As the Curtain Falls

by

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Master of Arts in Architecture
Royal College of Art, 2018

Submitted to the
Department of Architecture
in Partial Fulfillment of the Requirements for the Degree of

Master of Science in Architecture Studies
at the

Massachusetts Institute of Technology
May 2022

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As the Curtain Falls

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Submitted to the Department of Architecture on
May 25th, 2022

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Master of Science in Architecture Studies

ABSTRACT
For the last century, architects have embraced the efficiencies of the curtain wall. As a technological solution that mediates between our interior desires and the realities of the outside world, these envelope systems have been liberally applied to buildings across the globe. Regardless of longitude and latitude, minimal vitreous enclosures have grown to represent progress and modernisation - the triumph of capitalist logic over all else.

Today, however, as concerns surrounding climate change are pulled to the forefront of contemporary culture, the myopic tendencies with which these enclosures were designed is starting to become apparent. With use-lives rarely exceeding 50 years, many curtain walls are now struggling to keep pace with contemporary change, not only falling short of ever-more stringent performance standards, but also rapidly evolving cultural demands. With a vast number of these envelopes set to fail in the not-so-distant future, it is now simply a matter of time until the world’s first generation of crystalline skylines are either erased or replaced.

When considering the sheer quantity of curtain walls that have been assembled over the last fifty years, in urban canters as diverse as New York and New Delhi, the true magnitude of this issue starts to become apparent. As a generation of young architects, we are set to inherit an inventory of large buildings possessing perfectly sound structures, but fundamentally flawed envelopes. Concurrently sitting in the midst of what has come to be known as a “climate crisis”, it seems an appropriate time to question our current paradigm of enclosure design. Do we really need more short-term solutions, or a fundamental shift in the way we perceive and produce the outer inches of our architecture?

Thesis Supervisor: Marc Simmons
Title: Associate Professor of the Practice

Many thanks to Marc and Sheila for their
time, effort, and words of wisdom.

Contents

All images are the author's own work
unless captioned otherwise.

Exposition

Systemic Change

Change: the only constant. Significant, systemic, sporadic. Despite both the inevitability and unpredictability of change - the unceasing evolution of technology, climate, and culture - we still continually attempt to foresee the unforeseeable. Architecture, the world's slowest discipline, perils in the face of change. Building is slow, change is fast. Who, what, where, and when do we really design for?

One can strive to produce a building that lasts a century... maybe even two. But how can we possibly fathom the needs of one-hundred years' time? Architecture accommodates change, it adapts, it always has - but it seems that the occupational evolution of our buildings is evolving ever faster... warehouse-cum-school, chapel-cum-data center, home-cum-office, office-cum-home.

Alongside this occupational evolution lies a transmutation in the way buildings are constructed - the twentieth century witnessing both their production and product evolve beyond recognition. They are no longer simply four walls and a roof, but an assemblage of structural, envelope, and mechanical systems - a set of discrete products, each with its own agency and temporality. Inherently more complex than those of yesteryear, a plethora of new technologies and tectonics have enthusiastically been thrown up into our skylines without consideration of how and when they might come down. Airtight artificially controlled climates hundreds of meters tall have become the norm. Nobody looks twice.

With our buildings now larger and more complex than ever before, we have little understanding of how they will fare in an uncertain future - though it is clear that they will not last forever. But with climate change at our heels, we now more than ever need to design with tomorrow in mind. How, then, does one design for a future of incalculable and unrelenting change?

Tower 42

The UK's First Modern Skyscraper

A Brief History

Tower 42 is widely recognised as the United Kingdom's first modern skyscraper. The building was commissioned by the National Westminster Bank (NatWest) in the late 1960's and initially went by the name of NatWest Tower. Standing 183 meters (600ft) tall, it became the nation's tallest building upon its completion in 1980 and remained so for the subsequent decade.[1]

Occupy a tight urban site in the heart of the City of London, the structure was originally intended to accommodate NatWest's international headquarters. The tower's plan is arranged in three segments which appear to reference the bank's logo, though any relationship was adamantly denied by the building's architect, Sir Richard Siefert.[2] Despite its seemingly fitting design, the bank never completed their move to the building due to the financial industry "big-bang" of the early 1980's. This period of rapid deregulation combined with a switch from verbal to electronic screen-based financial trading rendered the tower's floor plates too small for the bank's increasing size and emergent ways of working. Opting to occupy larger open-plan spaces elsewhere in the city, NatWest initially moved only select divisions of the company to the building before selling it to real estate investors in the late 1990's.[3]

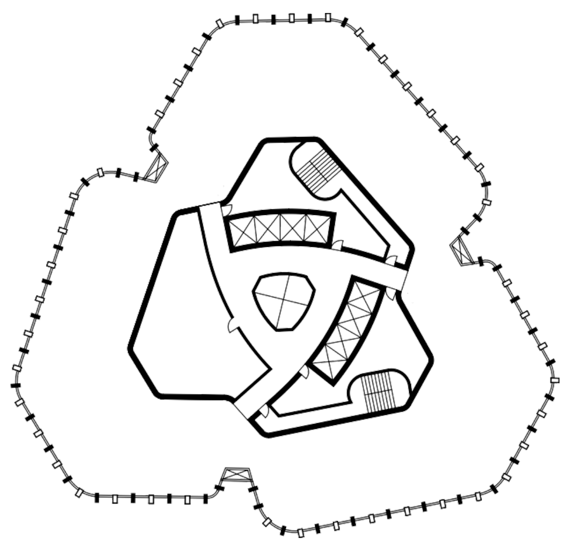
The building originally featured a series of new and innovative architectural technologies, some of which have aged better than others. These include double stacked elevators, computer-controlled air conditioning, now malfunctioned window cleaning robots, and a physical "mail-train" which was made obsolete due to the early 90's advent of email. The building's original envelope was also entirely replaced after just a decade of service due to the Bishopsgate bombing of 1993. This incident led to the tower sitting vacant for several years while its interior finishes where reinstated and it's devastated single-glazed façade was replaced with a new double-glazed system.[4]

Now known as Tower 42, and after being operated as a multitenant building for over two decades, our current cultural moment portends the possibility of yet another revision to the tower's materiality – this time to address the building's performance in response concerns surrounding climate change. Despite its heating, ventilation, and air-conditioning (HVAC) systems receiving multiple upgrades in recent years, the building still fails to meet the operational standards of more contemporary office buildings. This reality was highlighted in a recent survey of the City of London's towers, which found Tower 42 to feature the worst energy performance of all commercial buildings over 150m in height.[5] Unfortunately for the building's owners, its 2019 environmental performance certificate (EPC) was graded a D, while new regulations stipulate that from 2030 space cannot be leased in London building's that do not achieve at least a B grade.[6,7]

Therefore, without a significant intervention to address its poor performance, this tower risks becoming what's known as a “stranded asset” – a building unable to keep pace with the progress of legislation change; perhaps destined to be demolished and replaced by something that meets contemporary cultural concerns. It is reasonable to assume that the nation’s first modern skyscraper to go up may also be the first to come down.

Notes:
1) Weinreb, Ben, and Matthew Weinreb. (2010) “The London Encyclopaedia.” London: Macmillan.
2) Ike. n.d. (2011) “The Notorious Work of Richard Seifert.” Building.
3) The Independent (1998) “NatWest Could Sell Tower.”
4) GMW Partnership and RIBA Journal (1998) “TALL ORDER.” RIBA Journal, vol.105: 64-69.
5) Clarence-Smith, Louisa. n.d. (2019) “Skyscrapers Pump out Thousands of Tonnes of CO2.” The Times.
6) Ingleby Trice (2022) “Tower 42”
7) Amaro, Silvia (2021) “One in 10 London Offices Are at Risk of Becoming ‘Obsolete’ under New Energy Rules.” CNBC.

Natwest Bank Logo



Tower 42 Plan

Fig 01: Natwest logo and tower plan.

Fig 02: "Tower 42, City of London", David Barrie, 2006. Source: https://commons.wikimedia.org. CC BY 2.0.

An Architecture of Excess

Sustainable Agenda

The global construction industry is becoming increasingly aware of the importance of embodied carbon in architectural design. Currently accounting for approximately 25% of the industry's total carbon emissions, it is expected to represent closer to 75% as the operational performance of our building stock improves over the next 50 years.[8] Addressing the realities of embodied carbon will therefore be key to designing more environmentally responsible architecture over the next few decades, and amongst many strategies that may help architects address this issue, preserving the structure of large and materially intense buildings may be one key tactic.

Well maintained steel and concrete structures have the potential to last several hundred, if not thousands, of years.[9] However, with contemporary envelope use-lives typically being measured in decades, there exists an intrinsic disparity between the lifecycle of these essential architectural systems.[10] In addition to a difference of lifecycle, there also exists a huge variance in the material intensity of these elements, with preliminary calculations undertaken for this thesis indicating that the material tonnage of a tall building's structure typically exceeds forty times that of its envelope. Therefore, from an environmental perspective, if replacing a building's facade can extend the use-life of its structure, this is a far preferable alternative to the demolition and reconstruction of an entire building.

Tower 42 is a pertinent case study for this issue due to the huge amount of embodied carbon demanded by its structural design. It features a predominantly cantilevered system built upon former marshland which possesses around 3100kg of structural material per square metre, almost double that of an average building this size.[11,12] Therefore, if an envelope revision has the potential to extend the use-life of this building and prevent its being replaced by yet another large and materially intensive structure, this is certainly an avenue worthy of exploration.

Notes:

8) Adams, M, V Burrows, and S Richardson (2019) "Bringing Embodied Carbon Upfront." World Green Building Council.
9) Baker, William. 2016. "Will the Skyscrapers Outlast the Pyramids?" Interview by Zaria Gorvett. BBC.
10) Hartwell, Rebecca, and Mauro Overend (2019) "Unlocking the Re-Use Potential of Glass Façade Systems." University of Cambridge.
11) Frischmann, W W, D C Lippard, and E H Steger (1983) "National Westminster Tower: Design." Proceedings of the Institution of Civil Engineers, vol.73, 387–434.
12) De Wolf, Catherine (2019) "Low Carbon Pathways for Structural Design : Embodied Life Cycle Impacts of Building Structures." Massachusetts Institute of Technology.

Fig 03: Tower 42 - Structural Model (1:200)

Fig 04: Tower 42 - Structural Model (1:200)

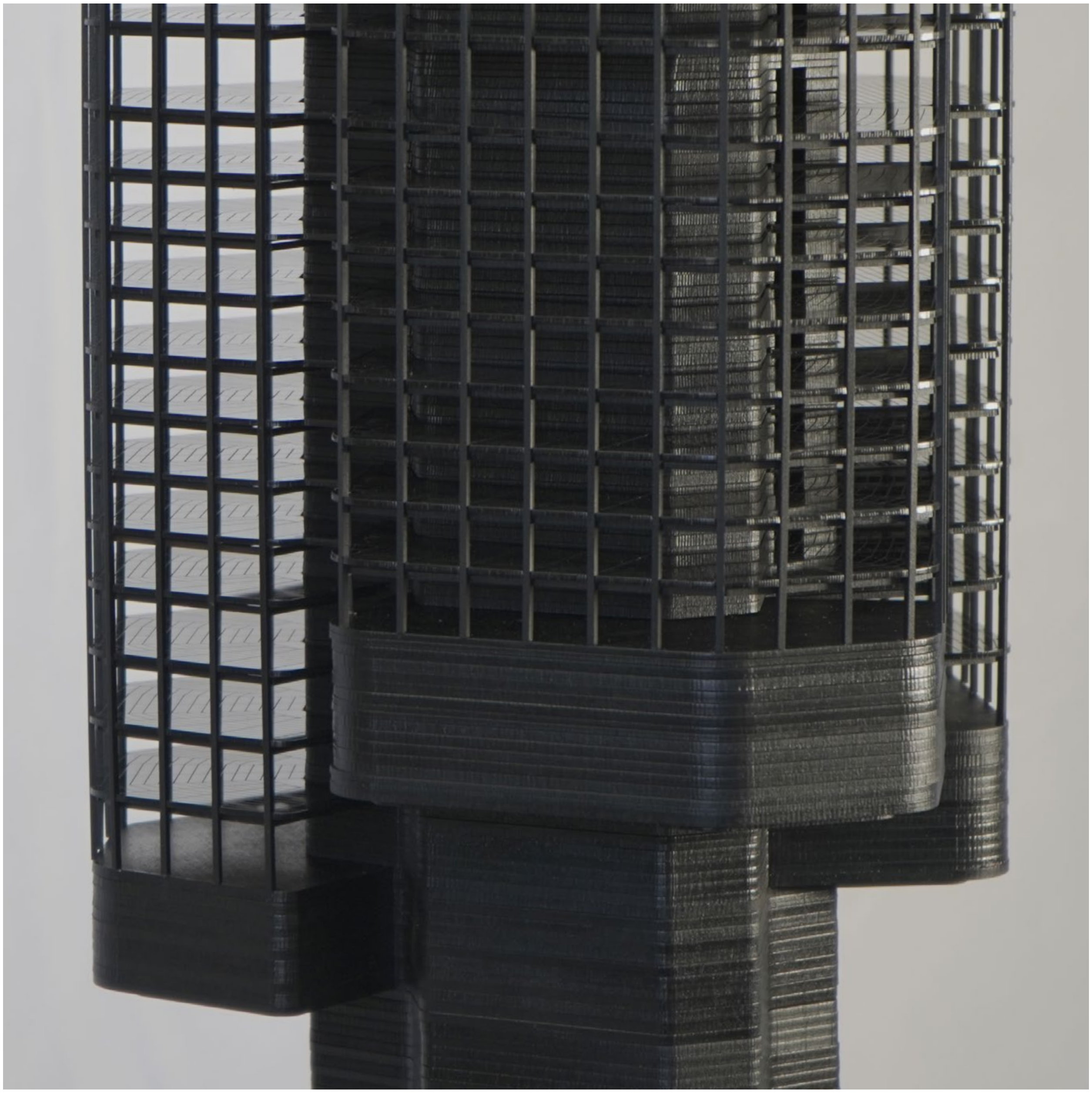


Fig 05: Tower 42 - Structural Model (1:200)

Fig 06: Tower 42 - Structural Model (1:200)

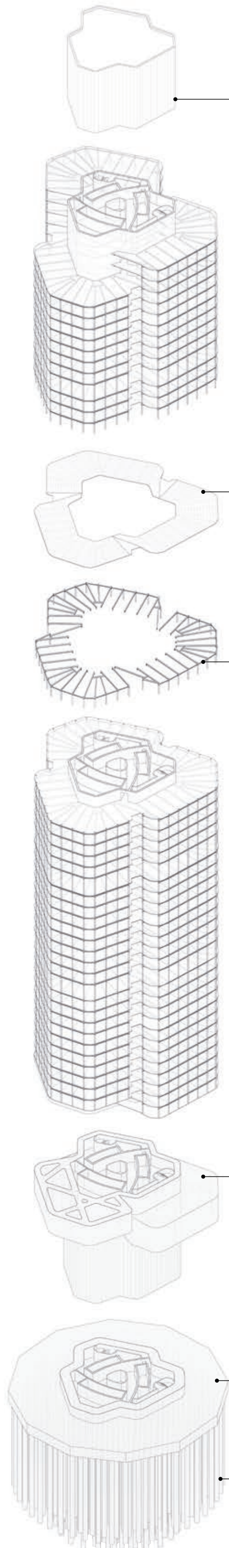
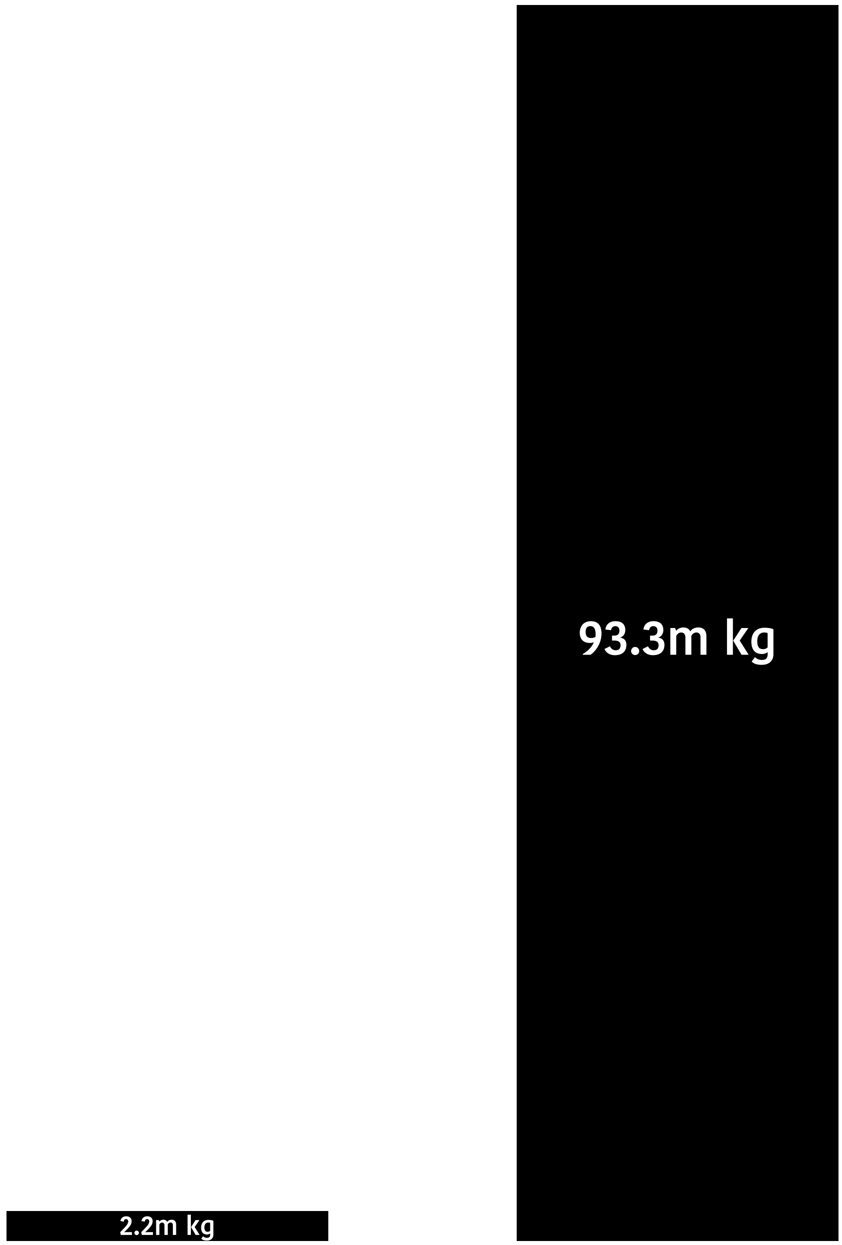


Fig 07: Structural analysis - exploded axonometric. Key dimensions from: "National Westminster Tower: Design", Frischmann, Lippard, and Steger, 1983.



Tower 42 Facade Tonnage:

Approx facade area: 23,000m^2
Approx facade weight: 97.5kg/m^2

Total weight: 2,242,500kg

Tower 42 Structural Tonnage:

Approx floor area: 30,100m^2
Approx structural weight: 3100kg/m^2

Total weight: 93,310,000kg

Fig 08: Tower 42 tonnage. Author's own calculations based on figures from: "National Westminster Tower: Design", Frischmann, Lippard, and Steger, 1983.

The Third Wall

Thoughts of a Future Facade

Design Intent

With the use-life of curtain walls rarely exceeding 50 years, there exists an intrinsic disparity between the lifecycles of a contemporary tall building envelope and that of its host structure, an issue many 20th century structures are now starting to comprehend. This thesis argues that this disparity is something that we need to learn to design for, especially when considering the huge number of curtain-walled buildings a new generation of architects will inherit in the not-so-distant future.

While many in the industry advocate for longevity – that we should design and specify buildings to last hundreds of years - the history of Tower 42 and its unpredictable occupation arguably illustrate the naivety of such objectives. It is currently unclear how buildings of this type will be used in the next 10 years, let alone the next 100. Therefore, as this structure's envelope approaches its third act, instigated by both rapidly changing workplace cultures and ever-increasing operational performance standards, the following studies explore what it might mean to deviate from current paradigms and design for the temporality of a façade's existence.

With an awareness that a building's envelope will need to be replaced multiple times if contemporary steel and concrete structures are to realise anywhere near their potential use-lives, the subsequent pages table three initial ideas for the design of a more sustainable and future-facing façade - a replacement envelope that is itself designed to be replaced.

01. Expandable

Design Strategy

An expandable strategy is based around the addition, and potential subtraction, of façade layers over time. The following pages show this concept applied to Tower 42, a study resulting in a proposal to overclad the tower's current façade in a second skin of ethylene tetrafluoroethylene (ETFE).

While overcladding is a well-tested solution for upgrading both the performance and aesthetics of aged buildings, ETFE is explored here as an alternative materiality that is more economic while possessing up to 80% less embodied carbon.[13] The minimal weight of an of ETFE system was a key factor influencing its selection for this study, as the building's cantilevered structure would likely require significant alterations to accommodate a glass alternative.

There are certainly fire concerns when it comes to using plastics on building exteriors and as it stands this proposal does not conform to international building code (IBC), an issue that would need resolution for this option to move forward.[14] However, the primary intention here was to investigate a strategy that could preserve the life and embodied carbon of the existing façade system by enhancing its performance with minimal additional materials and carbon emissions. With ETFE systems often exceeding the insulative performance glass envelopes, it is intended that the proposed intervention would improve the buildings performance enough to meet the city's impending 2030 EPC deadline through a non-mechanical environmental upgrade.[15]

Therefore, this design utilizes passive temperature regulation and ventilation strategies which complement the building's existing form and envelope. The overclad has been vertically divided into four sections by the building's existing mechanical levels, embracing and compartmentalizing stack effect cooling during warmer months and insulative warming during cooler months. In plan the overcladding is again divided, this time into three distinct compartments defined by the existing "leaves" of the tower's plan. This division allows each plan leaf to be regulated independently in response to the climatic reality of their differing orientations.

Tectonically the system would be supported by modifying the existing façade millions, with all existing glass façade panels remaining in place and unaltered. An accessible deck at the base of each overclad segment also introduces an occupiable buffer zone between interior and exterior. Accessed through new doors inserted into the existing façade, this 4-foot-deep semi-conditioned space is deep enough to provide an informal space for social breaks, conversations, and meetings – increasing the desirability of occupying this building and potentially the adaptability of these spaces for alternative uses in the future.

The cultural compromise implied by this

system is a distortion of the view out from the structure's interior. ETFE pillows feature up to 90% light transmission and would have minimal impact on the building's daylight autonomy. But views out would be distorted to differing degrees depending on the ETFE pillow specification. Therefore, this strategy implies that a more sustainable and low-carbon inhabitation of tall buildings may require an adaption of occupant expectations and a move away from the experience of an all-glass envelope. The building's exterior appearance would also be transformed - the materiality of the skyline somewhat diversified and expressive of a contemporary environmental agenda.

Notes:

13) DesigningBuildings (2013) "ETFE."

14) ICC (2021) "2021 International Building Code - CHAPTER 7."

15) Amaro, Silvia (2021) "One in 10 London Offices Are at Risk of Becoming 'Obsolete' under New Energy Rules." CNBC.

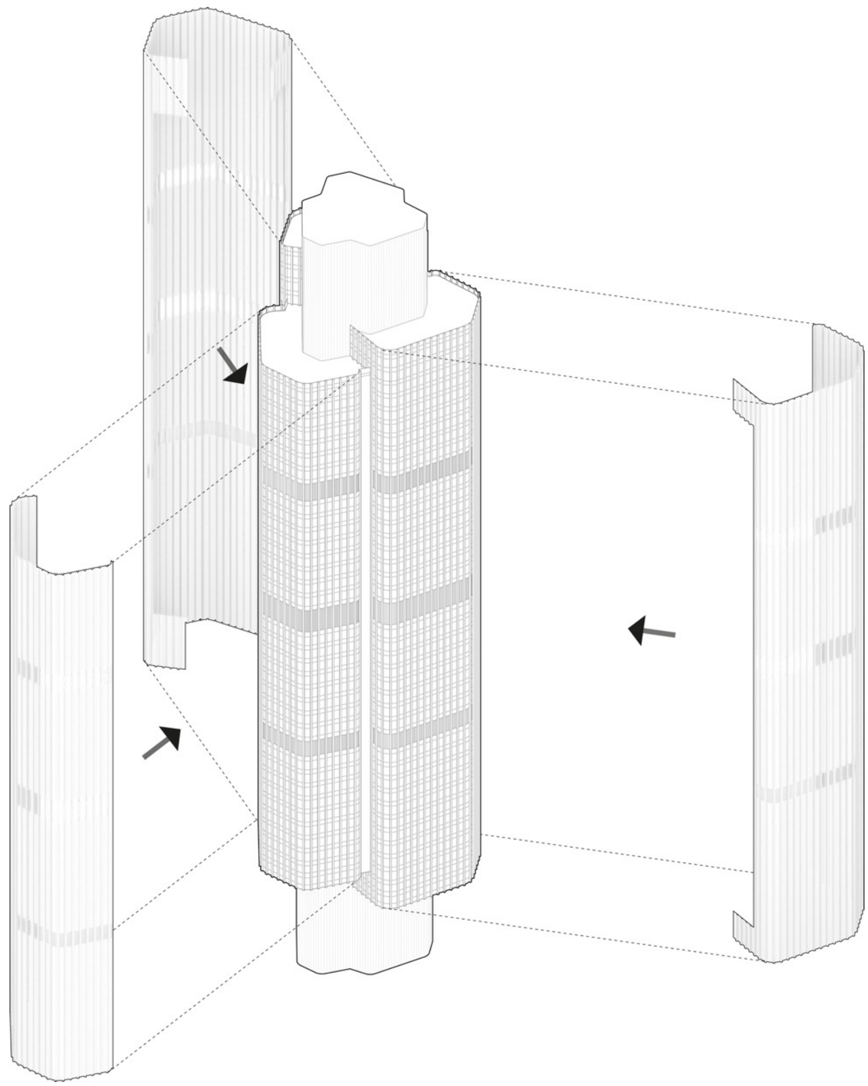


Fig 09: Expandable - Concept diagram.

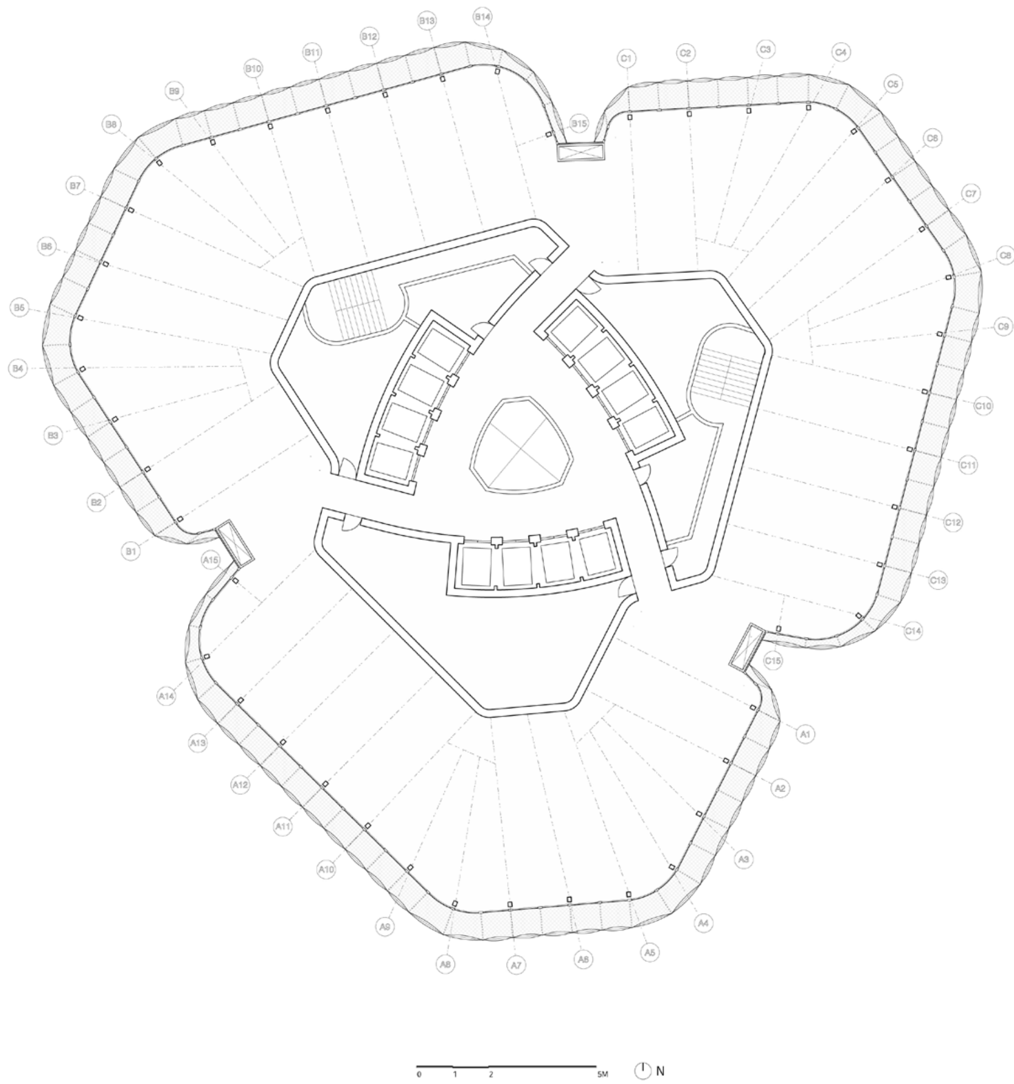


Fig 10: Typical plan illustrating the division of the overclad into segments.

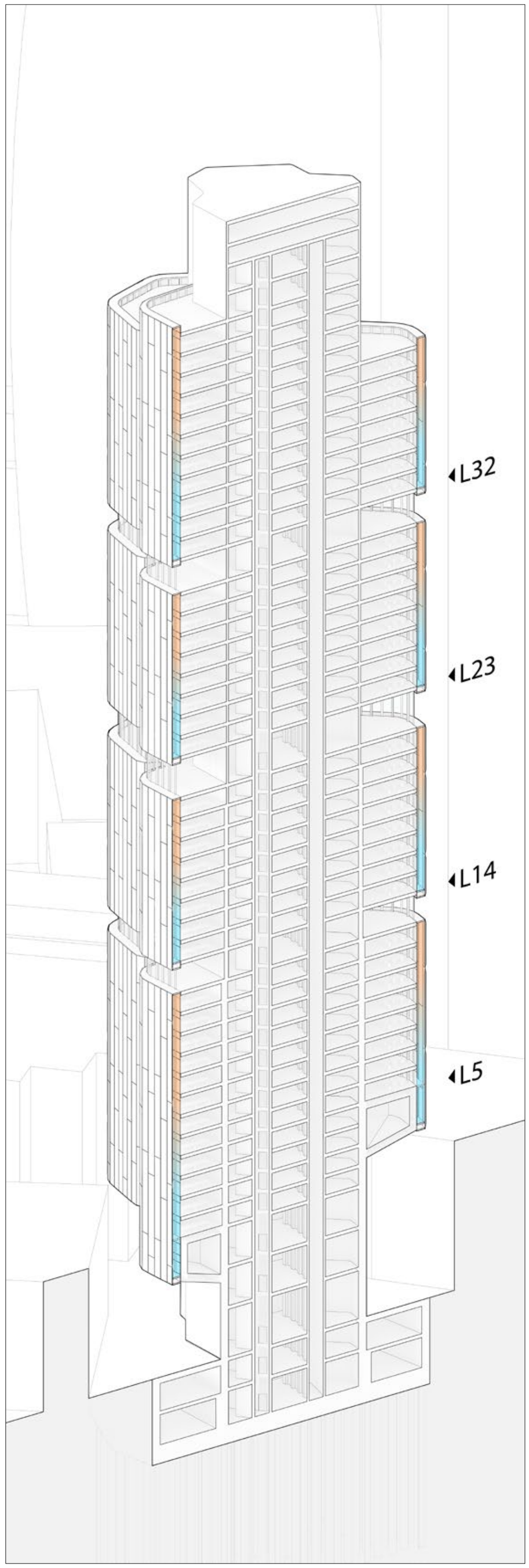
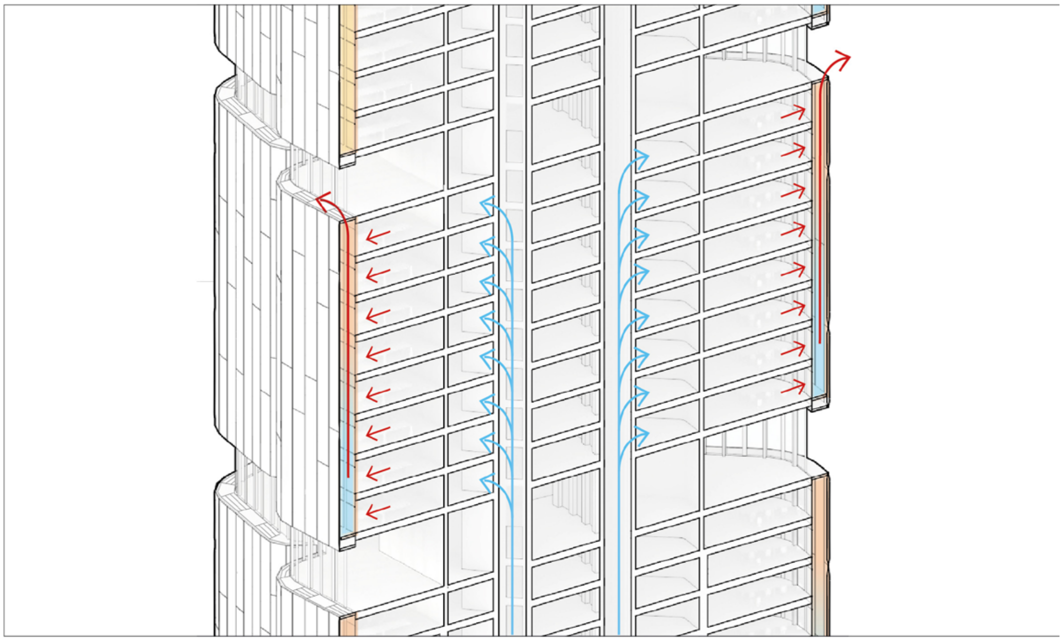
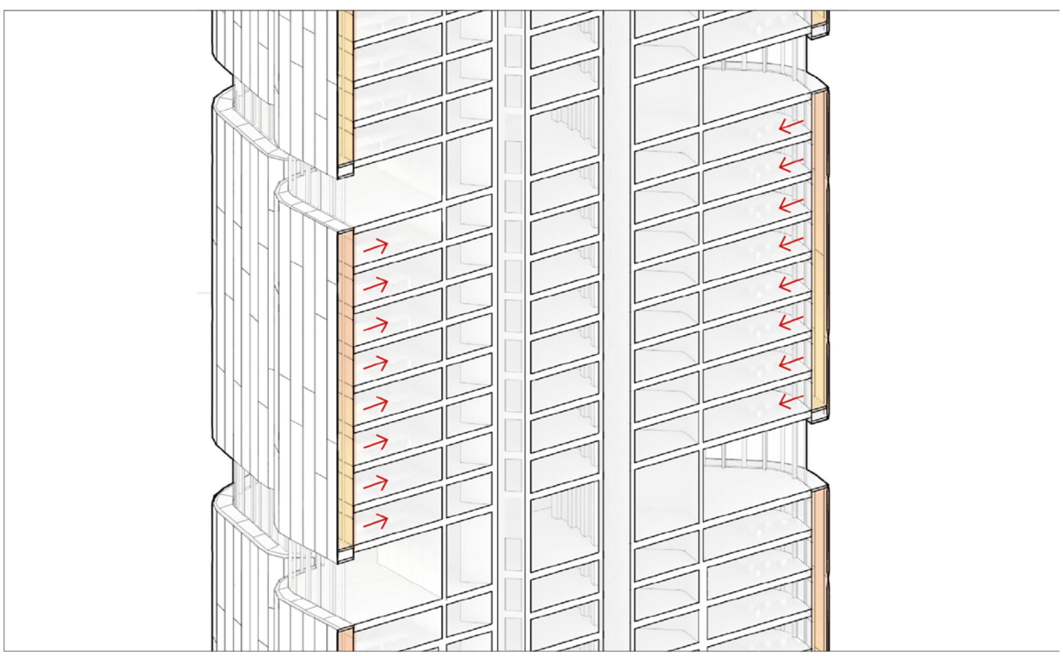


Fig 11: Sectional compartmentalization of the overclad defined by existing mechanical levels.



May - September



October - April

Fig 12: Stack effect ventilation and temperature regulation strategy.

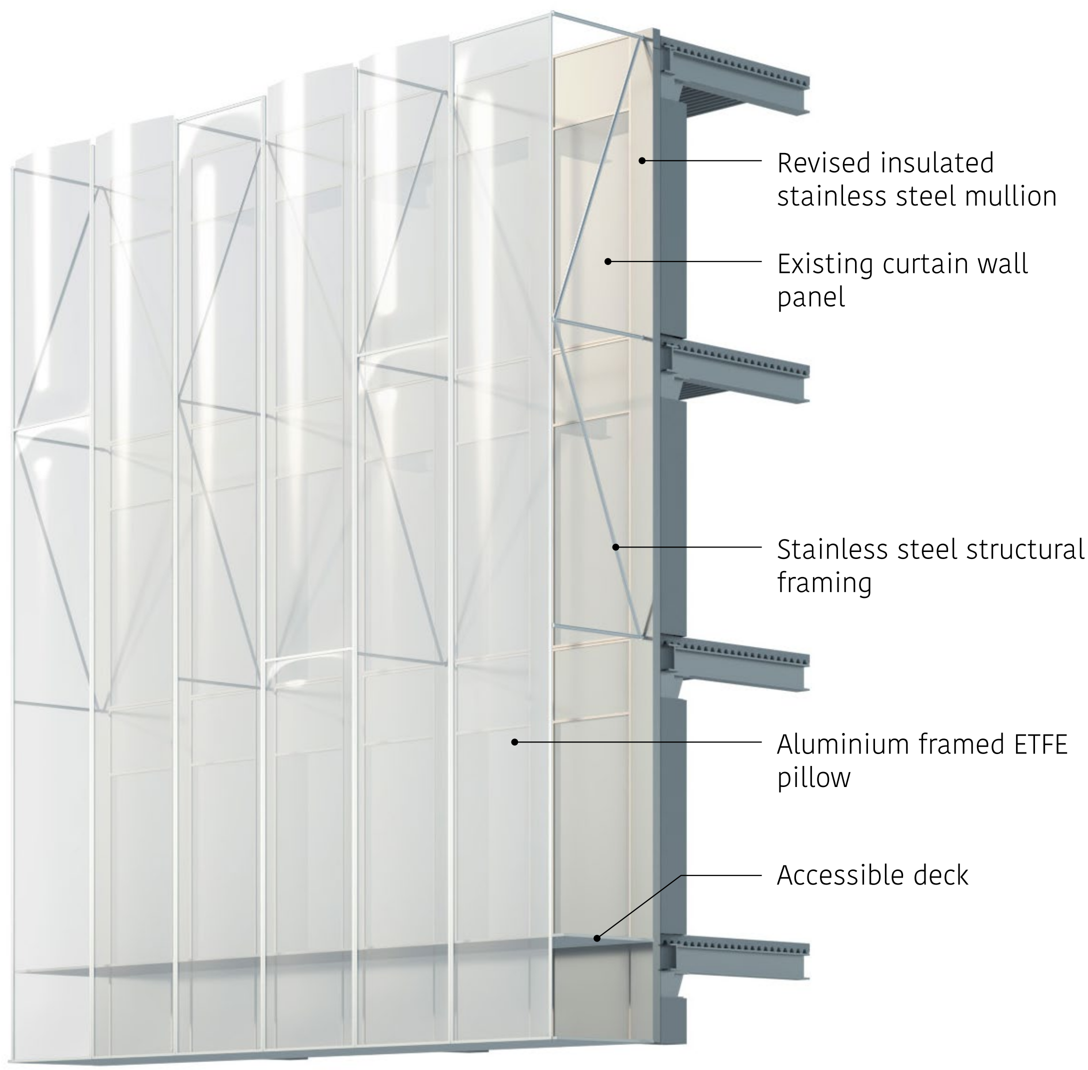


Fig 13: Techtonic strategy illustrating relationship to existing envelope.

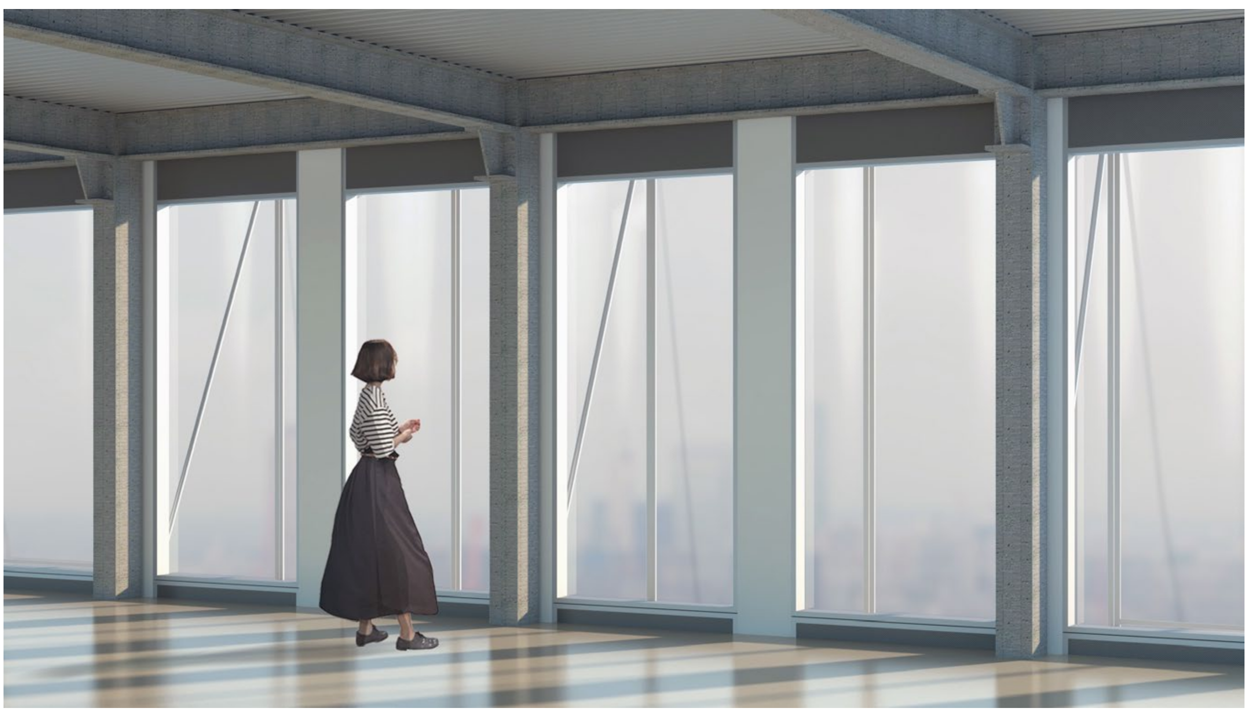


Fig 14 (above): View through occupied semi-conditioned space.
Fig 15 (below): Distorted view from building interior.

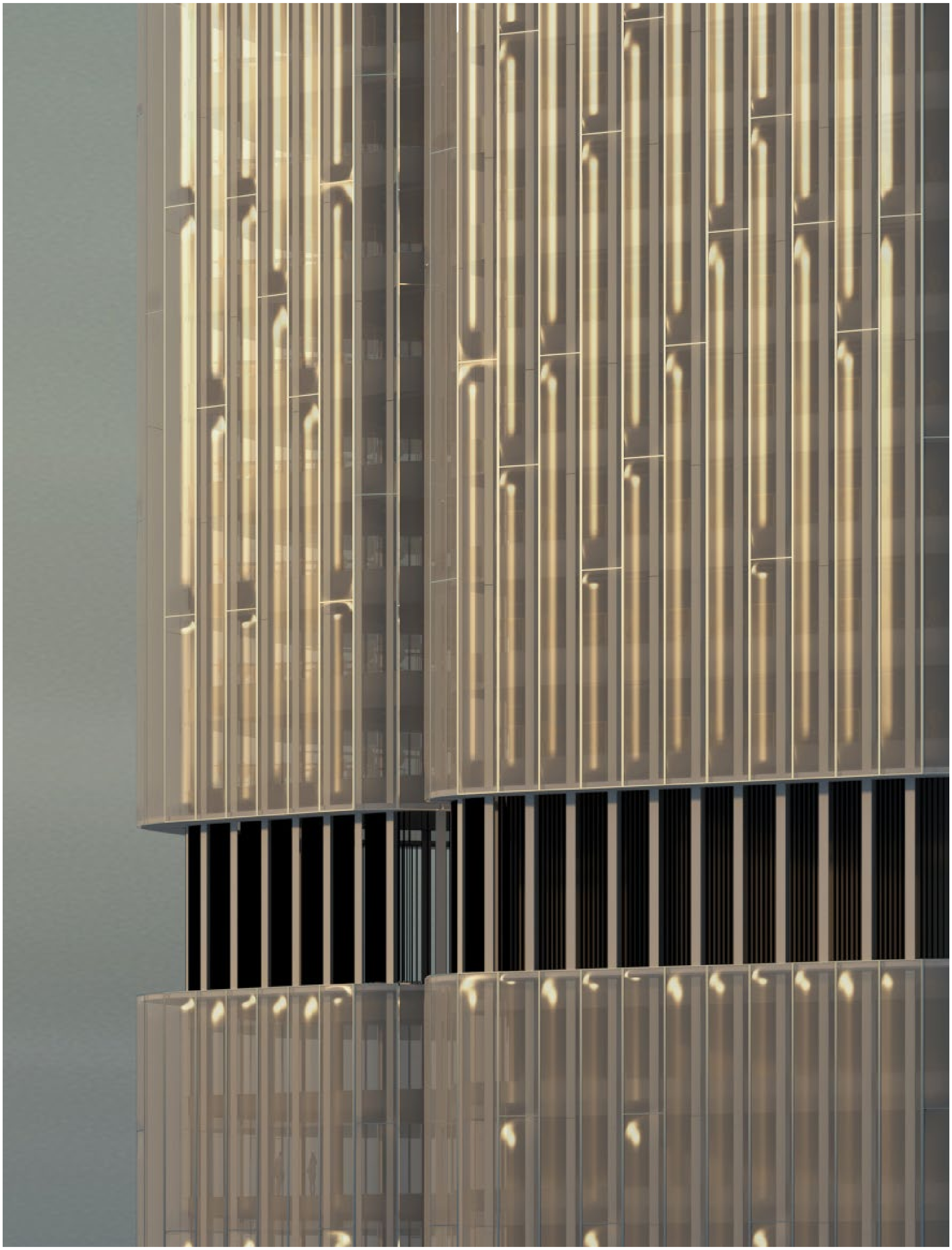


Fig 16: Exterior view of proposed ETFE system (close-up).

Fig 17: Exterior view of proposed ETFE system.

02. Editable

Design Strategy

An editable strategy is based around the change not of an entire envelope system but of its constituent parts - particularly at the level of each façade panel. The following exploration achieves this intent through the utilization of a semi-unitized cassette façade system.

Featuring an envelope sub-structure which is mounted upon the building's superstructure, this system possesses lightweight unitized panels that can be individually removed and replaced. This strategy can facilitate an array of panel changes or modifications over time, allowing a façade to be responsive to external influences and gradually evolve in response to economic, legislative, or environmental factors. Examples illustrated in the following pages include the future introduction of both photovoltaic façade panels and a series of covered outdoor terraces.

The proposed system could cater to the introduction of photovoltaic panels which will likely become more economically feasible over time, or could be demanded by future legislative changes as buildings continue trending towards net-zero performance. The insulated glass unit (IGU) of these photovoltaic panels is the same size as that of the standard panel, implying that the significant constituent parts of each panel may be reused as the envelope evolves over time. Editability at the level of a panel would also allow a photovoltaic array to be strategically distributed in response to solar exposure, and potentially respond to the changing conditions of the site over longer durations of time.

Editing a panel could also mean removing it entirely. The second scenario illustrated here introduces a cascade of terraces that pull inhabitable exterior spaces up and around the mass of the existing tower. In this example, such an intervention could be implemented at the scale of one plan leaf – rather than transforming an entire level of the building. This would allow exterior terraces to be distributed evenly throughout the structure, rather than being condensed and benefiting only those in particular zones. The illustrated application of this strategy has been complimented by the editability of the building's steel structural elements which could be partially dismantled and reassembled higher up the building to relocate a portion of the GFA subtracted for the terraces. Our current cultural moment would undoubtedly benefit from the ability to readily edit a building, both envelope and structure, to introduce directly accessible outdoor spaces suited to new modes of hybrid working and an increasingly health-conscious clientele.[16]

The editable strategy explored here implies the evolution of an envelope over time. A façade that both caters to, and visually represents, the emergence and influence of different cultural demands upon the skin of a building. This option suggests a cultural move away from the tall building as an unchanging sculptural object and indicates that a more sustainable future may require an openness to a diverse and changing urban aesthetic - buildings that are not treated like static statues, but as imperfect and constantly evolving urban elements.

Notes:
16) Grant, Peter (2021) “Will Outdoor Terraces and Chefs Lure You back to the Office? These Buildings Hope So.” Wall Street Journal.

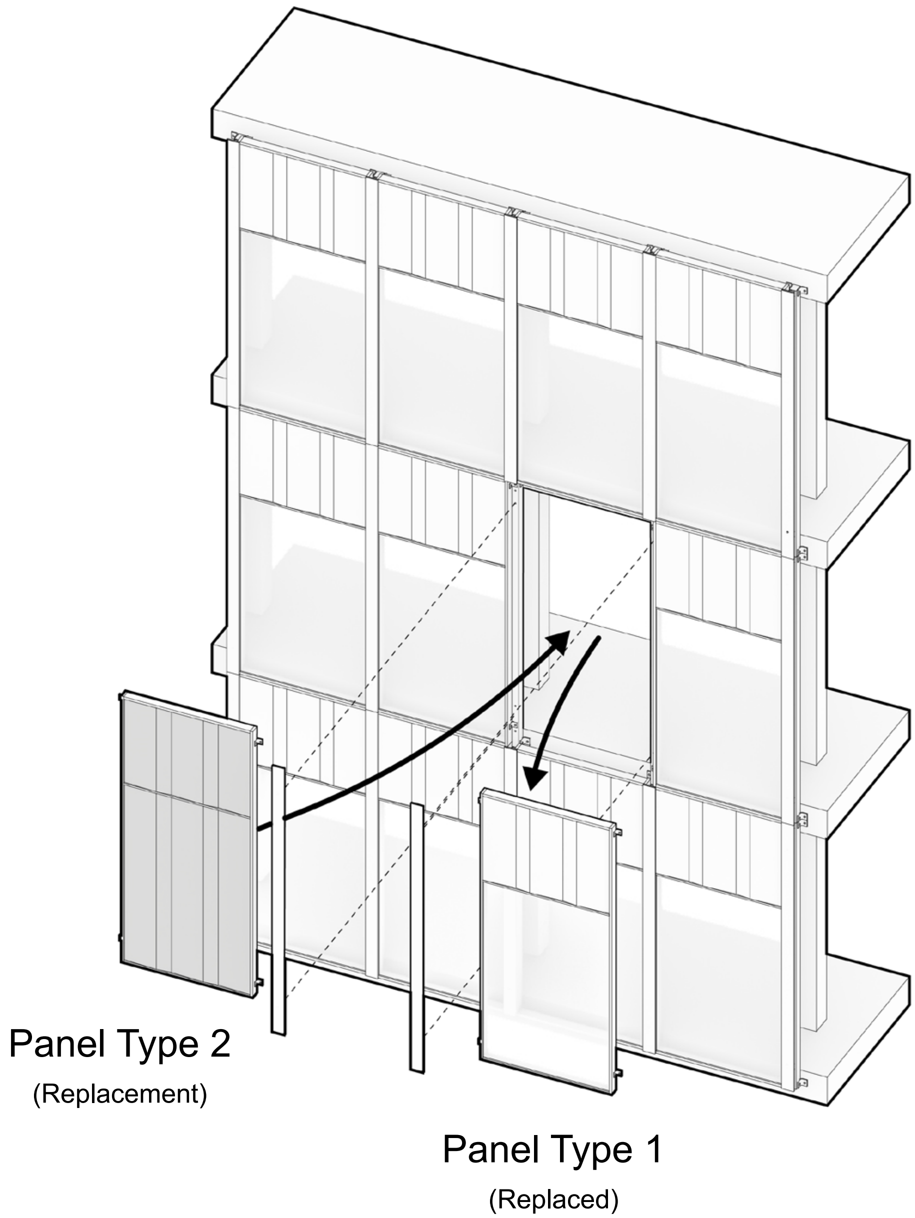


Fig 18: Editable - Concept diagram.

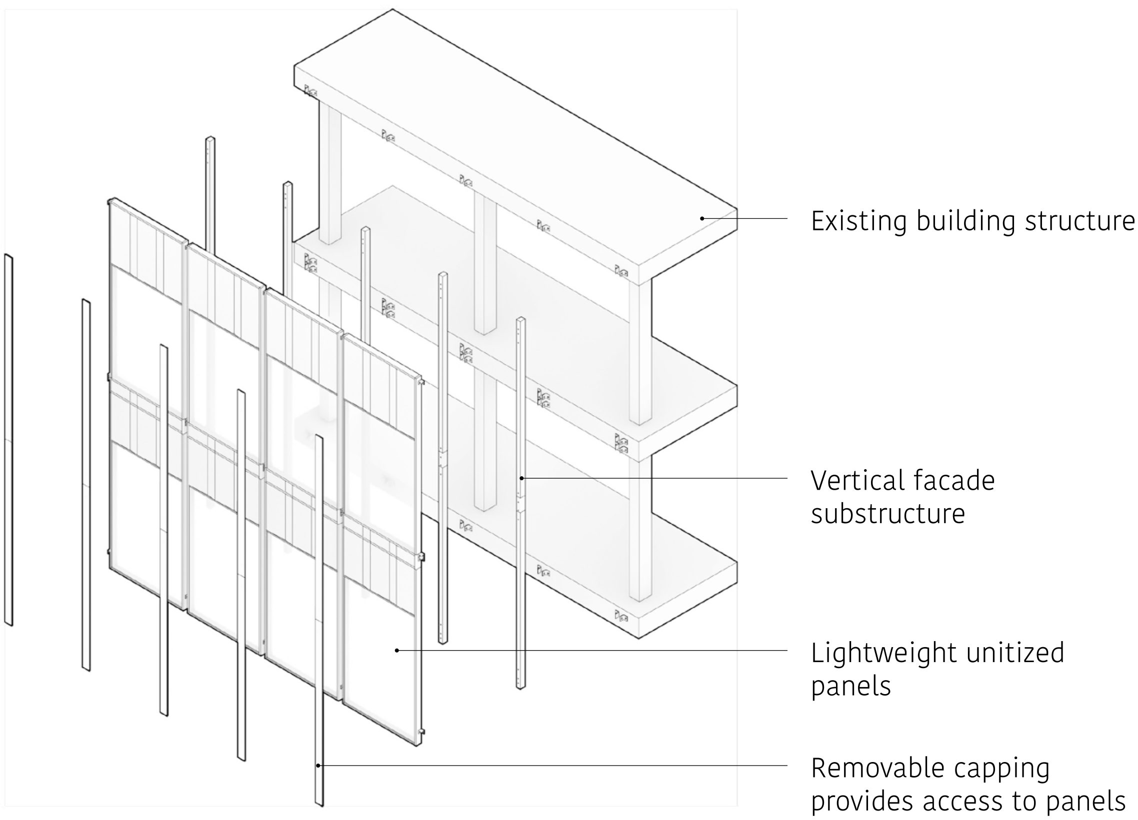


Fig 19: Semi-unitized cassette envelope system diagram.

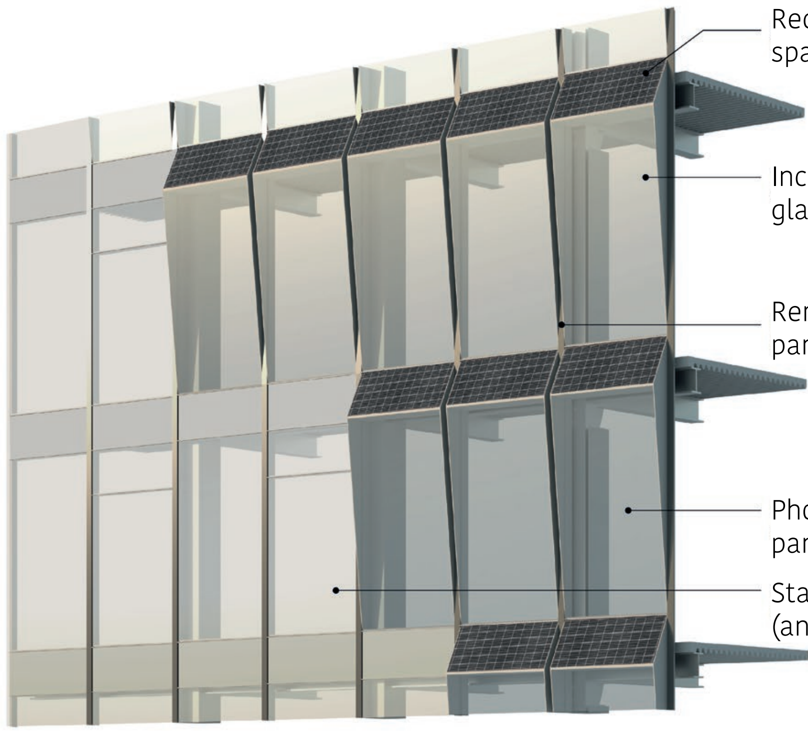


Fig 20: Techtonic strategy showing a combination of standard and photovoltaic panels.

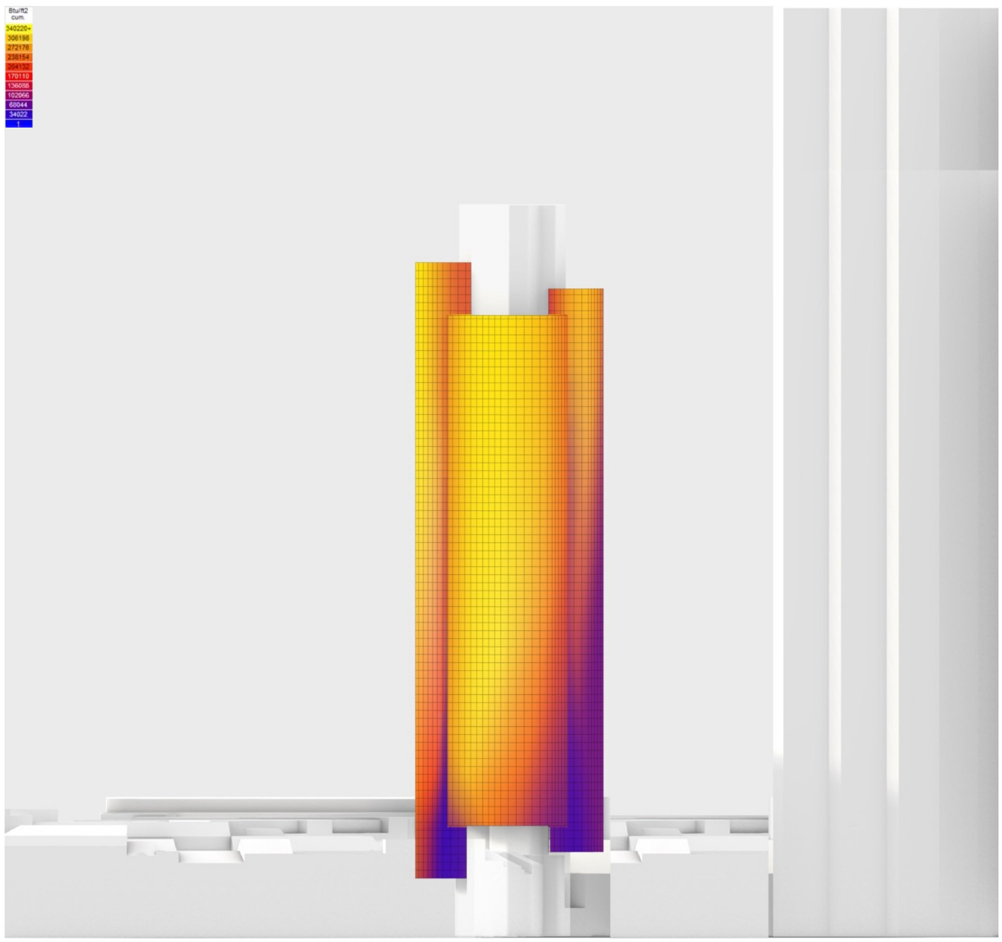


Fig 21: Analysis of envelope sun exposure to which an editable strategy could respond.

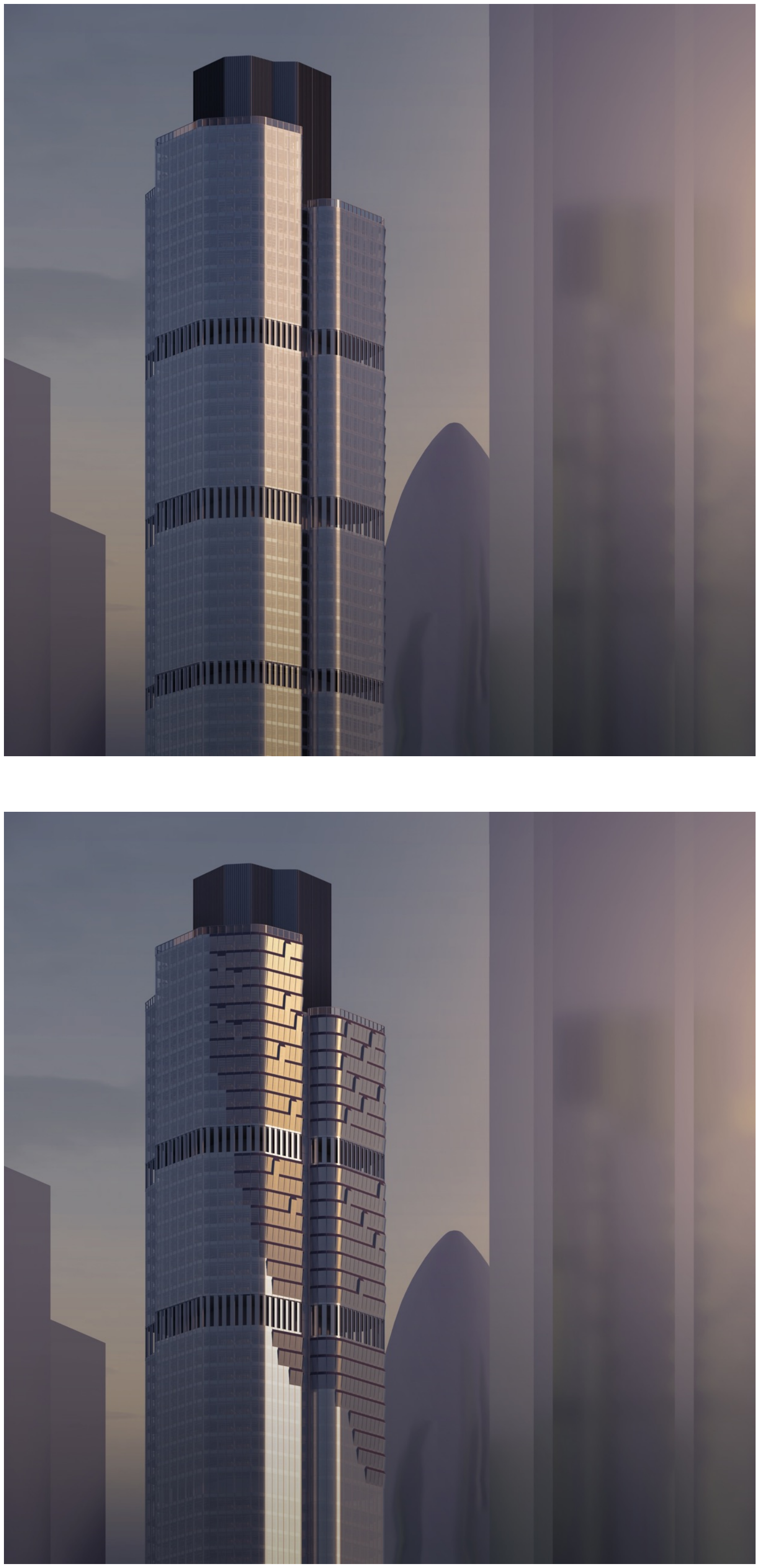


Fig 22: Introduction of a photvoltaic array - before and after.

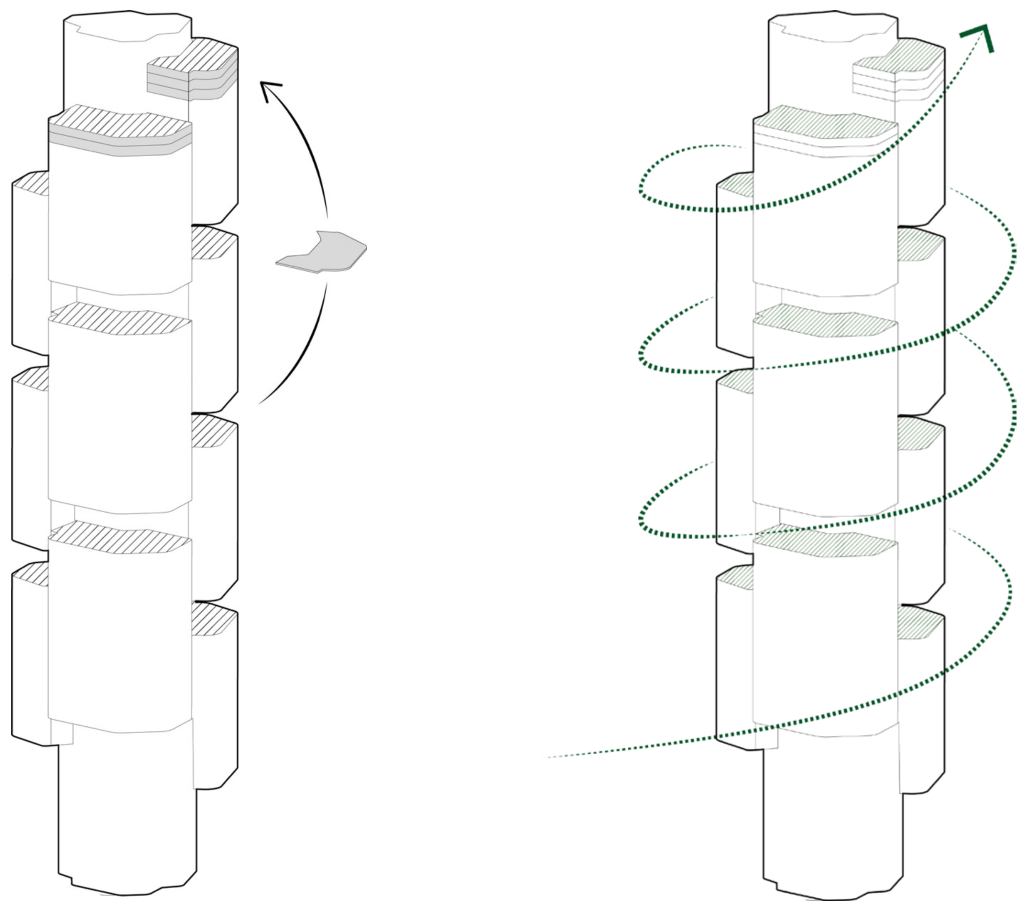


Fig 23: Diagrams illustrating modifications to the building's massing and new outdoor spaces.

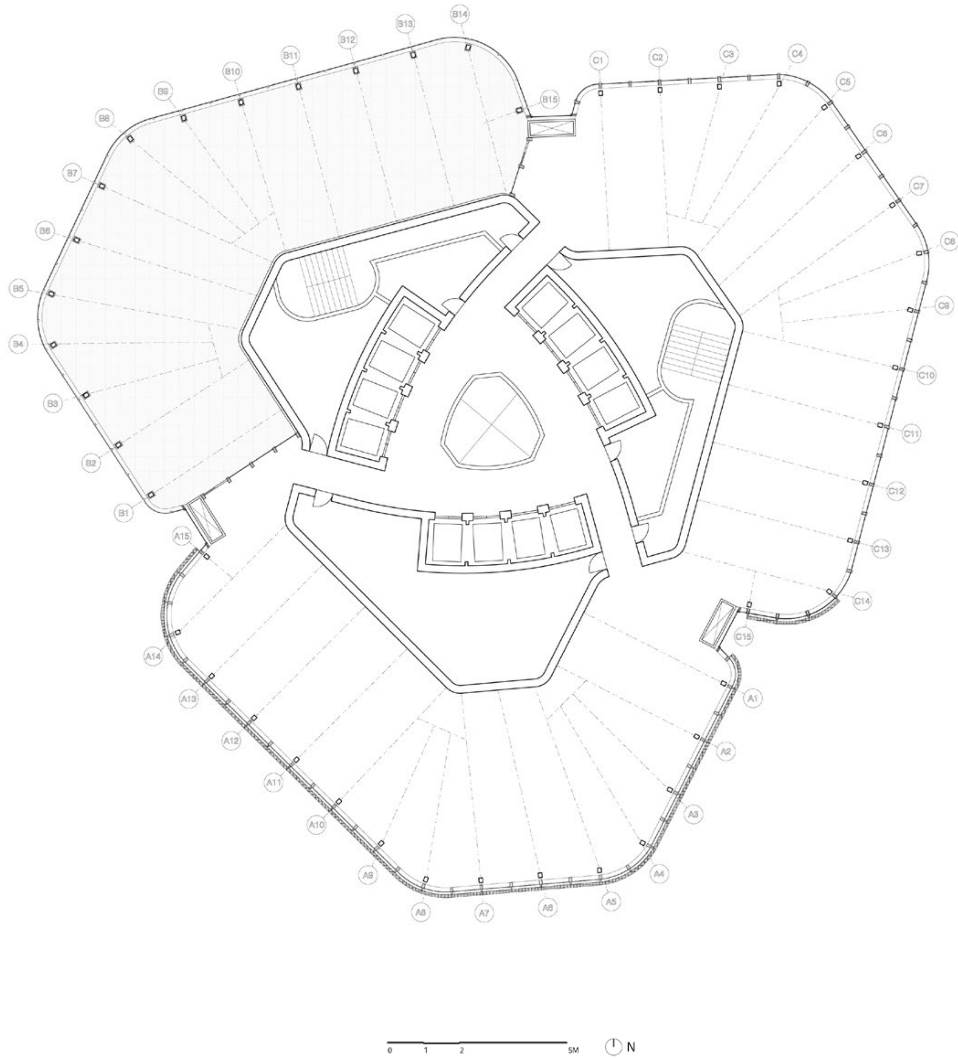


Fig 24: Typical plan showing the introduction of an outdoor terrace.

Fig 25: View of proposed terrace area directly adjacent to interior volume.

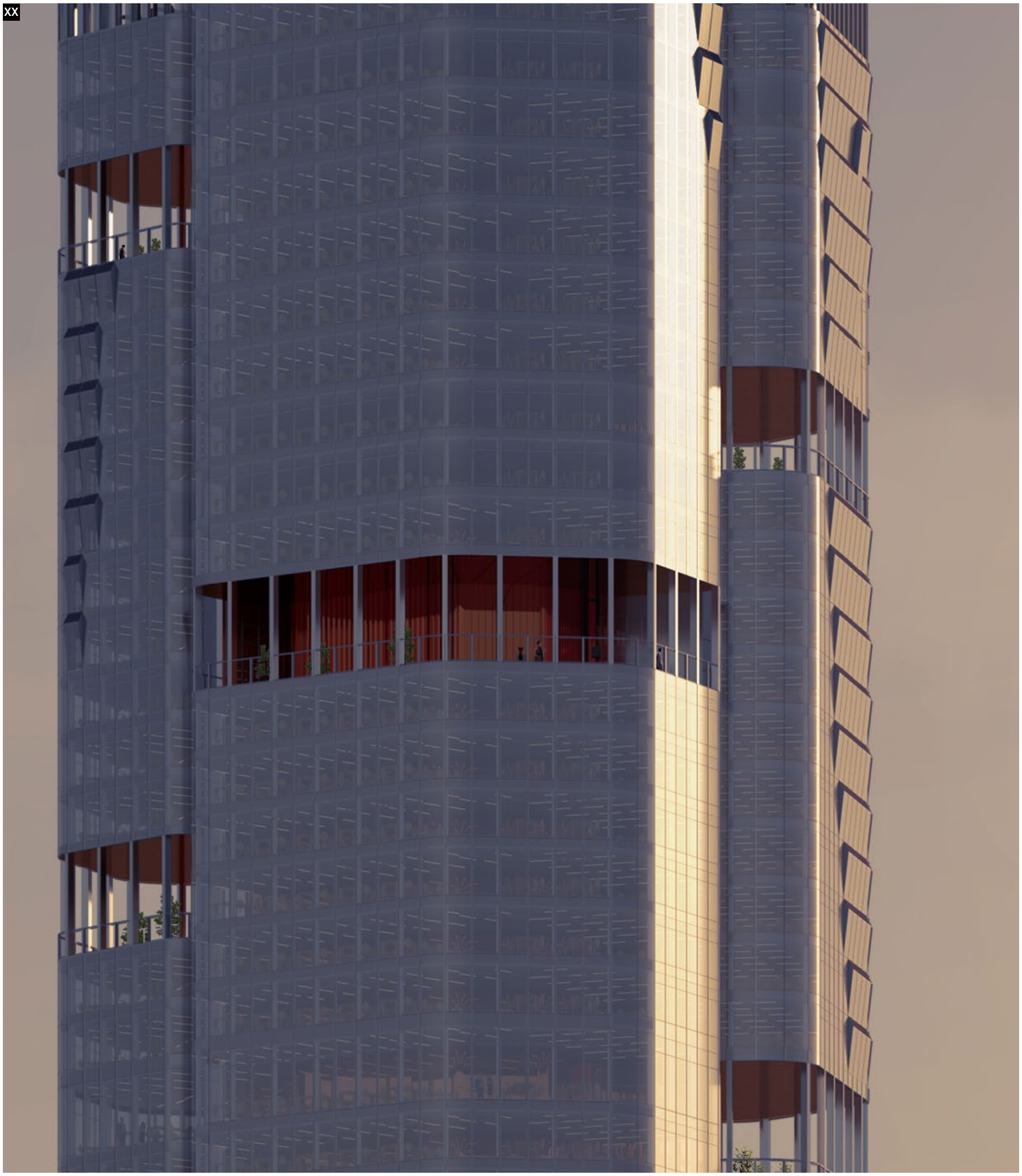


Fig 26: Terraces cascading around the building to increase accessibility.

Fig 27: Exterior view showing an agglomeration of facade conditions.

03. Disposable

Design Strategy

As indicated by its title, the third strategy presented is centered around disposability. It acknowledges that the envelope of this building type is, and arguably should be, temporary. This reality has been incorporated into the proposal by specifing a combination of low-carbon materials and products with the intention of minimizing the building's whole-life environmental impact.

The materially of the façade system proposed is predominantly glass due to the flexibility and experiential benefits provided by a transparent envelope, but its material specification aims to be as low carbon as currently possible. The option therefore features a cross laminated timber (CLT) frame, vacuum insulating glass (VIG), and terra cotta rain screens. This proposal does not specify timber or any other flammable material on the envelope exterior, while its internal timber mullions are broken by a steel transom beam - a detail which could feasibly meet the fire regulations currently stipulated by international building code.[17]

VIG has been selected due to its impressive insulative performance and low embodied carbon, with the limited size at which it can currently be produced defining the gridded aesthetic of this proposal.[18] The following visualizations illustrate a grid of 0.6x0.75m (2x2.5ft) glass units arranged within a larger panel grid informed by the building's structure; the resulting aesthetic and occupational experience arguably being unique for a tower of this height. The small sizing of the proposed IGUs also increases the feasibility of their reuse should the envelope be replaced sooner than the expiration of its design-life; a reality derived from the increased feasibility of physically handling and repurposing smaller window units.

The resulting interior condition is aesthetically differentiated by the dense and deep framing stipulated by the specification of a CLT frame. The experience of occupying the building, therefore, possesses a unique character absent of the unobstructed views that have become the norm for buildings of this typology.

Notes:

17) Barber, David, John Neary and Mic Patterson. 2020. "Review of Fire Safety and Code Challenges for Mass Timber in Curtain Wall Systems." Facade Techtonics.

18) Cuce, Erdem, and Pinar Mert Cuce (2016) "Vacuum Glazing for Highly Insulating Windows: Recent Developments and Future Prospects." Renewable and Sustainable Energy Reviews 54.

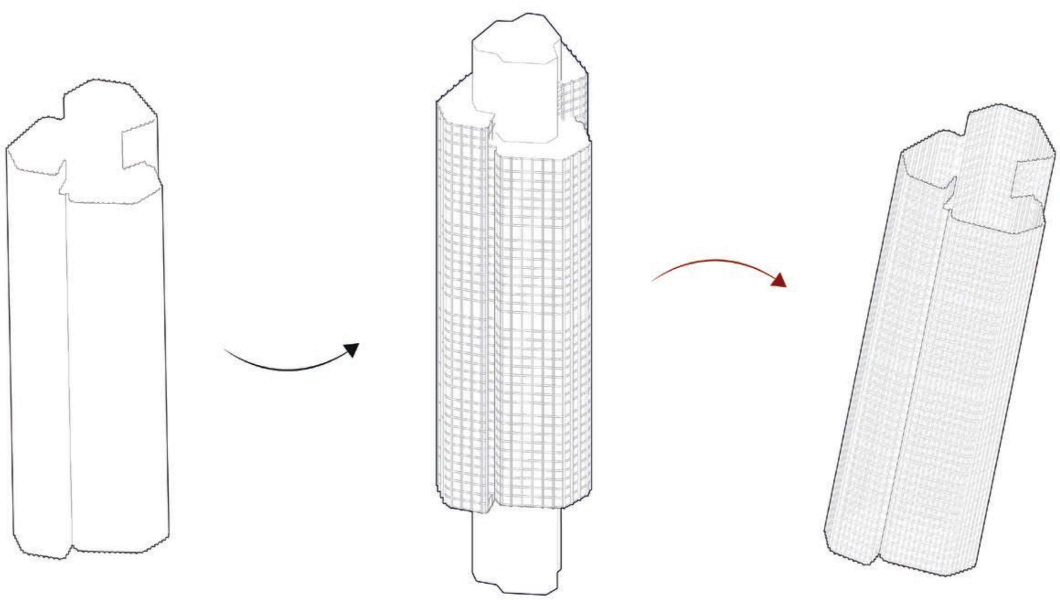


Fig 28: Disposable - Concept diagram.

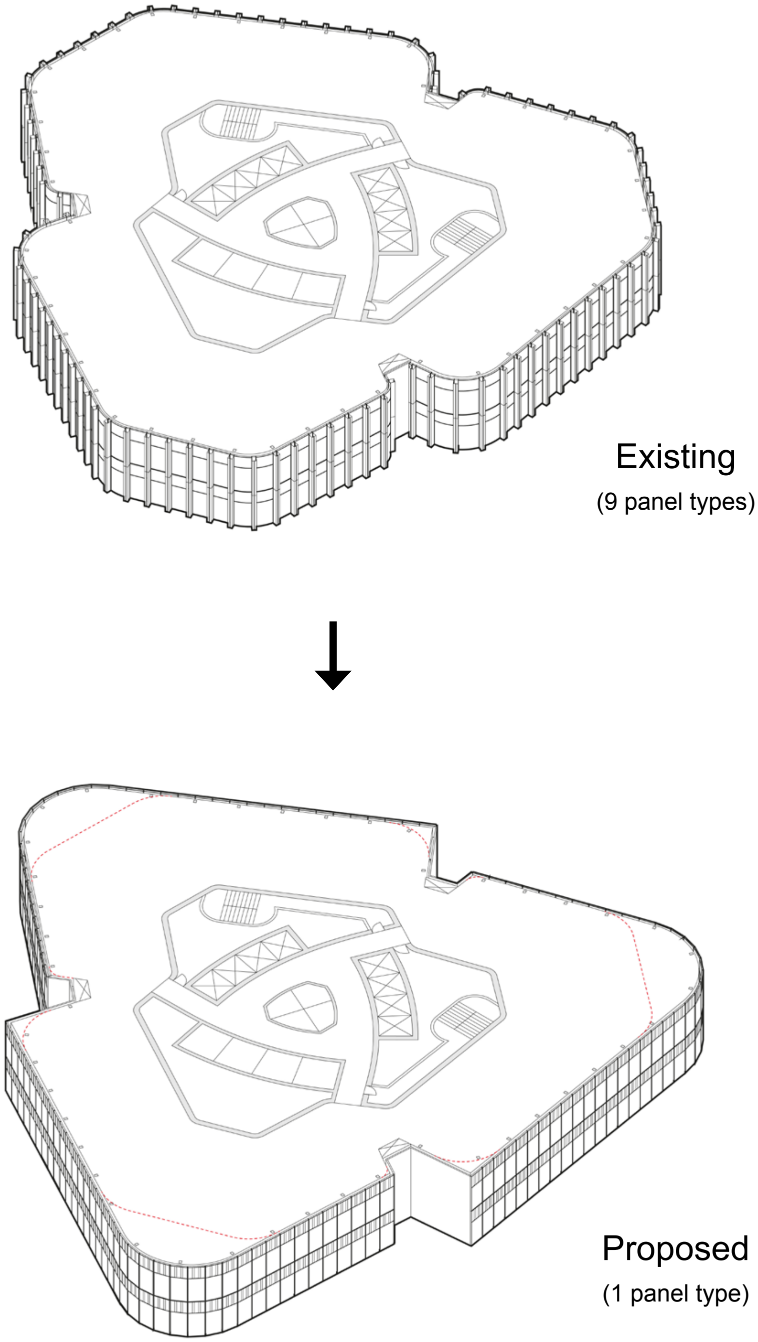


Fig 29: Structural modification to reduce panel types required to enclose the building.

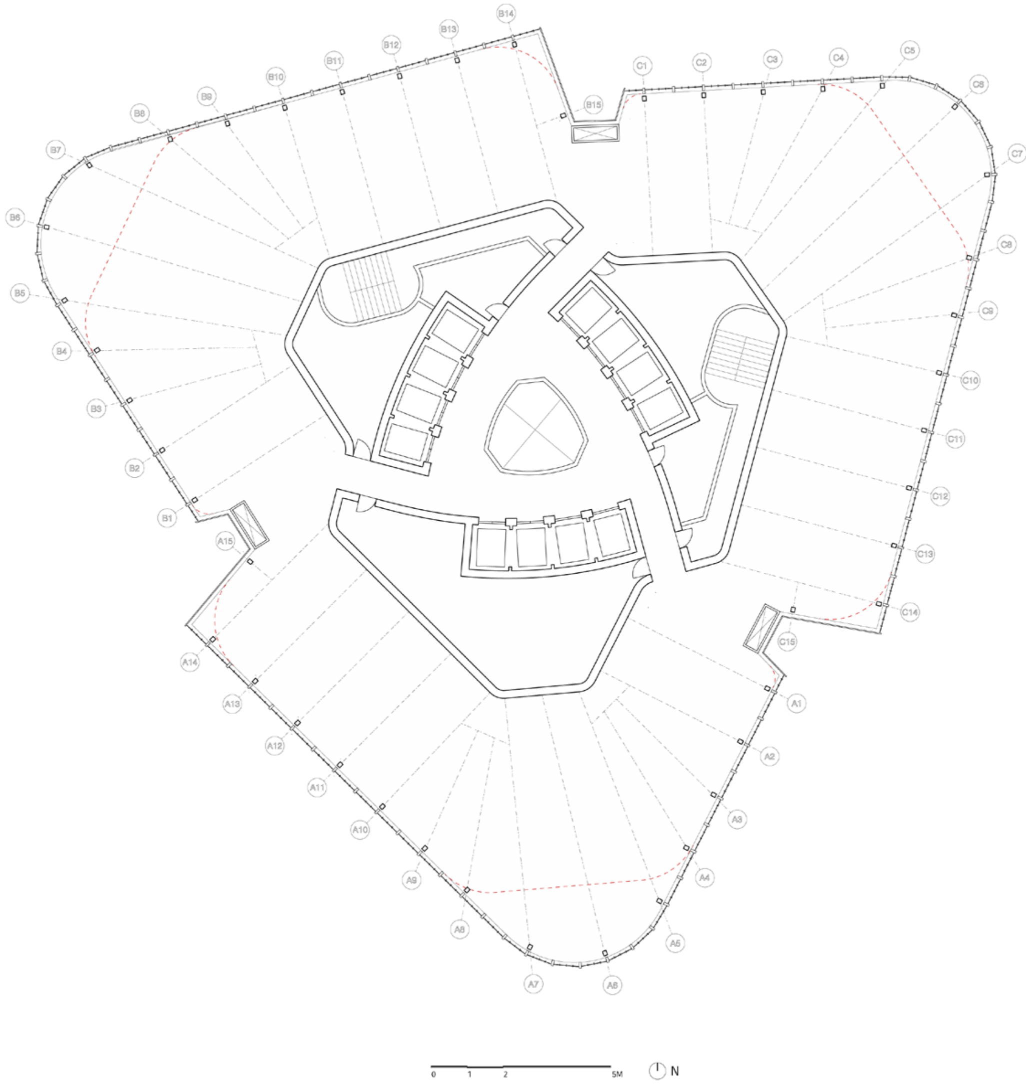


Fig 30: Disposable - Typical plan showing modifications.

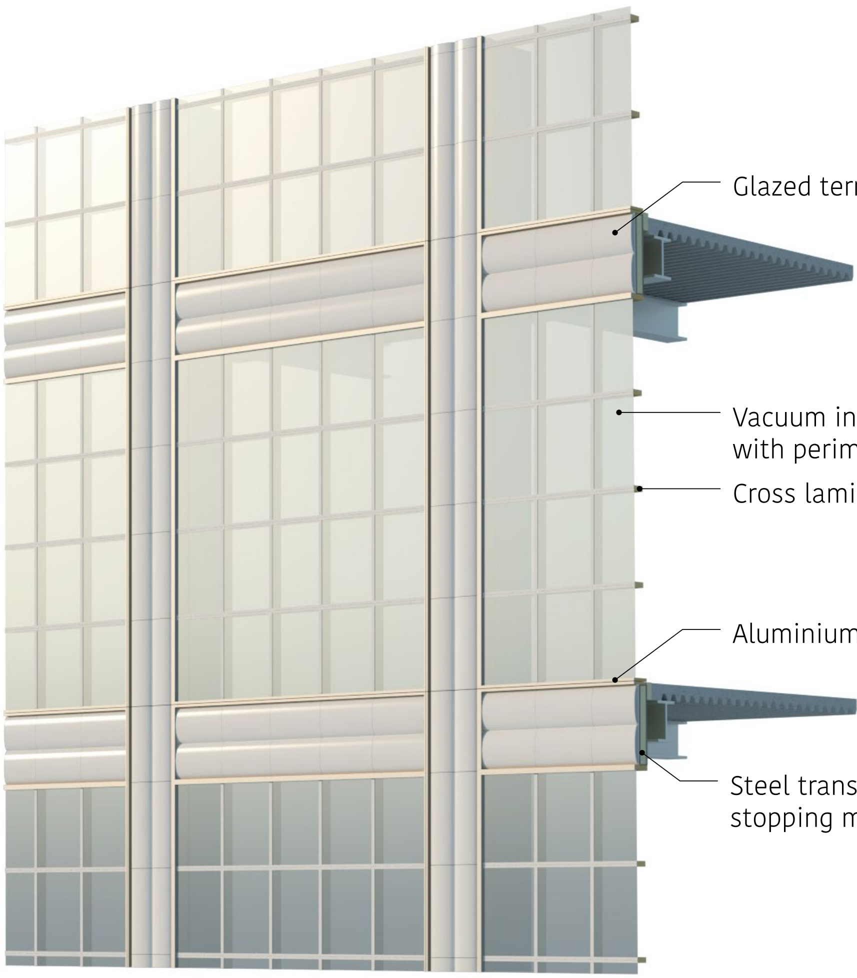
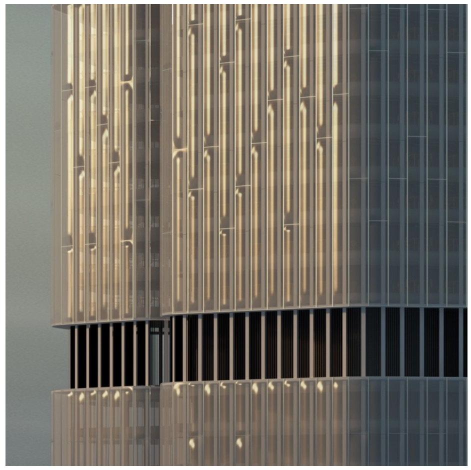


Fig 31: Techtonic strategy featuring VIG, CLT framing, and a terra cotta rainscreen.

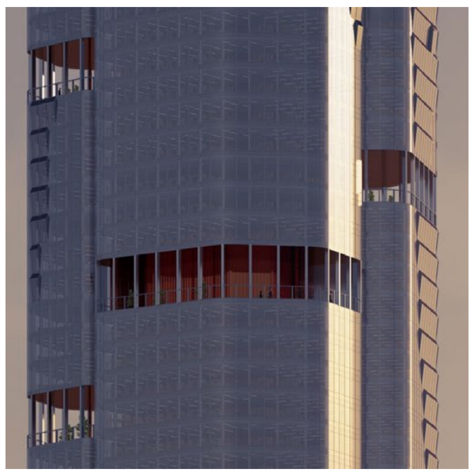
Fig 32: Interior condition defined by deep and dense CLT framing.

Fig 33: Resulting gridded aesthetic (close-up).

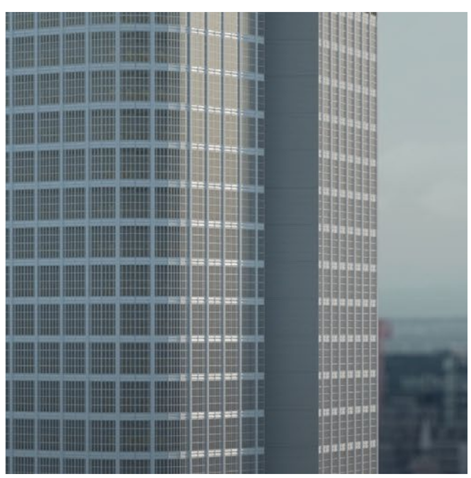
Fig 34: Resulting gridded aesthetic.



01. Expandable



02. Editable



03. Disposable

Epilogue

Above all else this thesis is a statement that a critical interrogation of the envelope is long overdue. It acknowledges that we currently sit at a juncture in the evolution of architectural enclosures - a moment in time when the world's first generation of curtain walls are starting to fail en masse, while simultaneously the culture and occupation of commercial buildings is swiftly changing. In response, it presents itself as an argument the façade is rapidly becoming a more important element of architectural design, and should assume a more prominent role in both practice and pedagogy.

The reality of climate change has generated an urgent need for architects to both manage and learn from the legacy of modernism, and while far from conclusive, the prior explorations are perhaps the first few steps of the author's own long journey defined by this issue... the curtain has yet to fall.

To be continued...

Curtain Call

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End.