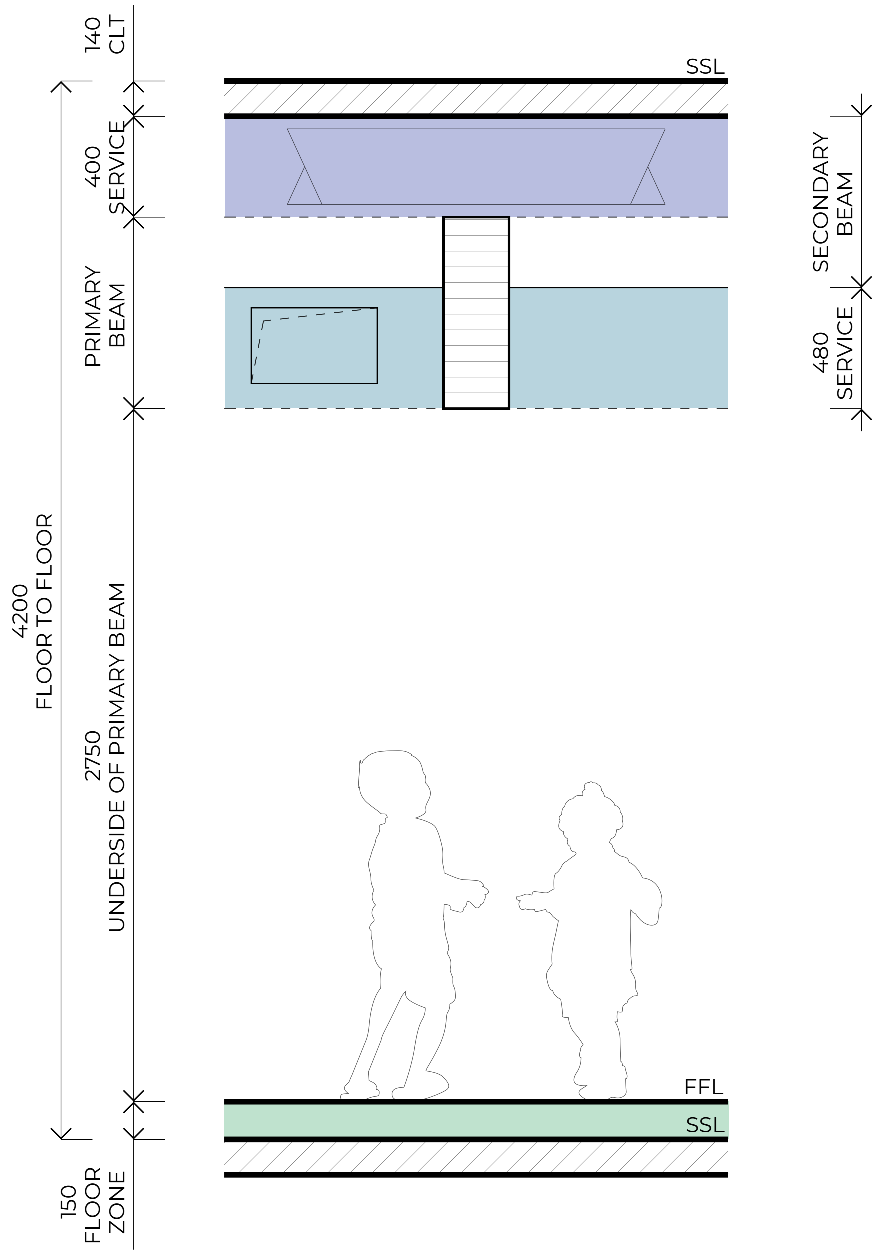
The diagrams to the right indicate the specific zones allocated to services. The timber structure has been designed to allow easy maintenance and access to all services while also taking advantage of showcasing the timber structure.

Services Zones

- Space above primary beams
- Space below secondary beams
- Floor zone (refer to floor zone section in guideline for further information)



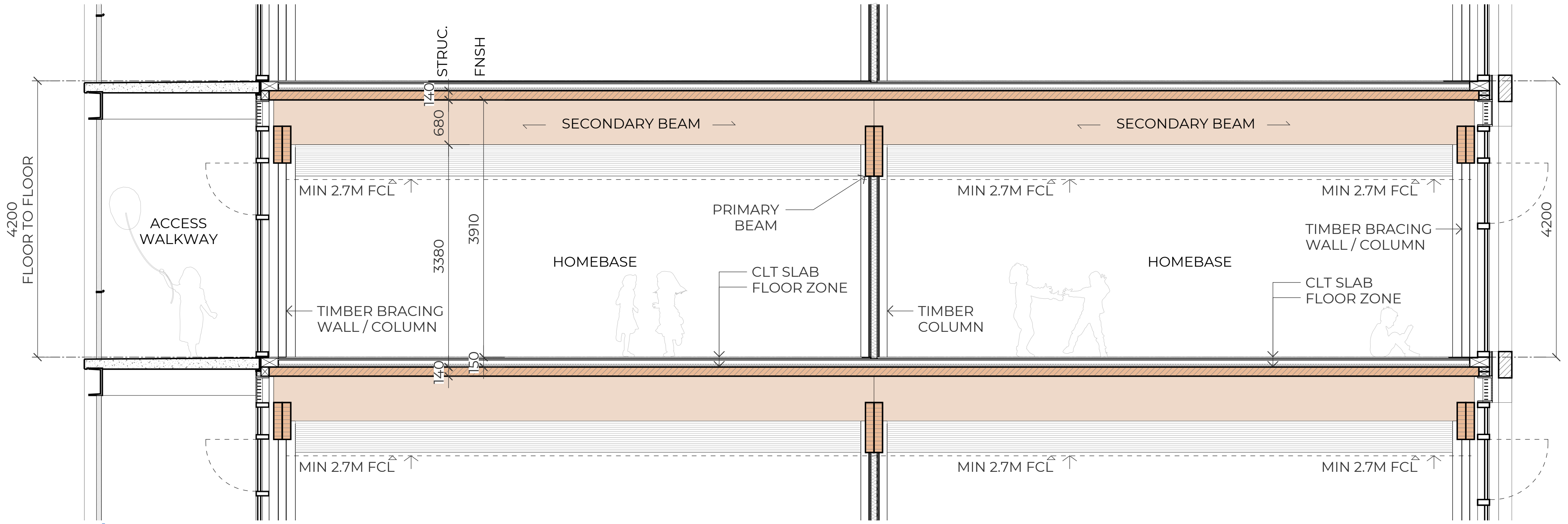
East / West Section



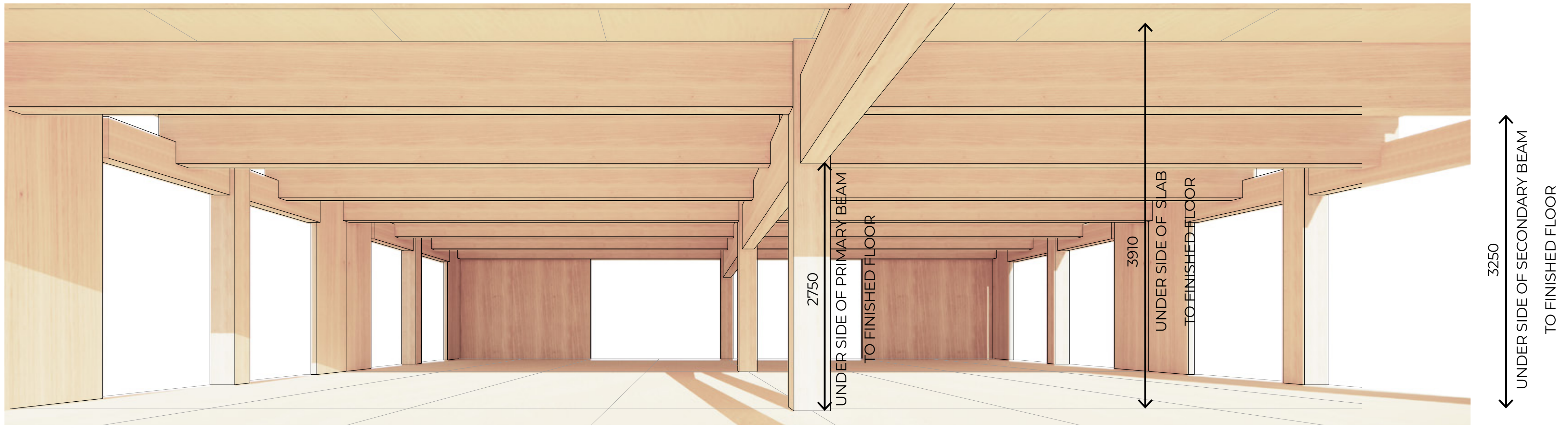
North / South Section

3.3 Timber Structure

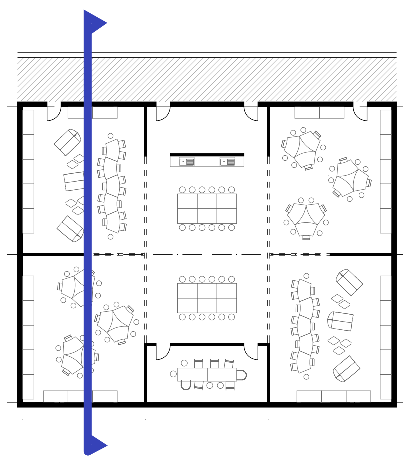
Timber System



East / West Section



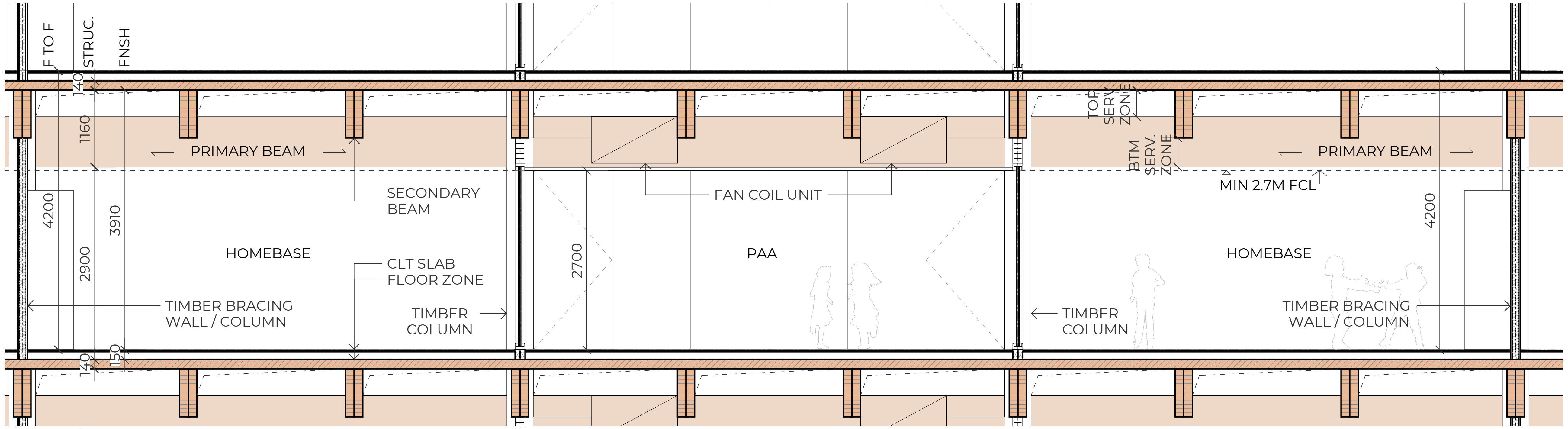
East / West Perspective



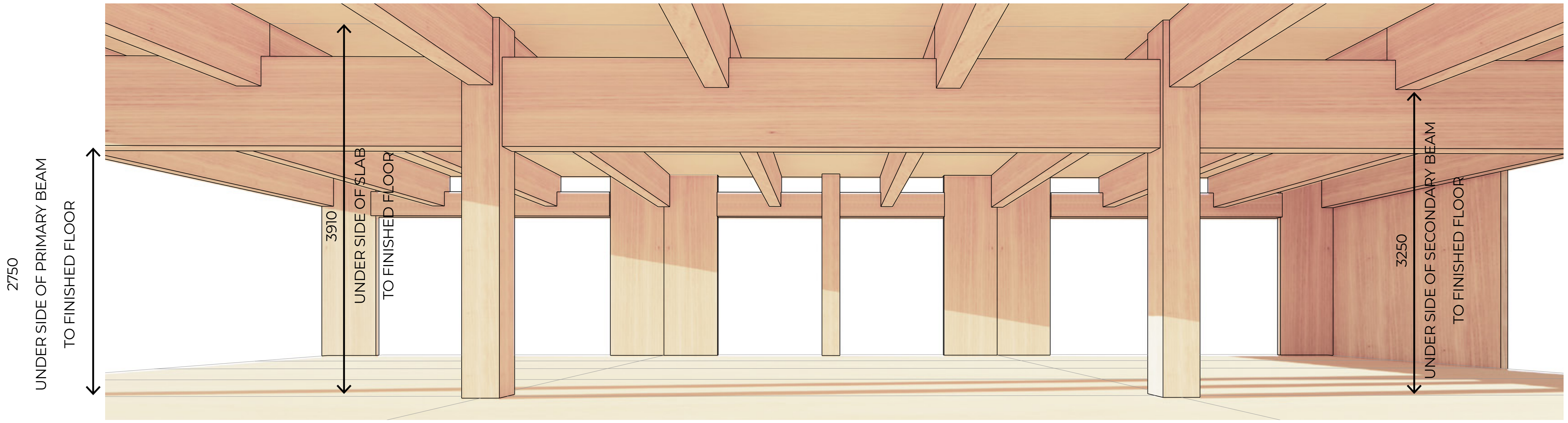
Key Plan

3.3 Timber Structure

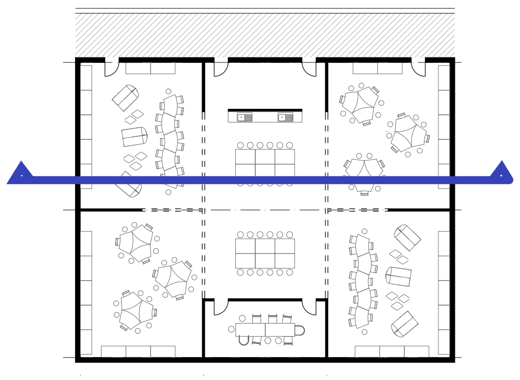
Timber System



North / South Section



North / South Perspective



Key Plan

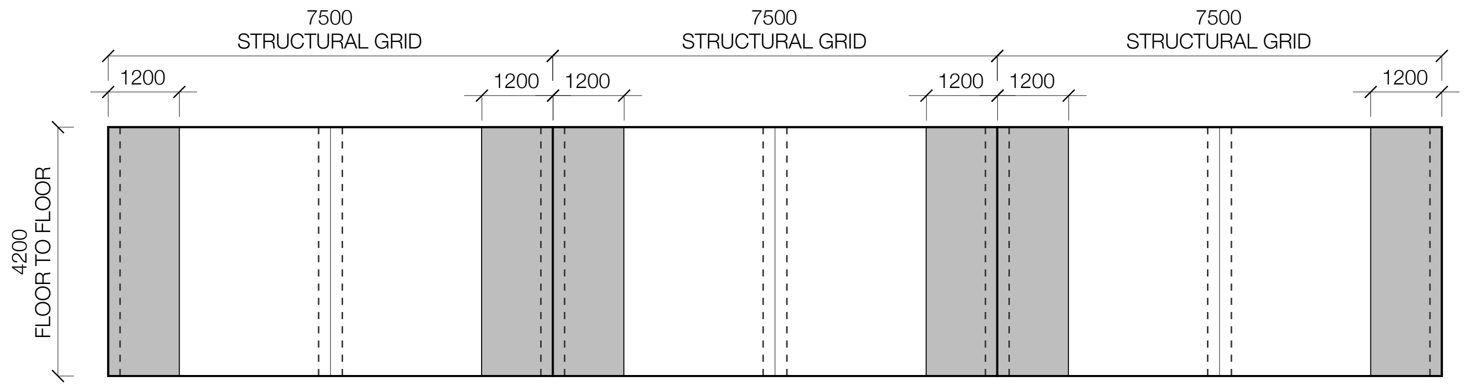
3.3 Timber Structure

Facade Bracing

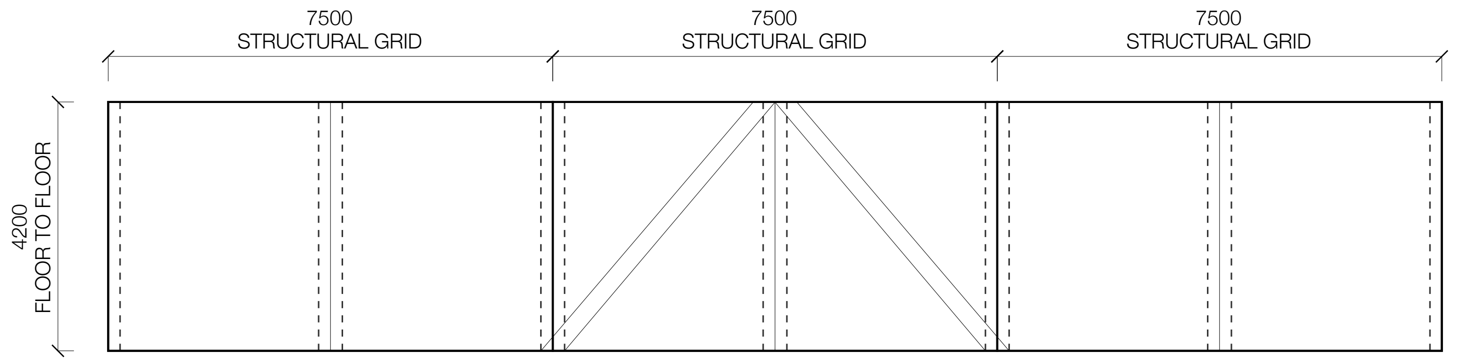
In designing the facade bracing system, the following factors should be considered:

- Site Context
- Climatic Zone
- Orientation
- Window to Wall Ratio (driven by daylighting, climatic zone and orientation)
- Natural Ventilation Ratio Requirements
- Equality of learning space (views, daylighting etc.)
- Materials of the bracing system

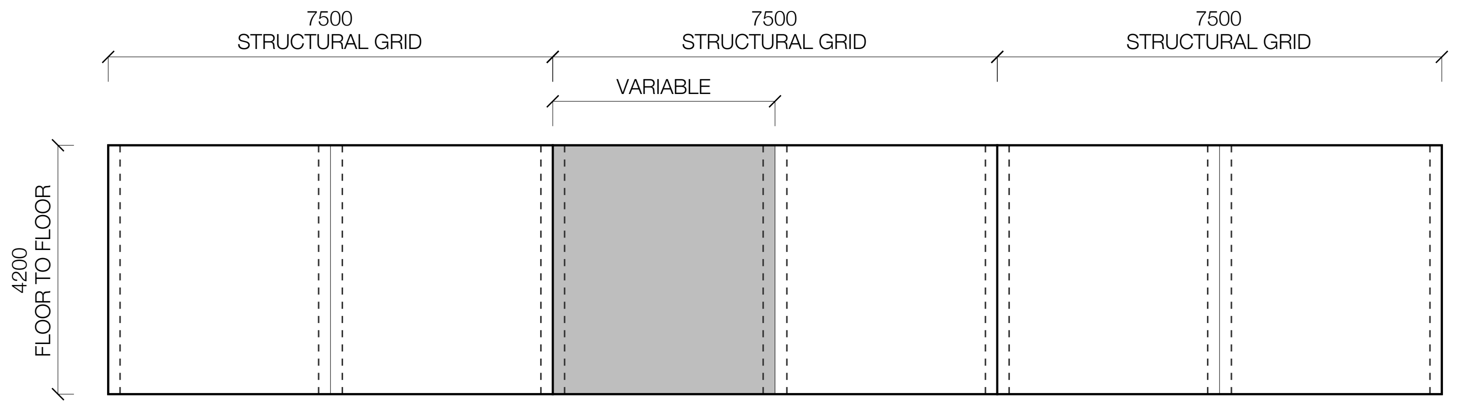
The three example diagrams shown on this page indicate some possible facade bracing methods of many solutions.



Bracing Diagram - Option 1 - Short Solid Bracing Wall (Indicative)



Bracing Diagram - Option 2 - Truss System (Indicative)



Bracing Diagram - Option 3 - Long Solid Bracing Wall (Indicative)

3.4 Steel Structure

Steel System

The steel system is composed of the following:

- Steel Columns spaced at 9m x 7.5m on the 9m framework set up by the planning system.
- Primary steel beams spaced 9m apart on the 9m framework
- Secondary steel beams spaced 7.5m apart
- Steel bracing system on the facade
- Steel cassette floor sitting within the framing system
- All steel structure and floor members require fire protection according to BCA subject to fire engineer's advice.

Fire resistant treatment or enclosure is required for the steel structural system. The following fire resistant systems are available with Pros/ Cons for each one:

Intumescent Paint

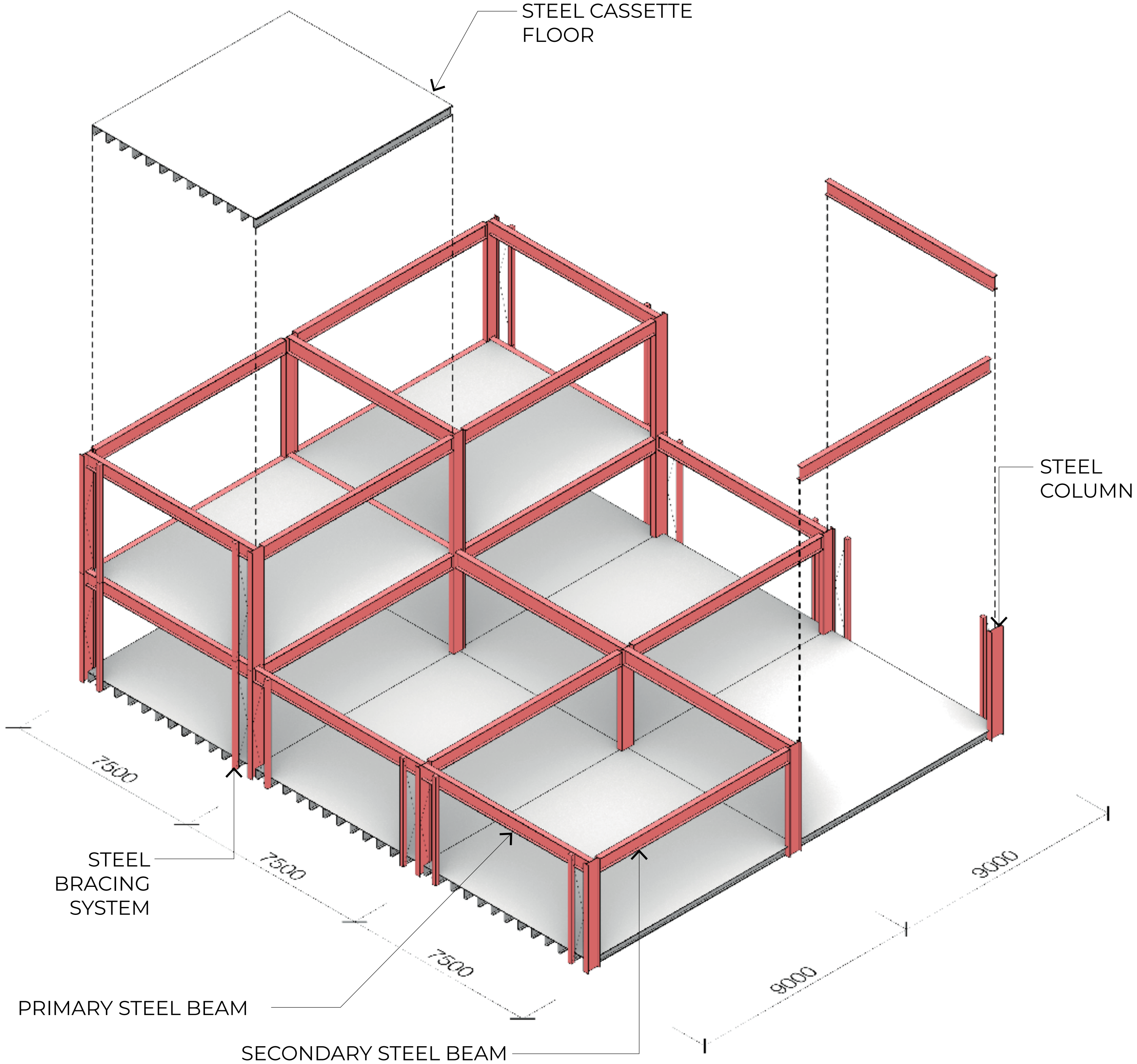
- Difficult at junction
- Regular maintenance is required
- Easy to be damaged
- Wet Trade

Prefabricated, Pre-finished component including junction

- Connection between panels needs to be detailed
- Maintenance - visual access behind panels

Boxed

- System needs to be assembled and finished on site, not DfMA



Steel Framing System - Axonometric Diagram

3.4 Steel Structure

Steel System

The RCP to the right details the structural component sizes for the steel structure system.

Disclaimer:

- All structural element sizes are indicative only, they are high level figures for the purpose of this report.
- The column size is designed for a 3 storey building

Steel Framing System - Kit of Parts:

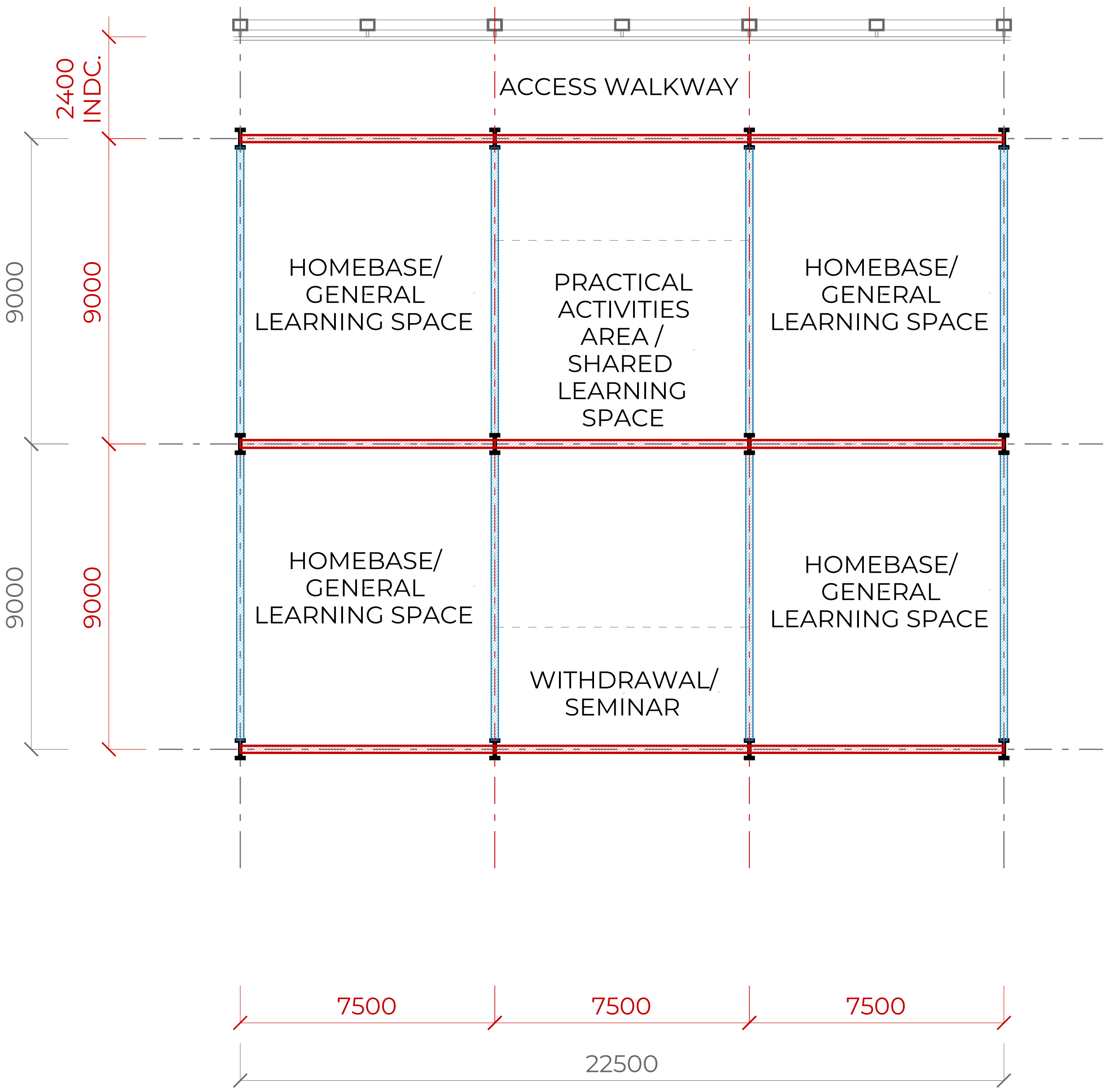
Indicative Steel - Primary Beam Internal

Indicative Steel - Primary Beam External

Indicative Steel - Secondary Beam

I Indicative Steel - Column

Unit of element size: mm



RCP - Full Steel Framing System

3.4 Steel Structure

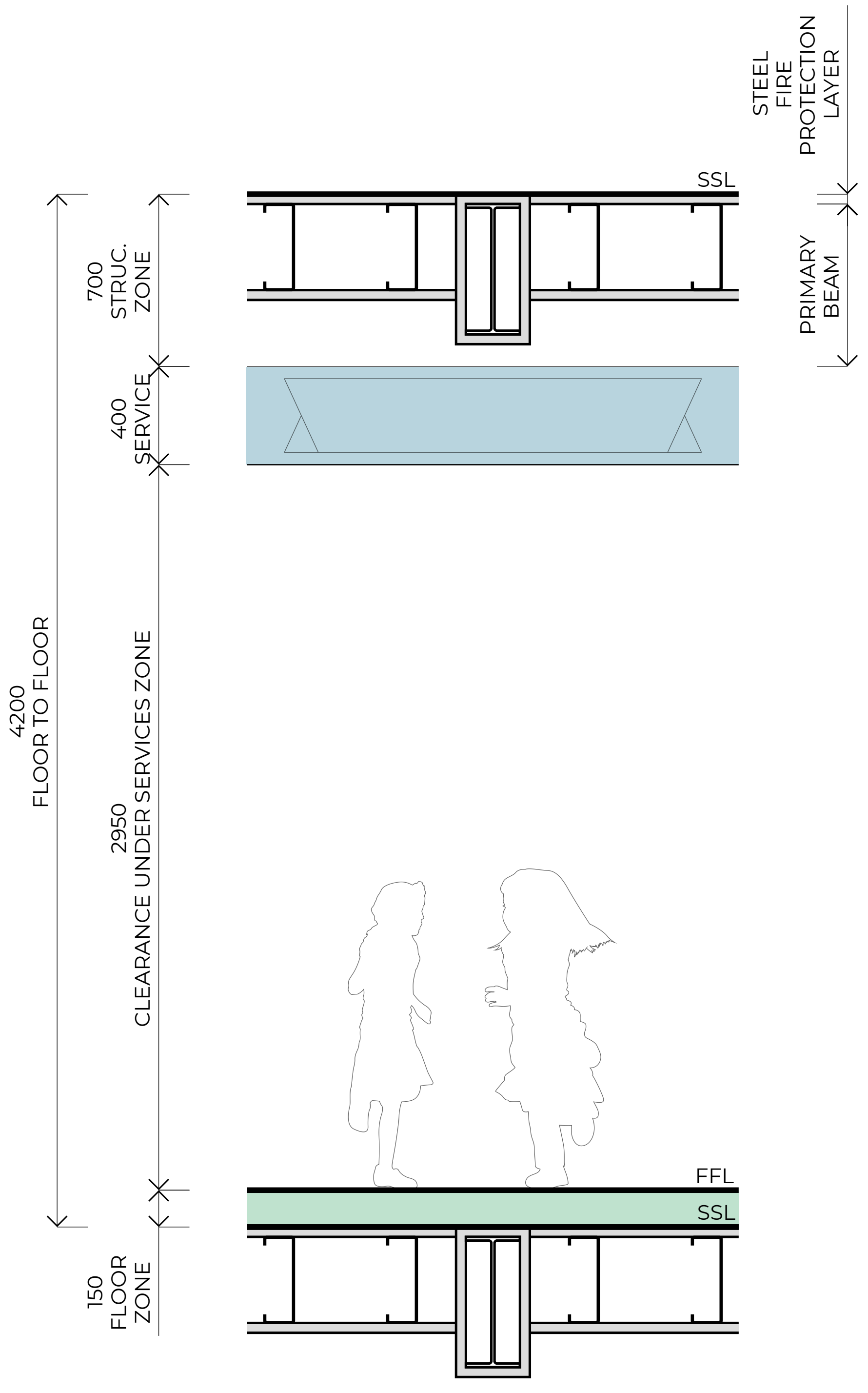
Structural / Services Zones

The diagrams to the right indicate the specific zones allocated to services. The steel structure has been designed to allow easy maintenance and access to all services.

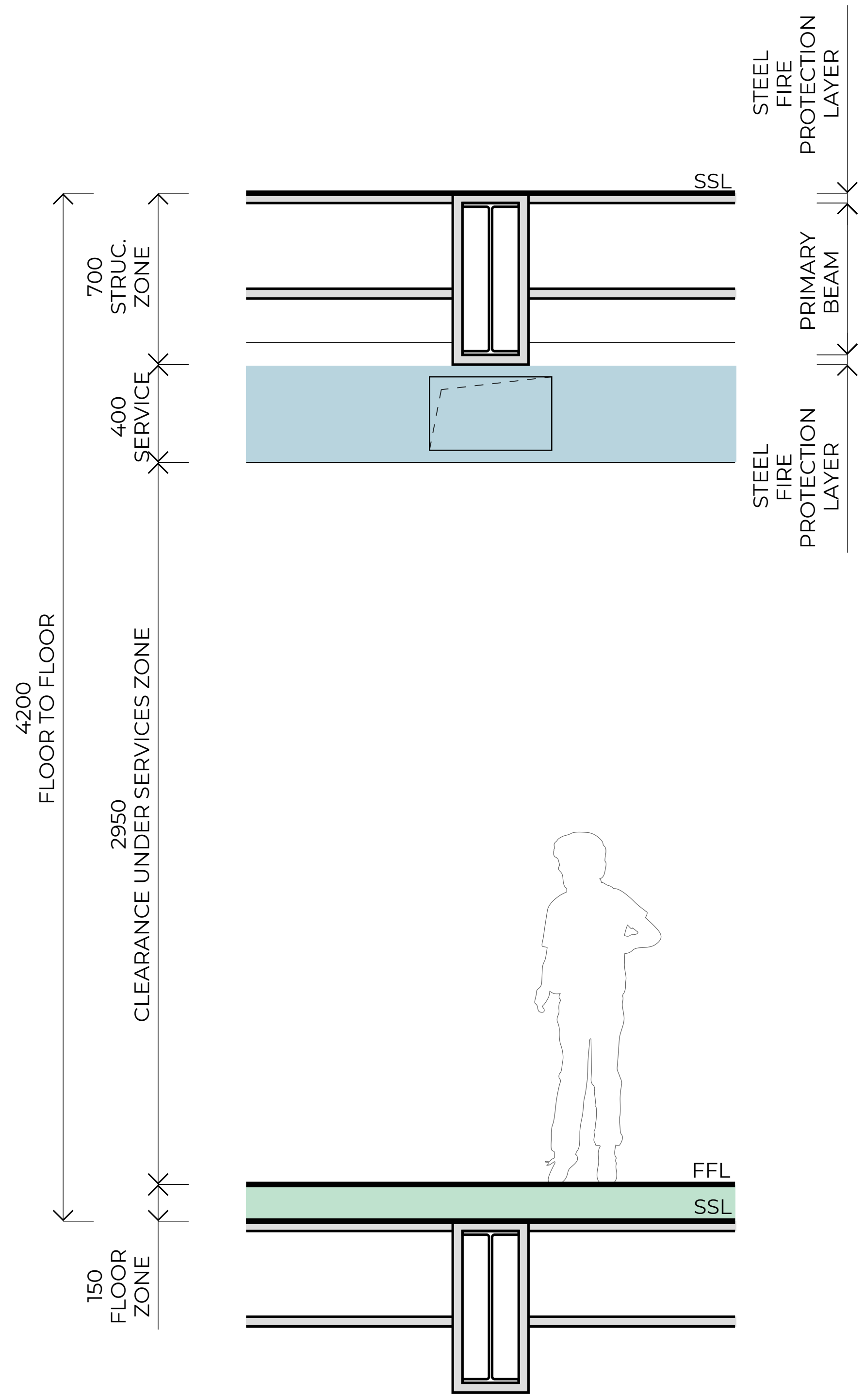
Services Zones

Services zone

Floor zone (refer to floor zone section in guideline for further information)



East / West Section



North / South Section

3.5 Concrete Structure

Concrete System

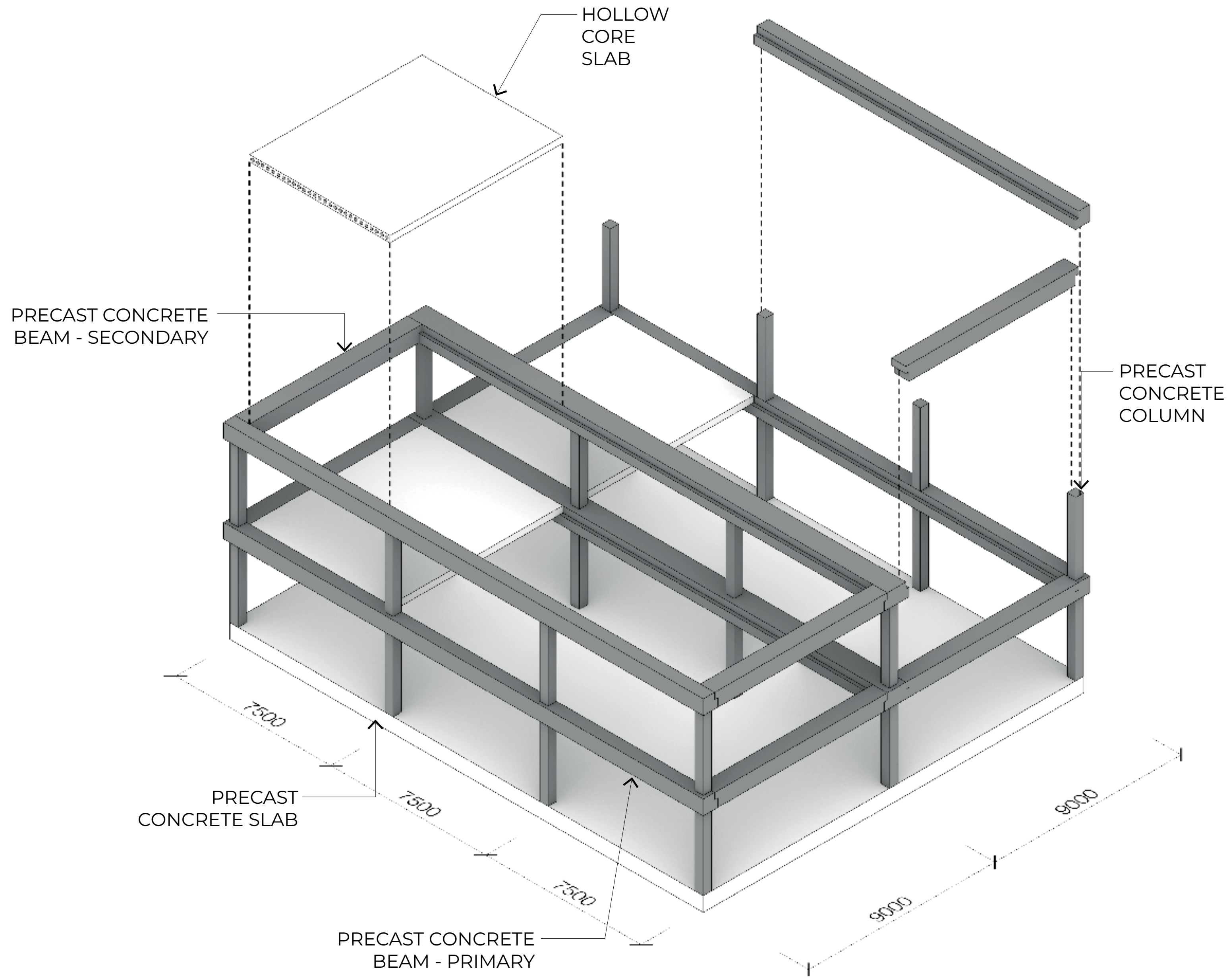
To eliminate wet trades on site, off site pre-cast concrete structural members in either RC (reinforced concrete) form or PT (pre-tensioned) form should be used.

A built-up floor zone of 150mm on top of structural slabs using lightweight materials should be used instead of a typical levelling topping screed system.

Fire protection needs to be achieved by a proper sealing system between slab panels.

The concrete system is composed of the following:

- Concrete Columns spaced at 9m x 7.5m on the 9m framework set up by the planning system.
- Primary concrete beams spaced 9m apart on the 9m framework
- Secondary concrete beams spaced 22.5m apart
- Hollow core slab spanning between the primary beams
- All concrete framing members are pre-fabricated RC (reinforced concrete) or PT (pre-tensioned) members.



Concrete Framing System - Axonometric Diagram

3.5 Concrete Structure

Concrete System

The RCP to the right indicates the structural component sizes for the concrete structure system.

Disclaimer:

- All structural element sizes are indicative only, they are high level figures for the purpose of this report.
- The column size is designed for a 3 storey building

Concrete Framing System - Kit of Parts:

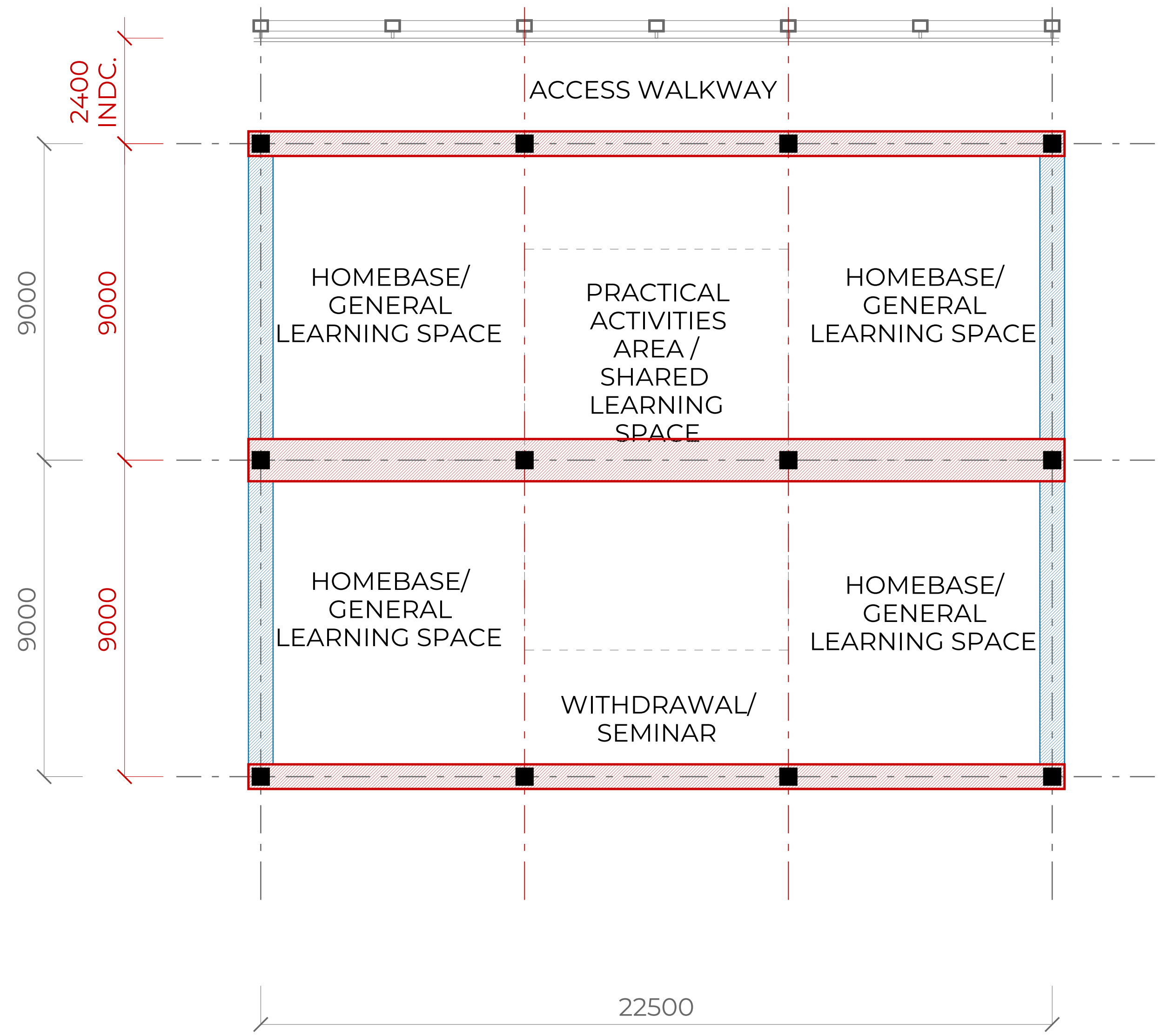
Indicative Concrete Primary Beam Internal

Indicative Concrete Primary Beam External

Indicative Concrete Secondary Beam

Indicative Concrete Column

Unit of element size: mm



RCP - Full Concrete Framing System

3.5 Concrete Structure

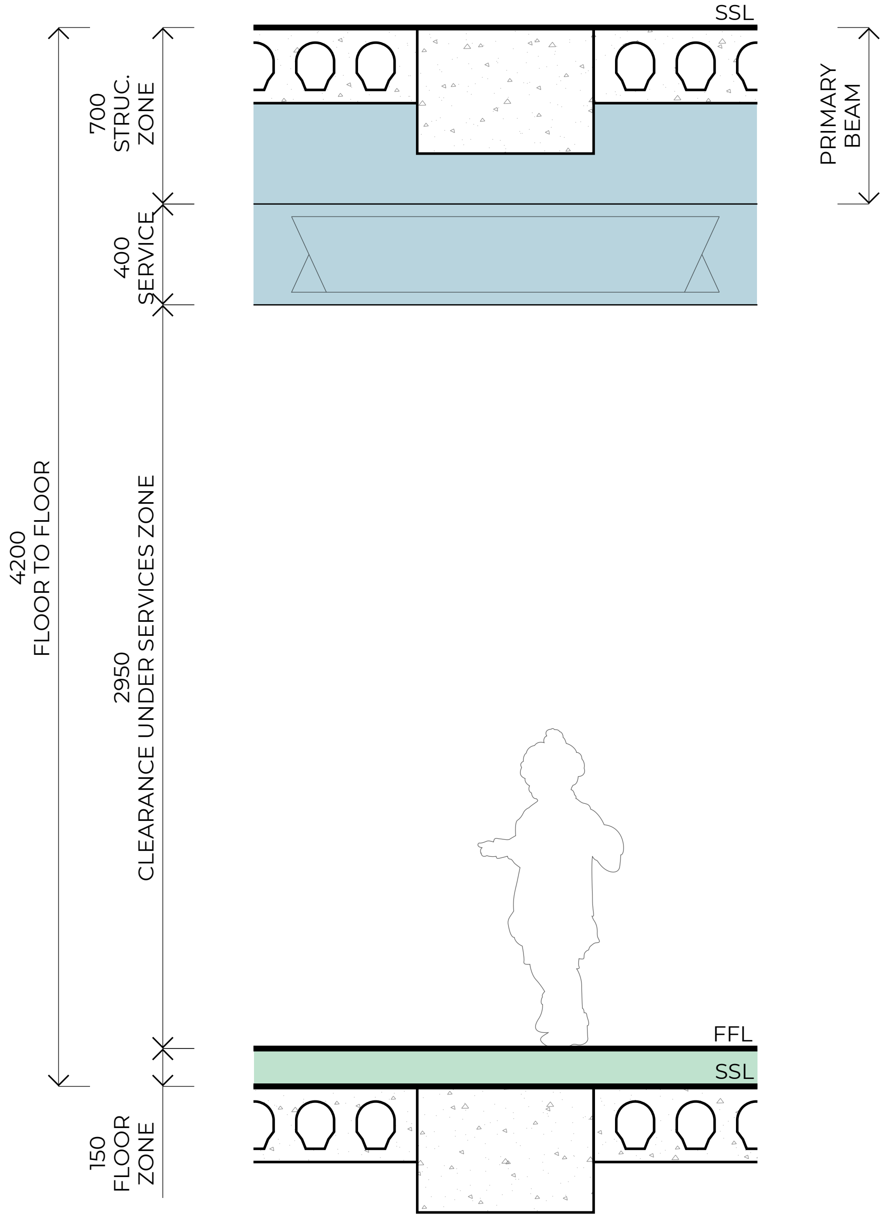
Structural / Services Zones

The diagrams to the right indicate the specific zones allocated to services. The alternative structure has been designed to allow easy maintenance and access to all services.

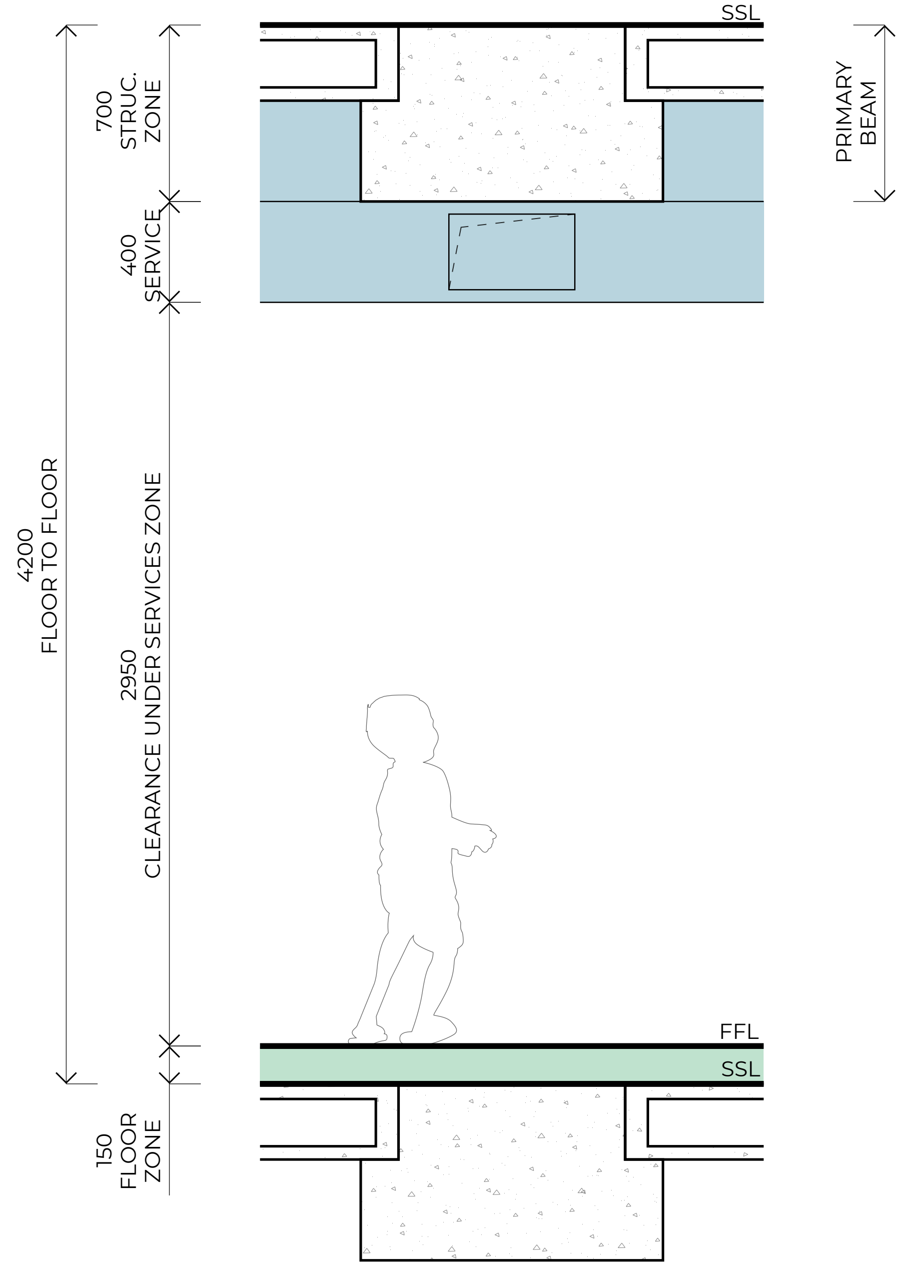
Services Zones

Services Zone

Floor zone (refer to floor zone section in guideline for further information)



East / West Section



North / South Section

3.6 Hybrid Structure

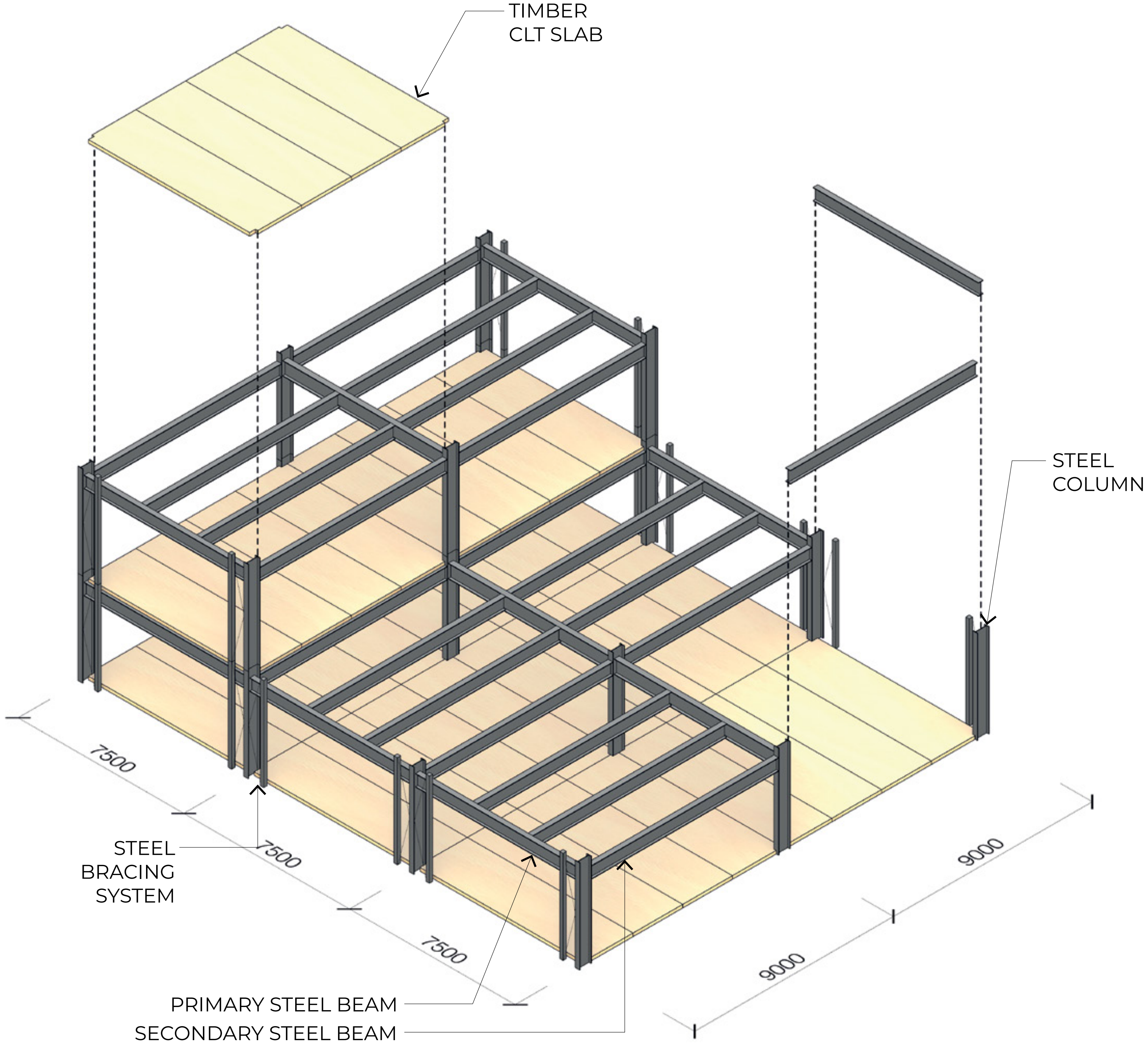
Hybrid System

There are many possible hybrid structural system scenarios, the common ones are as follows:

- Steel framing and bracing + Timber CLT floor
- Timber framing + Timber CLT floor + Steel bracing
- Prefabricated Concrete framing + Timber CLT floor
- Prefabricated Concrete framing + Steel cassette floor
- Steel framing + Prefabricated Concrete floor

The hybrid system indicated here is an example of many other possible solutions. This example is composed of the following:

- Steel Columns spaced at 9m x 7.5m on the 9m framework set up by the planning system.
- Primary steel beams spaced 9m apart on the 9m framework
- Secondary steel beams spaced 2.5m apart
- CLT slab spanning between secondary beams
- Steel bracing on facade.
- All steel members require fire protection according to BCA requirements subject to fire engineer's advice.



Hybrid Framing System - Axonometric Diagram

3.6 Hybrid Structure

Hybrid System Example -
Steel Framing + Timber Slab System

The RCP to the right details the structural component sizes for the hybrid structure system.

Disclaimer:

- All structural element sizes are indicative only, they are high level figures for the purpose of this report.
- The column size is designed for a 3 storey building

Hybrid System Framing System - Kit of Parts:

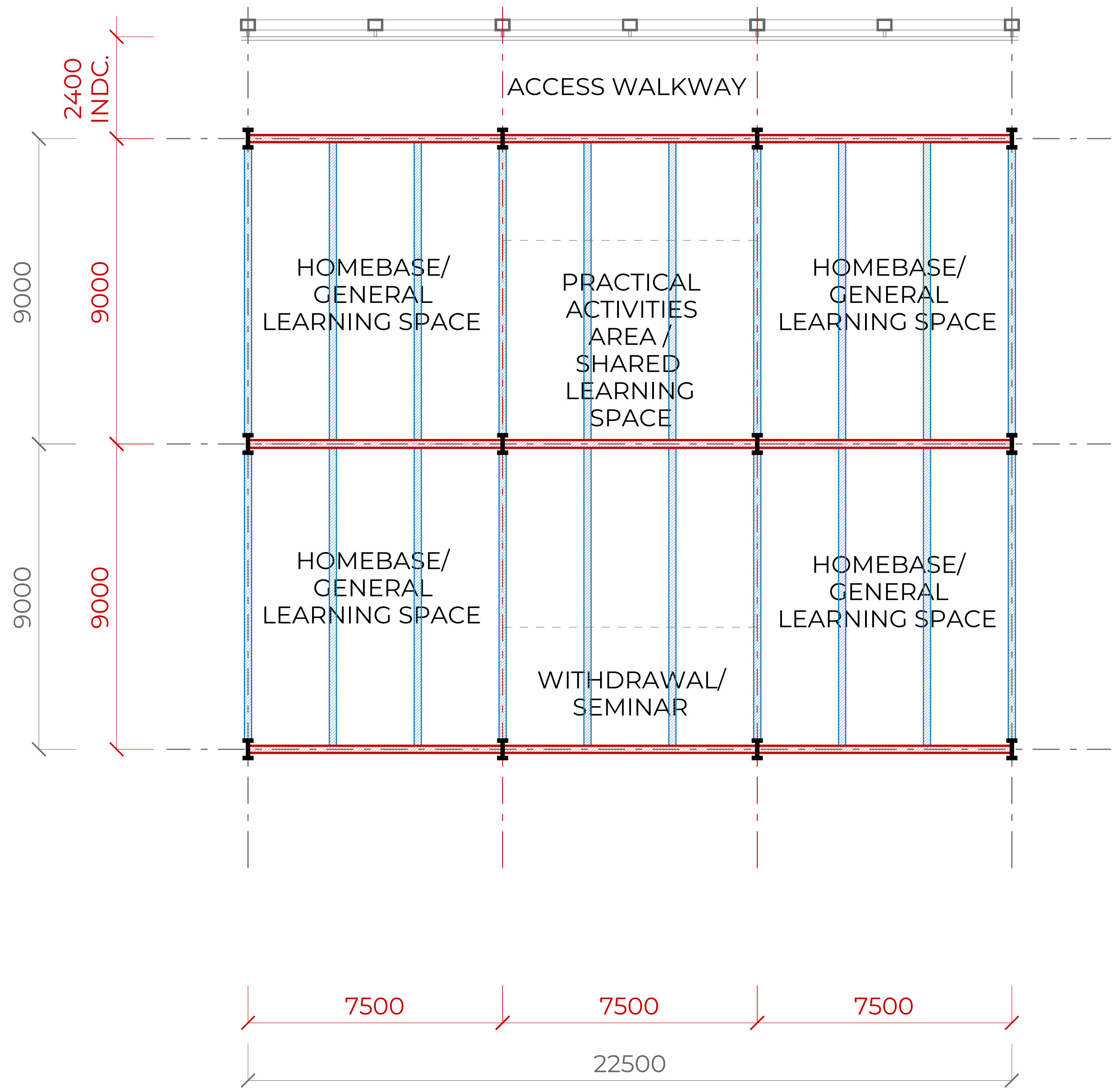
Indicative Steel Primary Beam Internal

Indicative Steel Primary Beam External

Indicative Steel Secondary Beam

I Indicative Steel Column

Unit of element size: mm



RCP - Hybrid System - Steel Framing + Timber Slab

3.6 Hybrid Structure

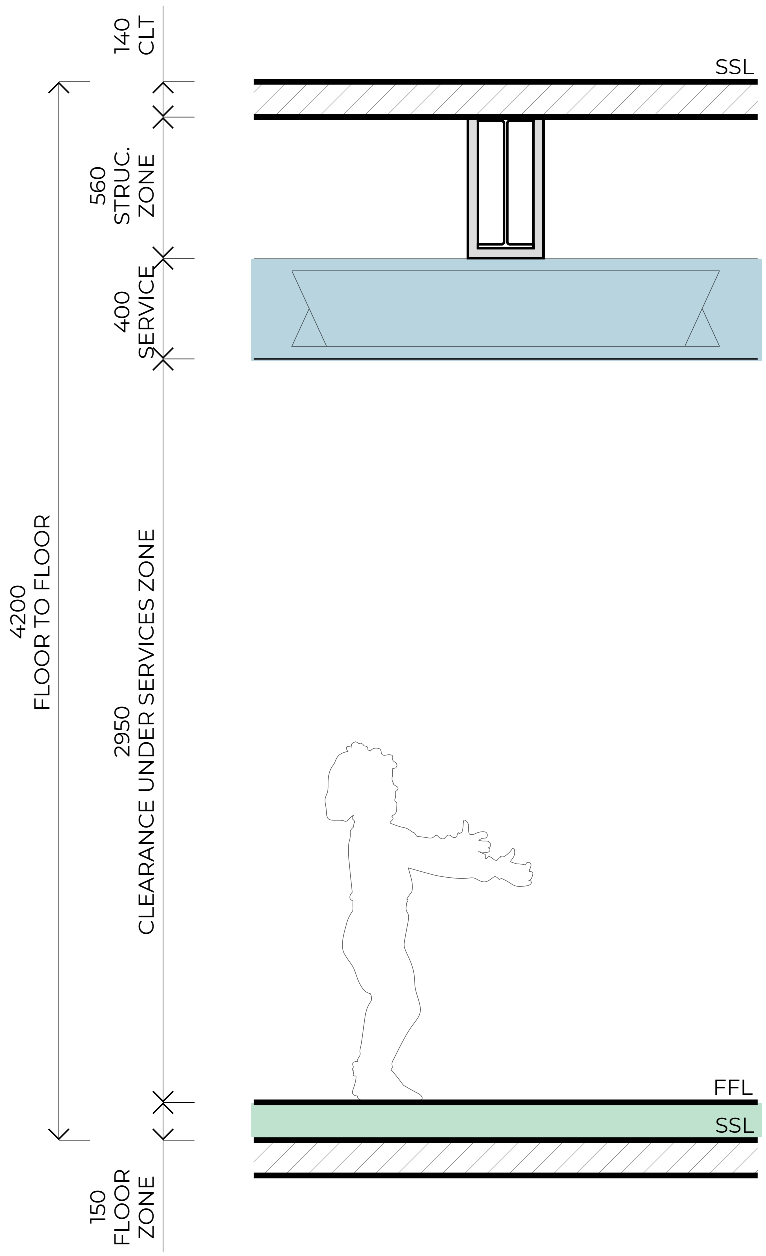
Structural / Services Zones

The diagrams to the right indicate the specific zones allocated to services. The alternative structural solutions also designed to allow easy maintenance and access to all services.

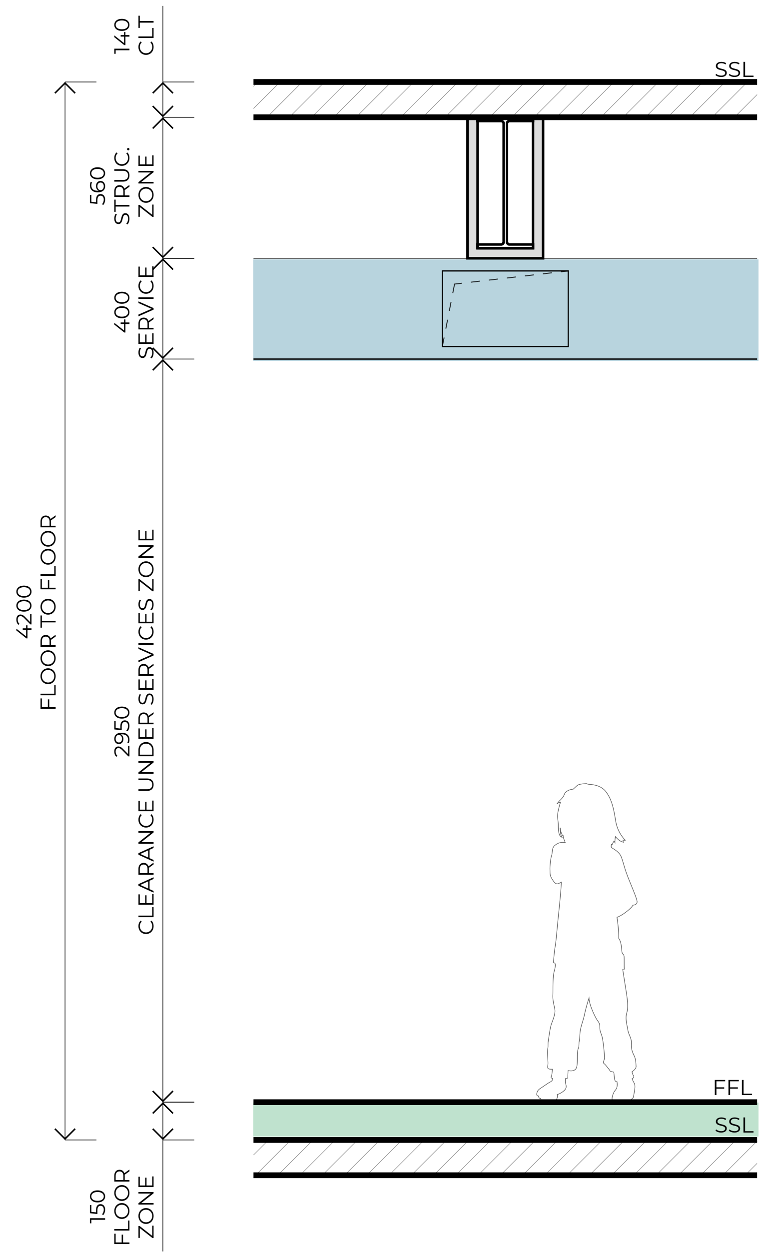
Services Zones

Services Zone

Floor zone (refer to floor zone section in guideline for further information)



East / West Section



North / South Section

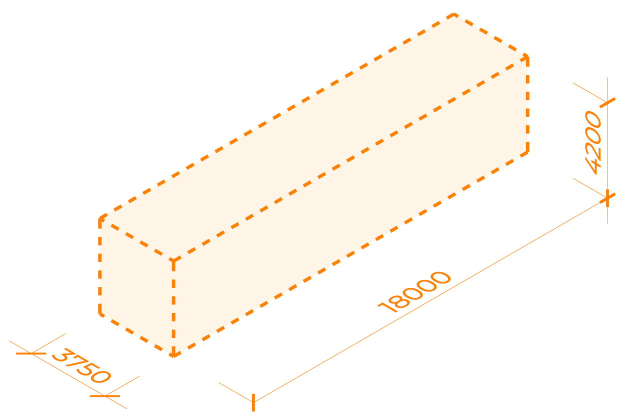
3.7 Volumetric Construction

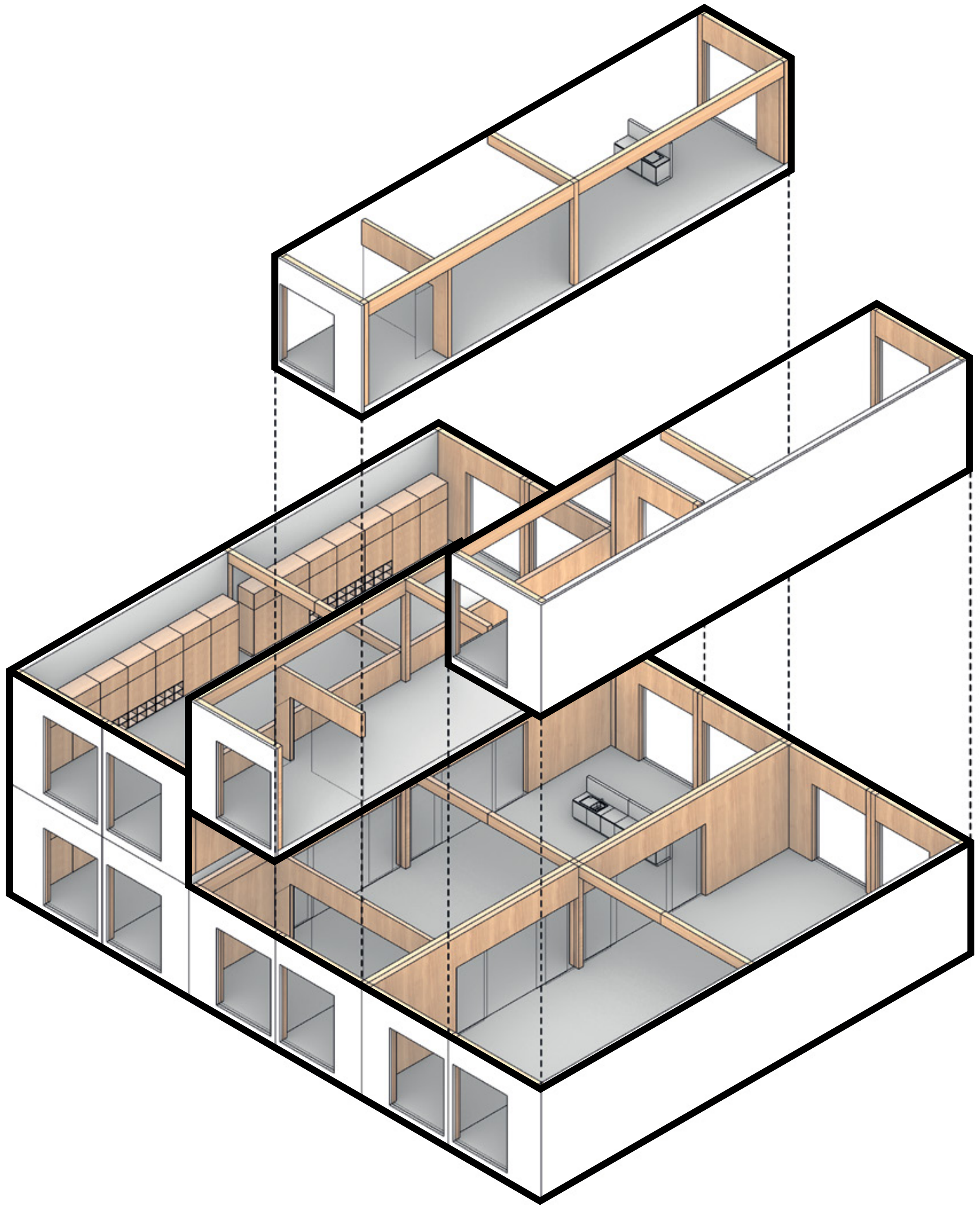
Volumetric System

The volumetric system shown is an example of one of many possible solutions. The following example system is composed of modules measuring 3.75m by 18m. The module size has been generated by the planning framework.

The volumetric system is fabricated off site and delivered to site complete with structure, services, external walls, internal walls, finishes and joinery.

Steel structure is recognized as a base for the current industry. Hybrid structure system or timber system could be explored for future volumetric construction methods.





Volumetric System Axonometric

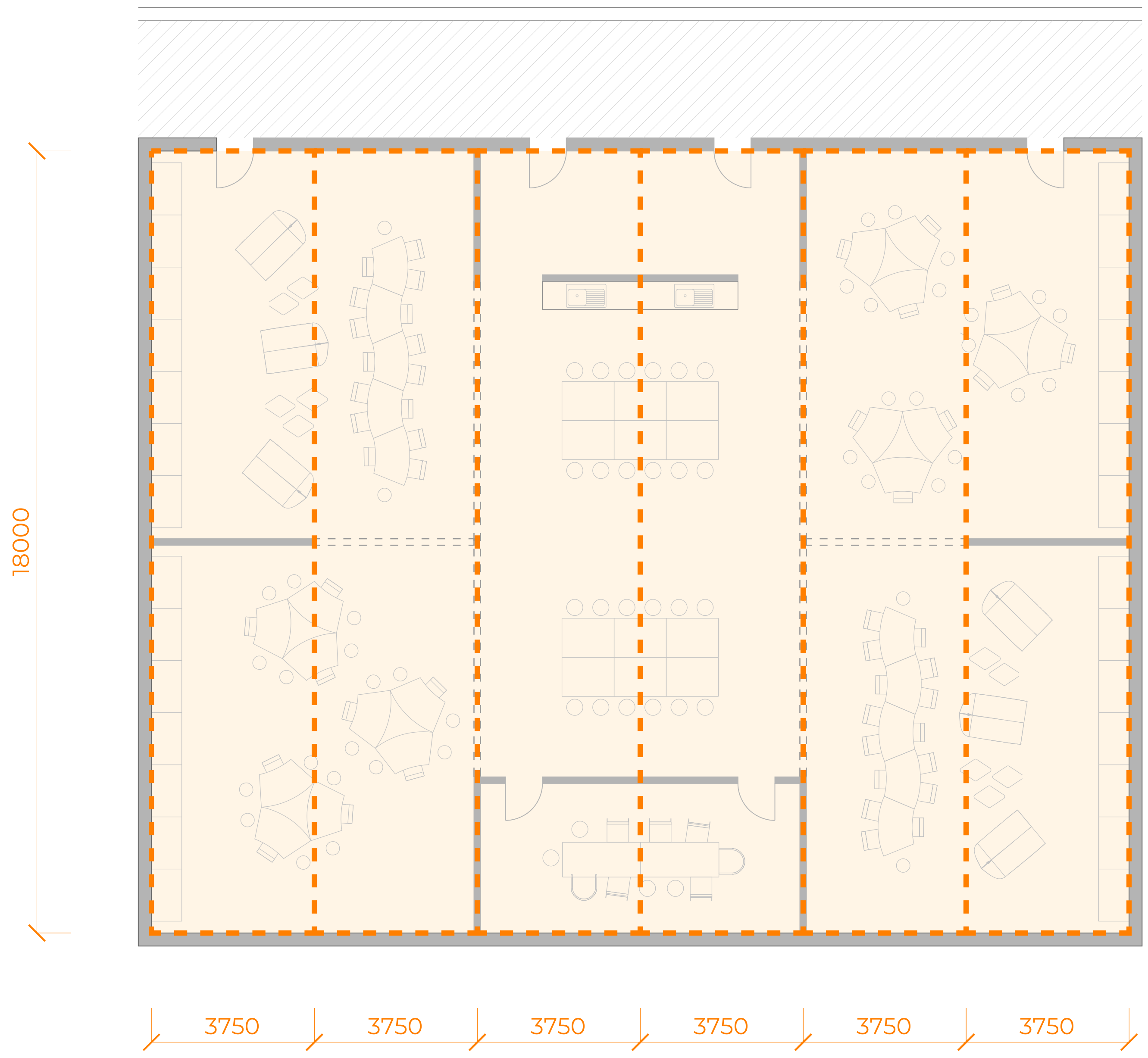
3.7 Volumetric Construction

Volumetric System

The following example shows a typical homebase hub of 4, overlaid with a volumetric module of 3.75m by 18m. This is an example of many other potential overlay options.

Volumetric manufacturers are to consider the internal and external wall locations when producing modules to ensure that system and planning integrity is maintained.

Columns should be placed according to the structural grid as per chapter 2.2. Column location and spacing should be similar as the aforementioned timber structure system (chapter 3.3) and steel structure system (chapter 3.4), where an internal beam of a volumetric module has no supporting edge column, it will be temporarily propped in the factory, then connected on site with the internal beam from the next volumetric module.



3.8 Services

The DfMA Services Components have been designed and detailed with the following principles:

Wellness

- Ensuring the system meets services requirements for day to day use.
- Minimising impact on daylight penetration and acoustic performance to the learning spaces.
- Services system as a learning opportunity.

Adaptability + Equality

- Design is fit for purpose
- System should be suitable for the planning requirements of all school spaces.
- Modular approach

Maintenance

- Robust materials and finishes - ensuring longevity of life
- Ease of cleaning/daily maintenance
- Ease of assembly and disassembly for maintenance/replacement
- Ease of replacement of parts - Use of widely/locally available materials and products
- Shorter life span in comparison to structure - Services to be designed to be replaceable as required.

Security and Safety

- Eliminate risk of entrapment and tripping hazards
- Concealed fixings
- Robust system to withstand high traffic and activity.

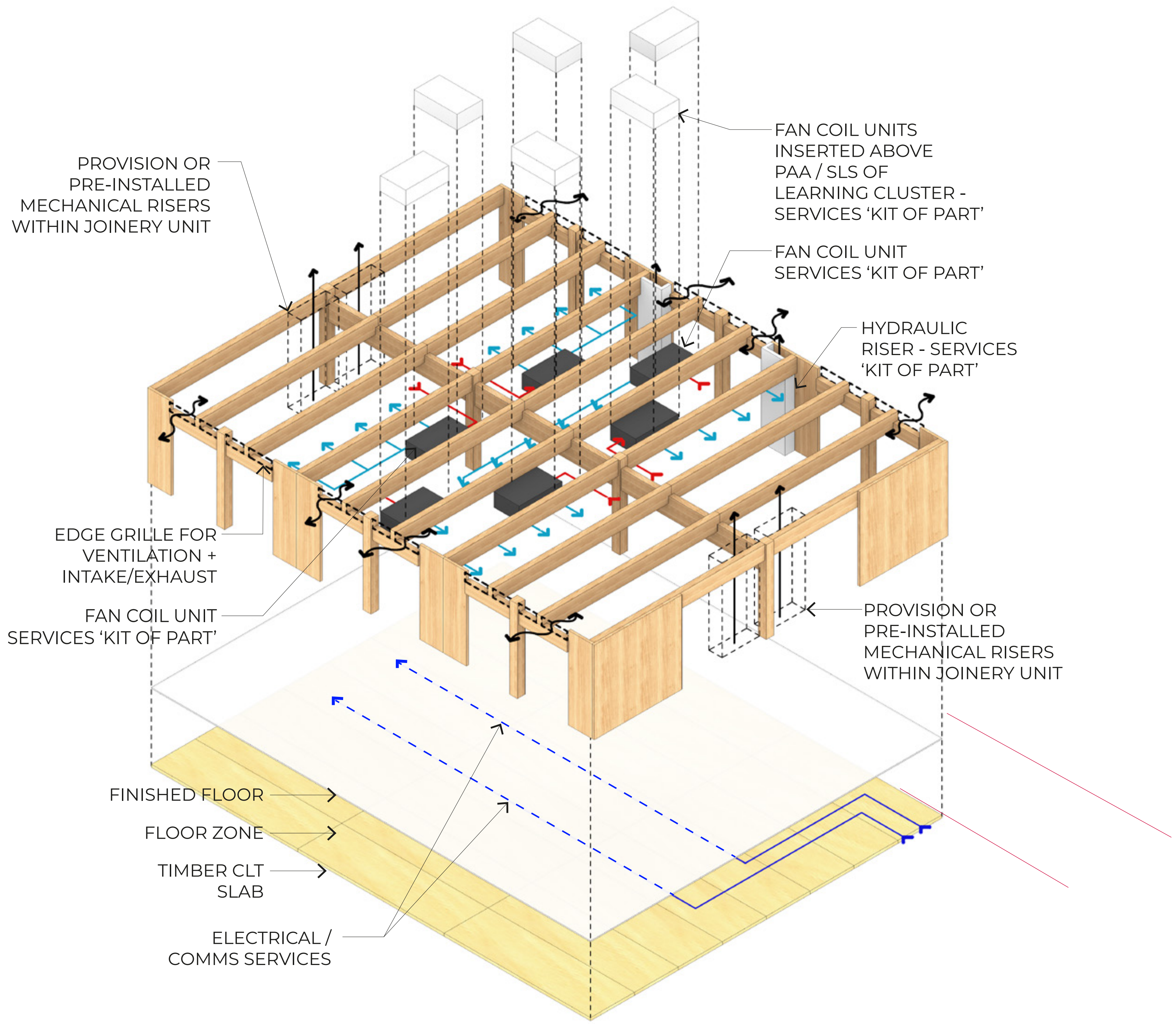
3.8 Services

Service Zones

The services systems have been designed to integrate efficiently with the structure system with the goal of providing for future flexibility. The services are composed of the following:

- Fan Coil Units located above a drop ceiling in the shared learning space between 4 classrooms.
- Hydraulic risers against the access walkway facing facade.
- Provision of mechanical risers for specialist learning spaces can be installed within the teaching wall joinery in High School GLS.
- Electrical and Comms services located in the floor zone where applicable.

The services system is not specific to one use. The structure can be consistent while the services can be interchanged as services typically have a shorter life span.



Service System Axonometric

3.8 Services

Floor Zone

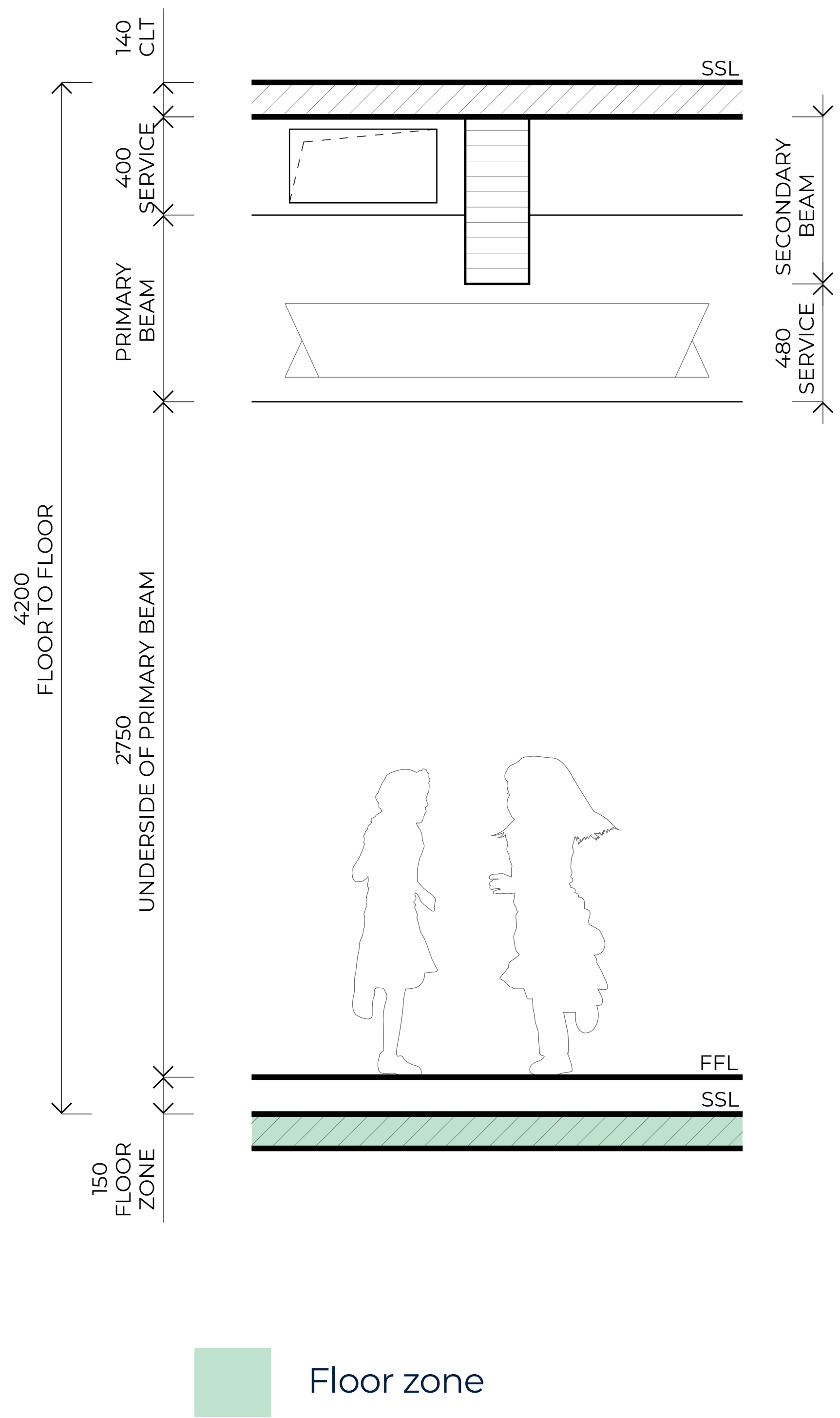
The floor zone can be adapted to suit a variety of space types. Using the following systems all spaces in the EFSG can be accommodated for acoustic, vibration and impact requirements. The following two pages set out each type of floor zone with finishes in accordance with EFSG requirements.

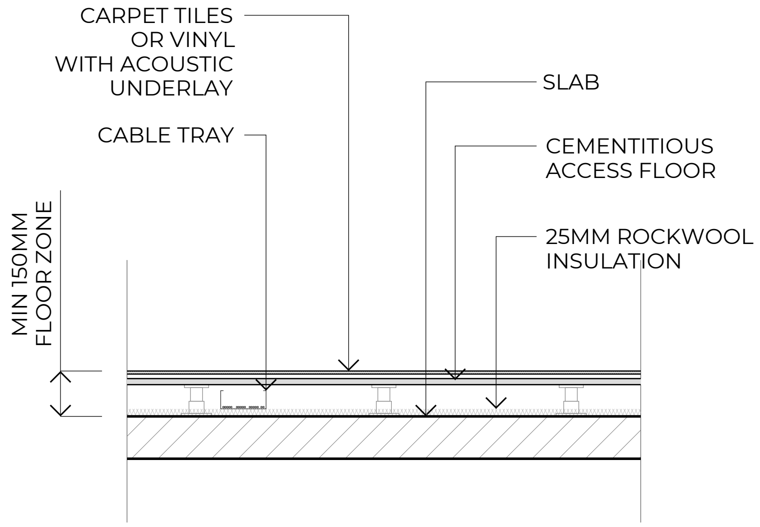
Diagram Notes:

- Slab size is indicative only
- Size of cable tray/waterpipes/floor waste etc are indicative
- Dimensions above pedestals are indicative for allowance only
- Waste pipe penetrations to be sealed underneath slab to meet fire safety and acoustic requirements

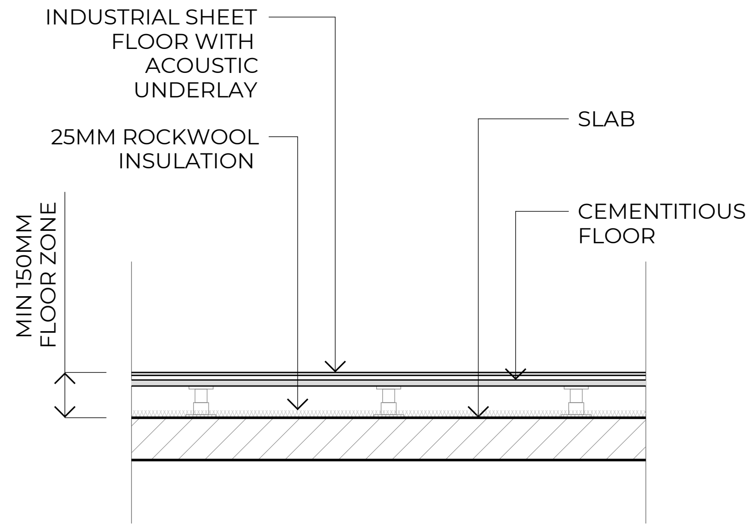
Floor Zone Systems

- **System A:** Suitable for homebases, general learning spaces, admin, staff rooms, practical activities areas and library.
- **System B:** Suitable for visual arts workshops, foodtech kitchens and science labs.





System A

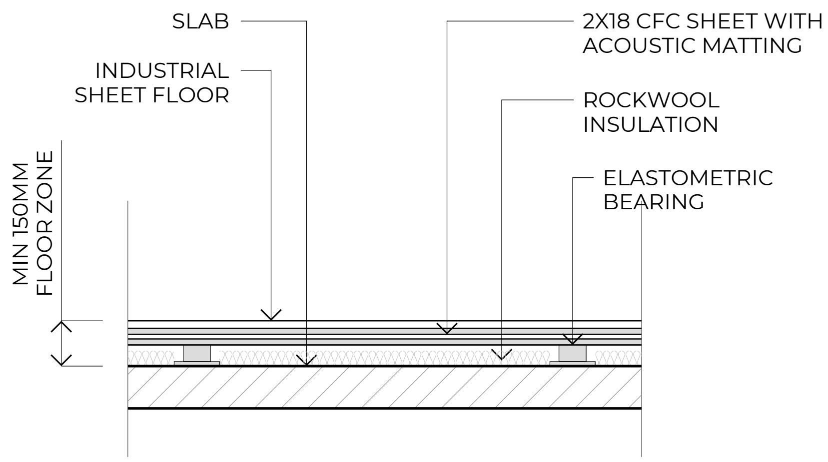


System B

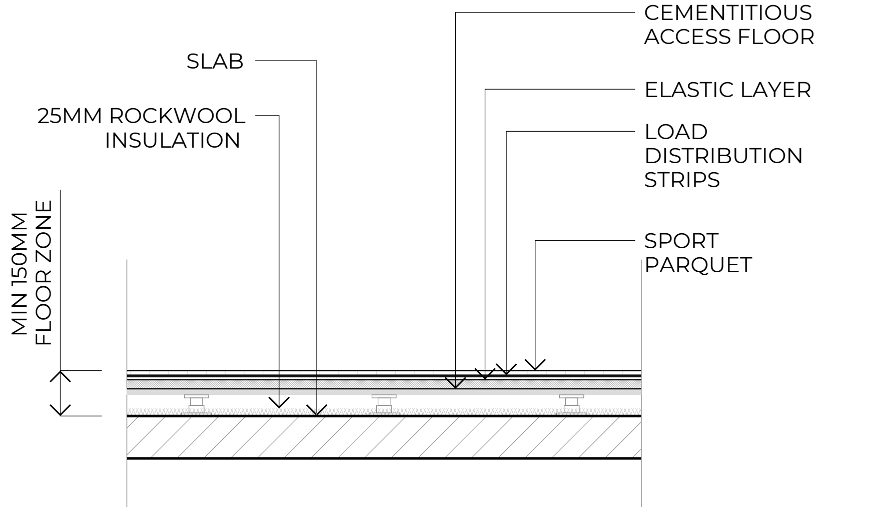
Floor Zone

Floor Zone Systems

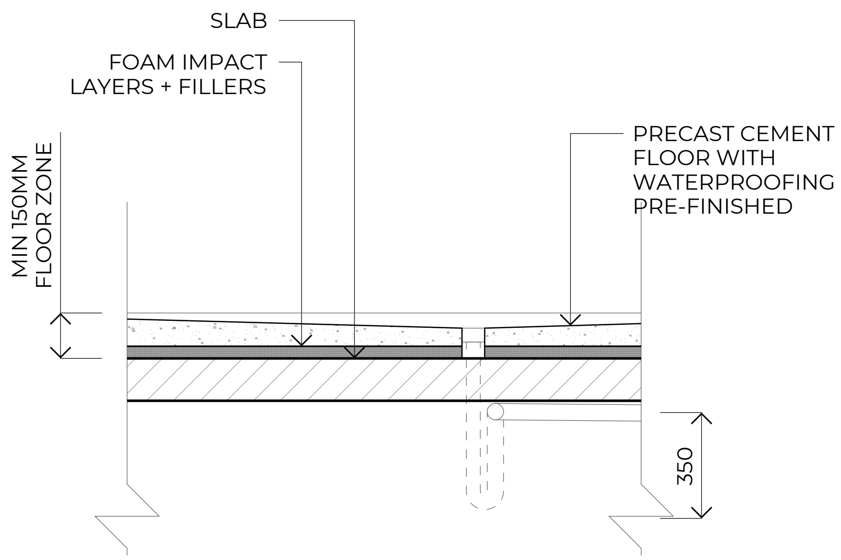
- **System C:**
  Suitable for wood/metal workshops with no services in floor zone.
- **System D:**
  Suitable for fitness &performing arts workshops
- **System E:**
  Suitable for wet areas, visual arts workshops, foodtech kitchens, science labs and wood/metal workshops.
- **System F:**
  Suitable for wet areas i.e. SELU showers and toilet areas



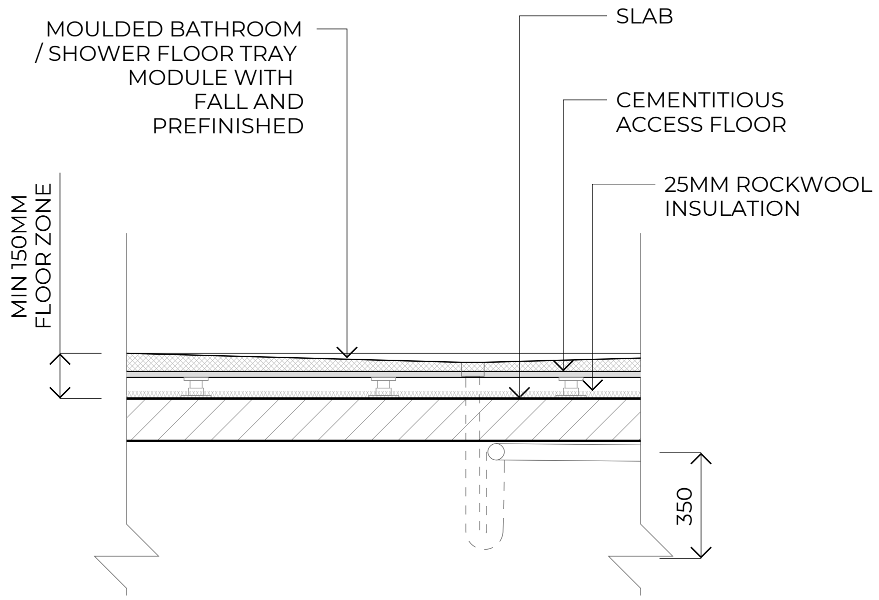
System C



System D



System E



System F

3.9 Facade

The DfMA Facade Components have been designed and detailed with the following principles:

Wellness

- Ensuring adequate daylight access in all usable spaces
- Enabling passive comfort strategies such as natural ventilation.
- Thermal performance

Adaptability + Equality

- Facade allows consistent amenity (Daylight and Natural Ventilation) in all spaces.
- System should be suitable for the planning requirements of all school spaces.

Maintenance

- Enable all construction methods from off-site volumetric to conventional to secure quality and program, and maximise use of budget.
- Standardised detailing addressing performance and maintenance requirements.

Sustainability

- Climate Resilience - Learning environment needs to be adaptable to a changing climate.
- Standardisation supporting higher performance versus cost.

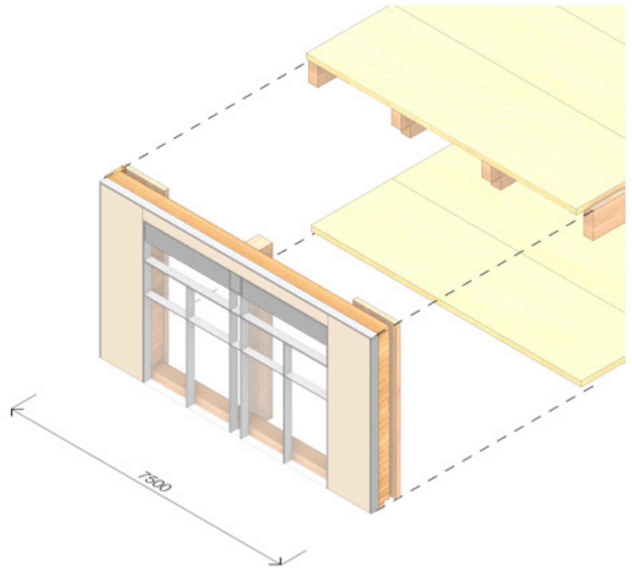
3.9 Facade

Facade Construction Methods

The DfMA Guidelines detail three methods of construction for the facade.

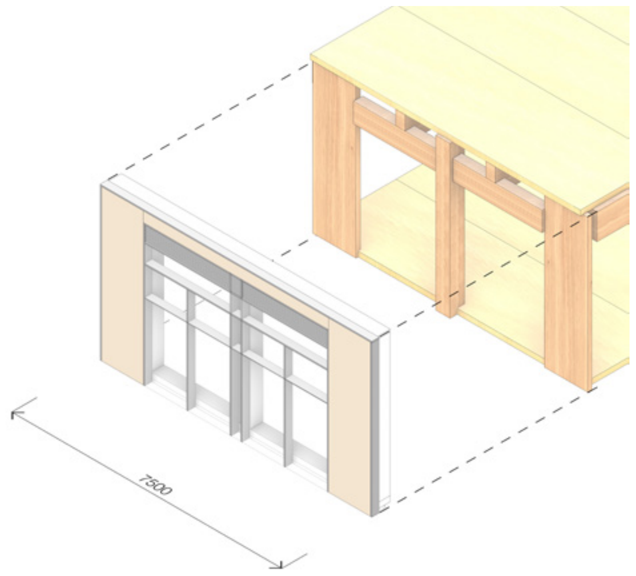
- **Construction Method 1:** Mega-panel System (with or without structure)
- **Construction Method 2:** Semi Panellised - Window Wall System
- **Construction Method 3:** Semi Panellised - Curtain Wall System

Example of Facade Construction with structure Integrated

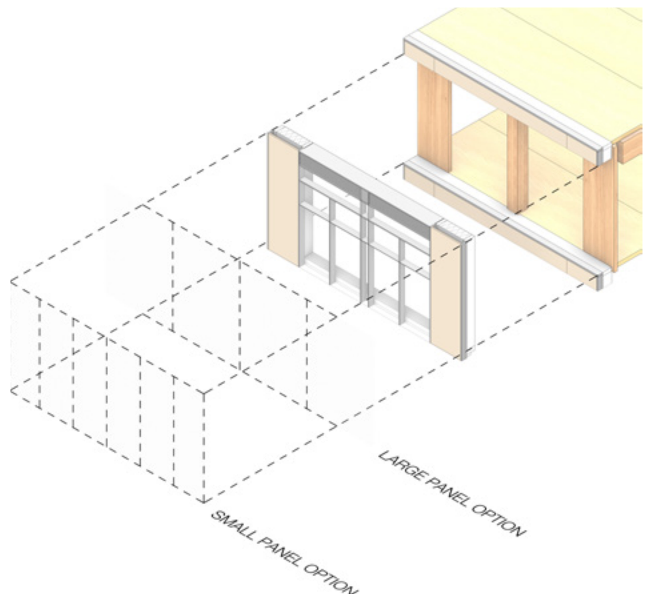


Mega-Panel System

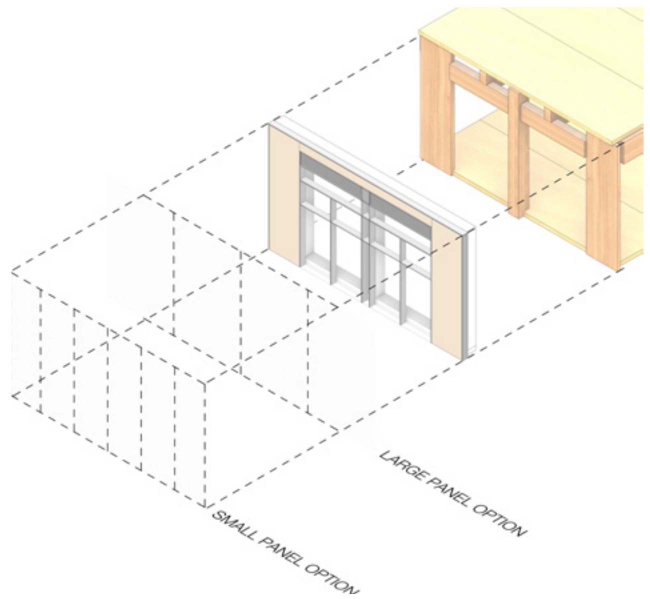
Examples of Facade Construction without Structure



Mega-Panel System



Window Wall System



Curtain Wall System

3.9 Facade

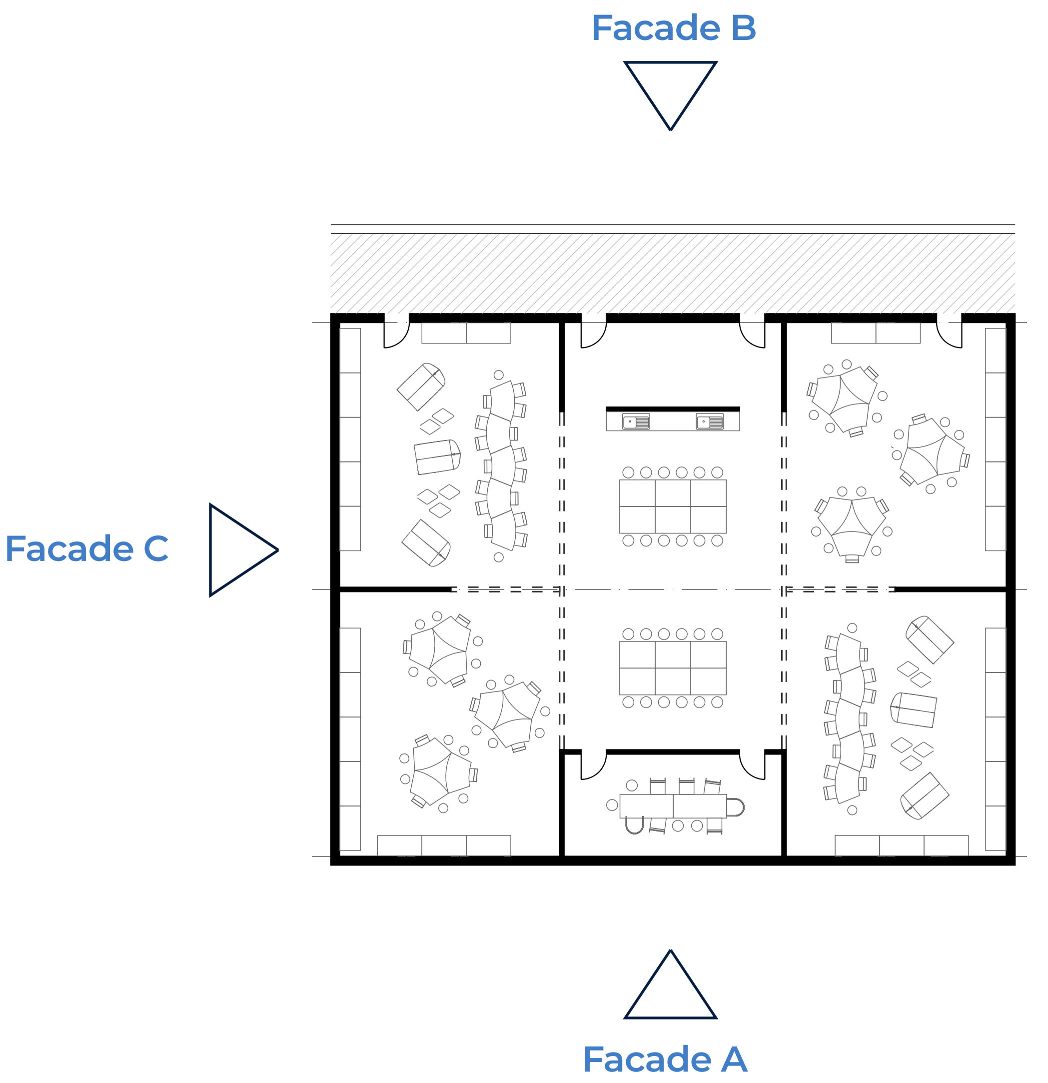
Facade Types

There are three facade types within the DfMA system:

- **Facade A:** External facing facade with sun shading. Window to wall ratio and shading ratio should be designed in accordance with the sustainability guidelines in Chapter 4. The facade solution should include a minimum of 5% of the enclosed floor area as ventilation area through an operable solution such as windows.

- **Facade B:** Internal facing facade within the access walkway. Window to wall ratio should be designed in accordance with the sustainability guidelines in Chapter 4. No additional sun shading is required. The facade solution should include a minimum of 10% of the enclosed floor area as ventilation area through an operable solution such as windows or doors. This can be decreased to 5% if the walkway screen solution provides more than 75% open area.

- **Facade C:** End facade provides lateral support in accordance with the Structural section in Chapter 4. Limited opportunity to provide daylight.



3.9 Facade

Facade Elements

The adjacent diagrams shows the required facade elements used to negotiate and tune the performance requirements of the space.

1. Grille Zone

- Required for mechanical ventilation - In spaces with an exposed ceiling can partially contribute to natural ventilation.

2. Operable Window

- To meet natural ventilation requirements
- To contribute to WWR - as outlined in Sustainability section in Chapter 4

3. Fixed Glazing Zone

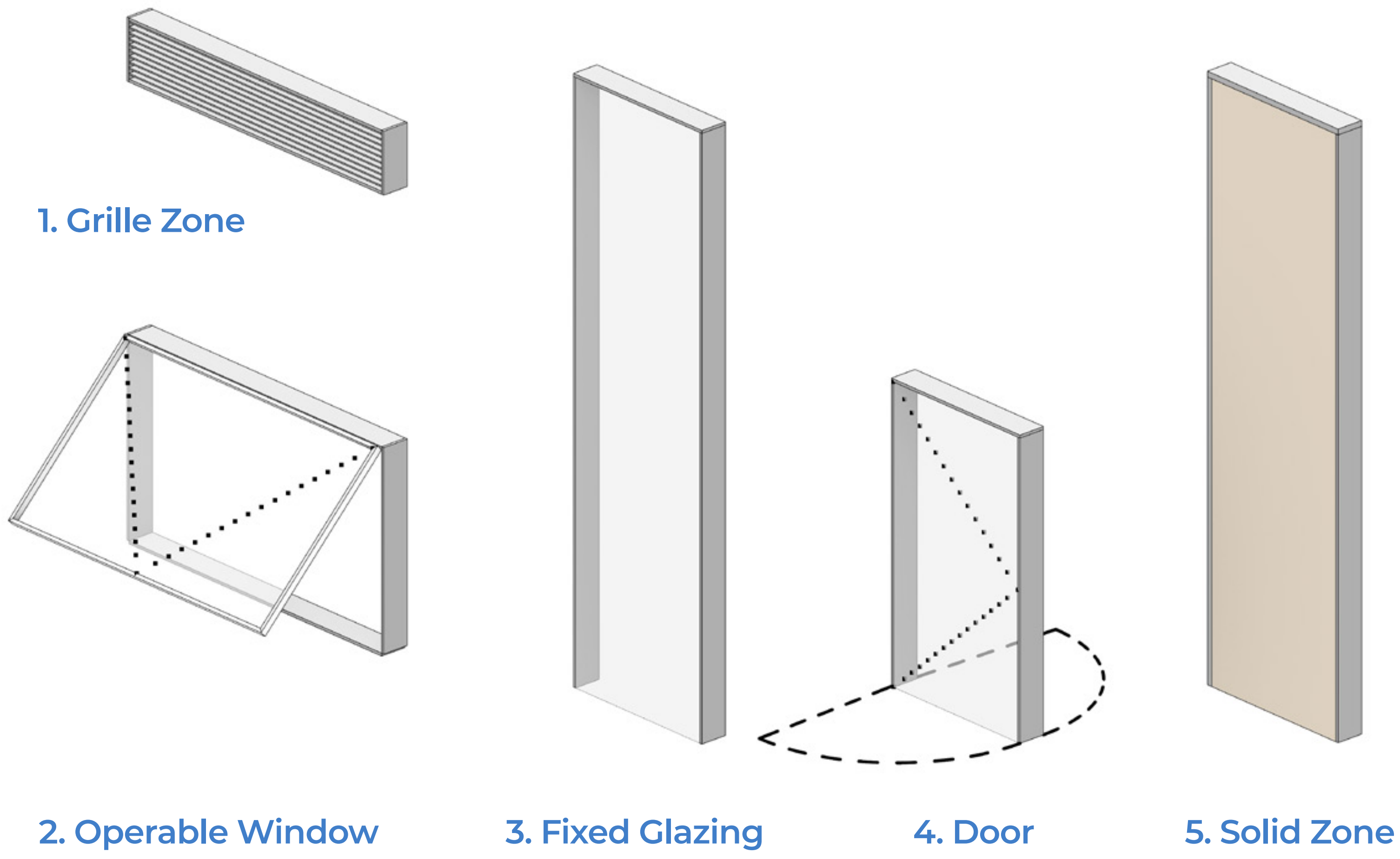
- To contribute to WWR - as outlined in Sustainability section in Chapter 4

4. Door

- Can be glazed -to contribute to WWR - as outlined in Sustainability section in Chapter 4
- Door swing direction to take into account both usability of the space and egress requirements under BCA

5. Solid Zone

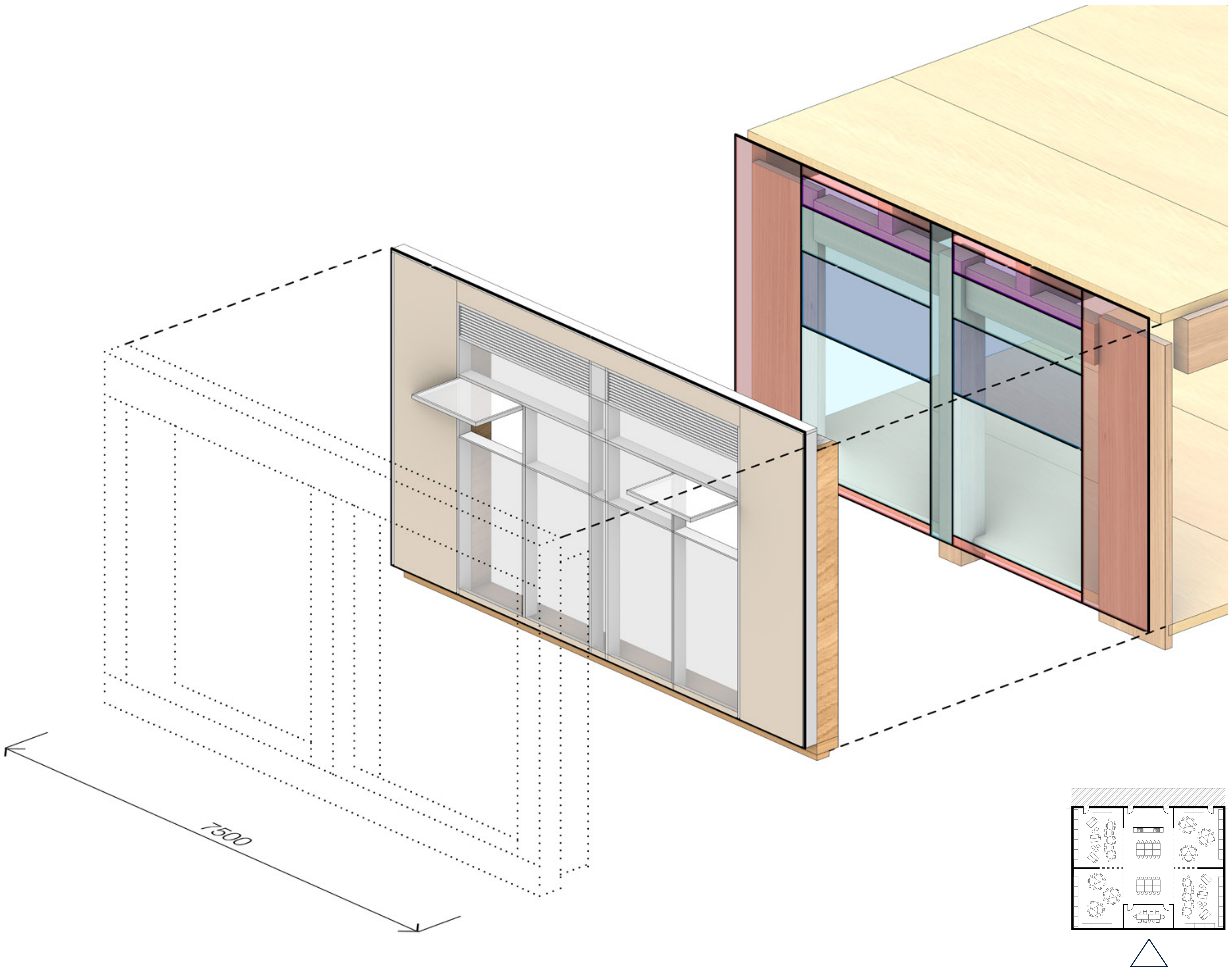
- Area be defined by required WWR - as outlined in Sustainability section in Chapter 4
- To provide protection and insulation to structure from solar exposure and moisture where required



3.9 Facade

Facade Type A - External Facing Facade

- External horizontal and vertical solar shading to mitigate solar gain. Shading depth to respond to building orientation and environmental conditions. Dependent upon shading depth, shading can either be fully supported by the façade or be ground supported and braced back to the structure
- Provide sufficient open area through the façade to achieve minimum deemed to satisfy provisions for natural ventilation (NCC F4.6)



Glazing

Operable Glazing - Natural Vent.

Optional Glazing - to expose timber structure

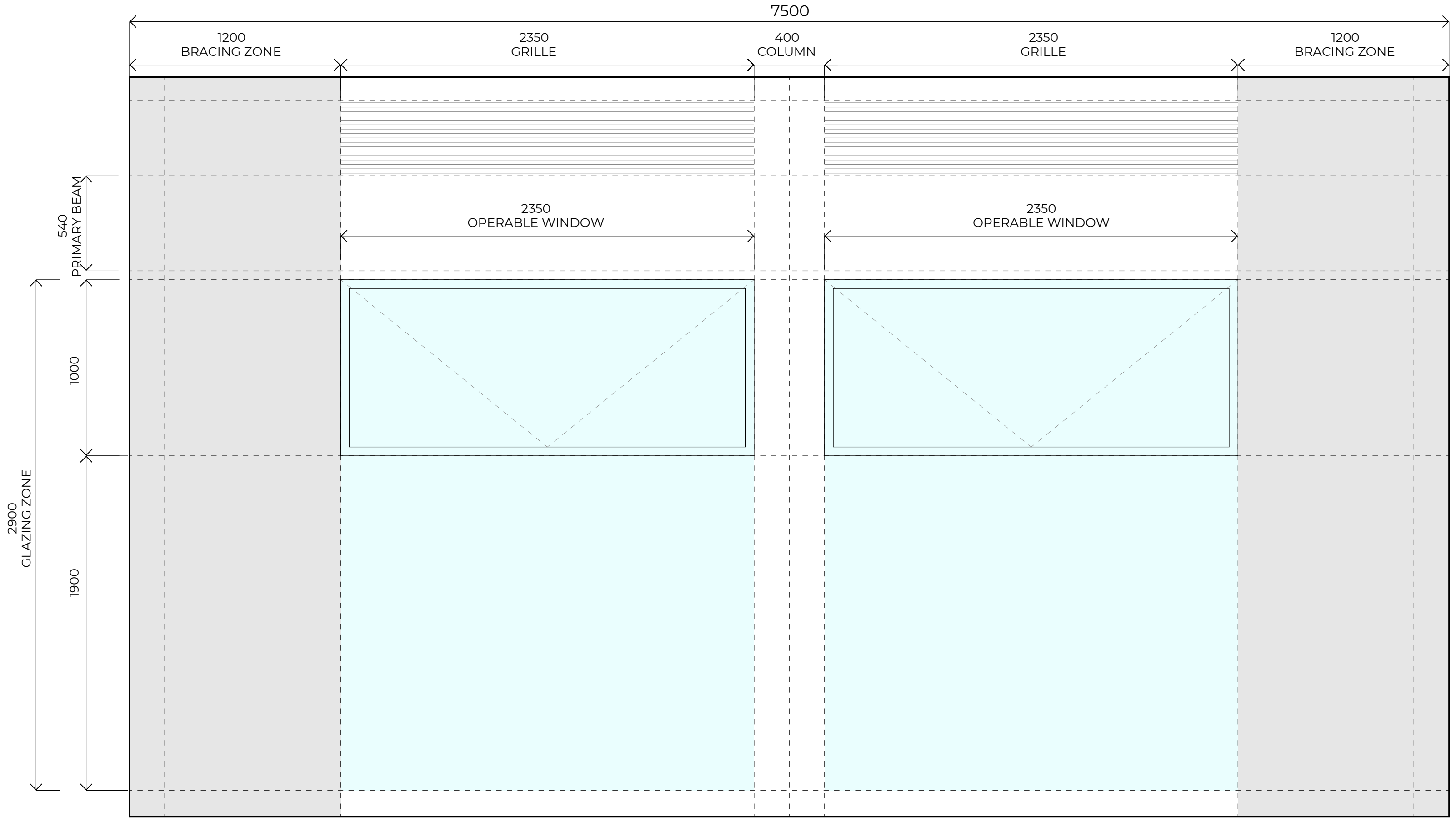
Solid - Protect CLT from Moisture and Solar Exposure

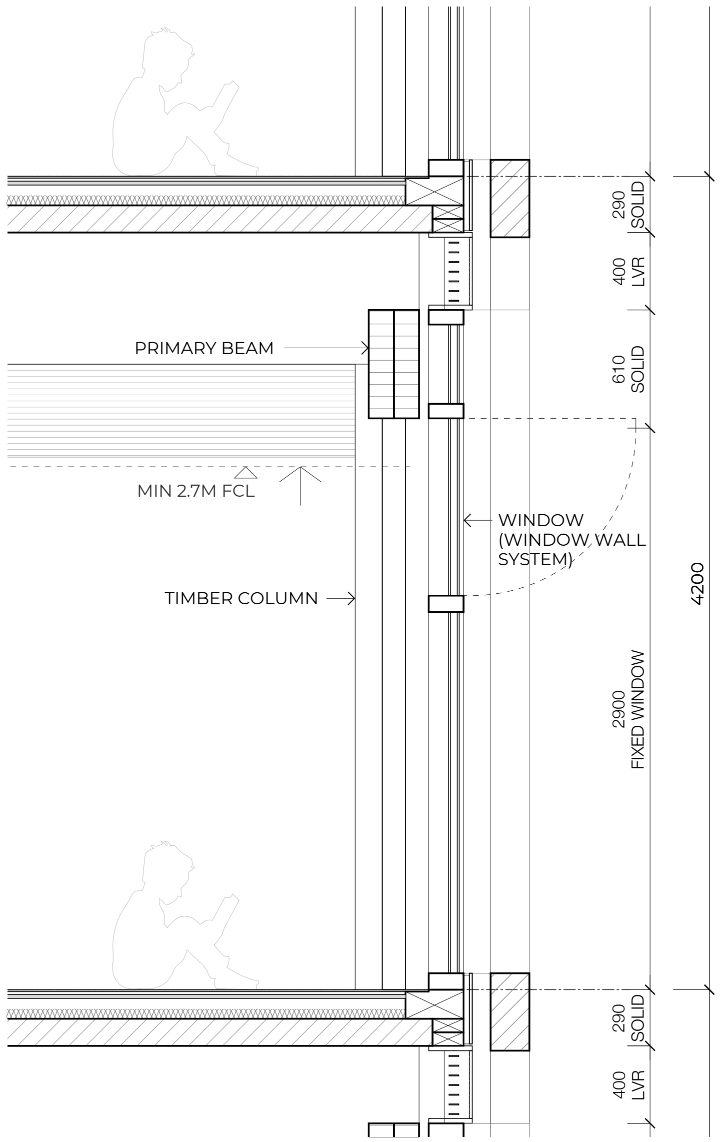
Open Grille - Mechanical Systems

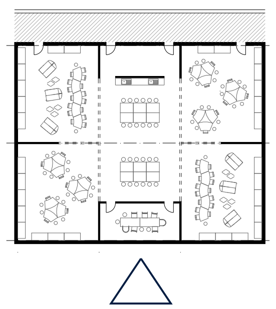
Interface with Floor/Walkway

3.9 Facade

Facade Type A - External Facing Facade







3.9 Facade

Facade Type B - Internal Facade with Accessway

- External horizontal and vertical solar shading to mitigate solar gain. Shading depth to respond to building orientation and environmental conditions. Dependent upon shading depth, shading can either be fully supported by the façade or be ground supported and braced back to the structure
- Provide sufficient open area through the façade to achieve minimum deemed to satisfy provisions for natural ventilation (NCC F4.6)
- Provide sufficient thermal comfort, daylight access, visual comfort and access to views (Section 1.6)

Glazing

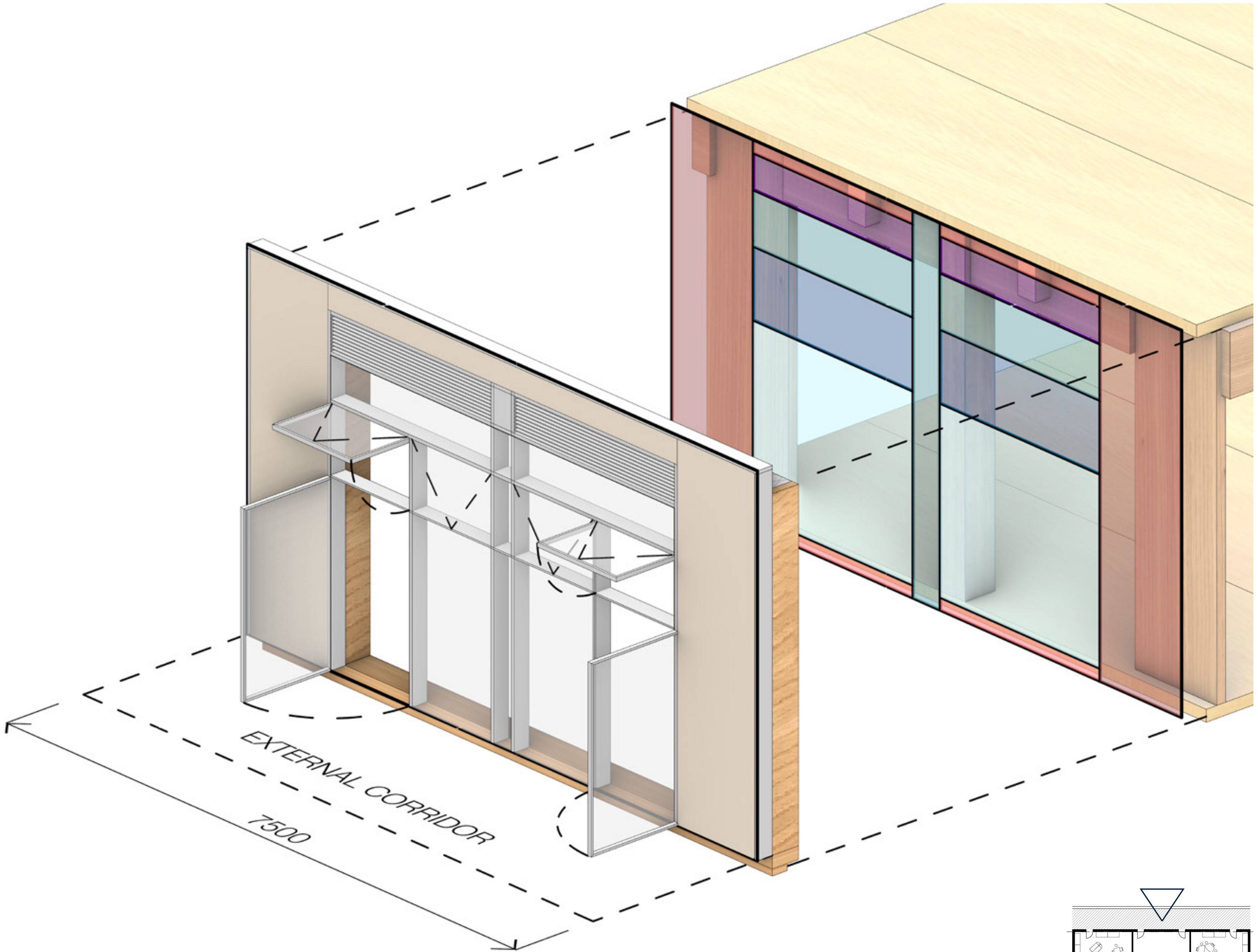
Operable Glazing - Natural Vent.

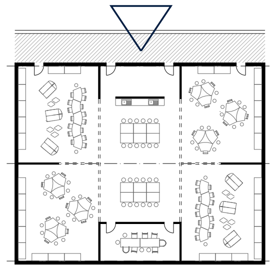
Optional Glazing - to expose timber structure

Solid - Protect CLT from Moisture and Solar Exposure

Open Grille - Mechanical Systems

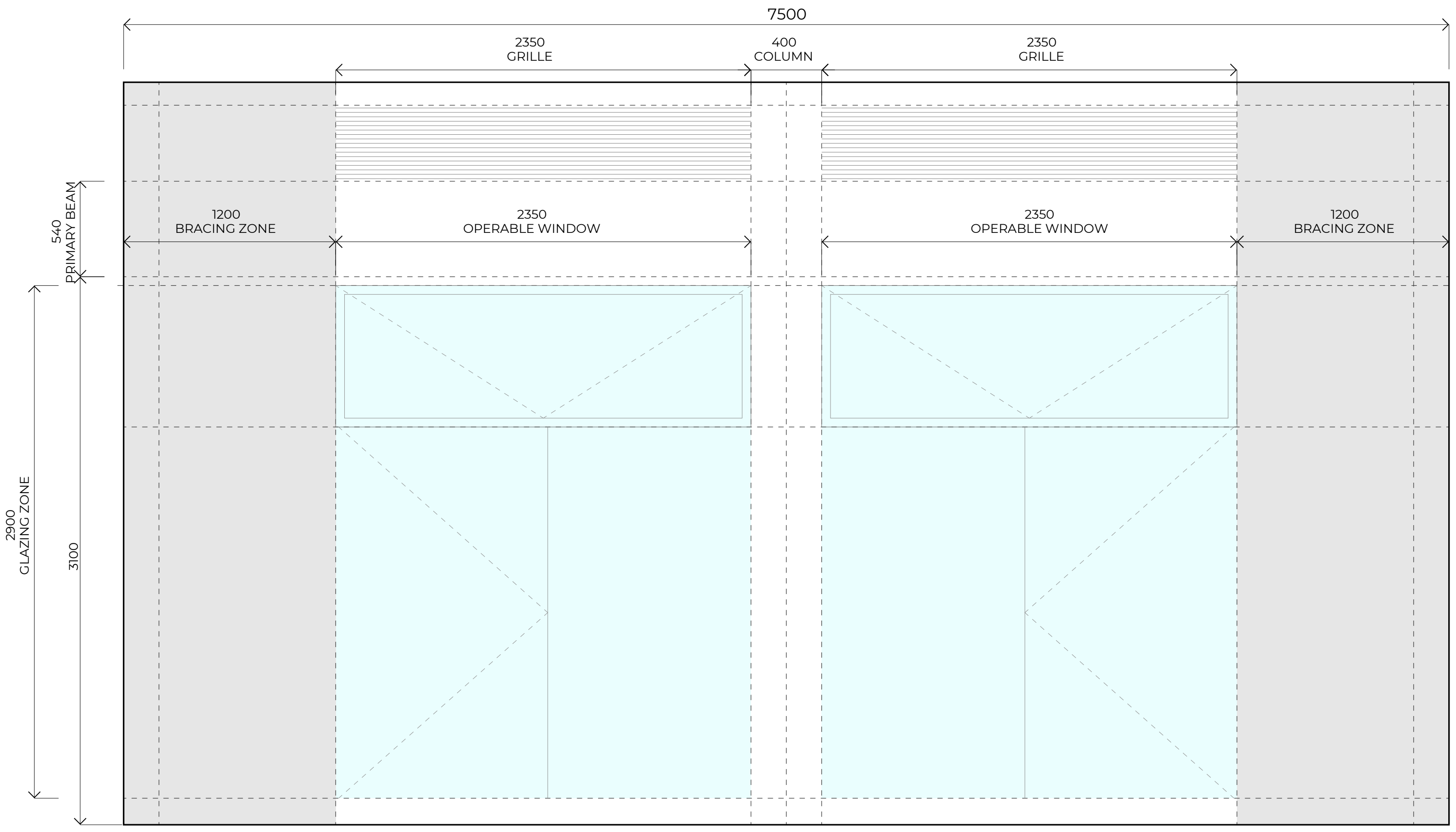
Interface with Floor/Walkway

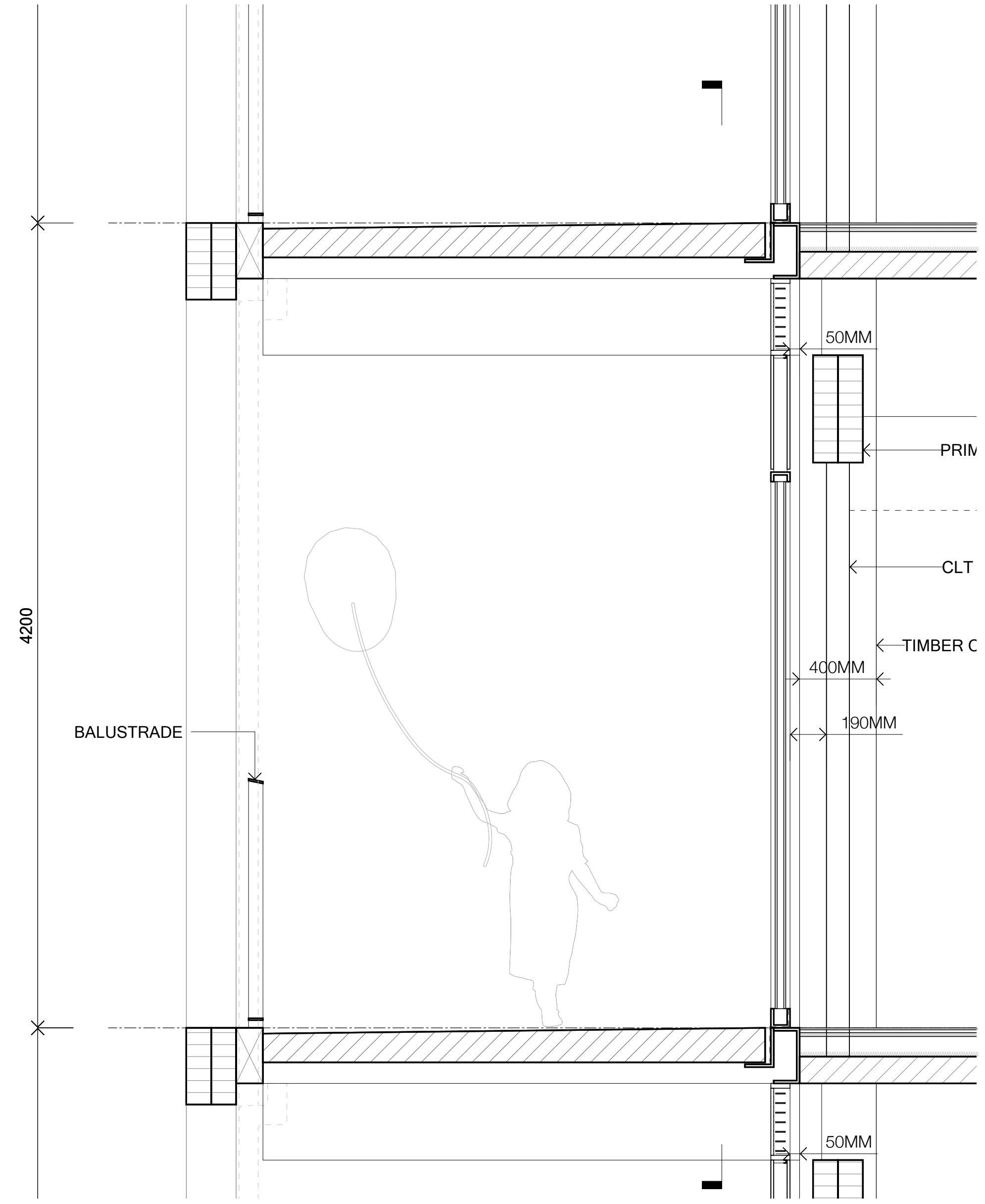


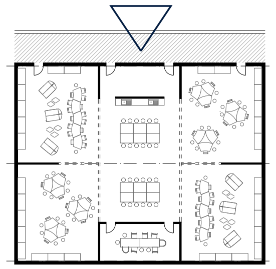


3.9 Facade

Facade Type B - Internal Facade with Accessway



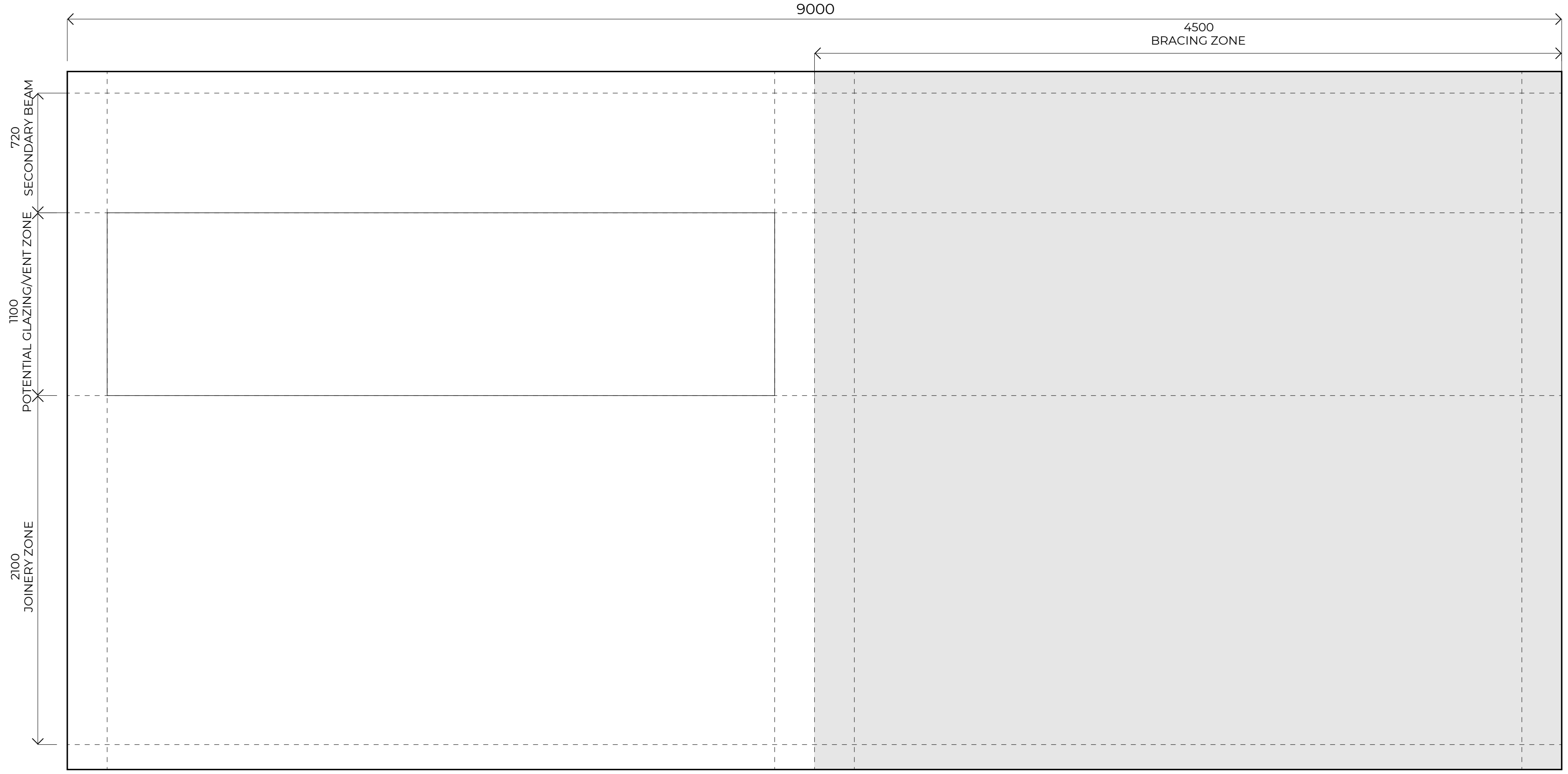


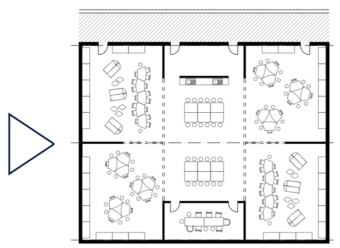


3.9 Facade

Facade Type C - End Facade

- Opportunities to provide daylight through the lateral side walls is encouraged where possible
- Provide a weathertight and highly insulated wall



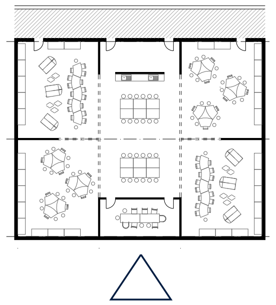


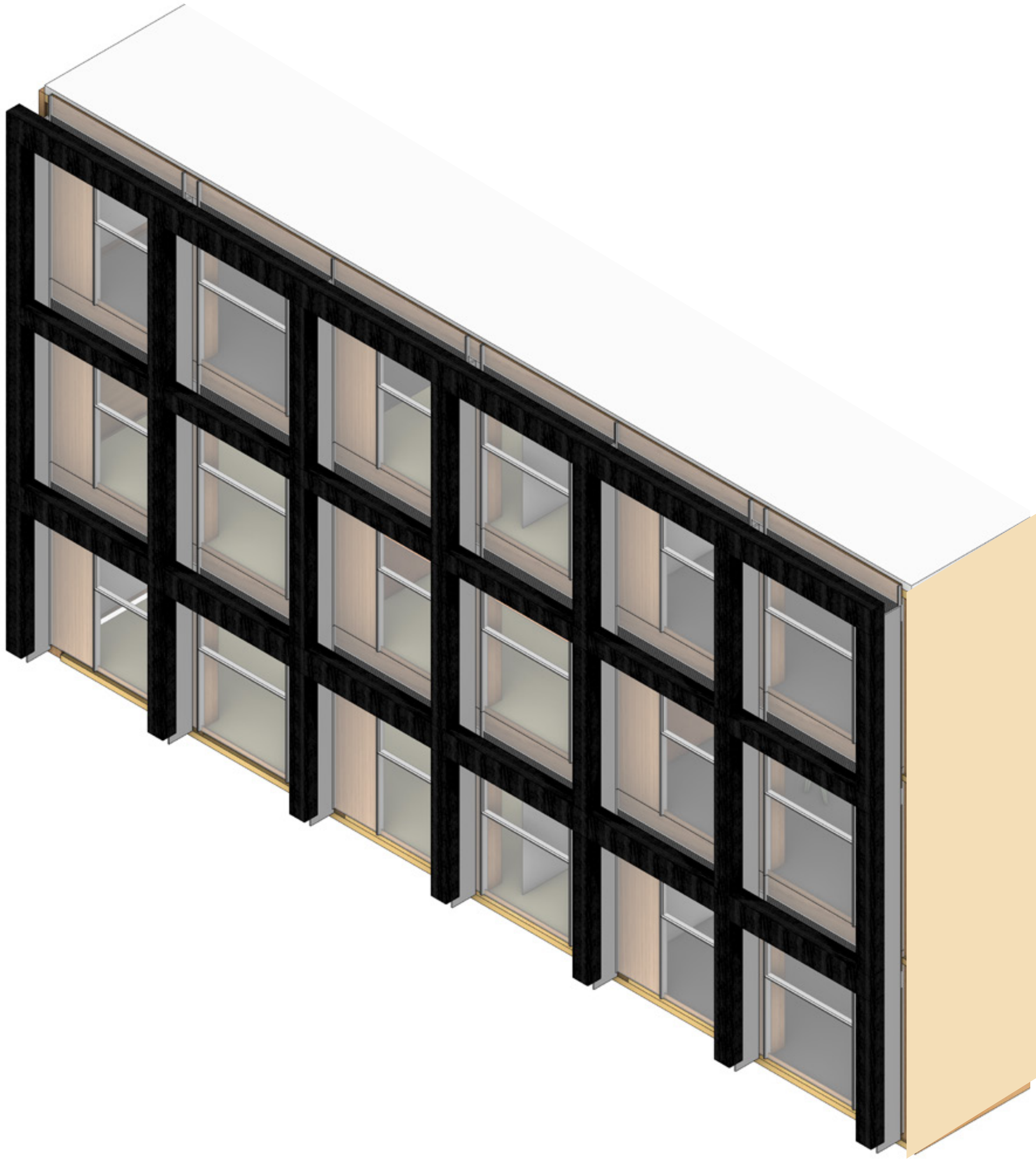
3.9 Facade

Sun Shading Strategy

- External horizontal and vertical solar shading to mitigate solar gain. Shading depth to respond to building orientation and environmental conditions.
- Dependent upon shading depth, shading can either be fully supported by the façade or be ground supported and braced back to the structure
- Not a commercial building - Design should reflect place and community identity.

The adjacent example works with the structural grid - a facade grid at 3.75m creating a flexible system which is able to adapt to orientation and climate zone.





3.9 Facade

Sun Shading Strategy

The adjacent diagrams show an example sun shading system with the ability to increase or reduce the protrusion distance in order to achieve the relevant sun shading ratio in keeping with the Chapter 4 - Shading Ratio Guidelines:

The examples to the right show how the shading strategy might be adjusted to accommodate different climate zones and orientations.

1. Climate Zone 7 - West Facing

Shading Ration - 0-20%

Vertical Shading

2. Climate Zone 7 - East Facing

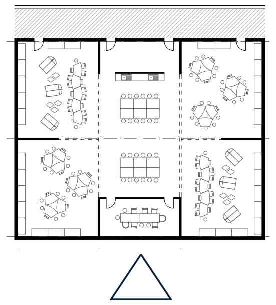
Shading Ratio - 20-60%

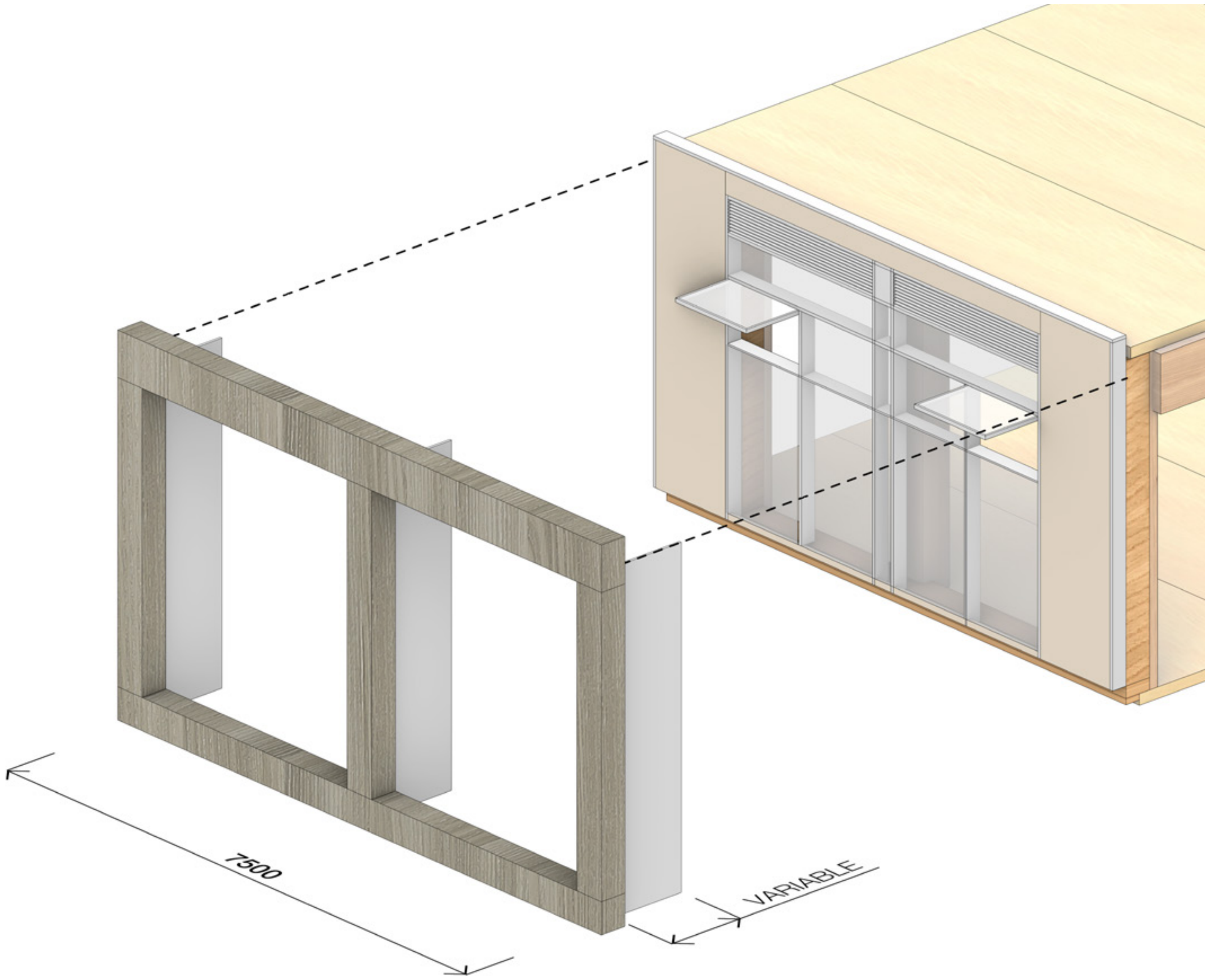
Vertical Shading

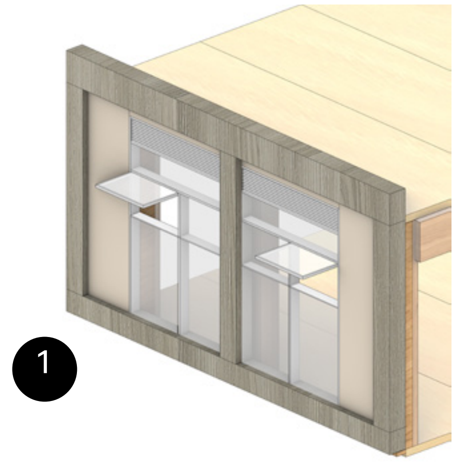
3. Climate Zone 5 - West Facing

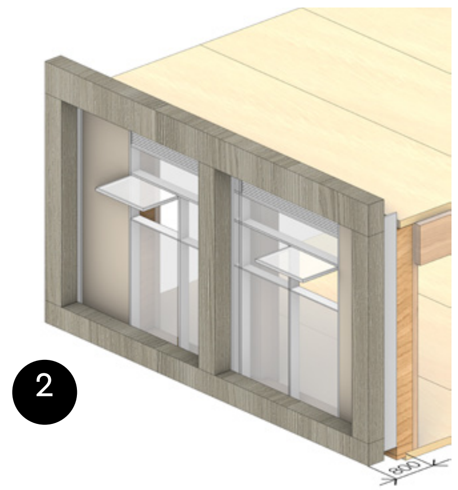
Shading Ratio

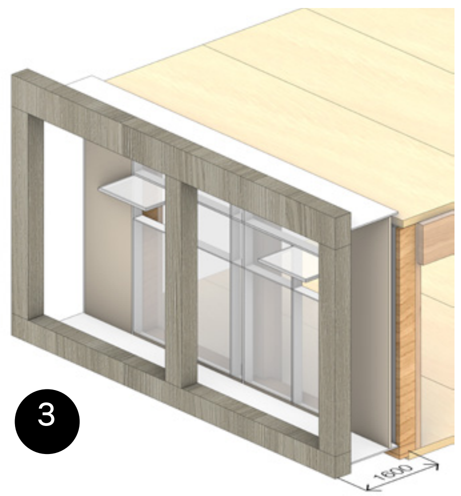
Horizontal Shading











3.10 Roof

The DfMA Roof Component have been designed and detailed with the following principles:

Efficiency

- Ease of Construction - Modular
- Elimination of Wet Trades
- Integrated system - eliminating requirements for major maintenance

Flexibility

- Customisation to reflect context and identity
- Ability to enable expansion where required.

Maintenance

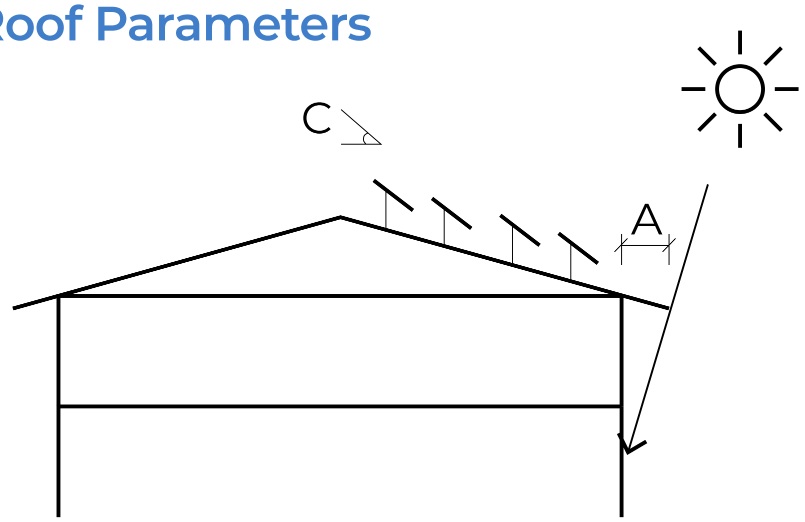
- Robust materials and finishes - ensuring longevity of life
- Ease of general maintenance
- Ease of assembly and disassembly for maintenance/replacement
- Ease of replacement of parts - Use of widely/locally available materials and products.
- Standardised detailing representing best practice.
- Standardised design addressing safe ongoing access and maintenance.

Sustainability

- Ensures adequate response to climate zone in mitigation of solar/ rain impact.
- Opportunity for energy generation, water collection and introduction of landscaping

3.10 Roof

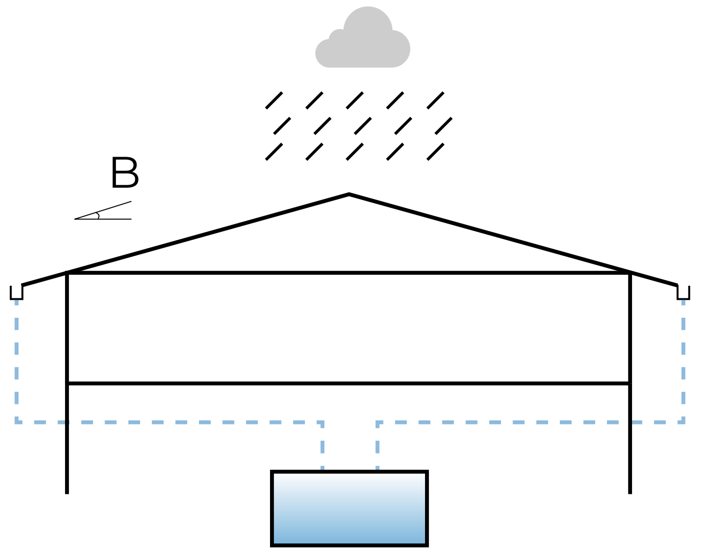
Roof Parameters



Climatic Zone & Orientation

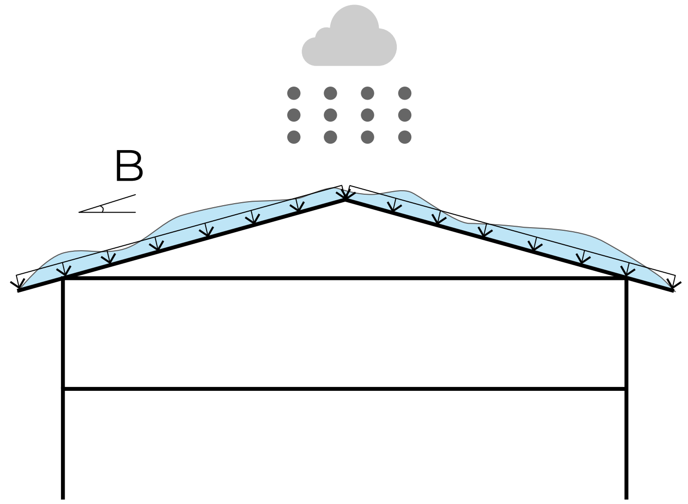
Optimise roof overhang to reduce excessive direct sunlight to maintain thermal comfort

Optimise solar panel angle to maximise energy generation



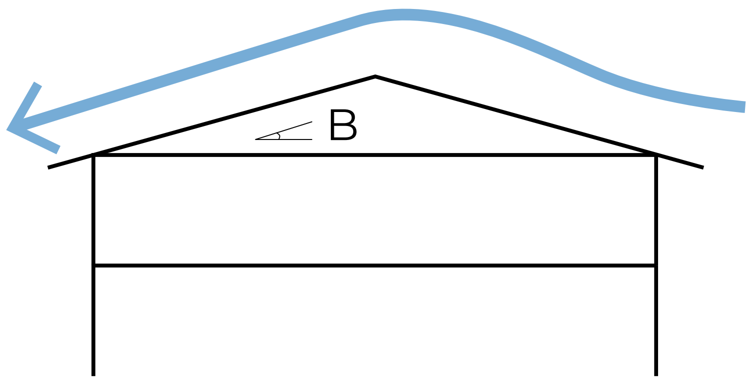
Rainwater Collection

Rainwater can be collected from the roof gutters and reused



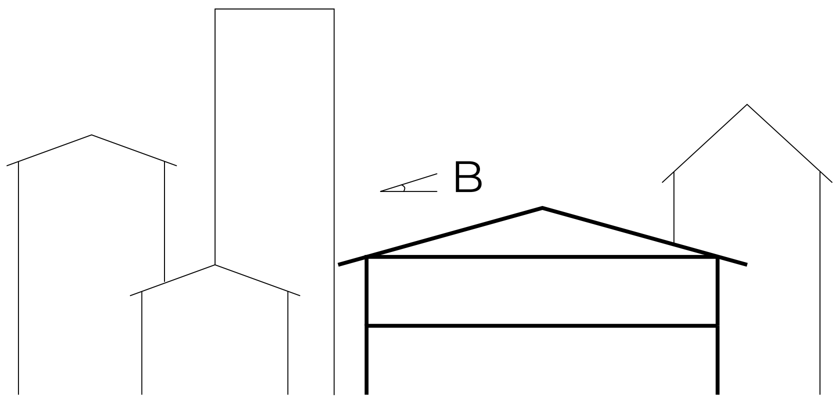
Snow Loading

Optimise roof pitch angle for snow loads in alpine areas



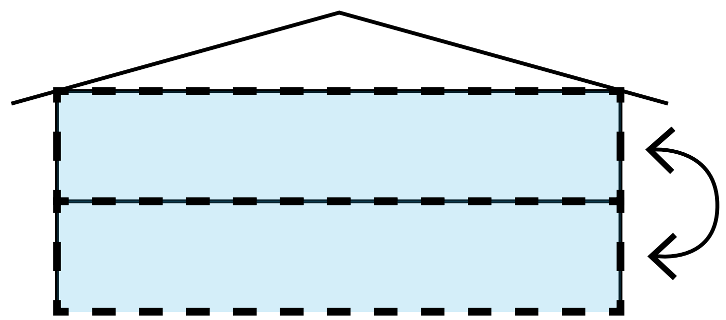
Respond to Prevailing Winds

Optimise roof pitch angle for better wind control



Community Integration, Respond to History and Heritage context

Opportunities for design to reflect site context



Equitable Space

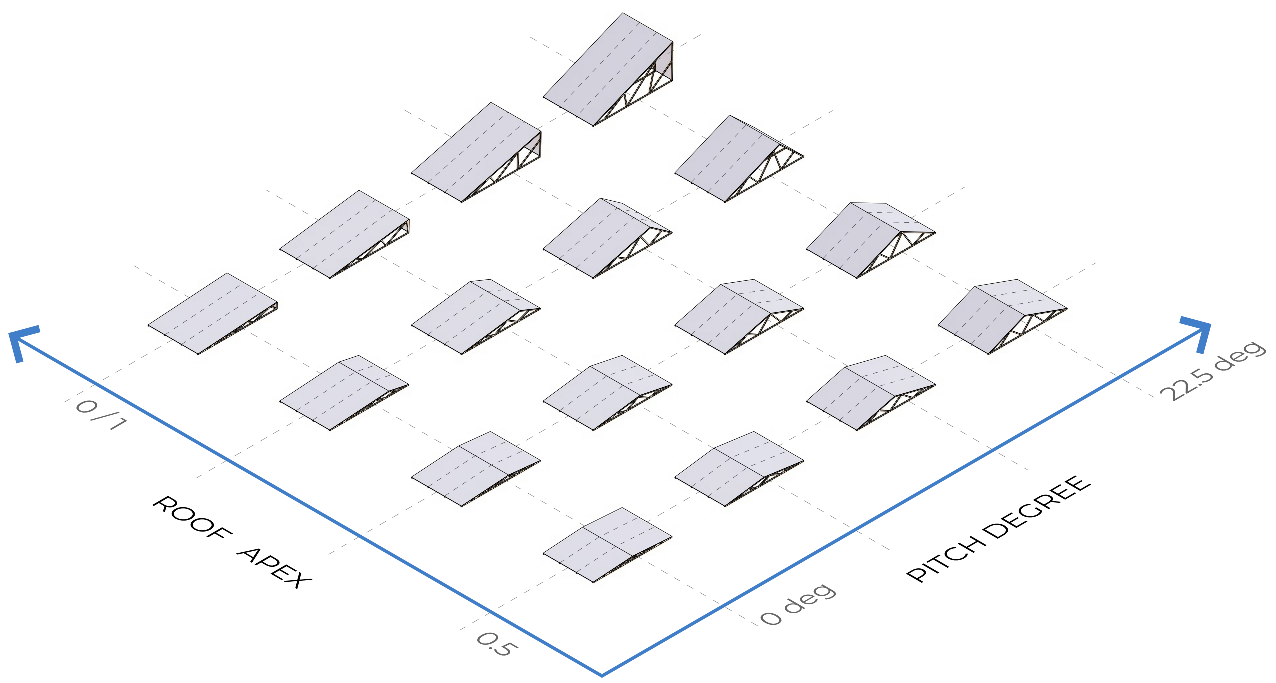
Space volume underneath the roof to remain consistent - ensuring equality in all teaching spaces

3.10 Roof

Roof Form Matrix

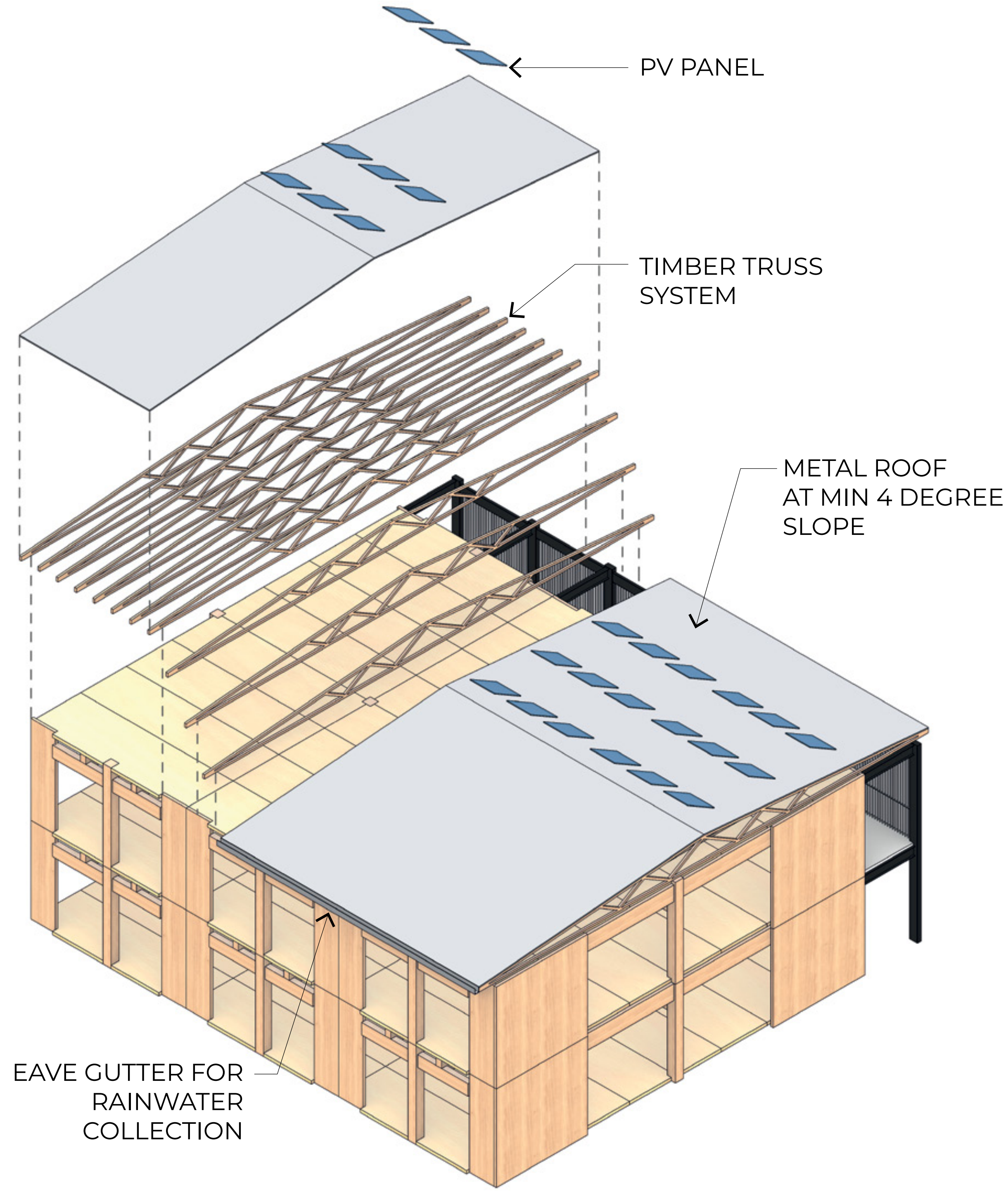
The design of the roof provides an opportunity to customise the design system. The approach should take into account and be tailored to respond to -

- Community Integration
- Climate Zone and Orientation
- History and Heritage
- Opportunities for Water Collection
- Energy Generation
- Thermal Performance
- Visual Identity



Roof - Base Option

The base option of the roof comprises of three main components - Structure, Sheeting and PV Panels. The roof pitch angle is set at 4 degree to comply with the current EFSG requirements.



3.11 Circulation

The DfMA Circulation Components have been designed and detailed with the following principles:

Informal Pedagogy Spaces

- To facilitate informal learning opportunities through the integration of collaboration or sensory spaces
- Vary in width based on school requirements whilst ensuring adequate daylight and ventilation performance is met in keeping with Chapter 4

Security and Safety

- Eliminate risk of climbing
- Robust structure to withstand high traffic and activity.
- Concealed fixings

Construction + Maintenance

- Robust materials and finishes - ensuring longevity of life
- Ease of cleaning/daily maintenance
- Ease of assembly and disassembly for maintenance/replacement
- Ease of replacement of parts - Use of widely/locally available materials and products.
- Elimination of wet trades on site
- Modular approach

Wellness

- Minimising impact on daylight penetration to interior
- Enabling adequate natural ventilation
- Facilitates "informal learning" - Can vary in width

3.11 Circulation

3.11 Circulation

Access Walkway Section

The access walkway is comprised of 2 main components -

- The balustrade or screen
- The walkway floor

The base case shows a corridor clear width of 2.4m. This distance can vary based on pedagogical requirements - in order to facilitate informal learning opportunities. However a departure from the base option requires design teams to consider and balance against impact on daylight and ventilation of internal teaching spaces.

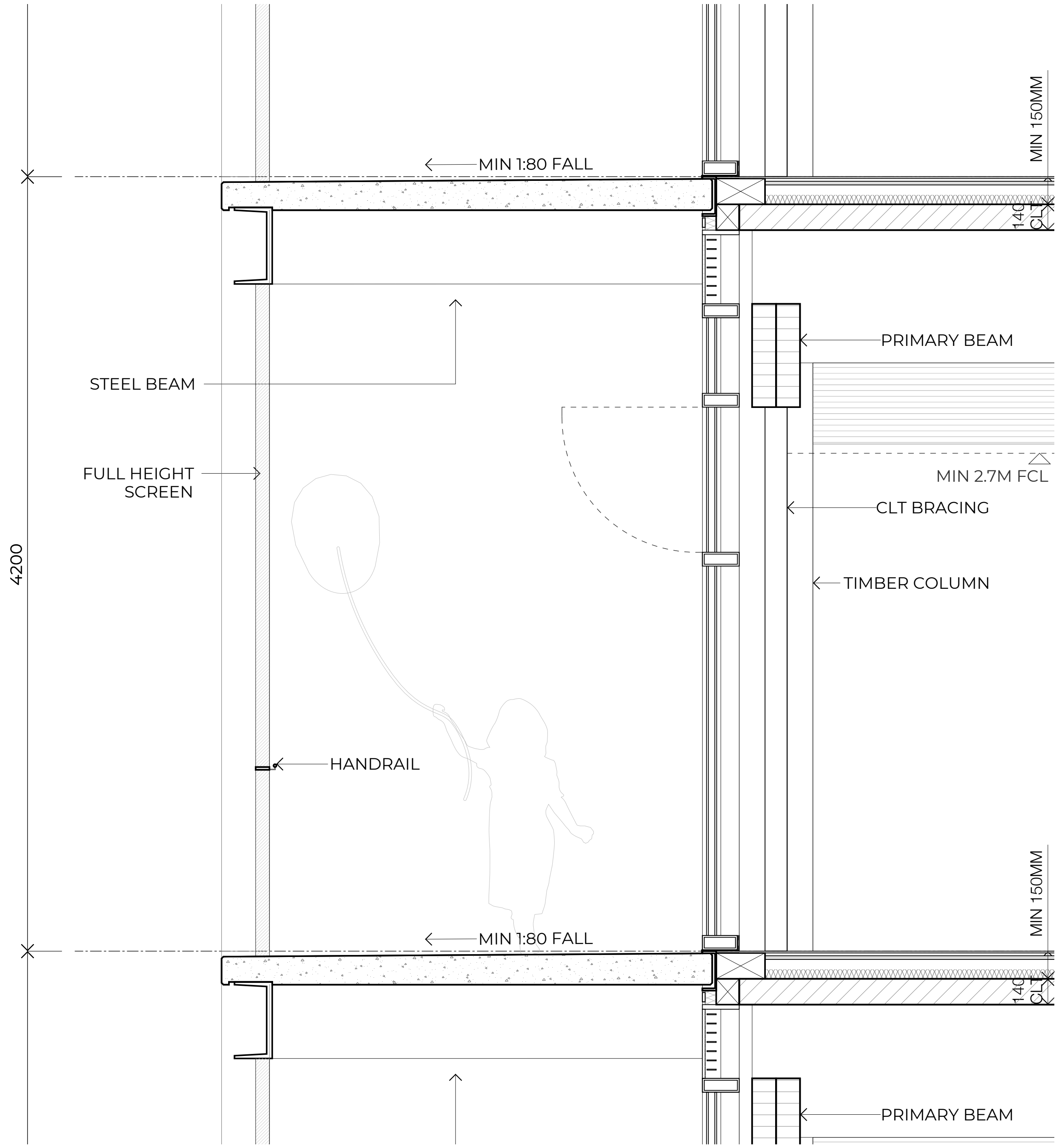
The base option uses concrete for the walkway floor material. This has been selected due to ease of construction and maintenance, as well as material durability. Steel structure in this area was selected on the basis that it is both light and highly durable when compared with concrete and timber.

The balustrade or screen presents an opportunity for a site specific response allowing for the mass-customisation of the design system to ensure each school presents a unique identity and connection to the community it sits within.

The screen component is to address the following criteria:

- Safety
- Climate/Orientation specific response - allowing for an added layer of wind/sun mitigation whilst ensuring sufficient light and natural ventilation is met
- Ease of maintenance and robust construction and finish.

The following five options present example approaches to this. The adjacent section provides a base option example of an approach to the walkway system.

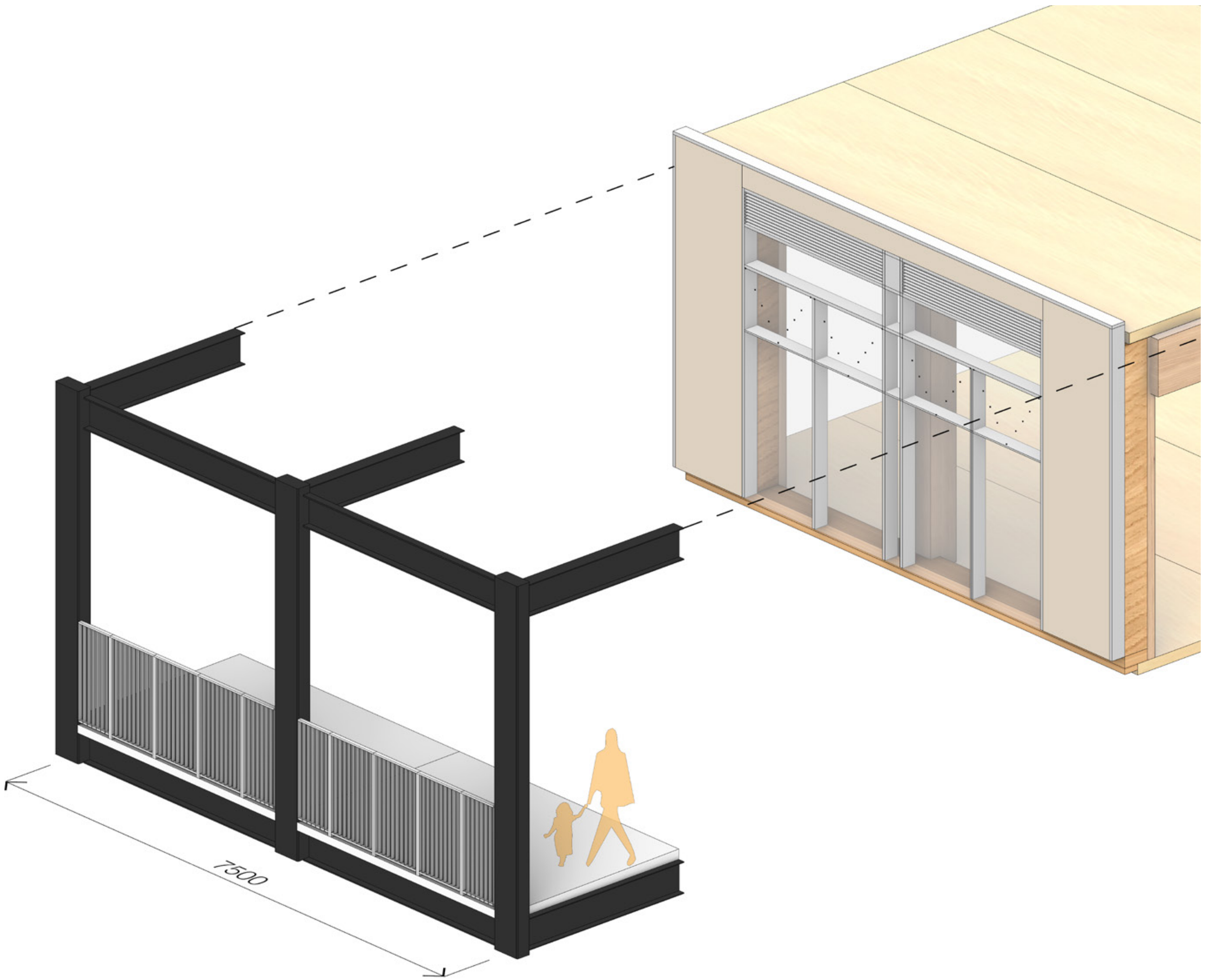


3.11 Circulation

Walkway Option 01 | 1.3m Balustrade

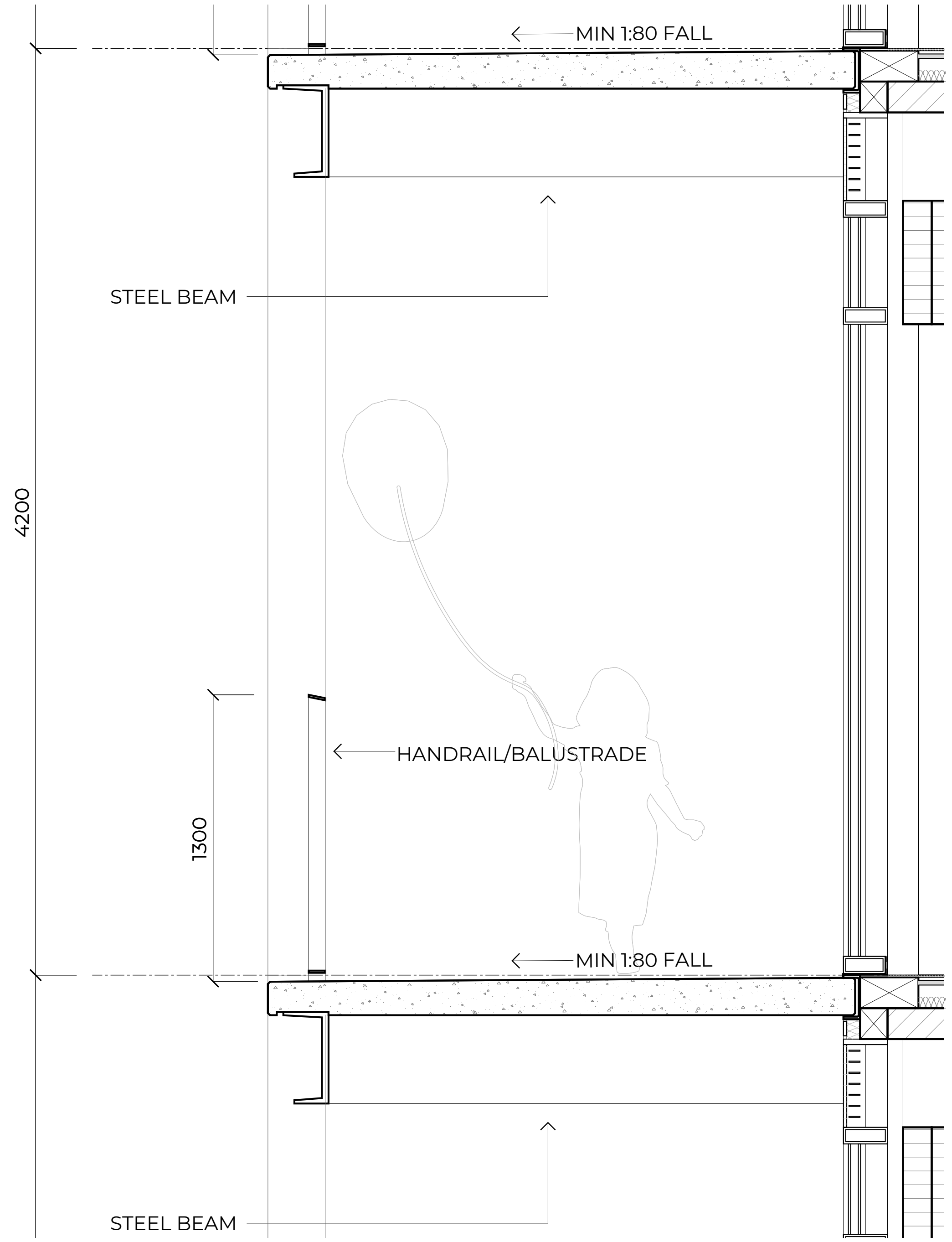
Example one presents a 1.3 m vertical balustrade - compliant to the current EFSG standards.

- Provides a high level of daylight and natural ventilation
- Vertical members remove opportunities for climbing
- Exceeds compliance with NCC
- Finish to take into consideration - ease of maintenance and durability
- Base Option uses marine-grade powder-coated finish on the balustrade with galvanised steel flat bar supports

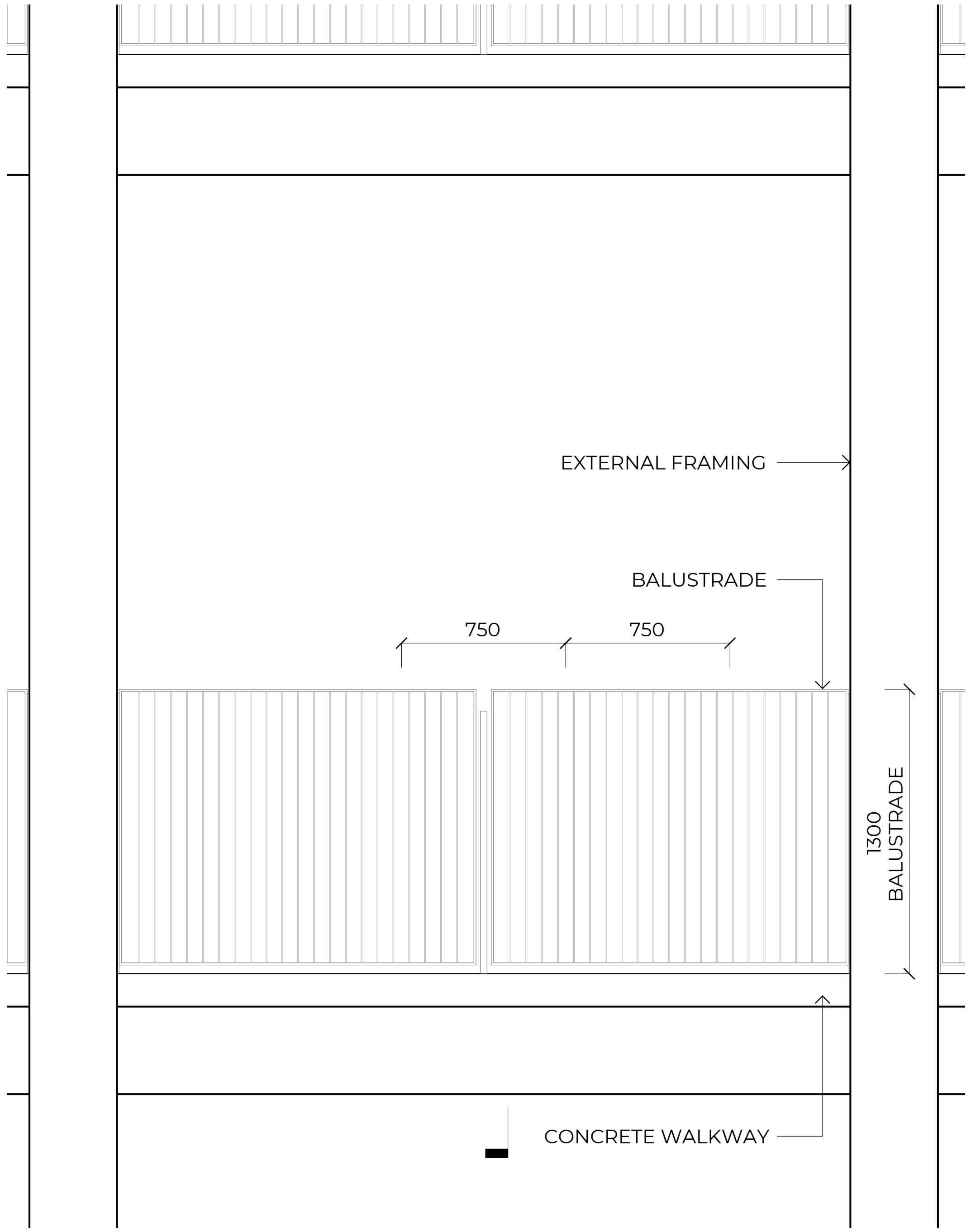


3.11 Circulation

Walkway Option 01 | 1.3m Balustrade



Walkway Section Option 1



Walkway Screen Module Elevation Option 1

3.11 Circulation

Walkway Option 01 | 1.3m Balustrade

Walkway Perspective Option 1

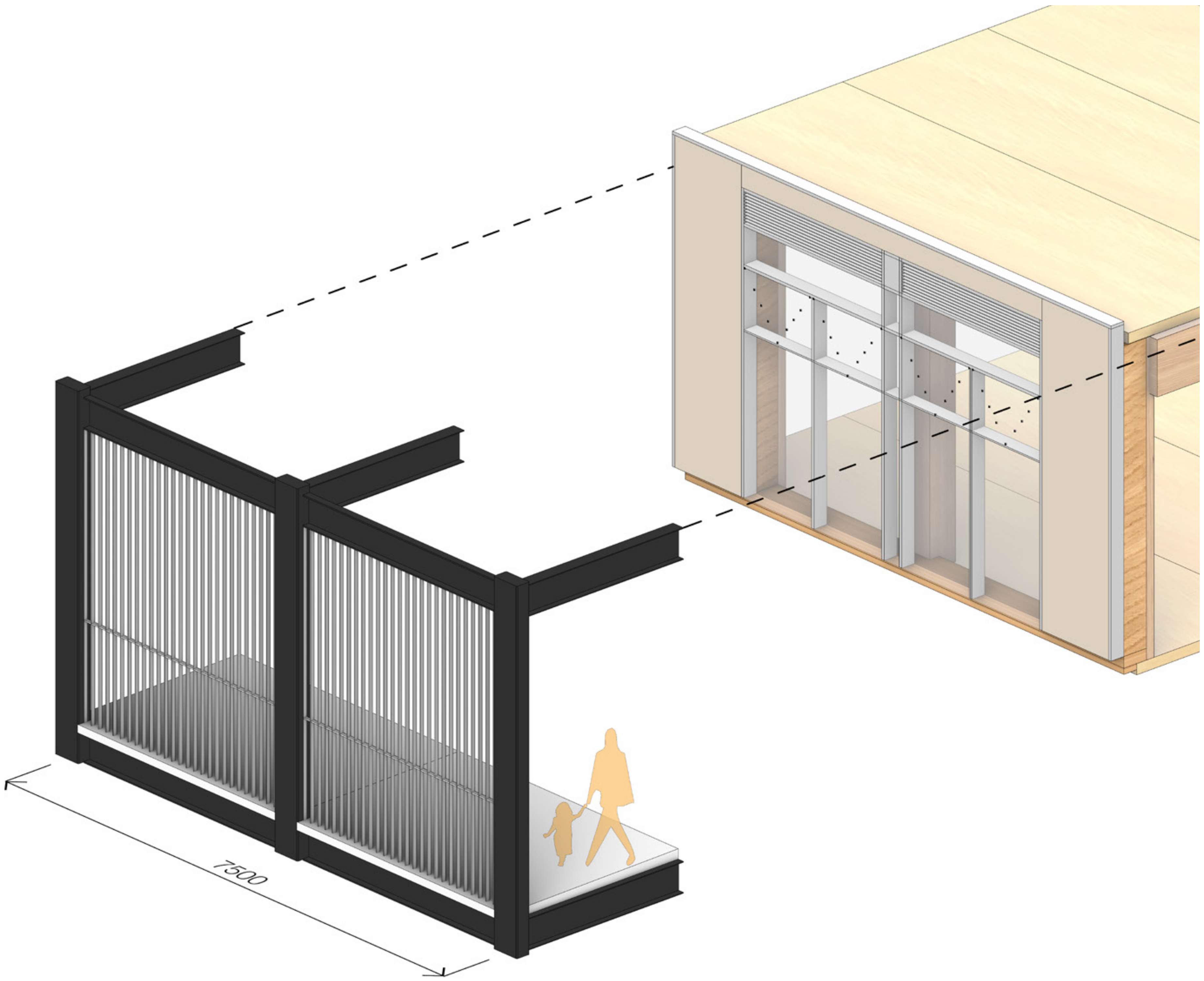
Walkway Screen Module Elevation Option 1

3.11 Circulation

Walkway Option 02 | Full Height Screen - Vertical

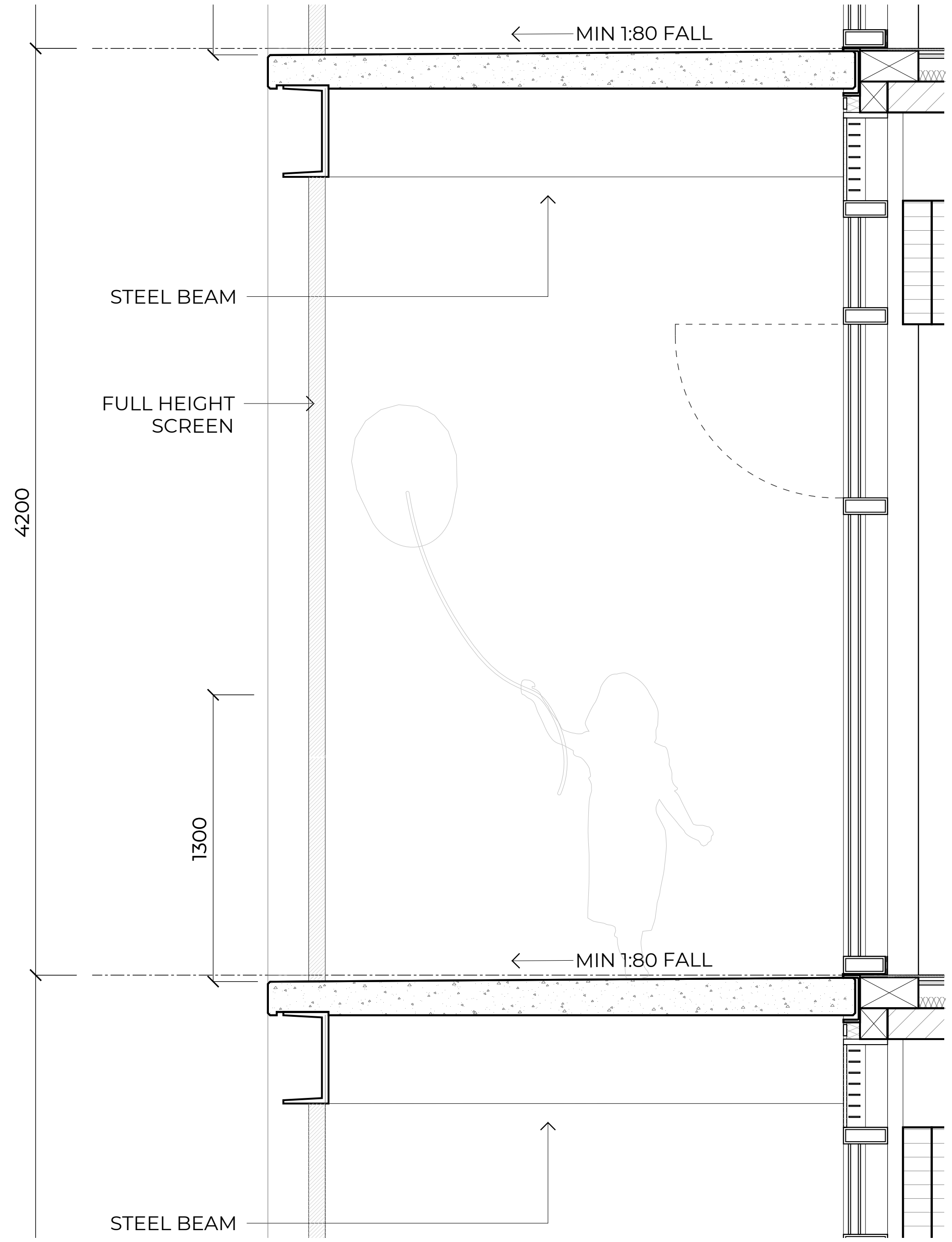
Example two presents a full height screen

- Vertical members remove opportunities for climbing
- Maximum openings of 125mm
- NCC Compliance
- May require additional horizontal supports.
- Finish to take into consideration - ease of maintenance and durability

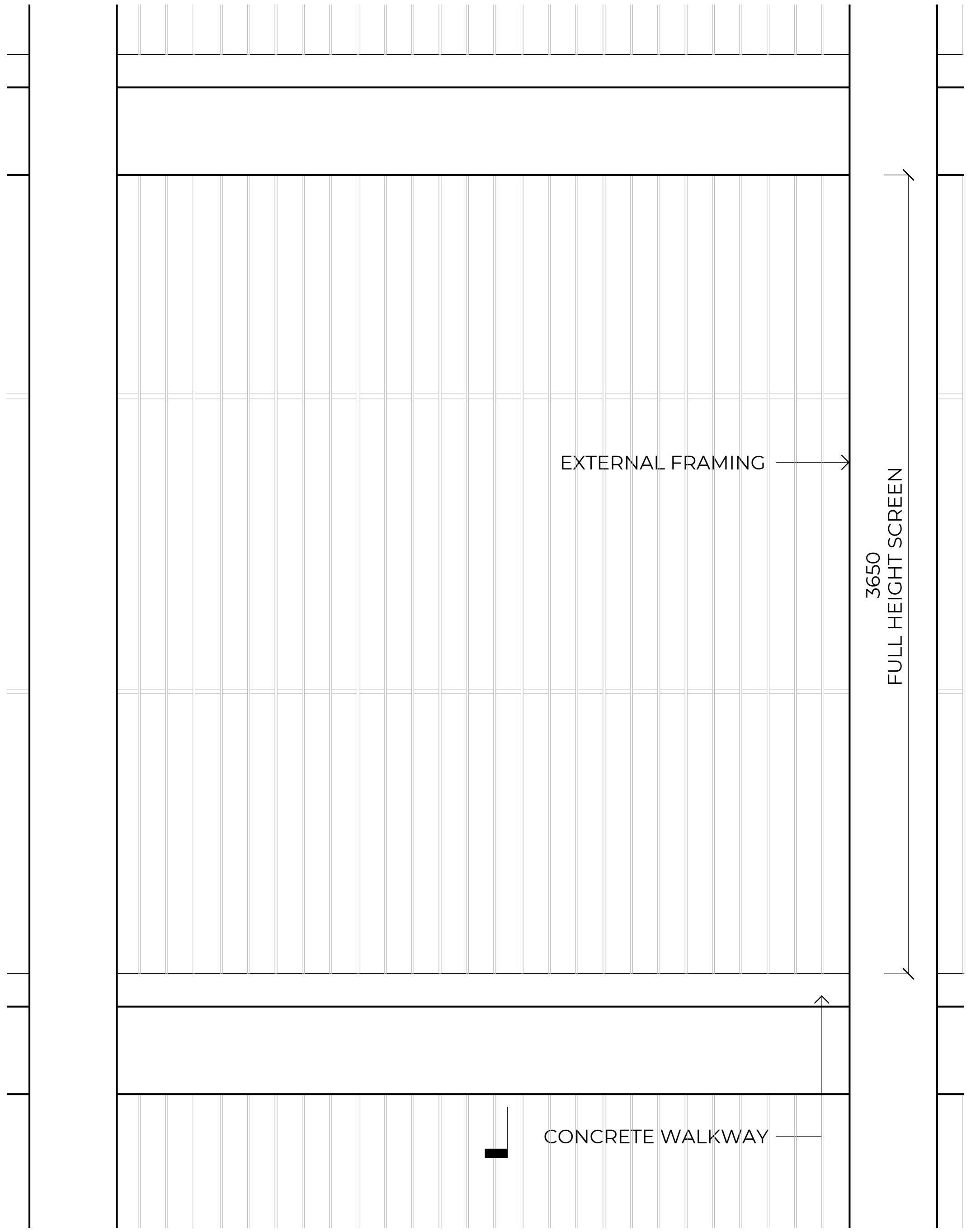


3.11 Circulation

Walkway Option 02 | Full Height Screen - Vertical



Walkway Section Option 2



Walkway Screen Module Elevation Option 2

3.11 Circulation

Walkway Option 02 | Full Height Screen - Vertical

Walkway Perspective Option 2

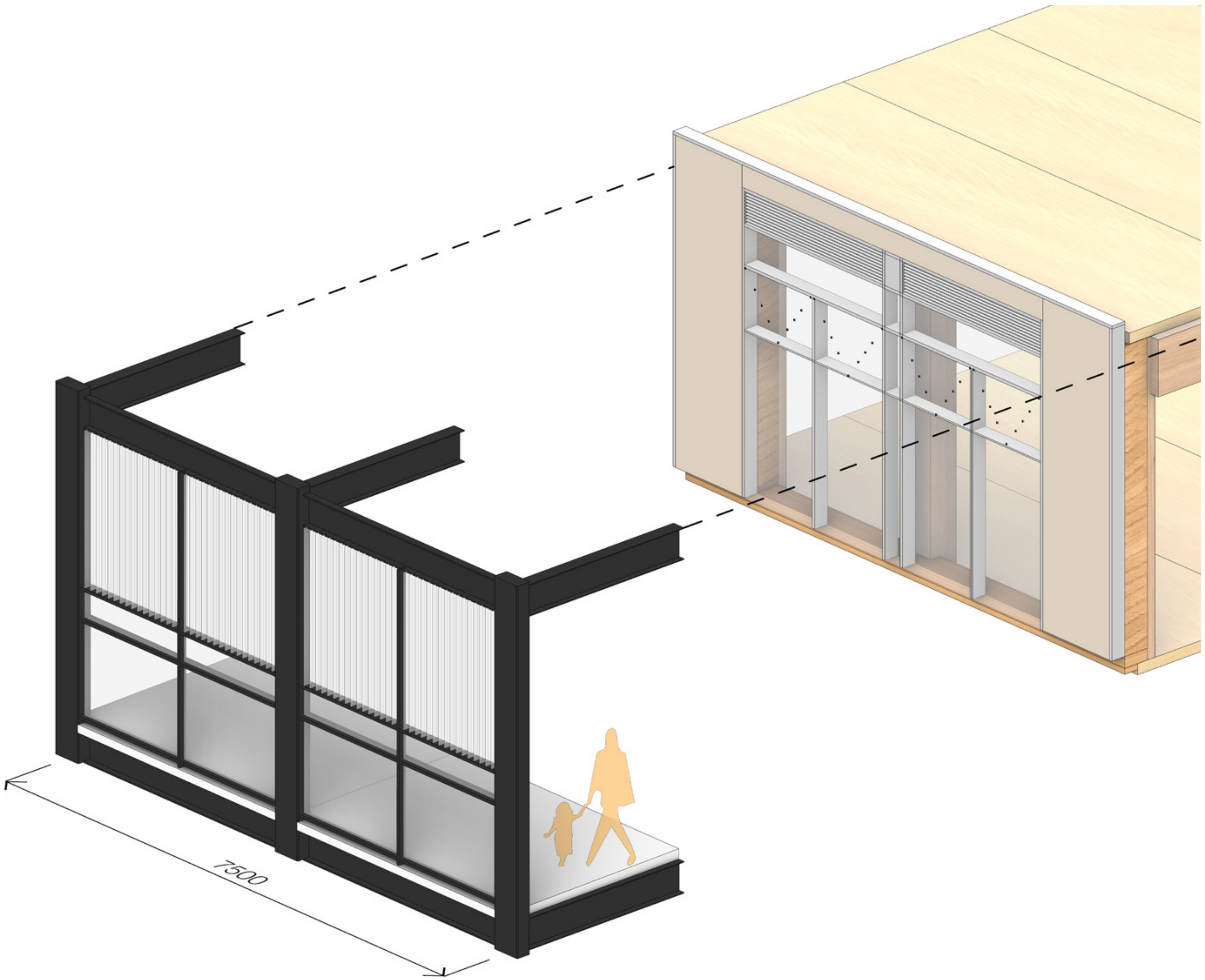
Walkway Screen Module Elevation Option 2

3.11 Circulation

Walkway Option 03 | Glazed Screen with Glazed Fins

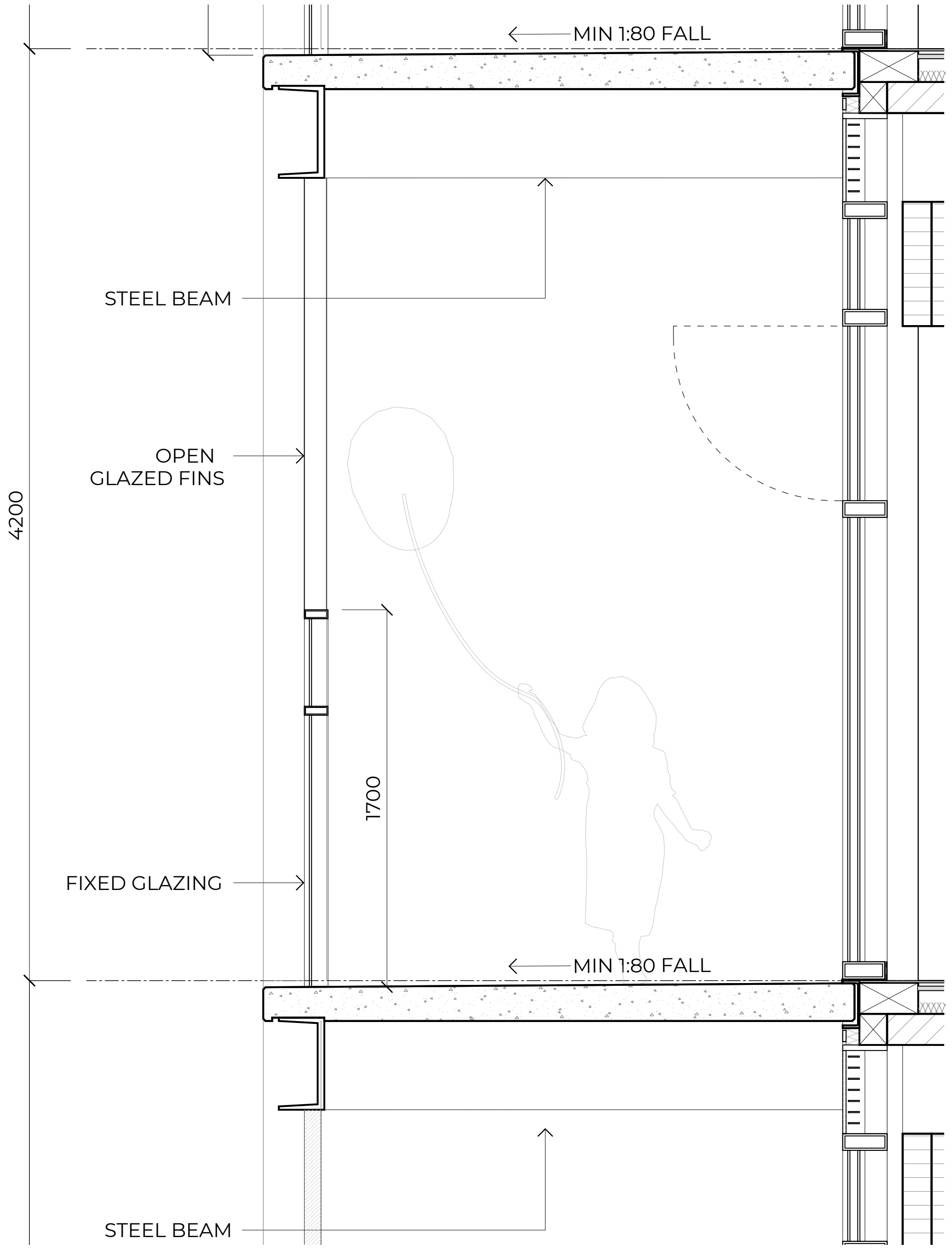
Example three presents a fixed glazed screen to 1.7m and fixed open glazed fins or louvers above.

- Provides some protection from wind/ rain - particularly in colder climates
- Minimises impact on daylight on the interior
- Minimum ventilating area of at least 10% of the adjacent floor area (Both walkway and adjacent interior space) in accordance with BCA requirements
- If open area of the screen is below 75% - Fire compartment zones will be reduced in accordance with chapter 4 guidelines - Fire safety
- Finish to take into consideration - ease of maintenance and durability

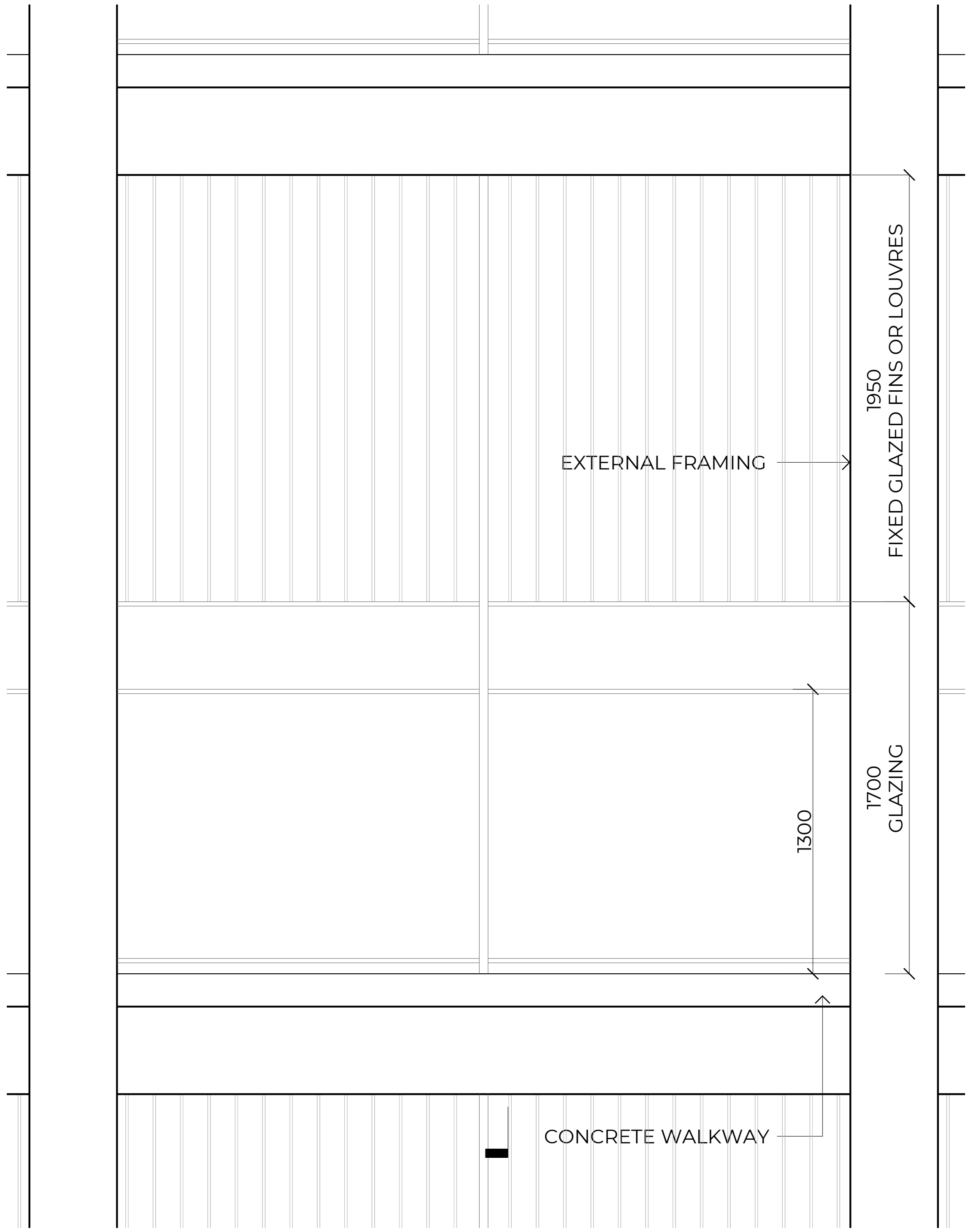


3.11 Circulation

Walkway Option 03 | Glazed Screen with Glazed Fins



Walkway Section



Walkway Screen Module Elevation

3.11 Circulation

Walkway Option 03 | Glazed Screen with Glazed Fins

Walkway Perspective Option 3

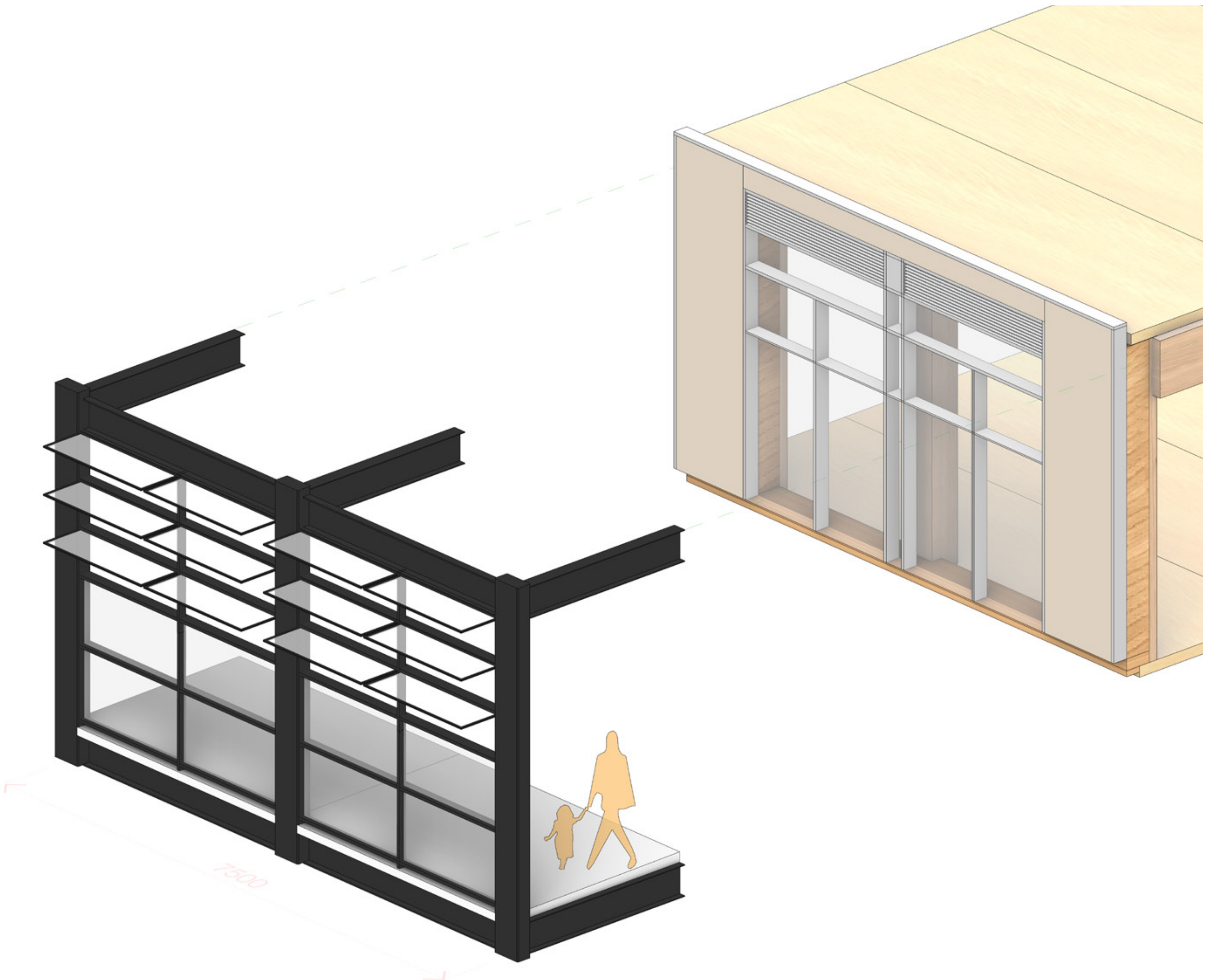
Walkway Screen Module Elevation Option 3

3.11 Circulation

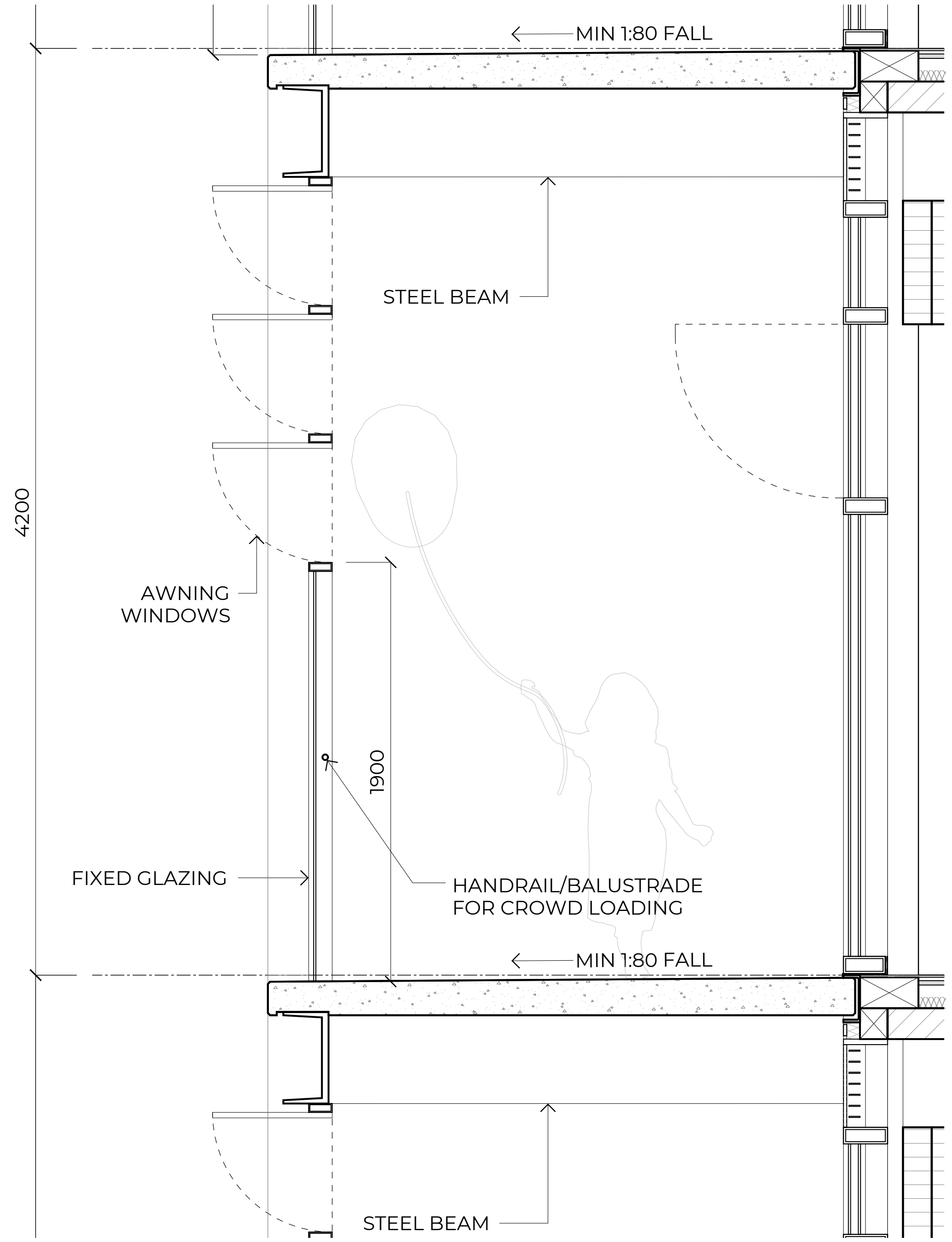
Walkway Option 04 | Glazed Screen with Awning Windows

Example three presents a fixed glazed screen to 1.9m and operable louvers above.

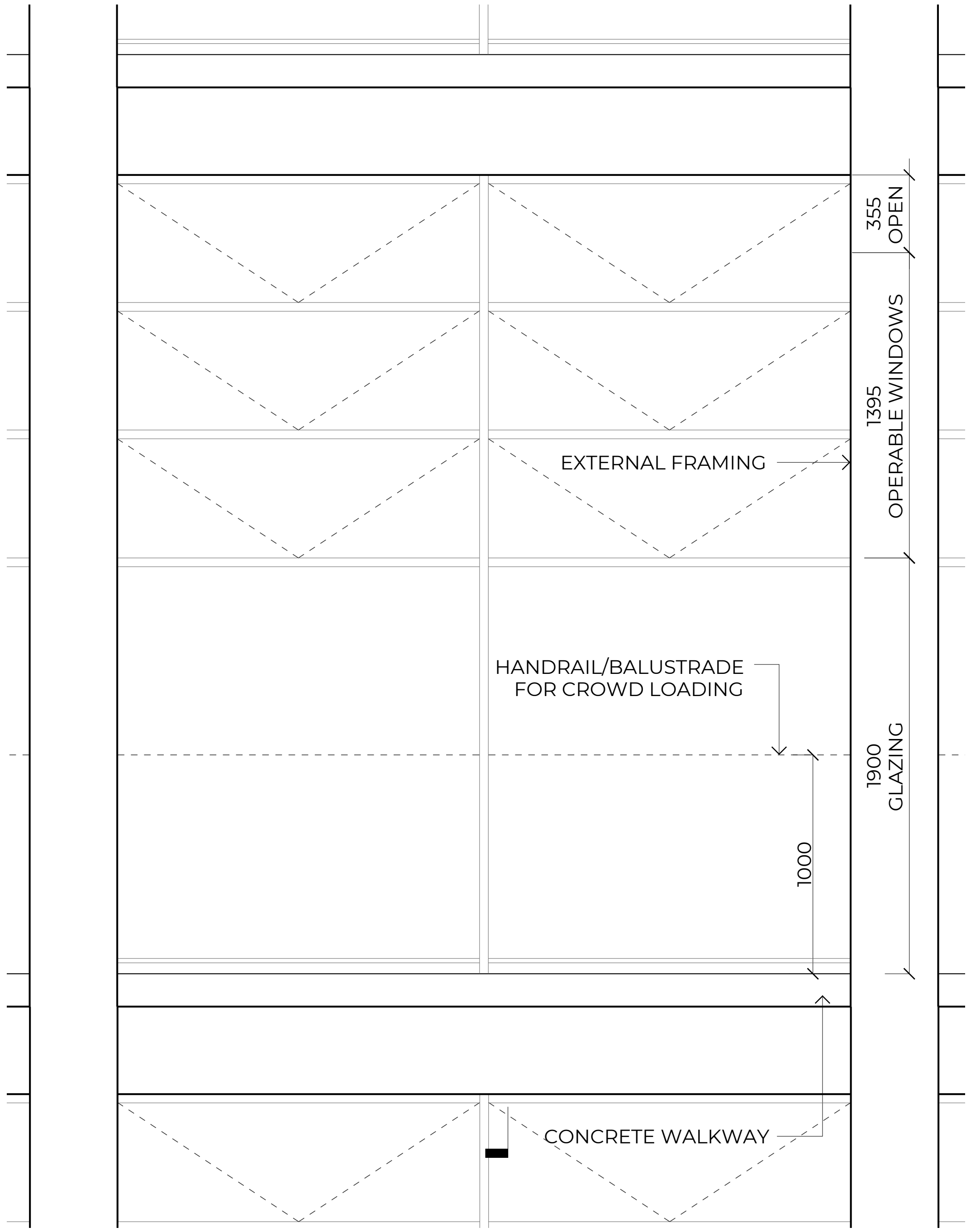
- Provides some protection from wind/ rain - particularly in colder climates
- Minimises impact on daylight on the interior
- Minimum ventilating area of at least 10% of the adjacent floor area (Both walkway and adjacent interior space)in accordance with BCA requirements
- If open area of the screen is below 75% - Fire compartment zones will be reduced in accordance with chapter 4 guidelines - Fire Safety
- Finish to take into consideration - ease of maintenance and durability



Walkway Option 04 | Glazed Screen with Awning Windows



Walkway Section Option 4



Walkway Screen Module Elevation Option 4

3.11 Circulation

Walkway Option 04 | Glazed Screen with Awning Windows

Walkway Perspective Option 4

Walkway Screen Module Elevation Option 4

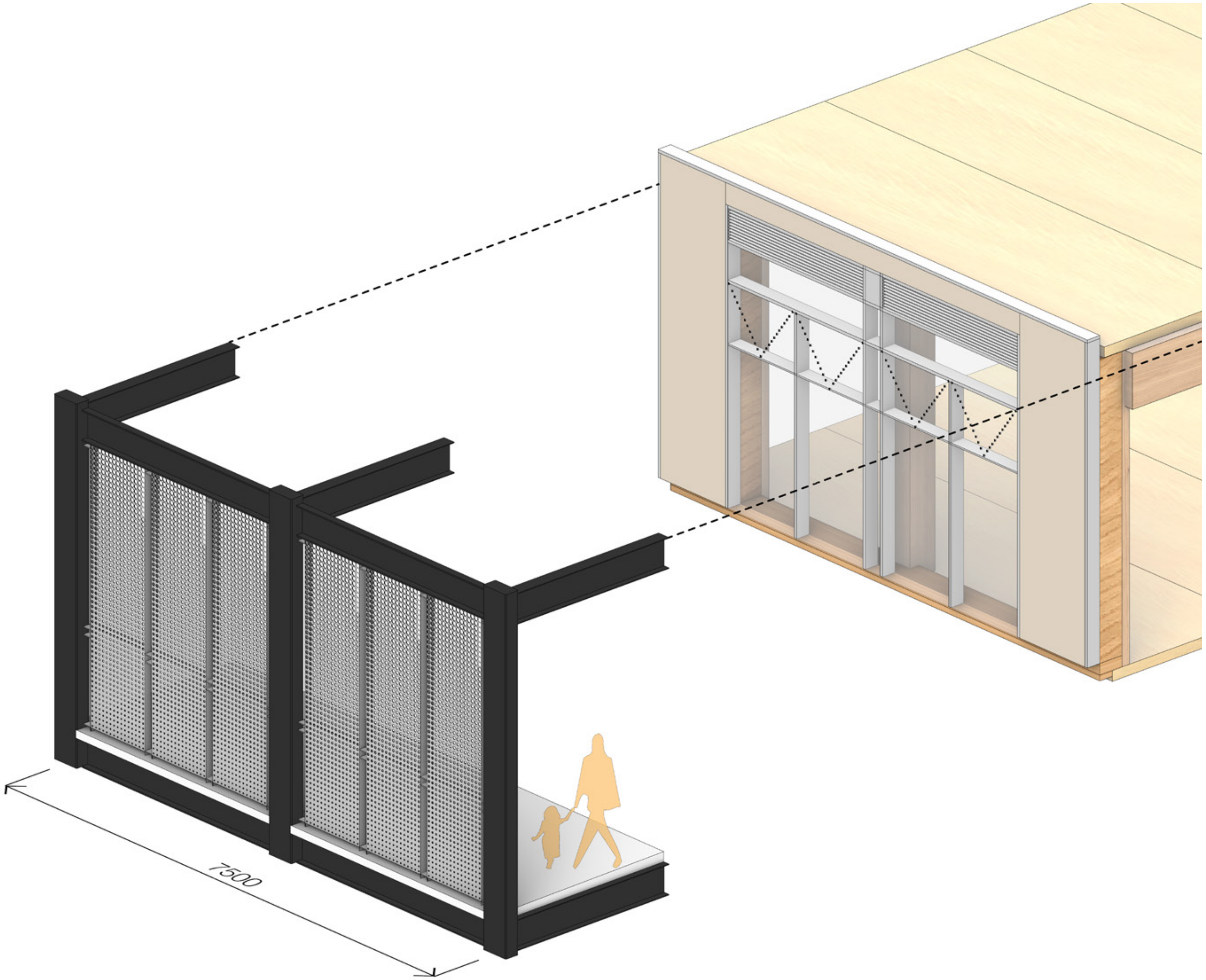
3.11 Circulation

3.11 Circulation

Walkway Option 05 | Full Height Perforated Screen

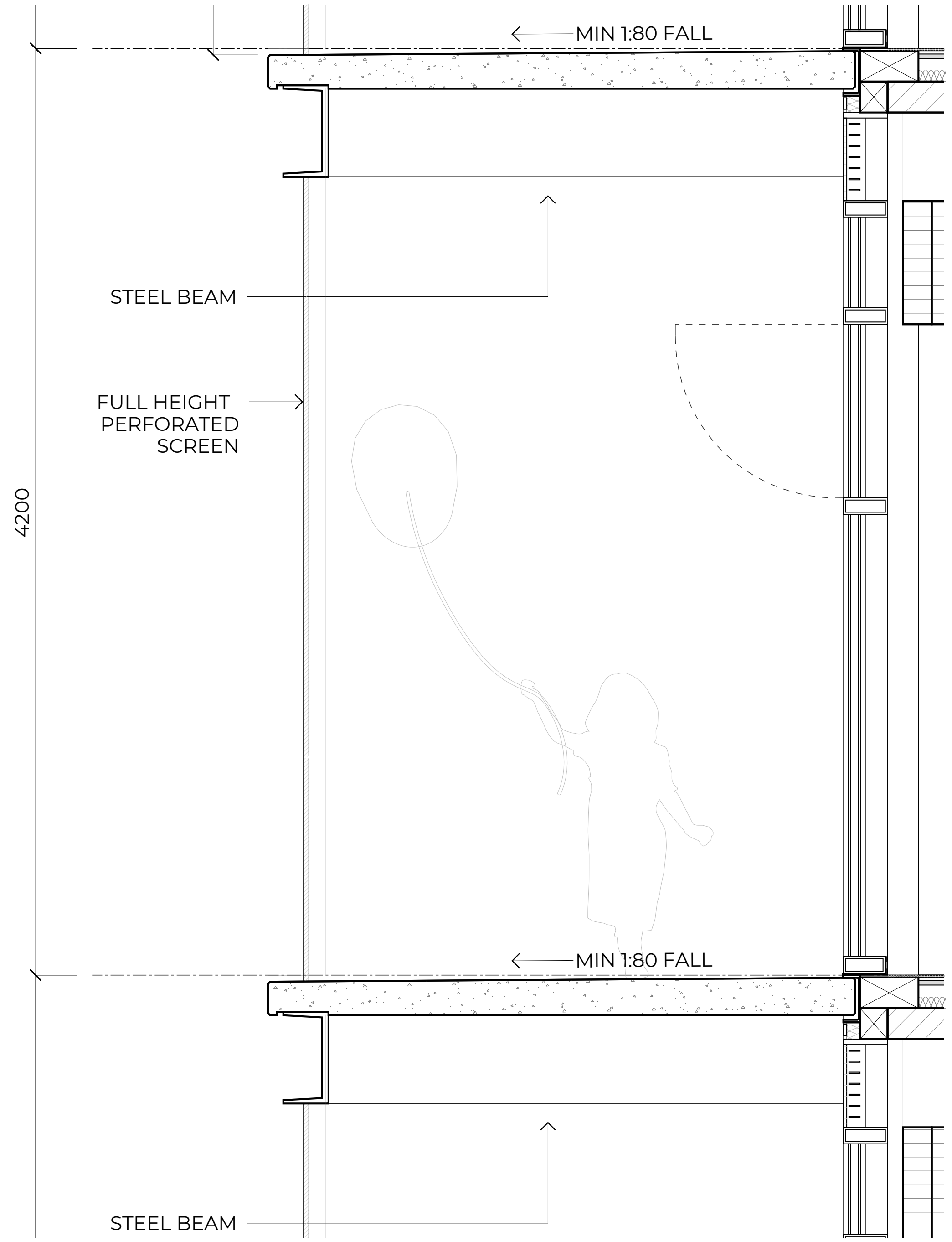
Example four presents a full height laser-cut screen.

- Provides some protection from wind/ rain - particularly in colder climate
- Consideration to impact on daylight required
- Requires minimum ventilating area of at least 10% of the adjacent floor area (Both walkway and adjacent interior space)
- If open area of the screen is below 75% - smaller compartmentalisation will be required in accordance with chapter 4 guidelines
- Finish to take into consideration - ease of maintenance and durability
- Screen option provides an opportunity for collaboration with local artists and community groups in order to ensure design is reflects place and country.

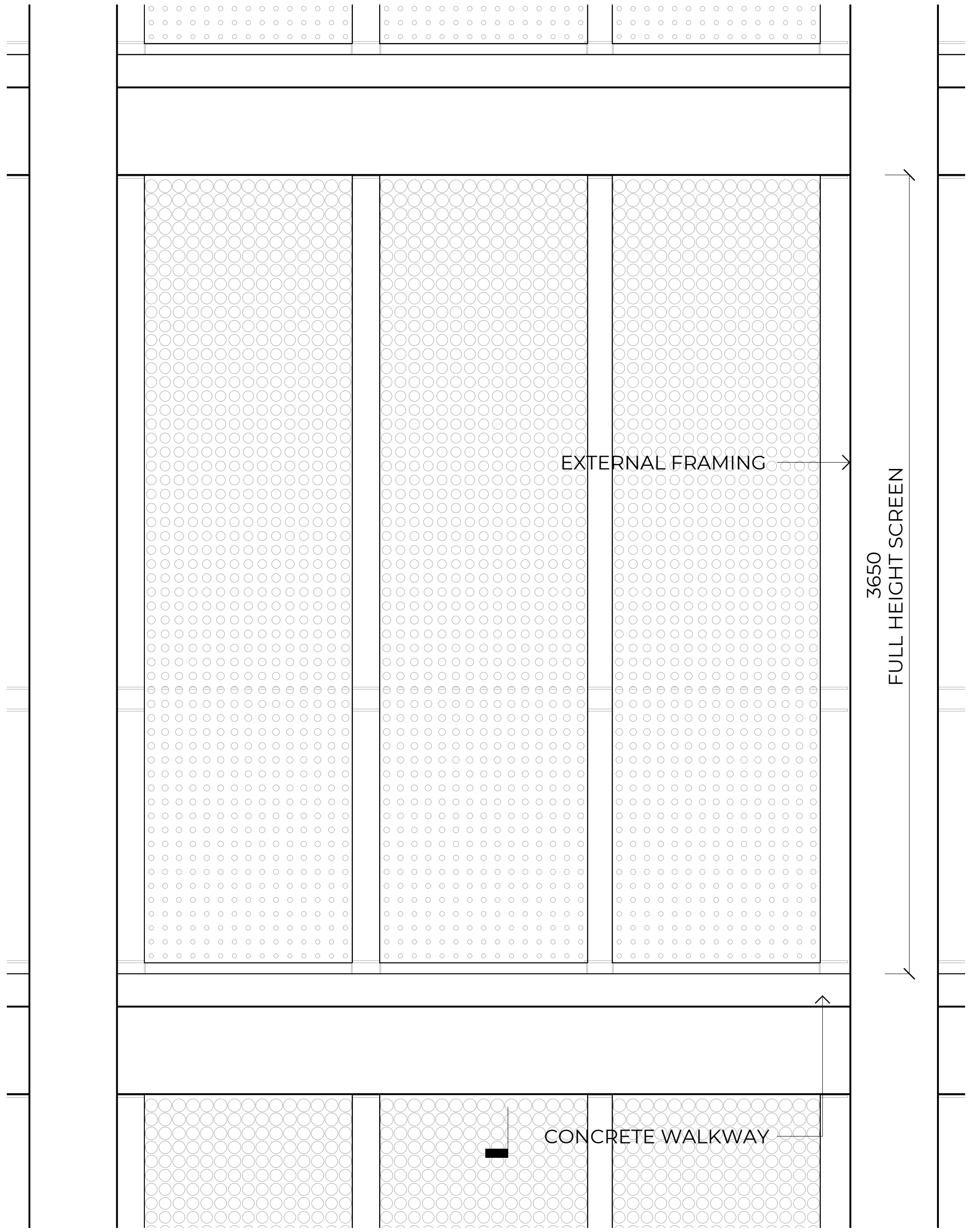


3.11 Circulation

Walkway Option 05 | Full Height Perforated Screen



Walkway Section Option 5



Walkway Screen Module Elevation Option 5

3.11 Circulation

Walkway Option 05 | Full Height Perforated Screen

Walkway Perspective Option 5

Walkway Screen Module Elevation Option 5

3.11 Circulation

Walkway Screen Summary

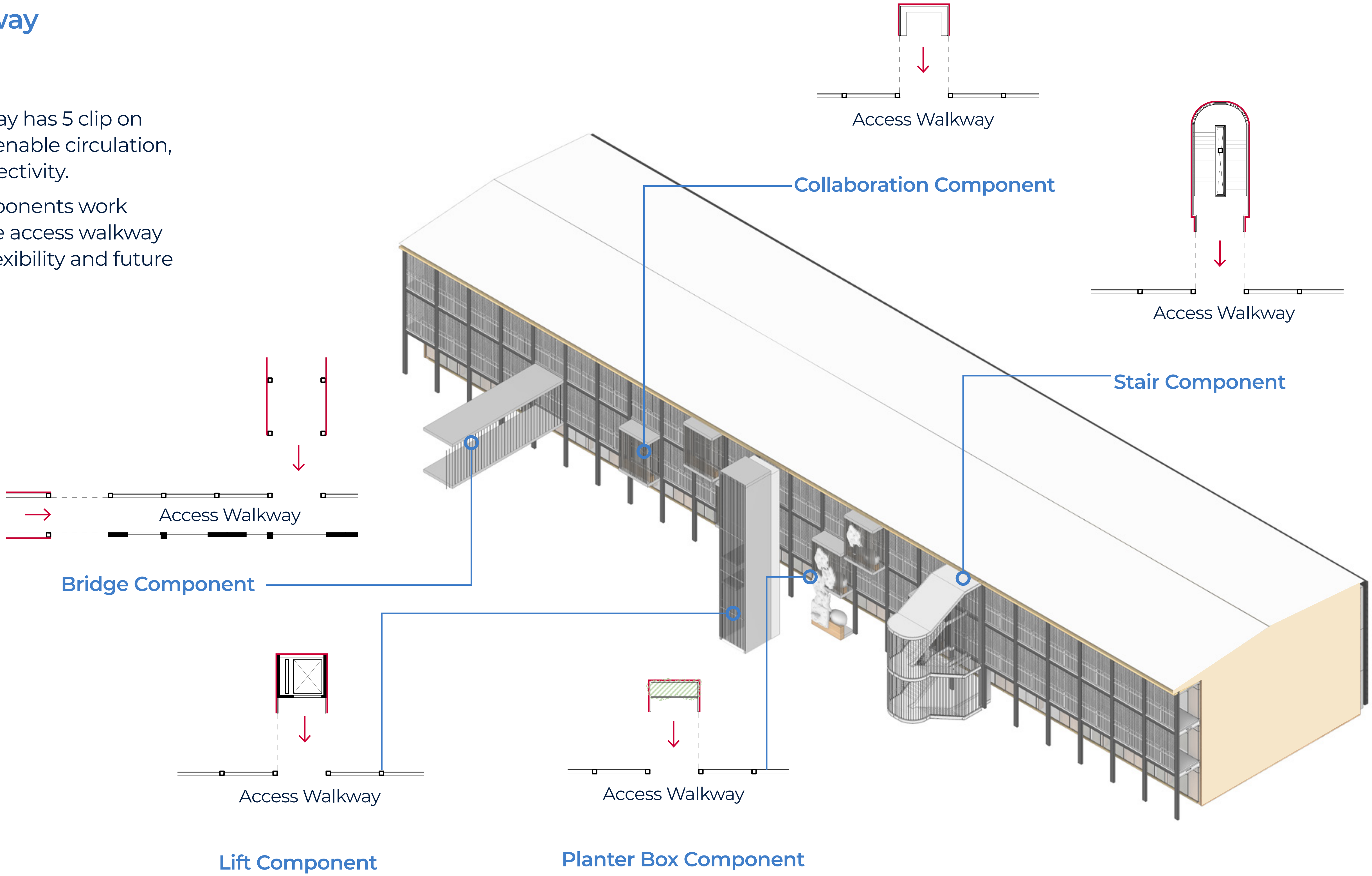
	Daylight	Natural Ventilation	Weather Protection	Safety	Ease of Maintenance
Walkway 1 - 1.3m Balustrade	●●●	●●●	●○○	●●○	●●●
Walkway 2 - Full Height Screen - Vertical Bars	●●○	●●●	●○○	●●●	●●●
Walkway 3 - Glazed Screen with Glazed Fins	●●●	●●○	●●●	●●●	●○○
Walkway 4 - Glazed Screen with Operable Windows	●●●	●○○	●●●	●●○	●○○
Walkway 5 - Full Height Perforated Screen	●○○	●●○	●●○	●●●	●●○

3.11 Circulation

Access Walkway Components

The Access Walkway has 5 clip on components that enable circulation, learning and connectivity.

The modular components work with the grid of the access walkway facade, allowing flexibility and future adaptability.

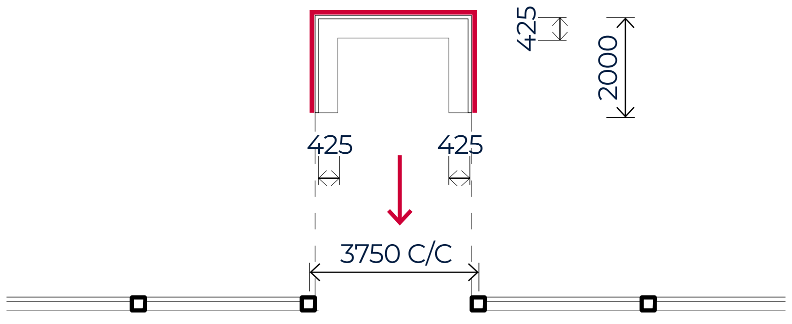


3.11 Circulation

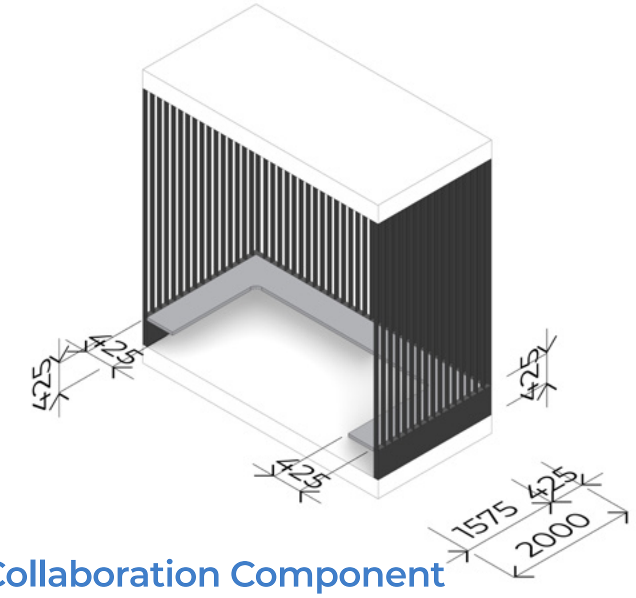
Collaboration Component

The collaboration component can be added to the walkway to break the long run of the circulation space and provide opportunity for informal learning spaces, sensory spaces or break-out spaces for senior learning groups.

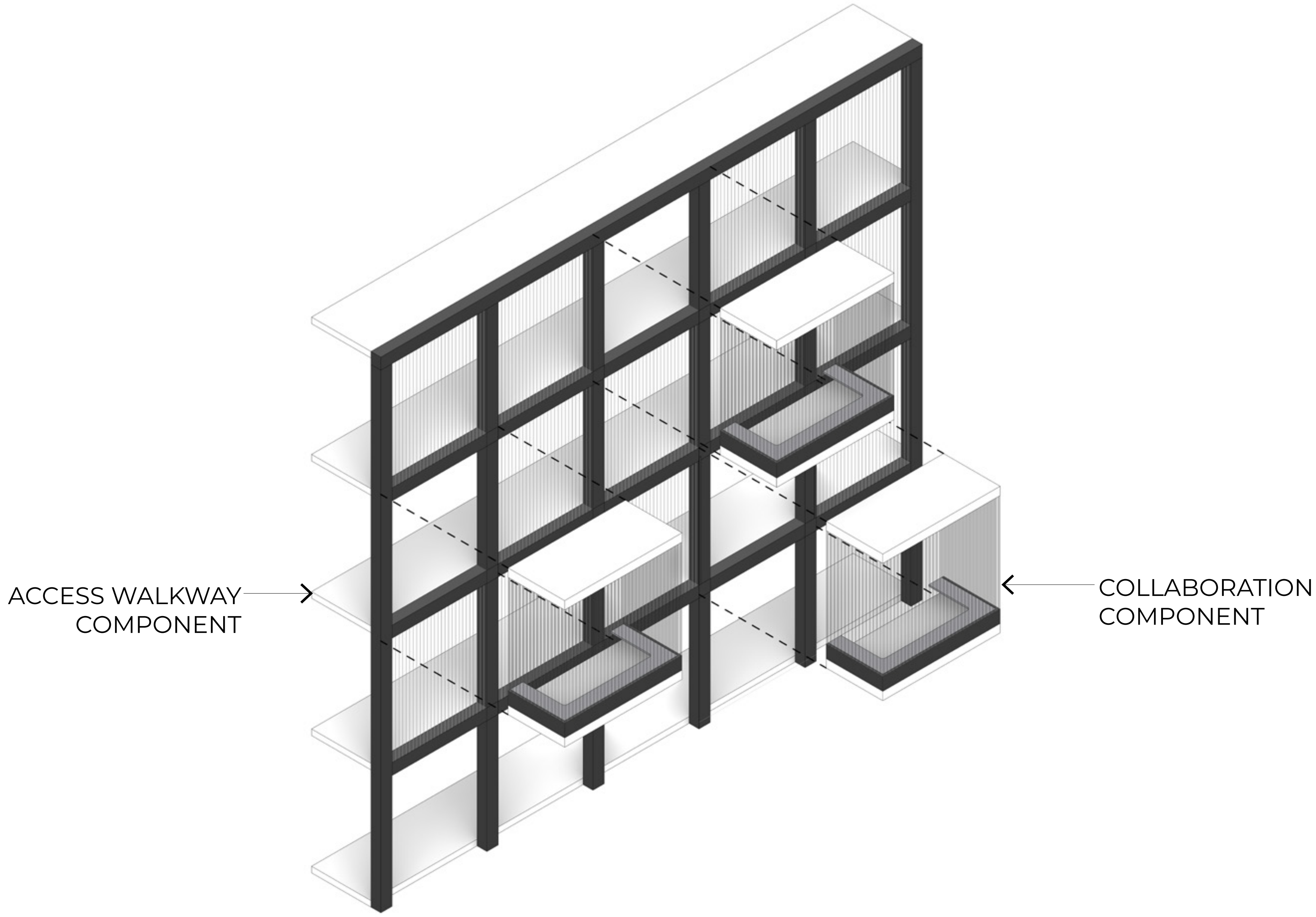
Consideration should be given to the location of these spaces in order to reduce impact on daylight within the internal teaching spaces.



Access Walkway



Collaboration Component Axonometric



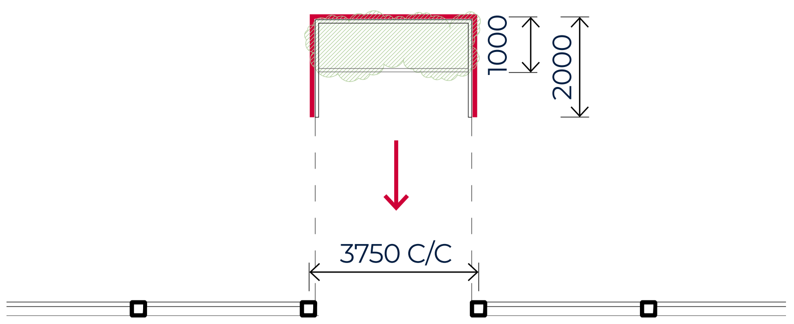
Collaboration Component Overview Example Axonometric

3.11 Circulation

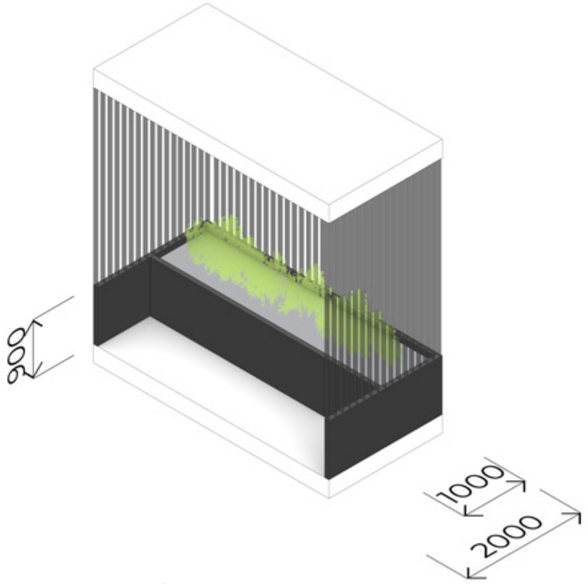
Planter Box Component

The planter component can be added to the walkway to break the long run of the circulation space and provide opportunity for a learning garden or informal break-out space.

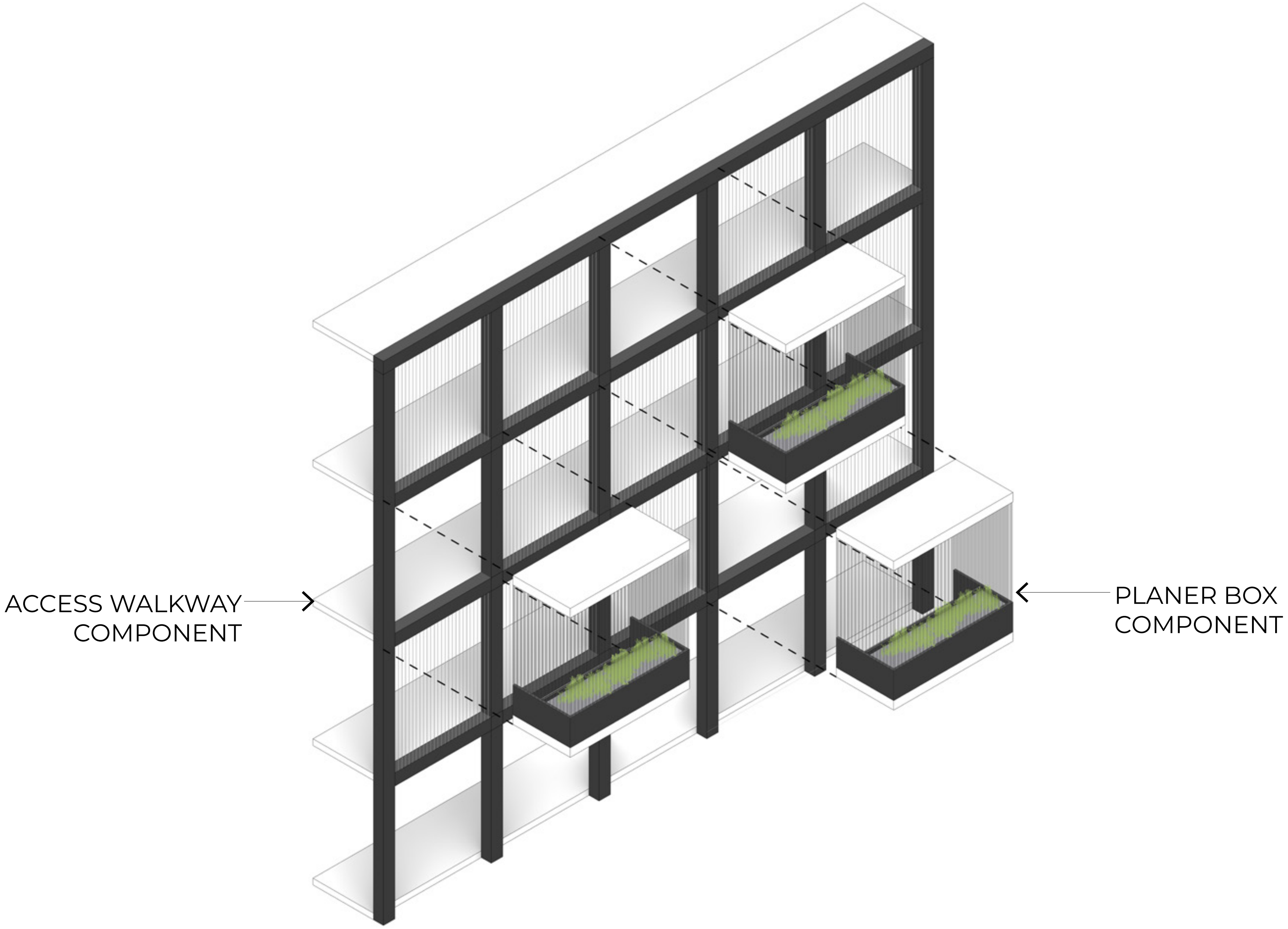
Consideration should be given to the location of these spaces in order to reduce impact on daylight within the internal teaching spaces.



Access Walkway



Planter Box Component Axonometric



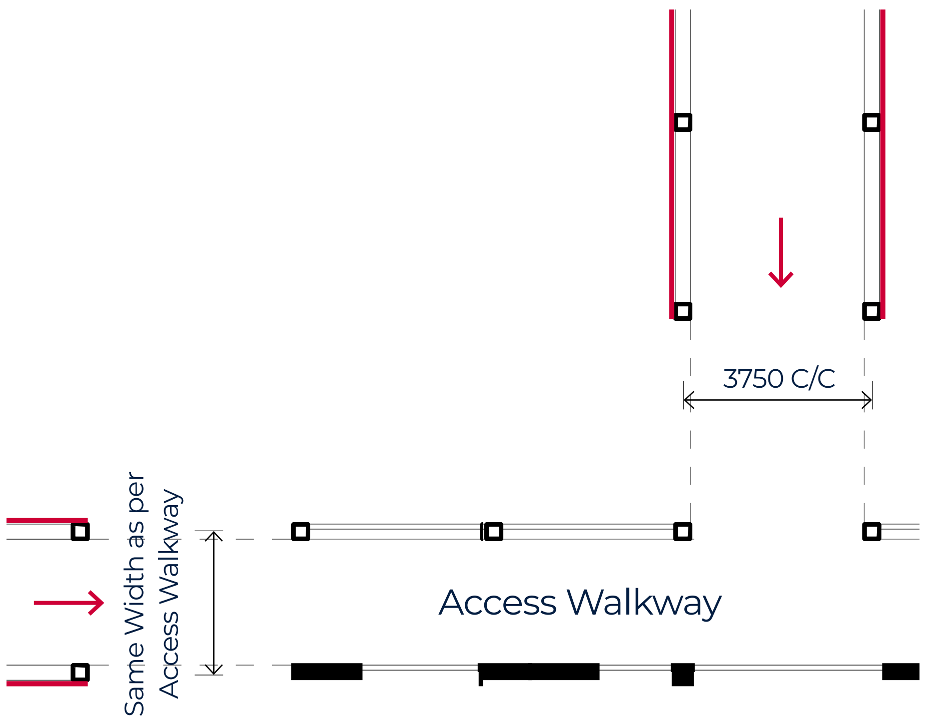
Planter Box Component Overview Example Axonometric

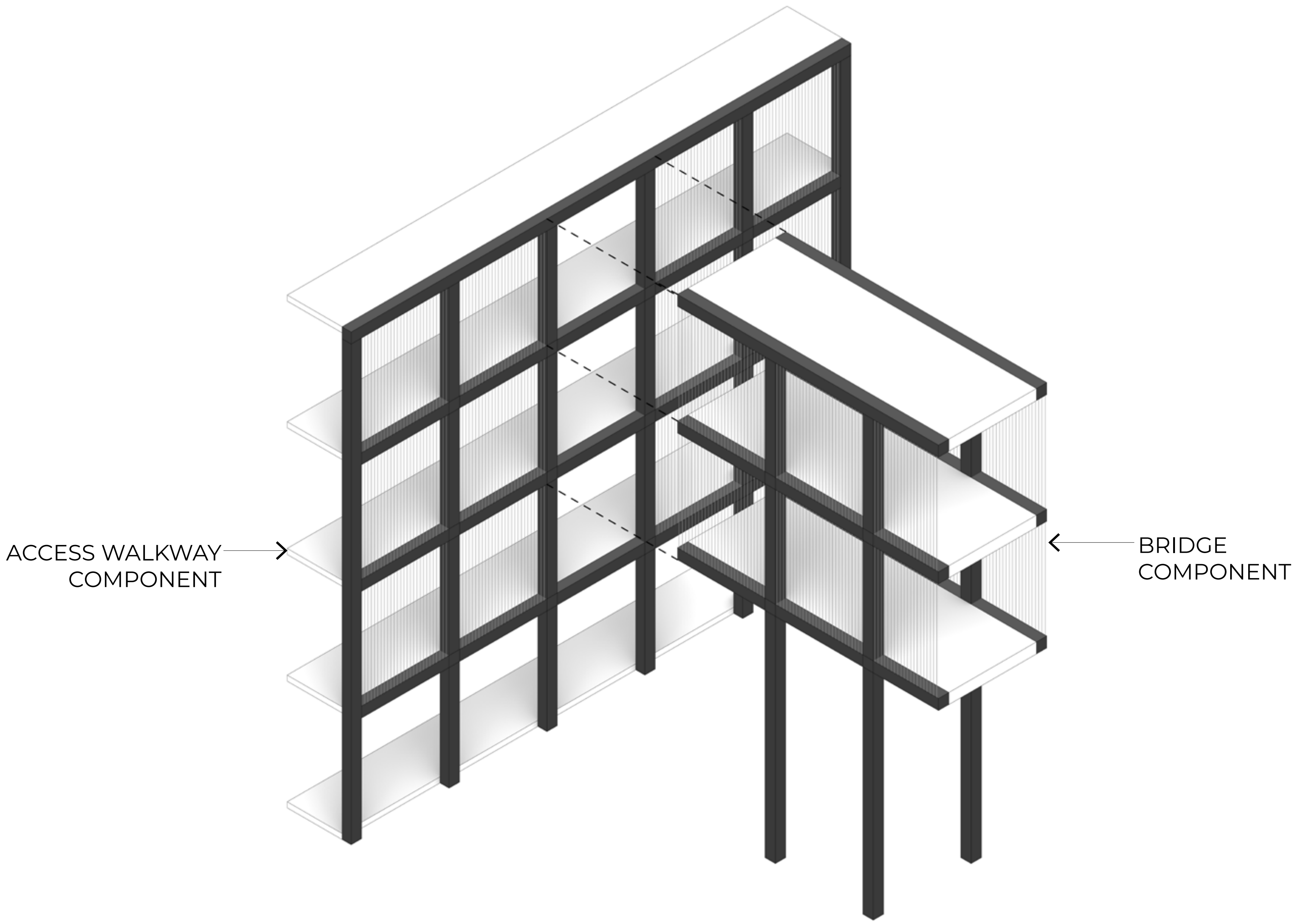
3.11 Circulation

Bridge Component

The bridge component can be added to the walkway in scenarios where separate school buildings/wings need to be connected, or where a new-build needs to connect with existing buildings/structures.

The bridge can be inserted perpendicular or as an extension to the access walkway component, maintaining the same structure layout and associated width dimensions.





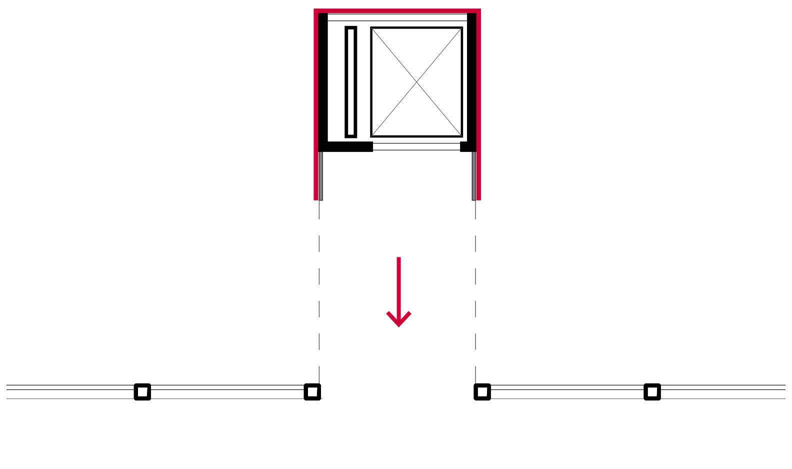
Bridge Component Overview
Example Axonometric

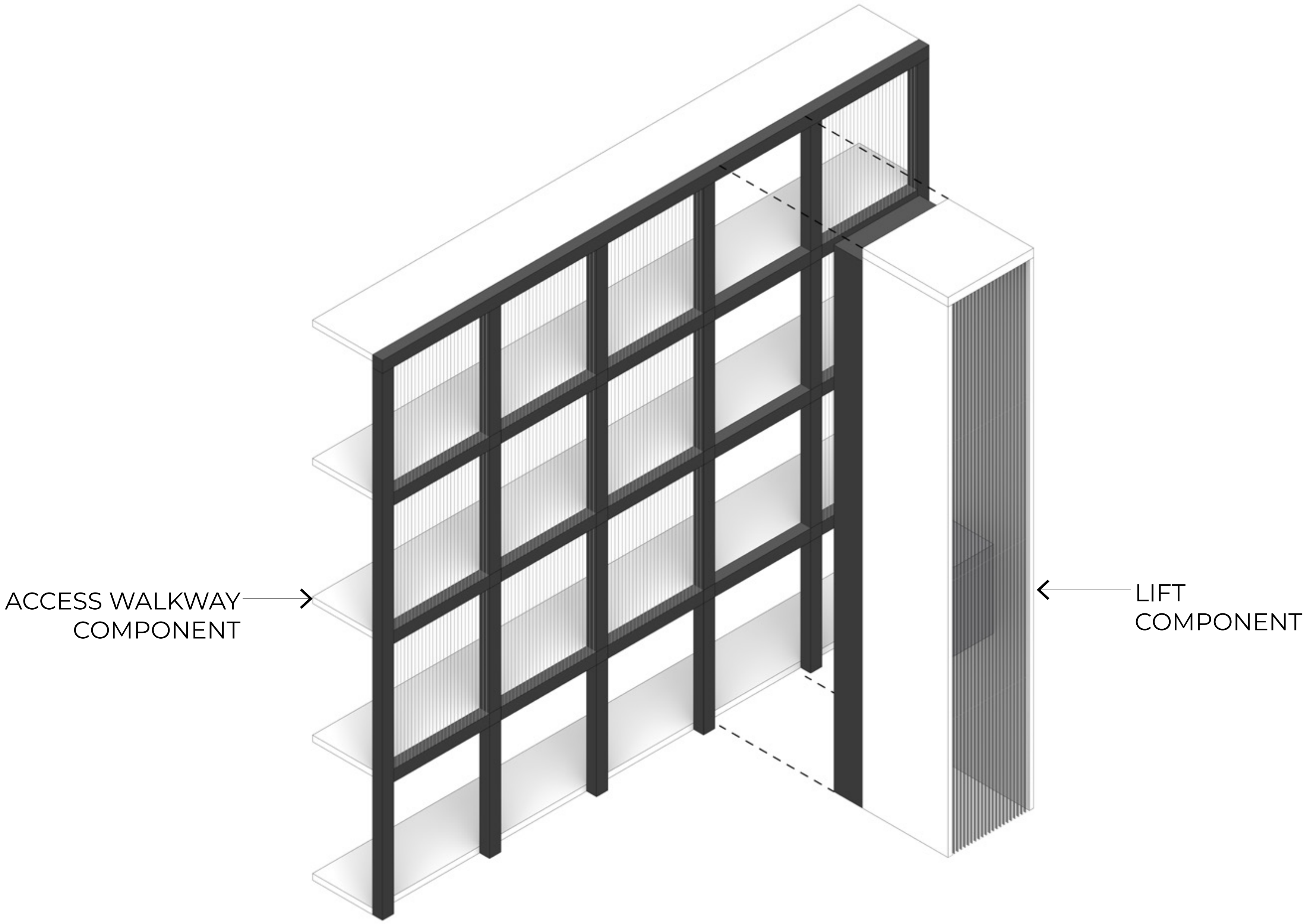
3.11 Circulation

Lift Component

The lift component can be added to the walkway near the core component to provide access and vertical circulation to buildings with 2 or more storeys. The base option shown on this page is a single lift system, multiple lifts option can be integrated according to lift demands to the population of the proposed school.

Consideration should be given to the location of these spaces in order to reduce impact on daylight within the internal teaching spaces. Ideally these should be located adjacent to the core.



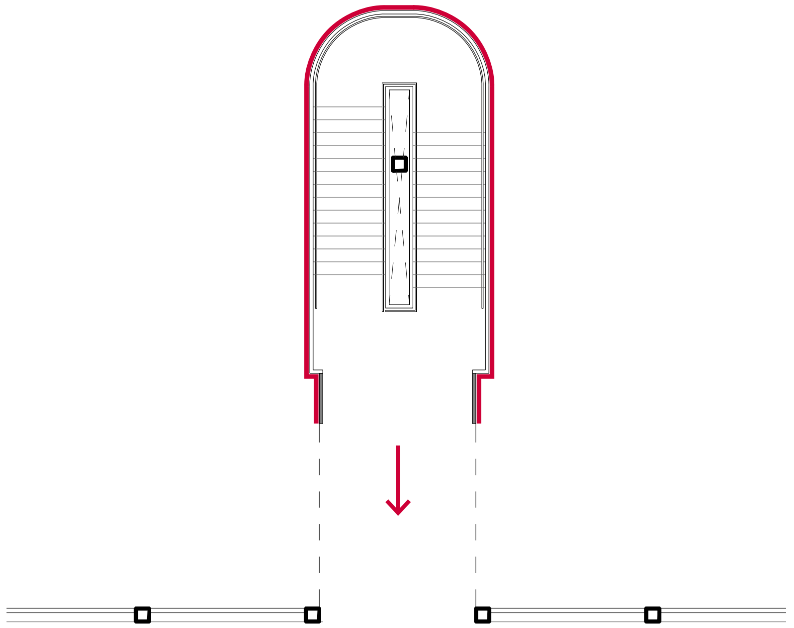


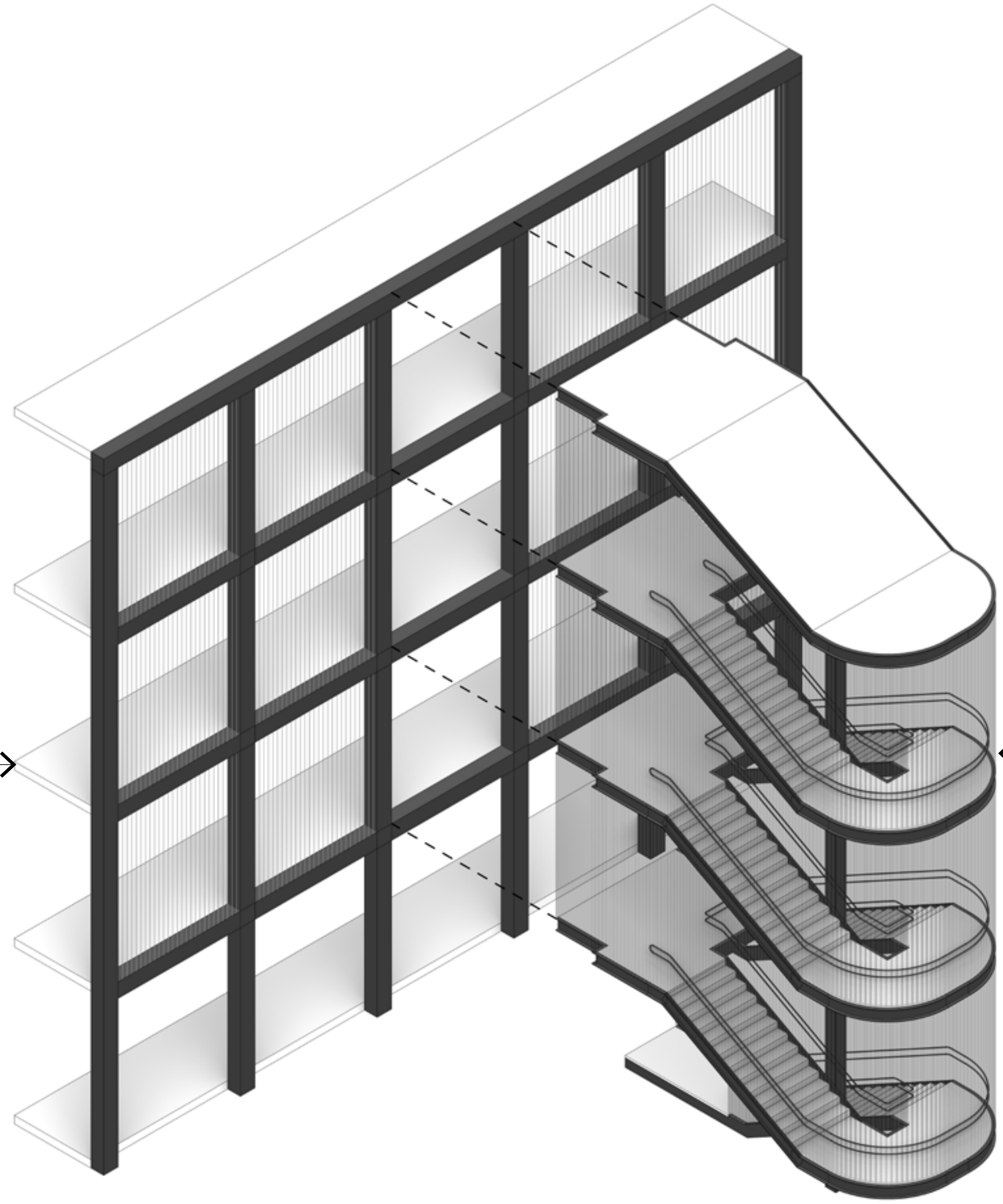
Lift Component Overview
Example Axonometric

3.11 Circulation

Stair Component

The stair component can be added to the walkway to comply with egress requirements in accordance with the BCA and circulation requirements within the EFSG. The base option shows a clear width of 2.1m and a floor to floor height of 4.2m. The 2.1m clear width is selected to allow for three lanes of student movement at the same time.





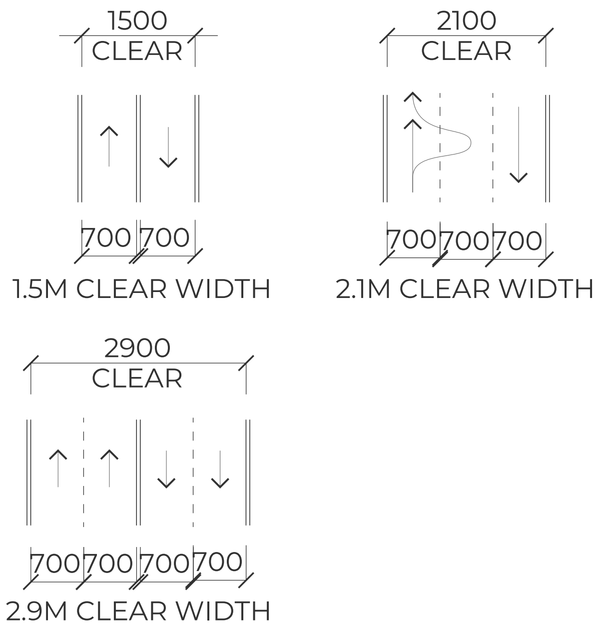
Stair Component Overview
Example Axonometric

3.11 Circulation

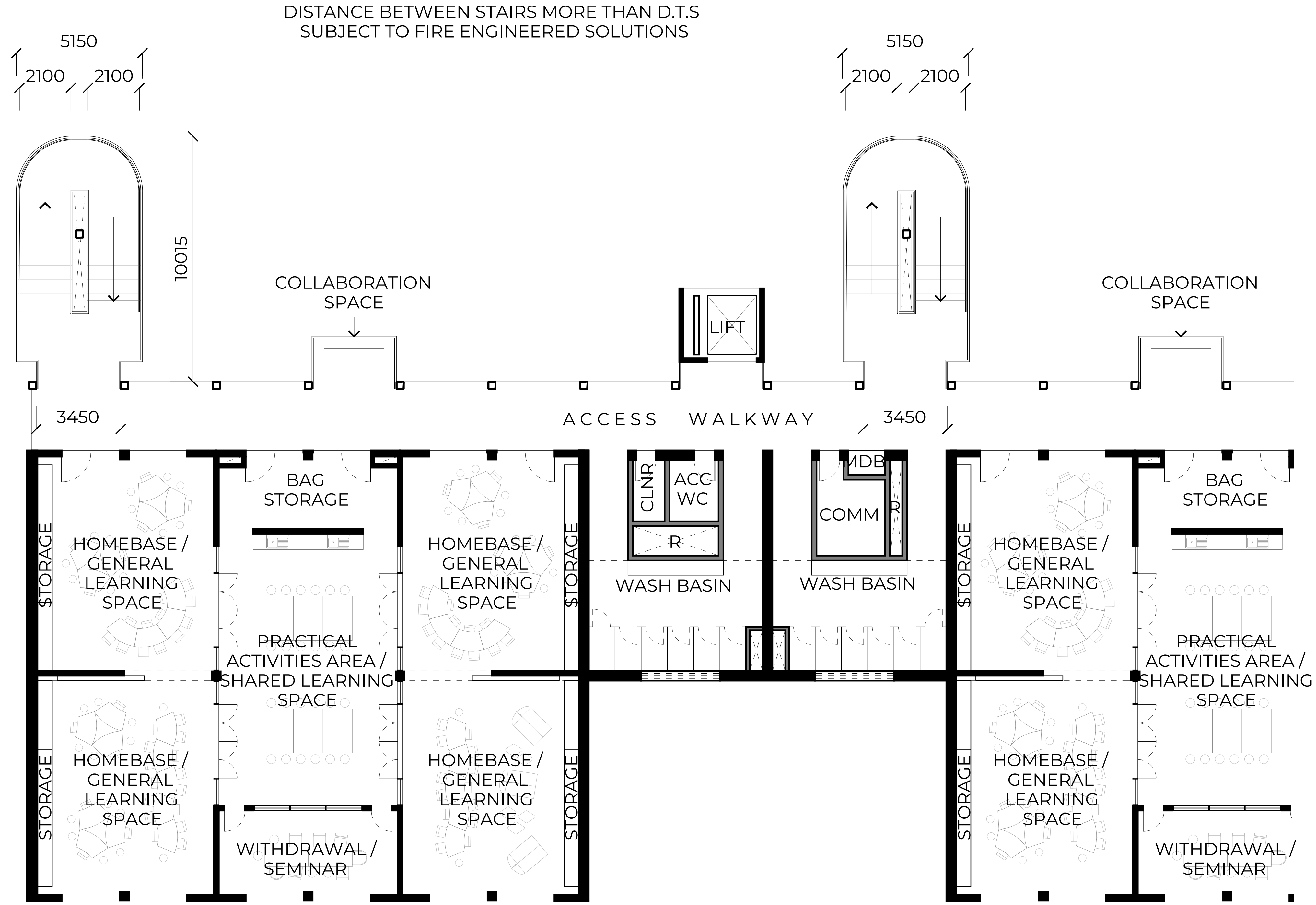
Stair Component Location Diagram

- Distance between stairs to comply with BCA egress requirements
- Stair width to comply with BCA egress and EFSG movement requirements
- The planning context shown with the stairs plan on this page is a worked example only.

The diagrams below show a number of stair width options can be considered aligning with the 700mm lane width under the EFSG student movement requirements.



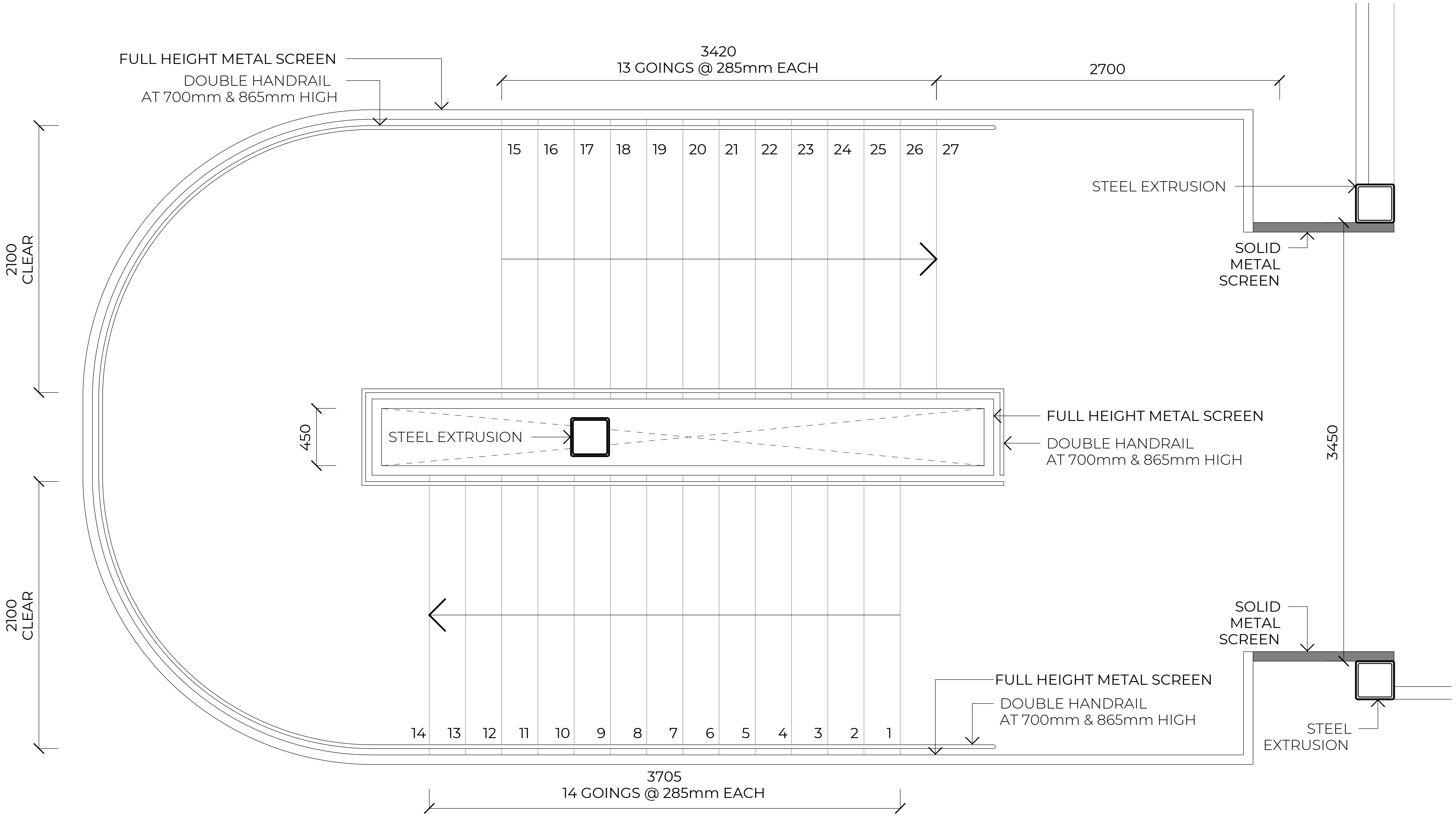
Stair Width Diagram



Stair Component - 2.1m Clear Width Example Plan

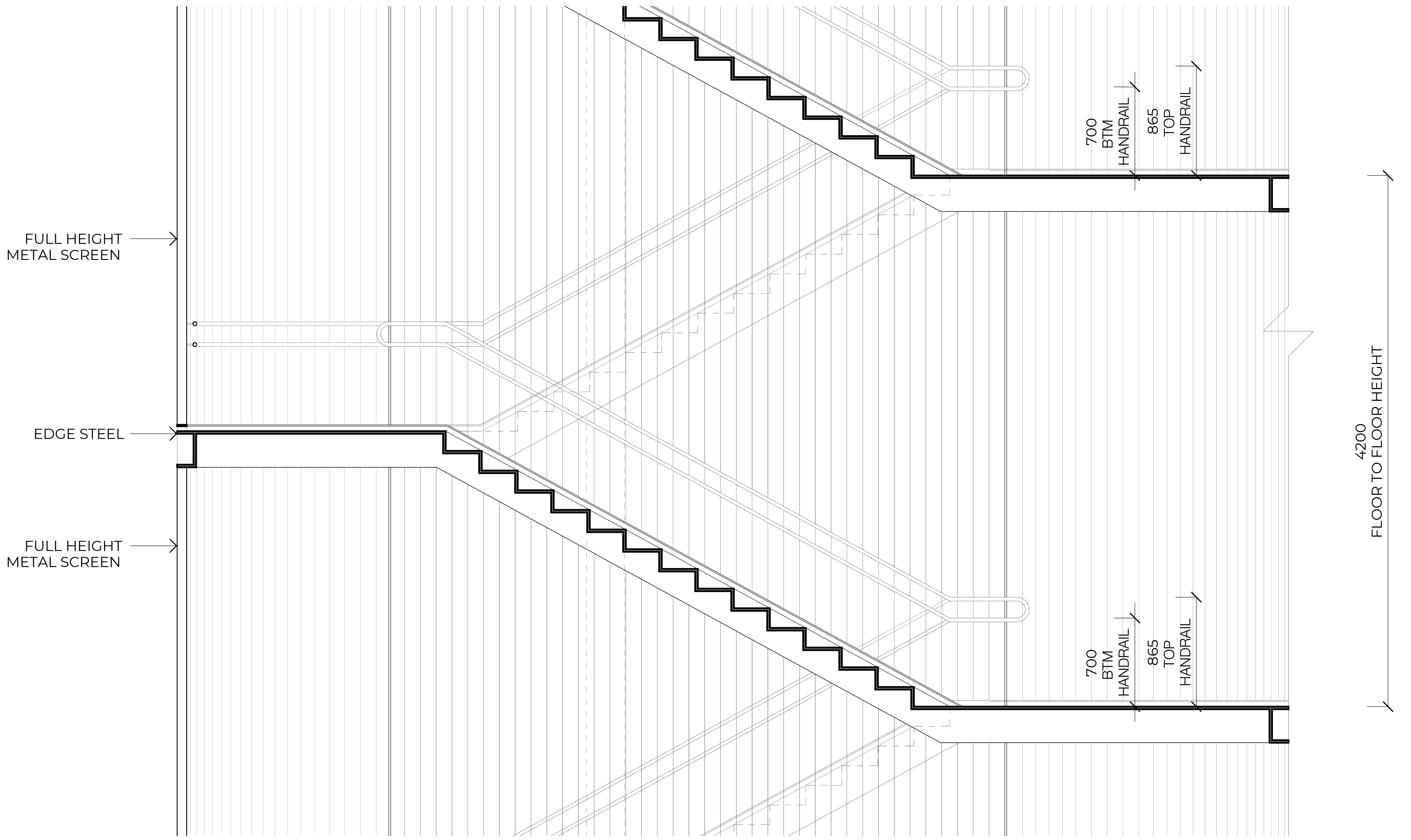
3.11 Circulation

2.1m Clear Width Stair Plan



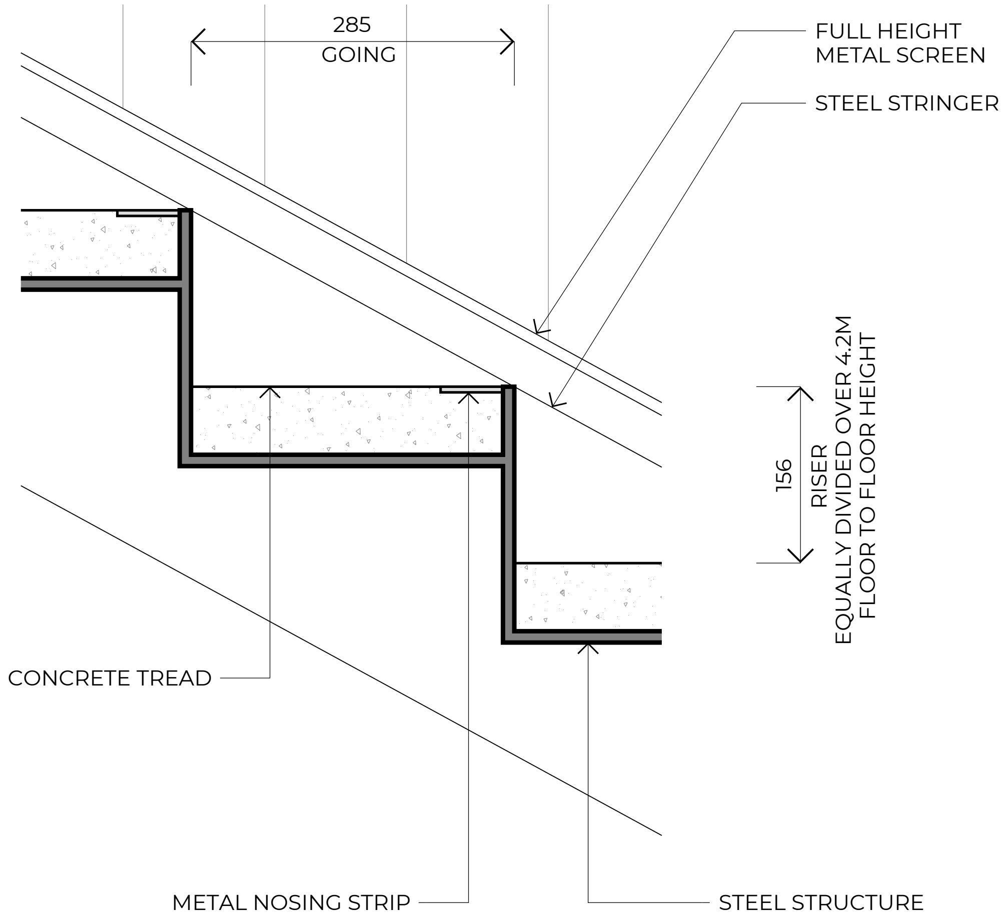
3.11 Circulation

Stair Section



Stair Tread Detail

The detail drawing on this page shows an example of a base option stair construction, with concrete treads laid on a steel stair structure. This example is one of the solutions of many possible scenarios.



3.12 Core & Amenities

The DfMA Core and Amenities Components have been designed and detailed with the following principles:

Constructibility

- Eliminate wet trades on site
- Ease of construction
- Ease of assembly and disassembly

Modularity

- The core component design is fit for the planning framework
- Enables mass production

Flexibility

- The system allows for flexible customization according to school and site specific requirements
- The core allows for adequate space for services risers and reticulation

Safety & Security

- Configuration of amenities spaces conforms with anti-bullying standards

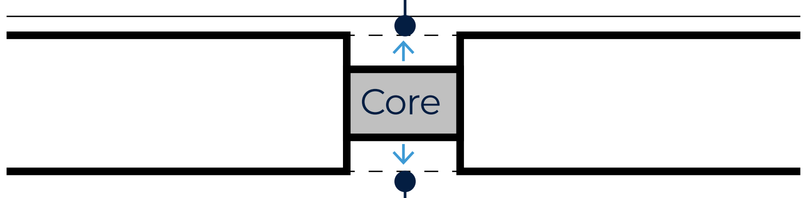
3.12 Core & Amenities

The core has been created to enable DfMA, providing student amenities and services.

- The core is on the 9m by 7.5m framework.
- Student amenities are configured to meet anti-bullying standards.
- Access to services of the core are open to the access walkway.

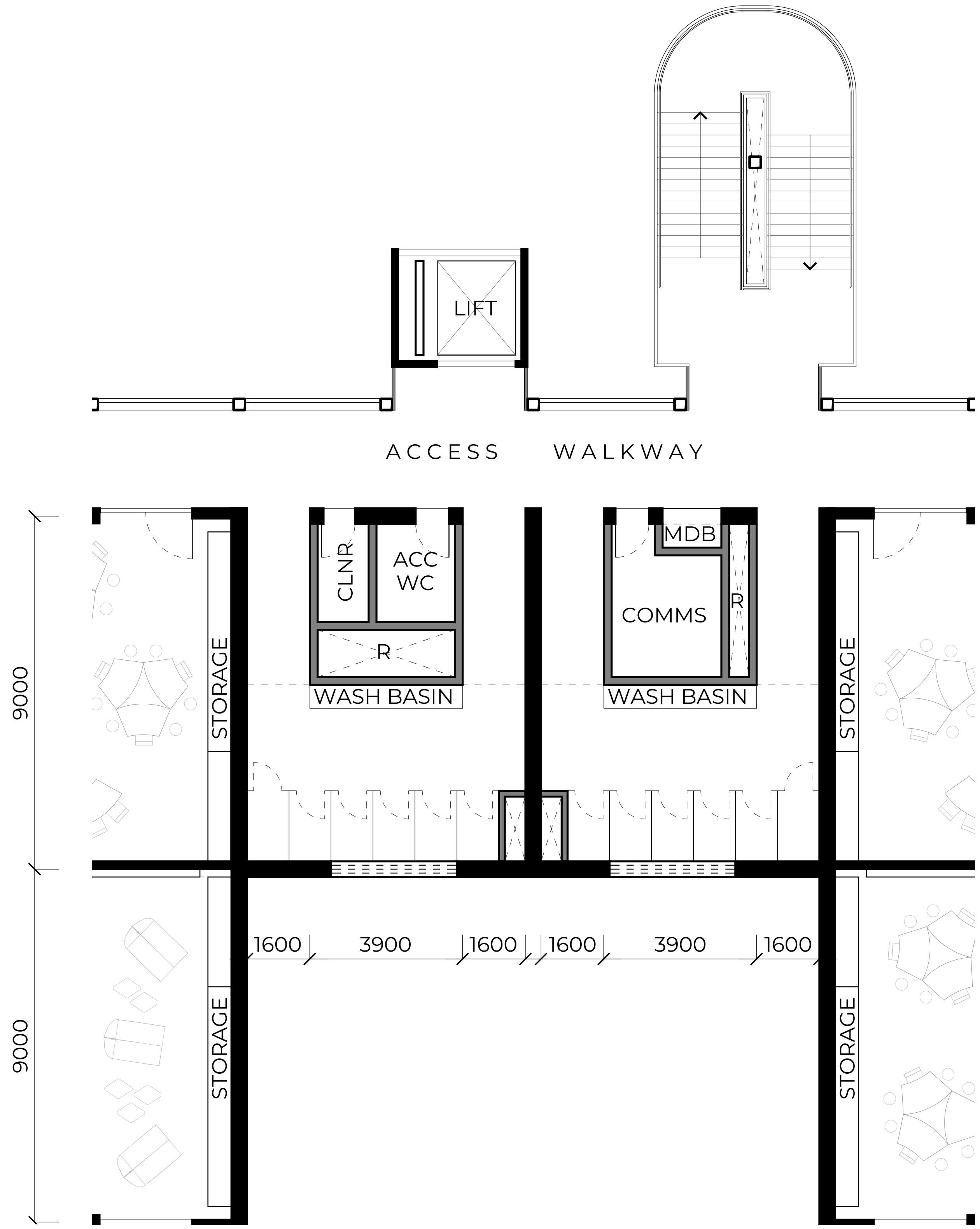
Space in front of Core

Opportunity for COLA space



Space behind Core

Opportunity for building articulation and to address site significant items

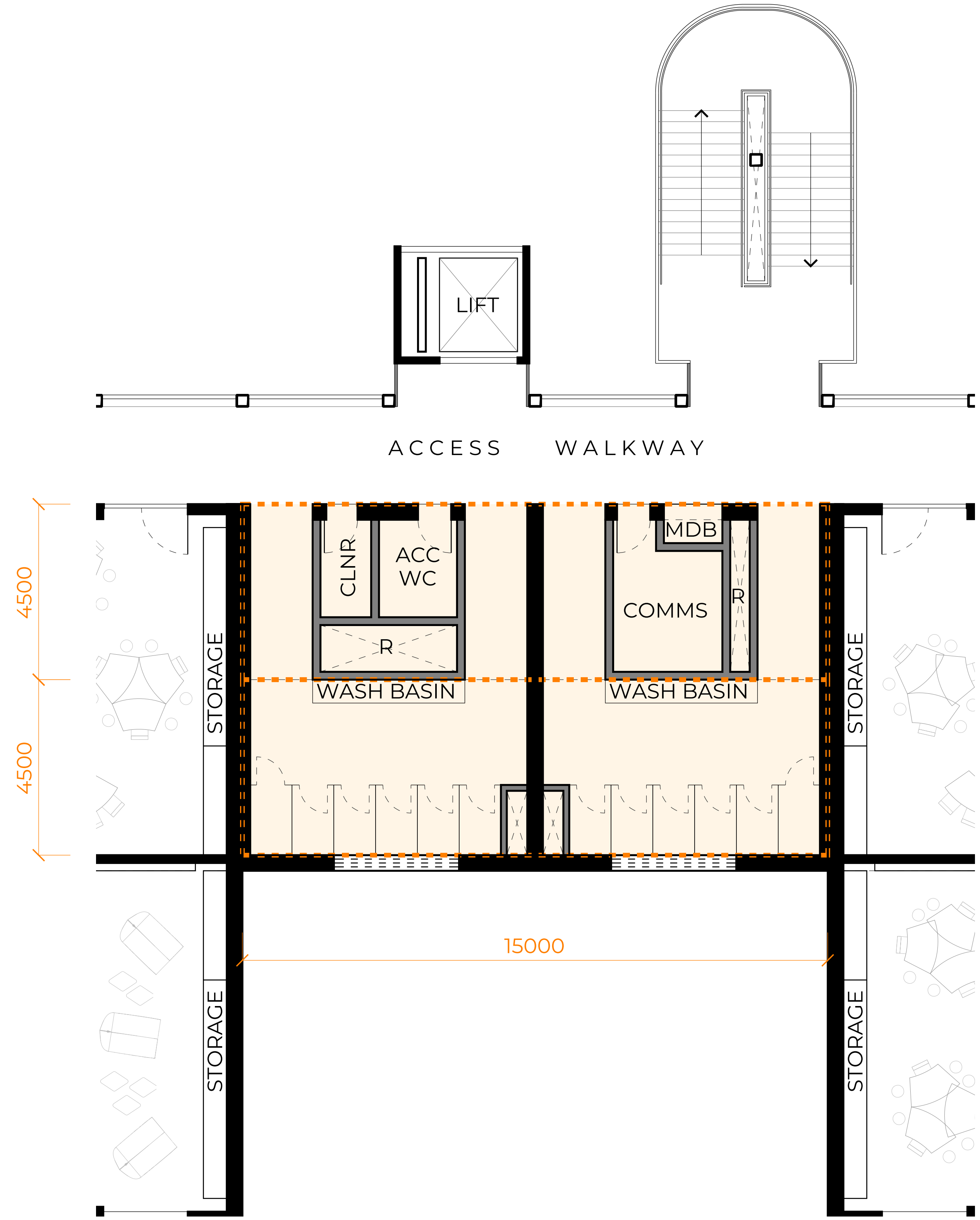


Typical Core Layout

3.12 Core & Amenities

Core - Volumetric Overlay

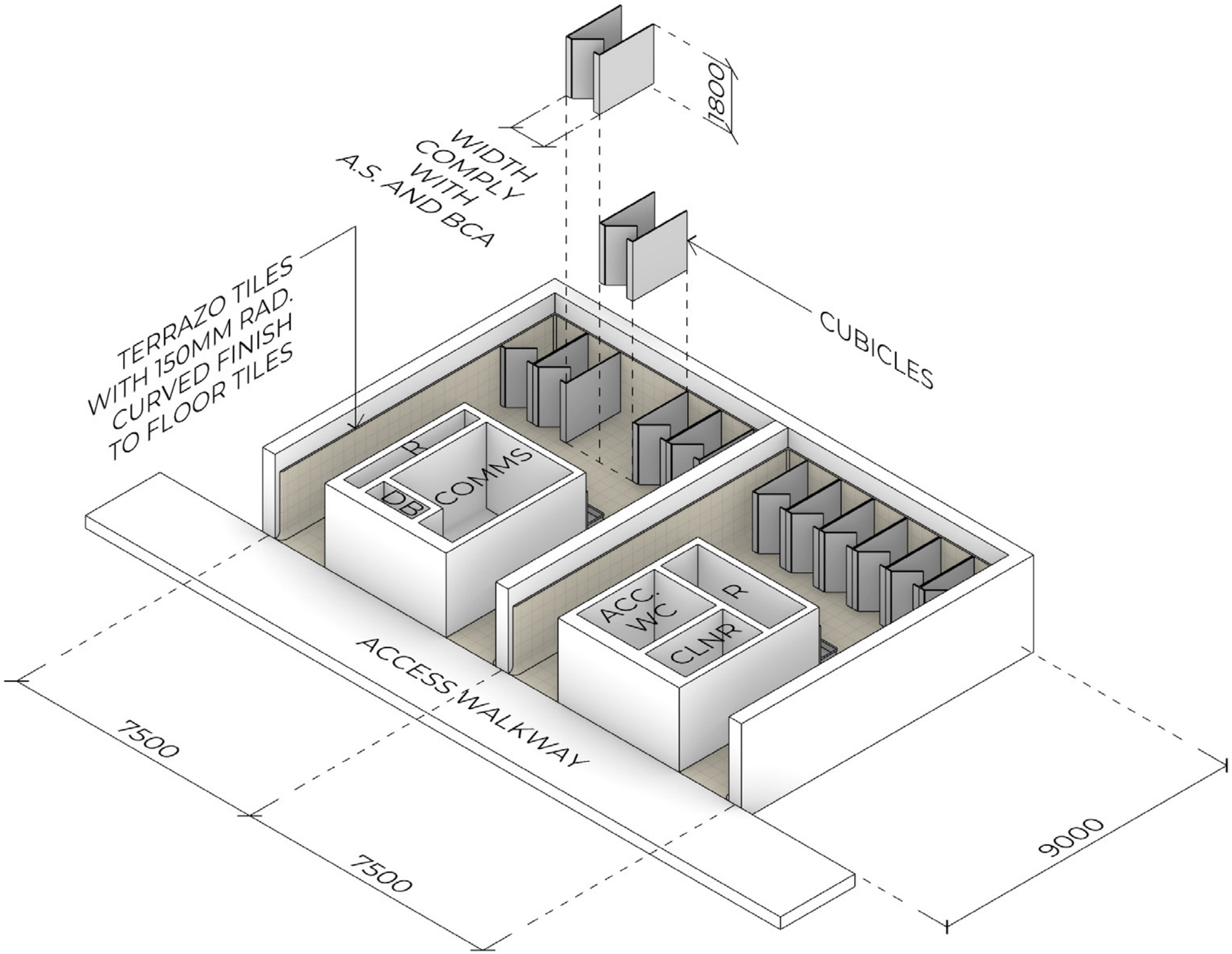
The core can be broken down into two volumetric parts, each being 4.5m (w) by 15m (l), this dimension fits within the current industry volumetric construction range which allows the core components to be mass produced in the factory off site.



Core Volumetric Overlay Example

3.12 Core & Amenities

Core & Amenities Axonometric Diagram



3.13 Internal Components

The DfMA Internal Components have been designed and detailed with the following principles:

Constructibility

- Eliminate wet trades on site
- Ease of construction
- Ease of assembly and disassembly

Adaptability

- Design is fit for purpose
- Ease of replacement of parts while learning space evolved

Maintenance

- Ease of cleaning and daily maintenance

Functional Materiality

- Robust system with durable finishes and concealed fixings for day to day use
- Provides a foundation for essential finishes that suits different types of teaching spaces to assist in learning
- Use of widely/locally available material products

3.13 Internal Components

Internal Components List

Ceiling

Exposed ceiling is desired for homebase and general learning spaces for mass timber construction buildings. A ceiling component is required to meet specific acoustic requirements for certain teaching spaces or to keep dust and fume out of teaching spaces in some labs or workshop areas.

Floor Finish

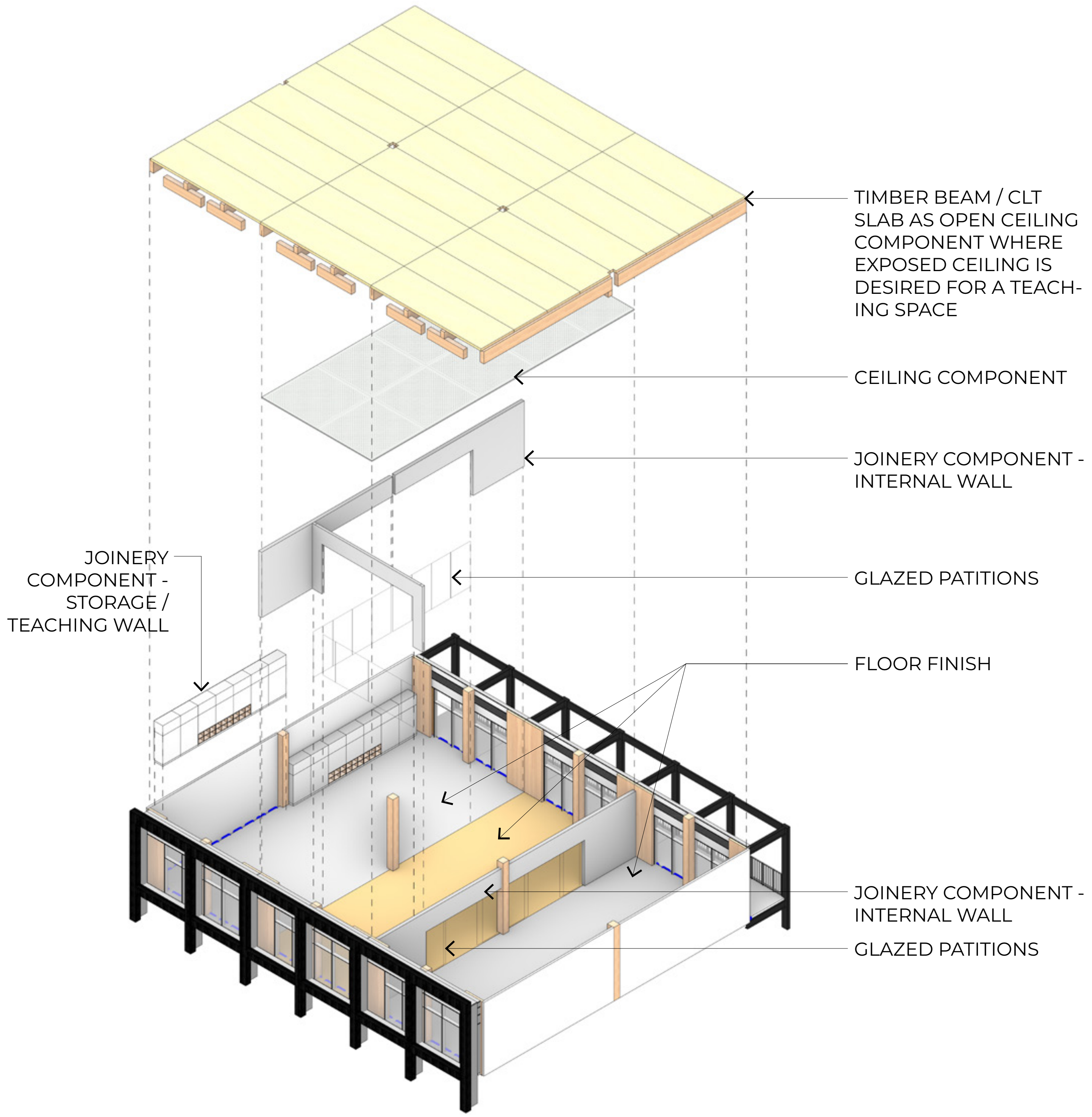
Floor finish to comply with EFSG requirements.

Joinery - walls / doors and storage units

The joinery system is composed of either self finished walls/ doors, or self finished storage units. The joinery system can be manufactured off site and easily be assembled on site to suit designated space types, or disassembled to accommodate future changes of teaching spaces. Refer to chapter 3.13 for the storage units of the joinery system.

Metal Framed Glazed Partitions

Glazed partitions are required within internal spaces to maximise daylighting and allow for visual supervision. The metal framing provides a robust, durable and easily maintainable system.



Internal Component Axonometric Diagram

3.13 Internal Components

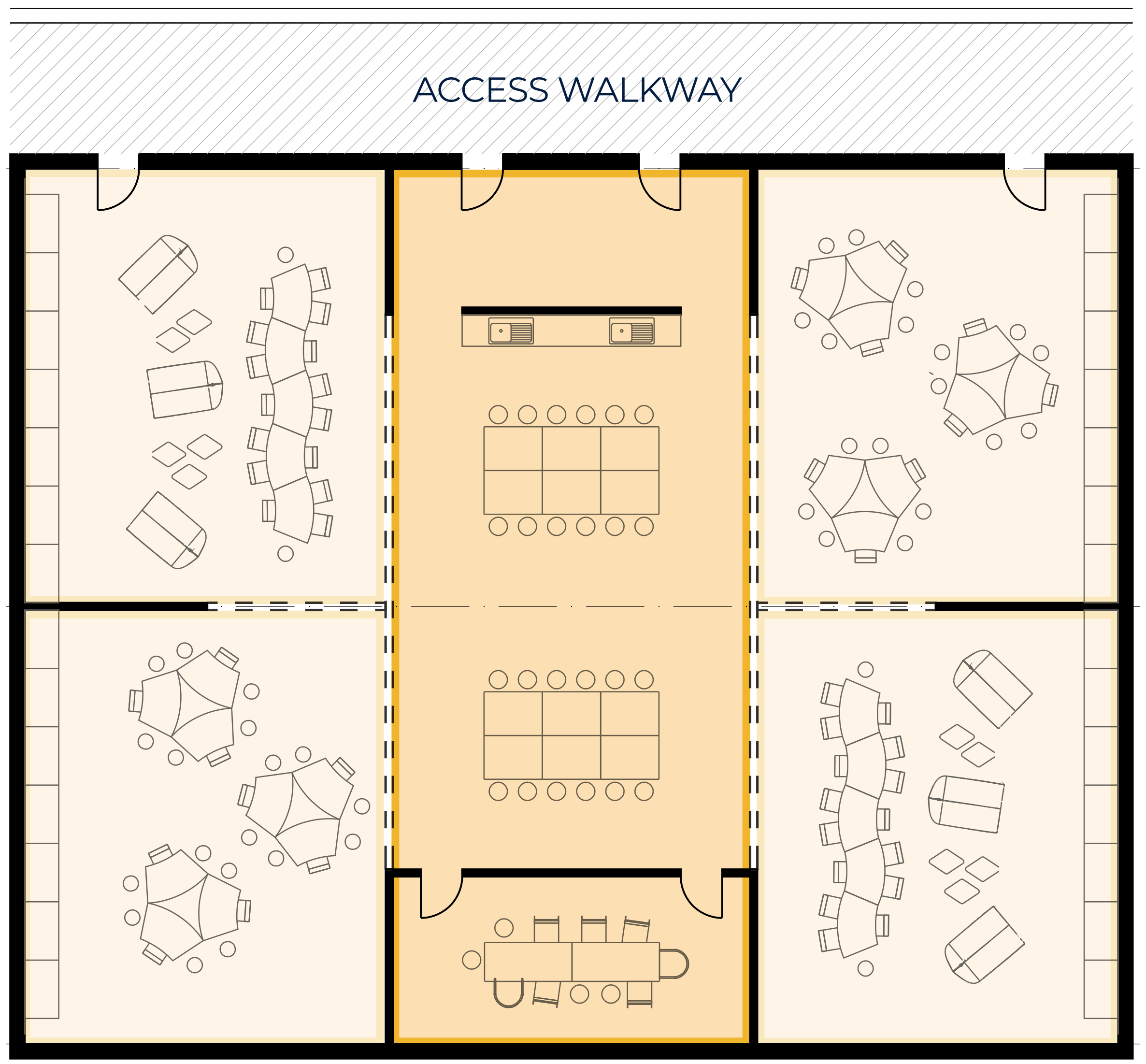
Ceilings

Home Base / General Learning Space Cluster

Exposed Timber Soffit
Treatment to exposed timber structure surfaces for internal use

Acoustic Seamless Perforated Plasterboard
Ceiling to meet acoustic requirements to learning spaces

Suspended Acoustic Raft Ceiling - 300 x 300 Spacing
Ceiling to meet acoustic requirements to learning spaces
Frontier raft suspended system



3.13 Internal Components

Ceilings

CCScience 2 GLS x 1 Lab Cluster

Exposed Timber Soffit

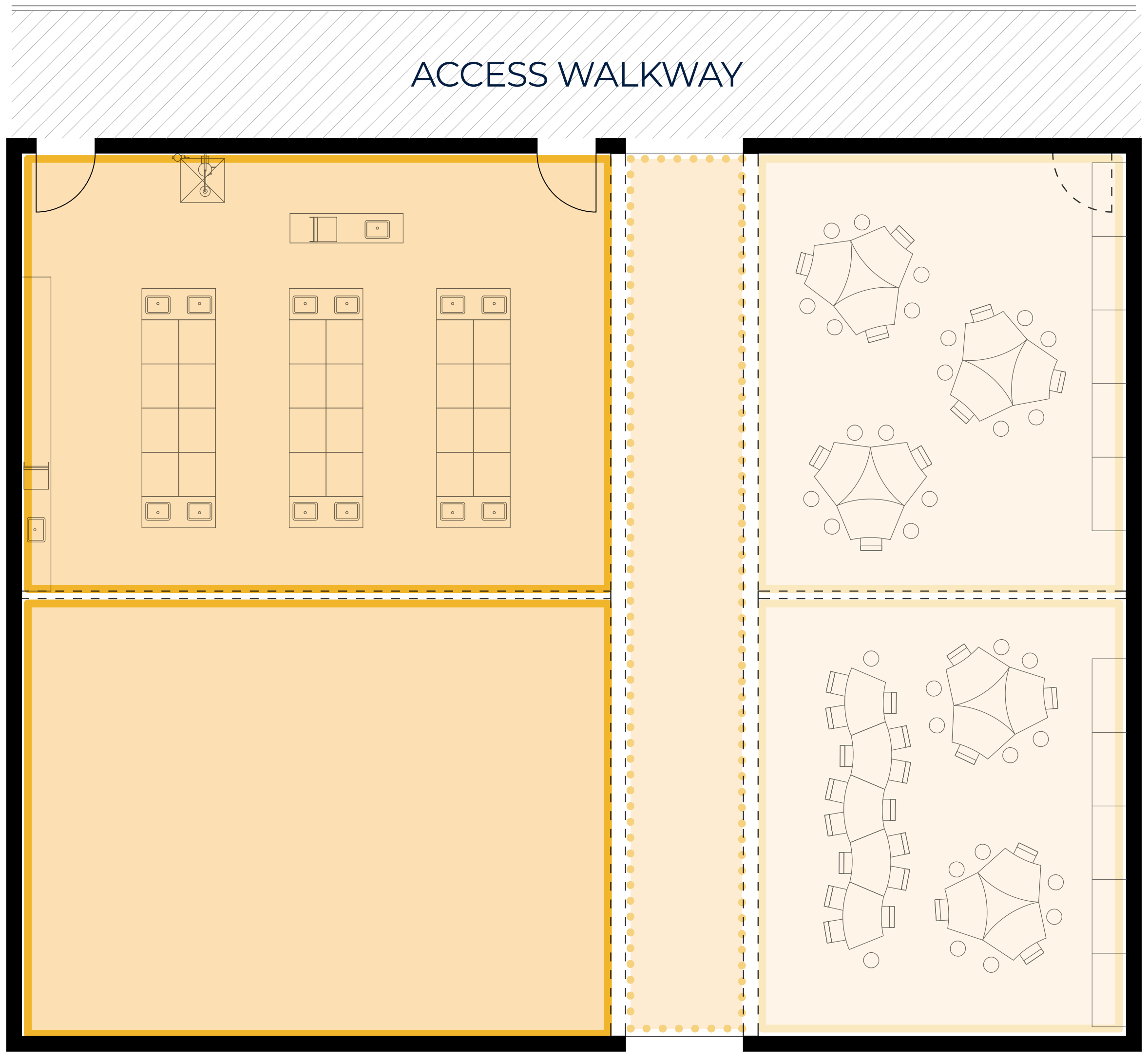
Treatment to exposed timber structure surfaces for internal use

Acoustic Seamless Perforated Plasterboard

Ceiling to meet acoustic requirements to learning spaces

Timber Batten Suspended Ceiling

Click-on Batten System with sound mesh backing to acoustic requirements



3.13 Internal Components

Floor Finishes

Home Base / General Learning Space Cluster

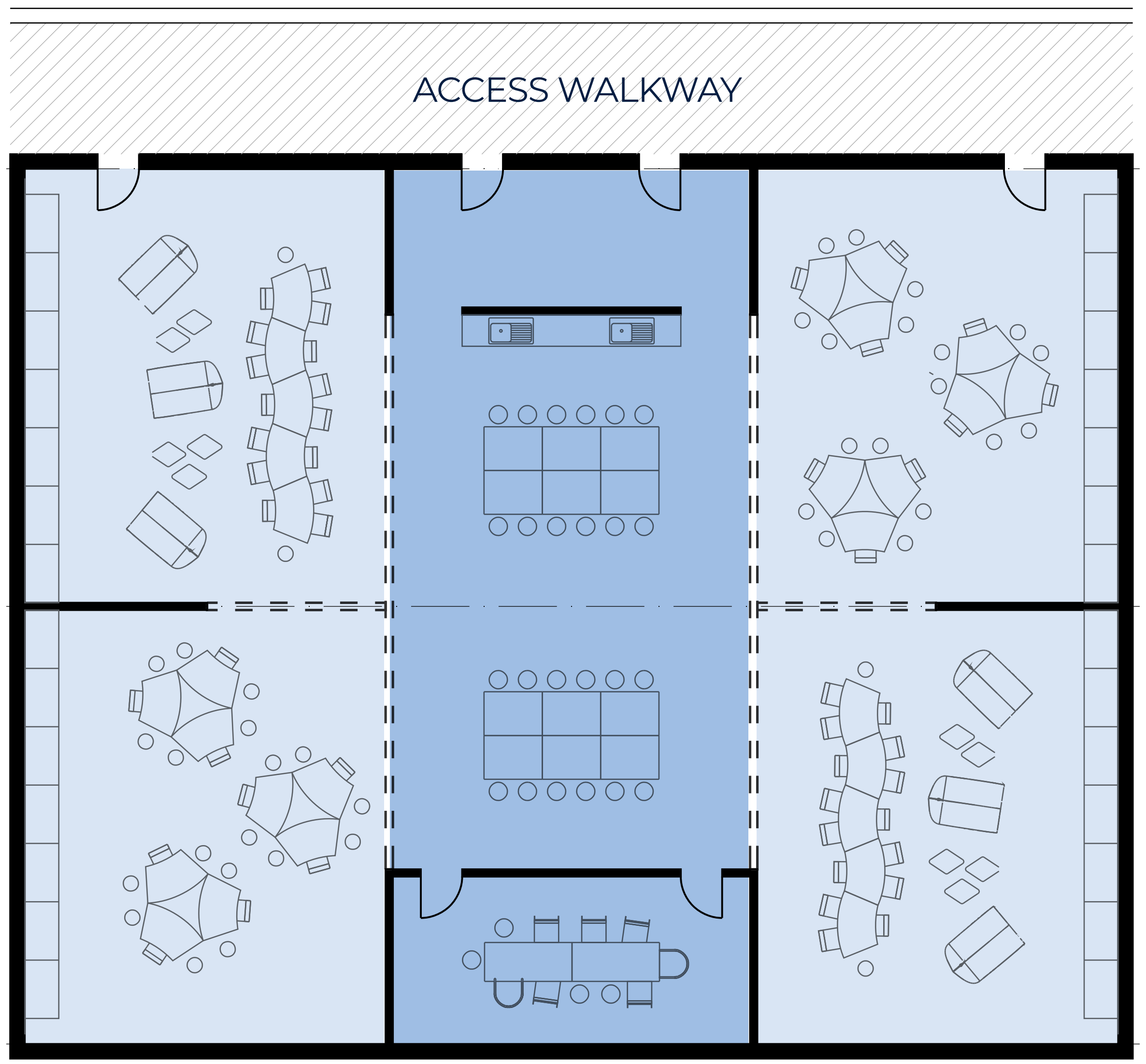
Carpet Tiles with Acoustic Underlay

System with Eco Backing underlay

Vinyl Sheet with Acoustic Underlay

Rapid drying levelling & smoothing compound applied to achieve a suitable smooth and level substrate

System with Eco Backing underlay



3.13 Internal Components

Floor Finishes

Science 2 GLS x 1 Lab Cluster

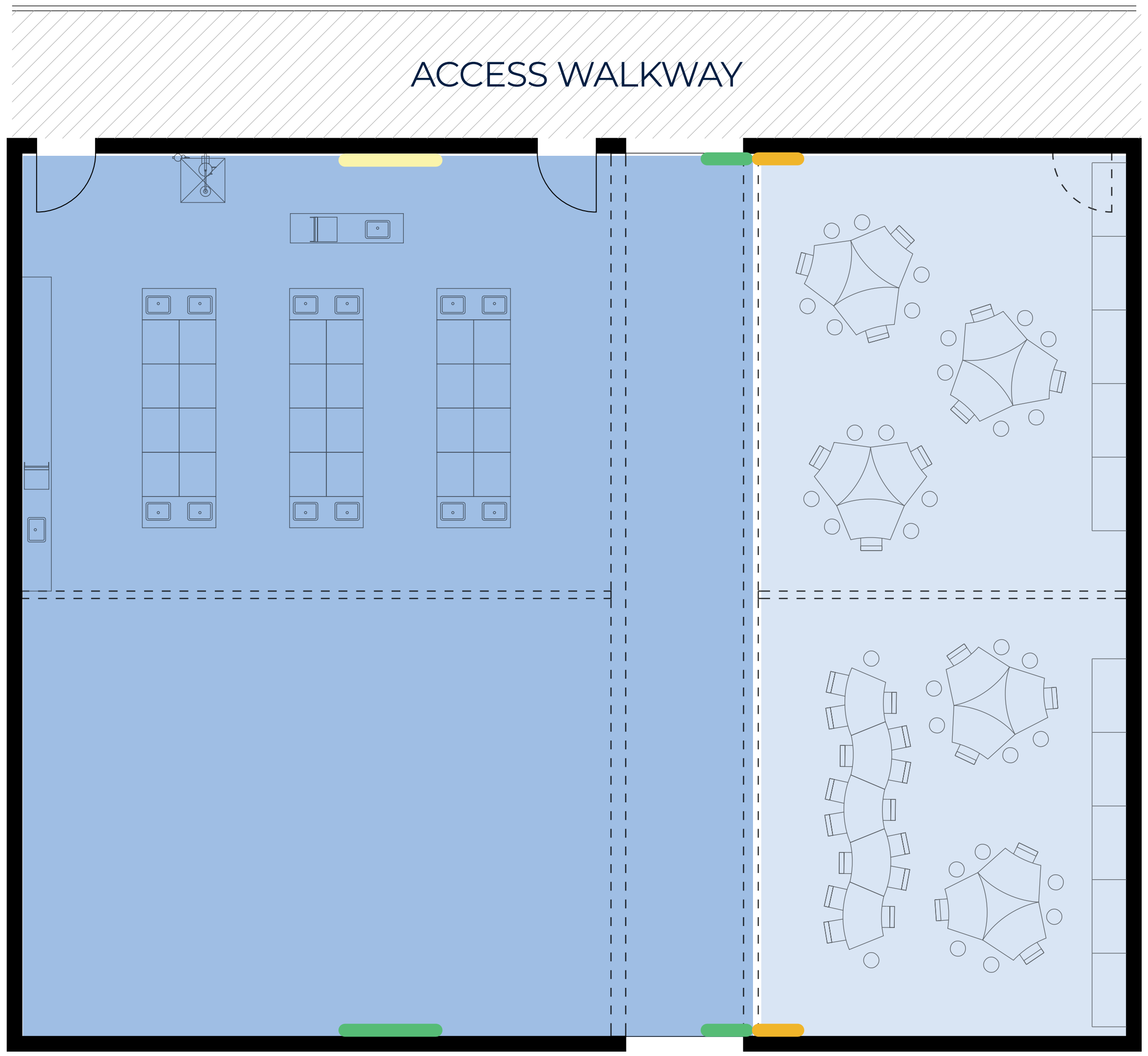
Carpet Tiles with Acoustic Underlay
System with Eco Backing underlay

Industrial Sheet Floor with Acoustic Underlay
IQ industrial sheet vinyl with welded joints

Acoustic Pinboard to Inner Face of External Walls or Insulated Partition Walls
Min 25mm thick to meet acoustic requirements

Sheet Vinyl to Wall Surfaces

Whiteboard - Magnetic Laminate
Formica magnetic glossy white; Typical 2.4m (w) x 1.2m (h); Start / end panels will vary in width.



3.13 Internal Components

Internal Walls & Doors

Home Base / General Learning Space Cluster

Insulated Internal Stud Wall with Acoustic Pinboard

Insulated Timber Stud wall to meet acoustic Rw45, with Min 25mm thick acoustic pinboard

Sliding Partition with Acoustic Pinboard

Solid slider with Min 25mm thick acoustic pinboard to meet acoustic requirements

Timber Framed Glass with Hinged Access Doors

System to meet acoustic Rw35 requirement.

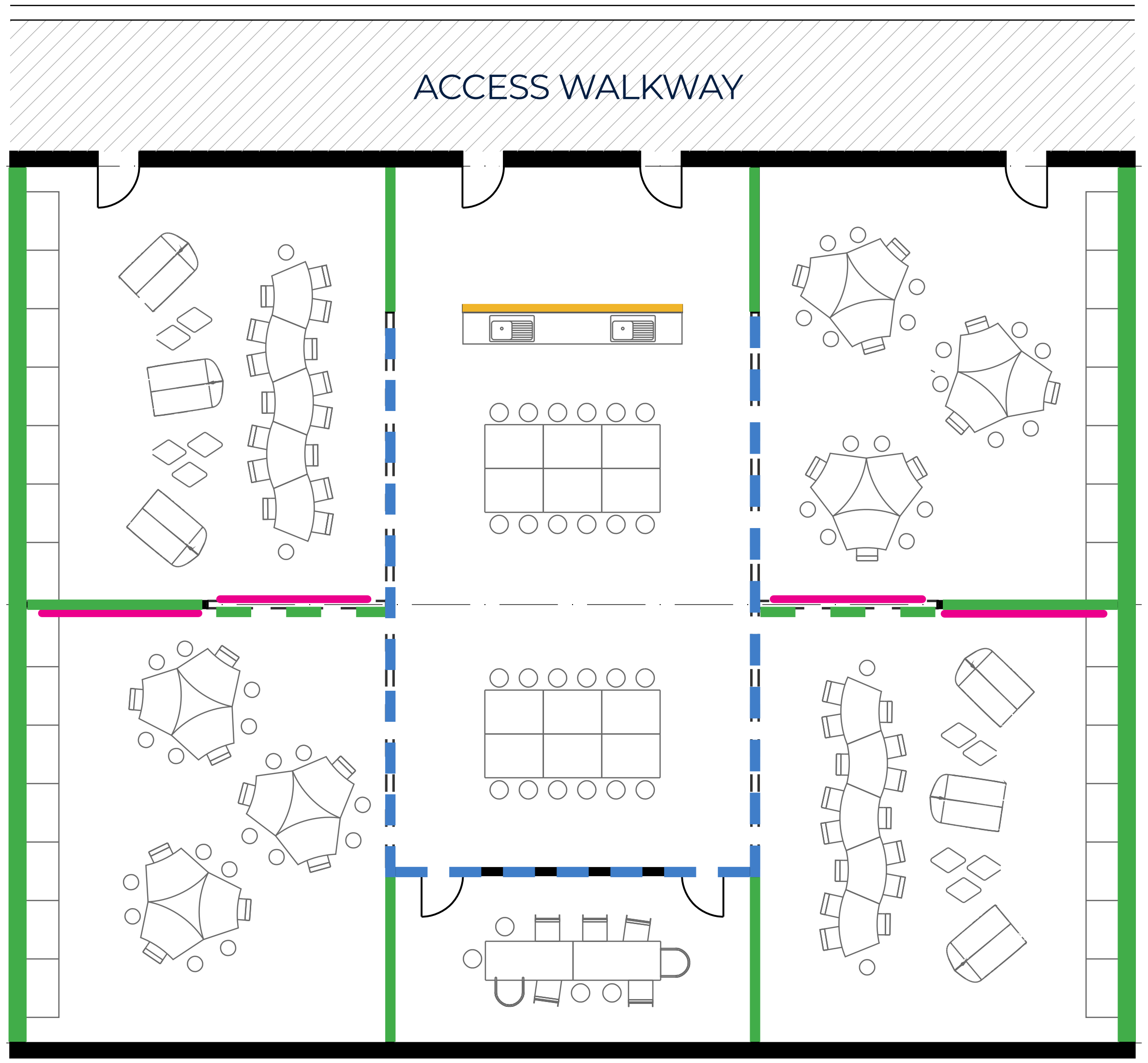
System to provide access to Home Base classrooms. Provide door frames including door stops, as an integral parts of the framing system.

Glazing up to 2.4m from FFL. Internal Stud Wall with acoustic lining above.

Internal Stud Wall with Sheet Vinyl

Whiteboard - Magnetic Laminate

Formica magnetic glossy white; Typical 2.4m (w) x 1.2m (h); Start / end panels will vary in width.



3.13 Internal Components

Internal Walls & Doors

Science 2 GLS x 1 Lab Cluster

Insulated Internal Stud Wall with Acoustic Pinboard

Insulated Timber Stud wall to meet acoustic Rw45, with Min 25mm thick acoustic pinboard

Sliding Partition with Acoustic Pinboard

Solid slider with Min 25mm thick acoustic pinboard to meet acoustic requirements

Timber Framed Glass with Hinged Access Doors

System to meet acoustic Rw35 requirement.

System to provide access to Home Base classrooms. Provide door frames including door stops, as an integral parts of the framing system.

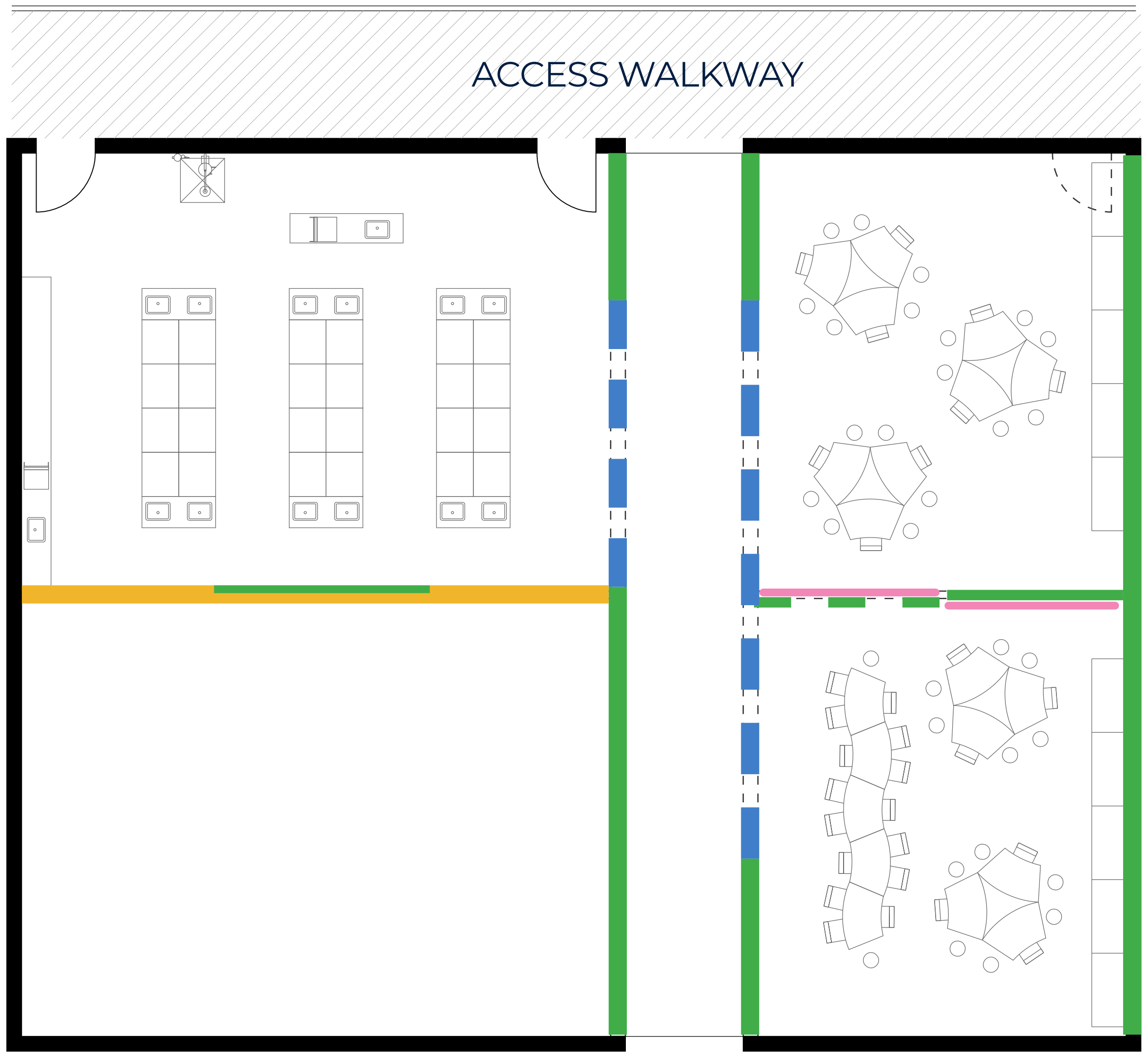
Glazing up to 2.4m from FFL. Internal Stud Wall with acoustic lining above.

Insulated Stud Wall with Sheet Vinyl

Insulated timber stud wall with sheet vinyl finish to meet acoustic Rw45 between rooms

Whiteboard - Magnetic Laminate

Formica magnetic glossy white; Typical 2.4m (w) x 1.2m (h); Start / end panels will vary in width.



3.14 Joinery

The DfMA Joinery Components have been designed and detailed with the following principles:

Modularity

- Modularity enables standardised assembly and disassembly
- Enables mass production by manufacturers
- Ease of replacement

Adaptability & Flexibility

- The system enables interchange of different types of joineries to suit the needs of different types of learning space.
- Allows for future change of pedagogy and teaching modes.

Maintenance

- Robust system with durable finishes and concealed fixings for day to day use
- Finishes to be selected according to local availabilities
- Ease of cleaning and maintenance

Activates learning spaces

- Joinery system is incorporated within learning spaces with convenient access
- Joinery units carry essential teaching facilities to enable a flexible teaching environment

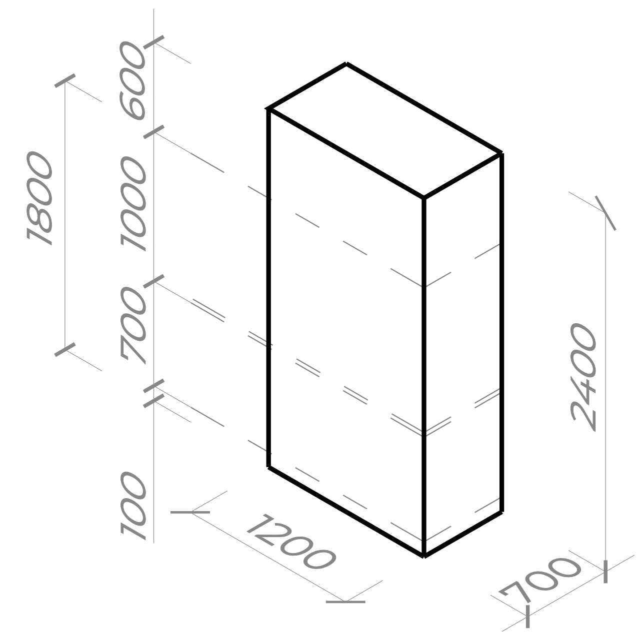
3.14 Joinery

Joinery System - 1.2m Module

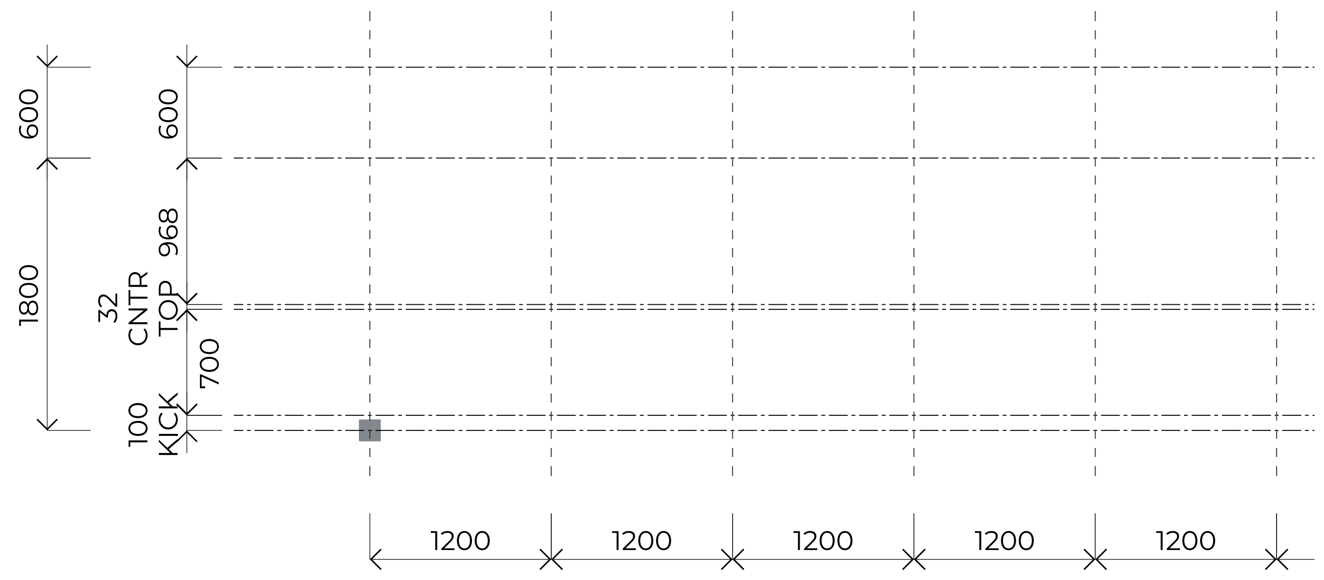
The joinery system uses a 1.2m module as the current standard used by manufacturers is typically 600mm. This ensures seamless integration of a new joinery system in future schools by adhering to current standards.

The maximum joinery storage height is 1.8m. A 600mm zone above is allocated for acoustic treatment, but can also provide additional storage space if required.

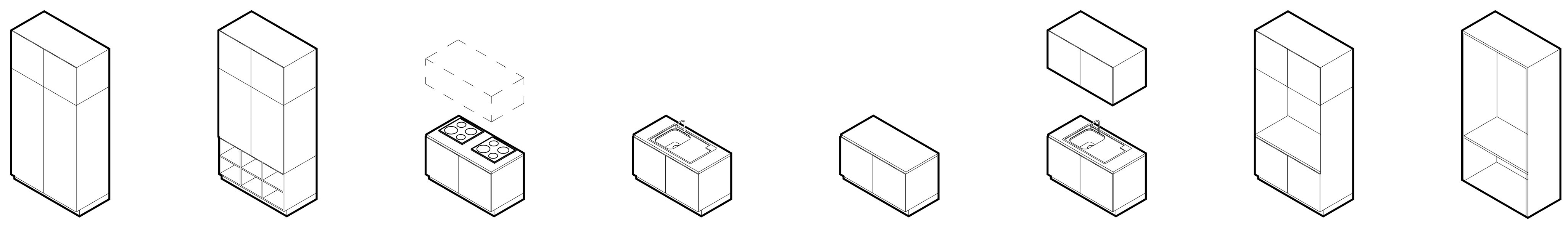
A 100mm kick board zone ensures joinery modules are protected.



Joinery Datum Axonometric



Joinery Datum Elevation

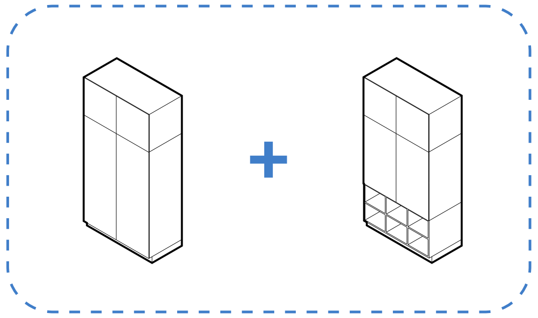


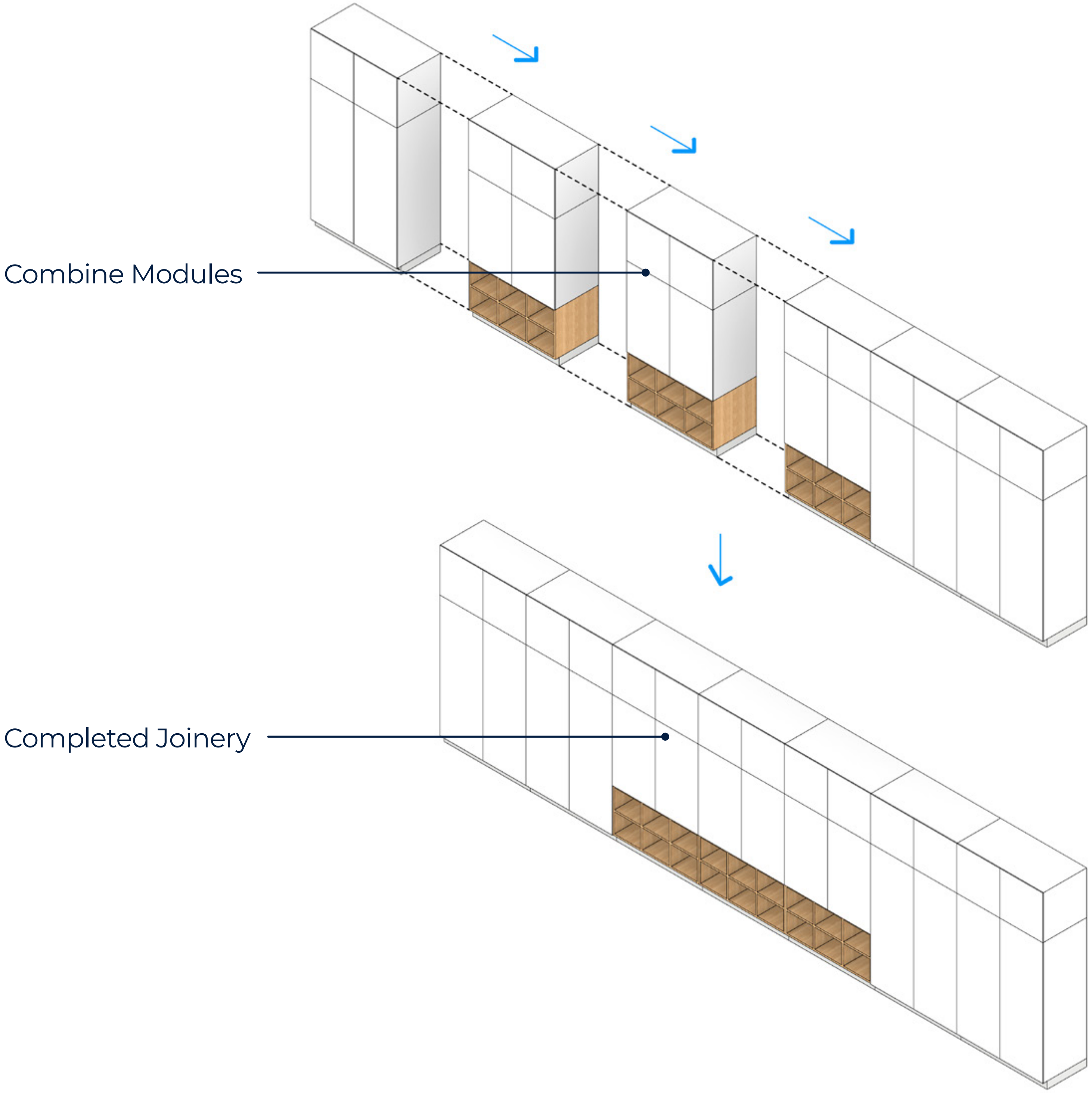
Joinery Modules

3.14 Joinery

Joinery Modules - Assembly

The joinery system enables multiple modules to be combined to suit the specific needs of each learning space.

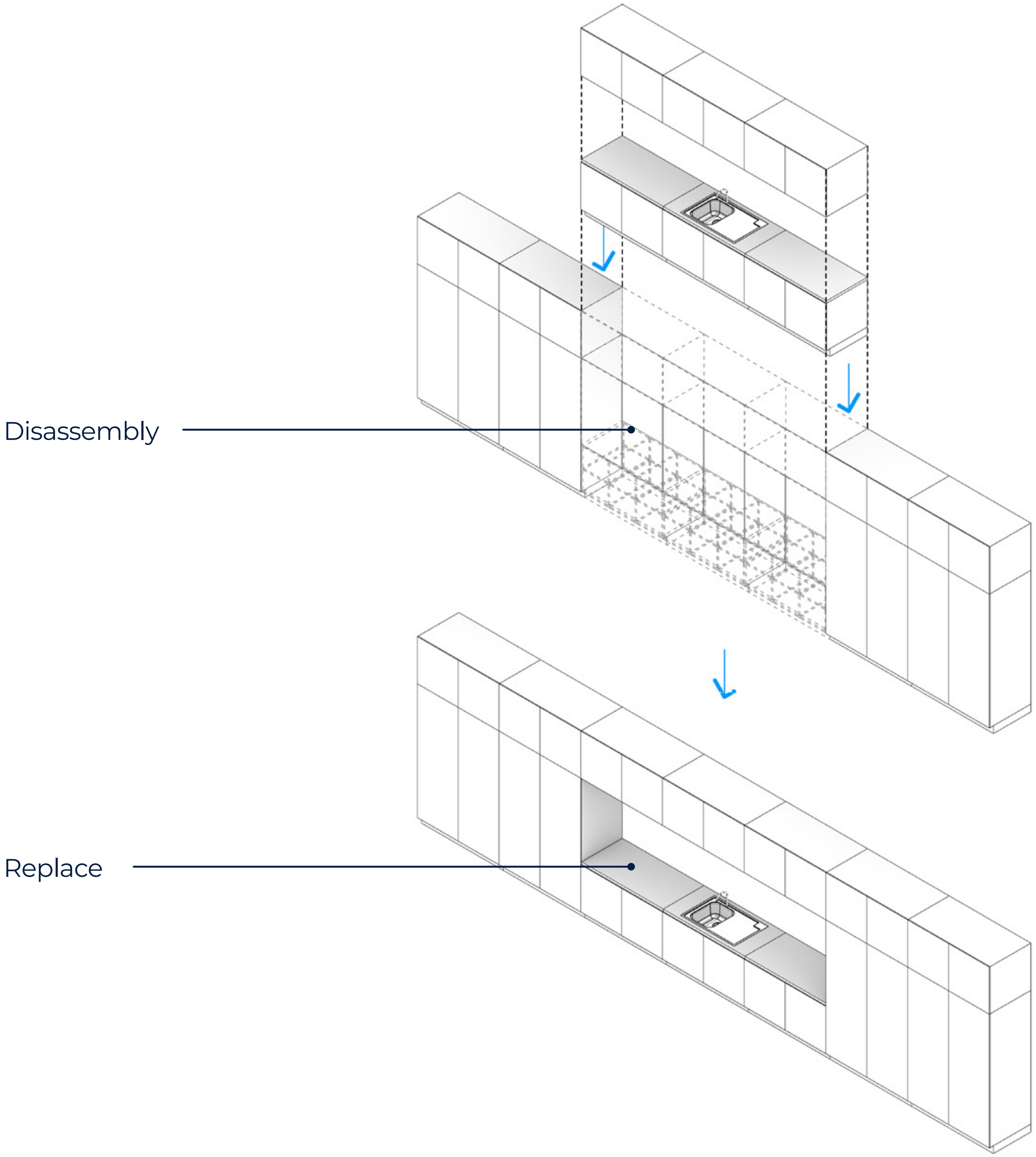


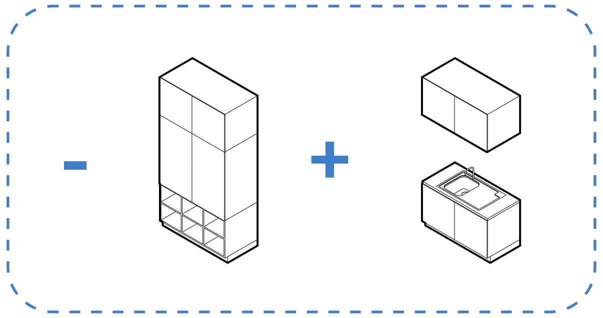


3.14 Joinery

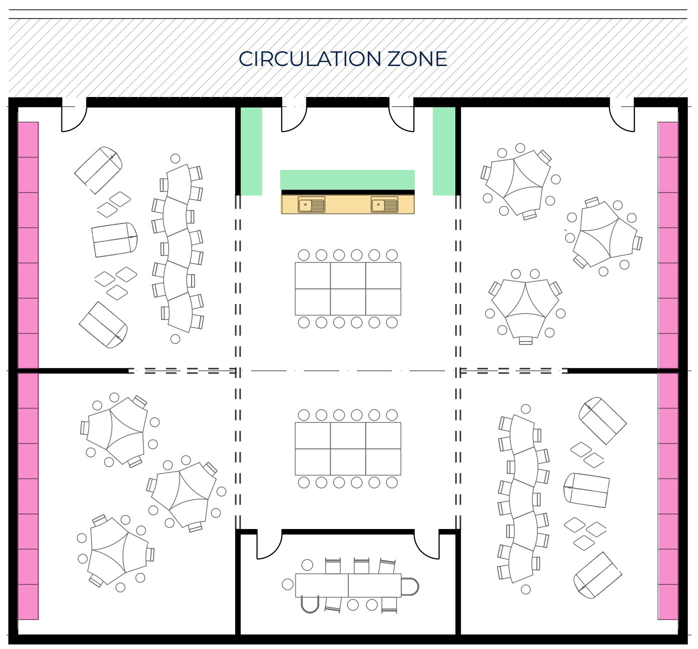
Joinery Modules - Disassembly & Replace

Adaptability and future flexibility of learning spaces is enabled by the ability to disassemble and replace joinery modules that suit the new learning space requirements.





Example Joinery - Homebase Hub



Homebase Hub of 4

PAA Sink Joinery

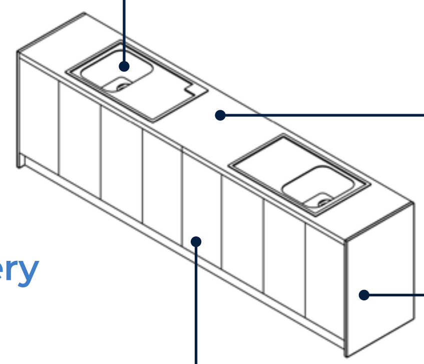
Sink joinery with storage below.

Teaching Wall Joinery

Teaching wall joinery with room for storage and AV.

Bag Hooks

PAA Sink Joinery

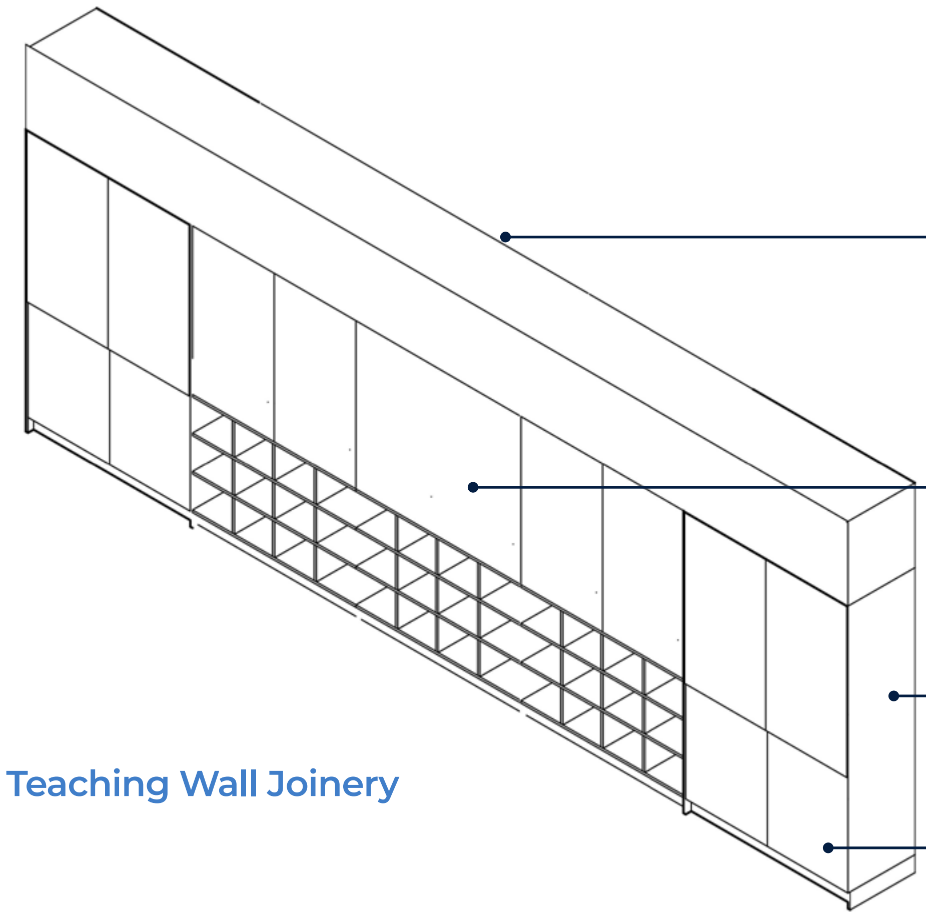


Sink: Stainless Steel trough

Benchtop & Splashback: Stainless Steel

Carcass: High moisture resistant MDF

Doors: High Pressure Laminate



Teaching Wall Joinery

Bulkhead: Acoustic panels on light weight studwork bulkhead

AV screen

Carcass: High moisture resistant MDF

Doors: High Pressure Laminate Whiteboard finish

Performance

4

4.1 Sustainability

DfMA embraces whole of life thinking in its approach to whole life carbon - adapting to a changing climate, driving a Zero Carbon objectives, and prioritising the health and wellbeing of students, teachers and staff for improved learning outcomes.

DfMA represents an opportunity to address and resolve whole life carbon by adapting to a changing climate, driving a Net Zero Carbon Buildings Commitment (see Figure 1), and prioritising the health and well-being of students, teachers and staff for improved learning outcomes.

Essential design elements: nature, people and design, are interrogated to offer different design approaches (see Figure 2):

1 Architecture considers design and people (informed by nature)

2 Passive design considers design and nature

3 Biophilic design considers the innate relationship between people and nature

Drawing on these principles, easy-to-use performance guidelines are presented that set simple rules and allow for innovation.

Whole Life Carbon

A net zero carbon building is : Highly energy efficient and fully powered from on-site and/or off-site renewable energy; with upfront carbon minimised to the greatest extend possible and all remaining embodied carbon offset. Near or net zero embodied and operational carbon should be pursued as part of a whole life cycle approach to carbon reduction.

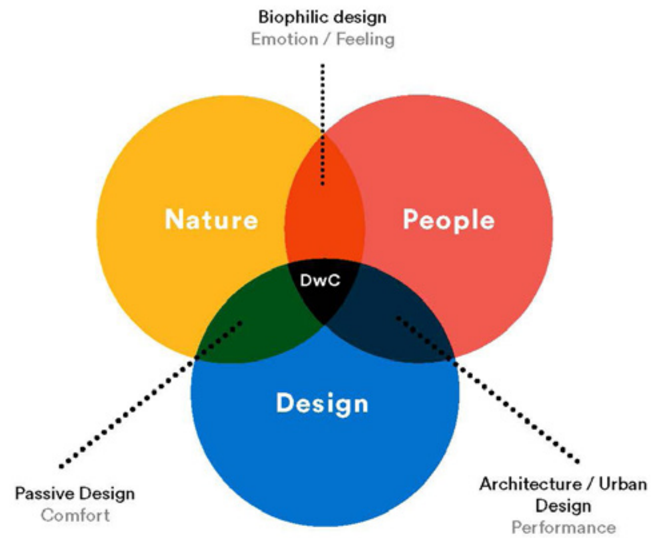
Health and Well being

It's critical that our learning environment is adaptable to a changing climate. A shift in mindset is needed. By changing the culture of how we perceive a comfortable indoor environment we can change the dialogue - comfort criteria instead of design criteria. Operational carbon reduction guidelines must be balanced with indoor environmental quality performance to deliver an equitable learning environment.

Current Standard and Guidelines

The Educational Facilities Standard and Guidelines (EFSG) Design Guide outlines the guiding principles for school design. It provides the minimum requirements of the technical components that make up an element of school design. This section acts to supplement and enhance these provisions.DG01 Whole of Life and DG02 Ecologically Sustainable Development set core recommendations and mandatory requirements. These are fundamental and inherent to the DfMA system and performance guidelines presented in Section 4.1.

Planning design guides (DG03-19) outline a range of design considerations that affect school planning. These are supplemented by the health + wellbeing and operational carbon performance guidelines presented in Section 4.1.Fabric design guides (DG20-27) and Openings design guides (DG31-39) outline the performance and specific design requirements of the structure and enclosure. These are supplemented by the upfront and operational carbon, and health + wellbeing performance guidelines presented in Section 4.1.Services design guides (DG51-65) outline the performance and specific services design requirements. These are supplemented by the operational carbon performance guidelines presented in Section 4.1.



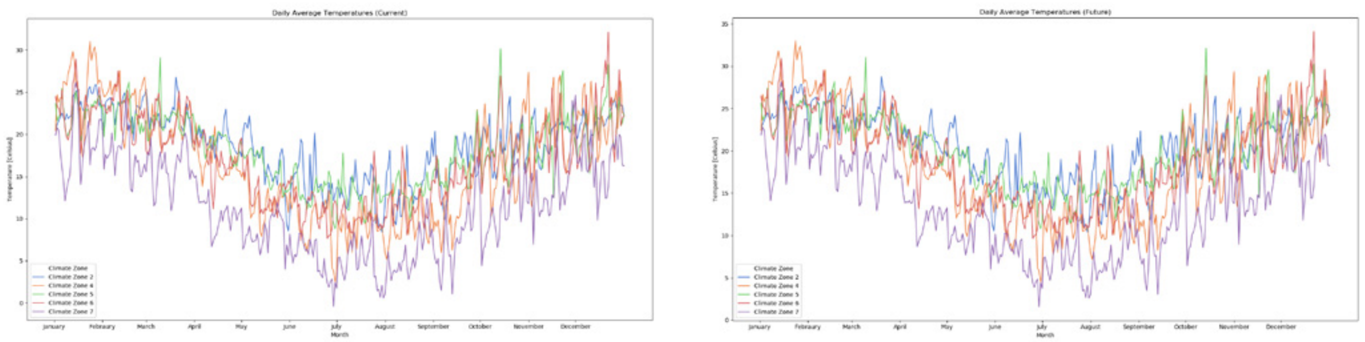
4.1 Sustainability

Climate Resilience

NSW has a varied climate. Locations, representing typical meteorological conditions were selected and analysed based on current and future (RCP 8.5 @2050) climate. This included:_ Climate Zone 2 - Coffs Harbour(warm humid summer, warm winter)_ Climate Zone 4 - Dubbo(hot dry summer, warm winter)_ Climate Zone 5 - Sydney(warm temperate)_ Climate Zone 6 - Richmond(mild temperate)_ Climate Zone 7 - Orange(cold temperate) Resiliency is fundamental to decision making. Government spending must take account of science-based climate modelling to ensure investment in social infrastructure is secure and assets can service the community long into the future. To affect sound decision making, RCP 8.5 climate modelling, in line with the NARCliM Project, has been adopted in the development of the DfMA system. The 2050 timeline horizon has been selected based on the design life of building services (15 year design life).

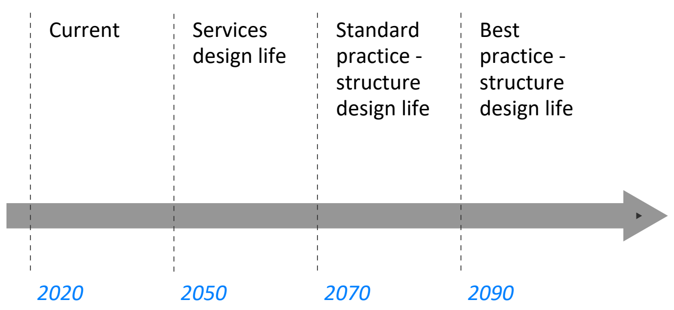
For the year 2050, NSW is expected to see a rise of 1.5-2.5 ºC in daily average dry bulb tempreture. This generally aligns with emissions scenario RCP 8.5 (Representative Concentration Pathway_ high emissions scenario). Generally, NSW will likely see an increase in hot days and fewer cold nights based on climate modelling.

Figure 5 illustrates an increase in hot days and fewer cold nights for Sydney based on future climate modelling.



Daily average dry bulb temperature for NSW applicable climate zones; [left] current climate; [right] future climate

Services and structures design life and alignment with future climate scenarios



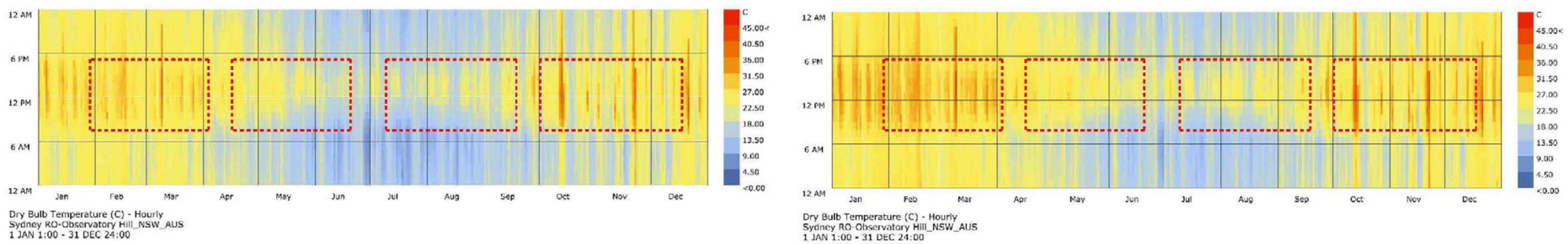
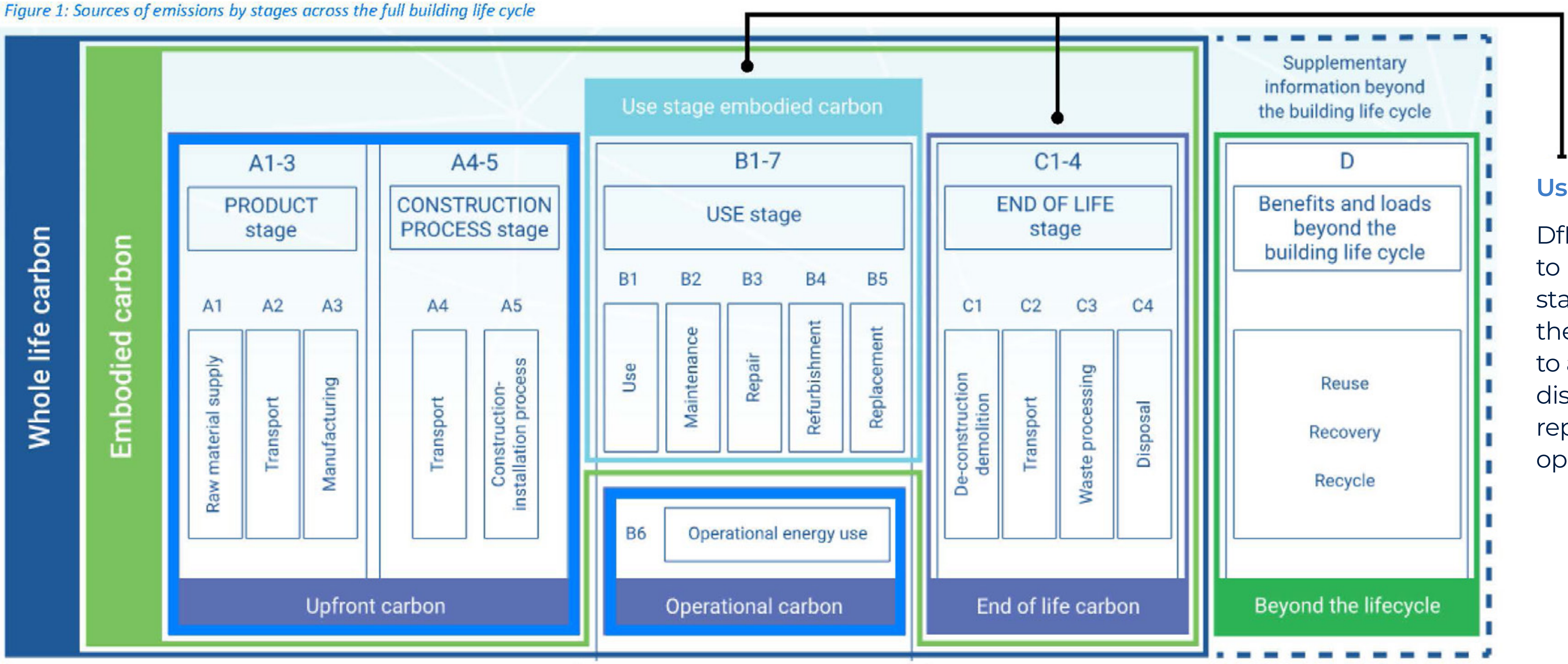


Figure 5: Visualisation of hourly dry bulb temperature for Sydney; [left] current climate; [right] future climate; red dashed line denotes academic calendar / annual occupied period

4.1 Sustainability

DfMA embraces whole of life thinking in its approach to whole life carbon - adapting to a changing climate, driving a Net Zero Carbon Buildings Commitment, and prioritising the health and well-being of students, teachers and staff for improved learning outcomes.

Figure 1: Sources of emissions by stages across the full building life cycle



Use Stage and End of Life

DfMA is wholly configured to respond to these life cycle stages. It seeks to transition the delivery of school facilities to a zero maintenance and disposal outcome. This represents a future focus opportunity for DfMA.

Upfront Carbon

DfMA superstructure configurations are evaluated to set embodied carbon reduction guidelines.

Health and Well-being

In coordination with operational carbon reduction guidelines, health and well-being guidelines are set to facilitate the delivery of a high quality and equitable learning environment.

Operational Carbon

Passive and active design initiatives are tested and evaluated to set operational carbon reduction guidelines. Core principles of building electrification are adopted.

4.1 Sustainability

Upfront Carbon Performance

DfMA presents real opportunities for upfront carbon reduction outcomes through a key focus on the superstructure design and performance specification (see Section 4.3 Structure).

DfMA superstructure configurations - mass timber and hybrid options - are evaluated to set embodied carbon reduction guidelines.

Health + Well-being Performance

Comfort criteria instead of design criteria. This key focus facilitates performance guidelines pertaining to daylight access, visual comfort, thermal comfort and connection to outdoors.

Indoor environment quality (IEQ) performance is measured based on adapted Green Star-derived metrics.

1 Daylight access - daylight autonomy (DA) - percentage of floor area at a working plane height that meets a target illuminance (160 lux) for at least 80% of the occupied hours

Visual comfort - annual sunlight exposure (ASE) - percentage of floor area at a working plane height that receives at maximum 2,000 lux for maximum 10% of occupied hours per year **3 Thermal comfort** - predicted mean vote (PMV) - percentage of floor area where 98% of occupied hours are deemed comfortable by not less than 80% of the occupants

4 Views - percentage of floor area that has a clear line of sight to a high quality internal or external view

Operational Carbon Performance

Passive Design

Passive design represents the most cost effective mechanism to realising operational carbon reductions.
Key passive design measures have been analysed and evaluated through the application of advanced parametric design techniques, e.g. facade optimisation analysis, and sophisticated computational design analysis.

access, visual comfort and thermal comfort performance; optimised for an enhanced IEQ performance.

1 Orientation - sensitivity of built form orientation with respect to the corridor and non-corridor facing elevations. This is evaluated on the basis of operational carbon reductions, and daylight access, visual comfort and thermal comfort performance; optimised for an enhanced IEQ performance.

2 Air permeability - sensitivity of achieving the air permeability rate in accordance with verification method JV4 Building envelope sealing of NCC 2019-Section J. This seeks to drive operational carbon reductions and an enhanced thermal comfort performance and improve air quality.

3 Glazing system performance - sensitivity of solar heat gain coefficient (SHGC) and visible light transmittance (VLT) with respect to operational carbon reductions; optimised for daylight access and visual comfort performance

4 Natural ventilation - minimum deemed to satisfy (DTS) provisions are prescribed in accordance with F4.6 Natural ventilation and F4.7 Ventilation borrowed from adjoining room of NCC 2019-Part F4

Overall performance is measured in accordance with Green Star protocols, i.e. Intermediate Building improvement when compared to the NCC 2019-Section J Reference Building.

Active Design

Active design responds to the those systems that are required to maintain comfort criteria beyond the limitations of the passive design initiatives.

1 Prescriptive measures - percentage improvement targets over NCC 2019-Section J DTS provisions nominated for mechanical, electrical and hydraulic services equipment (e.g. fan/pump motor input power, minimum energy efficiency ratio, lighting power density, etc.)

2 Economy cycle and energy reclaim - consideration of enhancement options to conventional fan coil unit system, including economy cycle operation or energy reclaim technology

Overall performance is measured in accordance with Green Star protocols,

Performance Guidelines

Performance guidelines are validated and defined in Section 4.1 across the key theme of:

- Upfront Carbon
- Health and Wellbeing
- Operational Carbon, incl. passive and active design measures

4.1 Sustainability

WWR - window to wall ratio

sDA - spacial daylight autonomy

ASE - annual solar exposure

SR - shading ratio

PMV -predicted mean vote - thermal comfort

GLA - general learning area

SLS - shared learning spaces

Uv - U value - thermal transmittance, glazed areas

SHGC - solar heat gain coefficient - solar admittance

Rv - thermal transmittance, solid element

VLT - visual light transmittance - glazing transparency

SRI - surface reflectance index

ACH - air changes hour

GBCA - Green Building Council of Australia

GS - Green Star

ME - minimum expectation

CA - credit achievement

EP - exceptional performance

4.1 Sustainability

The DfMA solution has been tested and validated on a whole life carbon basis. Upfront carbon, health + wellbeing and operational carbon performance guidelines are outlined.

Upfront Carbon

As buildings become more energy efficiency, driven by ever tightening energy efficiency regulations, embodied carbon is emerging as the most intensive emissions source in a building's life cycle. The DfMA system has sought to address this trend by tackling upfront carbon emissions (life cycle stages A1 - A5) in the specification of its superstructure. Considered decision making for this key component of the DfMA system has the highest potential to reduce upfront carbon emissions and overall life cycle emissions.

_ Analysis

High-level embodied carbon (EC) emissions and their reduction performance against a conservative baseline have been determined for the range of superstructure options presented.

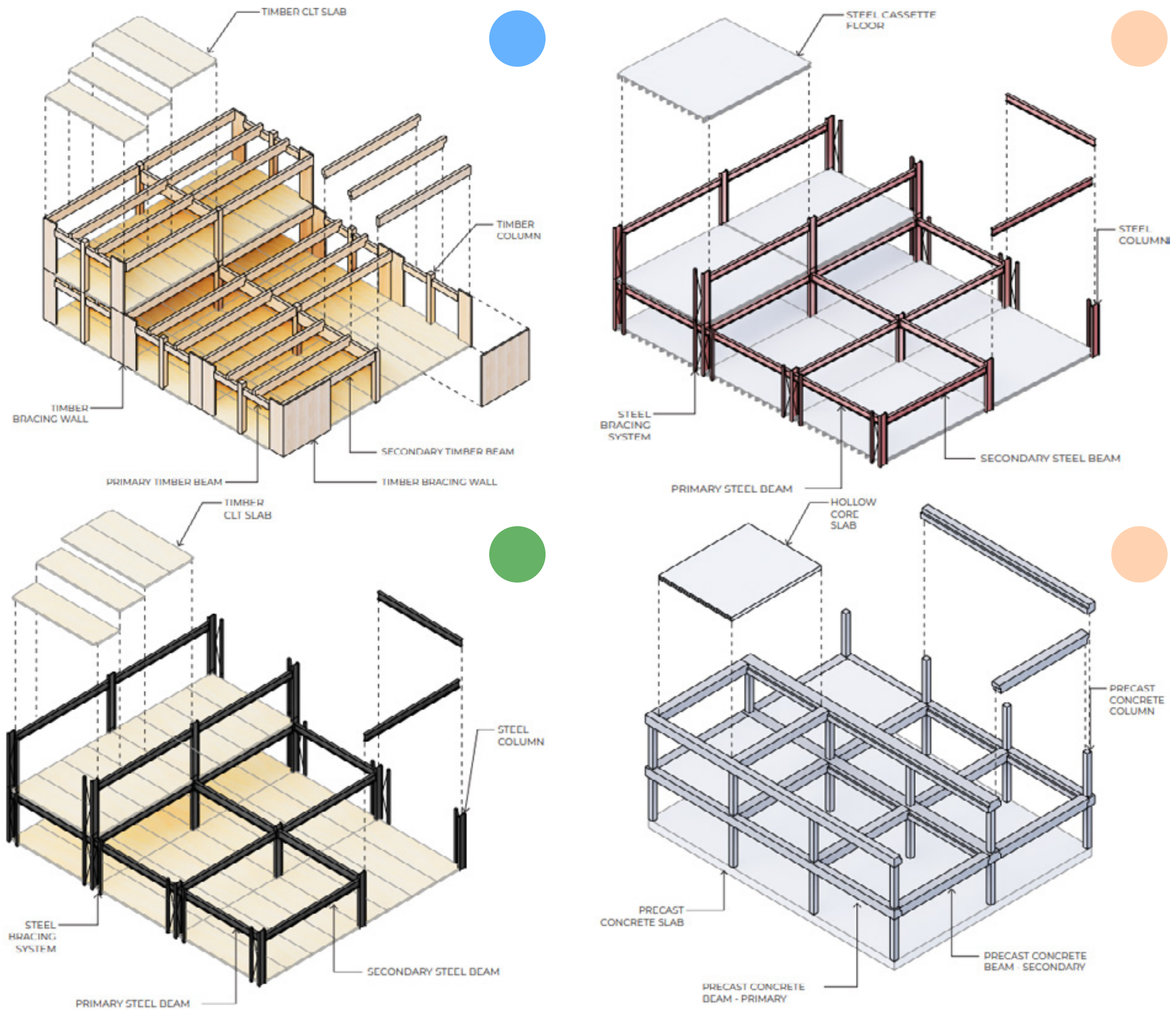
_ Benchmarking

For the purposes of benchmarking upfront carbon emissions reduction performance, the Green Star Buildings tool is referenced. It identifies the following upfront carbon reduction performance requirements:

_ Minimum Expectation (ME) - 10% *[generally equivalent to a hybrid steel frame + CLT floor option]*

_ Credit Achievement (CA) - 20% *[a mass timber option generally achieves a 50% upfront carbon reduction]*

_ Exceptional Performance (EP) - 20% with residual A1 - A5 emissions offset



DfMA superstructure options; [top left] mass timber; [top right] steel; [bottom left] hybrid steel frame + CLT floor; [bottom right] precast concrete; performance is denoted by visual indicator, as per the legend

- > 20% upfront carbon emissions reduction
- > 10% upfront carbon emissions reduction
- < 10% upfront carbon emissions reduction

_ Performance Guidelines

_ Minimum Expectation (ME) - > 10% upfront carbon emissions reduction

_ Target Performance (TP) - > 20% upfront carbon emission reduction

4.1 Sustainability

Health + Wellbeing

The balance in health + wellbeing and operational carbon performance must be carefully considered. Operational carbon reductions must be achieved without compromising the learning environment.

Health + wellbeing performance guidelines are first established before operational carbon reduction measures are evaluated and performance guidelines defined.

_ Benchmarking

The first step in validating the performance of the DfMA learning environment (Homebase / General Learning Space Hub) is comparing its performance across key indoor environment quality (IEQ) metrics to that of a conventional primary and high school planning grid; in this case Googong Primary School and Cumberland High School.

This comparative analysis and the specific performance of the DfMA learning environment is benchmarked against the Green Star - Design and As Built (D&AB) v1.3 and Green Star Buildings tools, where relevant. These industry recognised tools are applied as they represent a 'common language' for health + wellbeing or indoor environment quality (IEQ) performance.

The figures presented over the page reflect the performance results for Climate Zone 5. These are for illustration. As indicated in Section 1.12, all NSW relevant climate zones have been evaluated to establish a comprehensive evidence base that informs the performance guidelines outlined.

_ Performance Results

Daylight access

The DfMA system delivers a good quality daylight performance. A more consistent performance is achieved to that of the conventional case.

Visual comfort

Due to a good quality daylight performance, the DfMA system is nominally more prone to glare. However, a N-S (Corridor N) orientation delivers effective glare control. Walkway Options presented in Section 3.11 offer glare mitigation. Generally, the conventional case performs better with respect to glare but this can be considered as an outcome of a lower quality daylight performance than that of the DfMA system.

Thermal comfort

The DfMA system delivers a high quality thermal comfort performance.

Views

The DfMA system delivers high quality views, enhancing connection to outdoors in line with biophilic design.

_ Performance Guidelines

Daylight access

_ Minimum Expectation (ME) - > 40% of floor area with daylight access

Visual comfort

_ Target Performance (TP) - < 20% of floor area exposed to glare

Thermal comfort

_ Minimum Expectation (ME) - PMV ± 1.0 for ≥ 98% of the occupied period

Views

_ Minimum Expectation (ME) - > 60% of floor area has clear line of sight

_ Target Performance (TP) - > 80% of floor area has clear line of sight

4.1 Sustainability

Daylight access

- > 60% of floor area with daylight access *
- > 40% of floor area with daylight access **
- < 40% of floor area with daylight access

Visual comfort

- < 10% of floor area exposed to glare
- < 20% of floor area exposed to glare ***
- > 20% of floor area exposed to glare

* Equivalent to 2 points under Green Star D&AB
** Equivalent to 1 point under Green Star D&AB or Credit Achievement under Green Star Buildings
*** Minimum Requirement or Minimum Expectation under Green Star D&AB and Green Star Buildings, respectively

Thermal comfort

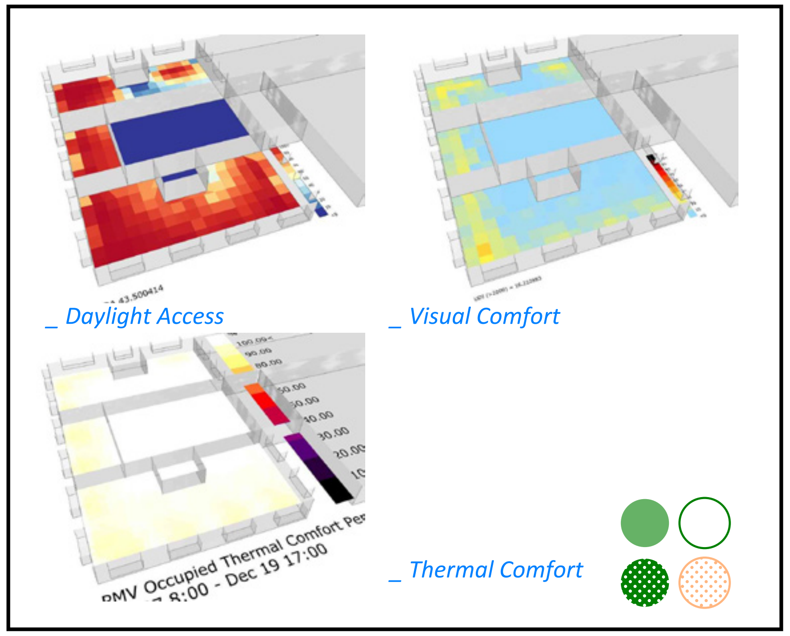
- PMV ± 0.5 for 98% of the occupied period ^
- PMV ± 1.0 for 98% of the occupied period ^^
- PMV ± 1.0 for > 95% of the occupied period

Views

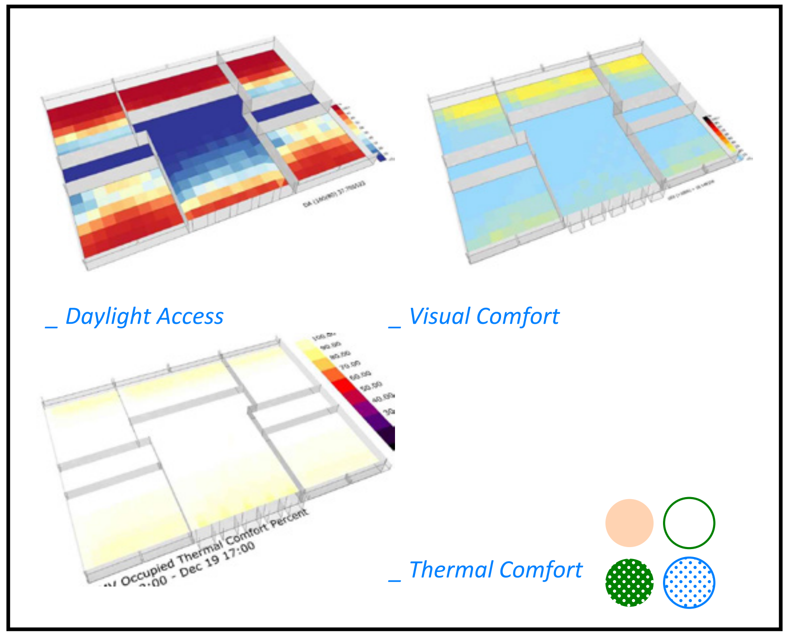
- > 80% of floor area has clear line of sight
- > 60% of floor area has clear line of sight ^^^
- < 60% of floor area has clear line of sight

^ Equivalent to 2 points under Green Star D&AB
^^ Equivalent to 1 point under Green Star D&AB or Minimum Expectations under Green Star Buildings; conforms to the EFSG
^^^ Minimum Requirement or Minimum Expectation under Green Star D&AB and Green Star Buildings, respectively

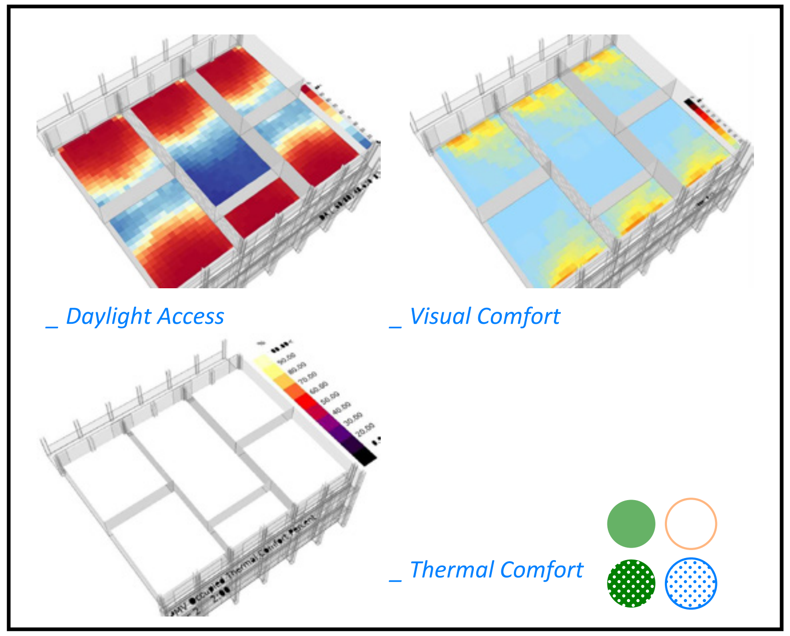
Googong E-W



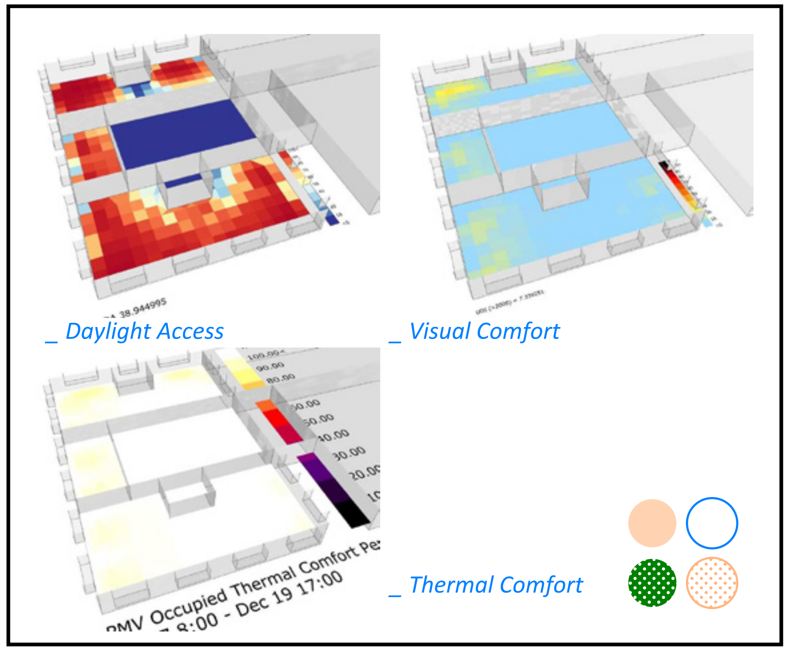
Cumberland E-W



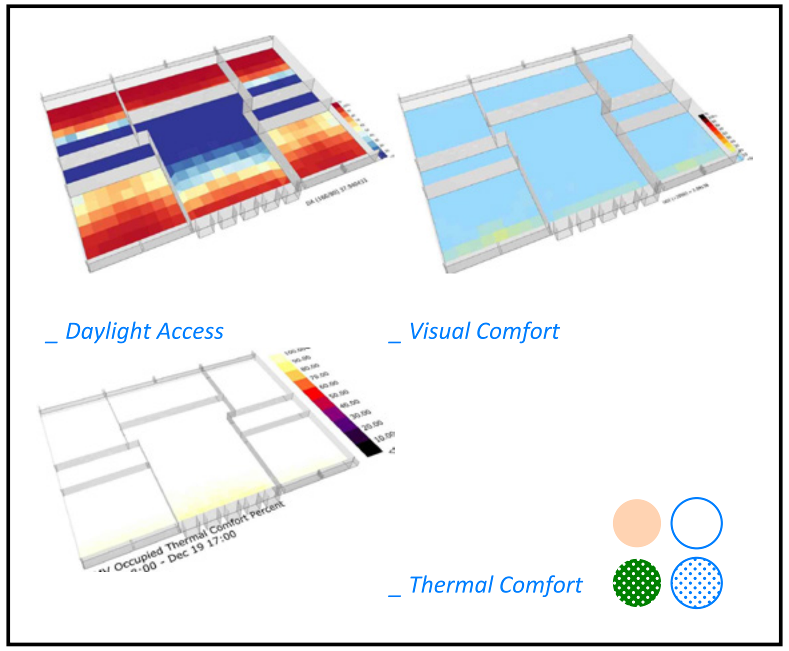
DfMA E-W (Corridor W)



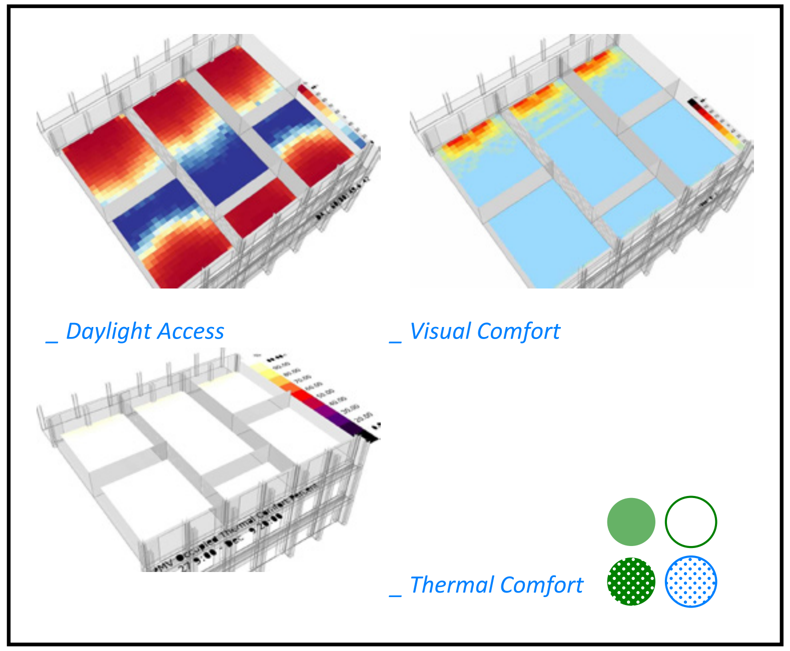
Googong N-S



Cumberland N-S



DfMA N-S (Corridor N)

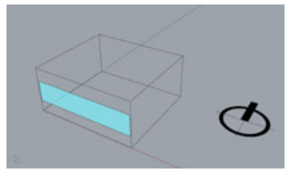
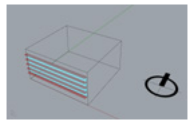
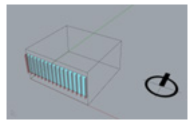


4.1 Sustainability

Health + Wellbeing

_ Alternative Scheme Design

Where an alternative scheme design is being considered, performance guidelines have been developed to effectively support this approach. These performance guidelines have been developed on the basis of the variables outlined below and account for over 5,000 unique simulations as part of the facade optimisation analysis conducted.

4 x Orientation - north | south | east | west

4 x Window to wall ratios (WWR) - 40% | 45% | 50% | 55%

2 x Shading types - horizontal | vertical

7 x Shading ratios (SR) - 0% | 10% | 20% | 30% | 40% | 50% | 60%

3 x Glazing system performance
- GL1 - U2.8 + SHGC 0.3 + VLT 60%
- GL2 - U2.8 + SHGC 0.25 + VLT 50%
- GL3 - U2.8 + SHGC 0.23 + VLT 50%

2 x Climate scenarios
- current climate
- future climate (RCP 8.5 @2050)

5 x Climate zones - CZ 2, 4, 5, 6 and 7

_ Performance Results

Daylight

_ West and north achieve a good daylight performance (40% < DA < 60%)
_ South and east under perform for daylight (DA < 40%)

Visual Comfort (Glare)

_South and east achieve very good visual comfort (ASE < 10%)
_ North achieves a reasonable visual comfort performance (10% < ASE < 20%)
_ West under performs for visual comfort (ASE > 20%)

Climate Zone	Window Orientation	Shading Type	WWR		SR		Daylight	Visual Comfort
			Minimum	Maximum	Minimum	Maximum		
2	South	Horizontal	45	55	40	60	Under	Very Good
		Vertical	45	55	40	60	Under	Very Good
	West	Horizontal	50	60	30	60	Good	Under
	North	Horizontal	50	60	20	50	Good	Reasonable
		Vertical	50	60	40	50	Good	Reasonable
	East	Horizontal	50	60	40	60	Under	Very Good
4	South	Horizontal	55	60	20	40	Under	Very Good
		Vertical	55	60	20	40	Under	Very Good
	West	Horizontal	50	60	20	50	Good	Under
		Vertical	50	60	30	50	Good	Under
	North	Vertical	45	60	20	60	Good	Reasonable
	East	Horizontal	50	55	20	60	Under	Very Good
		Vertical	50	60	20	60	Under	Very Good
5	South	Horizontal	45	55	40	60	Under	Very Good
		Vertical	45	55	30	60	Under	Very Good
	West	Horizontal	50	60	30	60	Good	Under
	North	Horizontal	45	60	30	50	Good	Reasonable
	East	Vertical	45	55	20	60	Under	Very Good
6	South	Horizontal	45	60	50	60	Under	Very Good
		Vertical	45	60	40	60	Under	Very Good
	West	Horizontal	50	60	40	60	Good	Under
		Vertical	50	55	40	60	Good	Under
	North	Horizontal	45	60	30	50	Good	Reasonable
		Vertical	45	60	40	60	Good	Reasonable
	East	Horizontal	45	50	40	60	Under	Very Good
		Vertical	45	55	30	60	Under	Very Good
7	South	Vertical	50	60	40	60	Under	Very Good
	West	Vertical	55	60	0	20	Good	Under
	North	Vertical	45	60	30	60	Good	Reasonable
	East	Horizontal	55	60	20	60	Under	Very Good
		Vertical	50	60	20	60	Under	Very Good

Figure 2: Facade optimisation summary results

_ Performance Guidelines

_ South and east
- target max. WWR; target min. SR

_ North and west
- target min. WWR; target max. SR

_ Climate Zone (CZ) 2 | west and east
- apply horizontal shading only

_ CZ 4 | north
- apply vertical shading only

_ CZ 5
- north and west - apply horizontal shading
- south and east - apply vertical shading

_ CZ 6 | south and east
- apply vertical shading

_ CZ 7 | north, south and west
- apply vertical shading

_ Glazing system application
- CZ 5 - east - GL2 or GL3 only
- CZ 6 - North - GL1 recommended
- CZ 6 - East - GL2 or GL3 only
- CZ 7 - West - GL1 recommended
- CZ 7 - East - GL1 only
- All other - GL1

These performance guidelines are targeted for non-corridor facing elevations. For corridor facing elevations, target max. WWR.

4.1 Sustainability

Operational Carbon

_ Strategy

A fundamental principle of School Infrastructure NSW is to align its facilities with Zero Carbon objectives. The application of the DfMA system is seen as a key intervention to achieving this objective. This drives the following operational carbon strategy for the DfMA system:

1 _ Highly energy efficient, considering effective passive and active design measures

2 _ Building electrification, whereby all regulated energy uses (heating, cooling, ventilation, hot water, lighting, equipment, vertical transportation and plug loads) utilise an electrical energy source

3 _ Solar ready for integration of on-site renewable energy technology, primarily solar photovoltaic (PV) and energy storage technologies

This operational carbon strategy puts in place a Zero Carbon Ready DfMA system, whereby off-site renewable energy can be supplied to achieve Zero Carbon in operation.

_ Benchmarking

The operational carbon performance of the DfMA system is benchmarked against the Green Star D&AB and Green Star Buildings tools, where relevant. These industry recognised tools are applied as they represent a 'common language' for operational carbon (or energy use) performance and energy source.

Green Star applies Section J as the comparative baseline in order to set reduction targets. Section J recognises Green Star protocols as a compliance path under an approved verification method.

_ Reference Building

The following provisions set the Reference Building built form, building envelope and building services performance parameters in order to establish the comparison benchmark needed to inform the effectiveness of the passive and active design measures considered.

<u>Built form</u>

_ Orientation - corridor to N

<u>Building envelope</u>

_ Window to wall ratio (percentage glazed area determined by dividing the building's total glazed area by its exterior envelope wall area)
- 40%

_ Shading ratio (the total shading element depth - vertical and/or horizontal; single or louvred element - as a proportion of window height for the full extent of window width; defined as a percentage)
- corridor (60%) | non-corridor (25%)

_ Glazing system performance
- Double glazing unit | thermally broken frame | SHGC 0.3 | VLT 0.6

_ Wall system performance
- R1.25

_ All other components to meet the DTS provisions, as per the relevant Parts of Section J

<u>Building services</u>

_ All components to meet the DTS provisions, as per the relevant Parts of Section J

_ Passive Design Measures

_ Orientation
- corridor to W | corridor to S

_ Improved air permeability rate
- 0.25 ACH (approx. 5 m3/hr/m2 and 50 Pa); achieved in accordance with Verification Method JV4 Building envelope sealing

_ Glazing system performance
- Double glazing unit | non-thermally broken frame | SHGC 0.4

_ Active Design Measures

_ Prescriptive measures must include -

1 _ Energy efficiency ratio (EER) must be 15% higher than the nominated DTS provisions or Minimum Energy Performance Standards (MEPS), as applicable

2 _ Fan and pump motor input power per unit of flow rate must be 15% less than the nominated DTS provisions

3 _ Lighting power density must be not more than 90% of the nominated DTS provisions

_ Consider application of economy cycle operation or energy reclaim technology

4.1 Sustainability

Operational Carbon

_ Performance Results

Passive design measures

1 _ Orientation - orienting the corridor to W delivers an improved energy use performance; orienting the corridor to S results in increased energy use

2 _ Non-thermally broken frame - the Reference Building glazing system performance is optimal

3 _ Air Permeability Rate - achieving an improved air permeability rate delivers a significant improvement in energy use

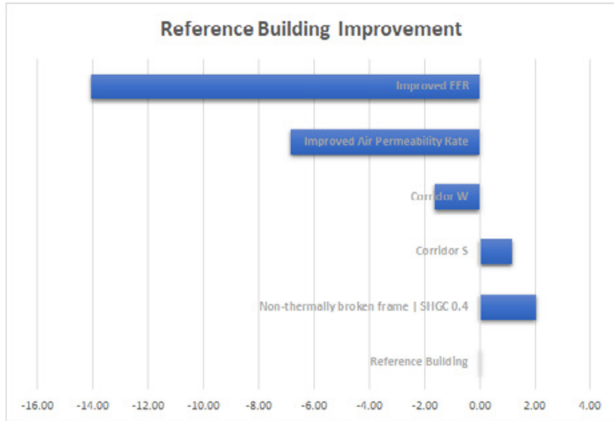
Active design measures

1 _ Improved EER - this measure achieves the most significant improvement in energy use

2 _ Economy cycle operation or energy reclaim technology - these system configurations primarily facilitate high indoor air quality (IAQ) by shifting to 100% outdoor air supply when conditions are suitable or at all times, respectively. Economy cycle operation can be implemented with energy use reductions whilst energy reclaim technology minimises any energy use penalty. A high IAQ acts to further improving the learning environment, boosting concentration levels and productivity.

Proposed building

A range of passive and active measures have been evaluated that, when combined, act to achieve significant operational carbon reductions for the DfMA system.



Passive and active measures - percentage improvement in energy use over the Reference Building

_ Performance Guidelines

Passive design measures

1 _ Orientation | Target Performance (TP) - orient corridor to N or W

2 _ Non-thermally broken frame | Minimum Expectation - specify double glazing | thermally broken frame | max. SHGC 0.3 | min. VLT 0.6

3 _ Air Permeability Rate | Target Performance (TP) - target compliance with Verification Method JV4 Building envelope sealing

Active design measures

1 _ Improved EER | Minimum Expectation (ME) - select equipment with an EER that is at least 15% higher than the DTS provisions or MEPS

2 _ Economy cycle operation or energy reclaim technology | Target Performance (TP) - integrate economy cycle operation or energy reclaim technology

Proposed building

_ Minimum Expectation (ME) - a combination of passive and active design measures must be implemented to achieve at least a 20% improvement over the Reference Building; all Green Star conditional requirements are to be achieved

_ Target Performance (TP) - a combination of passive and active design measures must be implemented to achieve at least a 30% improvement over the Reference Building; all Green Star conditional requirements are to be achieved

_ Resilience _ Performance Guidelines

Adapting to a changing climate is a key DfMA principle.

_ Minimum Expectation (ME) - the design of all relevant services will consider climate projections (RCP 8.5 @2050)

The frequency of bushfires and smoke haze conditions are forecast to increase due to global heating. Tackling infection risk in buildings has also emerged as a a key design principle.

_ Target Performance (TP) - outdoor air is to be supplied at a rate 100% greater than the minimum required by AS 1668.2:2012; wherever possible, implement 100% outdoor air systems; specify HEPA grade filters for ventilation systems

4.2 Fire Safety

Table 1 –NCC Fire Safety Compliance Requirements – Concrete, Steel, Mass Timber/Hybrid

Fire Safety Compliance Table			
Structural System	**Class ‘C’ Construction (1 Level)**	**Class ‘B’ Construction (2 Levels)**	**Class ‘A’ Construction (3+ Levels & under 25m)**
Concrete (Conventional – Business-as-usual)	**DtS**	**DtS**	**DtS**
Steel	**DtS**	**DtS** (when Steel is protected) Steel supported external walkways subject to further assessment.	**DtS** (when Steel is protected) Steel supported external walkways subject to further assessment.
Mass Timber (Incl. CLT and Hydrid Systems)	**DtS**	**DtS** Exposed Timber (Load and Non-Bearing – other than minor decorative elements (i.e. trims)) not permitted. Must be encapsulated. **P - Performance Solution** A Performance Solution is required in order to **expose** timber. **SPRINKLERS ARE REQUIRED FOR BOTH MASS TIMBER OPTIONS PROVIDED ABOVE.**	**DtS** Exposed Timber (Load and Non-Bearing – other than minor decorative elements (i.e. trims)) not permitted. Must be encapsulated. **P - Performance Solution** A Performance Solution is required in order to **expose** timber. **SPRINKLERS ARE REQUIRED FOR BOTH MASS TIMBER OPTIONS PROVIDED ABOVE.**

Note: 0. 'DtS' = Deemed to Satisfy Compliance with NCC; 1. 'P' = Fire Engineered Performance Solution; 2. Building over 25m in height requires sprinklers no matter which primary structural system is adopted.

4.2 Fire Safety

Fire Safety Guidance Note

1. Scope

Blackett Maguire + Goldsmith Pty Ltd (BM+G) have been engaged by the Department of Education C/- SINSW to provide BCA consultancy services in relation to the DfMA (Designed for Manufacture and Assembly) program. We have been advised that the proposed DfMA Structural Systems are:

- Concrete Frame (Hollow core slab / precast beams & columns)
- Steel Frame (Steel cassette floor / steel beams, columns and bracing).
- Timber System (CLT / mass timber construction).
- Hybrid (CLT floor system / steel beams, columns and bracing)

BM+G have subsequently been requested to compile a report which addresses; BCA compliance opportunities / risks, fire safety issues and recommendations, and an assessment of maintenance and mitigation strategies.

This report includes specialist advice from Holmes Fire in relation to the fire engineering aspects of this Guidance Note. Specifically, Section 8, and the recommendation in Section 9.1.

2. Documentation Relied Upon

The following documentation has been reviewed, referenced and/or relied upon in the preparation of this report:

- Building Code of Australia 2019 Amendment 1 (BCA).
- The Guide to the Building Code of Australia 2019 Amendment 1 (BCA)
- The NSW Schools DfMA System Guidelines – SINSW dated 30 October 2020.

3. Project Team

- The following consultants have contributed to this Report:

Name	Role	Company
Antonio Canuto	BCA Consultant/Report Preperation	Blackett Maguire + Goldsmith
David Blackett A1 Accredited Certifier	Project Leader/Peer Reviewer	Blackett Maguire + Goldsmith
James O'Neill	Fire Safety Engineer	Holmes Fire

4. Background - Compliance with the BCA

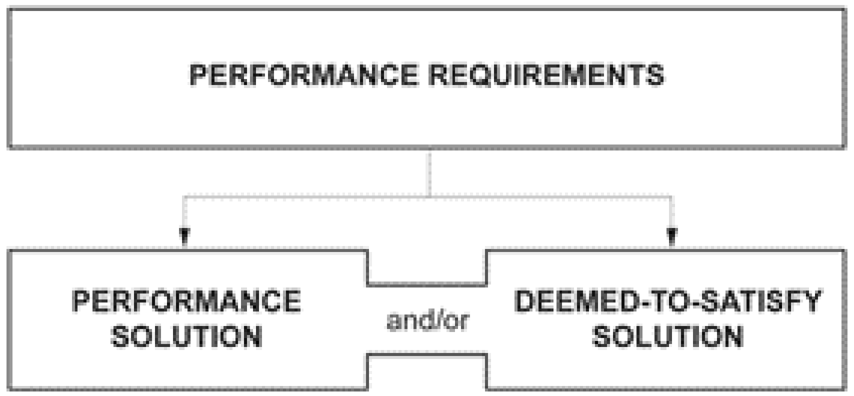
4.1 Compliance With The BCA

Compliance with the NCC is achieved by complying with—

- the Governing Requirements of the NCC; and
- the Performance Requirements.

Performance Requirements are satisfied by one of the following, as shown in the Figure below:

- A Performance Solution.
- A Deemed-to-Satisfy Solution.
- A combination of the above two options



4.2 Fire Safety

4.2 Type of Construction and Non-Combustibility Requirements

The rise in storeys of a building determines the 'Type of Construction' required for the building. The Type of Construction dictates the fire-resisting construction requirements applicable under Specification C1.1 of the BCA. There are three Types of Construction in the BCA, which in order of least to most fire-resisting are Type C, Type B and Type A. In regards to school buildings, the following generally applies:

- One Storey – Type C Construction
- Two Storey – Type B Construction
- Three Storey+ - Type A Construction

Below provides a general overview of the structural elements required to achieve a Fire Resistance Level (FRL) for the three Types of Construction, as well as associated non-combustibility requirements.

Table 1 - General Fire Resisting Construction Requirements for Type A, B, and C Construction

Type C Construction:	Type B Construction	Type A Construction
The following elements require an FRL on Type C Construction buildings: • Load-bearing and non-loadbearing external walls and columns, and external columns <3m from a boundary / separate building • Fire walls and common walls. • Any element providing direct or lateral support to an element requiring an FRL (e.g. bracing). The following elements are required to be non-combustible: • Nil – However noting internal linings are still subject to the fire hazard property requirements of BCA C1.10. Maximum fire compartment sizes limited to 3,000m2 and 18,000m3.	The following elements require an FRL on Type B Construction buildings: • Load-bearing external walls and columns, and external columns <18m from a boundary / separate building • Non load-bearing external walls (and columns incorporated within) <3m from a boundary or separate building. • Floors separating storeys. • Internal columns (excluding ones immediately below the roof). • Fire walls and common walls. • Any element providing direct or lateral support to an element requiring an FRL (e.g. bracing). The following elements are required to be non-combustible: • External walls and common walls (throughout). • The flooring and floor framing of lift pits. • Internal non-loadbearing fire walls. • Lift shafts • Any element providing direct or lateral support to an element which is required to be non-combustible. Maximum fire compartment sizes limited to 3,000m2 and 18,000m3	The following elements require an FRL on Type B Construction buildings: • Load-bearing external walls and columns, and external columns. • Non load-bearing external walls (and columns incorporated within) <3m from a boundary or separate building. • Floors separating storeys. • Internal columns (excluding ones immediately below the roof if the building does not exceed 3 storeys). • Roof (if the building does not exceed 3 storeys) • Fire walls and common walls. • Any element providing direct or lateral support to an element requiring an FRL (e.g. bracing). The following elements are required to be non-combustible: • External walls and common walls (throughout). • The flooring and floor framing of lift pits. • Internal non-loadbearing fire walls. • Lift shafts • Any element providing direct or lateral support to an element which is required to be non-combustible. Maximum fire compartment sizes limited to 3,000m2 and 18,000m3.

4.2 Fire Safety

4.3 Structural Systems Overview

Four structural systems have been captured within the NSW Schools DfMA System Guidelines, namely:

- Concrete Frame System (Hollow core slab / precast beams & columns)
- Steel Frame System (Steel cassette floor / steel beams, columns and bracing).
- Timber System (CLT / mass timber construction).
- Hybrid System (CLT floor system / steel beams, columns and bracing)

From a BCA compliance perspective, these systems have been separated in to two categories;

- Conventional Systems (concrete frame / steel frame), and
- CLT Systems (timber system and hybrid system)

Concrete frame and steel frame systems are typically used in the construction of buildings of varying degrees of complexity. There are a large number of systems and methods available to achieve BCA DtS compliance with these systems, and a large amount of certainty in relation to achieving prescriptive compliance.

Timber frame systems and hybrid systems (comprising timber and steel structure) are lesser common systems, which only recently have been captured in the BCA under DtS compliance pathways. Whilst there are methods of achieving strict BCA DtS compliance, there is generally a conflict with achieving an exposed mass timber design intent. Furthermore, there are complexities in meeting prescriptive BCA compliance, specifically around;

- the fire sealing of service penetrations (BCA C3.15), and
- detailing and constructability of fully encapsulated timber elements (BCA C1.13), and
- fire hazard properties of exposed timber (BCA C1.10), and
- and ultimately achieving required FRLs (BCA C1.1).

Due to this complexity and uncertainty, a performance based design is typically adopted, with compliance with the BCA demonstrated via compliance with the Performance Requirements.

5. Conventional Structural Systems - BCA Compliance

5.1 Overview

Concrete and steel framing systems are recognised non-combustible building elements, achieving prescriptive compliance with BCA Clause C1.9 and Specification C1.1. When utilised in buildings exceeding one storey (or buildings of one storey within proximity of a fire source feature), certain structural elements are required to achieve a Fire Resistance Level (FRL).

Concrete building elements inherently achieve an FRL via compliance with the relevant requirements of the structural design code (AS 3600). Unlike concrete, steel structure does not inherently achieve an FRL, however there are a multitude of systems on the market (intumescent paints and coatings, encapsulation in fire-rated board produces, etc.) which can be relied upon to achieve the required FRL.

The ability to use conventional structural systems in buildings is not limited under the BCA from a fire safety perspective. However, the complexity of the structure and degree of fire-resisting construction required is increased by the Type of Construction applicable.

4.2 Fire Safety

5.2 Implications of Rise in Storeys and Type of Construction

The implications of the three types of construction (with respect to conventional structural systems) are listed in Table 2 below. This table is written with respect to Deemed-to-Satisfy Solutions only.

Table 2 - Implications of Type of Construction on Use of Conventional Structural Systems

Type C Construction:	Type B Construction	Type A Construction
• Use of concrete systems generally permitted throughout. • Use of non-fire-rated steel systems generally permitted throughout. •	• Use of concrete systems permitted throughout, subject to elements requiring an FRL being designed in accordance with AS 3600 and BCA Section B. • Use of steel systems permitted throughout, subject to elements requiring an FRL being protected by proprietary passive fire protection systems tested in accordance with BCA C1.8.	• Use of concrete systems permitted throughout, subject to elements requiring an FRL being designed in accordance with AS 3600 and BCA Section B. • Use of steel systems permitted throughout, subject to elements requiring an FRL being protected by proprietary passive fire protection systems tested in accordance with BCA C1.8.

5.3 Limitations and Risk to Achieving Deemed-To-Satisfy BCA Compliance

- Compliance with the DtS provisions of the BCA insofar as the use of conventional structural systems is generally readily achievable.

5.4 Compliance with the Performance Requirements of the BCA

- Whilst it is unlikely there would be an aspiration to adopt a performance based design specifically in relation to the conventional structural systems mentioned, there is opportunity presented via utilising the Performance Requirements of the BCA in other aspects of the design. These matters have been tabulated in Table 4 of Section 8.1.
-

6. CLT Systems - BCA Compliance

6.1 Overview

Timber is inherently a combustible material, and as such, the Deemed-to-Satisfy provisions of the BCA limits it's use in certain buildings to specific circumstances. BCA 2019 currently only permits the use of CLT construction in buildings under an effective height of 25m (generally <8 storeys).

The ability to use CLT in buildings is further limited by the Type of Construction as determined by the Rise in Storeys.

4.2 Fire Safety

6.2 Implications of Rise in Storeys and Type of Construction

The implications of the three types of construction (with respect to CLT construction) are listed in Table 3 below. This table is written with respect to Deemed-to-Satisfy Solutions only.

Table 3 - Implications of Type of Construction on Use of CLT Construction

Type C Construction:	Type B Construction	Type A Construction
• Use of CLT generally permitted throughout. • Use of exposed CLT under Deemed-to-Satisfy Solutions is only limited by the fire hazard properties of the material as prescribed by Specification C1.10. This may itself lead towards requiring performance based design (i.e. a Performance Solution) if compliance cannot be demonstrated with the Deemed-to-Satisfy provisions.	• Use of CLT limited in instances where the BCA requires said element to be non-combustible (Generally load-bearing elements on the Ground Floor, external walls throughout, floors where supporting fire-rated loadbearing walls which are exposed to adjacent buildings / boundaries). • BCA C1.13 and Spec C3.13 / C3.13a require the CLT to be designed as 'fire-protective timber'. Requiring full encapsulation, the provision of cavity barriers, and the provision of a sprinkler system throughout. • Use of exposed CLT is not permitted for elements required to be non-combustible. • Exposed timber can be used on remaining elements subject to the fire hazard properties of the material as prescribed by Specification C1.10. This may itself lead towards requiring performance based design (i.e. a Performance Solution) if compliance cannot be demonstrated with the Deemed-to-Satisfy provisions.	• Use of CLT limited in instances where the BCA requires said element to be non-combustible (Generally load-bearing elements throughout, external walls throughout, floors where supporting fire-rated loadbearing external walls or non-loadbearing fire walls). • BCA C1.13 and Spec C3.13 / C3.13a require specific elements of the CLT to be designed as 'fire-protective timber', primarily being loadbearing walls (and any elements providing structural support). This requires full encapsulation of the CLT, the provision of cavity barriers, and the provision of a sprinkler system throughout. • Use of exposed CLT is not permitted for elements required to be non-combustible. • Exposed timber can be used on decorative non-structural elements subject to the fire hazard properties of the material as prescribed by Specification C1.10. This may itself lead towards requiring performance based design (i.e. a Performance Solution) if compliance cannot be demonstrated with the Deemed-to-Satisfy provisions.

Note: The above advice does not consider buildings over an Effective Height of 25m, as we understand DfMA designs will not be utilised on schools of this scale (8-9+ storeys in height).

4.2 Fire Safety

6.3 Limitations and Risk to Achieving Deemed-To-Satisfy BCA Compliance

Whilst the BCA offers prescriptive solutions for the construction of buildings with CLT, there are a number of limitations and risks to achieving prescriptive compliance. The following limitations and risks are noted:

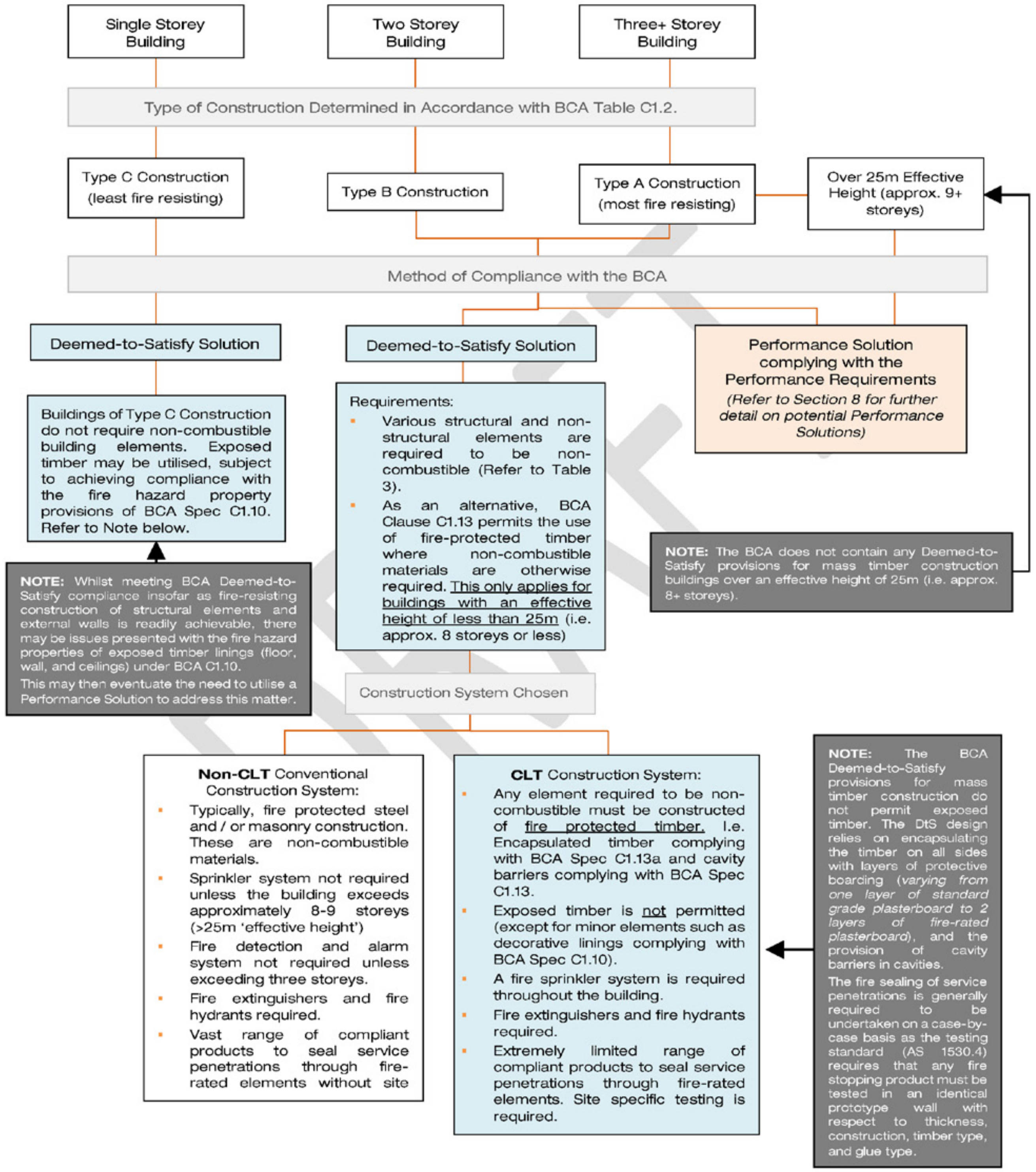
- Exposed CLT is generally not permitted in buildings of Type B and A Construction. The fire-protected timber provisions of the BCA rely on encapsulation. As such, any design intent relying on exposed timber is unable to be achieved.
- Where permitted, exposed CLT in elements such as exposed floor systems and wall systems are limited by the requirements of Specification C1.10 in relation to fire hazard properties. Noting the laminate nature of CLT, product specific testing would be required to confirm compliance.
- There are limited fire stopping products for services passing through CLT floors and CLT fire-rated walls (buildings of Type A and B Construction) on the market. This is exacerbated by a technicality in the testing standard (AS 1530.4) which doesn't offer the degree of 'permissible variations' to CLT as it does to conventional construction methods such as concrete floors, masonry walls and fire-rated plasterboard).
- There are likely cost implications with adopting a 'fire-protective timber' design and construction approach. Specifically, with regards to the degree of encapsulation required to all building elements.
- Any project-specific testing requirements may come with long lead times. Furthermore, there is no guarantee that testing may produce favourable results.

6.4 Compliance With The Performance Requirements of the BCA

A performance based approach would offer the ability to address risks and limitations presented by the DtS provisions. However, noting such an approach introduces new risks and limitations. From a CLT perspective, the flow chart in Figure 1 depicts the available respective pathways for compliance with the BCA covering a range of building types.

As noted in Section 5.4, additional common BCA departures that have opportunity to be addressed under a performance based design are listed in Section 8.1.

Figure 1 - BCA Correspondence Pathways for Mass Timber Construction Buildings



7. SINSW Building Works Approval Pathway

7.1 Overview

The Department of Education is considered a Public Authority under the Environmental Planning and Assessment Act 1979 (EP&A Act, the Planning legislation). As such, for the purposes of Part 6 of the EP&A Act, they are considered as the Crown for the purposes of Crown Building Work.

Section 6.28 of the EP&A Act requires that prior to commencing building works on behalf of the Crown, the works are certified on behalf of the Crown as complying with the Building Code of Australia as inforce at the date of invitation for tenders to carry out the Crown building work.

7.2 SINSW Approval Process

SINSW currently engages Building Surveyors registered with NSW Fair Trading to provide Crown Certification for its projects in accordance with legislative requirements and the SINSW consultant scope of services; however, there is no legislative requirement for Crown building work undertaken by SINSW to have a Principal Certifier (PC) appointed or to obtain a Construction Certificate, Compliance or Occupation Certificates. Only a Crown Certificate (s6.28) is required to be issued prior to commencement of Construction.

As part of the scope of services of the project 'Crown Certifier', the issuance of a non-statutory 'BCA Completion Certificate' generally signifies the completion of building work, and verifies the building is suitable for occupation in accordance with its building classification under the Building Code of Australia.

4.2 Fire Safety

7.3 Performance Based Design: Stakeholder Engagement - FRNSW

In NSW, there is no statutory requirement to consult with the fire services authority (FRNSW) in relation to building work undertaken by or on behalf of the Crown. However, in order to facilitate a performance based design, it is a key recommendation of BM+G that FRNSW will need to form a stakeholder of the DfMA program in its initial stages, as well as on a site specific basis for the potential roll-out of CLT DfMA schools.

The key principles and assumptions made during the fire engineering strategy developed for the DfMA program will need to receive in-principle support from FRNSW through an informal referral process (BM+G can organise this process). This will reduce authorities risk, and will provide certainty to the fire engineering strategy which will form the framework for the potential roll-out.

Noting each project will be subject to a site specific fire engineering report and performance solution, a Fire Engineering Brief will be required to be submitted to FRNSW via the FEBQ (Fire Engineering Brief Questionnaire) process. This will form a requirement prior to the issuance of a Crown Certificate (approval document for the commencement of Crown building works), noting in principle support will be required for the site specific performance solutions. Once the FEBQ process and the subsequent FER is finalised, the fire engineering report will need to be submitted to FRNSW for information purposes and record.

As a close out to the FRNSW engagement process, it is recommended FRNSW is requested to carry out an inspection of the building and provide a written report in relation to the building works. This will form a requirement prior to issuance of the final completion certificate (a non-statutory document issued at the completion of building works) for the building.

As the DfMA program progresses, should a performance based design be adopted, it is recommended that the above be incorporated in to a written policy in order to ensure the above obligations are met under the certification process for the roll-out of DfMA projects.

It is further noted that if these works were not undertaken on behalf of the Crown (i.e. private development), FRNSW would be an authority in which referral of CLT related performance solutions would be required under legislation (subject to building size).

4.2 Fire Safety

8. Fire Engineering - Performance Based Design

8.1. Fire Engineering Opportunity - Overview

General non-compliances with the BCA Deemed-to-Satisfy Provisions which are common in low and medium rise school projects are listed below in Table 4, these may be addressed with a fire engineered Performance Solution on a case by case basis. Note that specific non-compliances that not listed within the scope of this proposal may be identified by the Building Surveyor for each project in future.

Table 4 - Common Non-Compliances in Low and Medium Rise Schools

BCA Clause	Description	Performance Requirement
C1.1, C1.1, C1.10, C.13	Specification C1.1 requires structural elements within a Class 5 and Class 9b building of Type A construction to achieve a Fire-Resistance Level (FRL) of not less than (120)/120/120, with reductions for external walls and roof structures subject to site particulars. In addition, fire-protected timber is required for any loadbearing wall elements, and any elements that may provide structural support to those elements. The FRL requirements lessen for Type B, however the core fire safety issues are still prevalent. Due to the lack of viable test data for unprotected CLT systems, CLT elements in general must be fire protected throughout in order to achieve compliance with Clause C1.1 and Specification C1.1, or subject to a Performance Solution. This is also true for the glulam timber structural elements in general, in which passive protection must be applied to achieve a level of prescriptive performance under the BCA. In addition, all timber connections and penetrations are generally required to be protected to achieve the respective FRLs of the BCA. A Performance Solution may be provided to allow for the flexibility of unprotected mass timber elements, provide reductions to FRLs, to analyse connections and penetrations, and to aid in detailing interfaces at the façade interfaces, in order to satisfy the relevant Performance Requirements of the BCA.	CP1 and CP2
C1.1, C2.7, C2.8	Storage areas which comprise more than 10% of the floor area of a storey are required to be fire separated from the remainder of the building by fire rated construction achieving a Fire Resistance Level (FRL) of 240 minutes (or the entire storey / building shall be constructed to achieve this FRL). A Performance Solution may be provided to justify fire rated elements with a reduced FRL to storage areas, or other building classifications within the structure as required.	CP1 and CP2
C2.2	BCA C2.2 limits the maximum fire compartment size of buildings within maximum floor areas and volumes. For school buildings, this comprises; • 8,000m2 and 48,000m3 for Type A Construction • 5,500m2 and 33,000m3 for Type B Construction • 3,000m2 and 18,000m3 for Type C Construction Noting the nature of school design resulting in multiple building parts connected by semi-enclosed / covered walkways, it is typical that large assemblies of separate building parts form a single fire compartment. This can result in exceeding the maximum floor areas prescribed by C2.2. A Performance Solution may be provided to justify the presence of a fire compartment size larger than that prescribed by C2.2.	CP2
D1.4	The maximum travel distance is permitted to be 20 m to a single exit or point of choice and 40 m to an exit where 2 or more exits are available. A Performance Solution may be provided to justify travel distances greater than those stipulated in the BCA.	DP4 and EP2.2
E1.4	A Class 9b building (excluding classrooms) is required to be provided with a fire hose reel system in accordance with AS 2444-2001. A Performance Solution may be provided to omit fire hose reels from school buildings in general, utilising portable fire extinguishers as an alternative which may be more appropriate to the fire hazards present.	EP1.1

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BCA Clause	Description	Performance Requirement
E1.5	Due to the proposed mass timber construction, larger and taller school buildings are required to be provided with a sprinkler system throughout. A Performance Solution may be provided to rationalise the requirement for sprinkler protection throughout specific buildings or building portions. It should be noted that whilst Holmes Fire believes this Performance Solution is justifiable, there is a heightened degree of risk that the solution may not be accepted by Fire & Rescue NSW. This must be evaluated as appropriate on a case-by-case basis.	EP1.4

For further information on the fire safety engineering aspects of the DfMA design, refer to 'School Infrastructure NSW – Standardised DfMA Fire Engineering Advice' prepared by Holmes Fire.

9. Maintenance of Fire Safety Systems Required by CLT Design

9.1 Overview

In a CLT building of Type A or B Construction, the only additional fire safety system present over and above a conventional building is the provision of an automatic fire sprinkler system. Noting additional dry-fire measures may be required by a fire engineered design.

Clause 182 of the Environmental Planning & Assessment Regulation 2000 places the obligation on a building owner to maintain fire safety systems to a standard no less than that specified in the fire safety schedule for the building. Whilst there is no statutory maintenance standard, industry practice is to maintain these systems to AS 1851 – 2012 (Routine Service of Fire Protection systems and Equipment).

As such, according to AS 1851 - 2012 the required planned preventative maintenance frequency for this system is monthly, six monthly, yearly, five yearly, ten yearly, twenty-five yearly, thirty yearly.

9.2 Additional Maintenance of Fire Safety Systems Required by a Performance Solution Approach

There is unlikely to be any material difference in a wet-pipe sprinkler system required by a performance based approach, and a DtS based approach. As such, the maintenance requirements are considered like-for-like. Should a dry-pipe sprinkler system be used, some additional dry-fire services may be required as part of that system beyond the DtS requirements for a wet-pipe system.

10. Recommendations

10.1 Blackett Maguire + Goldsmith

Blackett Maguire + Goldsmith are supportive of a performance based approach to building design. We believe there to be great opportunity for maximising design innovation, safety in design, and in effectively meeting project budgets through performance based designs. With specific reference to CLT DfMA, we believe a performance based design will provide a greater level of certainty as to the design requirements, safety outcomes, and construction methodology. Furthermore, reliance on a performance based approach is absolutely necessary to satisfy the design intent, being learning spaces complimented with exposed mass timber building elements. The deemed-to-satisfy provisions of the BCA do not account for all building scenarios and the complexity of all projects. In such instances, a performance based approach proves more suitable.

It is imperative that if SINSW decide on adopting a performance based approach for compliance with the BCA, FRNSW must become a stakeholder in the development of any Fire Engineering Brief. Furthermore, as noted in Section 7.3, in principle support of the initial fire safety strategy as part of the DfMA program

4.2 Fire Safety

is highly recommended to be obtained to reduce authorities risk, and increase certainty in the program.

In conclusion, subject to the development of fire safety and building approvals guidelines for the planning, design, and delivery of these buildings, BM+G strongly believes; fit for purpose, cost effective, and safe outcomes can be achieved.

10.2 Holmes Fire

Holmes Fire is in agreement with Blackett Maguire + Goldsmith with utilising a performance based approach to DfMA proposed above, and the inclusion of key stakeholders.

It is understood by Holmes Fire that the design intent for the concept is to pursue a mass timber option, where the level of internal timber structure exposed is maximised, which may be inclusive of glulam columns and beams and CLT wall and floor structures. Holmes Fire believes this design intent is achievable for the majority of the building types proposed, however appropriate assessment quantification of building performance should be undertaken in design to achieve a favourable outcome.

A fire safety strategy must be developed which captures the issues which surround combustibility and construction which are prevalent with mass timber buildings. It should be noted that although a general recipe for compliance may be proposed in the Guidelines, each development will need to be evaluated on its merits with respect to fire safety (and other performance criteria). As such, the same approach and fire safety measures may not be proposed for every similar project.

Holmes Fire strongly recommends a holistic design process is followed, which may provide a quantified fire safety strategy that addresses the overarching concerns of timber construction, being the effects on occupant egress, the differing fire conditions as a result of the combustible structural elements and the resulting structural performance, and the potential impact on fire brigade operations. A piecemeal approach to addressing specific parts of the BCA in exclusion of others is not considered appropriate.

Holmes Fire considers that one of the most important roles of the fire engineer is the facilitation of the approvals process with the Building Surveyor and other approval and referral authorities. As such, Holmes Fire recommends proactive engagement by the fire engineer with the Building Surveyor, as well as all other key stakeholders such as Fire & Rescue NSW, to streamline the approvals process and obtain a favourable outcome for all parties.

4.2 Fire Safety

Fire Safety Strategy

Primary Objectives

The underlying philosophy for any proposed fire safety strategy should be to reduce the risk of a fire occurring within the building, provide early detection of a fire occurring within the building to all building occupants, provide occupants with safe means of egress from the building, to prevent catastrophic collapse due to a fire and to provide adequate facilities to allow for fire brigade intervention.

This is to achieve the objectives for the Fire Engineered Solution, which is to:

- Prevent fire,
- Suppress fire,
- Prevent the spread of fire;
- Prevent disproportionate and catastrophic collapse,
- Facilitate fire brigade intervention; and
- Ensure or promote the safety of persons in the event of fire.

The underlying principles of the fire safety strategy should focus on a separation of fire hazards, and implementation of redundancy within the building with regards to fire safety measures, such that the level of robustness in the design can be appropriately quantified.

Specifically, the fire safety strategy should rely wholly or in part on:

1. Fire-separating each level of the building as required;
2. Spatially separating or fire-separating high hazard areas from the remainder of the building;
3. Acknowledging the risks surrounding the primary construction materials and assemblies proposed (reinforced concrete, structural steel, mass timber), and applying a progressive passive protection strategy to designated members throughout the building where required. Structural damage in fire conditions is to be assessed and quantified. This forms the basis of the fire engineering design for the structure, and feeds back into the structural engineering design (and other disciplines) as required;
4. Restricting fire and smoke spread throughout levels of the building to an acceptable degree to facilitate occupant egress and fire brigade intervention, as necessary;
5. Providing an enhanced detection system to allow for earlier detection and warning of a fire, thereby promoting occupant egress during the early stages of fire development;
6. Providing an enhanced automatic sprinkler system installed throughout the building; and
7. Rely on fire brigade intervention only as a last resort. The fire safety strategy should assume the unlikely case that fire brigade intervention may not be effective in limiting total fire size and spread. Regardless, the building should be designed to facilitate the likely fire brigade operations that should occur.

General

A holistic fire safety approach is recommended, such that the compounding impact of all fire risks are accounted for and assessed in aggregate, without addressing specific non-compliances to the NCC in a piecemeal manner in isolation of each other non-compliance and the inherent risks they contain.

- Following an objective based, not ‘rule based’ approach to meet the Performance Requirements of the NCC.
- The approach may rely on the implementation of advanced design tools to model occupant egress, fire and smoke behaviour, and assess structural damage.
- This approach is generally required to develop a fire engineered solution to allow for the flexibility of unprotected mass timber elements within the concept design.
- Consideration is made to future proofing, which is essential to ongoing life safety especially in changing climatic conditions and ensuring that a compliant solution can be achieved with future NCC developments.

4.2 Fire Safety

Key Issues

The key fire related design issues which are expected to be encountered in the concept design are:

- Assuming a "Type A" construction as benchmark for the design concept (three storeys as a standardised model for effective height), to provide future flexibility in expansion and meet the general needs of the client.
- Understanding the fire egress strategy using external walkways and stairs.
- Optimising the design of structural elements, paying particular attention to issues such as connections and penetration detailing.
- Understanding the ongoing maintenance requirements of any proposed essential fire safety measures, to inform the potential specification of these systems.
- Recognising and accounting for the risks surrounding the proposed occupancy and use of the buildings, including potential malicious damage to essential fire safety measures and structure.

Assumptions

Some key factors which must be considered in the concept design are:

- Careful site planning to understand compartmentation and implications of connected buildings.
- Development of an external egress strategy to enable ongoing flexibility.
- Rationalising the level of protection to structural elements internally to achieve integral benefits.
- Basing the fire safety strategy on a permanent building design.
- Recognising that external fire hydrant provisions may provide the predominant form of fire brigade attack and intervention.

Process for Structural Fire Analysis

In the case of any Fire Engineered Solution rationalising required Fire-Resistance Levels (FRLs), or to justify the unprotected use of novel structural materials such a mass-timber, a structural fire engineering assessment should be conducted. This assessment should quantify the performance of the structure under a severe fire event.

The process of the structural fire analysis which may be undertaken to achieve the objectives and verify that the Performance Requirements of the NCC are satisfied are:

1. Define credible design fire(s) for the areas of the structure to be assessed.
2. Quantify the time-temperature variation within the structural elements for each structural configuration under exposure to the design fire(s).
3. Incorporate material specific behaviour, at a minimum being: expansion/contraction evaluation and section damage assessments for reinforced concrete, expansion/contraction evaluation for structural steel, quantification of the potential for self-extinction and the associated influences on fire behaviour for mass timber.
4. Calculate a total damage assessment of all structural elements after design fire exposure, for retrospective assessment under mechanical loading.
5. Re-analyse the structure based on newly proposed structural configurations and optimised member sizes, as required.

Design detailing of all major structural components (including connection details) should be investigated to provide guidance to the design team on appropriate methods of construction to avoid critical failure paths and the potential for catastrophic failure during a fire event.

4.2 Fire Safety

Should an alternate pathway be followed to assess structural behaviour under fire conditions, the methodology employed should at a minimum follow the guiding principles above, with outputs that quantify the level of damage to the structure after a worst-case fire event.

The structural fire analysis must evaluate the design assuming active suppression system failure as a base case scenario.

Essential Fire Safety Measures

Passive Systems

Passive systems may be specified to facilitate the fire safety strategy, and these may include the following:

- Fire-rated spay products, commonly used on steel construction but with a multitude of applications.
- Fire-rated intumescent coating products, generally for steel members but may be applicable to other material types.
- Fire-rated board products, primarily used for their cohesive integration with mass timber construction, being economical and simple to install and repair.
- Blanket products, developed as an alternative to wet-application systems.
- Concrete core filling or encasement for durability and fire resistance.
- Traditional systems, such as bricks, blockwork and plaster products which may form a barrier to fire and provide natural fire separations without the need for specific design.
- Proprietary penetration protection systems, such as rockwool and other mineral wool products, intumescent products, fire door systems and associated smoke seal barriers.

Passive separation may be provided as part of the strategy to separate and isolate high risk or high fire load areas. These high risk areas are likely to include laboratory spaces, libraries, cooking and food preparation spaces, large storage spaces and workshops. Note that due to the modular concept designs locating these areas within hub units, passive separation measures between these areas are relatively simple to implement and maintain along solid hub boundaries.

Active Systems

Active systems may also be specified to facilitate the fire safety strategy, and these may include the following:

- An automatic sprinkler system (pre-action is recommended) throughout the building.
- Smoke/heat detection throughout the building, with detectors specified and located as appropriate to the use of each area.

Risk Mitigation

Passive fire safety systems must be designed for robustness, and located in areas which may discourage or prevent malicious damage and mechanical degradation over time.

- Critical passive fire safety systems should be layered and specified in internal “occupied” areas, and not relied upon in external or communication zones.
- Durability is a key issue, from both weatherproofing and mechanical use perspectives. Product specification should make consideration to proprietary products which are appropriate for the proposed lifespan of these buildings (> 50 years), or a maintenance regime conducive to simple, economic, and infrequent repairs.

4.2 Fire Safety

Active fire safety systems must also be designed to be appropriate to the use of the buildings.

- A pre-action (dry) sprinkler system is recommended in lieu of a wet system. This will avoid the discharge of water from the sprinkler system upon malicious damage. The pre-action system may be linked to heat detectors in lieu of smoke detectors, purely to avoid interference and spurious alarms within the building.
- Guidance from the appropriate Australian standards should be followed (i.e. AS 2118.1, AS 1670.1).

Automatic Sprinkler Systems

Where the preferred aesthetic is to include exposed mass timber wall and/or floor elements, the instatement of an automatic sprinkler system should form part of the fire engineered solution for the development, at a minimum complying with AS 2118.1, with the added benefit of the provision of fast response sprinkler heads.

Approximate Install and Maintenance Costs

Indicative installation and maintenance costs for an AS 2118.1 compliant automatic sprinkler system are provided below. It should be noted that due to the risk of malicious damage being highlighted as a major ongoing concern for this building use, information on a pre-action sprinkler system is also provided.

The pre-action system includes some additional mechanical components, and a full AS 1670.1 smoke/heat detection system. Detectors can be used interchangeably to prevent malicious activation where needed.

- Total wet-pipe system = $190K + $40/m2 total building floor area.
- Total pre-action dry-pipe system = $230K + $70/m2 total building floor area.
- Ongoing maintenance = $5K – $8K per annum.

For example, a 5000 m2 building may elicit costs of approximately $350K (wet-pipe) / $500K (dry-pipe), while an 8000 m2 building may be $500K (wet-pipe) / $800K (dry-pipe).

The above costs have accounted for control valves, pumpsets, sprinkler heads, piping and associated components, power supplies, drains, connecting mains, rising mains, flow switches, dry-fire systems and cabling, smoke and heat detectors plus associated cabling and components, sprinkler booster, occupant warning system and associated components, fire detection indicating control equipment, and a town mains connection.

This is to be provided as an approximate price guide only for the year of publication of the guideline, each development will attract a different cost based on site particulars.

Benefits

Besides the tangible and significant benefits to fire safety when installing a sprinkler system throughout the buildings, in both reducing the likelihood of a fire developing and the consequence of a fire event, a number of other design and costing flexibilities may also be inherently achieved, such as:

- Omission of fire-rated spandrel construction for buildings three storeys or higher.
- Omission of a fire-rated roof for buildings over three storeys.
- Reductions in FRLs to building elements and entire classifications of buildings, thus allowing a higher number of available proprietary fire-stopping systems to be used and reducing overall building costs through reduced materials, labour, and wider market competition.
- Larger total building areas without spatial or fixed fire separation (exceeding the 8000 m2 floor area limit) under a Fire Engineered Solution.

4.2 Fire Safety

- A relaxation on the fire hazard properties of linings, materials and assemblies, such that a wider range of more combustible products may be allowable inside the buildings.
- A potential reduction in insurance premiums and improved insurance ratings. Note that should the NSW Government self-insure these buildings, this benefit may not be realised to significant degree depending on the perceived impact of a catastrophic fire event to the entire school sector.

It should also be noted that a pre-action system will incorporate a smoke detection system, such that an additional form of detection and occupant warning is provided with a dry-pipe system (which accounts for the majority of the increased cost).

4.3 Structure

		Aesthetic	Spatial	Wellness	Origin	Embodied Carbon	Modular & Long Term Value	Regulatory
			- Spatial - Dimensions - Volumes	- Biophilia - Internal Environment - Noise	-Manufacturing Location - Ability to nurture/kick start NSW industry	- Materials -Manufacturing Process	- Consistency - Maintenance - Future flexibility + adaptability	- Safety - Codes - Future
FLOOR / SLABS	TIMBER CLT FLOOR	Best Exposed Appearance	Thinnest floor depth	Biophilia: Best Internal: Best Noise: Medium	Local supply and manufacture possible	Material: Best Manufacture: Low	Consistency: HIGH Maintenance: MEDIUM Flexibility + adaptability: MEDIUM Reuse: MEDIUM	Safety: EXCELLENT Codes: MODERATE
FLOOR / SLABS	STEEL CASSETTE FLOOR	Ceiling required to protect steel structure for fire safety	Thickest floor depth	Biophilia: Poor Internal: Average Noise: Medium	Local supply and manufacture possible	Material: High Manufacture: High	Consistency: HIGH Maintenance: MEDIUM Flexibility + adaptability: MEDIUM Reuse: DIFFICULT	Safety: EXCELLENT Codes: EASY
FLOOR / SLABS	CONCRETE PRECAST FLOOR PLANKS	Ceiling is required to cover the bottom side of precast concrete planks	Medium floor depth	Biophilia: Poor Internal: Average Noise: Good	Local supply and manufacture possible	Material: High Manufacture: High	Consistency: HIGH Maintenance: LOW Flexibility + adaptability: MEDIUM Reuse: DIFFICULT	Safety: EXCELLENT Codes: EASY
FRAMES	STEEL COLUMNS AND BEAMS	Paints or cladding required to protect steel structure for fire safety.	Medium beam depth	Biophilia: Average Internal: Average	Local supply and manufacture possible	Material: High Manufacture: High	Consistency: HIGH Maintenance: MEDIUM Flexibility + adaptability: MEDIUM Reuse: EASY	Safety: EXCELLENT Codes: EASY
FRAMES	TIMBER COLUMNS AND BEAMS	Best Exposed Appearance	Deepest beam depth	Biophilia: Best Internal: Best	Local supply and manufacture possible	Material: Best Manufacture: Low	Consistency: HIGH Maintenance: MEDIUM Flexibility + adaptability: MEDIUM Reuse: MEDIUM	Safety: EXCELLENT Codes: EASY
FRAMES	CONCRETE COLUMNS AND PRECAST REINFORCED	Could be exposed, painted or cladded	Thinner beam depth	Biophilia: Poor Internal: Average	Local supply and manufacture possible	Material: High Manufacture: High	Consistency: HIGH Maintenance: LOW Flexibility + adaptability: MEDIUM Reuse: DIFFICULT	Safety: EXCELLENT Codes: EASY
FRAMES	CONCRETE COLUMNS AND PRECAST PRETENSIONED	Could be exposed, painted or cladded	Medium beam depth	Biophilia: Poor Internal: Average	Local supply and manufacture possible	Material: High Manufacture: High	Consistency: HIGH Maintenance: LOW Flexibility + adaptability: MEDIUM Reuse: DIFFICULT	Safety: EXCELLENT Codes: EASY

4.3 Structure

Codes Standards & References

Design Working Life

The design working life adopted must be at least 50 years. The structure must be designed in accordance with the National Construction Code (NCC) and comply with the minimum requirements of the referenced Australian Standards.

General Principles

The structure must be designed in accordance with the following standard:

Standard	Number
General Principles Part 0: General Principles	AS/NZS 1170.0

Table 1 General Principles

Actions

Actions or loads on the structure are derived in accordance with the following standards:

Standard	Action	Part
AS/NZS 1170.1	Gravity Loads	Part 1: Permanent, imposed and other actions
AS/NZS 1170.2	Wind	Part 2: Wind actions
AS/NZS 1170.3	Snow	Part 3: Snow and ice actions
AS 1170.4	Earthquake	Part 4: Earthquake actions in Australia

Table 2 Standards for actions on structures

Where applicable, consideration is to be given to accidental load events such as hail ponding, or impact loading.

Material Standards

Structural elements of different materials must be designed to support and resist the actions on them in accordance with the following standards:

Material	Standard	Name
Concrete	AS 3600	Concrete Structures
Steel	AS 4100	Steel Structures
Masonry	AS 3700	Masonry Structures
Timber	AS 1720	Timber Structures

Table 3 Standards for structural materials

Geotechnical Standards

The structure must be derived in accordance with the following geotechnical standards:

Standard	Name
AS 1726	Geotechnical site investigations
AS 2159	Piling-design and installation
AS 2870	Residential slabs and footings
AS 3798	Guidelines on earthworks for commercial and residential development
AS 4678	Earth-retaining structures

Table 4 Geotechnical standards

4.3 Structure

Key Criteria

Importance Level

The Importance Level is a minimum of 3, or as required as per the BCA.

Permanent and Imposed Loads

Permanent Actions (G) as follows:

- The self-weight of the structure as shown on the Structural General Arrangement drawings
- Superimposed Dead Loads taken as a minimum of 2.0 kPa to allow for future flexibility for partitions, services, raised floors, finishes and fire protection.
- 0.20 kPa to allow for PV cells on the roof (20 kg/m2)

Imposed actions (Q) as follows:

- Levels 1 and 2, a minimum load according to the BCA. If area not covered, then as per the EFSG, but no less than 3 kPa
- Ground floor, a minimum load according to the BCA. If area not covered, then as per the EFSG but not less than 5 kPa

Actions for Barriers

Barriers, including parapets, balustrades and railings, together with the members and connections that provide structural support, must be designed to sustain the imposed actions as per AS/NZS 1170.1

Maintenance Loading

Allowance must be made for operated equipment such as mobile elevated work platforms (MEWPs). A maintenance access report is to be provided to outline maintenance unit loads and maintenance methodology.

Robustness

Robustness must be addressed in accordance with the NCC.

4.3 Structure

Serviceability Criteria

Vertical and Lateral Displacement

Structural elements must be designed to achieve the serviceability limit state criteria set out in Table C1 of AS 1170.0, or as applicable to the usage.

Attention must be made to the effects of compound deflections on the structural elements.

Footfall Vibration Design Response Factors

Structural design must ensure that floor vibration does not have any adverse impact on the building occupants and must be designed to provide a suitable degree of vibration performance.

Durability

Structural elements must be designed in accordance with the relevant Australian Standard for the relevant site-specific conditions.

Finishes

- A maintenance plan is required for any applied coatings.
- For steel and concrete finishes refer to the EFSG.
- For timber elements, consideration must also be given to the following:

Moisture Management Plan During and Post Construction

A moisture management plan during construction is required. This should cover, but not limited to, loading and unloading, storage, transportation and handling, and erection. The moisture management plan is required and should consider timber in all applicable environments and exposure classifications.

UV and Surface Protection

All visual structural timber elements above the ground floor must be protected from UV damage and general wear and tear from the time of manufacture and throughout the life of the building. Protection of timber elements must have effective UV absorbing properties in addition to stabilisation of lignin. The protection system can be a water-based thin-film glaze or water-based impregnation. A timber colour tint is required for localised damage repair and colour matching, refer architectural details for the colour specification.

Termites

A termite management plan is required.

Termite protection must be to AS3660.1. The ground floor is to have a minimum termite resistant class of H2, H2S, or H2F as applicable.

Mould Prevention

A mould prevention plan is required. Detailing for mould prevention must be considered.

4.3 Structure

Reference Design

- The reference design comprises a 3-storey timber structure, with concrete ground floor, structural mass timber for levels 1 and 2, and light timber-framed trusses for the non-trafficable roof. The building footprint is 18m x 22.5m with 9 x 7.5m grids, with an option for the building footprint to be doubled to 18m x 45m.
- A concrete ground floor has been used with foundations to be determined on a site-specific basis. Alternate DfMA ground floor solutions will be considered, provided they address durability and exposure issues including termite protection.
- The timber reference design is based on Cross Laminated Timber (CLT) floor panels on glulam primary and secondary beams supported by CLT walls and glulam columns. The primary beams are dropped below the plane of the secondary beams to allow for reticulation of services under the CLT floor. A glulam grade of GL13 has been used as it is cost-effective and available from multiple timber suppliers. Alternative material options and combinations of materials would be considered as part of a DfMA strategy.

Lateral Bracing

- Lateral bracing can be provided by enclosed shear walls, or enclosed cross bracing. Exposed cross-bracing can be considered, provided they address the issues of climbing and entrapment.
- For the timber reference design, bracing in the long direction is proposed to be a series of short CLT walls on a regular grid for lateral stability. This system achieves the natural light requirements into the building and allows for repeated prefabricated façade and structural panels to be used.
- Bracing in the short direction is achieved over 4.5m segments at each corner of the building for a 22.5m length. If the building footprint is doubled to 45 m wide, then the length of the bracing walls is to increase.

Future Vertical Expansion

Where the school requires the option for future vertical expansion at a later stage, the structure must be designed to allow for the addition of the extra floors and re-installation of the roof. The structure and façade detailing are to allow for the additional levels to be added without needing to remove the façade elements.

Options to be considered are:

- Provide vertical structure, and roof structure only, with the additional floor to be added later as part of expansion work.
- Provide vertical structure, and future floor and roof at roof level (double structure), with the floor not needing to be added as part of future expansion work.

Each project and its viable options are to be assessed on a project-by-project basis.

4.4 Acoustics

Principles

Acoustics play an important role in any learning environment.

A room that allows for clear and comfortable communication will improve learning outcomes for students and allow educators to focus on delivering content rather than battling noise.

Acoustics in the learning environment can broadly be grouped into the following categories:

- Background noise
- Sound insulation
- Reverberation
- Speech intelligibility
- Noise emissions to nearby properties

DfMA offers improved quality control for acoustics in each of these categories compared to traditional construction methods.

Acoustics In The EFSG

The NSW DoE EFSG gives acoustics performance criteria and design guidelines.

The advice from the EFSG is largely suitable for DfMA projects, with some amendments or additions described here relating to modular and lightweight construction.

Of particular note is the possibility DfMA provides for lightweight timber construction. This construction type offers many benefits for sustainable and attractive architecture, while presenting unique challenges for acoustics.

Where the EFSG has referenced superseded Australian Standards, the most recent revision is used throughout this section.

4.4 Acoustics

Background Noise

Many noise sources can contribute to background noise within a space – the principle noise sources in SINSW educational facilities are expected to be external noise sources such as industrial noise, traffic noise from nearby roads, railways and aircraft, rain noise, and internal sources such as building services noise.

Where not properly controlled, these noise sources can have an adverse impact on the learning environment and serve as a disruption in classrooms. An excessive background noise level can reduce speech intelligibility making clear communication difficult, and it can put undue stress on the voice of an educator who is forced to compete with the background noise.

The EFSG acoustics guideline provides background noise criteria for internal spaces. These criteria align with a superseded version of Australian Standard 2107 (AS/NZS 2107:2000). As shown in Table 1, the criteria for DfMA schools projects refers to AS/NZS 2107:2016, which revises the acceptable noise levels in different spaces and typically gives a background noise target range (e.g. 40 to 45dB(A)) rather than just an upper limit.

Table 1: Design background noise levels for DfMA Space Types. Criteria adopted from Australia/New Zealand Standard AS/NZ 2107:2106

DfMA Space Type	AS2107:2016 occupancy	Design sound level range, L_{Aeq}
Homebase	Teaching spaces - Primary schools	35 to 45
General Learning Space	Teaching spaces - Primary schools	35 to 45
Withdrawal	Interview/counselling rooms	40 to 45
Seminar Room	Interview/counselling rooms	40 to 45
Practical Activities Area	Manual arts workshops	< 45
Shared Learning Space	Manual arts workshops	< 45
Science Lab	Laboratories – Teaching	35 to 45
Science prep/apparatus store	Laboratories – Working	40 to 50
Visual Arts Workshop	Art/craft studios	40 to 45
Project/pottery store	Art/craft studios	40 to 45
Darkroom	Art/craft studios	40 to 45
Food-tech kitchen	Laboratories – Teaching	35 to 45
Food-tech prep/storeroom	Laboratories – Working	40 to 50
Performing arts lab	Music studios	30 to 35
Fitness lab	Weight training/Fitness room	< 50
Fitness/performance store/change	Toilet/Change/Showers	< 55
Wood/metal workshop	Engineering workshops	< 45
Library – main area	Libraries – General areas	40 to 50
Computer learning space	Computer rooms - Laboratories	45 to 50
Senior study	Staff studies/collegiate	40 to 45
Offices/admin	Office areas	40 to 45
Staff room	Staff common rooms	40 to 45
Core	Light machinery	< 70
Internal Corridors	Corridors and lobbies	< 50
Toilet/Change/Showers	Toilet/Change/Showers	< 55

4.4 Acoustics

Sound Insulation

Reducing noise transfer between spaces is important in the education setting to minimise disruption to learning.

In the context of DfMA, noise is expected to travel between spaces through one of two modes: airborne noise and impact noise. Airborne noise, as the name suggests, is noise travelling through the air. This noise strikes a partition, and depending on the construction of the partition, some noise will pass through into the air on the other side. Impact noise occurs when an object strikes a partition or floor, such as a ball or footfall. Both of these transmission paths can be either vertical partitions, such as a wall, or horizontal partitions, such as for a floor or ceiling.

The requirement of a partition to resist the transfer of both airborne and impact noise is guided by the spaces it separates.

The amount of noise a room produces, and how tolerant it is to noise coming in from outside will inform the acoustic design of partition elements. A wall separating a drama studio (very low tolerance) and a gymnasium (high noise generation), for instance, would have a much more stringent requirement than a wall separating two bathrooms (high tolerance, average noise generation).

Sound insulation requirements are detailed in the EFSG acoustics guideline. These recommendations for sound insulation ratings remain valid under DfMA, and are to be adopted by equating Space Types identified in these Kit of Parts chapters to Rooms identified in the EFSG Guideline 11.

Table 2 shows the weighted sound reduction index (RW) for partitions, given the noise generation of a space and the noise tolerance of the adjoining space (identified in Table 3).

Table 2: Sound insulation requirements (minimum design R_w) for adjacent rooms without operable walls, entry doors or glazed panels

Receiver tolerance	Activity noise in source room			
	Low	Average	High	Very High
High	30	35	45	55
Medium	35	40	50	55
Low	40	45	55	55
Very Low	45	50	55	60

4.4 Acoustics

Sound Insulation

Table 3 gives noise generation and tolerance ratings for the various spaces identified for DfMA.

Table 3: Sound insulation requirements (minimum design R_w) for adjacent rooms without operable walls, entry doors or glazed panels

DfMA Space Type	AS2107:2016 occupancy	Noise generated as source room	Noise tolerance as receiver room
Homebase	Teaching spaces - Primary schools	Average	Low
General Learning Space	Teaching spaces - Primary schools	Average	Low
Withdrawal	Interview/counselling rooms	Average	Low
Seminar Room	Interview/counselling rooms	Average	Low
Practical Activities Area	Manual arts workshops	Average	Medium
Shared Learning Space	Manual arts workshops	Average	Medium
Science Lab	Laboratories – Teaching	Average	Low
Science prep/apparatus store	Laboratories – Working	Average	Medium
Visual Arts Workshop	Art/craft studios	Average	Medium
Project/pottery store	Art/craft studios	Average	Medium
Darkroom	Art/craft studios	Average	Medium
Food-tech kitchen	Kitchens	High	High
Food-tech prep/storeroom	Laboratories – Working	Average	Medium
Performing arts lab	Music studios	Very high	Very low
Fitness lab	Gymnasiums	High	Medium
Fitness/performance store/change	Toilet/Change/Showers	Average	High
Wood/metal workshop	Engineering workshops	High	High
Library – main area	Libraries – General areas	Low	Low
Computer learning space	Computer rooms - Laboratories	Average	Low
Senior study	Study Rooms	Low	Low
Offices/admin	Office areas	Low	Low
Staff room	Staff common rooms	Average	Medium
Core	Plant Room	High	High
Internal corridors	Corridors and lobbies	Average	High
Toilet/Change/Showers	Toilet/Change/Showers	High	High

4.4 Acoustics

Sound Insulation

Table 4 gives impact isolation ratings for the various spaces identified for DfMA.

Table 4: Impact isolation requirements for spaces in DfMA schools

DfMA Space Type	AS2107:2016 occupancy	Floor impact isolation (L'_{nTw})
Homebase	Teaching spaces - Primary schools	55
General Learning Space	Teaching spaces - Primary schools	55
Withdrawal	Interview/counselling rooms	55
Seminar Room	Interview/counselling rooms	55
Practical Activities Area	Manual arts workshops	65
Shared Learning Space	Manual arts workshops	65
Science Lab	Laboratories – Teaching	60
Science prep/apparatus store	Laboratories – Working	65
Visual Arts Workshop	Art/craft studios	60
Project/pottery store	Art/craft studios	60
Darkroom	Art/craft studios	60
Food-tech kitchen	Kitchens	-
Food-tech prep/storeroom	Laboratories – Working	65
Performing arts lab	Music studios	50
Fitness lab	Gymnasiums	65
Fitness/performance store/change	Toilet/Change/Showers	-
Wood/metal workshop	Engineering workshops	65
Library – main area	Libraries – General areas	55
Computer learning space	Computer rooms - Laboratories	60
Senior study	Study Rooms	55
Offices/admin	Office areas	55
Staff room	Staff common rooms	60
Core	Plant Room	-
Internal corridors	Corridors and lobbies	65
Toilet/Change/Showers	Toilet/Change/Showers	-

4.4 Acoustics

Reverberation

Sound reflects off surfaces and creates reverberation and echoes. Some acoustic reflections are useful as passive reinforcement to improve speech intelligibility, however too much reverberation within a space can quickly muddle speech and have a negative impact. Allowing acoustic reflections to continue building up raises the noise level in the room, putting stress on the voices of educators and potentially disrupting learning. As noise levels continue to build, voices are forced to be raised in order to be heard - which raises the noise level, which forces voices to be raised further (this is called the Lombard effect).

Strategic placement and orientation of sound-absorbing materials is used to control reverberation and maintain speech intelligibility. Fortunately, most materials do absorb some sound, although not all materials are created equal in terms of acoustic performance. Hard surfaces like concrete or timber will readily reflect sound, which quickly becomes noise. Soft materials like carpet and insulation are much better at absorbing that sound, before it becomes noise.

Reverberation time is the key indicator for room acoustics in smaller teaching and learning environments. It is typically denoted by the RT60, which is the time it takes for a sound in the room to decay by 60dB. For typical learning spaces, the RT60 is taken as the average of reverberation times of the 500Hz and 1,000Hz octave band centre frequencies. In acoustically critical environments, the reverberation time criteria should be achieved for all octave band centre frequencies from 63Hz to 8,000Hz.

The reverberation time targets given in Table 5 are generally for the average RT60 of the 500Hz and 1,000Hz octave band centre frequencies. In acoustically critical environments, the reverberation time criteria should be achieved for all octave band centre frequencies from 63Hz to 8,000Hz.

The EFSG acoustics guideline provides reverberation time criteria for internal spaces. Like the background noise criteria, these criteria are based on AS/NZS 2107:2000. This document adopts the updated criteria given in AS/NZS 2107:2016, which is generally consistent with EFSG criteria.

Speech Intelligibility

Speech intelligibility is closely linked to background noise and reverberation.

The EFSG acoustics guideline recommends a minimum Speech Transmission Index (STI) of 0.6 for all teaching and study spaces. An STI of 0.6 equates to “Good” speech intelligibility and is therefore suitable to adopt in DfMA.

This is generally expected to be achieved wherever reverberation targets are achieved. Large-volume spaces such as halls and gymnasia will require specific design in coordination with the audiovisual services designer to ensure intelligibility targets are met if speech reinforcement (public address) is required.

The requirement for speech intelligibility does not apply in typically unoccupied or transient spaces, such as storerooms, corridors, or bathrooms.

4.4 Acoustics

Reverberation

Table 5 gives reverberation time criteria for the various spaces identified for DfMA.

Table 5: Design reverberation time targets for DfMA Space Types. Criteria adopted from Australia/New Zealand Standard AS/NZ 2107:2106

DfMA Space Type	AS2107:2016 occupancy	Design reverberation time range, s
Homebase	Teaching spaces - Primary schools	< 0.8[1]
General Learning Space	Teaching spaces - Primary schools	< 0.8[1]
Withdrawal	Interview/counselling rooms	0.3 to 0.6
Seminar Room	Interview/counselling rooms	0.3 to 0.6
Practical Activities Area	Manual arts workshops	< 0.8
Shared Learning Space	Manual arts workshops	< 0.8
Science Lab	Laboratories – Teaching	0.5 to 0.8
Science prep/apparatus store	Laboratories – Working	0.5 to 0.8
Visual Arts Workshop	Art/craft studios	< 0.8
Project/pottery store	Art/craft studios	< 0.8
Darkroom	Art/craft studios	< 0.8
Food-tech kitchen	Laboratories – Teaching	0.5 to 0.8
Food-tech prep/storeroom	Laboratories – Working	0.5 to 0.8
Performing arts lab	Music studios	See note [2]
Fitness lab	Weight training/Fitness room	< 1.0
Fitness/performance store/change	Toilet/Change/Showers	-
Wood/metal workshop	Engineering workshops	See note [3]
Library – main area	Libraries – General areas	< 0.6
Computer learning space	Computer rooms - Laboratories	0.4 to 0.6
Senior study	Staff studies/collegiate	0.4 to 0.6
Offices/admin	Office areas	0.4 to 0.7
Staff room	Staff common rooms	< 0.6
Core	Light machinery	See note [3]
Internal corridors	Corridors and lobbies	< 0.8
Toilet/Change/Showers	Toilet/Change/Showers	-

[1] Reverberation time for a standard classroom <250m^3. For larger classrooms, guidance from an acoustical engineer shall be sought.

[2] The appropriate reverberation time shall be influenced by the internal volume and intended use of the space. Guidance from an acoustical engineer shall be sought.

[3] Reverberation time should be minimised for noise control.

4.4 Acoustics

Noise Emissions

Noise emissions from the educational facilities have the potential to impact neighbouring properties.

This is typically governed by the NSW Noise Policy for Industry and local council requirements, and forms part of the consenting process.

As such, an acoustic assessment and report are expected to be required for each site.

The acoustic report should identify any noise mitigation measures that will be required to meet the site-specific noise criteria.

Vibration

Vibration of building services equipment, footfall, sporting activities and workshop tools can transfer through the structure and present itself as re-radiated noise or unsettling vibrations. To reduce the transfer of vibration into the structure, all mechanical equipment should be equipped with vibration isolation as given in the ASHRAE Handbook – HVAC Applications "Selection Guide for Vibration Isolation".

Vibration isolation of workshop equipment must be selected on the basis of the floor system to be used. It is generally expected that machine tools will be located on a plinth directly placed on the structural slab, with vibration isolation to suit the mass and stiffness of the floor. If a raised floor is included, both vertical and horizontal vibration isolation must then be used to prevent vibration transferring into either the raised floor or the slab.

Vibration from building services and workshop machinery should not exceed the values given in Figure 1 in nearby learning and teaching spaces. For this assessment, classrooms, libraries and administration areas should use the ISO curve for offices (rms velocity of 0.4 mm/s), while food technology, art rooms, and laboratories should use the ISO curve for workshops (rms velocity of 0.8 mm/s).

Note that vibration can travel through the structure via the most rigid connections, and could potentially produce annoyance to a classroom some distance away without impacting those classrooms which are closer.

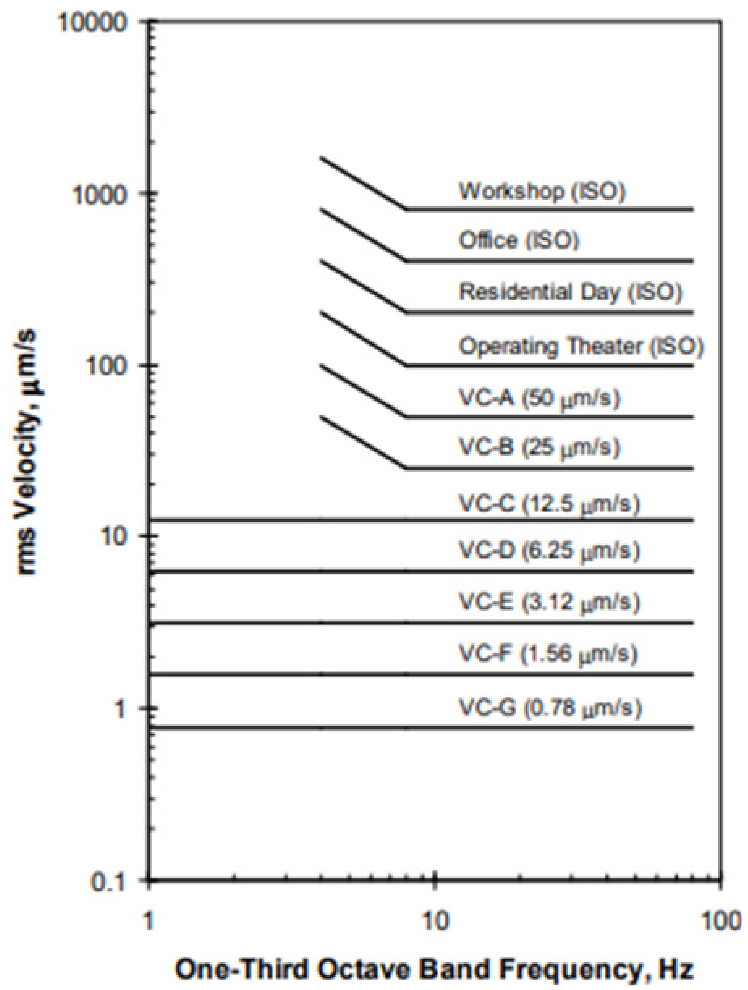


Figure 1: Vibration criteria adopted for SINSW DfMA schools, reproduced from Amick, Gendreau, Busch, & Gordon (2005)

4.5 Services

Mechanical

Services design to comply with EFSG and deemed to satisfy (DTS) requirements of the National Construction Code (NCC) and project specific ESD principles. Services strategy is to: - Maximise passive design - Consistent solution across all climatic conditions - Enhance indoor air quality and boost well being and productivity - Comfort control - Simple solutions that avoid complexity - future flexibility for change in use of space All material selected to meet whole of life principles. Installed services must be safe to install, maintain and replace at end of life.

Spatial

Key spatial consideration in the design include:- Centralised cooling and heating plant.- Decentralised local air conditioning system to suit zoning with individual room level control.- Vertical reticulation within services riser. Utilise services core where appropriate.- Horizontal reticulation on floor.- Coordination with structural and architectural layouts and other services.- Facade louvres for natural ventilation, outdoor air, make-up and relief air.- Exhaust to discharge as per EFSG, NCC and relevant Australian Standards.- Use of passive fire protection measures in accordance with NCC and fire engineering brief and report.

Heating Ventilation and Air conditioning (HVAC) Strategy

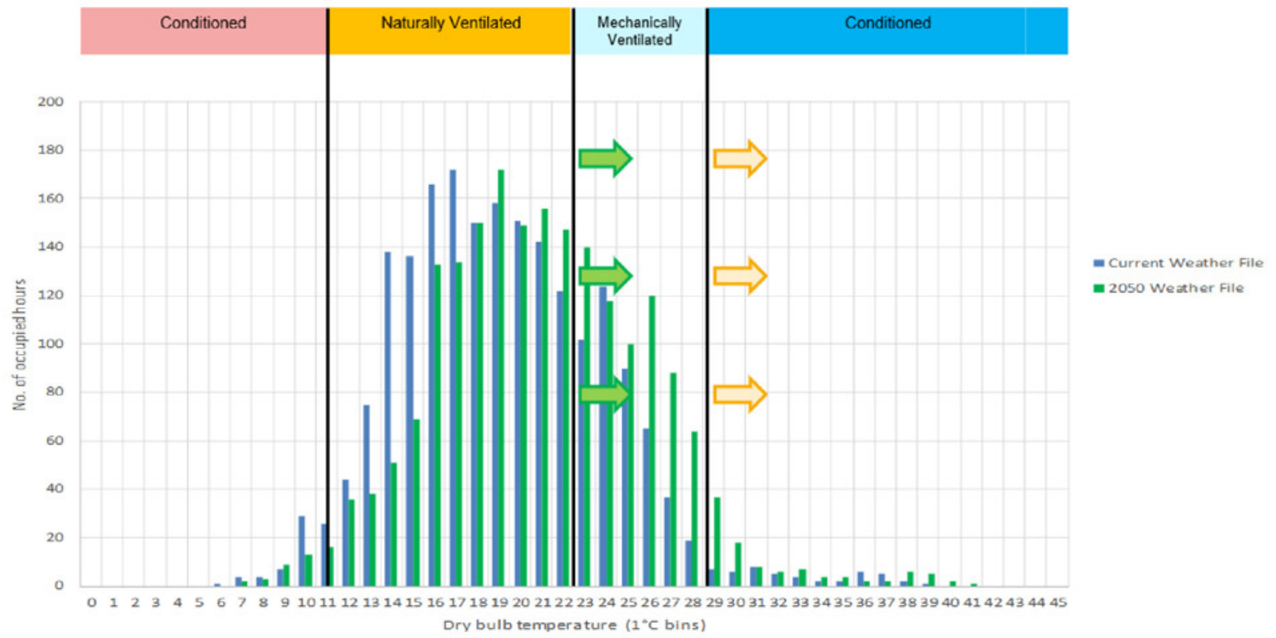
Utilise passive design strategy by reviewing weather data from current year and 2050. Figure 1 provides graphical representation of the operating strategy to align with EFSG guidelines on thermal comfort. Figure 2 shows a typical HB/GLS cluster room ventilation modes. Selection of air conditioning plant to suit climate zone and weather data. Ventilation as per EFSG for all specialist rooms. Integrate acoustic treatment to mechanical systems to meet project acoustic requirements. Fully integrated Building Management System (BMS) to allow for efficient operation of all plant and equipment.

4.5 Services

Energy Efficiency Measures

Each installed fan to exceed the required full load operating efficiency by 10% (ηmin x 1.1).- Consider the application of energy reclaiming system to precondition outdoor air.- Consider the application economy cycle operation for air handling plant- Each installed pump to achieve an improvement of 10% on relevant energy efficiency index (EEI) requirements- Consider water based cooling and heating circuits to suit individual project.- Where chillers are provided, utilise a 4-pipe multi-functional chiller (air-cooled) with high efficiency in all operating modes. - Use

Passive Design | Strategy



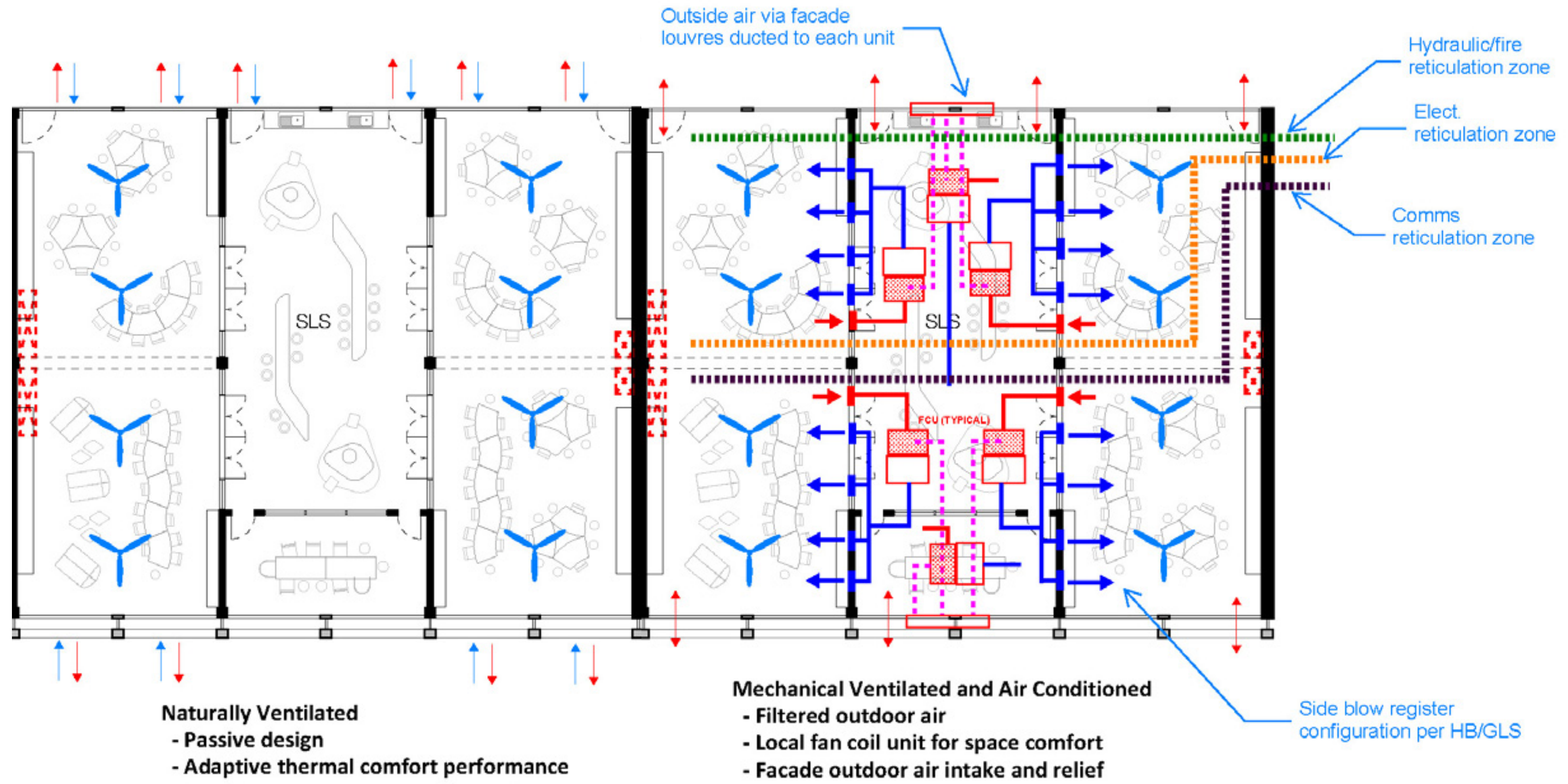


Figure 2: Typical ventilation strategy for HB/GLS cluster rooms

4.5 Services

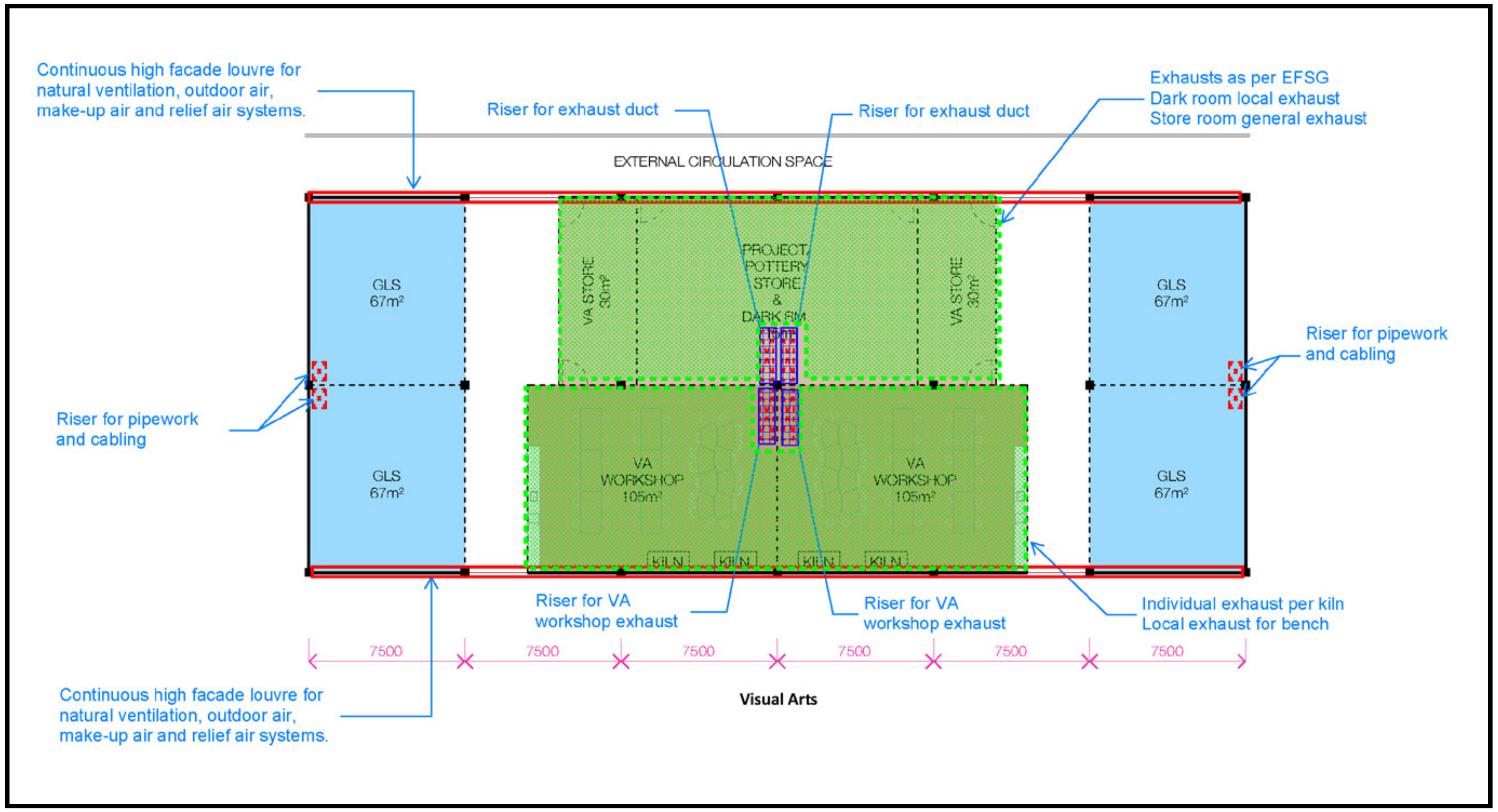
Specialist Rooms Ventilation Consideration

Reference / Baseline (NCC and EFSG):VA Workshop: Mechanical exhaust per kiln, local exhaust for bench activities, dark room local and general exhaust, store room general exhaust. Make-up air from air conditioning unit and facade louvres. Exhaust duct reticulated within central risers to discharge above roof via roof mounted fans. Refer to Figure 3.Food Tech: Mechanical exhaust for food tech kitchen island cooktop, general and local exhausts for pantry, laundry and stores. Make-up air from air conditioning unit and facade louvres. Exhaust duct reticulated within central risers to discharge above roof via roof mounted fans. Refer to Figure 4.Science: Mechanical exhaust per fume cupboard, local exhaust for chemical stores and general exhaust for stores. Make-up air from air conditioning unit and facade louvres. Exhaust duct reticulated with central risers to discharge above roof via roof mounted fans. Refer to Figure 5.Wood/ metal workshop: Mechanical exhaust for workshop activities and general exhaust for stores. Spatial provision for dust extraction unit for wood workshop. Make-up air from air conditioning unit and facade louvres. Exhaust duct reticulated within central risers to discharge above roof via roof mounted fans. Refer to Figure 6.Fitness/Performance: Mechanical exhaust for stores. Make-up air from facade louvres. Exhaust duct reticulated within central risers to discharge above roof via roof mounted fans. Refer to Figure 7.

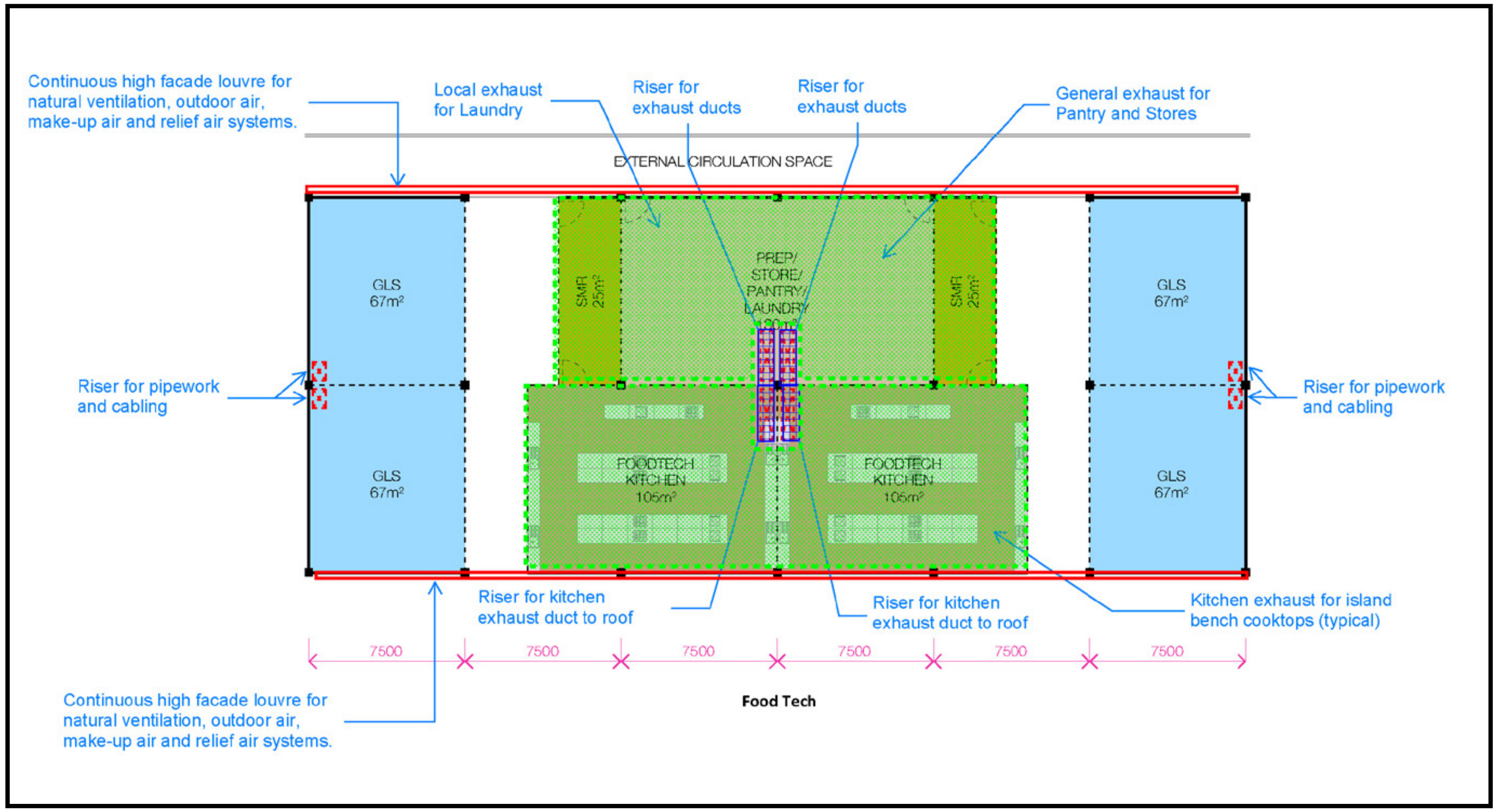
4.5 Services

DfMA opportunities

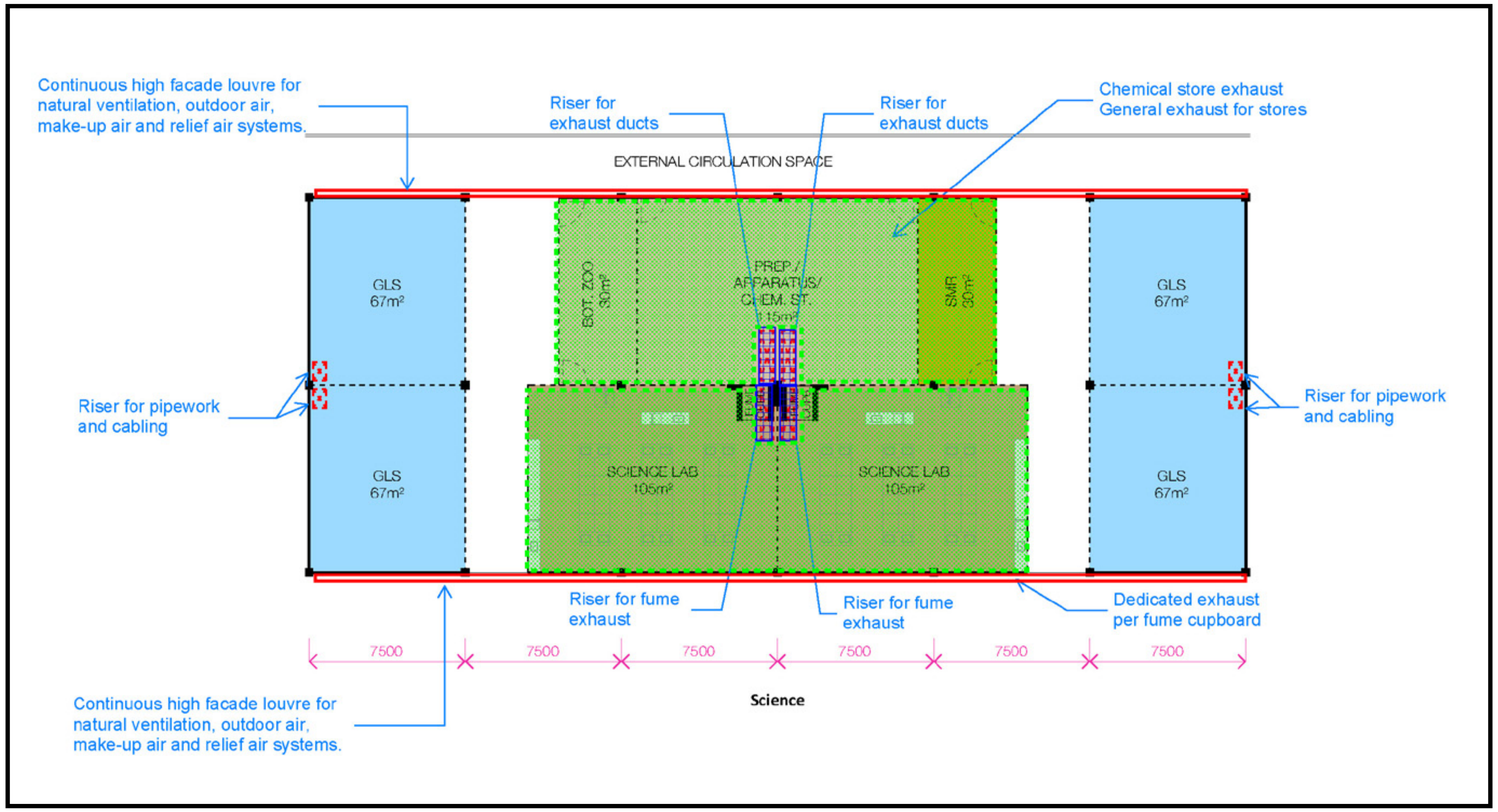
Standardised riser configuration allowing flexibility for change in space for future flexibility.- Pre-installed services in the modules prior to delivery.



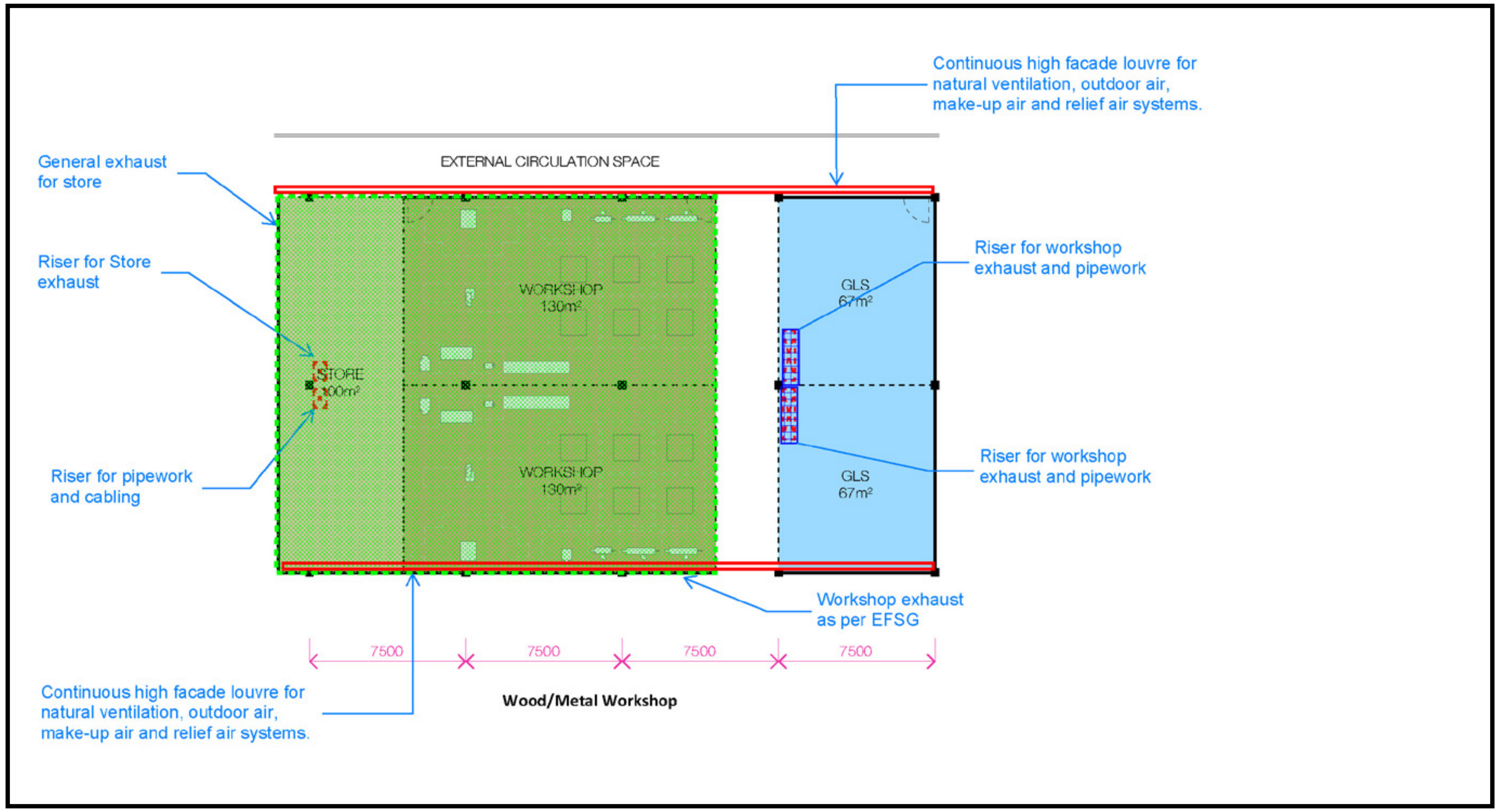
4.5 Services


Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.
Local exhaust for Laundry
Riser for exhaust ducts
Riser for exhaust ducts
General exhaust for Pantry and Stores
EXTERNAL CIRCULATION SPACE
GLS 67m²
SMFI 25m²
PREP/ STORE/ PANTRY/ LAUNDRY
SMFI 25m²
GLS 67m²
Riser for pipework and cabling
Riser for pipework and cabling
FOODTECH KITCHEN 105m²
FOODTECH KITCHEN 105m²
GLS 67m²
GLS 67m²
Riser for kitchen exhaust duct to roof
Riser for kitchen exhaust duct to roof
Kitchen exhaust for island bench cooktops (typical)
7500
7500
7500
7500
7500
7500
Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.
Food Tech

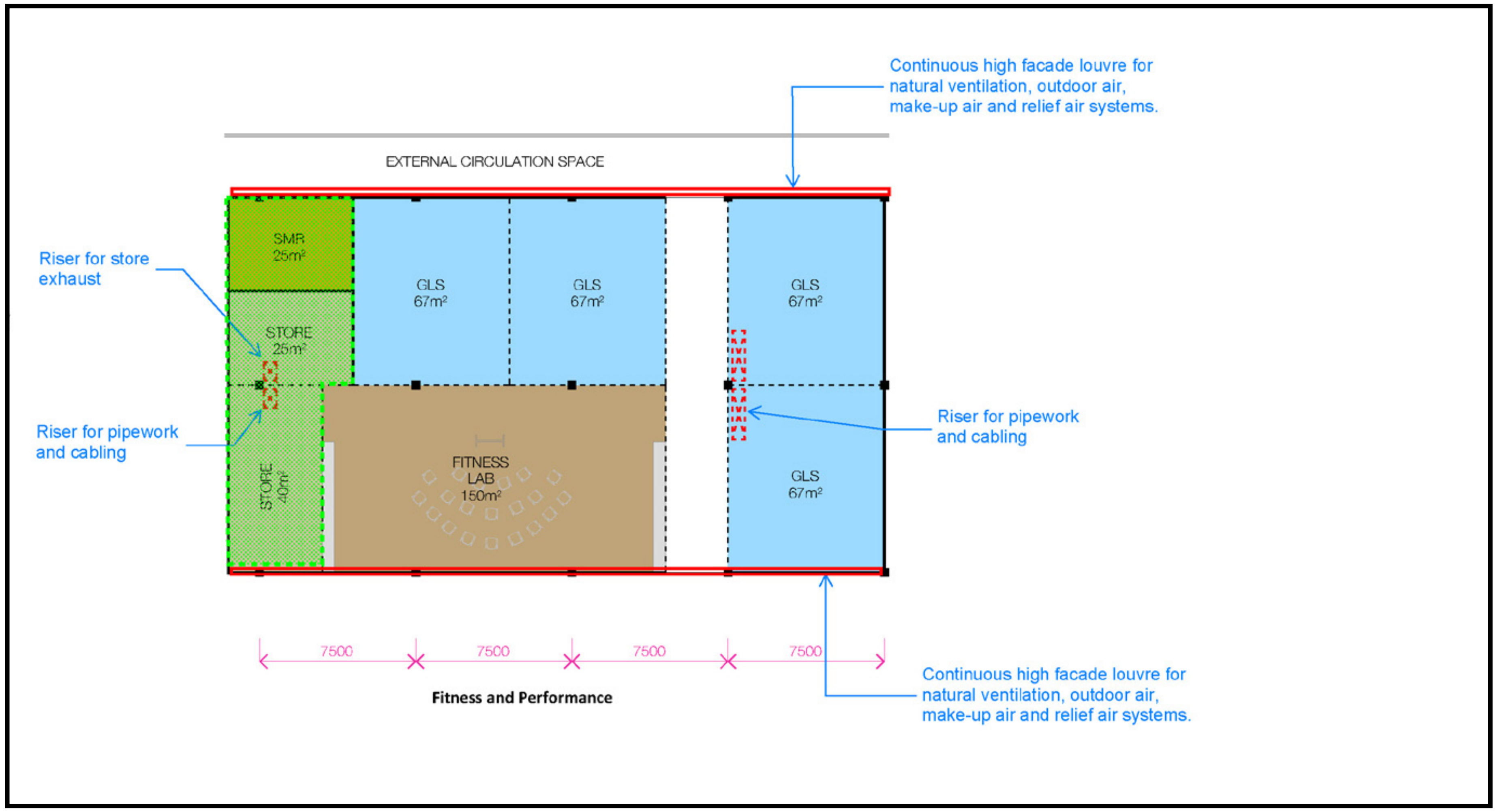
4.5 Services


Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.
Riser for exhaust ducts
Riser for exhaust ducts
Chemical store exhaust
General exhaust for stores
EXTERNAL CIRCULATION SPACE
GLS 67m²
BOT. ZOO 30m²
PREP / APPARATUS/ CHEM. ST. 115m²
SMR 30m²
GLS 67m²
Riser for pipework and cabling
Riser for pipework and cabling
SCIENCE LAB 105m²
SCIENCE LAB 105m²
GLS 67m²
GLS 67m²
Riser for fume exhaust
Riser for fume exhaust
Dedicated exhaust per fume cupboard
7500
7500
7500
7500
7500
7500
Science
Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.

4.5 Services


Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.
General exhaust for store
EXTERNAL CIRCULATION SPACE
Riser for Store exhaust
Riser for workshop exhaust and pipework
WORKSHOP 130m²
STORE 100m²
GLS 67m²
Riser for pipework and cabling
WORKSHOP 130m²
GLS 67m²
Riser for workshop exhaust and pipework
Workshop exhaust as per EFSG
7500
7500
7500
7500
Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.
Wood/Metal Workshop

4.5 Services



Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.
EXTERNAL CIRCULATION SPACE
Riser for store exhaust
SMR 25m²
STORE 25m²
GLS 67m²
GLS 67m²
GLS 67m²
Riser for pipework and cabling
FITNESS LAB 150m²
STORE 40m²
Riser for pipework and cabling
GLS 67m²
7500
7500
7500
7500
Fitness and Performance
Continuous high facade louvre for natural ventilation, outdoor air, make-up air and relief air systems.

4.5 Services

Electrical Services

Electrical design to meet EFSG, NCC and AS/NZS 3000 requirements.

Distribution

- Centralised main switch room (MSB) to be provided for each site.
- Electrical distribution board (EDB) to be located one per each building and one per floor by not exceeding a radius of 25m of supply equipment.- Services Core to be provided for vertical reticulation of submain power cabling and installation of EDBs. - Utilised overhead cable trays for power cable reticulation within each floor.

Segregated Distributions

- Low voltage cables to be separated from other services for safety and interference.

Lighting

- Lighting zones to consist of perimeter and internal zoning, daylighting and dimming control by Digital Addressable Lighting Interface (DALI).- Exit and emergency lighting to be provided in the event of emergency evacuation

DFMA Opportunities

- centralised risers within core - low voltage cabling on trays under floor void subject to detailed assessment and accessible floor requirements

Energy Efficiency Measures

- Use of photovoltaic solar power grid on-site to offset power consumption costs.- Aggregate design power load must achieve a 10% improvement on the sum of the allowances obtained by multiplying the area of each space by the maximum illumination power density in Table J6.2a (NCC Section J6). - Lighting and power control devices must meet the requirements of Specification J6; at minimum, all side- or roof-lit spaces must employ daylight sensors and dynamic lighting control devices within the adjoining occupiable space; all other occupiable spaces (incl. transitory spaces, e.g. stairways, amenities, etc.) to be provided with motion detectors. Lighting control zones not to exceed 100m². Lighting levels and individual controls to be addressed for relevant functional areas (e.g. laboratories)- External lighting to be high efficacy luminaries by incorporating lighting control system.- Consider application of fully addressable lighting control system (e.g. DALI).

Reference/Baseline (NCC and EFSG)

Science: Service core located externally for vertical submain cable reticulation. EDB shall be located inside the service core with full access available. Additional EDB shall be provided to cover an area every 25m radius. Refer to Figure 8.Homebase: Service core located externally for vertical submain cable reticulation. EDB shall be located inside the service core with full access available. Refer to Figure 9.

4.5 Services

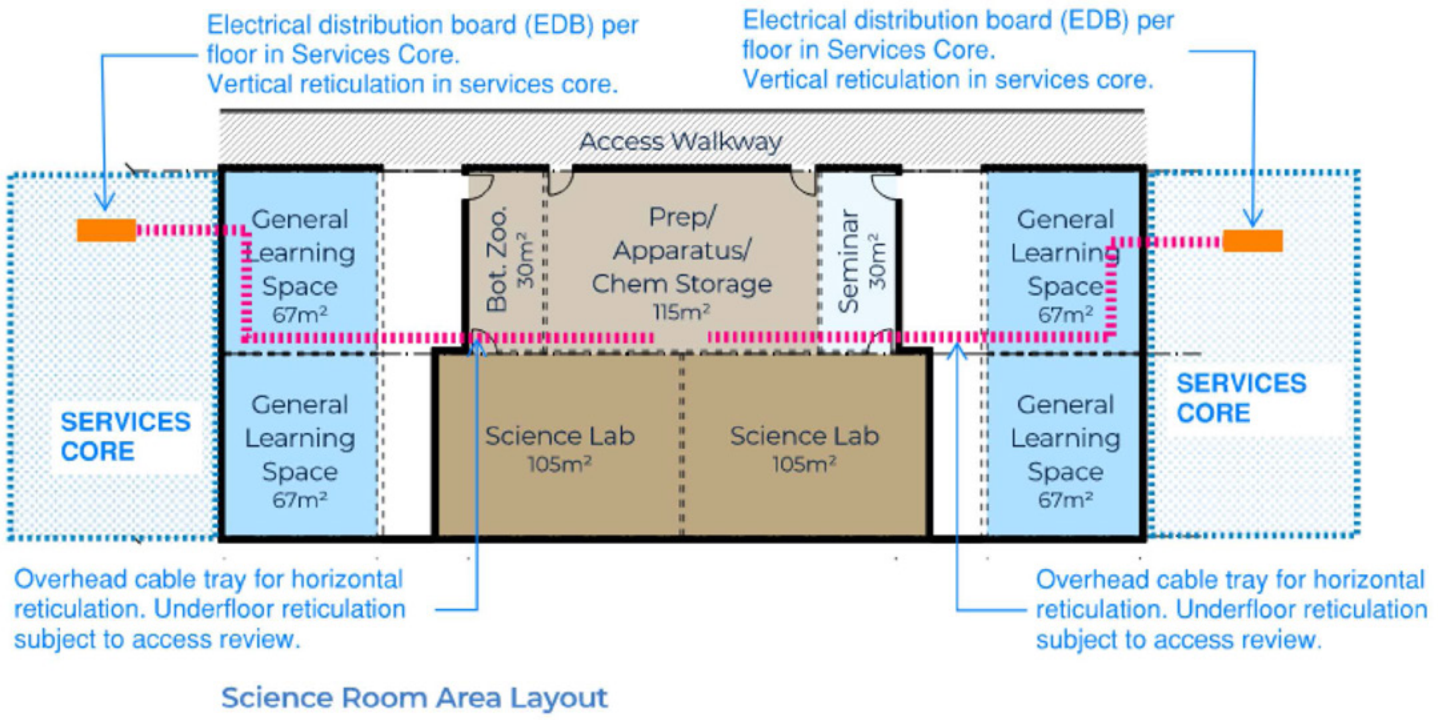


Figure 8: Typical Science Vertical and Horizontal Power Cabling Reticulation

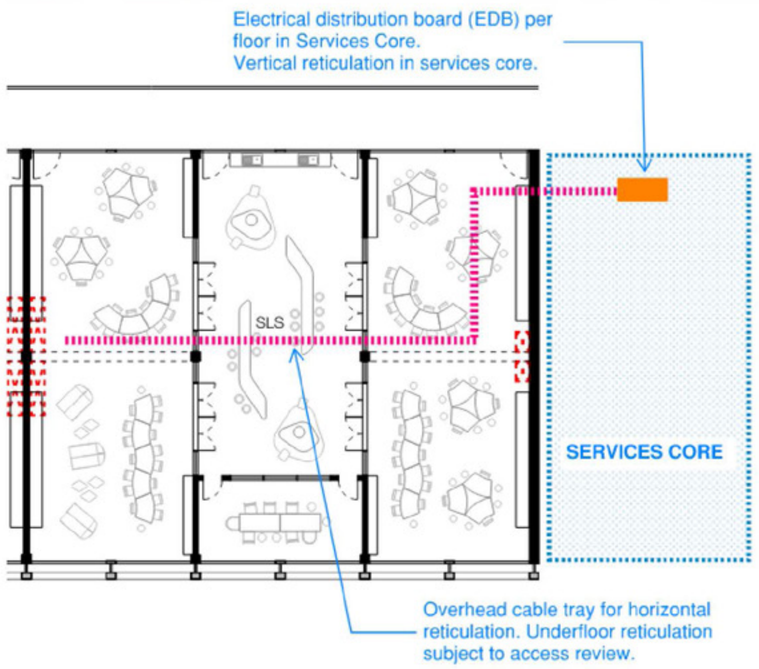


Figure 9: Typical Homebase Vertical and Horizontal Power Cabling Reticulation

4.5 Services

Communication Services

Communications design to comply with EFSG requirements and achieve the benefits of fully integrated solutions as part of the DfMA approach.

Spatials

Key spatial considerations in the design include:- A centralised main communications room (CD/MCR) for each site. - A centralised building communications room (BD/BCR).- Floor by floor distributor (FD). - A services core to allow for MCR, BCR and FDs. - Vertical reticulation within services core.- Horizontal reticulation via overhead cable trays.

Cabling

- Use of single mode optical fibre (SMOF) as backbone and CAT6A for horizontal cabling. - Cable paths to be less than 70m radius from CD/MCR and BD/BCR for outlets.

DFMA Opportunities

- Consolidation points within space provides DfMA opportunities however, it is departure from EFSG and subject to approval from DoE ITD.- Opportunity to integrate joinery / fabric for distribution i.e. Modularisation, plug and play and concealment.- Opportunity to pre-install cable trays within modules prior to delivery to site.

Active Networks

- Managed by ITD Network Design Team- WiFi- Shut down / low power mode for out of hours

Flexible Spaces

- Consolidation points enable local reconfiguration therefore space can be flexible for change in use.

Audio Visual System

- Room AV systems- Leverage off EWIS speakers- Public address- Period alarms

Latent Conditions

- Communications trade works will extend outside the DfMA footprint and integrate with existing site systems such as PABX, network, AV and period alarms.

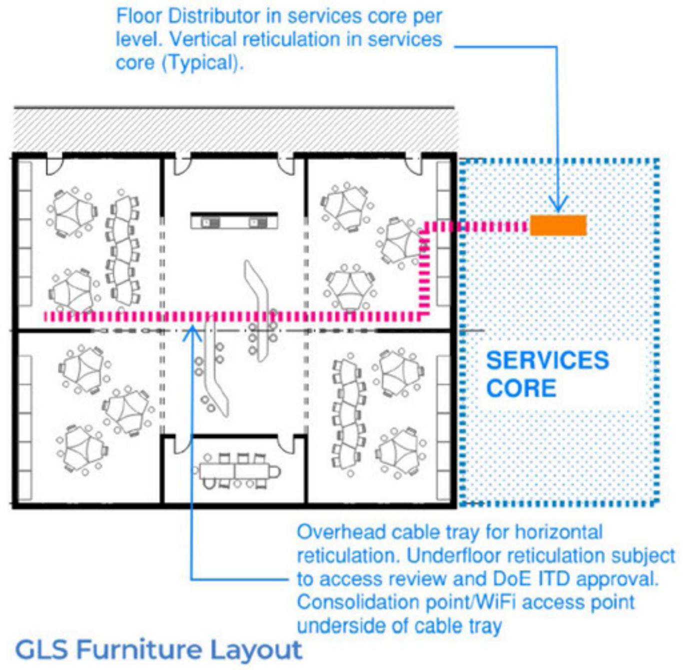


Figure 10: Typical Communications reticulation

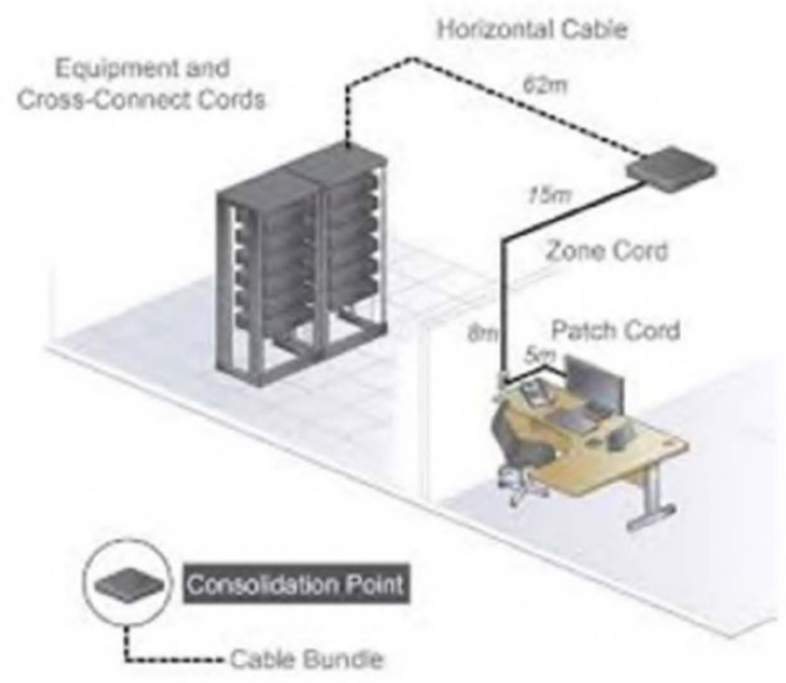


Figure 11: Typical reticulation with Consolidation Point

4.5 Services

Hydraulic Services

Hydraulic design to comply with EFSG and deemed to satisfy (DTS) requirements of the National Construction Code (NCC) and project specific ESD principles.

Spatials

- Centralised Solar/Electric Hot water generation plant for each site. - Centralised Grease Arrestor for each site where pre-treatment is required.- Authority Water meter assembly and backflow prevention arrangement located externally to schools building- Externally/Internally routed downpipes collecting roof water, diverted to in-ground re-use tank.- Min. 25kL in-ground rainwater harvesting tank for WC flushing and irrigation system for each site. - Class A Rainwater harvesting filtration system located externally, adjacent to re-use tank

General Reticulation

- Vertical drainage risers required for multi-level sites, including sanitary drainage/vents, trade waste/vents and stormwater.- Vertical pressure services riser requirements for multi-level sites includes; hot water flow/ return, domestic cold water and rainwater reuse.-

High level horizontal reticulation will occur below beam line, main pipework runs in some instances will penetrate beam line in coordinated locations.

Clarifications

- At the request of the client, no gas systems have been allowed for spatially.

- All main drainage runs will be kept external to the building structure to facilitate modular construction design.

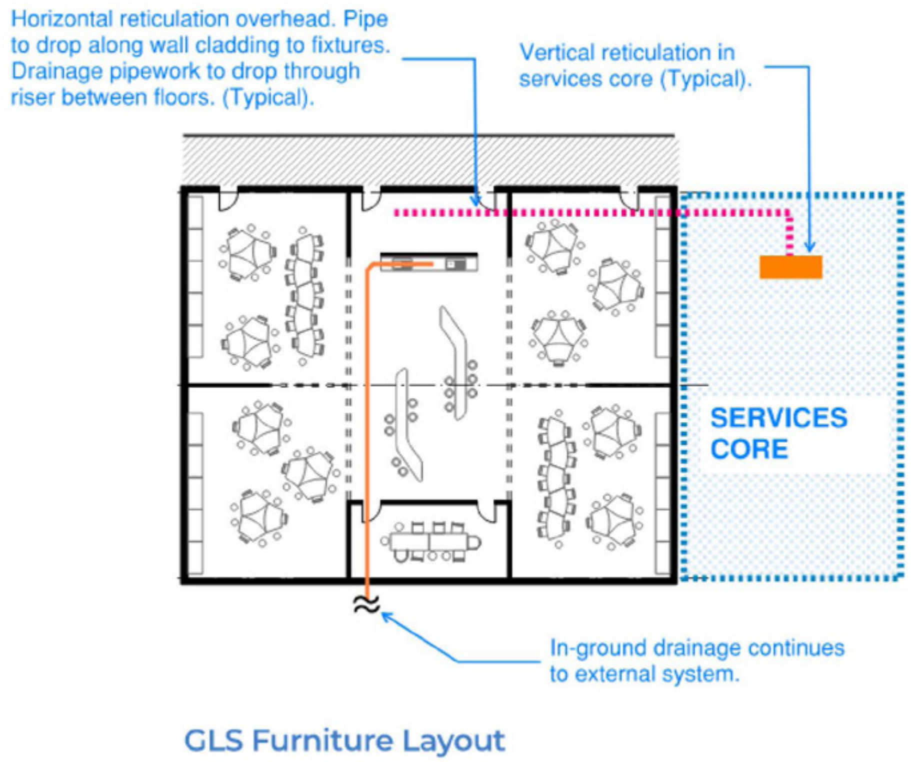


Figure 12: Attach homebase hydraulic design (water and drainage)

4.5 Services

Fire Protection Services

Fire Protection design to comply with EFSG and deemed to satisfy (DTS) requirements of the National Construction Code (NCC) and project specific Fire Engineering Brief.

Spatials

- Centralised, externally located fire pumpset within acoustic enclosure for each site, subject to available pressure and flow within authority water mains- Centralised Fire Indicator Panel (FIP) and Building Occupant Warning System (BOWS) module located within entrance lobby for each site.

General Reticulation

- Vertical fire main risers required for all multi-level sites, subject to final fire hydrant coverage diagrams. External Dual-Pillar Fire Hydrants positioned not less than 10m from building providing coverage to all ground floor areas. Internal Hydrants required for upper floors, Hydrant points to be located adjacent or within fire-isolated exits - Fire Hose Reels required within 4m of fire isolated exits.- Fire Blankets and Extinguishers located in strategic positions throughout the school facilities.- High level horizontal reticulation will occur below beam line, main pipework runs in some instances will penetrate beam line in coordinated locations.- Smoke detection, fire alarm speakers and light hazard sprinkler protection required in accordance with Fire Engineering Brief.

Clarifications

- Firefighting pumpsets may not be required at each site, subject to review of water authority information and further site analysis- All fire main runs will be kept external to the building structure to facilitate modular construction design.

4.6 Facade

Building façades are of significant importance in both communicating the architectural expression and in providing a required level of performance throughout their service life.

The role of the building façade is multi-faceted but primarily filters the external fluctuating conditions to provide a moderated internal environment for its occupants.

Achieving a high level of internal comfort is a key objective with specific focus to daylight access, visual comfort, thermal comfort and connection to outdoors. These objectives are expanded upon within Section 1.6.

Principles

The building façades are to be designed and constructed using the following underlying principles:

_ Prioritise off-site pre-assembly / minimise on site trades and interfaces;

_ Provide a high level of internal comfort to the building users;

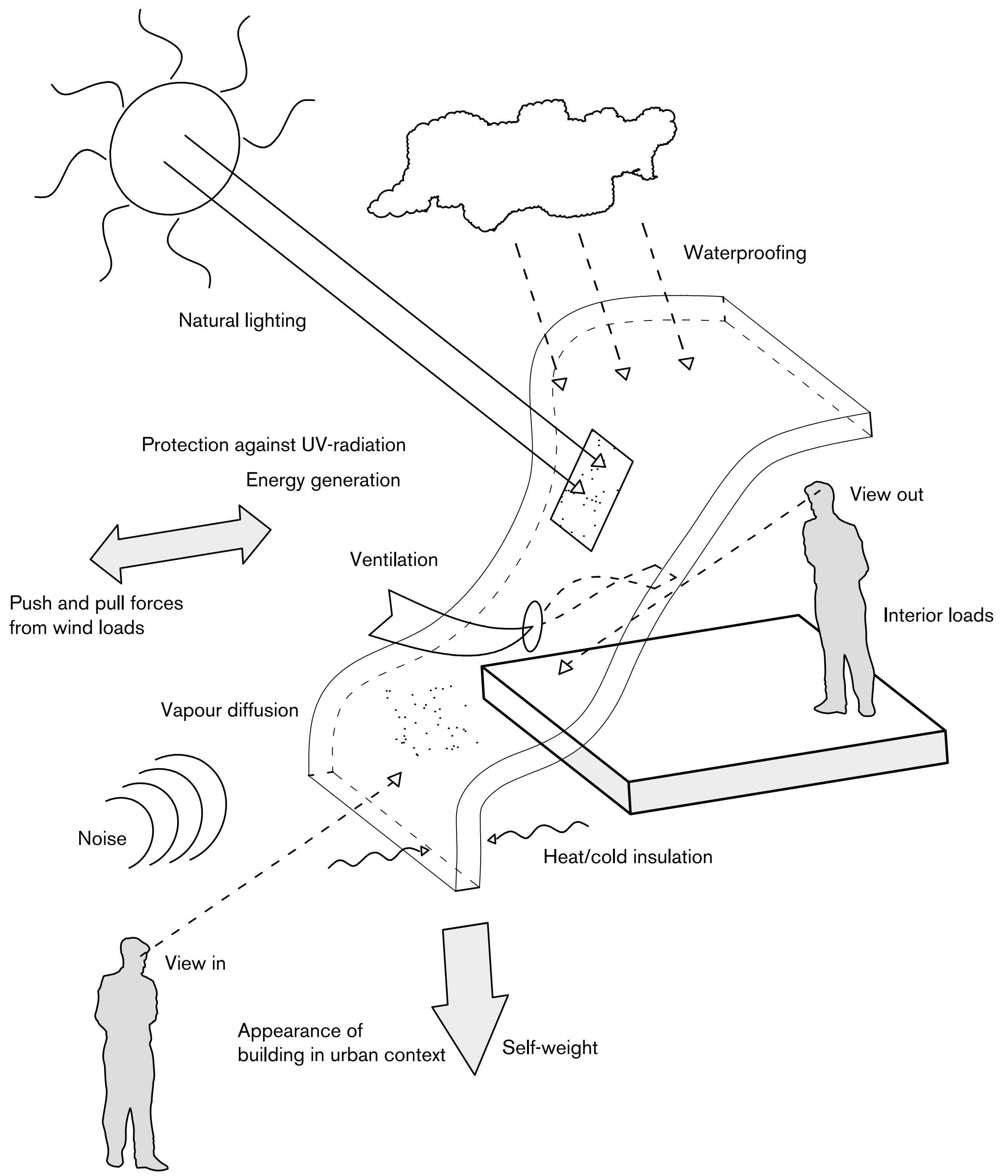
_ Promote near or net zero embodied and operational carbon;

_ Provide robust façade solutions that are highly durable, low maintenance and sustainable.

Educational Facilities Standards and Guidelines

The Educational Facilities Standards and Guidelines (EFSG) outlines the guiding principles for school design. It provides the minimum requirements of the technical components that make an element of school design.

Fabric design guides (DG20-27) and Openings design guides (DG31-39) outline the performance and specific design requirements of the structure and enclosure which are further supplemented by the guidelines presented within this document.



4.6 Facade

Façade Construction Options

The façade construction can be approached in various ways leaving the design team the freedom to innovate within the boundaries of this guide.

The Façade may be incorporated into the load bearing structure or form a series non-load bearing elements. Off-site pre-assembly and modularisation is encouraged.

Three approaches are indicatively shown:

_ Structure & Façade Mega Panel

_ Façade Mega Panel

_ Semi Panelised Façade

Structure & Façade Mega Panel

Factory assembled large format panellised façade with integrated load bearing structure.

Typical panel 7.5m wide x 4.2m high.

The load bearing structural system of CLT nib walls, central glulam column and perimeter glulam beams form a structural frame to which the façade elements are factory fixed and weatherproofed.

This would typically comprise of glazing systems, doors, ventilation, cladding, support framing, membranes, insulation, seals and pre-installed bracketry for site attachment of any shading devices.

Perimeter interlocking two-stage joints are to provide weather resistance, transfer of loads and the required movement capacity. AS 4284 tested.

Façade Mega Panel

Factory assembled large format panellised façade. Non load bearing and fixed external to structural elements.

Typical panel 7.5m wide x 4.2m high.

Formed of a self-supporting non load bearing frame to which the façade elements are factory fixed and weatherproofed.

This would typically comprise of glazing systems, doors, ventilation, cladding, support framing, membranes, insulation, seals and pre-installed bracketry for site attachment of any shading devices.

Perimeter interlocking two-stage joints are to provide weather resistance, transfer of loads and the required movement capacity. AS 4284 tested.

Semi Panellised Façade

Factory constructed sub-assemblies that are site fixed to the structure. Interfaces between façades elements to be weatherproofed on site.

Typical module width <1.5m.

Factory glazed panels to be installed to site fixed sub-head/sub-sill perimeter framing systems.

Opportunities for primary structure to be factory fitted with required membrane, insulation and cladding panels.

Further opportunities for spandrel zone to be pre-fabricated to achieve better performance and simplify site construction.

4.6 Facade

Façade Types

The Kit of Parts building outlined within this guide comprises of four principal façade types:

_ Façade Type A: Shaded façade

_ Façade Type B: Inner corridor façade

_ Façade Type C: Shear wall

_ Façade Type D: Outer corridor façade

Façade Type A: Shaded Façade

_ External horizontal and vertical solar shading to mitigate solar gain. Shading depth to respond to building orientation and environmental conditions. Dependent upon shading depth, shading can either be fully supported by the façade or be ground supported and braced back to the structure

_ Provide sufficient open area through the façade to achieve minimum deemed to satisfy provisions for natural ventilation (NCC F4.6)

_ Provide sufficient thermal comfort, daylight access, visual comfort and access to views (Section 1.6)

Façade Type B: Inner Corridor Façade

_ External horizontal and vertical solar shading to mitigate solar gain. Shading depth to respond to building orientation and environmental conditions. Dependent upon shading depth, shading can either be fully supported by the façade or be ground supported and braced back to the structure

_ Provide sufficient open area through the façade to achieve minimum deemed to satisfy provisions for natural ventilation (NCC F4.6)

_ Provide sufficient thermal comfort, daylight access, visual comfort and access to views (Section 1.6)

Façade Type C: Lateral Side Wall Façade

_ Opportunities to provide daylight through the lateral side walls is encourage where possible

_ Provide a weathertight and highly insulated wall

_ Provide an external rainscreen cladding system

Façade Type D: Outer Corridor Façade

_ Provide a barrier function (AS1170.1)

_ Provide sufficient daylight to through to the classrooms

_ Provide an element of weather protection in climate zone 6 regions

_ Materials and finishes to be robust, impact resistant and low maintenance due to heavier traffic

_ Provide sufficient open area through this outer façade (NCC F4.7) to allow the inner façade to achieve minimum deemed to satisfy provisions for natural ventilation (NCC F4.6)

4.6 Facade

Façade Performance

Codes

_ NCC National Construction Code – Building Code of Australia Volume One

_ AS/NZS 1170 Structural Design Actions

_ AS 4100 Steel Structures

_ AS 3600 Concrete Structures

_ AS 1720 Timber Structures

_ AS 3700 Masonry Structures

_ AS/NZS 1664 Aluminium Structures

_ AS 4312 Atmospheric Corrosivity Zones in Australia

_ AS 2047 Windows in Buildings – Selection and Installation

_ AS 4420 Windows - Methods of Test

_ AS 1288 Glass in Buildings – Selection and Installation

_ AS/NZS 4666 Insulating Glass Units

_ AS/NZS 2208 Safety Glazing Materials in Buildings

_ AS/NZS 4200 Pliable Building Membranes and Underlays

_ AS/NZS 4859 Thermal Insulation Materials for Buildings

_ AS/NZS 4284 Testing of Building Façades

_ AS 1530 Methods for Fire Tests on Building Materials

Structural Requirements

All façade elements are to be designed for:

_ 50 year minimum design life for structural integrity

_ 25 year minimum service life (life to first major maintenance)

_ General requirements AS1170.0

_ Wind loads to AS 1170.2

_ Barrier loads to AS 1170.1

_ Earthquake loads to AS 1170.4

_ Impact loads: Cladding types to be assessed against CWCT TN75 and tested to CWCT TN76

_ Maintenance loads: 1.1kN concentrated load for horizontal elements. 0.5kN concentrated load for vertical surfaces (applied anywhere)

_ Rope access loads (where applicable): Serviceability - 3kN concentrated load (no permanent damage permitted). Ultimate – as loads given in AS/NZS 4488 (no failure or dislodgement permitted)

_ Temporary and construction loads: design the system to include all handling and installation loads without causing over-stress or permanent deformation.

All anchors and supports shall be designed, fabricated and installed in full compliance with the performance criteria specified without over stress to itself or other elements. All fixings shall be of adequate strength for their purpose and are to accommodate the worst combination of structure tolerances.

Movement and Tolerances

The façade design shall be coordinated with the project Structural Engineer to confirm structural tolerances and building movements.

Indicative movements and tolerances shown below only:

_ Structural tolerances: Slab Level (RL) +/- 10mm. Slab Edge (On Plan) +/- 20mm.

_ Structural deflections: +/-10mm differential floor slab deflection.

The façade shall accommodate movements and imposed deflections due to primary structure deflections / elastic shortening / settlement / shrinkage / creep / movements due to wind or earthquake / thermal / frost / moisture-induced movements, without any reduction in performance.

_ Fabrication tolerances: Glass to AS 4667. Framing members cut to +/-1mm. No visible oil canning in metal panels.

_ Installation tolerances: +/3mm maximum deviation in plan. +/2mm maximum deviation in elevation. 3mm per 4,000mm run in any direction for maximum change in deviation.

Deflection Limits

_ Single glazing, lesser of span/60 or 20mm

_ Double glazing, lesser of span/90 or 20mm

_ Metal cladding: lesser of span/90 or 20mm

_ Aluminium and steel framing: Span/250 (out of plane); lesser of span/500 or 3mm (in plane dead loads)

_ Cantilever members: Span/150

_ Ultimate limit state: No non-linear (permanent) distortion

4.6 Facade

Weather Integrity

Glazing systems shall be designed as a pressure equalised framing system incorporating the following features:

_ A rainscreen. To prevent the majority of water entering the façade joints

_ An air barrier. Design for the full wind load and so that water penetrating the cavity does not reach the air barrier

_ A cavity between rainscreen and air barrier. This cavity shall be sufficiently ventilated and bounded by baffles, seals etc. to reduce the air pressure difference across the rainscreen and drained to the outside.

Cladding systems shall be designed as a drained and rear ventilated (or be pressure equalised) rainscreen system to the following principles:

_ Primary structure protected by control layers (air control, vapour control, water resistive layer, thermal control);

_ Suitable vapour permeable membrane to form air barrier and water resistive layer;

_ Continuous external insulation (non-combustible) to increase thermal performance, minimise thermal bridges and reduce condensation risk

_ Air cavity vented to the outside allowing drainage and ventilation and each level

_ Suitably robust rainscreen cladding panels supported by substructure with thermally broken pads to limit thermal transfer.

Interfacing assemblies shall incorporate a 2 stage drained joint and have equal performance of the systems they abut.

Energy Performance

The combined wall and glazing performance is to comply with NCC Section J and the façade optimisation studies outlined in Section 4.1.

The intent is to minimise energy use without compromising indoor environment quality (IEQ) performance. Daylight access, visual comfort, thermal comfort and views are critical IEQ performance parameters affecting the delivery of high quality learning environments.

The minimum thermal performance of façade elements will be determined on a project basis. Guidance system performance is given below:

_ Glazing system U value <2.8 W/m2k. Thermally broken framing system, DGU + low-e

_ Opaque wall system U value <0.8 W/m2k. Externally insulated wall.

(Calculations to NFRC 100-2014 and to include all framing and thermal bridging)

Hydrothermal modelling is recommended to evaluate the risk of interstitial condensation.

4.6 Facade

Acoustic Performance

The acoustic attenuation of the building façades and glass build-ups are to meet the requirements of Section 4.4 Acoustics.

The façades must be free of rattles, and other noise due to thermal or structural movements.

The wind noise generating properties of façade elements should be considered during design.

Fire Performance

Façade system are to be composed of non-combustible materials in accordance with the NCC and be verified through testing in accordance with AS1530.2 where required.

Materials which are deemed not non-combustible in accordance with the NCC may only be used where they form part of a Fire Engineered solution that has been developed and approved by the project Fire Engineer and Building Certifier.

All insulation products to be non-combustible. Aluminium composite panels are not permitted.

Maintenance

Façade systems and their materials and finishes are to be selected on the basis of:

_ Low maintenance

_ High durability

_ Appropriate when assessed to AS4312

_ Sufficiently resistant to impact (CWCT TN75, TN&76)

_ Sufficiently resistant to vandalism and graffiti

_ Sufficiently resistant to attack or infestation by, but not limited to: Micro-organisms, fungi, insects, rodents, birds & bats.

_ Allow replacement of damaged elements without removing adjacent panels or elements.

_ Have concealed fixings

Glazing

The glazing configuration will respond to project specific requirements but is to adhere to the following principles where possible:

_ Be laminated grade A safety glass to each accessible side of a double glazed unit;

_ Be generally heat strengthened for additional robustness and resistance to thermal stress;

_ Avoid toughened glass overhead;

_ Be sufficiently sized to resist project wind pressures, impact loads from persons and sports equipment, maintenance loads;

_ Be sufficiently sized to comply with the project specific acoustic requirements;

_ Appropriately respond to the NCC Section J requirements and the façade optimisation performance studies (Section 4.1). This typically requires double glazed units with a solar control coating;

_ Limit external reflectivity;

_ Comply with AS3959 in bush fire zones.

Shading

External solar shading is an effective method of mitigating solar heat gains through glazing. The efficiency of a shading device is dependent on its orientation, depth, position relative to the glass and permeability. Guidance shading ratios have been provided in Section 4.1 Sustainability.

Solar shading approaches are to consider the following:

_ Solar mitigation / occupant glare reduction / reduction of views;

_ Maintenance loads

_ Wind loads

_ Consideration of impact where at ground level

_ Avoid creating surfaces where objects can be thrown on to

_ Wind induced noise

_ High durability of materials and finish to minimise associated maintenance

_ Weathertightness of connections through the façade system

_ Structural connections

4.6 Facade

Ventilation Strategies

Minimum deemed to satisfy provisions are prescribed in accordance with F4.6 and F4.7 of the NCC. For cross ventilation to occur, openings positioned on opposing walls is encouraged where possible to promote cross ventilation.

Ventilation strategies are to consider the following:

_ Operability

_ Thermal performance

_ Water penetration resistance

_ Placement to avoid impact from persons at ground level

_ Wind induced noise

_ High durability of materials and finish to minimise associated maintenance

Testing

All façade systems are to be tested in a registered laboratory or test facility to demonstrate performance:

_AS 4284: unitised/mega panel façade systems

_AS 2047: windows and doors

DfMA

Kit Of Parts Cost Planning Report

Version 1.0

For: SINSW – Megan Boazman

2067-0080 - 25/11/2020

Prepared By Nigel Ho

Reviewed By Richard Smith

Contents

4.7 Cost

A. Glossary of Terms & Acronyms

Term/Acronym	Explanation
FECA	Fully Enclosed Covered Area which includes all spaces that are enclosed with a roof, a façade and a floor slab. This includes stairs, engineering, plant and circulation
UCA	Unenclosed Covered Area which includes all spaces that have a roof and slab but are unenclosed (without a façade). This includes circulation and COLA spaces that are bounded by balustrades or perforated mesh
GFA	Gross Floor Area which combines the area of UCA and FECA
COLA	Covered Outdoor Learning Area
UFA	Useable Floor Area which are teaching spaces and support spaces and include homebases, storage, general learning spaces, labs, workshops, libraries etc but exclude circulation, engineering, outdoor spaces, toilets, plant, etc.
Efficiency	The result of UFA divided by GFA and expressed as a percentage, the better the building efficiency.
DfMA	Design for Manufacturing & Assembly
DfMAD	Design for Manufacturing & Assembly & Disassembly. An additional methodology to designing product and its components to be broken back down into its most basic components.
DfMADR	Design for Manufacturing, Assembly, Disassembly & Reuse. An additional methodology to designing components in a way that allows their reuse (repurposing) in other products.
Standardisation	The process of making something conform to a standard in aim of ensuring designs and product are efficient, re-usable, compliant, provided on volume, utilising readily available components (KoPs) and ultimately continually improved to improve quality and cost effectiveness.
KoP's	Kit of Parts – Readily available, efficient, tested/proven easy to manufacture components that are used within standardised designs that are DfMA. Kit of Parts include both basic Components and also Assemblies such as Volumetric Modules and Pods.
Components	Individual manufacture components and elements that are deliverd and assembled on site. These may include wall panels, floor panels, columns, beams, trusses, windows/glazing, services components, joinery, handrails, FF&E Etc.
Assemblies	The pre-assembly of components to produces a higher value Part (part of KoP's) manufactured off-site such as Volumetric Modules or Pods.
Volumetric Modules	A module manufactured off site to a mostly finished standard, including structure, external finishes, services and internal finishes and assembled on site in a quick and efficient manner. This methodology typically focus on a smaller number of larger modules.

Pods	A Pod/module manufactured off site to a mostly finished standard, including structure, services and internal finishes and assembled within a traditional build or hybrid DfMA product. This methodology typically focus on a smaller modules or singular use such as bathrooms, amenities, services cores, lift or stair cores, etc. They are focused on critical path items to reduce construction time frames and where quality control is more critical and required.
Volumetric DfMA	Where designs are focused on the predominant use of manufactured Volumetric Modules.
Hybrid DfMA	Where designs are focused on the predominate use of manufactured Pods and Components.
Component DfMA	Where designs are focused on the predominate use of manufactured Components.
BSM	Base Structural Material – is a usual preferred structural material focused on by individual manufacturers, including steel, timber, concrete or composite.
Composite Materials	The use of 2 or more BSM materials together in composite leaning on strengths of all of the materials.
Project Cost	The cost to deliver a project including design, planning, manufacturing, construction and FF&E.
Building Cost	The cost to deliver a build product excluding design, planning, infrastructure, external works and FF&E.
Manufactured Off-site Cost	The Value or percentage of the Building Cost that is manufactured off-site. This will run between 10-90% of Building Cost, dependent upon the DfMA approach (Volumetric DfMA v Hybrid DfMA v Component DfMA).
Solutions	Typically a combination of a number of parts that are combined efficiently to a product that adds value to projects.
FEBQ	Fire Engineering Brief Questionnaire – What is provided to the Fire Brigade to advise them and start the consultative process around proposed alternate solutions.
FER	Fire Engineering Report – the report that following the consultative process for proposed Alternate Solution (FEBQ) that comprehensively explains and supports the Solutions.
Live Loads	Loads imposed by occupants – typically 3kpa (3kN/m2)
Dead Loads	Loads imposed by the structure and building itself
Mass Timber	Is a structural solution characterised by the use of large solid engineered wood panels for wall, floor and roof construction. It includes the use of materials such as Glulam and Cross Laminated Timber (CLT).
Glulam	Engineered timber where timber lamellas (planks) are glued in parallel layers to form elements ideally suited for columns, beams and rafters.
Cross Laminated Timer (CLT)	Engineered timber where timber lamella's (planks) are glued in perpendicular layers to form elements ideally suited for wall and floor panels.
Primary Beams	Beams that support floor or roof loads and span between primary supports such as loading bearing walls or columns.
Secondary Beams	Beams that help support floor or roof loads and span between primary beams.
In-situ concrete	Concrete elements that are constructed and poured on site in their final position.
Precast concrete	Concrete elements that are constructed off-site and handled into their final position on site.

4.7 Cost

1. Introduction

An Opportunity, an Accidental DfMA Think Tank and MBM's Challenge in costing DfMA Schools

Whilst SINSW have been procuring non-traditional schools since 2018, the methodology of DfMA is still very much an outlier in terms of the construction market. With SINSW's explicit message to industry that 'DfMA is the methodology of choice for all future schools' still resonating in contractors board rooms, the onset of COVID-19 provoked a pause in activity and a true 'silver lining' moment via the much needed 'stop and think' period. This slowdown has, in MBM opinion, unwittingly provoked potential for a wholesale industry rethink and an unprecedented opportunity for new construction methods. In fact, MBM's research and work in the DfMA team has given us encouragement that the many new and exciting contributors we are witnessing will force the positive evolution of DfMA methodology not just in the education sector but in building projects across all sectors.

DfMA is, it must be reiterated, a new methodology and as such, little benchmarking or historical cost data is accessible. As such, capturing the full cost and productivity benefits of prefabricated construction is not a straightforward proposition. It requires careful understanding in the choice of materials and spatial requirements. In addition, the challenges in design, manufacturing, technology, logistics, and assembly are simple in theory but with little historical context, difficult to estimate construction costs for.
How MBM overcame this challenge is detailed in the coming pages.

An Important Qualification: MBM's research and estimating here does assume that builders and suppliers are given license to operate in a market where they can achieve scale and repeatability. If the methodology is not granted sufficient scale, the estimates here are subject to review.

DfMA – MBM's Role as Cost Planners

Since early 2020, SINSW have been developing a 'universal design' for the design, manufacturing and assembly of new schools, both Primary and Secondary, based on a set dimensional planning grid.
An experienced team was assembled and led by the SINSW in-house DfMA SME, Megan Boazman.

SINSW requested MBM to provide cost planning services based on our experience of working with DfMA initiatives,

The team of Woods Bagot (Architects) and Mott MacDonald (integrated engineering, sustainability and DfMA subject matter experts), puts together an outline for the MBM scope of works.

Context

A new universal education planning grid (9m x 9m*) and design approach was to replace the current SINSW EFSG, means that certain spaces will be bigger than the current EFSG. While SINSW are clear on the reasons behind this (improved pedagogy, future flexibility, DfMA ready, etc.), the team wanted to counter any perception that it is more expensive to build bigger rooms (for example, just because a room is bigger does not increase the furniture or number of GPOs)

Specifically, SINSW required MBM to play an objective role in its assessment of DfMA in terms of both cost benefits and risks.

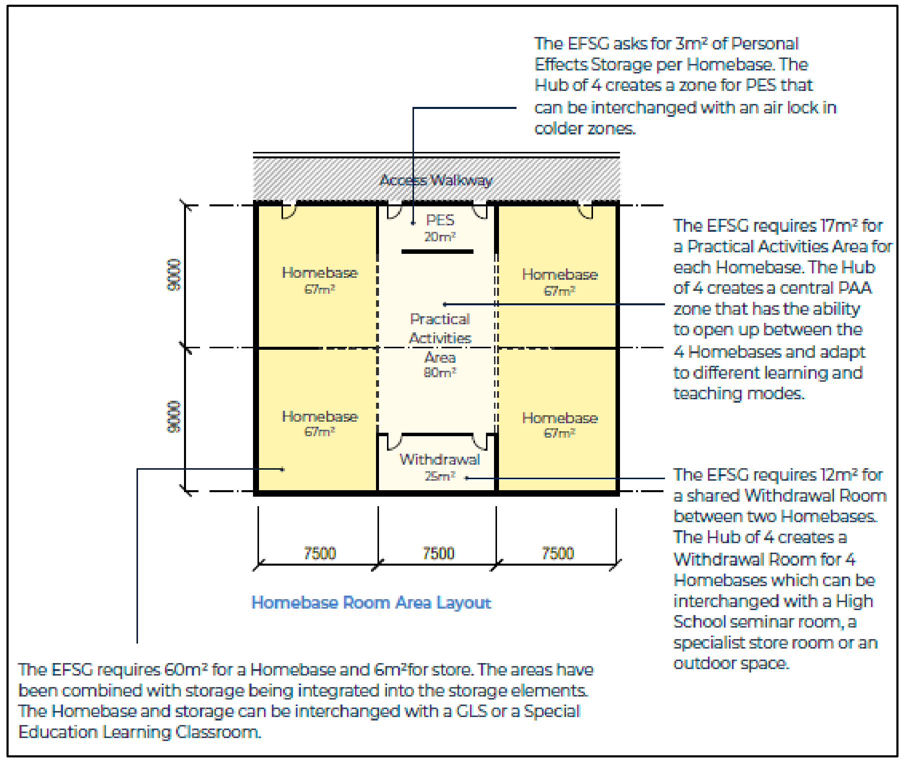
Planning Principles

Woods Bagot had compiled several Planning principles based on the original 9m x 9m grid, which were outlined in their initial report "Principles with Kit of Part External Finishes Samples: A Reference for Industry" dated 29th July 2020.

To be clear, the Education planning grid is applicable to *all* types of construction methods including the DfMA Component (KoP). The grid provides a consistent and standardised approach to the design of schools that promotes several key principles:

1. Prioritizing Pedagogy – The method and practice of teaching and learning is shifting and there is a need to provide the ability to transition between various different learning modes.
2. Equity – Consistency across all schools provide a huge leverage to deliver the same level of facilities and can be cost beneficial in delivering design, layout, construction and fitout.
3. Resilience and Wellness – Ability to adapt and protect against weather to focus on providing optimum teaching and learning environment.

4. Kit of Parts – A standardized universal education planning grid that have interchangeable modules for all types of schools: Primary, High School & Special education teaching spaces.
5. Investment & Infrastructure – Encourage to maximise off-site volumetric manufacturing to improve quality and maximise effective use of budget spending.
6. Whole of Life – Evolutionism of focus from Capital Spending to include whole of life costs, flexibilities and durability.



Standardised Hub of 4 – Extract from Woods Bagot Report "DfMA System Guidelines"

Spaces are to be designed to be able to adapt around within the planning framework for ease of transformation between various uses of the spaces, say from primary and high schools. Similarly it provides a template for future adoption of multi-disciplinary curriculum teaching space with either open plan, collaboration rooms or even shared specialist spaces.

2. Scope

2.1 Architecture Brief for Cost Planning

The following objectives were considered when undertaking costing exercises supporting the design principles established in this Guideline. (The New Schools DfMA System Guidelines)

1. **Construction costs**
   a. Modularity and repetition
   b. More efficient layouts with less circulation space and more outdoor areas
   c. Off-site manufacture, less waste, less vehicle movements, faster construction times
   d. Removal of wet trades on site
   e. Enhanced façade/ envelope performance (more cost but repetitive elements) allows installed building service provision to be reduced
   f. Site specific service strategy based on climate and context with potential for savings

2. **Whole life costs (see MBM Note in final section of report)**
   a. Flexibility to change function and use of spaces through fit-out
   b. Ease of maintenance with repetition
   c. Opportunity to grow and establish demand for NSW manufacturing capacity
   d. Enhanced façade/ envelope performance
      i. allows installed building service running costs to be reduced,
      ii. by removing plant so maintenance could be reduced,
      iii. addressing climate resilience by appropriate passive design
   e. Possibility in future dis-assembly and re-use of the building fabric on other sites. This relates to investing in quality products now to allow longer sustainable life of the materials used.

2.2 Engineering and Whole of Life Brief for Cost Planning

(see MBM Note in final section of report)

The following scope represents the Mott MacDonald requirements:

1. Inform and conduct whole-of-life costing analysis, including CAPEX and OPEX (maintenance and plant/equipment/material replacement cost) [4] across the following scenarios:
   a. Conventional, hybrid and alternative component and volumetric structures (bill of quantities by others); incl. floors and roofs, unique acoustic requirements, single- and multi-storey configurations [1, 3]

4.7 Cost

b. Conventional, component and volumetric façade elements, incl. sub-assemblies, walls, partitions, unitised systems and mega panels [1]

c. Conventional and alternative services components and modules, incl. HVAC systems (+ bushfire smoke haze control) for single- and multi-storey configurations, risers, plantrooms and horizontal distribution [1]

d. Renewable energy technologies, incl. solar PV (roof-mounted) and energy storage [1, 2]

2. Consider and advise on materials durability and constructability
3. Evaluate NCC 2019 uplift impacts, e.g. double glazing in lieu of single glazing; this further informs item 1. above (relevant uplift requirements to be identified by others)
4. Cost conventional building sealing solutions (NCC 2019, Section J, Part J3) and test against Verification Method JV4 (sample-based air permeability testing) (incl. enhanced sealing for bushfire smoke haze control)

Notes:

1. *Coordinated with acoustic and sustainability consultant, where required*
2. *Building integrated PV not considered due to non-combustible façade testing limitations*
3. *Multi-storey configuration to consider typical wing and stack planning (by others)*
4. *Running cost/savings by others*

Costing the different Construction Methodologies. An Explanation

Traditional

Building and structures are fully constructed on site. Conventional and established method of building. All trades are mostly engaged on site to complete the works. Given this is the tried and tested method of cosntruction, MBM and SiNSW had sufficient data to present accurate costings.

DfMA Volumetric (Modular Construction)

Volumetric prefabricated method is mostly manufactured off site in a factory and delivered to site. These modules are usually large and creates opportunity for future flexible changes. Adoption of Building Information Modelling (BIM) technology plays an important role to streamline the project delivery that stretches across various professional discipline in order to reduce both time and costs.

Again this methodology was market tested prior to the establishment of the DfMA team and parallels could be drawn with the existing demountables program. Regardless, MBM did carry out sanity checks and COVID-19 related costing updates.

4.7 Cost

DfMA Component (Kit of Parts)

The Component (Kit of Parts) methodology adopts a coherent process between on- and off-site construction. This approach leverage the efficiency in applying Building Information Modelling (BIM) technology, establishing a standardised range of building components. Kit of Parts methodology allows the ability to reap the benefits of streamlined delivery of projects.

This methodology was untested in NSW and as such MBM undertook three stages in which to arrive at a costing estimate it was comfortable with.

The three stages of cost plan evolution are detailed below:

a) Price the components of the job on first principles ie measure every piece of steel, timber, beam, window, nut and bolt in isolation and then overlay the attendant costs including but not limited to manufacturing and site-based installation costs

b) Seek market pricing from a select list of suppliers and builders acknowledging that any pricing was provided with no guaranteed pipeline of work.

c) Compile and compare all the various cost data available and attempt to establish an estimate as accurate as possible.

Specific Notes on Construction Considerations relevant to cost

Fire Engineering

Fire rating to the buildings have been efficiently designed to incorporate and satisfy fire requirement to the buildings.

Substructure

Typically, there are a few delivery methodologies that may apply to the delivery of Kit of Parts construction. Screw piers will most likely be the most efficient footing option which it can be used on land with mostly sand and silt.

Another method is to apply a domestic style concrete slab on ground, even potentially waffle pod construction if it is a single storey building. All solutions depend on the unique design and brief of each school.

Structural Elements

The main structural approach for Traditional & Volumetric would be a combination of structural steel framing infilled with light weight steel gauge walls and roof trusses.

Component (Kit of Parts) DfMA proposes an Architectural expressed Mass Timber portal frame to the main building structure. External walls will be prefinished with light weight timber and steel walls, where panels would come to site closed with windows an doors pre-installed, insulated lined with internal plasterboard and clad externally. Internal walls may also be pre-finished.

Taking into account of the structural elements, visually, a Component (KoP) based DfMA approach would effectively have the same look and feel as Traditional Build, whereas, Volumetric based DfMA would require the buildings to be raised off the ground, sitting on piers, giving slightly more temporary appearance.

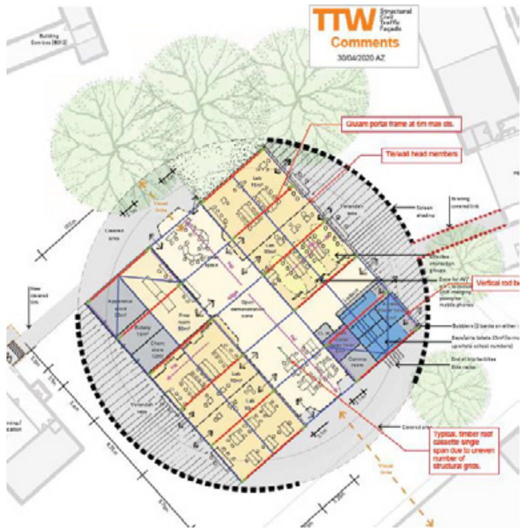
3. Projects and Basis of Research

3.1. First Cost Studies – Hawkesbury Centre of Excellence

Hawkesbury Centre of Excellence (CoE) is one of the first two school projects MBM explored using various construction delivery methodologies, Traditional Build, Volumetric & Kit of Parts (KoP).

3.2. First Cost Studies – Richmond STEM

Richmond High School STEM is the second project MBM explored.



3.3. First Cost Studies – Summarised

MBM have prepared estimates for each of the methodologies applicable. The traditional construction estimate was based on the extensive internal benchmarking data and recent completed projects. Quotes were obtained for cost estimates for the Modular Volumetric estimates

For the Kit of Parts estimates, TTW provided structural advice utilizing mass CLT (Cross Laminated Timber) With that guidance, MBM completed the estimate utilizing first estimating principles, measuring all elements and components.

The key findings of the cost planning exercise are tabulated below:

	Hawkesbury					Richmond				
	Traditional	DfMA Volumetric		DfMA Component		Traditional	DfMA Volumetric		DfMA Component	
	Cost/m2	Cost/m2	Variance to Traditional	Cost/m2	Variance to Traditional	Cost/m2	Cost/m2	Variance to Traditional	Cost/m2	Variance to Traditional
Building Works (Works to Building Structure Only, excl Landscaping, outbuildings etc.)	$ 2,653.17	$ 3,079.66	16%	$ 2,495.03	-6%	$ 2,977.84	$ 3,255.15	10%	$ 2,738.84	-8%
Main Contractor Preliminaries	$ 1,347.33	$ 949.40	-30%	$ 1,025.79	-24%	$ 593.42	$ 508.02	-14%	$ 520.40	-12%
Main Contractor Margin	$ 299.41	$ 316.47	6%	$ 293.08	-2%	$ 158.25	$ 169.34	7%	$ 148.69	-6%
TOTAL Building Cost	$ 4,299.92	$ 4,345.53	1%	$ 3,813.90	-11%	$ 3,729.51	$ 3,932.51	5%	$ 3,407.92	-7%
Professional Fees	$ 913.19	$ 917.76	0.5%	$ 864.59	-5%	$ 617.16	$ 491.08	-20%	$ 438.62	-29%
TOTAL Building Cost + Professional Fees	$ 5,213.11	$ 5,263.29	1%	$ 4,678.50	-10%	$ 4,346.67	$ 4,423.59	2%	$ 3,846.55	-12%

NB. Building works (as noted above) includes all substructure works, construction of the building shell (floor, walls & roof), internal fitout and typical building services. It excludes any allowances for FFE, IT, External works & service, landscaping and civil works. It is also important to note that any roof enhancements, and architectural external treatments are excluded.

3.4. First Cost Studies – Summary Findings

Utilizing Traditional construction methodology as the constant, on average the Volumetric construction costs presented as **1.5%** higher at approx. **$4,138/m2** excl Professional Fees and the Kit of Parts (KoP) methodology suggested a saving of **11%** lower at approx. **$3,610/m2**

4.7 Cost

3.5. Second Cost Studies – Googong Primary School

Googong Primary School cost estimates were prepared based on Woods Bagot overlay over the original SHAC design building footprint. Generally, the redesigned space is smaller with reduced external circulation areas as represented on the extracted sketch below.

Cost Estimate – Googong Primary School

Estimates include the construction of all buildings and facilities, including landscaping, external works and external services. Below is a summary extract of the cost plans prepared for Googong Primary School.

	Traditional			DfMA Volumetric			DfMA Component		
Description	Rate	Cost	Cost/m2 (GFA)	Rate	Cost	Cost/m2 (GFA)	Rate	Cost	Cost/m2 (GFA)
01 - Early & Enabling Works		$ -			$ -			$ -	
02 - Demolition & Site Prep		$ 761,361	$ 84		$ 761,361	$ 84		$ 618,730	$ 68
03 - New Build		$ 28,966,727	$ 3,195		$ 30,433,027	$ 3,357		$ 27,887,641	$ 3,076
04 - FECA		$ -	$ -		$ -	$ -		$ -	$ -
05 - UCA		$ -	$ -		$ -	$ -		$ -	$ -
06 - New Build - Project Specifics		$ 1,730,000	$ 191		$ 1,730,000	$ 191		$ 1,730,000	$ 191
07 - Refurb - Medium		$ -	$ -		$ -	$ -		$ -	$ -
08 - Refurb - Project Specifics		$ -	$ -		$ -	$ -		$ -	$ -
09 - External Works		$ 5,181,560	$ 572		$ 5,181,560	$ 572		$ 5,181,560	$ 572
10 - Demountable		$ -	$ -		$ -	$ -		$ -	$ -
11 - Temporary Works		$ -	$ -		$ -	$ -		$ -	$ -
12 - FF&E		$ 2,823,187	$ 311		$ 2,823,187	$ 311		$ 2,823,187	$ 311
13 - ICT		$ 785,264	$ 87		$ 785,264	$ 87		$ 785,264	$ 87
14 - Offsite Works & Infrastructure		$ 1,760,000	$ 194		$ 1,760,000	$ 194		$ 1,760,000	$ 194
15 - Other Allowance		$ -			$ -			$ -	
NETT CONSTRUCTION COSTS		$ 42,008,088	$ 4,634		$ 43,474,388	$ 4,796		$ 40,786,372	$ 4,499
Main Contractor's Preliminaries	18.00%	$ 7,561,456	$ 834	12.00%	$ 5,216,927	$ 576	14.00%	$ 5,710,092	$ 630
Main Contractor's Overheads and Profit	4.00%	$ 1,680,324	$ 185	4.00%	$ 1,738,976	$ 192	4.00%	$ 1,631,455	$ 180
Staging Costs	0.00%	$ -		0.00%	$ -		0.00%	$ -	
Prelims & Margin		**$ 9,241,779**			**$ 6,955,902**			**$ 7,341,547**	
GROSS CONSTRUCTION COSTS		$ 51,249,868	$ 5,654		$ 50,430,291	$ 5,563		$ 48,127,919	$ 5,309
Escalation to Main Works Construction to construction commencement (2 years Escalation)	4.00%	$ 2,049,995	$ 226	4.00%	$ 2,017,212	$ 223	4.00%	$ 1,925,117	$ 212
		$ -	$ -		$ -	$ -		$ -	$ -
Project Escalation Subtotal		**$ 2,049,995**			**$ 2,017,212**			**$ 1,925,117**	
Professional fees including HDC, QS, PM, Other and Insurance	15.00%	$ 7,687,480	$ 848	15.00%	$ 7,564,544	$ 834	15.00%	$ 7,219,188	$ 796
Consultant Fees Subtotal		**$ 7,687,480**			**$ 7,564,544**			**$ 7,219,188**	
Authority Charges incl LSL, Section 73, Section 96 etc.	0.70%	$ 358,749	$ 40	0.70%	$ 353,012	$ 39	0.70%	$ 336,895	$ 37
Authority Fees Subtotal		**$ 358,749**			**$ 353,012**			**$ 336,895**	
TOTAL BUILDING COSTS		$ 61,346,092	$ 6,767		$ 60,365,058	$ 6,659		$ 57,609,119	$ 6,355

Market pricing was received for Volumetric & Kit of Parts costs from MBS and Viridi respectively. Costs are adopted into the estimates to include on site construction, internal fitout, external works and external services.

Project Gross Construction Costs for Traditional build is at **$6,767/m2**, DfMA Volumetric costs is -2% lower compared to Traditional Build at **$6,659/m2** meanwhile DfMA Component is -6% lower at **$6,355/m2**. Costs include escalation, authority fees & consultant fees.

Normalised Estimate – Googong Primary School

In order to present a meaningful comparison of the various methodologies, we have removed any component that is specific to a methodology. In this way we can observe a direct comparison rather than a distorted one.

For this reason, the initial Googong estimate is normalised via the following steps:

1. Include Building costs of the core building facility – lifts, stairs and external covered walkways (verandahs)
2. Exclude FFE, IT, Landscaping, External Services, Civil Works, PV cells and any architectural enhancement allowances.
3. Include Preliminaries, Overheads and Margin
4. Adjust Consultant Fees for DfMA Component from 15% to 8% as per industry feedback.
5. Exclude Escalations and Authority Fees as this is a fluctuating constant that will skew the analysis result.

The Normalised estimate derived is shown in the table below:

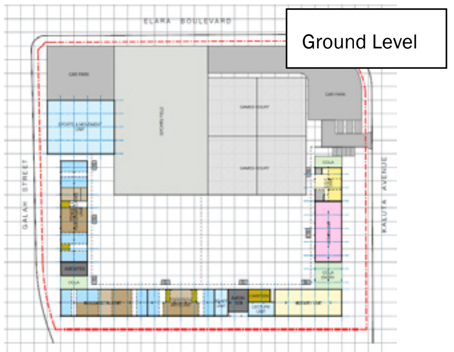
	Traditional			DfMA Volumetric			DfMA Component		
	%	Cost	Cost/m2	%	Cost	Cost/m2	%	Cost	Cost/m2
Construction Costs *(New build only, excluding external works, external services, landscaping, etc.)*		$ 28,966,727	$ 3,195		$ 30,433,027	$ 3,357		$ 27,887,641	$ 3,076
Main Contractor Preliminaries	18%	$ 5,214,011	$ 575	12%	$ 3,651,963	$ 403	14%	$ 3,904,270	$ 431
Main Contractor Overhead & Profit	4%	$ 1,158,669	$ 128	4%	$ 1,217,321	$ 134	4%	$ 1,115,506	$ 123
Subtotal		**$ 35,339,407**	**$ 3,898**		**$ 35,302,311**	**$ 3,894**		**$ 32,907,416**	**$ 3,630**
Consultant Fees	15%	$ 5,300,911	$ 585	15%	$ 5,295,347	$ 584	8%	$ 2,632,593.30	$ 290
TOTAL		**$ 40,640,318**	**$ 4,483**		**$ 40,597,658**	**$ 4,479**		**$ 35,540,010**	**$ 3,921**

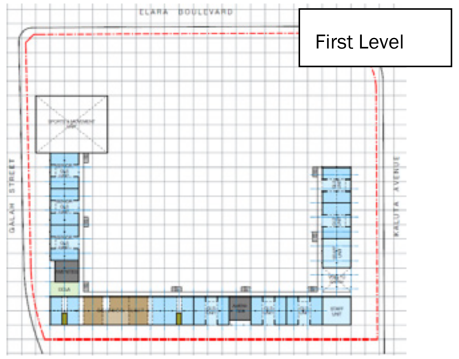
The costs of Traditional & Volumetric is at $4,483 and $4,479 respectively. Meanwhile DfMA Component or Kit Of Parts is at **$3,921/m2**, -13% lower compared to Traditional.

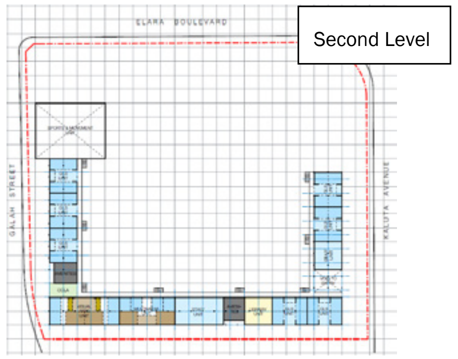
4.7 Cost

3.6. Second Cost Studies – Marsden Park High School

Marsden Park High School estimates were prepared based on sketch designs, spanning over 3 Levels including Ground Floor from Woods Bagot as shown below.







Cost Estimate – Marsden Park High School

Estimates include the construction of all buildings and facilities, including landscaping, external works and external services.

Below is a summary extract of the cost plans prepared for Marsden Park High School.

	Traditional			DfMA Volumetric			DfMA Component (KoP)		
Description	**Rate**	**Cost**	**Cost/m2 (GFA)**	**Rate**	**Cost**	**Cost/m2 (GFA)**	**Rate**	**Cost**	**Cost/m2 (GFA)**
01 - Early & Enabling Works		$ -			$ -			$ -	
02 - Demolition & Site Prep		$ 1,662,190	$ 70		$ 1,662,190	$ 70		$ 1,662,190	$ 70
03 - New Build		$ 75,775,910	$ 3,211		$ 82,494,100	$ 3,496		$ 65,806,994	$ 2,788
04 - FECA		$ -	$ -		$ -	$ -		$ -	$ -
05 - UCA		$ -	$ -		$ -	$ -		$ -	$ -
06 - New Build - Project Specifics		$ 440,000	$ 19		$ 440,000	$ 19		$ 440,000	$ 19
07 - Refurb - Medium		$ -	$ -		$ -	$ -		$ -	$ -
08 - Refurb - Project Specifics		$ -	$ -		$ -	$ -		$ -	$ -
09 - External Works		$ 6,810,120	$ 289		$ 6,810,120	$ 289		$ 6,860,120	$ 291
10 - Demountable		$ -	$ -		$ -	$ -		$ -	$ -
11 - Temporary Works		$ -	$ -		$ -	$ -		$ -	$ -
12 - FF&E		$ 5,800,350	$ 246		$ 5,800,350	$ 246		$ 5,800,350	$ 246
13 - ICT		$ 1,791,360	$ 76		$ 1,791,360	$ 76		$ 1,791,360	$ 76
14 - Offsite Works & Infrastructure		$ 1,130,000	$ 48		$ 1,130,000	$ 48		$ 1,130,000	$ 48
15 - Other Allowance		$ -			$ -			$ -	
NETT CONSTRUCTION COSTS		**$ 93,409,920**	**$ 3,958**		**$ 100,128,110**	**$ 4,243**		**$ 83,491,004**	**$ 3,538**
Main Contractor's Preliminaries	18.00%	$ 16,813,786	$ 712	12.00%	$ 12,015,373	$ 509	14.00%	$ 11,688,741	$ 495
Main Contractor's Overheads and Profit	4.00%	$ 3,736,397	$ 158	4.00%	$ 4,005,124	$ 170	4.00%	$ 3,339,640	$ 142
Staging Costs	0.00%	$ -		0.00%	$ -		0.00%	$ -	
Prelims & Margin		**$ 20,550,182**			**$ 16,020,498**			**$ 15,028,381**	
GROSS CONSTRUCTION COSTS		**$ 113,960,102**	**$ 4,829**		**$ 116,148,608**	**$ 4,922**		**$ 98,519,385**	**$ 4,175**
Escalation to Main Works Construction to construction commencement (2 years Escalation)	4.00%	$ 4,558,404	$ 193	4.00%	$ 4,645,944	$ 197	4.00%	$ 3,940,775	$ 167
		$ -	$ -		$ -	$ -		$ -	$ -
Project Escalation Subtotal		**$ 4,558,404**			**$ 4,645,944**			**$ 3,940,776**	
Professional fees including HDC, QS, PM, Other and Insurance	15.00%	$ 17,094,015	$ 724	15.00%	$ 17,422,291	$ 738	8.00%	$ 7,881,551	$ 334
Consultant Fees Subtotal		**$ 17,094,015**			**$ 17,422,291**			**$ 7,881,551**	
Authority Charges incl LSL, Section 73, Section 96	0.70%	$ 797,721	$ 34	0.70%	$ 813,040	$ 34	0.70%	$ 689,636	$ 29
Authority Fees Subtotal		**$ 797,721**			**$ 813,040**			**$ 689,636**	
TOTAL BUILDING COSTS		**$ 136,410,243**	**$ 5,780**		**$ 139,029,883**	**$ 5,891**		**$ 111,031,347**	**$ 4,705**

Market pricing was received for Volumetric & Kit of Parts costs from MBS and Viridi respectively. Costs include on site construction, internal fitout, external works and external services.

Total Building Costs for the Traditional build is at **$5,780/m2**, DfMA Volumetric costs is approx. 2% higher compared to Traditional Build at **$5,891/m2** meanwhile DfMA Component is -19% lower at **$4,705/m2**. Costs includes escalation, authority fees & consultant fees.

Normalised Estimate – Marsden Park High School

In order to present a meaningful comparison of the various methodologies, we have removed any component that is specific to a methodology. In this way we can observe a direct comparison rather than a distorted one.

For this reason, the initial Marsden Park estimate is normalised via the following steps:

1. Include Building costs of the core building facility – lifts, stairs and external covered walkways (verandahs)
2. Excludes FFE, IT, Landscaping, External Services, Civil Works, PV cells and any architectural enhancement allowances.
3. Include Preliminaries and Overheads & Margin
4. Include Consultant Fees for DfMA Component (Initial estimate already at 8% - Learning from Googong Estimate)
5. Escalations & Authority Fees are excluded in this calculation as it is considered to be a fluctuating constant that will skew the analysis result.

4.7 Cost

Normalised estimate derived is shown in the table below:

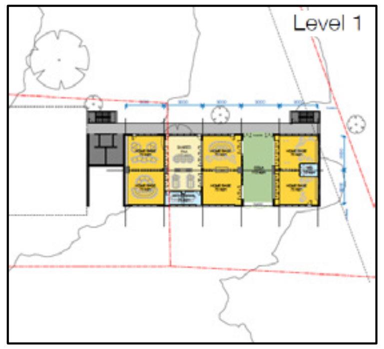
	Traditional			DfMA Volumetric			DfMA Component		
	%	Cost	Cost/m2	%	Cost	Cost/m2	%	Cost	Cost/m2
Construction Costs *(New build only, excluding external works, external services, landscaping, etc.)*		$ 75,775,910	$ 3,211		$ 82,494,100	$ 3,496		$ 65,806,994	$ 2,788
Main Contractor Preliminaries	18%	$ 13,639,664	$ 578	12%	$ 9,899,292	$ 419	14%	$ 9,212,979	$ 390
Main Contractor Overhead & Profit	4%	$ 3,031,036	$ 128	4%	$ 3,299,764	$ 140	4%	$ 2,632,280	$ 112
Subtotal		$ 92,446,610	$3,917		$ 95,693,156	$4,055		$ 77,652,253	$3,290
Consultant Fees	15%	$ 13,866,992	$ 588	15%	$ 14,353,973	$ 608	8%	$ 6,212,180.24	$ 263
TOTAL		$ 106,313,602	$4,505		$ 110,047,129	$4,663		$ 83,864,433	$3,554

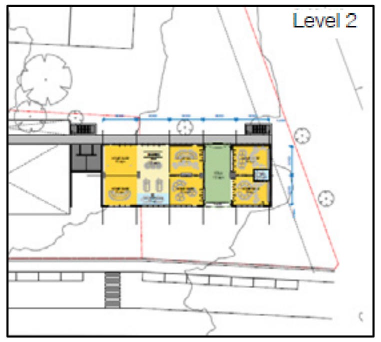
As can be seen, the costs of Traditional & Volumetric build is **$4,505 and $4,663** respectively. Meanwhile DfMA Component or Kit Of Parts is at **$3,554/m2**, -21% lower compared to Traditional

The lower costs for DfMA is in part due to the reduced consultant fees at 8%, projected by MBM and supported to some extent by market feedback. The theory being that a standardised design will require less professional consultant engagement throughout the project life. This projection, is however, subject to ongoing monitoring.

3.7. Second Cost Studies – Westmead South Primary School (Stage 2)

Westmead South Primary School (Stage 2) estimate were prepared based on sketches, spanning over 3 Levels including Ground Floor from Woods Bagot as shown below.





Cost Estimate – Westmead South Primary School (Stage 2)

Estimates include the construction of all buildings and facilities, including landscaping, external works and external services. Below is a summary extract of the cost plans prepared for Westmead South Primary School (Stage 2).

	Traditional			DfMA Volumetric			DfMA Component		
Description	Rate	Cost	Cost/m2 (GFA)	Rate	Cost	Cost/m2 (GFA)	Rate	Cost	Cost/m2 (GFA)
01 - Early & Enabling Works		$ -			$ -			$ -	
02 - Demolition & Site Prep		$ 487,640	$ 171		$ 487,640	$ 171		$ 487,640	$ 171
03 - New Build		$ 8,740,614	$ 3,060		$ 9,876,894	$ 3,458		$ 8,128,771	$ 2,846
04 - FECA		$ -	$ -		$ -	$ -		$ -	$ -
05 - UCA		$ -	$ -		$ -	$ -		$ -	$ -
06 - New Build - Project Specifics		$ 210,000	$ 74		$ 210,000	$ 74		$ 210,000	$ 74
07 - Refurb - Medium		$ -	$ -		$ -	$ -		$ -	$ -
08 - Refurb - Project Specifics		$ -	$ -		$ -	$ -		$ -	$ -
09 - External Works		$ 1,614,000	$ 565		$ 1,614,000	$ 565		$ 1,614,000	$ 565
10 - Demountable		$ -	$ -		$ -	$ -		$ -	$ -
11 - Temporary Works		$ -	$ -		$ -	$ -		$ -	$ -
12 - FF&E		$ 840,706	$ 294		$ 840,706	$ 294		$ 840,706	$ 294
13 - ICT		$ 567,955	$ 199		$ 567,955	$ 199		$ 567,955	$ 199
14 - Offsite Works & Infrastructure		$ 565,000	$ 198		$ 565,000	$ 198		$ 565,000	$ 198
15 - Other Allowance		$ -			$ -			$ -	
NETT CONSTRUCTION COSTS		**$ 13,025,915**	**$ 4,560**		**$ 14,162,195**	**$ 4,958**		**$ 12,414,072**	**$ 4,346**
Main Contractor's Preliminaries	18.00%	$ 2,344,665	$ 821	12.00%	$ 1,699,463	$ 595	14.00%	$ 1,737,970	$ 608
Main Contractor's Overheads and Profit	4.00%	$ 521,037	$ 182	4.00%	$ 566,488	$ 198	4.00%	$ 496,563	$ 174
Staging Costs	0.00%	$ -		0.00%	$ -		0.00%	$ -	
Prelims & Margin		**$ 2,865,701**			**$ 2,265,951**			**$ 2,234,533**	
GROSS CONSTRUCTION COSTS		**$ 15,891,616**	**$ 5,564**		**$ 16,428,146**	**$ 5,752**		**$ 14,648,606**	**$ 5,129**
Escalation to Main Works Construction to construction commencement. (to FY20)	9.00%	$ 1,430,245	$ 501	9.00%	$ 1,478,533	$ 518	9.00%	$ 1,318,374	$ 462
		$ -	$ -		$ -	$ -		$ -	$ -
Project Escalation Subtotal		**$ 1,430,245**			**$ 1,478,533**			**$ 1,318,374**	
Professional fees including HDC, QS, PM, Other and Insurance	15.00%	$ 2,383,742	$ 835	12.00%	$ 1,971,378	$ 690	8.00%	$ 1,171,888	$ 410
Consultant Fees Subtotal		**$ 2,383,742**			**$ 1,971,378**			**$ 1,171,888**	
Authority Charges incl LSL, Section 73, Section 96	0.70%	$ 111,241	$ 39	0.70%	$ 114,997	$ 40	0.70%	$ 102,540	$ 36
Authority Fees Subtotal		**$ 111,241**			**$ 114,997**			**$ 102,540**	
Land Acquisition - Capital expenditure, fees etc.		$ -	$ -		$ -	$ -	0.00	$ -	$ -
Land Fees Subtotal		**$ -**			**$ -**			**$ -**	
TOTAL BUILDING COSTS		**$ 19,816,846**	**$ 6,938**		**$ 19,993,054**	**$ 7,000**		**$ 17,241,408**	**$ 6,036**

Costs for Volumetric & Kit of Parts are adopted from market pricing previously received. Costs are applied to the estimates to include on site construction, internal fitout, external works and external services.

Total Building Costs for Traditional build are estimated at **$6,938/m2**, DfMA Volumetric costs is approx. 1% higher compared to Traditional Build at **$7,000/m2** meanwhile DfMA Component is -13% lower at **$6,036/m2**. Costs includes escalation, authority fees & consultant fees.

Normalised Estimate – Westmead South Primary School (Stage 2)

In order to present a meaningful comparison of the various methodologies, we have removed any component that is specific to a methodology. In this way we can observe a direct comparison rather than a distorted one.

For this reason, the initial Westmead South Primary School (Stage 2) estimate is normalised via the following steps:

1. Include Building costs of the core building facility – lifts, stairs and external covered walkways (verandahs)
2. Excludes FFE, IT, Landscaping, External Services, Civil Works, PV cells and any architectural enhancement allowances.
3. Include Preliminaries and Overheads & Margin
4. Include Consultant Fees for DfMA Component (Initial estimate already at 8% - Learning from previous estimates)

5. Escalations & Authority Fees are excluded in this calculation as it is considered to be a fluctuating constant that will skew the analysis result.

	Traditional			DfMA Volumetric			DfMA Component		
	%	Cost	Cost/m2	%	Cost	Cost/m2	%	Cost	Cost/m2
Construction Costs *(New build only, excluding external works, external services, landscaping, etc.)*		$ 8,740,614	$ 3,060		$ 9,876,894	$ 3,458		$ 8,128,771	$ 2,846
Main Contractor Preliminaries	18%	$ 1,573,311	$ 551	12%	$ 1,185,227	$ 415	14%	$ 1,138,028	$ 398
Main Contractor Overhead & Profit	4%	$ 349,625	$ 122	4%	$ 395,076	$ 138	4%	$ 325,151	$ 114
Subtotal		**$ 10,663,549**	**$3,733**		**$ 11,457,197**	**$4,011**		**$ 9,591,950**	**$3,358**
Consultant Fees	15%	$ 1,599,532	$ 560	12%	$ 1,374,864	$ 481	8%	$ 767,356	$ 269
TOTAL		**$ 12,263,081**	**$4,293**		**$ 12,832,060**	**$4,493**		**$ 10,359,306**	**$3,627**

AS can be seen, the costs of Traditional & Volumetric is at **$4,293/m2 and $4,493/m2 res**pectively. Meanwhile DfMA Component or Kit Of Parts is at **$3,627/m2**, -16% lower compared to Traditional.

Consultant costs for Westmead South PS are estimated at 12% of Gross Building Costs as a result of discussions with the project team, taking into account that most of the engaged consultants are already working on Stage 1 of the project. As in the previous estimate, the lower costs for DfMA is in part due to the reduced consultant fees at 8%, projected by MBM and supported to some extent by market feedback. The theory being that a standardised design will require less professional consultant engagement throughout the project life. This projection, is however, subject to ongoing monitoring.

3.8. Second Cost Studies – Summary Findings

The second stage of cost estimates was prepared with more detailed industry input and as such the estimates are validating all previous MBM research and projections. A pleasing result. The input of more advanced design advice, improved detailing and market feedback has helped promote confidence in the methodology and importantly the acceleration in the knowledge gained by the DfMA team will hopefully reflect the future progress of the methodology in the construction market

As stated at the outset of this report the MBM estimates are all based on the prerequisite that the DfMA pipeline is presented en masse to the market and guaranteed. Failure to fulfill this qualification will mean these estimates will need to be reviewed.

4. Summary

4.1. DfMA Component/KoP Cost Summary

Summarizing the analysis for 5 projects, the cost estimates have yielded a consistent result showing a cost saving of 14% compared to a traditional build.

Below is a compilation of all KoP estimates prepared:

		Googong		Marsden Park HS		Westmead PS (Stage 2)		Hawkesbury		Richmond	
		Cost	Cost/m2	Cost	Cost/m2	Cost	Cost/m2	Cost	Cost/m2	Cost	Cost/m2
Construction Costs *(New build only, excluding external works, landscaping)*		$ 27,887,641	$ 3,076	$ 65,806,994	$ 2,788	$ 8,128,771	$ 2,846	$ 13,605,420	$ 2,495	$ 3,083,930	$ 2,739
Main Contractor Preliminaries	14%	$ 3,904,270	$ 431	$ 9,212,979	$ 390	$ 1,138,028	$ 398	$ 1,904,759	$ 349	$ 431,750	$ 383
Main Contractor Overhead & Profit	4%	$ 1,115,506	$ 123	$ 2,632,280	$ 112	$ 325,151	$ 114	$ 544,217	$ 100	$ 123,357	$ 110
Subtotal		$ 32,907,416	$3,630	$ 77,652,253	$3,290	$ 9,591,950	$3,358	$ 16,054,396	$2,944	$ 3,639,037	$3,232
Consultant Fees	8%	$ 2,632,593	$ 290	$ 6,212,180	$ 263	$ 767,356	$ 269	$ 1,284,352	$ 236	$ 291,123	$ 259
TOTAL		$ 35,540,010	$3,921	$ 83,864,433	$3,554	$ 10,359,306	$3,627	$ 17,338,748	$3,180	$ 3,930,160	$3,490

Based on the table above, the average Construction cost **$3,554/m2**

4.2. Typical Normalised Kit of Parts Cost Breakdown

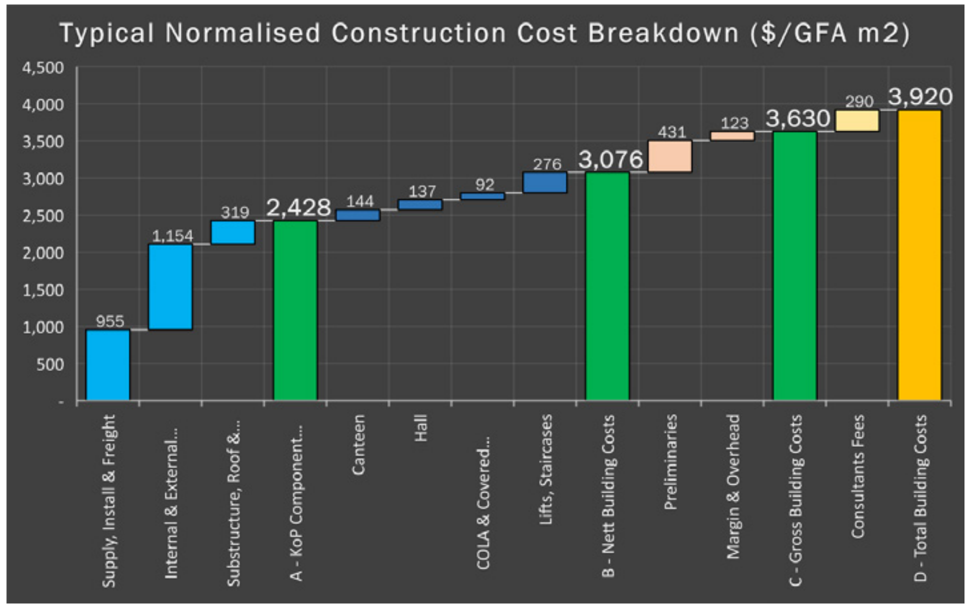


Chart: Typical KoP Construction Estimate Breakdown

Googong cost estimate comprises of a hybrid delivery, both KoP and traditional build. Canteen, Halls and reticulation areas are estimated to be traditional build. Utilizing Googong cost estimate as an example, the Chart above shows the breakdown of the cost estimate which primarily consists of 4 Major Components;

a. Kit of Parts Construction – Supply, Installation, Delivery; includes Substructure, Roofing and Fitout
b. Traditional Outbuilding Construction – Canteen, Halls, COLAs that require traditional on site constructions. Vertical reticulations (Lifts, Stairs) are included in this category.
c. Contractor's Preliminaries, Overheads & Margin
d. Consultants Fees

	Scope	Cost ($)	Cost/m2 ($)	% of Total Building Costs
Kit of Parts	Supply, Install & Freight	8,657,434	955	24%
	Internal & External Fitout	10,462,160	1,154	29%
	Substructure, Roof & Roof Plumbing	2,888,370	319	8%
	Subtotal Kit of Parts	22,007,964	2,428	62%
	A - KoP Component Total	22,007,964	2,428	62%
Traditional Building	Canteen	1,308,000	144	4%
	Hall	1,239,300	137	3%
	COLA & Covered Walkway	832,377	92	2%
	Lifts, Staircases	2,500,000	276	7%
	Subtotal Traditional Building Costs	5,879,677	649	17%
	B - Nett Building Costs	27,887,641	3,076	78%
Prelims & Margin	Preliminaries	3,904,270	431	11%
	Margin & Overhead	1,115,506	123	3%
	Subtotal Prelims & Margin	5,019,775	554	14%
	C - Gross Building Costs	32,907,416	3,630	93%
Fees	Consultants Fees	2,632,593	290	7%
	Subtotal Fees	2,632,593	290	7%
	D - Total Building Costs	35,540,010	3,920	100%

The above table shows The Supply, Installation & Delivery of the structural component is in the range of $955/m2 to $1100/m2. Meanwhile the internal and external fitouts costs including substructure components totals approx. $1,500/m2 which brings the total of the main KoP structure costs to approx. $2,500/m2.

This cost should also needs to include the cost of vertical reticulation which at approx. $276/m2 means a totals of approx. $2,776/m2 for the classrooms. To form nett building costs, costs for Canteen, Hall and COLA & Covered Walkway is added.

Preliminaries and Margin & Overhead are calculated at 14% and 4% of Nett Building Costs respectively. Consultant fees is 8% of Gross Building Costs.

5. Conclusion

5.1. Conclusion

Based on the current benchmarking data from SiNSW which shows traditional build costs at $4,500/m2 and the 14% (average) saving provoked by the DfMA methodology, the above findings validate the pursuance of standardised DfMA construction.

It is in fact MBM's opinion that longer term analysis – and assuming as we have throughout this exercise, that DfMA will be taken up wholesale by the sector, will provoke further cost reductions and at the same time improve programme efficiencies.

5.2. Future Cost Savings

Our previous research suggested that prefabricated construction can reduce build programs by 15-25% and construction costs by 5%. MBM believes that these savings can be increased over time. Below we discuss some of the potential areas of focus for time related cost savings.

<u>Consultants and Design</u>

There is clearly a learning curve as designers become familiar with the manufacturing process. Quantity Surveyors play an important role in providing advice on design decisions as these decisions need to be made quickly to avoid changes later in the process which are both more costly and more difficult.

MBM believes that once the standardisation design principles are established, savings of around 15% in design time could be achieved.

<u>Substructure</u>

Given that prefabricated classrooms are designed to be lightweight for transportation, this can reduce the size and complexity of the concrete slab as well as foundations. This knock on effect will produce some time and cost savings. In addition, manufacturing can take place in parallel with early site works (including slabs and foundations) unlike the linear timeline of a traditional project.

<u>The Manufacturing Process</u>

Eventually as standardisation is established, the factory manufacturing process will eclipse the equivalent building process on site.

<u>Building Works Onsite</u>

Outside of the external works scope, the process of essentially assembling prefabricated classrooms on site and connecting services to the main site connections is a much simpler role for the builder and therefore significantly faster and in theory cheaper than traditional construction.

<u>Defects, Defects, Defects!</u>

One of the less tangible factors, but to SiNSW stakeholders, most attractive benefits of prefabrication, is the quality control evident in a controlled factory environment. This process reduces and eliminates onsite human error and ultimately negates 'difficult to detect' defect rectification, significantly improving programs and costs.

4.7 Cost

5.3. Whole of Life and Lifecycle Costs

Lifecycle costs have been developed in accordance with whole of life costing guidelines as a % of capital costs These results have been derived from cross referencing benchmark data obtained from an elemental breakdown of capital costs on a particular school.

We have then utilised 'industry standard' percentages for the likely replacement timelines (in years and cross-referencing benchmark data).

To place some context on the challenge of producing meaningful data, it is important to accept that a key component of life cycle cost analysis is determined by cost and quality of materials and workmanship, therefore, the differences in life cycle costs between a traditionally construction school and a DfMA procured school are – in theory – negligible since both are using the same materials albeit a DfMA schools is assembled via a different process or method. There is some reasonable grounds, in MBM's opinion to support the theory that work taking place in a quality controlled environment, will produce a higher level of quality and workmanship, therefore the likelihood of embedded or superficial defects and ultimately the maintenance costs is reduced significantly. In addition, the reduced time on site and lessend exposure to inclement weather would also dramatically reduce weather sourced defects.

5.4. Assessing Marsden Park and Googong school life cycle costs

Projected Annual Maintenance Costs – Overview

	Googong PS			Marsden Park HS		
	CAPEX ($)	Projected Annual Maintenance Costs ($)	Average %	CAPEX ($)	Projected Annual Maintenance Costs ($)	Average %
Traditional	36,040,935	1,072,919	2.98%	78,822,436	2,451,229	3.11%
DfMA Component (KoP)	35,144,849	1,045,366	2.97%	70,594,127	2,197,469	3.11%

Table above shows a straight-line approach in determining projected maintenance costs derived from capital expenditure (CAPEX) and a typical life cycle profile for a school.

Using a traditional build methodology and the available historical data (there is no DfMA historical data) as a basis for calculating DfMA lifecycle costs, the table suggests a small saving per year for using DfMA methodology.

A more detailed analysis follows:

Marsden Park - Projected Annual Maintenance Costs – Breakdown

Description	Annual Maintenance Costs					
	Capital Cost ($)	Planned Preventative Maintenance		Capital Cost ($)	Planned Preventative Maintenance	
		%	$		%	$
	Marsden Park HS - Traditional			Marsden Park HS - Component (KoP)		
Early & Enabling Works	0	0.00%	-	0	0.00%	-
Demolition & Site Preparation	1,662,190	0.00%	-	1,662,190	0.00%	-
Substructure	3,141,263	0.00%	-	2,730,391	0.00%	-
Columns and Upper Floors	8,488,066	0.00%	-	7,377,841	0.00%	-
Stairs & Ramps	1,295,965	0.00%	-	1,126,455	0.00%	-
Roof & Roof Plumbing	11,301,838	1.33%	236,445	9,823,576	1.33%	205,518
External Walls	10,421,776	1.50%	245,902	9,058,625	1.50%	213,738
Windows	4,199,427	3.00%	198,171	3,650,149	3.00%	172,251
External Doors (Incl. Hardware)	1,799,784	1.50%	42,466	1,564,375	1.50%	36,911
Internal Walls	4,851,569	1.25%	95,394	4,216,992	1.25%	82,917
Internal Doors	625,564	1.60%	15,744	543,741	1.60%	13,685
Wall Finishes	1,909,191	1.00%	30,032	1,659,472	1.00%	26,103
Floor Finishes	1,759,254	1.30%	35,975	1,529,146	1.30%	31,270
Ceiling Finishes	1,946,385	1.33%	40,720	1,691,801	1.33%	35,394
Joinery (Incl. Loose & Fixed FF&E)	5,067,204	1.00%	79,707	4,404,422	1.00%	69,282
Hydraulic Services (Incl. Fixtures)	2,260,141	2.56%	91,013	1,964,519	2.56%	79,109
Mechanical Services	8,883,980	2.67%	373,119	7,721,970	2.67%	324,316
Fire Services	679,781	3.25%	34,752	590,867	3.25%	30,207
Electrical Services (incl Communications, Security)	5,602,318	3.78%	333,110	4,869,544	3.78%	289,540
Vertical Transportation Services	1,982,403	3.00%	93,550	1,723,108	3.00%	81,313
Landscaping	3,564,820	1.00%	56,075	3,614,820	1.00%	56,861
Carpark, Roadworks and Walkways	3,195,300	1.00%	50,262	3,195,300	1.00%	50,262
Signage	50,000	1.00%	787	50,000	1.00%	787
FF&E	5,800,350	3.00%	273,719	5,800,350	3.00%	273,719
ICT	1,791,350	3.78%	106,513	1,791,350	3.78%	106,513
Offsite Works & Infrastructure	1,130,000	1.00%	17,775	1,130,000	1.00%	17,775
Main Contractor's Preliminaries	16,813,786	0.00%	-	11,688,741	0.00%	-
Main Contractor's Overheads and Profit	3,736,397	0.00%	-	3,339,640	0.00%	-
Project escalation	4,558,404	0.00%	-	3,940,775	0.00%	-
Consultants Fee	17,094,015	0.00%	-	7,881,551	0.00%	-
Authority Fees	797,721	0.00%	-	689,636	0.00%	-
SINSW Costs	9,889,743	0.00%	-	8,049,773	0.00%	-
Project Contingency	40,923,073	0.00%	-	33,309,404	0.00%	-
	$187,223,058		$ 2,451,229	$152,390,523		$ 2,197,469

Table above demonstrates a typical breakdown and calculations for projected planned annual preventative maintenance. The calculation includes allowances for preliminaries, contingency and capital replacement matrixes based on industry historical data.

4.7 Cost

Googong PS - Projected Annual Maintenance Costs – Breakdown

Description	Capital Cost ($)	Planned Preventative Maintenance %	Planned Preventative Maintenance $	Capital Cost ($)	Planned Preventative Maintenance %	Planned Preventative Maintenance $
	Googong PS - Traditional			Googong PS - Component (KoP)		
Early & Enabling Works	0	0.00%	-	0	0.00%	-
Demolition & Site Preparation	761,361	0.00%	-	618,730	0.00%	-
Substructure	1,265,175	0.00%	-	1,220,701	0.00%	-
Columns and Upper Floors	3,418,654	0.00%	-	3,298,478	0.00%	-
Stairs & Ramps	521,963	0.00%	-	503,614	0.00%	-
Roof & Roof Plumbing	4,551,020	1.33%	95,230	4,391,015	1.33%	91,883
External Walls	4,197,475	1.50%	99,039	4,049,921	1.50%	95,558
Windows	1,691,362	3.00%	79,815	1,631,905	3.00%	77,010
External Doors (Incl. Hardware)	724,881	1.50%	17,104	699,399	1.50%	16,502
Internal Walls	1,954,018	1.25%	38,421	1,885,329	1.25%	37,070
Internal Doors	251,952	1.60%	6,341	243,095	1.60%	6,118
Wall Finishes	768,946	1.00%	12,096	741,915	1.00%	11,670
Floor Finishes	708,557	1.30%	14,489	683,649	1.30%	13,980
Ceiling Finishes	783,926	1.33%	16,400	756,369	1.33%	15,824
Joinery (Incl. Loose & Fixed FF&E)	2,040,868	1.00%	32,103	1,969,125	1.00%	30,974
Hydraulic Services (Incl. Fixtures)	910,295	2.56%	36,656	878,295	2.56%	35,368
Mechanical Services	3,578,113	2.67%	150,278	3,452,331	2.67%	144,995
Fire Services	273,789	3.25%	13,997	264,164	3.25%	13,505
Electrical Services (incl Communications, Security)	2,256,390	3.78%	134,164	2,177,071	3.78%	129,447
Vertical Transportation Services	798,433	3.00%	37,678	770,365	3.00%	36,354
Landscaping	3,365,000	1.00%	52,931	3,365,000	1.00%	52,931
Carpark, Roadworks and Walkways	1,766,550	1.00%	27,788	1,766,550	1.00%	27,788
Signage	50,000	1.00%	787	50,000	1.00%	787
FF&E	2,823,187	3.00%	133,226	2,823,187	3.00%	133,226
ICT	785,264	3.78%	46,691	785,264	3.78%	46,691
Offsite Works & Infrastructure	1,760,000	1.00%	27,005	1,760,000	1.00%	27,005
Main Contractor's Preliminaries	7,561,456	0.00%	-	5,710,092	0.00%	-
Main Contractor's Overheads and Profit	1,680,324	0.00%	-	1,631,455	0.00%	-
Project escalation	2,049,995	0.00%	-	1,925,117	0.00%	-
Consultants Fee	7,687,480	0.00%	-	7,219,188	0.00%	-
Authority Fees	358,749	0.00%	-	336,895	0.00%	-
SINSW Costs	4,447,592	0.00%	-	4,176,661	0.00%	-
Project Contingency	18,403,828	0.00%	-	17,282,736	0.00%	-
	$ 84,197,511		$ 1,072,919	$ 79,068,515		$ 1,045,366

Despite the lack of cost data available for prefabricated buildings in Australia, MBM are of the opinion that there is potential for a more precise and represented positive results based on the following factors:

1) Current DfMA concepts by Woods Bagot has exposed timber and mostly pinboards & whiteboards. It also finished with minimal prefinished ceilings (PSA only) and therefore there are reduced painted surfaces that require ongoing repainting.
2) Cladding is proposed to be colour-through or precoated where extended warranties are typically provided. Painting is whereby not required on these surfaces.
3) Concept designs to use natural light and ventilation requires reduced A/C and lighting requirements, hence will be able to shift priorities into procuring products with better longevity – less replacements.

4) Access floors and reduced requirements for ceilings allows for re-adaption and flexibility of spaces without costly remedial works.

Projected Life Cycle Expenditure over 20 Years – Overview

	Googong PS	Marsden Park HS
Traditional	$ 26,624,797	$ 55,298,015
DfMA Component (KoP)	$ 21,100,165	$ 42,686,261

Table above shows the projected life cycle expenditure over the course of 20 years, which various elements attracts a certain typical replacement cycle. Similarly, to maintenance costs, it uses a model for a typical Traditional construction delivery methodology.

Projected Life Cycle Expenditure over 20 Years – Overview

Description	Capital Cost ($)	Contingency	Prelims, Staging, OH&M	Capital Replacement	Strip Out Installation	Cost per event ($)	Cycle (YR)	Total Lifecycle Cost ($)
		Life Cycle Expenditure (LCE)						
Early & Enabling Works	0	30%	21%	0.00%	0.00%	-	100	-
Demolition & Site Preparation	1,662,190	30%	21%	0.00%	0.00%	-	100	-
Substructure	3,141,263	30%	21%	0.00%	0.00%	-	100	-
Columns and Upper Floors	8,488,066	30%	21%	15.00%	20.00%	2,307,056	100	-
Stairs & Ramps	1,295,965	30%	21%	50.00%	20.00%	1,174,144	100	-
Roof & Roof Plumbing	11,301,838	30%	21%	24.00%	20.00%	4,914,943	15	4,914,943
External Walls	10,421,776	30%	21%	20.00%	20.00%	3,776,852	15	3,776,852
Windows	4,199,427	30%	21%	30.00%	20.00%	2,282,809	20	2,282,809
External Doors (Incl. Hardware)	1,799,784	30%	21%	20.00%	5.00%	570,712	10	570,712
Internal Walls	4,851,569	30%	21%	50.00%	20.00%	4,395,522	20	4,395,522
Internal Doors	625,564	30%	21%	20.00%	5.00%	198,366	15	198,366
Wall Finishes	1,909,191	30%	21%	50.00%	5.00%	1,513,511	15	1,513,511
Floor Finishes	1,759,254	30%	21%	50.00%	10.00%	1,461,060	10	1,461,060
Ceiling Finishes	1,946,385	30%	21%	30.00%	10.00%	969,884	20	969,884
Joinery (Incl. Loose & Fixed FF&E)	5,067,204	30%	21%	35.00%	8.00%	2,892,259	20	2,892,259
Hydraulic Services (Incl. Fixtures)	2,260,141	30%	21%	60.00%	20.00%	2,457,226	20	2,457,226
Mechanical Services	8,883,980	30%	21%	50.00%	10.00%	7,378,146	7	7,378,146
Fire Services	679,781	30%	21%	50.00%	10.00%	564,558	15	564,558
Electrical Services (incl Communications, Security)	5,602,318	30%	21%	10.00%	15.00%	972,843	5	1,945,686
Vertical Transportation Services	1,982,403	30%	21%	100.00%	2.00%	3,053,297	24	-
Landscaping	3,564,820	30%	21%	50.00%	5.00%	2,826,011	15	2,826,011
Carpark, Roadworks and Walkways	3,195,300	30%	21%	25.00%	10.00%	1,326,848	30	-
Signage	50,000	30%	21%	100.00%	15.00%	86,825	15	86,825
FF&E	5,800,350	30%	21%	80.00%	8.00%	7,567,369	5	15,134,737
ICT	1,791,360	30%	21%	20.00%	20.00%	649,185	15	649,185
Offsite Works & Infrastructure	1,130,000	30%	21%	60.00%	25.00%	1,279,725	20	1,279,725
Main Contractor's Preliminaries	16,813,786	30%	21%	0.00%	0.00%	-	0	-
Main Contractor's Overheads and Profit	3,736,397	30%	21%	0.00%	0.00%	-	0	-
Project escalation	4,558,404	30%	21%	0.00%	0.00%	-	0	-
Consultants Fee	17,094,015	30%	21%	0.00%	0.00%	-	0	-
Authority Fees	797,721	30%	21%	0.00%	0.00%	-	0	-
SINSW Costs	9,889,743	30%	21%	0.00%	0.00%	-	0	-
Project Contingency	40,923,073	30%	21%	0.00%	0.00%	-	0	-
TOTAL Marsden Park HS - Traditional	187,223,058							55,298,015

4.7 Cost

The table shows the calculations for projected Life Cycle Expenditure which includes costs of Capital replacements, the associated costs based on the industry recommended effective life years. The table suggests guidelines on the duration of effective use of the said items before they are required to be replaced. For this instance, the example shows values for **Marsden Park High School** over a period of 20 years.

The costs related to Kit of Parts methodology are calculated using the same principles albeit the effective life years will vary depending on quality and choice of products adopted and selected.

It is of MBM's opinion that, with the increasing number of projects adopting prefabrication, a more positive result can be confidently pursued.

MBM notes that adoption of natural building materials e.g. timber, previous studies have shown there is a much reduce tendency to damage and deface. As mentioned previously, the benefit of processes taking place in a factory environment have a significant impact on the performance of the building.

MBM will continue to research and provide further comment on this area in future reports.

5.5. A Final Note – The Environmental Life Cycle

As economists continue to place a value on sustainability, there are several basic principles intrinsic to the DfMA Construction process that make it more environmentally attractive than traditional build school construction

The reduced time on-site as a result of a shortened construction cycle, (the outcome of the simultaneous activities of on-site development and off-site building construction), notably minimizes the overall negative environmental impact on a site.

The precise construction methodology inherent in factory-based manufacturing means less waste in landfill.

And interestingly, and as the demountable program has highlighted, the benefit of schools being mobile is extremely useful to an organisation constantly required to adapt and move quickly and at speed. Put simply, DfMA technology allows a building to be readily dis-assembled and potentially moved to another location.

This recycling option is a benefit that will, in MBM opinion, make DfMA the obvious choice for future builds across ALL sectors.

6. Our Expertise

Quantity Surveying

- Feasibility studies
- Cost planning and estimating
- Bills of Quantities
- Tender estimates, analysis and evaluation
- Contract administration
- Financier reporting
- Replacement cost analysis

PPP Advisory

- Business case and reference project
- Technical and services specifications
- Public sector comparator (PSC)
- Bid evaluation and negotiation
- Post contract administration and audit
- Support to private sector bidder

Building Consultancy

- Technical due diligence
- Make good schedules
- Condition audits
- Life cycle costing
- Asset registers
- Sinking funds
- Capital expenditure forecasting and analysis
- BCA consultancy and certification
- Sustainability services

Infrastructure

- Independent/Probabilistic estimating
- Cost planning
- Cost & contract administration
- Audits/assurance reviews
- Expert witness and dispute resolution

Tax & Assets Services

- Tax depreciation and capital allowance schedules
- Management of fixed asset registers
- Depreciation modelling and auditing
- Transaction support for acquisition, disposal and leasing

Facilities Management Advisory

- Review of maintenance services
- Redevelopment of contract models
- Preparation/review of scope of works and specifications
- Procurement of FM maintenance and cleaning
- Assistance with transition

Expert Witness

- Financial evaluation of claims
- Negotiation of costs
- Dispute Resolution
- Tribunal and Court Proceedings
- Quantum Reports

4.7 Cost

OUR LOCATIONS

MBM has offices in Sydney, Parramatta, Brisbane, Gold Coast, Melbourne, Canberra, Perth and Adelaide.

We operate as a single entity and are able to utilise specialised skills from any office to deliver a successful outcome for your project or development.

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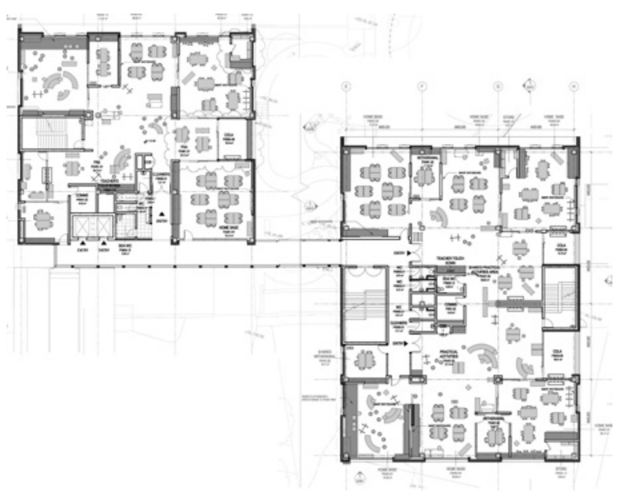
4.8 Design Efficiency Case Studies



Original Layout

Proposed Layout

Original Layout

Proposed Layout

		Units	Before	After	Diff	Diff%
FECA		m^2	1321.8	1088.3	-233.5	-18%
UCA		m^2	207.5	493.7	286.2	138%
GFA		m^2	1550	1550	0	0%
COLA		m^2	46.3	94.2	47.9	103%
UFA		m^2	953	1000.2	47.2	5%
Efficiency		%	61%	65%		

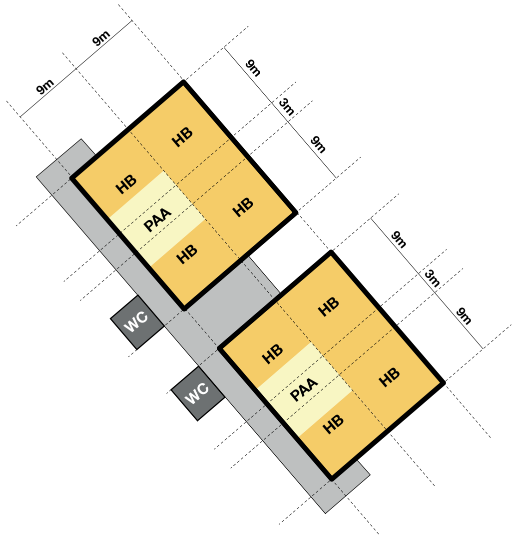
Rate ($/m²)	Before	After	Diff	Diff%
$ 2,900.00	$ 3,833,220.00	$ 3,156,070.00	-$ 677,150.00	
$ 1,155.00	$ 239,662.50	$ 570,223.50	$ 330,561.00	
$ 4,055.00	$ 4,072,882.50	$ 3,726,293.50	-$ 346,589.00	-9%

		Units	Before	After	Diff	Diff%
FECA		m^2	1412.8	1126.2	-286.6	-20%
UCA		m^2	242.2	527.6	285.4	118%
GFA		m^2	1655	1653.8	-1.2	0%
COLA		m^2	133.4	232.6	99.2	74%
UFA		m^2	910.5	1083.8	173.3	19%
Efficiency		%	55%	66%	11%	

Rate ($/m²)	Before	After	Diff	Diff%
$ 2,900.00	$ 4,097,120.00	$ 3,265,980.00	-$ 831,140.00	
$ 1,155.00	$ 279,741.00	$ 609,378.00	$ 329,637.00	
$ 4,055.00	$ 4,376,861.00	$ 3,875,358.00	-$ 501,503.00	-11%

4.8 Design Efficiency Case Studies

Original Layout

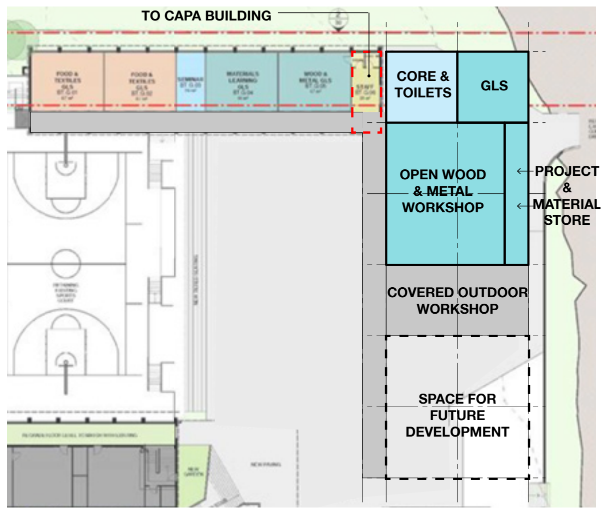


Proposed Layout

	Units	Before	After	Diff	Diff%
FECA	m^2	1006.3	794.3	-212	-21%
UCA	m^2	1	208	207	20700%
GFA	m^2	1007.3	1002.3	-5	0%
COLA	m^2	1	61	60	6000%
UFA	m^2	654.9	752.8	97.9	15%
Efficiency	%	65%	75%	10%	

Rate ($/m²)	Before	After	Diff	Diff%
$ 2,900.00	$ 2,918,270.00	$ 2,303,470.00	-$ 614,800.00	
$ 1,155.00	$ 1,155.00	$ 240,240.00	$ 239,085.00	
$ 4,055.00	$ 2,919,425.00	$ 2,543,710.00	-$ 375,715.00	-13%

Original Layout



Proposed Layout

	Units	Before	After	Diff	Diff%
FECA	m^2	1032	971	-61	-6%
UCA	m^2	73	138	65	89%
GFA	m^2	1105	1109	4	0%
COLA	m^2	1	1	0	0%
UFA	m^2	855	878	23	3%
Efficiency	%	77%	79%	2%	

Rate ($/m²)	Before	After	Diff	Diff%
$ 2,900.00	$ 2,992,800.00	$ 2,815,900.00	-$ 176,900.00	
$ 1,155.00	$ 84,315.00	$ 159,390.00	$ 75,075.00	
$ 4,055.00	$ 3,077,115.00	$ 2,975,290.00	-$ 101,825.00	-3%