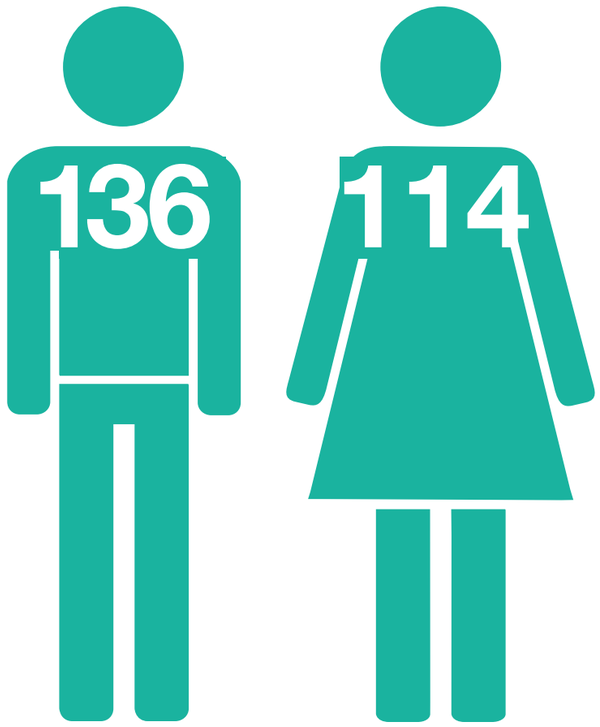
DfMA optioneering in residential design
Buildoffsite Residential Hub
04.07.19

Hawkins\
Brown

Facts & Figures

Graduated from at least **25** different schools of architecture

250



Brilliant People in 4 Homes

5% of us work part time

Our Average age is

Sector Turnover

25%

Residential

7%

Civic Community & Culture

25%

Transport & Infrastructure

10%

Workplace

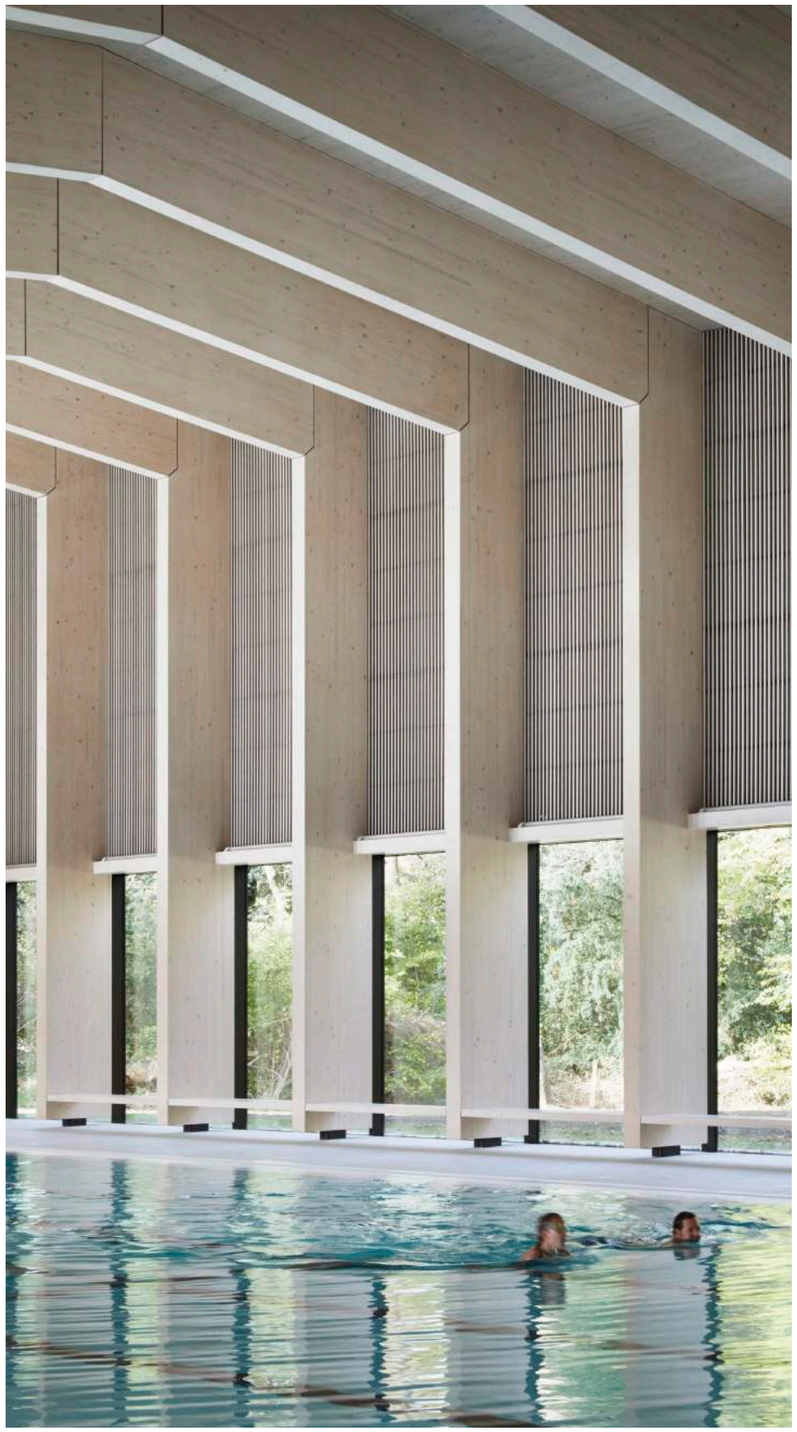
23%

Higher Education

10%

Schools & Colleges

Hawkins\Brown's Experience

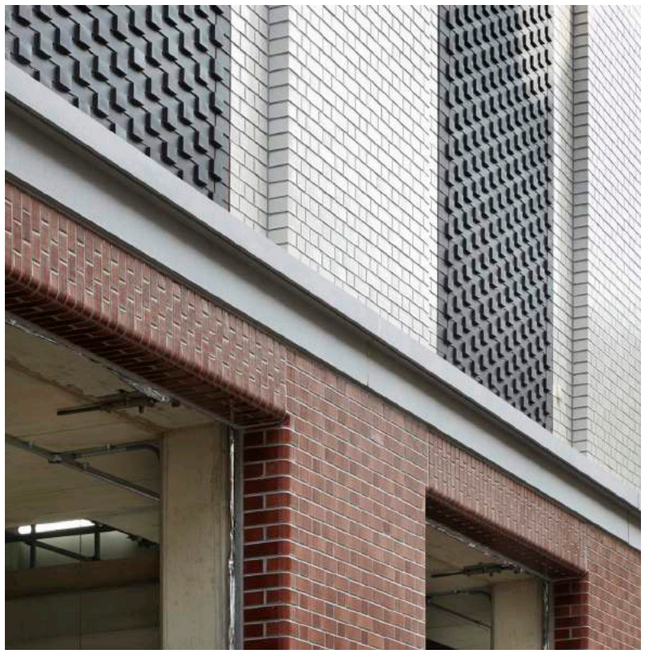


Hawkins\Brown's Experience

In the same way BIM is not just Revit,
DfMA is more than one product or method

DfMA in residential

What is DfMA



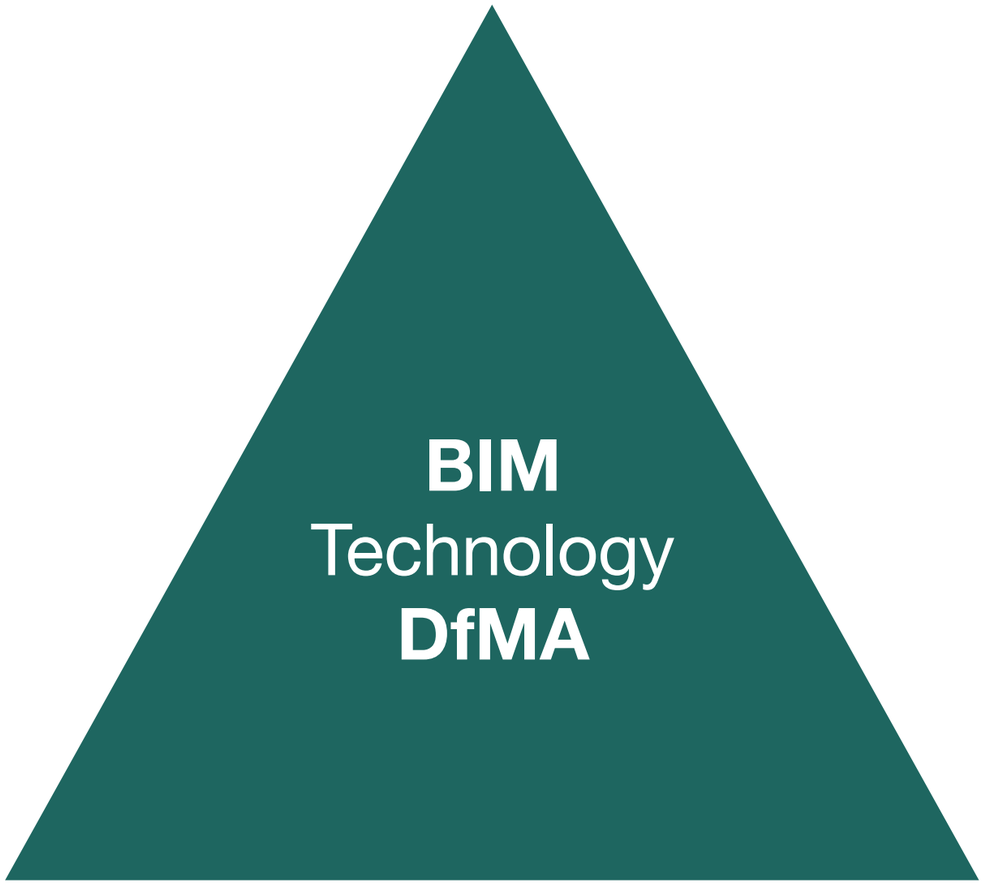
The first change required to succeed with DfMA is not technological but behavioural

Our innovation strategy is integrated

Using innovation to strengthen our key values

(Building of the year)

Great Design



Happy Staff

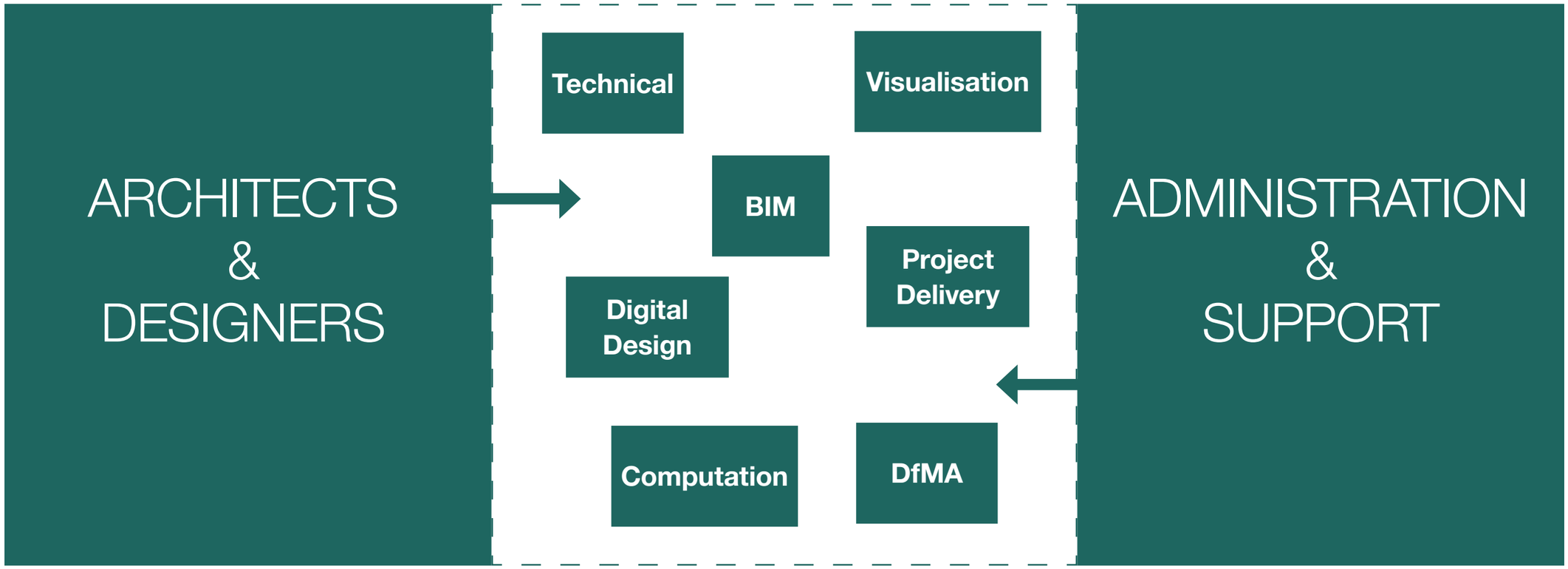
(Employer of the year)

Sustainable Business

(Practice of the year)

More specialists

How might we be structured in the future?



DfMA

Behavioural changes

- Prioritise high quality design

- Define project (DfMA) goals

- Appoint design teams differently

- Embrace different procurement methods

- Adopt a collaborative approach

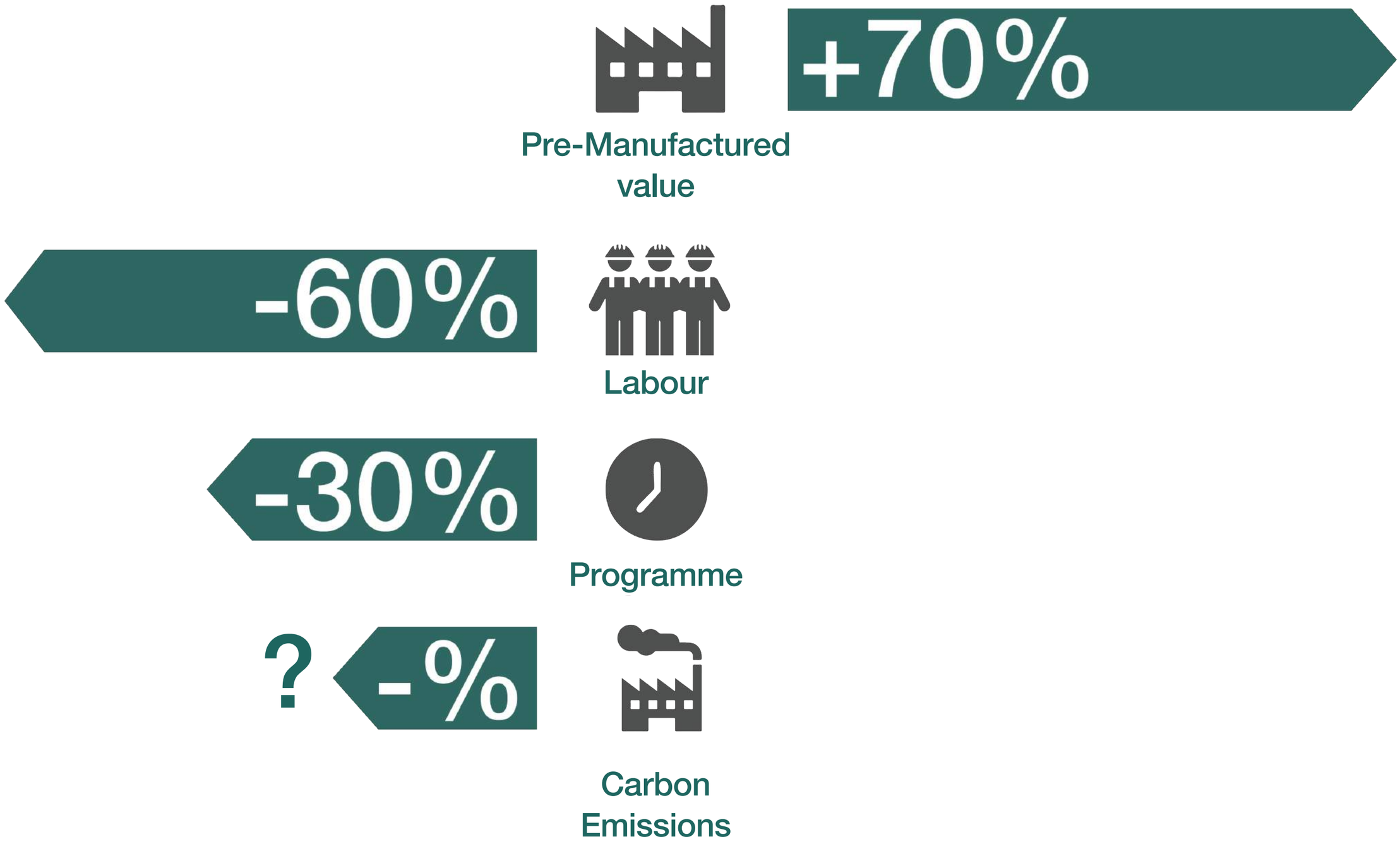
- Early specialist subcontractor involvement

- Early design coordination

- Early site logistics assessment

DfMA in residential

The potential

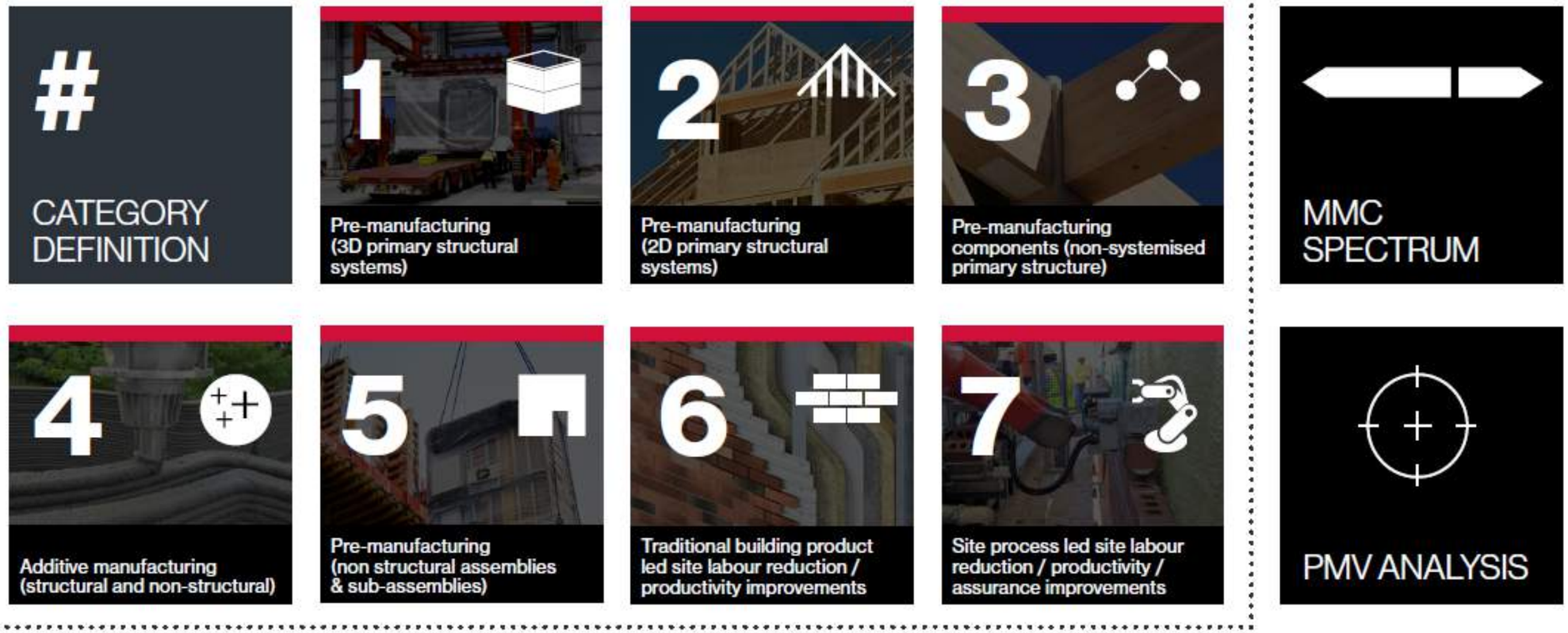


Residential evaluating the options
Defining Project Goals

DfMA in residential
Making Consistent Decisions

Category
DEFINITIONS

The term 'pre-manufacturing' encompasses processes executed away from final workface, including in remote factories, near site or on-site 'pop up' factories. The pass test is the application of a manufactured led fabrication or consolidation process in controlled conditions prior to final assembly / install. On-site 'workface factories' are included in Category 7).



DfMA in residential
Decision Making

Prefabricated Structure Options for Residential Development

Key Factors Comparison

Construction Option	Option 1A Modular (Steel)	Option 1B Modular (CLT)	Option 1C Concrete	Option 2A SIPs	Option 2B CLT	Option 2C Concrete	Option 2D Timber	Option 2E LSF
Health & Safety	Low Risk	Low Risk	Medium Risk	Medium Risk	Medium Risk	Medium Risk	Medium Risk	Medium Risk
Construction Rate	25 to 30 modules/week	25 to 30 modules/week	TBC	Up to 500m²/week	Up to 500m²/week	Up to 400m²/week	Up to 700m²/week	Up to 700m²/week
Cost/m² (Note 3)	£1,500 – £2,000	TBC	TBC	TBC	TBC	TBC	TBC	£130 – £250
Offsite Completion	Circa 80%	Circa 80%	Circa 80%	Circa 30%[4]	Circa 30%[4]	Circa 45%[4]	Circa 20%[4]	Circa 20%[4]
Current Height Limitation	28 storeys[5]	12 storeys		10 storeys	18 storeys[6]	30 storeys	6 storeys	20 storeys
Immediately Stable Structure	Yes[7]	Yes[7]	Yes[7]	No	Yes[7]	No	No	No
Immediately Load Bearing Structure	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No[8]
Loading Principles[9]	Point & Line	Line	Point & Line	Line	Line	Line	Line	Line[10]
Logistics	Size of modules to consider	Size of modules to consider	Size of modules to consider	Delivered flat pack	Delivered flat pack	Delivered flat pack	Delivered flat pack	Delivered flat pack
Fire Compliance	Simple	Simple	Simple	Complex	Simple	Simple	Complex	Moderate
Sound Attenuation	Simple	Simple	Simple	Moderate	Simple[11]	Simple	Complex	Moderate
Pre-installed windows & doors	Yes	Yes	Yes	Yes	N/A	Yes	No	Yes
Carbon Footprint	Moderate	Low	Moderate	Moderate	Low	Moderate	Low	Moderate[12]
Market Availability	Multitude of UK & EU Manufactures.	Limited number of UK & EU Manufacturers	Limited Number of EU & Overseas Manufacturers	Multitude of UK & EU Manufacturers.	EU Manufactures only	Limited UK & EU Manufacturers	Multitude of UK & EU Manufactures.	Multitude of UK & EU Manufactures.
Skills Shortage	Unaffected	Unaffected	Unaffected	Limited Impact	Limited Impact	Limited Impact	Major Impact	Major Impact
Holistic Benefits	Finish Quality & Fewer Interfaces	Finish Quality & Fewer Interfaces	Finish Quality & Fewer Interfaces	Fewer Interfaces	Lightweight Structure	Erect without Scaffolding	Lightweight Structure	Lightweight Structure

DfMA in residential
Defining project goals

01. Reduce

On-site activity

Environmental impact

Impact on Students and the wider campus

Risk

Redesign

Whole Life Cost & Whole Life Carbon

02. Improve

Quality

Certainty

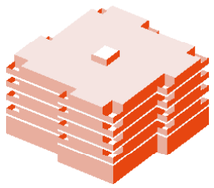
Overall design

Facilities management processes

Site Health & Safety

Which option is right for you?

Big decisions, made simple



Low-rise
≤5 Storeys

does it stack walls and services?

Y

can it be designed to stack?

N

timber frame, timber panel or CLT?

pods for bathrooms and kitchens

steel/ concrete frame with infill

are room sizes regular?

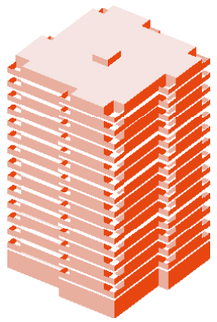
Y

pre-fab infill with SIPs or LGS

Y

panels or modular volumetric

design for transport of large elements



Mid-rise
6-15 Storeys

not timber frame?

Y

is it below 60ft?

N

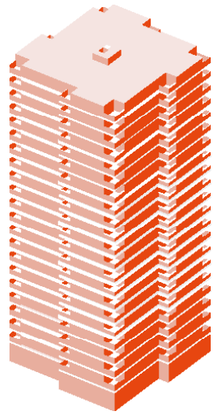
why not?!

Y

Pods for bathrooms and kitchens

Y

LGS frame, LGS panel, or CLT



High-rise
15 + Storeys

does it stack walls and services?

Y

Can it be re-designed to stack?

N

CLT

pods for bathrooms and kitchens

steel/ concrete frame with infill

are room sizes regular?

Y

pre-fab infill with SIPs or LGS

Y

modular volumetric

design for transport of large elements

Potential for Pre-Manufactured Value

40% ⟵ ⟶ **80%**

Which option is right for you?

Big decisions, made simple

SYSTEM See Note 1			BASELINE C1 CIP CONCRETE		CFS1 CFS JOISTS AND LATERAL		CFS2 CFS JOISTS WITH CORE WALLS		CFS3 CFS DECK WITH CORE WALLS		PC1 PRECAST T WITH MOMENT FRAMES		PC2 PRECAST T WITH MOMENT FRAMES		PC3 PRECAST TEE WITH INTERIOR FRAME		PC4 PRECAST T WITH INTERIOR WALL		PC5 PRECAST T WITH CORE WALLS		ST1 CONC/EPICORE/BEAM WITH MF		ST2 CONC/EPICORE/BEAM WITH CORE WALLS		PRECAST
		IMPORTANCE	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING	FACTORED	1-5 RATING
AESTHETICS	Does the proposal facilitate or limit the architectural design?	0.5	2.5	1.25	1.5	0.75	1.5	0.75	1.5	0.75	1	0.5	2	1	2.5	1.25	2.5	1.25	2.5	1.25	2.5	1.25	2.5	1.25	2.5
CODE - HEIGHT LIMIT	Is the Height achievable in the system subject to code restrictions?	1	2.5	2.5	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5
CODE - FIRE/LIFE SAFETY	Does the proposal pose a risk to fire signoff?	1	2.5	2.5	0.5	0.5	0.5	0.5	1	1	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	1.5	1.5	1.5	1.5	1.5
SEISMIC	Does the proposal pose limitations or require extra measures to deal with seismic considerations?																								
INTEGRATION OF SYSTEMS - MEP	Is early or additional coordination required to integrate MEP systems. Can solutions such as thermal mass be used to augment MEP systems	1	2.5	2.5	1	1	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1	1	1.5	1.5	2	2	2	2	2	2	1.5
INTEGRATION OF SYSTEMS - OTHER	Does the chosen system limit or impose restrictions on other DIMC opportunities? E.g. is pod plank possible? Are better tolerances requried for prefabricated wall panel integration?																								
FLOOR ASSEMBLY DEPTH	Overall floor assembley depth? Impact on floor to floor height? Need for transfer structures?	1	2.5	2.5	1.5	1.5	1	1	1	1	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
SCHEDULE IMPACT	Reduction in schedule / increased certainty of schedule?	0.75	2.5	1.875	3.5	2.625	3	2.25	3	2.25	4	3	4	3	4	3	2.5	1.875	2.5	1.875	3	2.25	2.5	1.875	3.5
SITE LOGISTICS	Improvement in site safety? Reduction in deliveries? Reduction in on site labour and associated vehicle movements? Increases in crane need?	1	2.5	2.5	3.5	3.5	3	3	3	3	4	4	4	4	4	4	2.5	2.5	2.5	2.5	3.5	3.5	3	3	3.5
QUALITY	does the propsosed system meet or exceed minimum quality benchmarks?	0.75	2.5	1.875	1.5	1.125	1.5	1.125	1.5	1.125	3.5	2.625	3.5	2.625	3.5	2.625	3.5	2.625	2.5	1.875	2.5	1.875	2.5	1.875	2
SUSTAINABILITY	Waste reduction? Embodied Carbon? Whole Life Carbon Impact? Redcution of vehicle movements and associated pollution?	1	2.5	2.5	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
DURABILITY	Can elements of the system be exposed? Is additional lining required to meet code of protect system?	1	2.5	2.5	1	1	1.5	1.5	1.5	1.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2	2	2	2	2
INITIAL COST	Intial costs of structural system for design, manufacture and assembly	0.8	2.5	2	4	3.2	3.5	2.8	3.5	2.8	3.5	2.8	3	2.4	3.5	2.8	2.5	2	2.5	2	4	3.2	3.5	2.8	4
LIFETIME COSTS	Lifetime cost implications for building management	1																							
GRID FLEXIBILITY		1	2.5	2.5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	2	2	3	3	2
STACKING IMPACT		1	2.5	2.5	1	1	1	1	1	1	2	2	2	2	2	2	2	2	3	3	1.5	1.5	1.5	1.5	3
SUBCONTRACTOR MARKET	What is the availability of trades in the locality/region with suitable capacity and expertise?	1	2.5	2.5	3	3	3	3	3	3	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	2.5	3	3	3	3	3
COMPATIBILITY OF WALL SYSTEMS		0	2.5	0		0		0		0		0		0		0		0		0		0		0	
FAÇADE	How does each system impact façade design and assembly, eg. Tension head setting out.	1	2.5	2.5	1	1	1	1	1	1	1	1	2	2	2.5	2.5	2.5	2.5	2.5	2.5	2	2	2.5	2.5	2.5
FLOOR FINISHES	Are wet trades requitred to make-good floor finishes, eg. Screed over precast slabs.	0.5	2.5	1.25	1	0.5	2.5	1.25	2.5	1.25	2	1	2	1	2	1	1.5	0.75	2.5	1.25	2.5	1.25	2.5	1.25	1.5
CANTILEVER CORNERS		0.5	2.5	1.25	2	1	0.5	0.25	0.5	0.25	2	1	2	1	2	1	2	1	2.5	1.25	3	1.5	3	1.5	4
TOTAL				37		26.7		26.4		26.9		35.4		36.5		37.2		34.0		37.5		36.3		36.6	

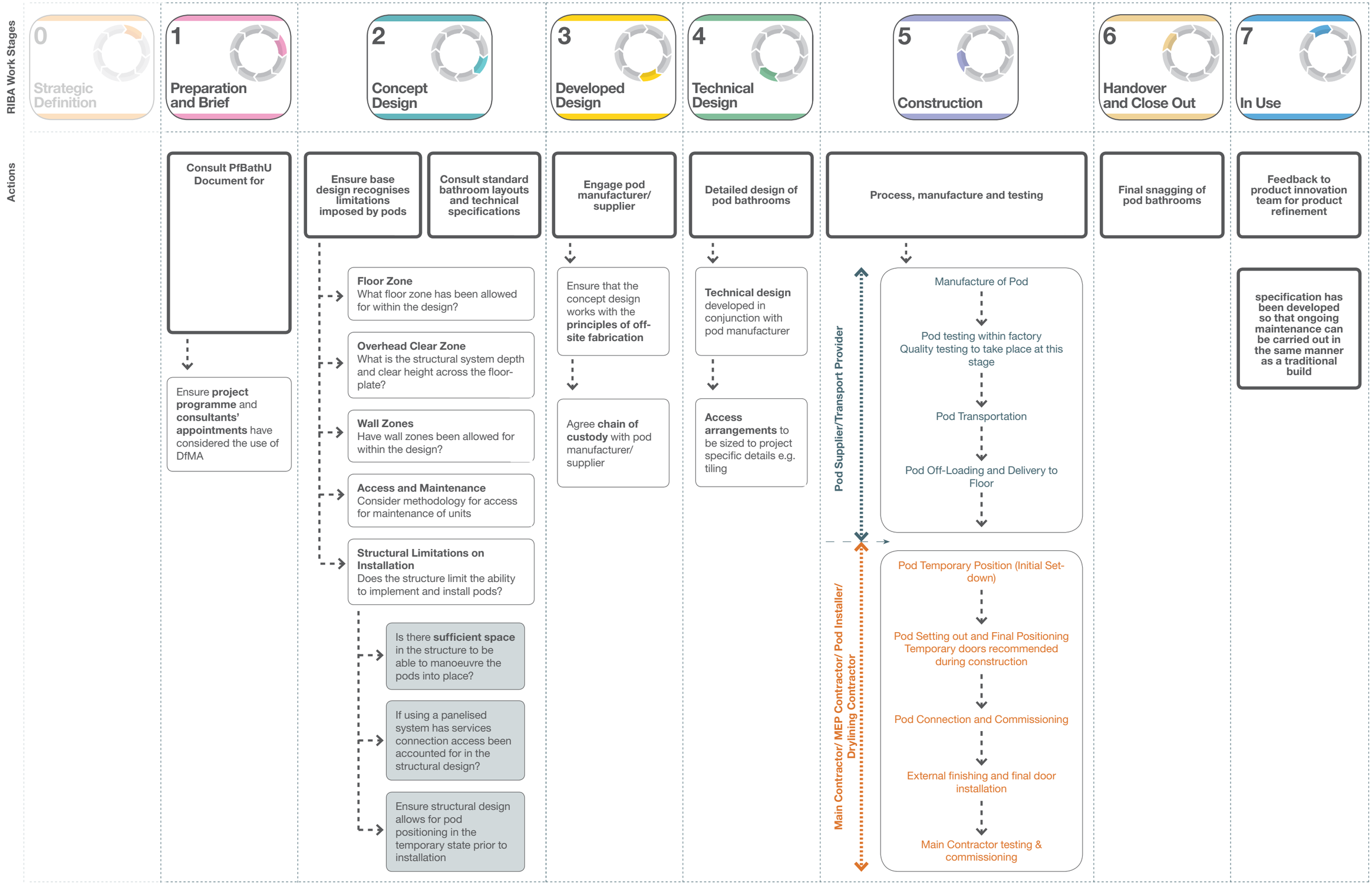
NOTE 1 : RATE EACH ITEM FROM 1 (LOWEST) TO 5 (HIGHEST) WITH CONCRETE AT 2.5

NOTE 2 : COMPARISION MADE FOR STRUCTURAL GRID OF APPROXIMATELY 30 FEET BY 30 FEET

Legend
Improvement over baseline
Neutral to baseline
Reduction from baseline

Which option is right for you?

Big decisions, made simple



Residential key decisions
Flexible vs lean

Design considerations

A lean approach

- Maximise area efficiencies

- Reduce overall building footprint

- Solve eccentricities on a case by case basis

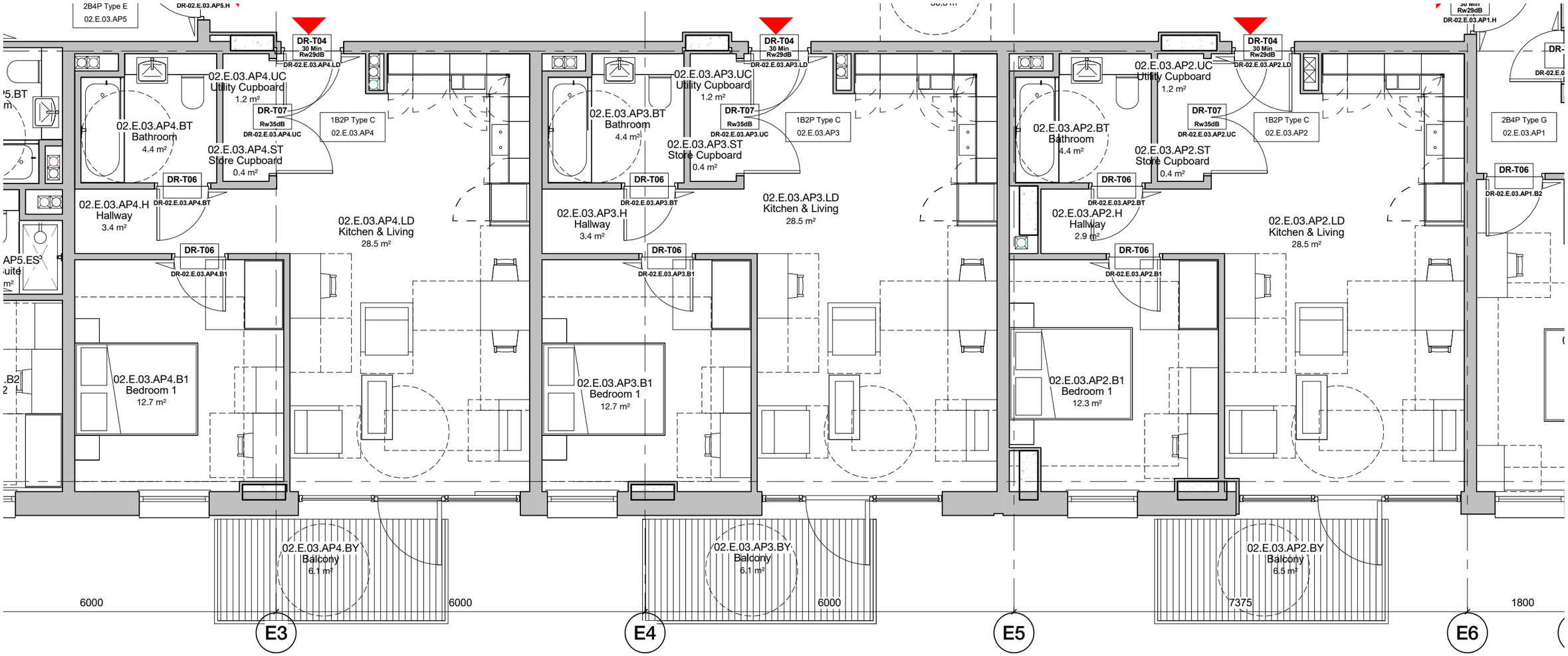
- Increased coordination requirements

- Potential for increased waste

- Not best suited to DfMA

Design considerations

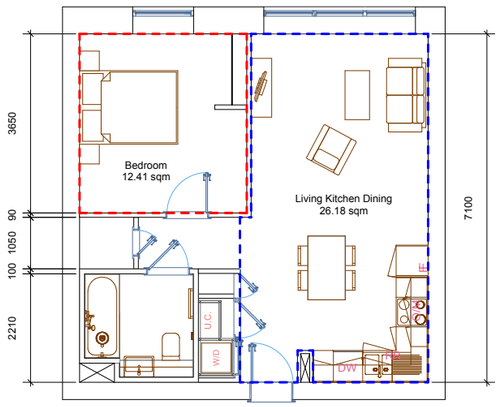
Maximising efficiency



Design considerations

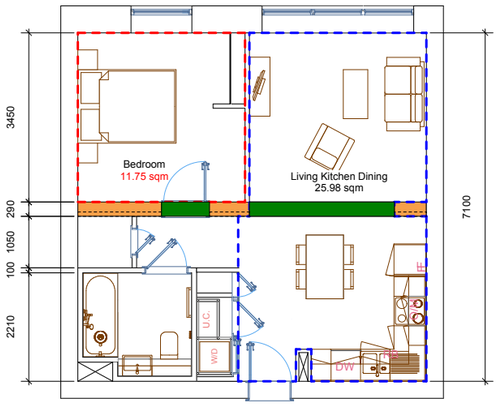
Adapting to different systems

Base Design



Flat Area = 50.3m² GIA

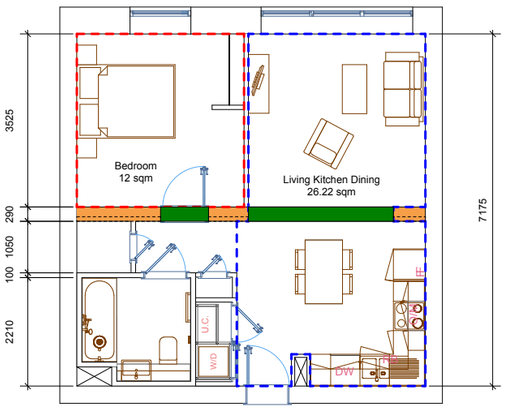
Base Design GIA with CLT wall



Flat Area = 50.3m² GIA

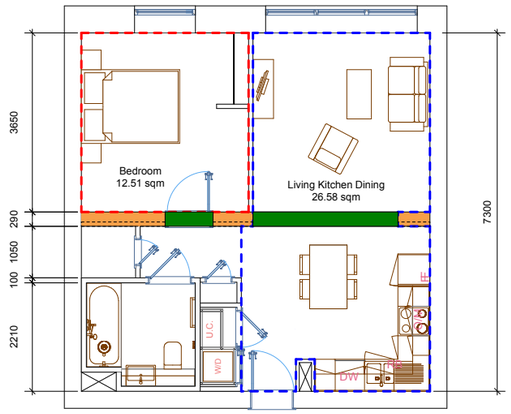
- The introduction of a CLT structural internal wall reduces the bedroom area to below 12m²

Maintaining Base Design Room Widths



Flat Area = 50.9m² GIA

- The unit depth has increased by 75mm which is the minimum distance to achieve a bedroom area of 12m²



Flat Area = 51.8m² GIA

Internal CLT Structural Wall

Steel Beam

Bedroom Area

Living Dining Kitchen Area

Design considerations

A flexible approach

- Designing for worst case systems

- Slight increase in area

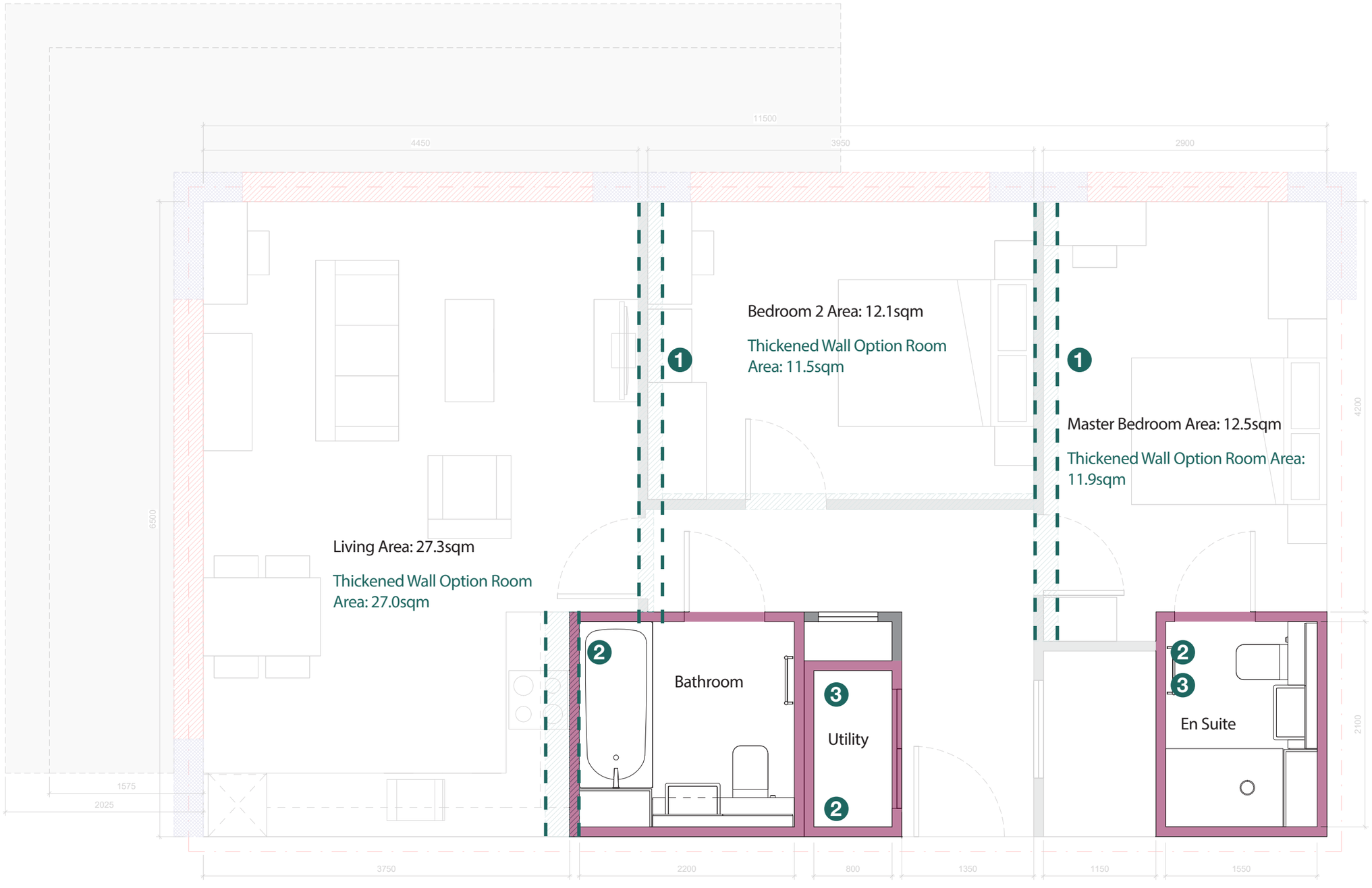
- Easier construction

- Suited to DfMA

- Reduced waste

- Reduced design and coordination

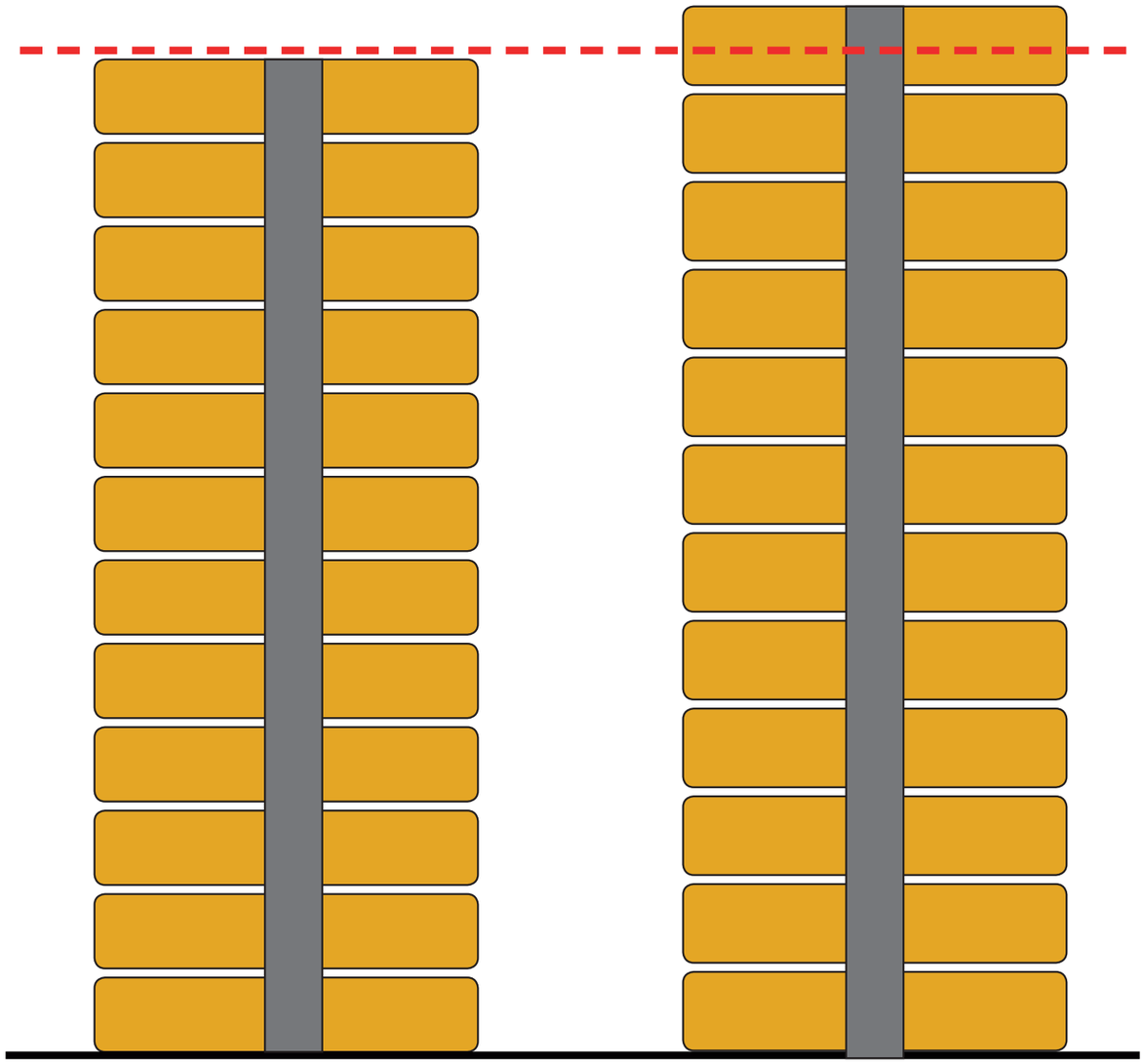
Design considerations
A flexible approach

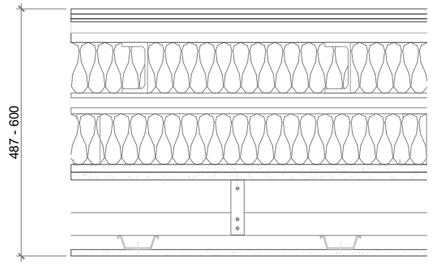


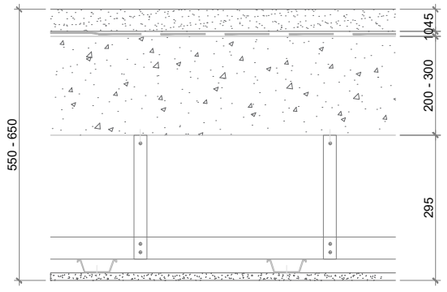
Walls thickened to 250mm
(worst case scenario thickness for
CLT construction type option)

DfMA in residential

Adopting a flexible approach to height?



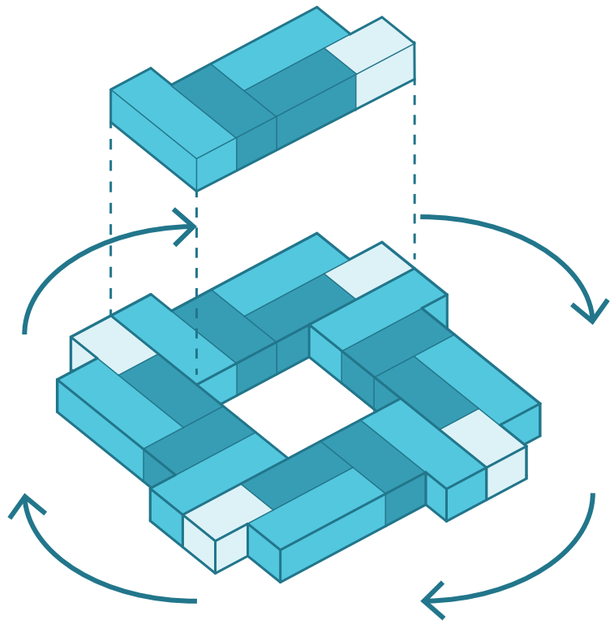




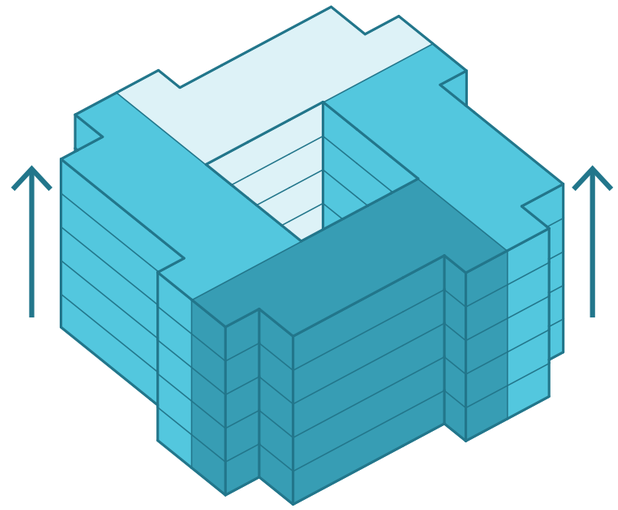
System Selection
Knock on Impacts

DfMA in residential

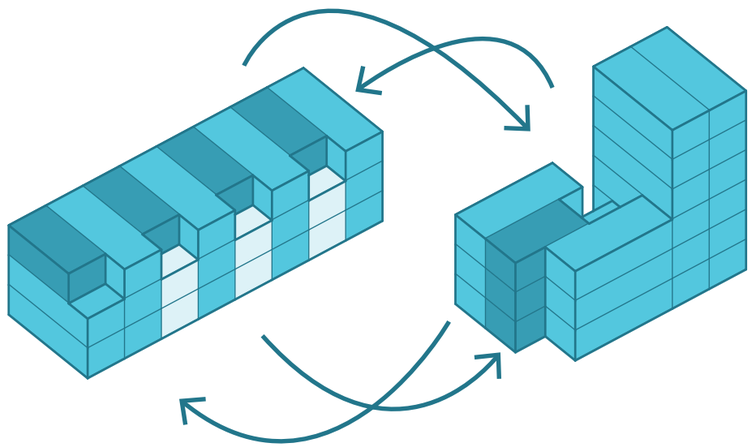
The impact of block arrangement



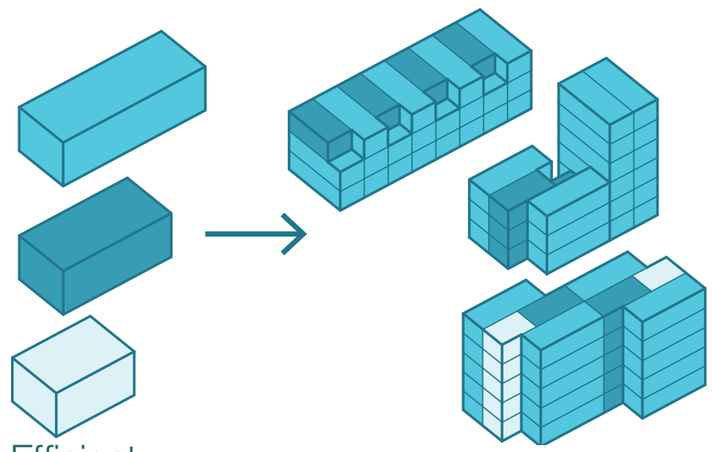
Repeatable



Stackable



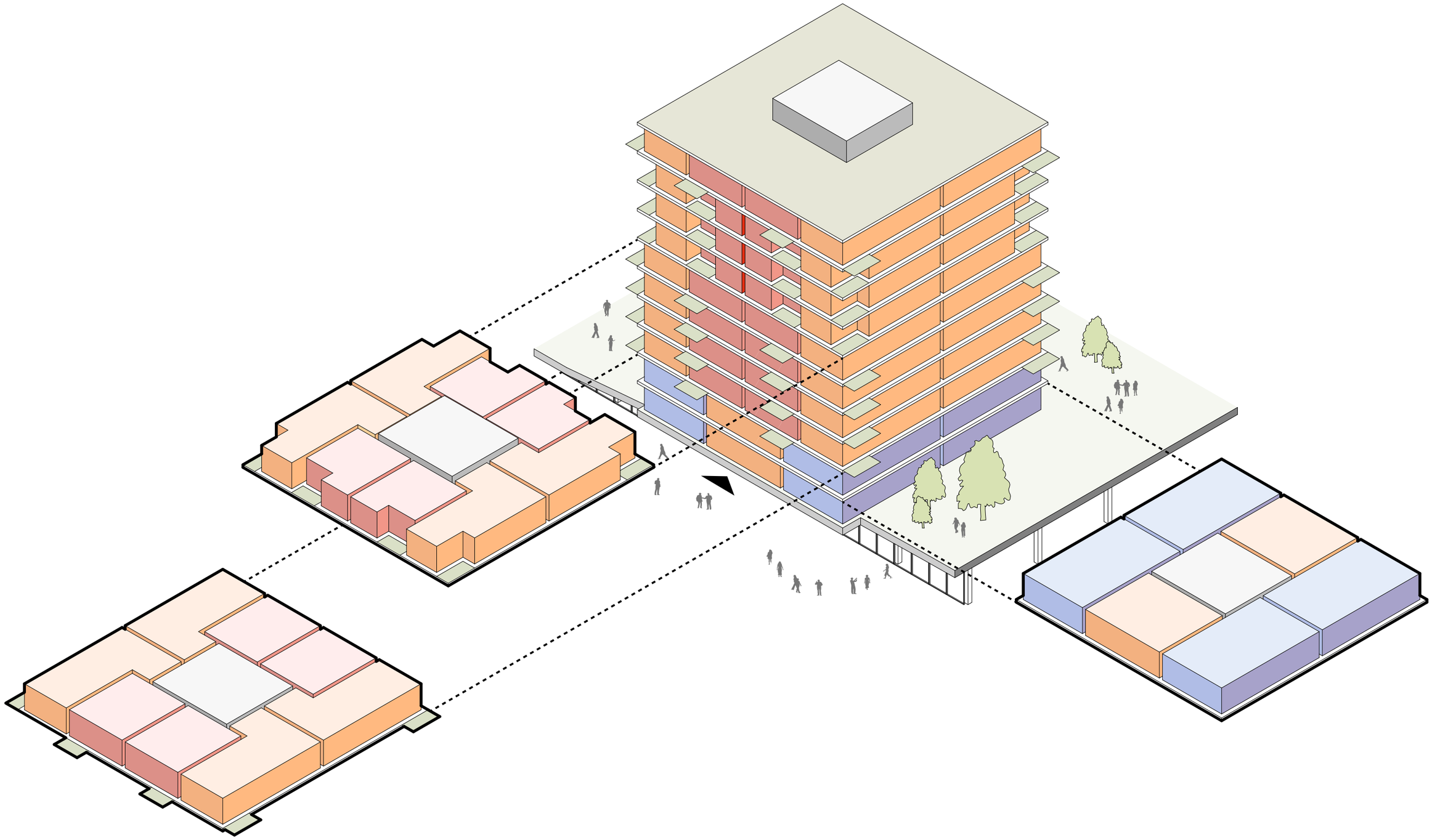
Flexible



Efficient

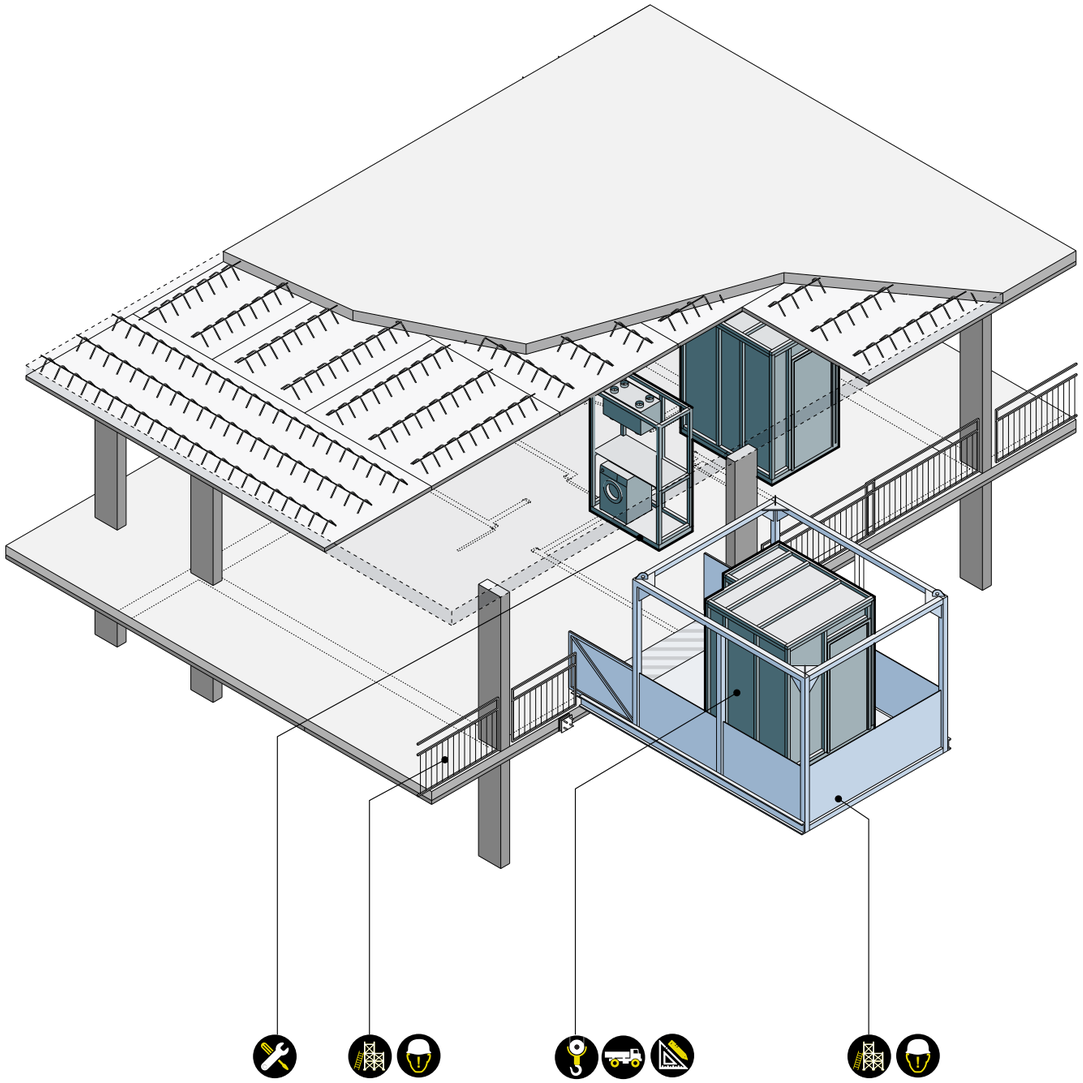
DfMA in residential

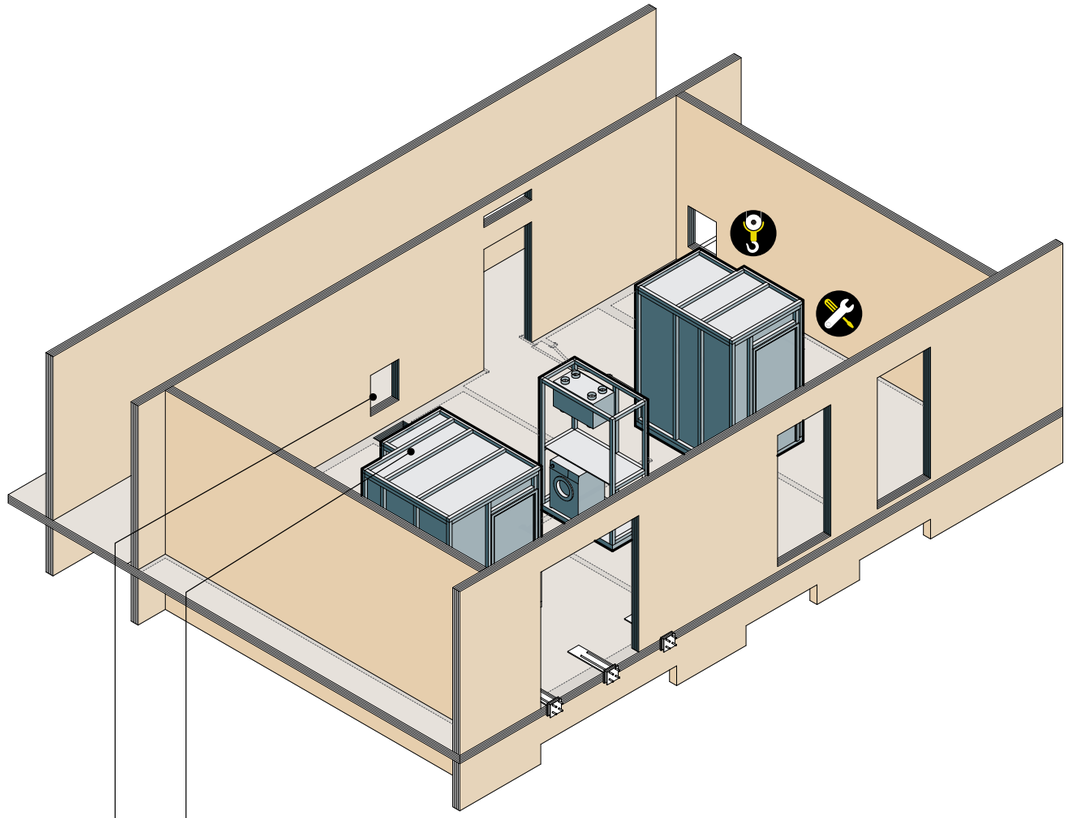
The impact of block arrangement



DfMA in Residential

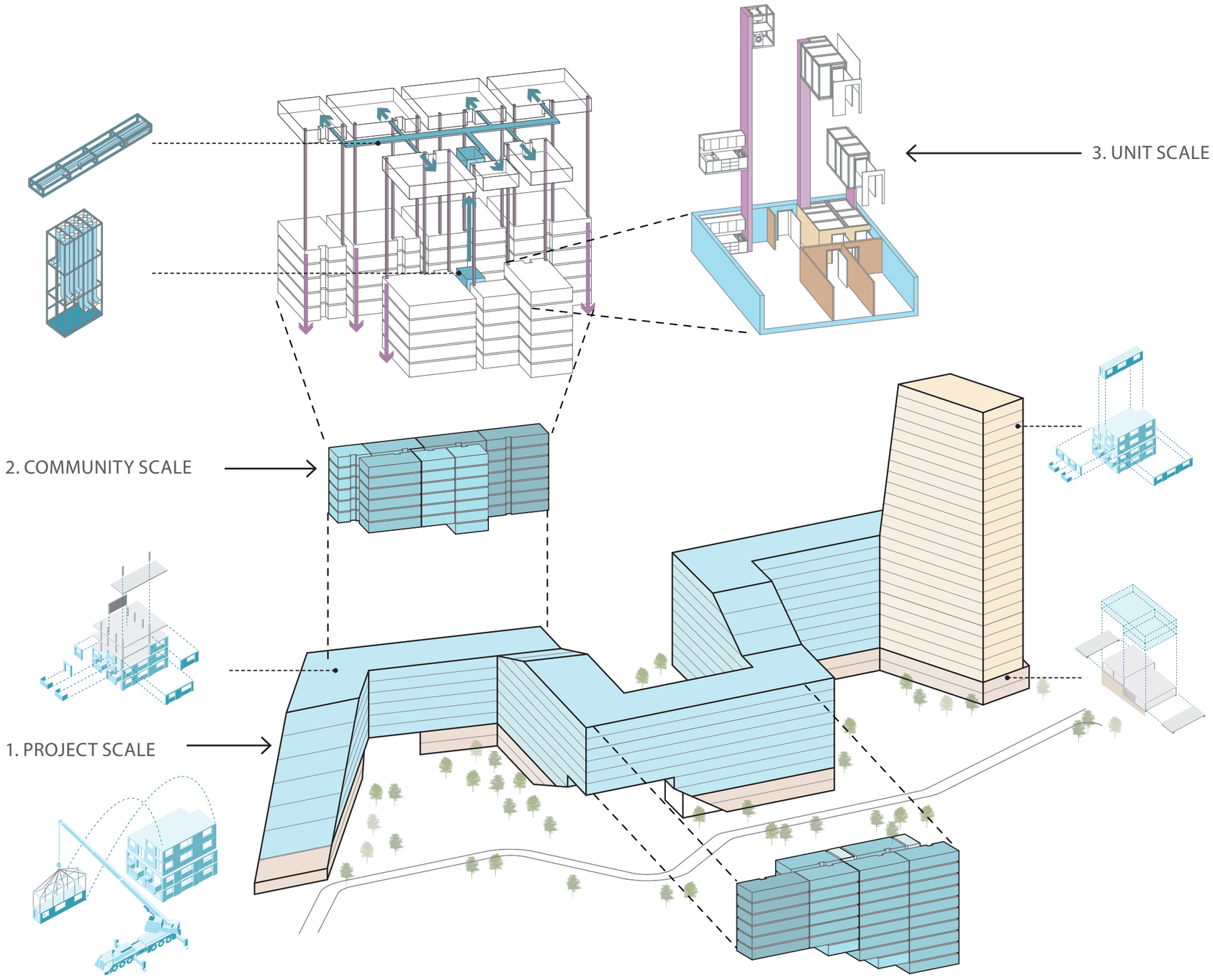
Knock on effects





System Selection
Optioneering in student residential

Testing options
Student residential



Testing options

Establishing supply chain capability

Offsite supplier interviewed at Programming stage

	System Name	Location	Desciption	Website
1	MiTek	Ventura	Closed Panel Timber Frame & Facade Panels	https://www.mitek-us.com/
2	CarlDietrich	Sacramento, Riverside	Light Gauge Steel Frame	https://www.clarkdietrich.com/
3	Advanced Building Systems	Industry	Light Gauge Steel Frame	http://advancedbuildingsystem.net/
4	CEMCO	Industry	Light Gauge Steel Frame	http://cemcosteel.com/
5	Deluxe Building Products	Pamona	Light Gauge Steel Frame	http://www.deluxebuildingproducts.com/
6	Frametek	Riverside	Light Gauge Steel Frame	https://frametek.com/
7	Superior Wall Systems	Anaheim	Light Gauge Steel Frame	https://www.superiorwallsystems.com/
8	The Raymond Group	San Diego	Light Guage Steel Frame	https://www.raymondgroup.com/
9	West Coast SIPs	Wasco	SIPs	https://www.westcoastsips.com/
10	Silver Creek Industries	Perris	Steel-framed Volumetric	https://silver-creek.net/
11	US Modular Inc	Carlsbad	Steel-framed Volumetric	http://www.usmodularinc.com/
12	Meehleis Modular Building	Lodi	Steel-framed Volumetric	http://meehleis.com/
13	Plant Prefab	Rialto	Steel-framed Volumetric	https://www.plantprefab.com/
14	Nevell Group	Carlsbad	External Wall Panels	http://nevellgroup.com/
15	Coreslab Structures	Perris	Precast Concrete	https://www.coreslab.com/
16	Clark Pacific	Fontana	Precast Concrete	https://www.clarkpacific.com/
17	RAD Urban	Lathrop	Steel-framed Volumetric	https://radurban.com/
18	ConXTech	Pleasanton	Steel Structure	https://www.conxtech.com/
19	Brady SoCal	La Mesa	Steel Structure	https://www.brady.com/socal/
20	WS Klem Contractor	El Segundo	Timber Frame, CLT and Glulam Contractor	https://www.wsklem.com/

Testing options
Student residential

A. Structural solutions
Primary considerations

01. Height - Can the system achieve both the tower and the ribbon?
02. Code - Are there code considerations that prevent a system achieving the necessary heights or require excessive additional works to achive code?
03. Vehicle movements - will the system result in more or fewer vehicle movements to site
04. Foundation sizes - What is the mass of the system? will it increase or decrease foundation sizes?
05. Sustainability & Embodied carbon - will the proposed system have negative or positive impact on the schemes sustainability aspirations
06. Tolerances - are finer structural tollerances than usual required to facilitate other DIMC opportunities?
07. Are there area / space implications of the chosen system?
08. Additional Benefits / limitations / oppotunities?

review structural system selection

Note:
The chosen structural system may facilitate non stacking elements however if they are required a change in system or hybridisation of the chosen system required to achieve this. Changes may include increases in floor to floor height or transfer slabs to facilitate the design.

Select prefered system(s)

B. Stacking & undercuts
Primary considerations

01. Does the structure and services stack?
02. Can they be made to stack?
03. Are the non stacking elements localised or spread throughout the scheme?
04. Can the undercroft achieve the column or near column free design intent?

Not all elements stack

Stacking and structural system resolved

C. Facade
Primary considerations

01. Does the system meet the design and quality aspirations for the project?
02. Does the system work with the chosen structural system?
03. Does the panelisation strategy work with the crane?
04. Can scoffolding be ommited from the scheme?

Note
facade system options can be hugely influenced by structural system selection, heavy or tradition facades can negate time and mass savings gained by some DIMC structrual systems

Select additional DIMC opportunities

D. Pod Bathrooms
01. have the bathroom types been rationalised and reduced to a feasible number to facilitate manufacture?
02. Do floor plans allow for additional area required for thicker walls etc.
03. does the sequencing require consideration to ensure pods can be installed in sequence with the structrue
04. Ensure programme allows for earlier coordination

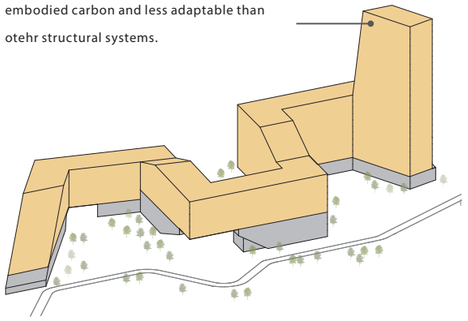
E. Services
01. are service runs consistent throughout the scheme?
02. Does the structure allow for install of large scale pregabricated elements? e.g whole plant rooms / partial plant rooms?
03. ensure strategy for commisioning/ testing is in place
04. will mutliple subcontractors be required to manufacture DIMC elements?

F. Other Systems
01. internal wall systems
02. stairs / balustrades
03. Kitchens
04. Facades

* better than usual tolerances may be reuqired to facilite other DIMC elements such as prefabricared internal wall elements.

PRE-CAST CONCRETE - PANELIZED

Suitable across entire scheme. High embodied carbon and less adaptable than otehr structural systems.



A. Primary Structural Considerations
01. Height - Precast Panelized Concrete can achieve the full building structure
02. Code - No issues with code
03. Vehicle movements - reduced number of vehicle movements over traditional concrete.
04. Foundation sizes - mass of concrete likely to necessitate large foundations
05. Sustainability & Embodied carbon - high embodied carbon. GBFS use can help offset carbon emissions from concrete production.
06. Tolerances - DIMC elements e.g. façades and bathrooms
07. Space Implications - Panelized wall thicknesses and structural grid may impact on room layouts & sizes, structural grid should be optimised to work with standardised unit layouts
08. Other Opportunities - there are opportunities to hybridise an insitu frame with elements of precast structure to reduce works on site, this could include the use of precast concrete columns and walls.
09. Schedule - reductions likely however earlier coordination will be required in the design phase

B. Stacking and undercrofts
When utilising panelized systems stacking of structure is critical to ensure the system is optimised. Where non stacking elements are required they should either be designed in such a way that the structural lines can still stack while the or these areas should be located within the podium or on the upper floors to minimise the extent of any transfer structure required.

Achieving the undercrofts without columns will likely require significant thickening of slabs to the floors 2-4 to transfer load as the building sets back. This may effect overall building height.

D. Bathroom Pods
Bathroom pods are suitable for use with precast concrete panels with the following considerations:
Pod installation will be required as the structure is constructed. Pods will be craned into their temporary positions prior to the installation of the floor above due to limited opening sizes in panelized systems.
Early coordination required to ensure openings for services connections are fully designed into and cast into the panels.

C. Facades
Structurally precast panelized concrete frames can provide capacity for a large number of DIMC facade systems.
Significant benefits can be gained by constructing the facade with the same panelized system. Precast facade panels can also be designed to be structural. Tolerances will be better than insitu concrete and better suited to other DIMC façade systems

E. Services
Larger elements of prefabricated services should be coordinated with available structural openings to ensure installation is possible. Sequencing may need to be examined to maximise opportunities.
Prefabricated risers and common distribution possible, increased stacking will benefit this.

F. Other DIMC Opportunities
Hybrid structural solutions may facilitate the successful use of panelized concrete structure, insitu concrete may facilitate some of the complexity at lower level. More lightweight systems may also aid with step backs and no standard areas to the tops

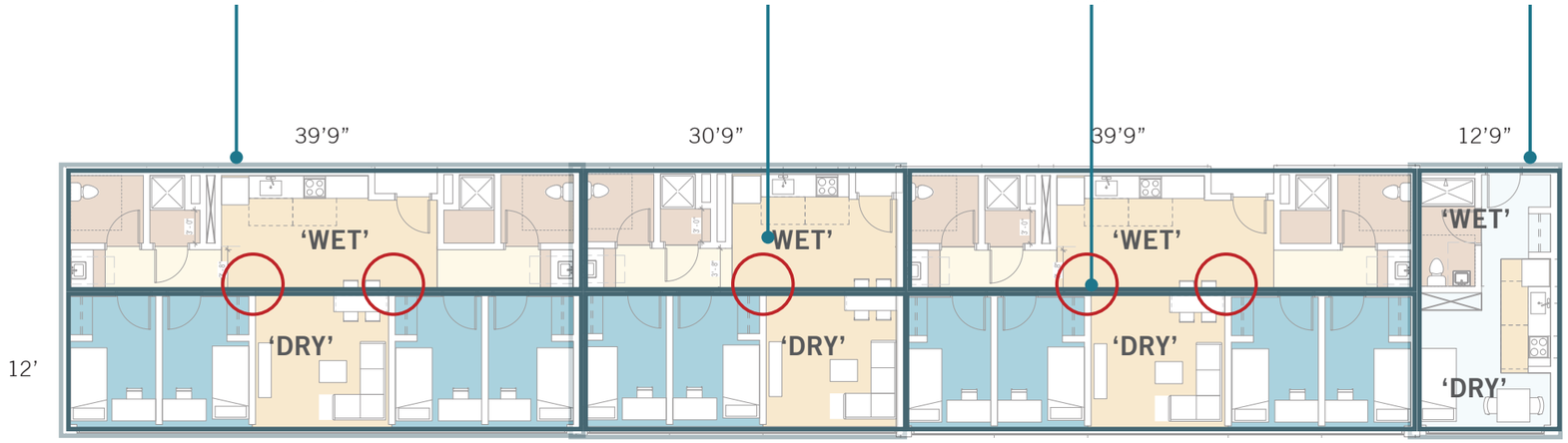
Testing options
Student residential

Primary module allignment could be broken down to restrict width of modules to 13’ for road tansport and broken parrallel to facade in accordance to ‘wet’ and ‘dry’ spaces.

Living spaces would be split over two modules, allowing for living or kitchen spaces to extend beyond 12’9”.

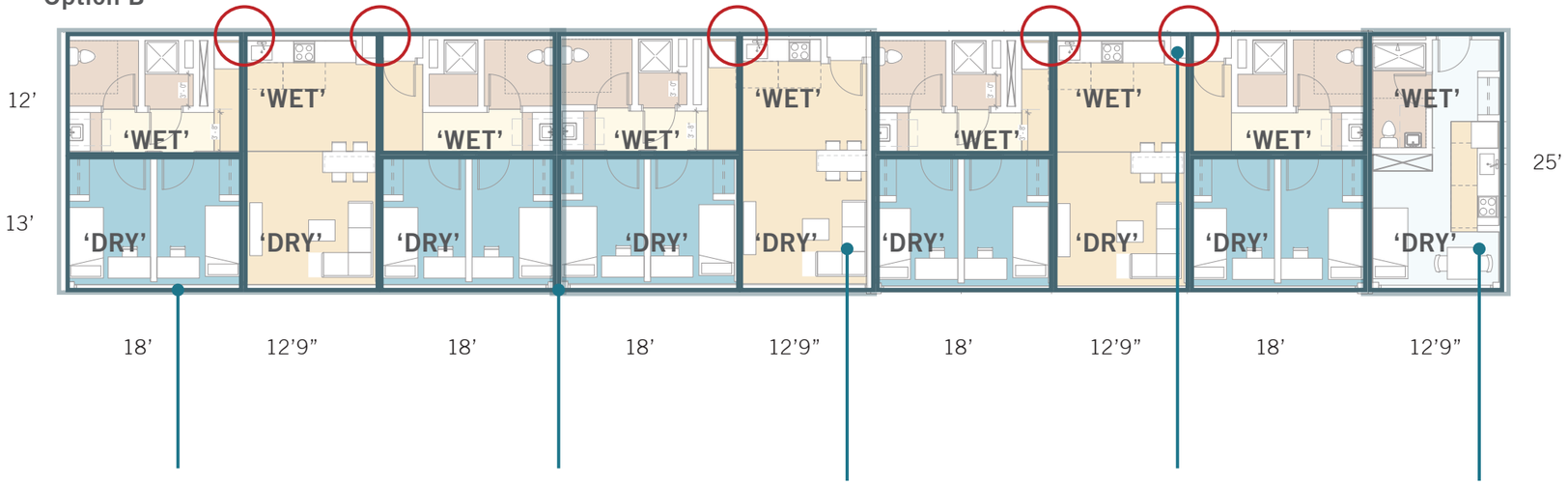
Openings in module walls to be carefully considered to ensure structural stability around opening in Living area. Columns potantially required.

Micro units of appropriate size for construction as single module



Option A

Option B



Modules broken down into two bedroom component which can be standardised and repeated across most unit types.

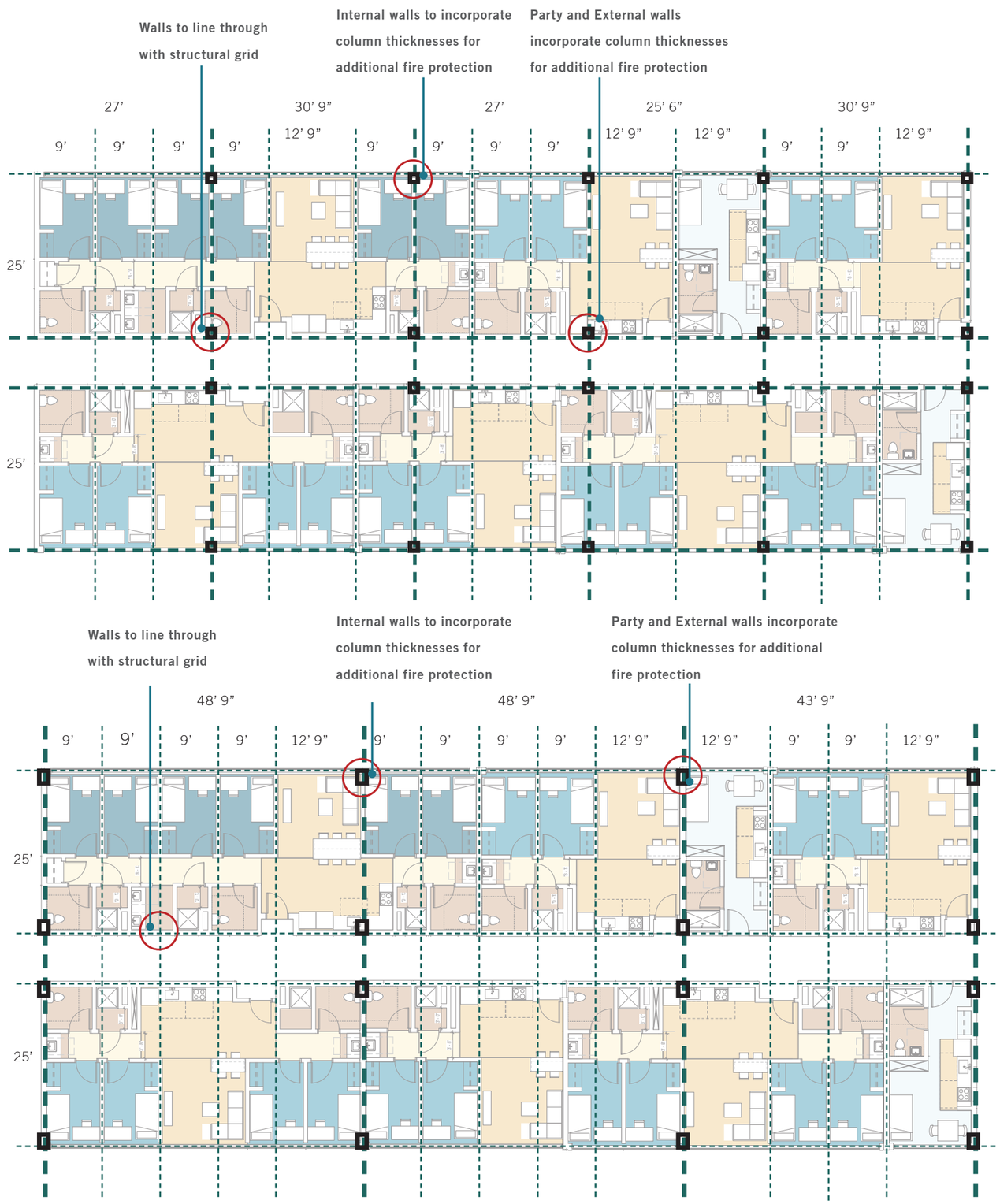
Structural walls to line up at module partitions

Living spaces would be combined in single module with standard width of 12’9”.

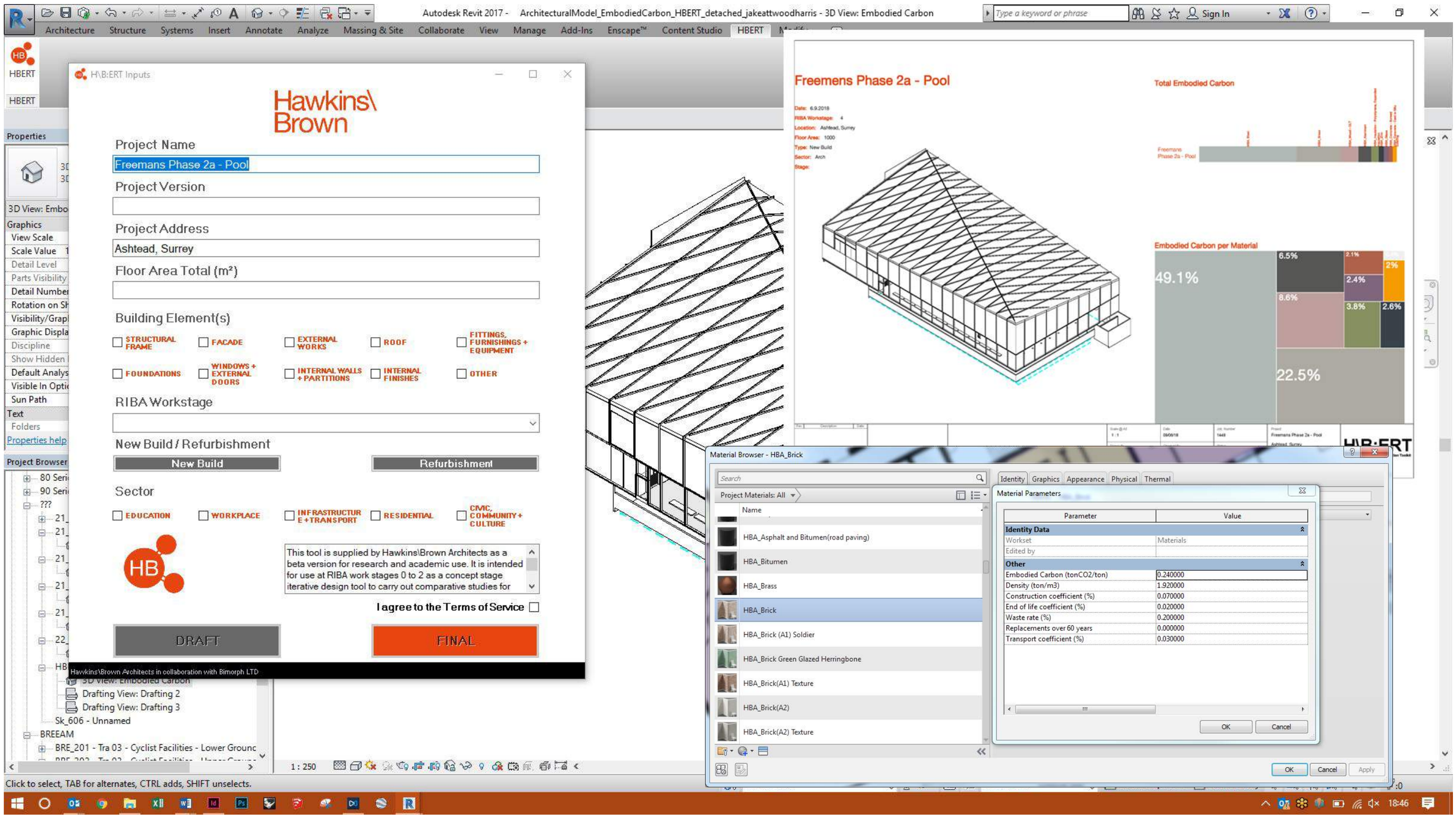
Columns required at corners to ensure structural stability of modules.

Micro units of appropriate size for construction as single module

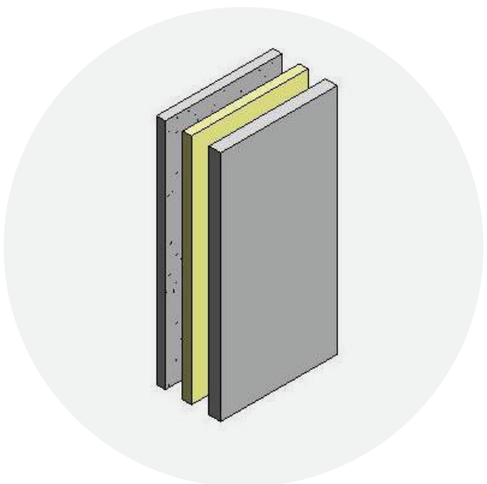
Testing options
Student residential



Testing options
Embodied carbon analysis

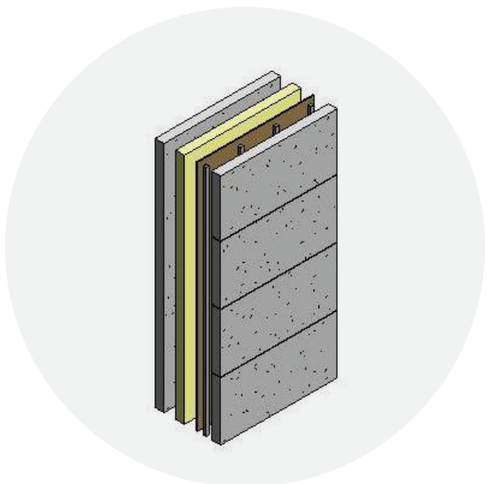


Testing options
Embodied carbon analysis



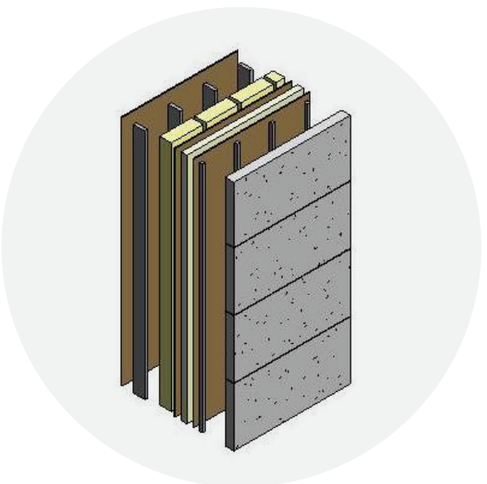
Reinforced & rammed concrete

156 $kg/CO_2e/m^2$
Average embodied carbon



Reinforced & pre-cast concrete panel

231 $kg/CO_2e/m^2$
Average embodied carbon



SFS & pre-cast concrete panel

514 $kg/CO_2e/m^2$
Average embodied carbon

Reinforced rammed earth

108 $kg/CO_2e/m^2$
Average embodied carbon

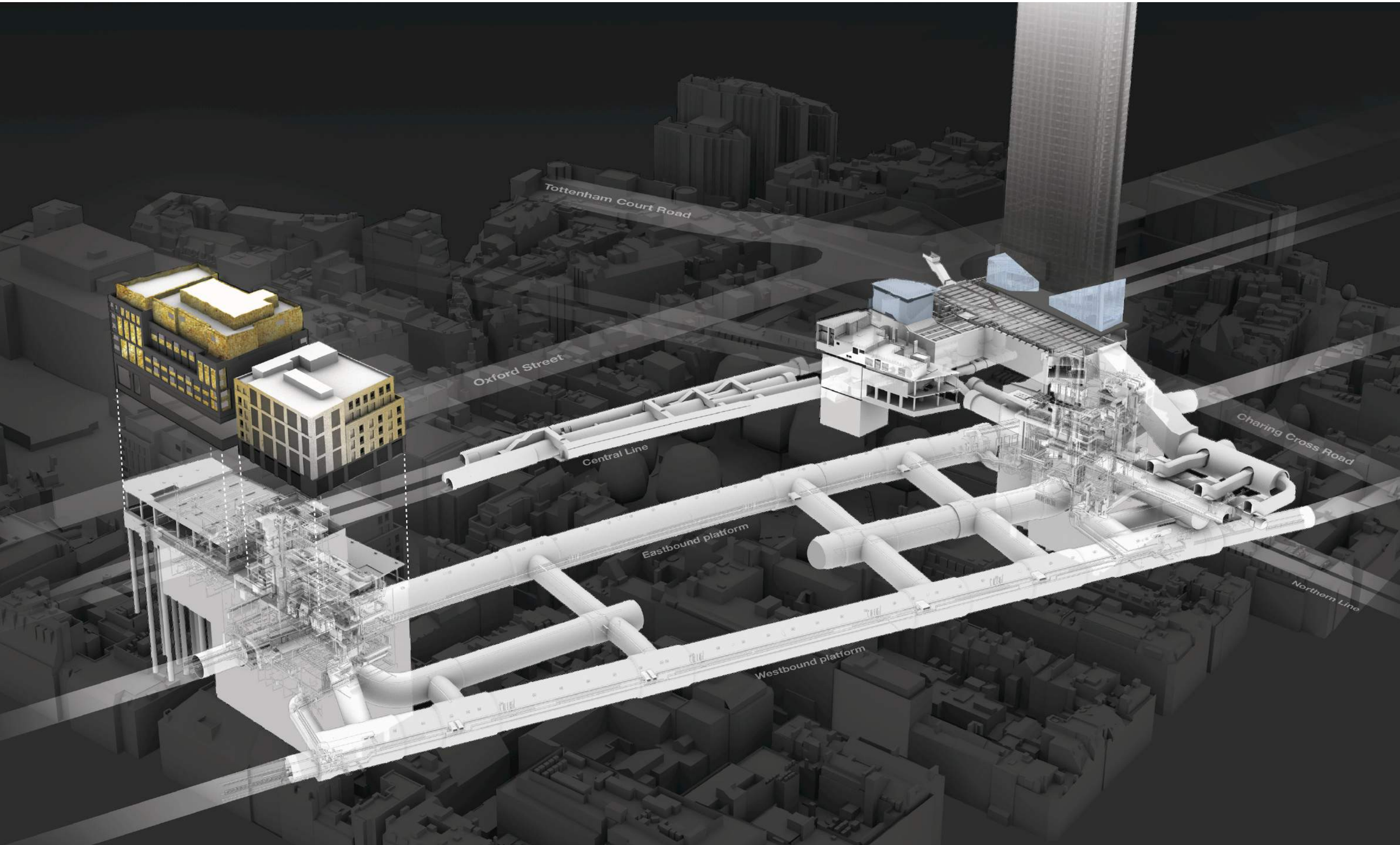
Delivering complexity with DfMA
Tottenham Court Road OSD

Cross Rail

Combining Infrastructure, Residential & Commercial

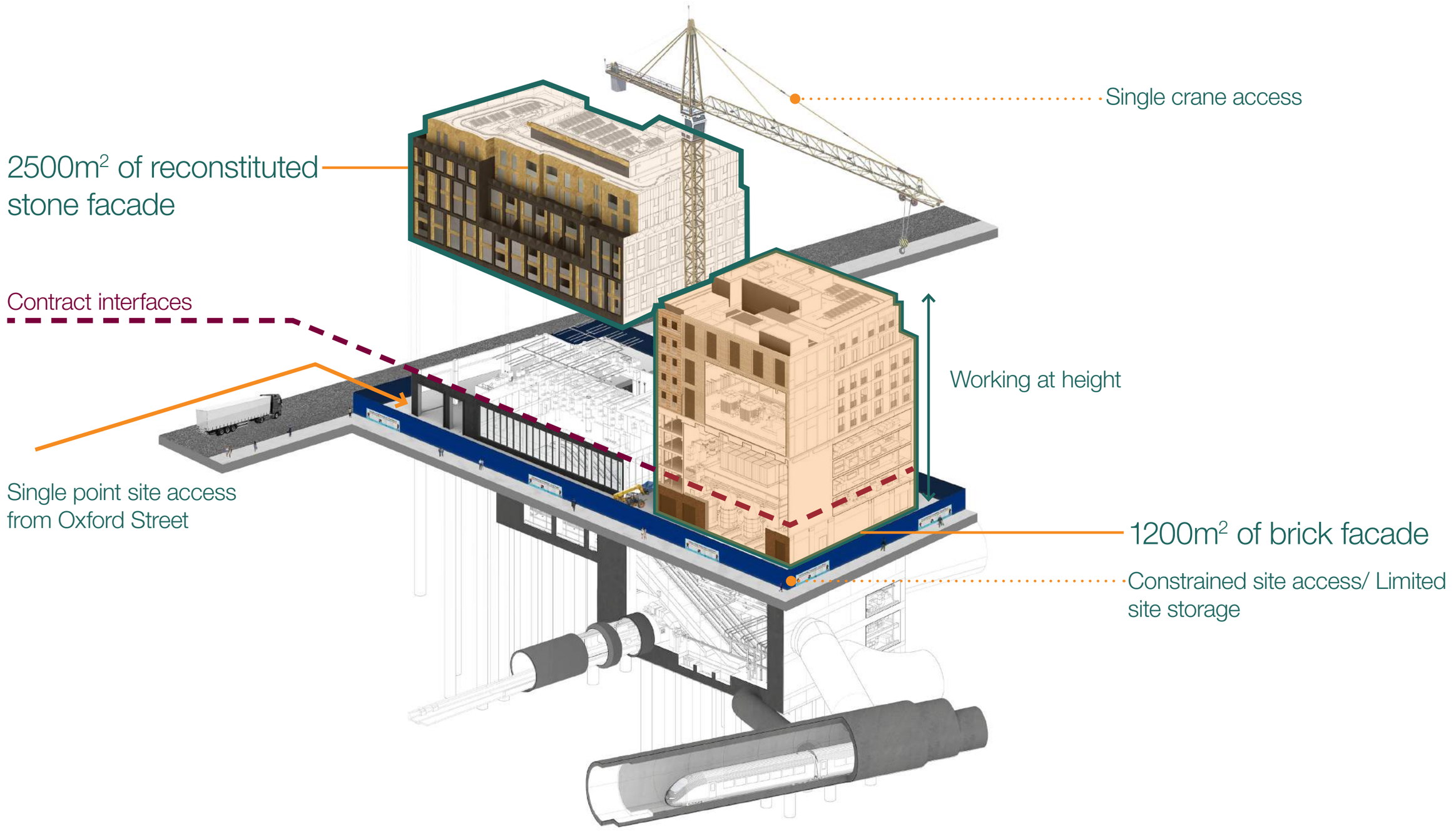
Cross Rail - Tottenham Court Road

Reducing Complexity



Cross Rail - Tottenham Court Road

Reducing Complexity



Cross Rail - Tottenham Court Road

Bespoke Design

1) Pigmented, diagrid textured concrete to penthouse. Swatch to the right is indicative of concrete relief only.

2) Recessed balustrade

3) Projecting polished concrete banding

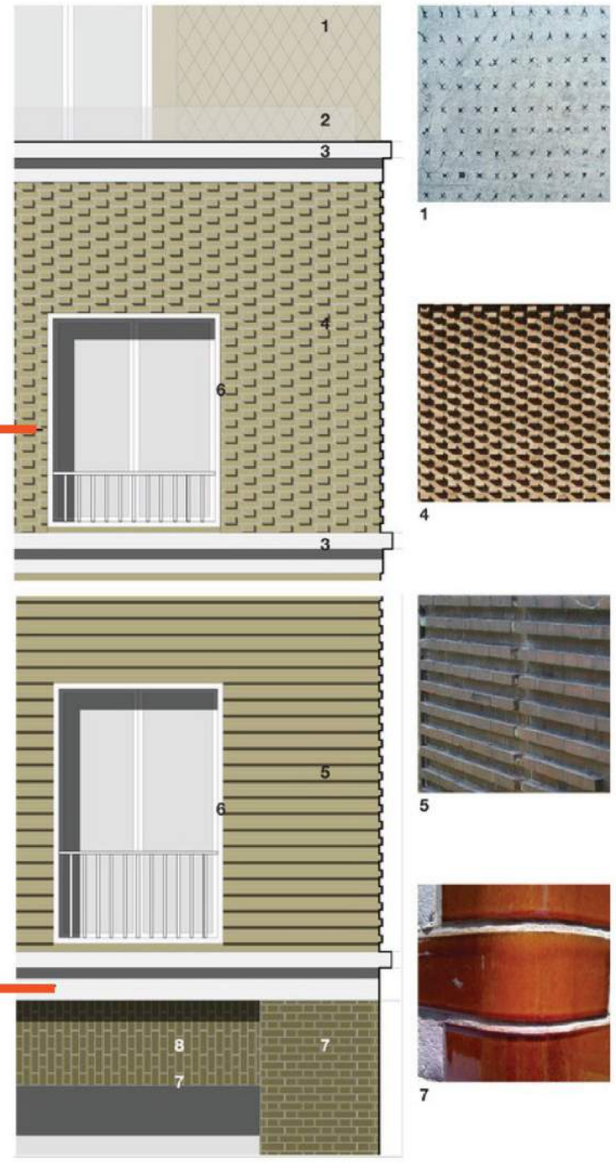
4) Textured brickwork in different shades expressing individual facade bays

5) Projecting bands of textured brickwork

6) Light coloured powder coated aluminium window frames recessed into matching linings and balustrades.

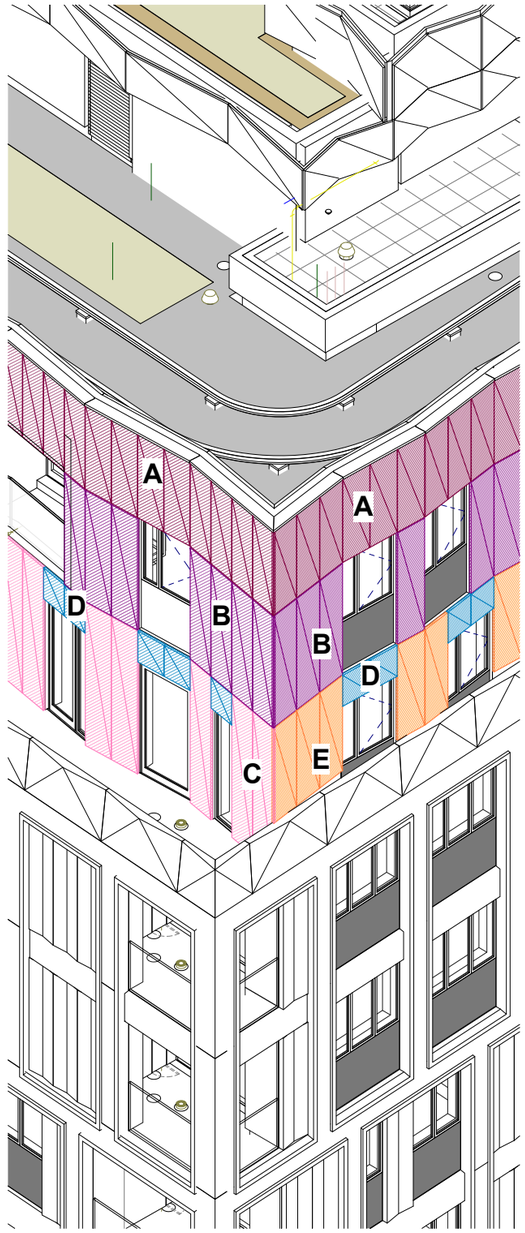
7) Glazed bricks with rounded edges to retail piers and recessed transom. Bright mortar joints.

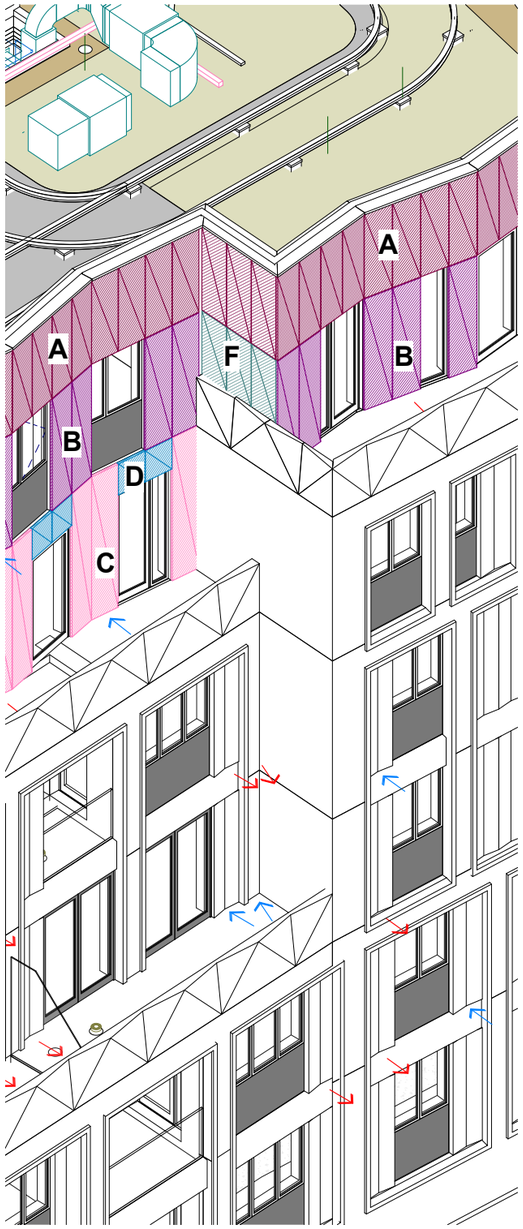
8) Recessed area for controlled signage zone. Surface mounted cut-out lettering only.



Cross Rail - Tottenham Court Road

The Kit of Parts





Crown Panel Schedule

Location	Level	Family and Type	Crown Panel Height	Crown Panel Width	Count	Type Mark
Dean Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 615mm	3255	615	17	
Dean Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 684mm	3255	684	3	
Dean Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x615mm	705	615	15	
Dean Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x660mm	705	660	7	
Dean Street Elevation	FFL - Level C+5	CrownPanel: (E) 2175 x 660mm	2165	660	11	
Dean Street Elevation	FFL - Level C+5	CrownPanel: (E) 2175 x 684mm	2165	684	2	
Dean Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 596mm	2530	596	9	
Dean Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 615mm	2530	615	19	
Dean Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 660mm	2530	660	11	
Dean Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 684mm	2530	684	5	
Dean Street Elevation	FFL - Level C+6	CrownPanel: (F) 1450mm x 657mm	1440	657	3	
Dean Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 596mm	1900	596	16	
Dean Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 615mm	1900	615	32	
Dean Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 657mm	1900	657	3	
Dean Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 660mm	1900	660	18	
Dean Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 684mm	1900	684	5	
Fareham Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 628mm	3255	628	14	
Fareham Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 750mm	3255	750	2	
Fareham Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x590mm	705	590	6	
Fareham Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x628mm	705	628	10	
Fareham Street Elevation	FFL - Level C+5	CrownPanel: (E) 2175 x 590mm	2165	590	10	
Fareham Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 590mm	2530	590	12	
Fareham Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 628mm	2530	628	14	
Fareham Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 750mm	2530	750	2	
Fareham Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 590mm	1900	590	16	
Fareham Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 628mm	1900	628	24	
Fareham Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 750mm	1900	750	2	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 595mm	3255	595	11	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 641mm	3255	641	8	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 692mm	3255	692	8	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (C) 3265 x 925mm	3255	925	2	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x595mm	705	595	13	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x641mm	705	641	8	
Great Chapel Street Elevation	FFL - Level C+5	CrownPanel: (D) 715mm x692mm	705	692	4	
Great Chapel Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 595mm	2530	595	12	
Great Chapel Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 641mm	2530	641	8	
Great Chapel Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 675mm	2530	675	12	
Great Chapel Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 692mm	2530	692	7	
Great Chapel Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 925mm	2530	925	2	
Great Chapel Street Elevation	FFL - Level C+6	CrownPanel: (F) 1450mm x 649mm	1440	649	3	
Great Chapel Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 595mm	1900	595	24	
Great Chapel Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 641mm	1900	641	16	
Great Chapel Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 649mm	1900	649	3	
Great Chapel Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 675mm	1900	675	20	
Great Chapel Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 692mm	1900	692	12	
Great Chapel Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 925mm	1900	925	2	
Oxford Street Elevation	FFL - Level C+6	CrownPanel: (B) 2540mm x 745mm	2530	745	21	
Oxford Street Elevation	FFL - Level C+7	CrownPanel: (A) 1910mm x 745mm	1900	745	32	
Grand total: 516					516	

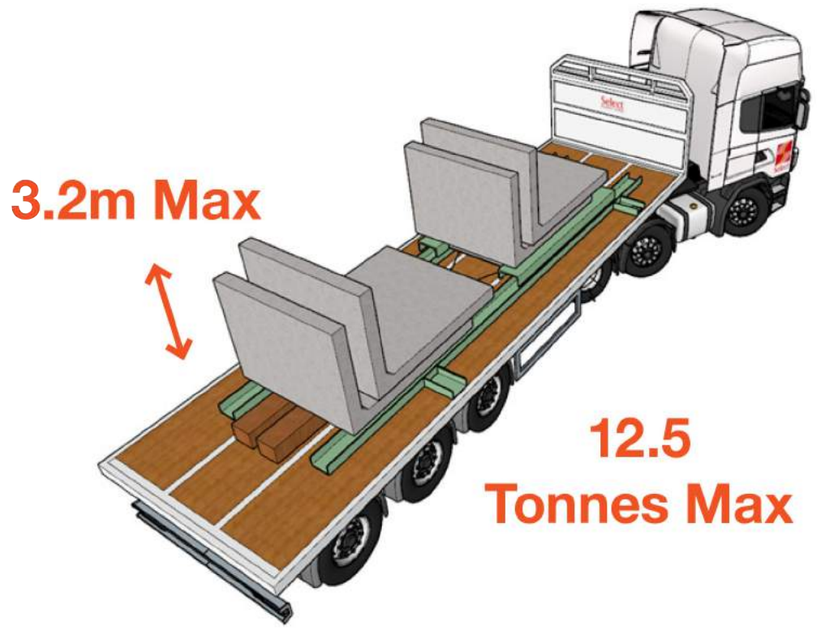
Cross Rail - Tottenham Court Road

The Kit of Parts

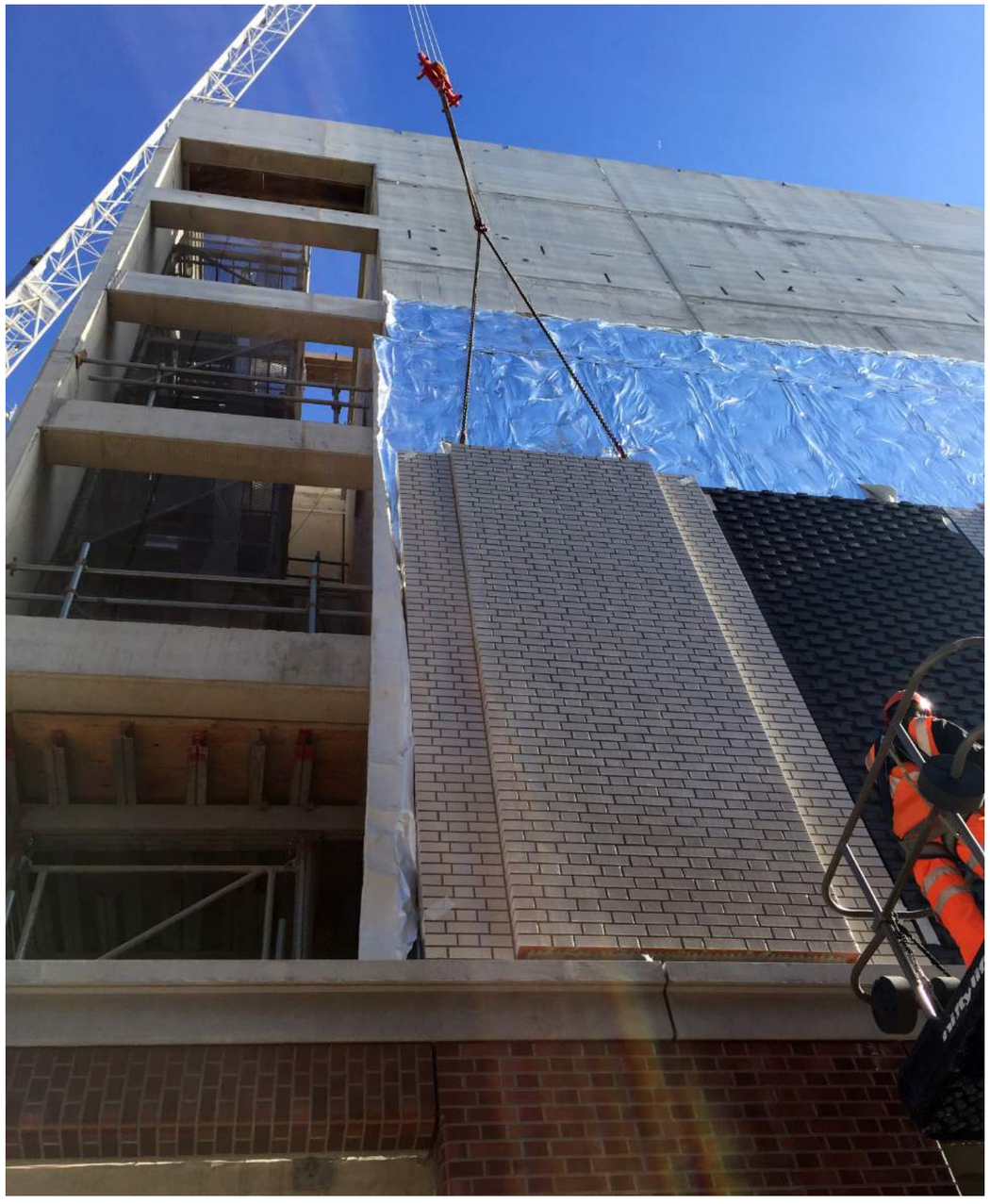
Cross Rail - Tottenham Court Road
testing the theory

Cross Rail - Tottenham Court Road

Logistics



Cross Rail - Tottenham Court Road
facade panel install



Cross Rail - Tottenham Court Road

Results

3 Weeks

9 Weeks

13 Weeks

Prototype

4 Weeks →

Fabrication

Delivery

Install

Based upon 30 panels per week

-4 Weeks

Site Preparation

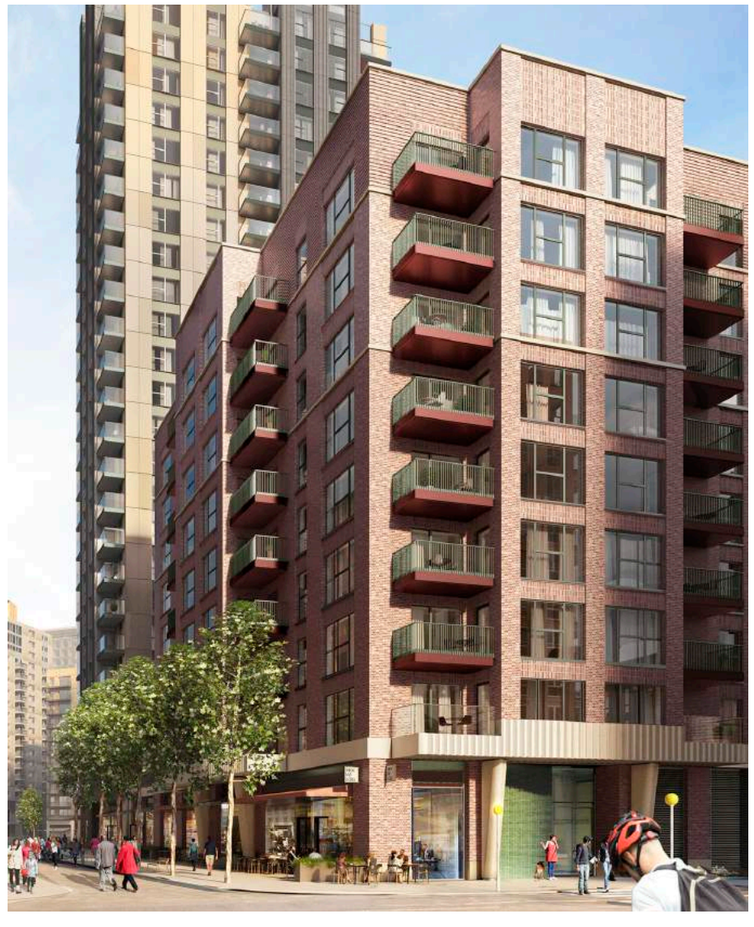
Traditional Construction

External finished face only based upon 4:2 gang ratio @ Circa 10m² per day

Modular Construction
Elephant Park

Volumetric modular construction

Site specific decision making



Volumetric modular construction

Site specific decision making

2900 Max

Typical Upper Plan - Modular Construction

No. of Modules on Typical floor:	**158**
Total No. of Modules in Scheme:	**1632**

Note
- These figures assume traditional construction for Duplex units.
- Corridors are brought as separate modules
- Kitchens cut due to small nature of modular units. Kitchens would need redesigning
- Walls do not align with modules. Columns would be required within flats or unit sizes increasing to allow for inefficient layouts

Module Sizing

< 2900mm

Unit Types

- 1B1P
- 1B2P
- 2B3P
- 2B4P
- 3B5P
- 3B6P

Volumetric modular construction

Site specific decision making

Typical Upper Plan - Modular Construction

No. of Modules on Typical floor: **90**

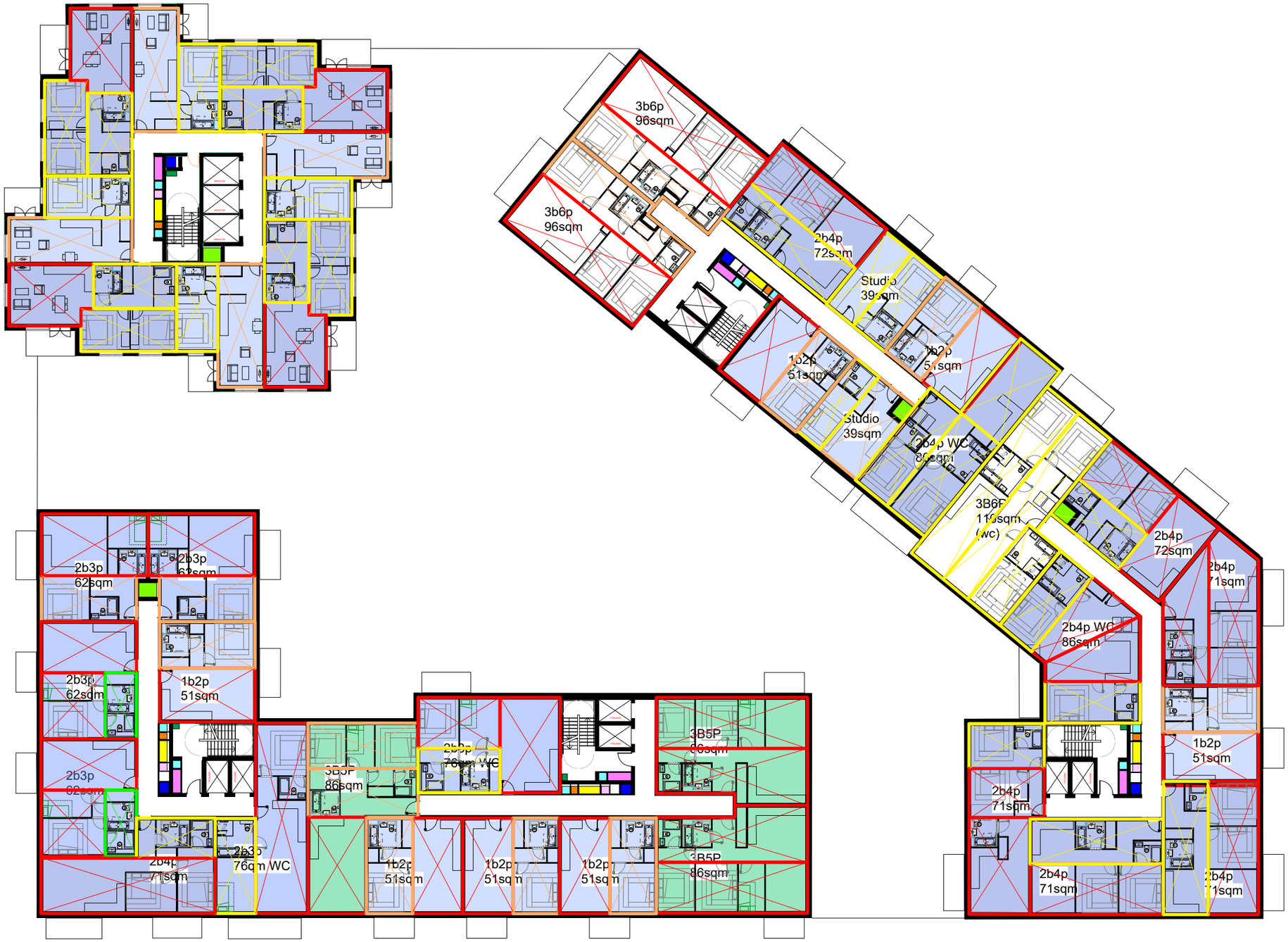
Total No. of Modules in Scheme: **1004**

Note
- These figures assume traditional construction for Duplex units.
- Corridors are brought as separate modules
- Largest sized unit: 4060x14747mm

Module Sizing	Total per floor	
< 2900mm	2	3%
2900mm - 3500mm	31	34%
3500mm - 3800mm	18	20%
3800mm - 5000mm	39	43%

Unit Types

- 1B1P
- 1B2P
- 2B3P
- 2B4P
- 3B5P
- 3B6P



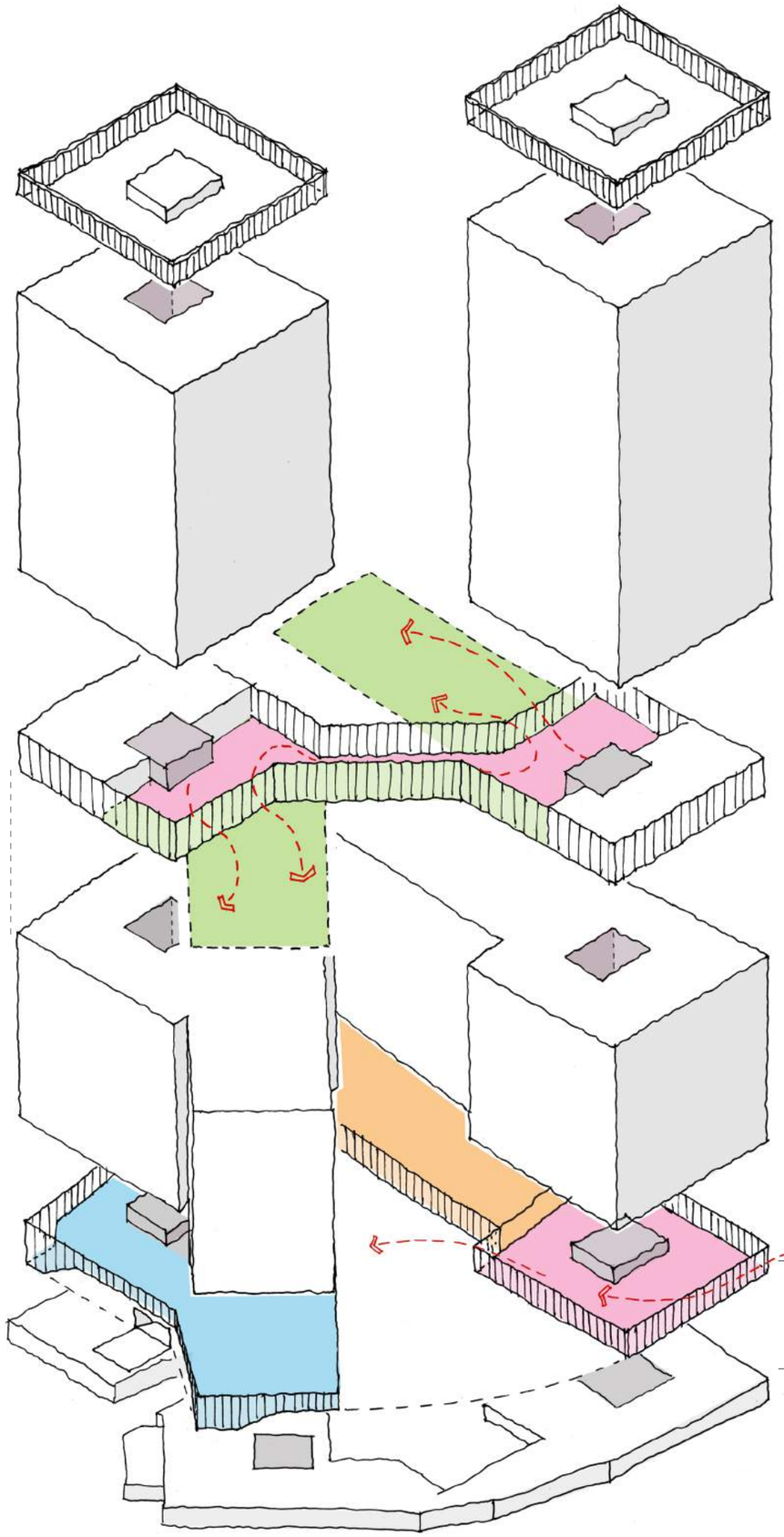
High Rise Solutions
N06 East Village

Plot N06 - East Village Stratford

524no. Build to rent apartments in 31 & 26 storey towers and podium tails

MACE

Plot N06
Building diagram



Crown

Residential Levels 12-30

Amenity and Duplexes

Residential Levels 1-9

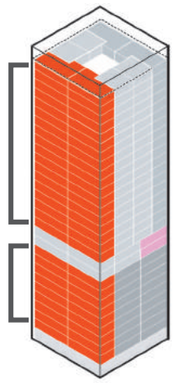
Mixed Use Ground Floor

Basement

Plot N06

DfMA - Standardisation from the outset

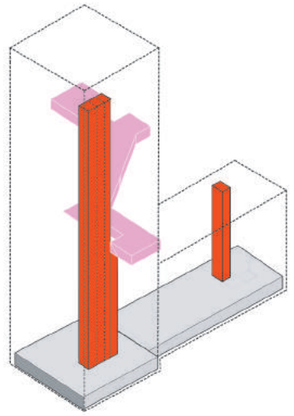
Stacking of apartments



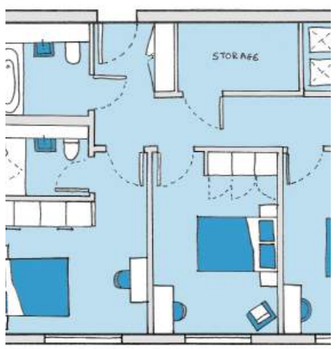
Limited number of apartment types

15 x Unit Types

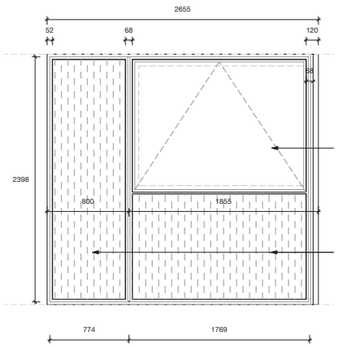
Efficiency in cores and number of lifts



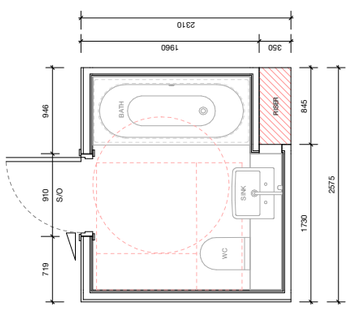
Prioritisation of key facade design elements



Modularisation / prefabrication of facade elements



Modularisation / prefabrication of building elements



Plot N06

Wetlands View

Plot N06

DfMA - Facade

Prefabricated \ Unitised System

Opportunities

- Certainty of resource
- Certainty of quality
- Reduced programme risk
- Highest standards of safety
- A trusted team
- Reduced on site labour
- Less deliveries
- Reduced impact on the local environment and residents

Plot N06
standardising variation

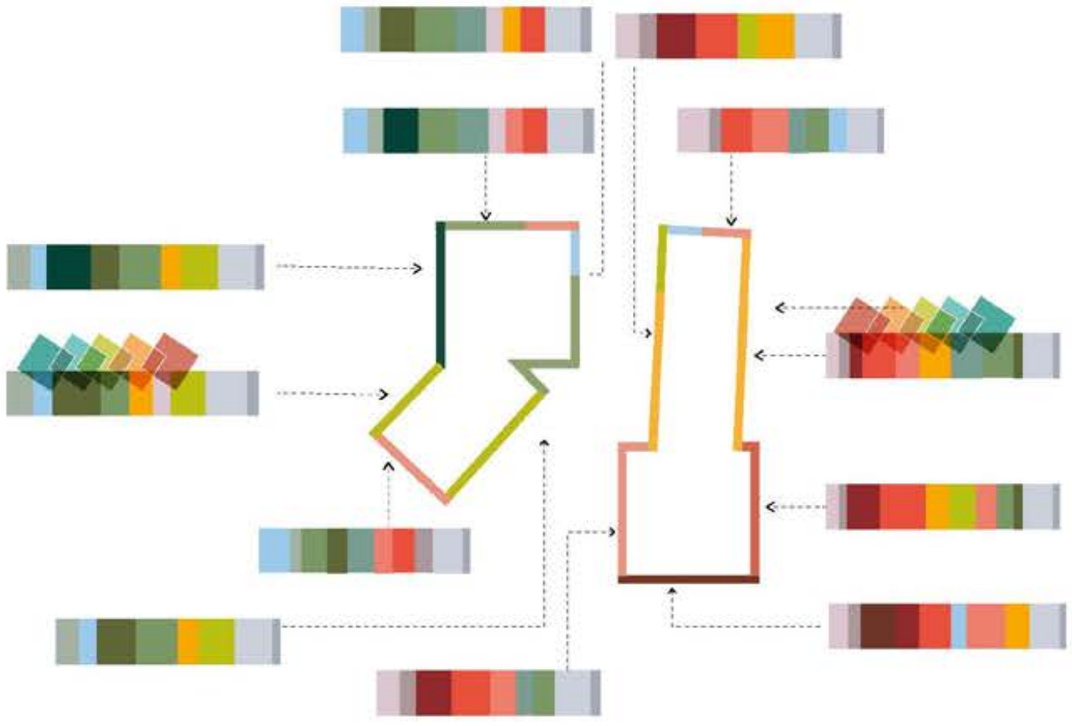
Concept imagery / inspiration to evolve colour palette

Tower 2

Tower 1

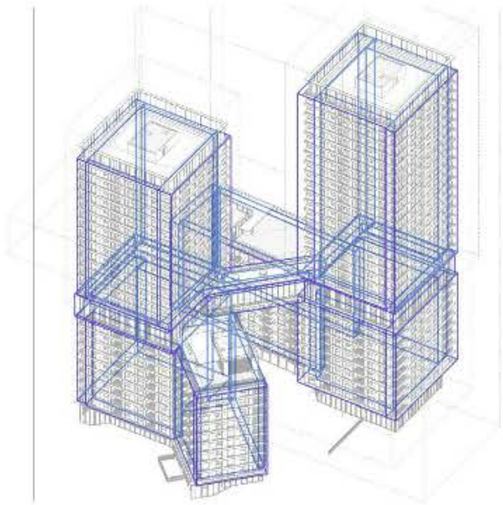
Pantone Solid Coated 130 C	Pantone Solid Coated 2344 C	Pantone Solid Coated 7625 C	Pantone Solid Coated 7623 C	Pantone Solid Coated 175 C	Pantone Solid Coated 436 C	Pantone Solid Coated 5175 C	Pantone Solid Coated 291 C	Pantone Solid Coated 5645 C	Pantone Solid Coated 3308 C	Pantone Solid Coated 5753 C	Pantone Solid Coated 2263 C	Pantone Solid Coated 624 C	Pantone Solid Coated 583 C
Highlights	Base Palette				Shared Palette / Amenity Floor				Base Palette				Highlights

Plot N06
standardising variation

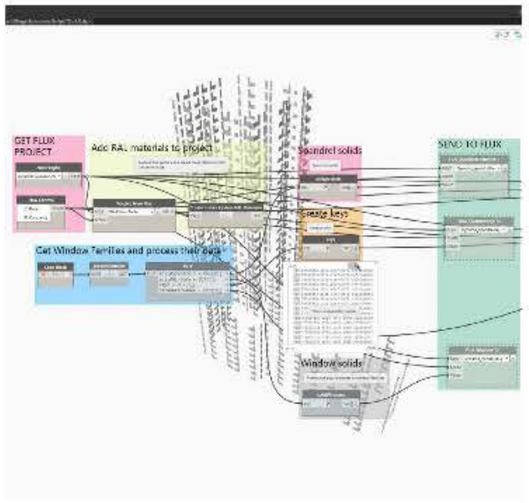


Plot N06
standardising variation

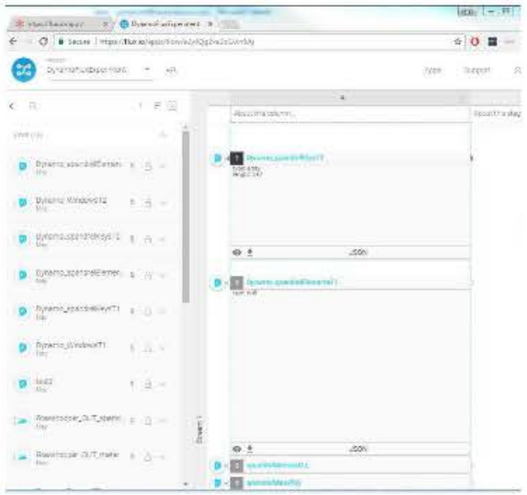
Zone panels in Revit



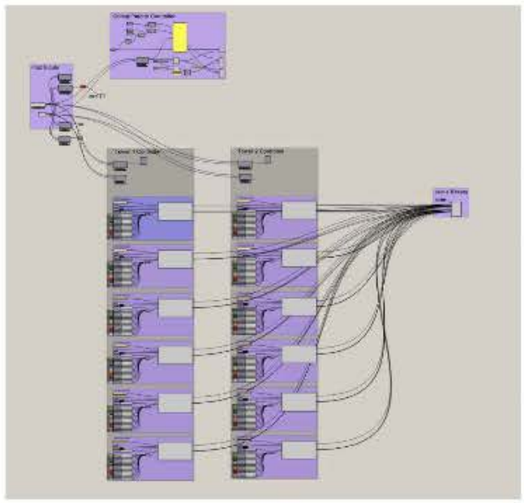
Extract Panels from Revit



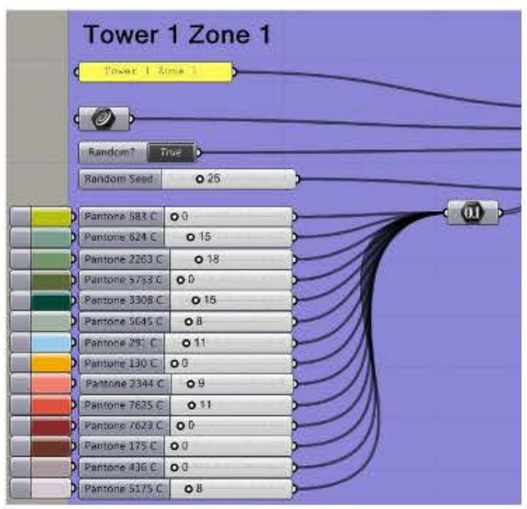
Push panels to Flux



Pull panels to GH

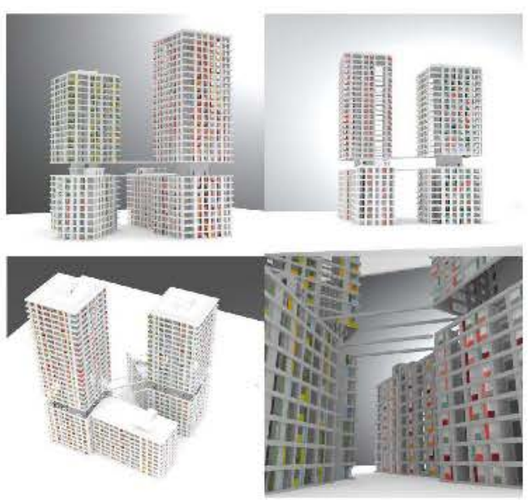


Alter colour mixes

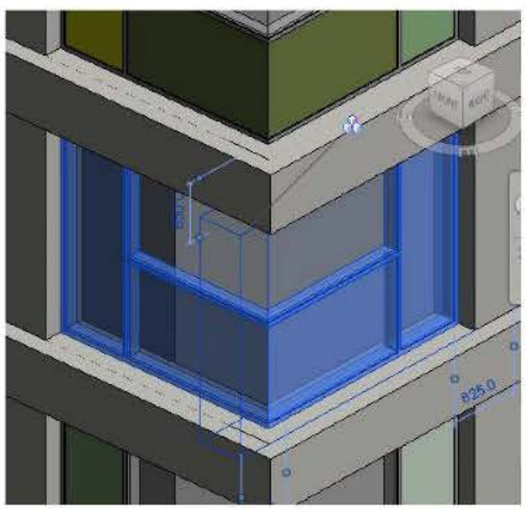


Quickly visualise

Quickly render

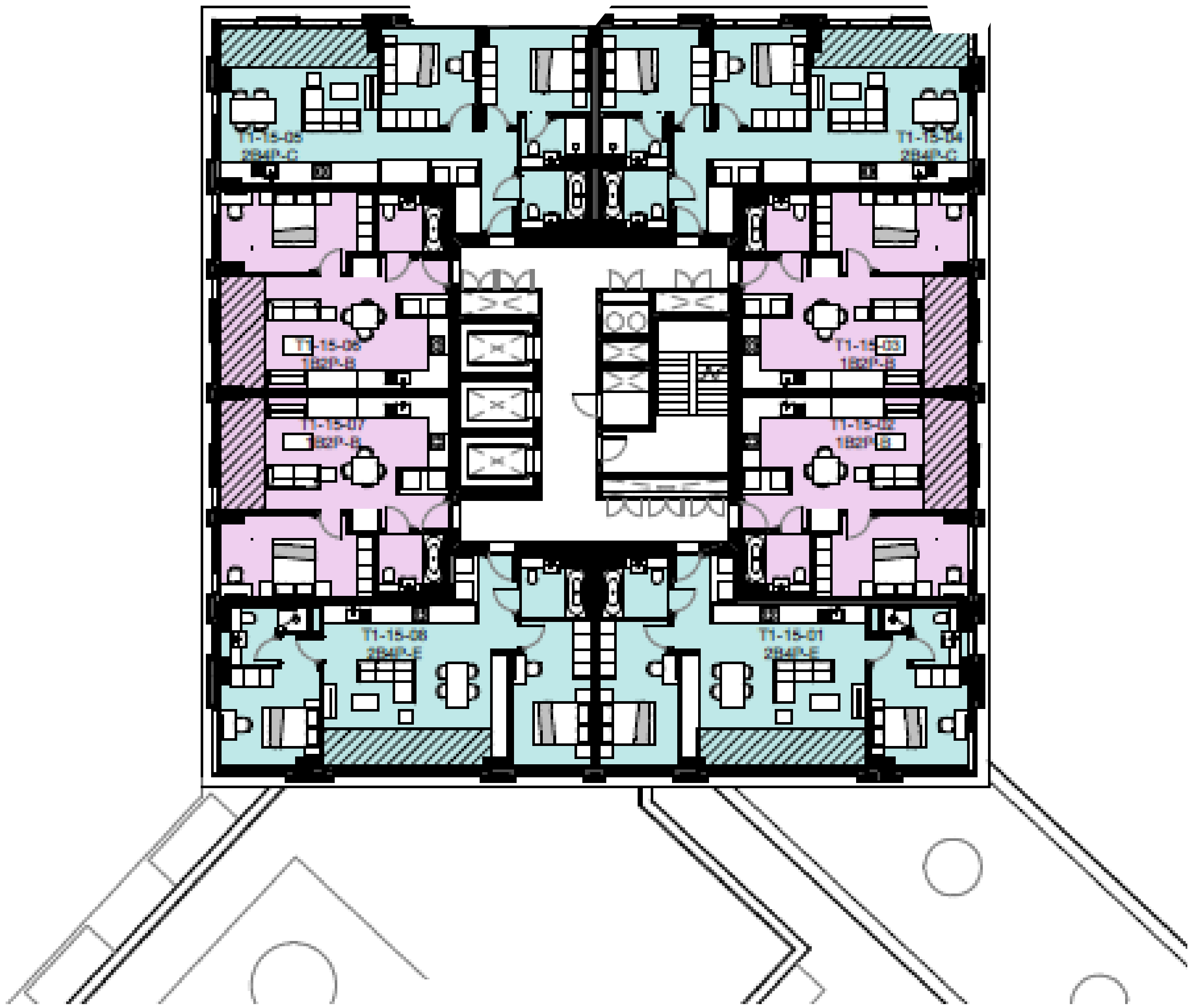


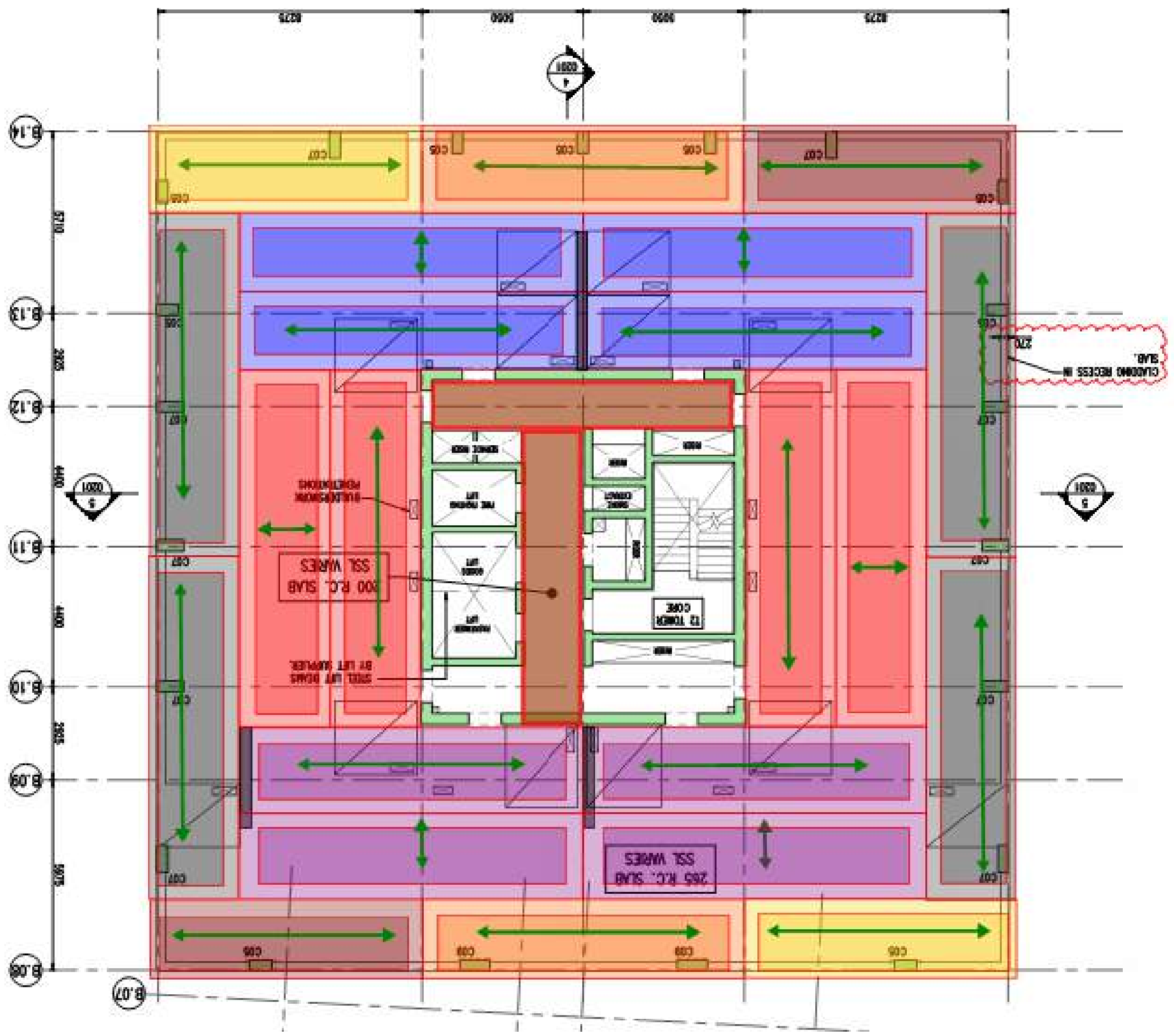
GH > Flux > Dyn > Revit



Plot N06

DfMA - HRS system





Plot N06

DfMA - HRS system

Get Living & Qatari Diar

Hickory System - On Site Mock-up

Thank you