THE RE-AMORTIZATION ACT: A MATERIAL DURATIONAL AGENDA FOR CONSERVATION

by

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Authors Declaration:

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners.

I understand that my thesis may be made electronically available to the public.

Abstract:

With the urgency of the climate crisis, we need to begin thinking of new systems that properly value the existing embodied energy invested in Toronto's built forms, challenging existing neoliberal patterns of development, where existing buildings are demolished due to land value and future densification of a site. Current legislation in Toronto has fallen short of addressing the energetic material cycle of buildings as a tool to address climate change. Instead, legislation such as the Toronto Green standard focuses on the LEED points system for building reuse. In this points system material reuse and adaptation rank considerably lower than other measures such as operational energy. Furthermore, the current highest material value system in Toronto, the Ontario Heritage Act, focuses on historically narrative-driven criteria, a nostalgic and aesthetic-based agenda. These current models for the continuation of materials fail to address the large stock of post-industrial and modernist buildings worthy of keeping with the pressure to densify the city.

In response, this thesis will look at bridging heritage and sustainability legislation through the designing of a new perspective for the urbanism of our cities; the concept of a Re-Amortization Act, an experimental political act that will focus on re-valuing material energy invested in existing buildings rather than just historical narrative and aesthetic values. The opening chapter will contextualize historical ideas of conservation and bring us into the current discourses around conservation and Life Cycle Analysis. Chapter 2 gives an annotated insert of the proposed Re-Amortization Act laying out the specific criteria needed to meet its three main categorizations (Remain, Adapt & Disassemble) along with their associated material output & input restrictions. Also included is a description of the radical net embodied energy measures that the experimental Act seeks to reduce carbon input in future designs significantly. Chapter 3 illustrates the three categories with a series of emblematic precedents ranging from least extreme net embodied energy material usage to most extreme, along with the associated deconstruction and material technologies used. Emerging from this body of research is the pragmatic understanding of how a material durational agenda such as this can be achieved, along with the architect's role within it, and the importance of material continuation for both addressing the dual cultural and environmental crises.

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Introduction:

A recent study conducted by the Weizmann Institute of Science concluded that in the 21st century, the earth's total biomass as accounted for by plants and shrubs had been surpassed by the total mass of made materials such as concrete, brick, and asphalt.[1] We now live in a world that is dominated by our human-initiated environment. Worst of all, this study does not consider the mass of waste humans have produced. Currently, the construction industry globally accounts for a staggering 38.8% of the 100.6 billion tons of material consumption per year and accounts for 31% of annual landfill waste.[2] With the ever-pressing climate crisis, these metrics are hard to believe as the materials accounted for in them all have a significant amount of embodied carbon in them that is cheaply valued

1. "Human-Made Materials Now Outweigh Earth's Entire Biomass – Study." *The Guardian*, Sandra Laville, last modified December 9, 2020. https://www.theguardian.com/environment/2020/dec/09/human-made-materials-now-outweigh-earths-entire-biomass-study.
2. "World's Consumption of Materials Hits Record 100bn Tonnes a Year." *The Guardian*, Damian Carrington, last modified January 22, 2020. https://www.theguardian.com/environment/2020/jan/22/worlds-consumption-of-materials-hits-record-100bn-tonnes-a-year.

Figure 1 Balance paradigm between man made and natural materials. (Self Authored)

as it is thrown away. It brings light to our current material paradigm, an abstracted relationship between finished materials and the environmental cost.

This abstraction is most prevalent in the practice of real estate development in Toronto where the market works within a frontier mindset, flipping low-value areas into more desirable places for capital to flow through. In this pressure to revitalize and densify neighborhoods, existing buildings factor as a minuscule part of the capital equation making their continuation irrelevant. However, the negative externalities of existing building life cycles and end-of-life demolition waste in Toronto must be addressed and existing material systems re-valued to address the climate crisis properly.

Legislative measures for material duration, such as the Ontario Heritage Act, choose instead to focus on a limited scope of aesthetic values. Its three criteria for selection are design value or physical value, historical or associated value, and contextual value, all making a qualitative value argument for the historical narrative of keeping a building.[3] After its criteria are reviewed, buildings are either listed or designated. Being designated provides official legal protection from any drastic change, whereas the only legal requirement for listed buildings is that they give 60 days' notice before demolition so that the city or public may object.[4] This 60 day rule is often a loophole taken advantage of by developers to demolish a building before it becomes designated.[5]

The city of Toronto currently has 15,615 buildings included in the Ontario Heritage Register, of which only 8,000 are designated under the

3. Ontario Heritage Trust and Ministry of Culture, *Heritage Property Evaluation: A Guide to Listing, Researching and Evaluating Cultural Heritage Property in Ontario Communities* (Ontario: Ministry of Heritage, Sport, Tourism and Culture Industries, 2006), 22.
4. *Ibid*., 9.
5. "Explaining the Heritage Designation Process in Ontario." *Urban Toronto*, Mark Mitanis, last modified: January, 6 2015. https://urbantoronto.ca/news/2015/01/explaining-heritage-designation-process-ontario.

Figure 2 The Toronto Purchase with present urban material overly (Ontario Archives, 1787)

Ontario Heritage Act.[6] When put into perspective with Toronto's total building stock of 1,092,628 buildings, that means that less than 1% of buildings are considered worthy of being designated heritage and protected from demolition.[7] In light of this data, it only further reinforces the idea that heritage legislation and the rhetoric it uses were never intended to incorporate the growing importance of the ecological value of materials when thinking of a building's duration. This has resulted in its inability to address the large stock of postindustrial and modernist buildings, classified as not worthy of keeping with pressure to densify the city.

Additionally, sustainable agendas such as the Toronto Green Standard fall short by making building reuse and adaptation a voluntary measure under their Tier 2. The Green Standard is based on LEED (Leadership in Energy and Environmental Design), a points-based system that encourages sustainable building practices. Under its points system, building adaptation requires the maintenance of 55% of the existing building structure & envelope measured by surface area to gain those points.[8] These adaptation points coupled with other points from building performance act as its form of encouragement for reuse, giving the incentive of reducing 20% of development fees, which, although generous, will not result in the widespread material reuse that we need to get to reduce new carbon. Similarly, if a developer were to also work towards a LEED certification, this 50% building reuse would earn a maximum of 3-5 points, and when put into perspective with their certifications of certified (40–49 points), Silver (50–59 points) and Gold (60–79 points), adaptation and reuse are trumped by other higher point systems such as building efficiency from insulation and operational energy.[9] Retaining surface area should

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6. "City of Toronto's Heritage Property Search." *City of Toronto*, last modified October, 2020, http://app.toronto.ca/HeritagePreservation/search.do.
7. "The Open Database of Buildings." *Statistics Canada*, last modified February 02, 2020, https://www.statcan.gc.ca/eng/lode/databases/odb
8. "Toronto Green Standard." *Planning & Development*, City of Toronto, Last modified March, 2019, https://www.toronto.ca/city-government/planning-development/official-plan-guidelines/toronto-green-standard/.
9. LEED, *LEED v4 for Building Design and Construction* (Washington: U.S. Green Building Council, 2019), 65.

not be the approach to awarding material reuse. It is a two-dimensional description that does not consider the complexity of the various building material systems and how much embodied energy they could contain. For instance, that 50% could be the surface area of simple materials rather than a complex assembly with a higher environmental cost with multiple layers of structure, insulative, and control layers. The Green Standard's building reuse approach is too general and does not address the more nuanced practice needed for continuing existing buildings and their associated carbon reduction benefits.

In response to challenging these cheap systems of urban development, this thesis will look at the possibilities of designing a new perspective for our cities' urbanism, the concept of Re-Amortization. An experimental proposed Act that will focus on re-valuing material energy invested in existing buildings over their life cycles through life cycle analysis and material circularity, preventing further material extraction and production. When we begin to re-value the embodied energy qualities of existing buildings and not just those of aesthetics such as heritage, a new hybrid legislative model for material duration can be made to address the urgency of the climate crisis.

The first chapter will introduce concepts of the durable world, from historical polemics of conservation that are foundational to our current view on heritage to the current problem of building obsolescence. It will then give an overview of current discourses on material reuse and life cycle analysis's integration into building conservation. Chapter two will describe and annotate the proposed Re-Amortization Act, delving into the rules, criteria, and design steps that it uses. Attention will particularly be given to understanding its three main categorizations of Remain (the building stays in place), Adapt (a sizable percentage of materials can leave to let the existing building be adapted), and Disassemble (all materials can leave the site) along with their associated material output and input restrictions. Also included is an in-depth description of its radical material input restrictions set to reach net embodied carbon for our future building materials.

Finally, chapter three puts the Act in context with the illustration of the three categories with a series of precedents, ranging from the least extreme material measures to the most extreme. It begins with introducing some of the other material reuse agents that would be associated with the experimental Act to function. Additionally, in correspondence with the precedents, a section will be devoted to describing some of the deconstruction technologies used in each example, offering an understanding of the existing, deconstruction, and completed material phases and their associated risks. Finally, the chapter shows the six examples with flow charts, vignettes, and annotations of the rationale behind each one to show that the Act's restrictions provide many creative and exciting opportunities for design. The thesis's conclusion will consist of reflections on where potential barriers to this experimental proposal could be and the importance of the architect's role in the discourse of material reuse. It will lay out the importance of fusing cultural values with environmental values as an important emancipating force for both the cultural amnesia experienced from the fast-paced erasures of existing fabric and reducing our urban environment's carbon cost.

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The Durable World:

1.1 Historical Driven Narrative for Conservation

Western Architects have long sought to understand the importance of gradual change over time on a building and its relevance to memory and perception. The painter John Gandy's famous watercolor rendering of The Bank of England in 1830 sought to express the building's future in its "ruin" state. It was an architectural representation that was stripped bare, only accessible through the use of our imagination of what the building could be after it had long been unoccupied. This "ruin" state is emblematic of a discourse in architecture where conceptualizing the future existence of a building inherently questions material duration and the role of restoring a building to a functional state. Out of this discourse came the English architect, John Ruskin, who argued in his seminal work The Several Lamps of Architecture that the preservation of monuments in their original condition with its materials carrying the patina of time, allowed us to face our mortality through the authenticity and truth that the wear over time

Figure 3 John Gandy, Bank of England (Sir John Soane Museum, 1830)

evoked.[1] Ruskin argued conservation differed from restoration because it destroyed the original intent. To Ruskin, no matter how true to archival drawings and descriptions the restoration took, it was still a false description. In arguing restoration as a false authenticity, Ruskin shifts the importance of a building's functional and operational performance in favor of viewing the marked passing of time on material duration. By romanticizing material decay with human mortality, Ruskin neglects the importance of material continuity and the possibility of a building's use value to evolve.

On the other side of the conservation discourse of the 19th century was Violet-le-Luc, who believed that the architect was instead legitimately positioned to 'fill in the gaps' of existing buildings in decay and therefore reconstruct and remodel existing buildings in a historical style of his choosing.[2] This perspective led to incorporating new materials, such as steel, and gave the architect importance in translating those new materials into the existing building. Both le Duc and Ruskin reacted to buildings restored to their original construction, questioning the authenticity and truth that conservation should have with the existing. These questions of conservation and material authenticity culminated in a formal solution in the modern era during the Athens charters of 1931-1933. The charter promoted modern construction techniques when approaching existing buildings, with a defined contrast between old material and new.

The Italian architect Carlo Scarpa is credited with influencing much of the ensuing century, after the charter, with his building adaptations that contained a strong narrative between the recorded history and the current situation's context.[3] Strongest felt in his Castelvecchio project, where through his design practice of subtracting parts of the existing building that did not contribute to the historical narrative and then adding careful interventions, he enhanced the sequential historical narrative of the building in

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1. Sally Stone, *Undoing Buildings: Adaptive Reuse and Cultural Memory* (Oxford: Routledge, 2020), 7.
2. *Ibid., 8.*
3. *Ibid., 10.*

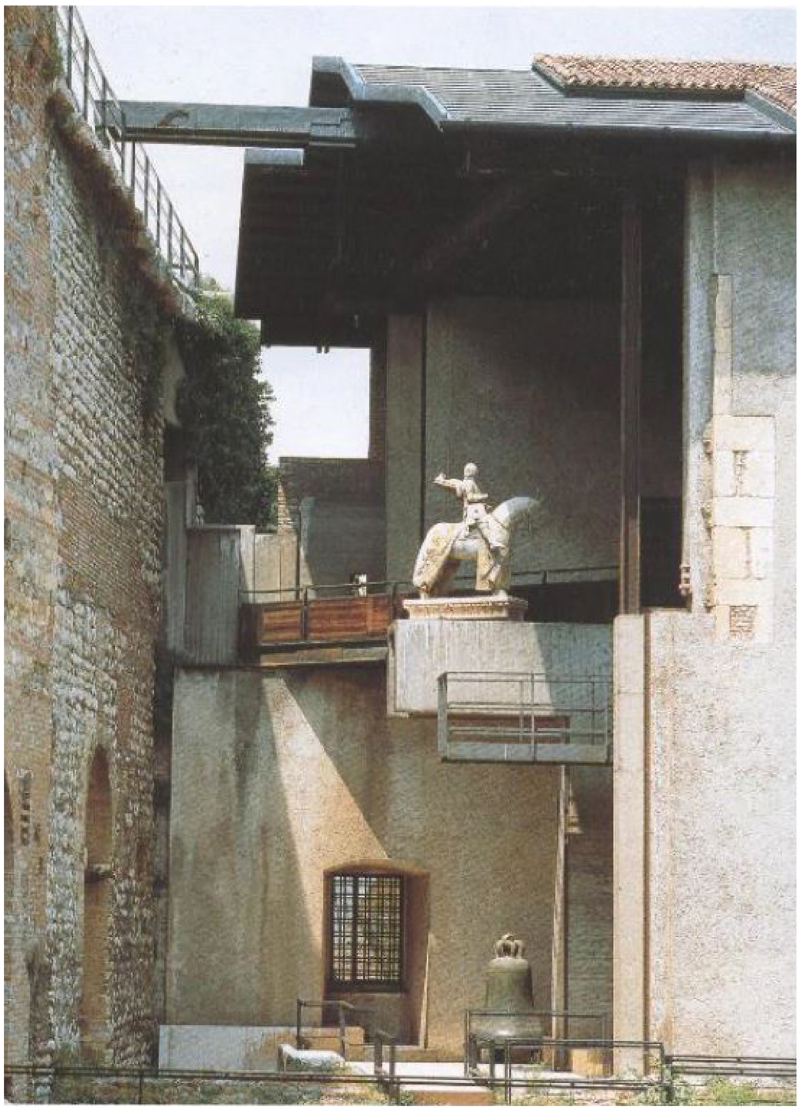

Figure 4 *Castelvecchio, the often emblematic example of historically narrative driven architecture (CCA, 1999)*

its context. This form of adapting has lent itself to particular uses, such as museums, where they were self-conscious of their monumentality. This begs the question, where has the discourse of conservation evolved today? In the 21st century, there needs to be a more radical approach to the existing than this carefully curated set of interventions such as those that Scarpa makes, not to mention that not every reuse project calls for a monumental quality. Modern conservation fails to address the importance of reuse for the sake of a material's continuation rather than linking duration to a historical narrative with its context.

1.2 Obsolescence and the removal of connections

The act of buildings remaining is primarily a decision not made by the architect but by the developer who works within the market's quantitative capital forces. Built into Toronto's urban fabric and all other capital cities is the concept of obsolescence, where buildings are income-producing commodities with a limited life span. Daniel M.Abramson, professor of architectural history at Boston University, conceptually frames obsolescence concerning architecture as "a paradigm for comprehending and managing change." It helps society comprehend the mass erasures of urban fabric that capitalist development requires to match the market's competitive force.[4] Abramson's analysis of early 20th-century building obsolescence studies showed just this. The example he uses is the Marshall Field Wholesale building in Chicago, demolished 40 years after its construction, which showed that the building's inability to be adapted to compete with the commercial pressure faced from new mail in order stores of the time. Due to thick brick masonry load-bearing walls, which made larger, more marketable shopfront windows unattainable, it was demolished.[5] Its obsolescence did not come from material decay but rather from "financial decay" as the disruptive communication technology of mail-in

4. Daniel Abramson, "Obsolescence: Notes towards a History" in *Building Systems: Design Technology and Society*, ed. Kiel Moe and Ryan E. Smith (New York: Routledge, 2012), 161.
5. *Ibid.,162.*

Figure 6 *The Marshall Field Wholesale in Chicago store was demolished in 1930 only 40 years after it's completion. (Zukowsky, 1987)*

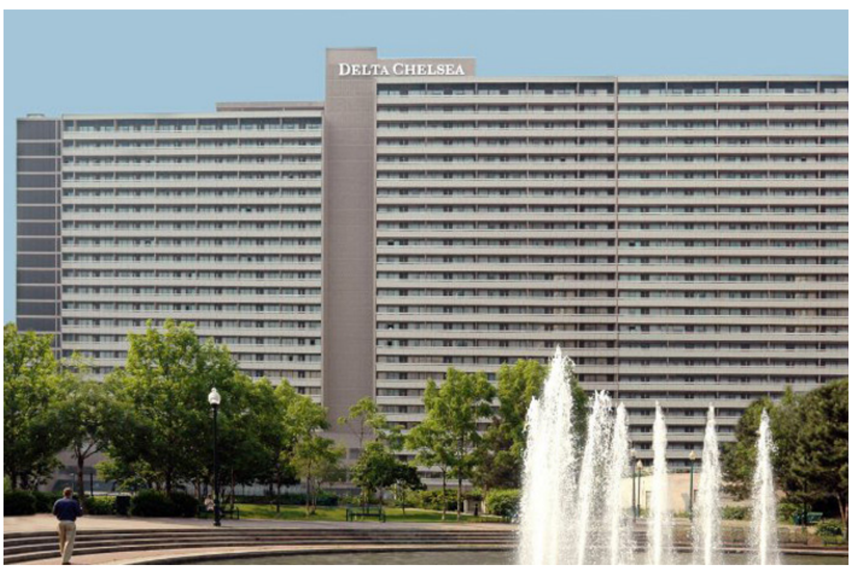

Figure 5 *The Delta Chelsea hotel set for demolition 2021, 45 years after being built. (ERA Architects, 2015)*

orders rendered its commercial success unprofitable. Similarly, today, the Chelsea Hotel in Toronto, only 45 years old and completed at the end of the 20th century, has been made obsolete by the competitive forces of companies such as Air BnB, making large scale hotels unable to compete with the innovation from this disruptive technology. Furthermore, it is made of a highly rigid cast-in-place concrete structure that makes its ability to adapt to a larger, more successful mixed-used building more difficult.

The problem with this temporality of architecture under capitalism is that it primarily relies on extraction, production, consumption, disinvestment, demolition, and eventually reinvestment. This model falsely assumes that we live in a world of endless cheap carbon where material value is just a cheap externality that the building industry deals ignores. In this development model, material systems must are designed for fast production, assembly, and naturally the cheapest bottom line, often making them largely unfit for reuse. Furthermore, the modern enclosures such as the typical curtain wall are complex and fail to address the final stages of this cycle and the potential for them to be designed for disassembly.[6]

These fast-paced erasures due to financial decay fail to consider existing materials as active agents in their decision-making to continue a building or demolish it. By demolishing a building purely due to financial obsolescence, the demolition also removes the context of the societal and environmental cost of its creation. Instead of severing this link for one determined by market capital, adaptation processes can better match a culture's evolving attitudes. Our future urbanism will have to account for the ever-pressing environmental externalities not accounted for in Toronto's cheapened real estate development model. To understand the importance of existing buildings in the future will be to understand its true cost of carbon and its ability to be integrated into the future use-values through adaptation and reuse, ensuring that processes of financial decay do not entirely decide a building's future.

6. Satu Huuhka and Inge Vestergaard, "Building Conservation and the Circular Economy: A Theoretical Consideration." *JCHMSD* 10, no. 1 (2020): 33.

Figure 7 *George Brown House is an example of Part IV Heritage status. If material reuse was to just be applied to the existing values of The Ontario Heritage act, it would include a narrowed material palette and many materials that have reached their highest entropy such as the predominant material here of brick. (Ontario Heritage Trust, 1989)*

1.3 Conservation as Continuation

With obsolescence concepts becoming the prevailing logic for demolishing an existing building, current discourses around conservation have evolved, emphasizing re-defining conservation values concerning adaptation. Prominent adaptive reuse scholar Salley Stone of Manchester University UK remarks on how architectural difference between existing buildings and new construction is not as important today, as has been the agenda since the Athens Charter, and that conservation does not have to have an outright agenda of a historical narrative to drive the design process.[7] Continuation instead is seen as the emphasis needed for pragmatic material continuity. Other more critical issues to the continuation of buildings can drive adaptation processes rather than nostalgia. Things such as the relationship with its present context, its contribution to its urban environment, and the importance of the composite whole should supersede this historical narrative-driven design.[8]

Alongside the developing discourse of conservation, legislative heritage values and policy's influentiall role is also being questioned. In particular, its role with construction, renovation, and demolition waste, otherwise known as CRD. Canadian scholar Susan Ross of the University of Carleton speaks of how limited and isolating material selection is within classified heritage buildings.[9] Even if a more significant policy legislating reuse were applied to heritage status buildings, this would still work within a limited, isolated material system that would avoid all existing materials' fate as having conservation value. She expresses the importance of heritage policy to work within the broader sustainable design practices of building deconstruction and material reuse to increase building duration.[10] By linking re-interpreted heritage values with CRD management, new potential legislative reuse measures would instead work within a circular economy, where quantitative values of carbon can be fused into qualitative ideas of adaptation and material reuse with heritage. Instead of isolating materials and limiting the range of applicable buildings within existing heritage values, the circular economy will address the larger set of building stock and provide greater insight into the potential of reuse in larger CRD metabolisms.

Dr.Mark Gorgolewski, professor of Architectural Science at the University of Ryerson, remarks on the importance of understanding these

7. Sally Stone, *Undoing Buildings: Adaptive Reuse and Cultural Memory* (Oxford: Routledge, 2020), *15.*
8. *Ibid., 15.*
9. Susan Ross, "Re-Evaluating Heritage Waste: Sustaining Material Values through Deconstruction and Reuse." *Historic Environment: Policy and Practice* 00, no.1 (February 2020): 19-20.
10 *Ibid.*, 19-20.

CRD material metabolisms concerning the age and stage of a city's development.[11] For a city such as Toronto, there is still a moderate need to create new infrastructure, making the inflows of materials significantly higher than that of an older city. Therefore, it is conceivable that as Toronto, over time, enters a more steady state of development that it will be essential for it to reduce the inflows and outflows of materials from the city, concentrating on its existing stock. Thinking of Toronto in this metabolic way would also help reach net carbon, allowing existing building material to remain within the closed-loop system, and balance out the new material inputs needed to reach net-zero carbon. This is where heritage can be readdressed and concepts of circularity incorporated to address the flow of materials in relation to urban growth.

1.4 Circularity & LCA

So what does circularity exactly mean? Understanding the material world through the circular metabolic flow of materials questions the prevailing linear material flow of extraction, production, consumption, and waste, bringing notions of cascading the lifespan of materials before reaching their end of life. This cascading quality is the foundational idea of the circular economy, which focuses on extending the life cycles and conserving the environmental and economic values of already extracted and refined resources.[12] The famous butterfly diagram produced by the Ellen McCarther foundation in 2011 (see fig. 8) shows this cascading principle, with recycling being the lowest on the sequence for extending lifespans.

This cascading is further elaborated in Satu Huuhka's diagram that shows the circular economy's cascading principles applied to building conservation (see figure 9). This diagram shows the much more nuanced

11. Mark Gorgolewski, *Resource Salvation: The Architecture of Reuse* (Hoboken, NJ: Blackwell, 2018), 46.
12. Susan Ross, "Re-Evaluating Heritage Waste: Sustaining Material Values through Deconstruction and Reuse." *Historic Environment: Policy and Practice* 00, no.1 (February 2020): 4.

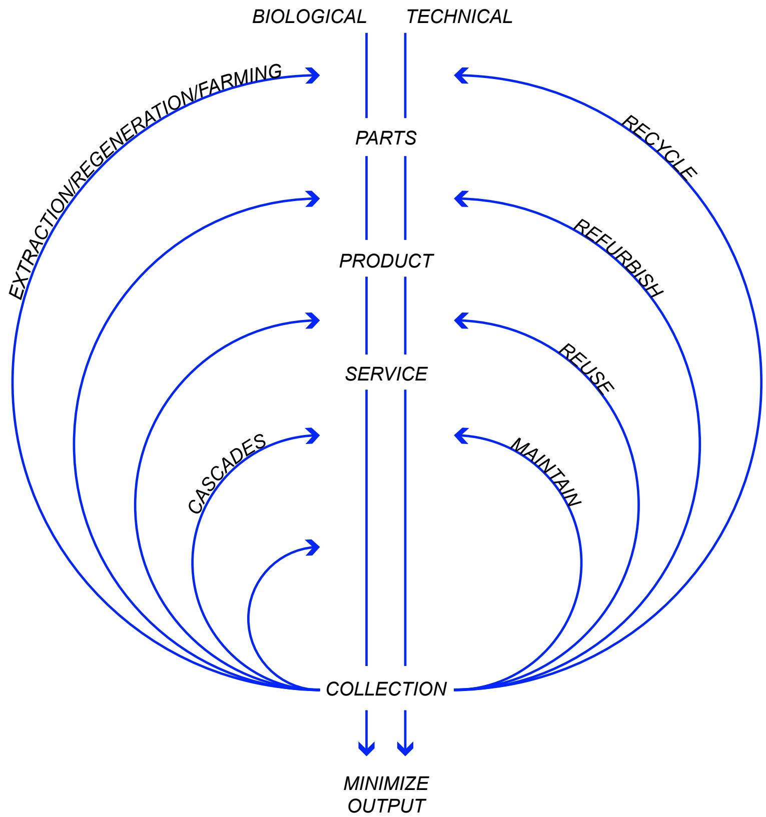

Figure 8 *The Circular Economy and it's cascading principles. (Adapted from Ellen McArthur Foundation, 2015)*

cascades that circular theory can give to the end of life of buildings and how limited the construction industry's current scope is when thinking of existing buildings. However, it is not as simple as other industries, such as consumer products that have circularity applied to them in their manufacturing processes. There are many unique material configurations of existing buildings with their own logistical and technological parameters that need to be understood. Furthermore, specific eras have, as previously mentioned, more complexity in their building systems. Vernacular or traditional building methods such as brick and timber potentially have less harmful substances and less complexity in their connections, allowing for a higher yield of reuse.[13] Modern buildings instead consist of more com-

13. Satu Huuhka and Inge Vestergaard, "Building Conservation and the Circular Economy: A Theoretical Consideration." *JCHMSD* 10, no. 1 (2020): 33.

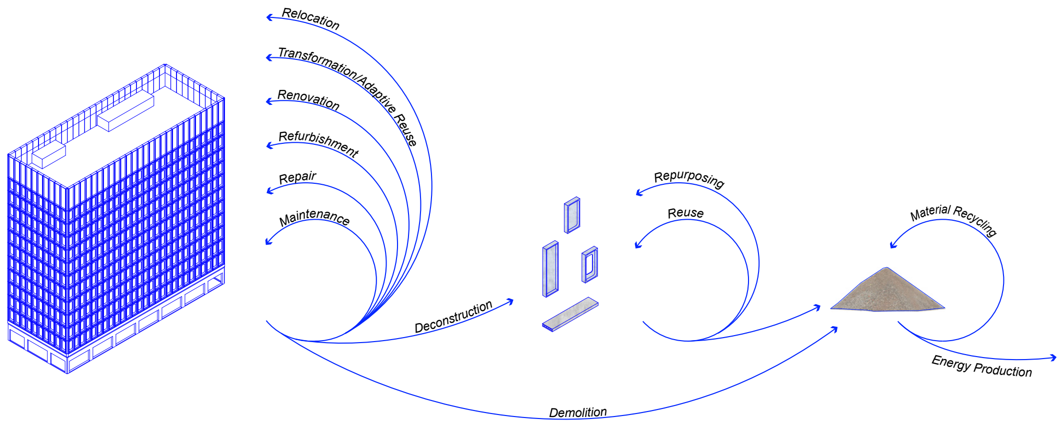

Figure 9 *Circularity in relationship to existing buildings. (Adapted from Hukka & Vestergaard, 2020)*

plex hybrid structures formed from a conglomeration of materials such as reinforced concrete, engineered wood, steel, thermal layers, and control layers, making them have a lower potential for reuse as they are harder to disassemble. Therefore, specialists must analyze each building to determine the appropriate technologies required to maintain these composite layers in a reusable form or otherwise separate them while keeping their components. In thinking of existing buildings within the circular economy, they can be understood as 'material banks' that can have hierarchies of the building to be preserved, the components worth preserving, and the materials worth preserving.[14]

It is also important to use empirical evidence to understand the environmental impact that each of these hierarchies would have on the carbon embedded in them to maximize the embodied energy saved.[15] Fundamental to the circular economy is the empirical backing of life cycle analysis (LCA) which measures the environmental burden in Tons of carbon equivalent (tCO2e). Many are confused by the mysterious "e" in this metric. The simplest way to explain it is that other gases such as methane and NO2 (famous for diesel car emissions) also have a global

14. *Ibid.*, 33.

15. Kiel Moe, *Convergence: An Architectural Agenda for Energy* (Harvard: Routledge, 2013)

warming potential that can significantly higher heat-trapping to carbon dioxide.[16] So the “e” is simply the conversion to the universal carbon that incorporates those other gases that also cause the heat-trapping effect of carbon dioxide. To put tCO2e in a non-abstracted number, the average suburban passenger car consumes 4.73 tCO2e per year.[17]

It will help to keep this number in mind when seeing the larger numbers that buildings will present us. The reason to use the quantitative method of LCA alongside the circular economy is to help justify which components in a building will most impact carbon saved for either remaining or being selected for reuse and recycling. It adds to the criteria and understanding of how vital conservation can become if the quantitative and qualitative are both used in determining design decisions.

1.5 Circularity in a Canadian Context

So, what materials do we primarily waste in Canada? The Canadian Construction Association reported a study involving samples of waste generated from various commercial and residential structures at different points in their building, demolition, or renovation (see figure 10). Wood and rubble were the two major constituents of C&D wastes in the country.[18] So what is currently being taken advantage of within the demolition industry? By weight, the largest industry within material reuse that is currently the most economically viable is the processing of building rubble, from concrete and masonry, into recycled aggregate.[19] In Ontario, under the Aggregate Recycling Promotion Act, this form of recycling is allowed once tested for quality and consistency and is used primarily in public infrastructure

16. Bruce King, *The New Carbon Architecture: Building to Cool the Climate (*Gabriola Island, BC: New Society Publishers, 2017), 41.
17 “Greenhouse Gases Equivalencies Calculator - Calculations and References.” *USEPA*, United States Environmental Protection Agency, last modified: February 16, 2016, https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.
18. Kasun Hewage, “An Overview of Construction and Demolition Waste Management in Canada: An Analysis Approach to Sustainability.” *Clean Technologies and Environmental Policy* 15, (2013): 83-84.
19. *Ibid., 83-84.*

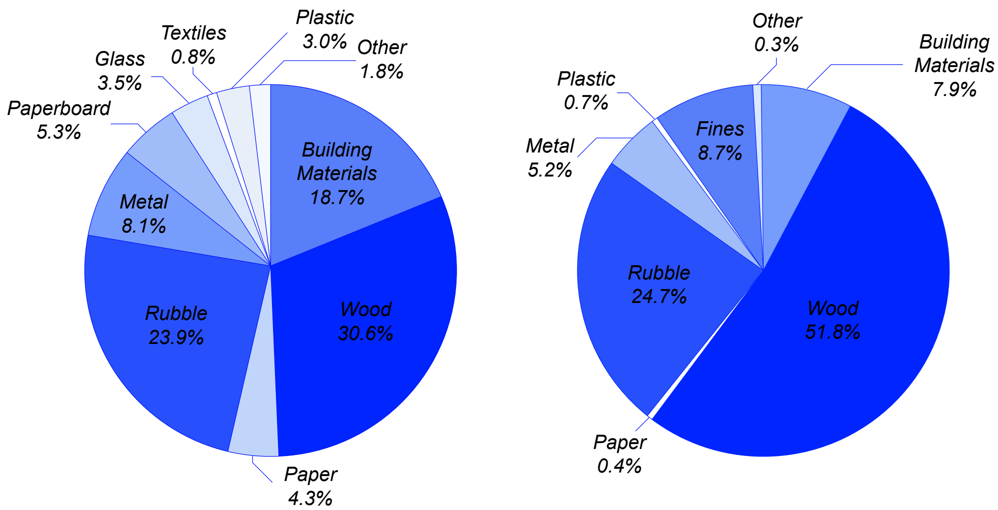

Figure 10 *Construction and demolition waste composition: Left. Construction Waste Composition, Right. Demolition Waste Composition (The Canadian Construction Association, 1992)*

projects such as highways - making recycled aggregate a highly usable product.

Similarly, other recycling industries that deal with construction waste such as plastics, wood, metals/steel, and other mixed materials work with transfer stations where materials with a universal use are separated from inert materials and bought by smaller subsidiary companies that will eventually recycle them back into standard forms.[20] Incineration of waste is often the last possible option for harnessing the energy embodied in the material, and only a few of these Waste to Energy Plants exist in Toronto.[21] Most demolition rubble in recent history that is inert regrettably ends up in a landfill, as seen with the Leslie Street Spit in Toronto, which exemplifies the problems with material disposal being the cheapest cycle of a building's life. Even if the existing materials are fit for reuse, by and

20. Ken Kieswetter, "The Role of The Demolition Contractor in Salvaged Materials." interview by Alexander Robinson, *Personal Audio Recording*, January 15, 2020.

21. "We Asked 3 Companies to Recycle Canadian Plastic and Secretly Tracked It. Only 1 Company Recycled the Material." CBC, Katie Pederson and Eric Szeto, last modified: October 9, 2019. https://www.cbc.ca/news/technology/marketplace-recycling-trackers-b-c-blue-box-1.5299176.

Figure 11 *Ken Kieswetter's salvage yard (Photo by Author)*

large, the costs of disassembly, transport, storage, and reassembly currently require too high of a manual labor cost to justify for developers as worthwhile.

However, there is a small architectural salvage industry in Ontario, which arose from demolition contractors' ability to take advantage of opportunistic moments during the demolition of a building. Ken Kieswetter and his Timeless material company is an example of a company that invests the time and effort into salvaging materials from their projects by creating an economy of recycling, refurbishing, storing, and eventually selling of the salvaged materials back to the building industry as well as for smaller DIY home improvement projects.[22] For someone like Ken Kieswetter, he looks at a structure from a building systems perspective, where complexity is valued less as the material configuration requires significant labor and energy to deconfigure.[23] Typically, older buildings have more value as their building technology does not rely on composite materials, which are not as easy to deconstruct. Hearing Ken's frustrations, it is easy to see that the salvage and demolition industry still heavily relies on manual labor processes.

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22. Ken Kieswetter, "The Role of The Demolition Contractor in Salvaged Materials," interview by Alexander Robinson, *Personal Audio Recording*, January 15, 2020.
23. *Ibid.*

Other cities in Canada, such as Vancouver, have a more assertive legal approach to circularity. In Vancouver, their Green Demolition policy sees the emphasis of conservation shift towards the deconstruction and salvaging of character-defined houses pre-1940's mandating that 95% of the building has to be reused, recycled, or diverted from a landfill.[24] Such a high yield is possible since most of these character houses are built from heavy timber products, which can be reused in many different forms as structural, cladding, and interior finishes. Demolition and salvage contractors see this high yield of salable material advantageously, resulting in adverse effects such as increasing the value of these character buildings not because of their historical or social values but for their economic mining value in material reuse. This practice's unfortunate outcome is an increase in the demolition of historic buildings from the material markets' forces.[25] Furthermore, suppose cities only promote deconstruction and salvage processes such as Ken Kieswetter and the policies similar to Vancouver's Green Demolition Policy. In that case, frank discussions need to be held around the provenance of the material origin and whether it is such a good idea to create a discontinuity between site and material.

Although recycling advancements, waste to energy plants, and small-scale salvage yards are all promising processes that see the diversion of materials from simply becoming waste, nothing is more effective than the adaptation of buildings to new users to allow for material configurations to remain in place. If there were a coupling of the principles of adaptation alongside the processes of deconstruction, component reuse, and recycling taken from circular thinking, there would be a more nuanced practice to a given site's embodied material qualities. To understand this, we need to look at the most radical forms of legal material duration, that of heritage and conservation, and critique it for its shortfalls. Additionally, how

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24. "Green Demolition By-Law Update." Vancouver Administrative Report, City of Vancouver, last modified: May 12, 2018, https://council.vancouver.ca/20180516/documents/pspc2c.pdf.
25. Susan Ross, "Re-Evaluating Heritage Waste: Sustaining Material Values through Deconstruction and Reuse." *Historic Environment: Policy and Practice* 00, no.1 (February 2020): 16.

can we use Life Cycle Analysis and the metrics of embodied energy to experiment in analyzing existing buildings and allow architects to start taking agency over material reuse processes? How can circularity concepts become a part of a political agenda that promotes the duration of materials? These are the questions that the experimental Re-Amortization Act seeks to incorporate into its learnings.

02

The following pages describe and annotate a speculative act which incorporates ideas of life cycle analysis and heritage values. It is a work in progress for potential future legislation.

The Re-Amortization Act:

In the financial world, amortization is the gradual expensing of an asset over a number of years instead of expending it in the initial year of purchase.[1] For a fixed asset such as property, the value of land and the building's material value are factored into this amortization schedule. It is only until the property is sold again that the depreciation of the existing building and its new lower financial value is taken into account. Through this quantification in economic terms of depreciation, obsolescence is built into our financial ownership of property as its future land value supersedes the material value of the building on that land over time. However, this does not necessarily mean that the existing building materials are obsolete once this amortization schedule has been complete, and the speculative increase that the land value gains over time compared to the financial value of an existing building's materials leads to their financial obsolescence and demolition.

Re-Amortization's experimental concept speaks of a different model, where before the purchasing of a property, the existing building is evaluated, and its materials undergo both a cultural and an embodied energy analysis, assigning a new value to existing building materials that depreciation does not. The Re-Amortization act sets the restrictions of materials that must remain in place, be reused as salvaged components, or reprocessed through recycling, each determined by the category it is put in. Those categories are determined by criteria that relate to each building's embodied energy, structural type, and its material circularity. There are three resulting categories: **Remain (I), Adapt (II), and Disassemble (III)**, Each of which will have a set of associated material restrictions for what remains on-site and what can leave. If the developer were to ignore the Act, they would have to pay a considerable embodied energy fee to account for the actual life cycle cost.

1. "Glossary - Amortization and Depreciation." *Tax Tips*, last modified: February 18, 2021, https://www.taxtips.ca/glossary/amortization.htm.

1.1 Ontario Heritage Act Analysis:

Three criteria determine acceptance into the Ontario heritage register for official designation: design value or physical value, historical or associative value, and contextual value (see figure 13).[1] These values all require qualitative analysis of buildings such as **Heritage Criteria 2**, which shows the strongest narrative-driven values, which link history and culture through the building's potential to "yield information" or "directly associate" with the past. The experimental Act does not reinterpret Heritage Criteria 2 because it wishes to have a more flexible conception of memory and culture linked to physical material continuity and not to a community, or individual.

The Re-Amortization Act reinterprets parts of the Heritage Act, particularly **Heritage Criteria 1 & 3**, design/physical value & contextual value. In design value or physical value (Heritage Criteria 1), the proposed Act emphasizes the importance of **"a material or construction method"** by viewing it through the lens of building adaption. If an existing building had a material or construction method that was easier to remove selectively, it would have a high adaptation value. Furthermore, in contextual value (Heritage Criteria 3), the proposal will reinterpret the meaning of "**physically and functionally linking a property to its surroundings"** through the lens of material reuse. It focuses on the importance of a material's ability to contextualize its surroundings and not just the buildings kept as a whole. Defining contextual value in this way speaks of a greater material provenance that would develop in Toronto over time. Unique material languages would develop around a closed circular material system and re-contextualize them in different buildings across the city, making every future building materially linked to its surroundings.

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1. Ontario Heritage Trust and Ministry of Culture, *Heritage Property Evaluation: A Guide to Listing, Researching and Evaluating Cultural Heritage Property in Ontario Communities* (Ontario: Ministry of Heritage, Sport, Tourism and Culture Industries, 2006), 22.

Ontario Heritage Act Criteria

Heritage Criteria 1. The property has design value or physical value because it, i. is a rare, unique, representa- tive or early example of a style, type, expression, material or construction method, ii. displays a high degree of craftsmanship or artistic merit, or iii. demonstrates a high degree of technical or scientific achievement.

Heritage Criteria 2. The property has historical value or associative value because it, i. has direct associations with a theme, event, belief, person, activity, organization or institu- tion that is significant to a community, ii. yields, or has the potential to yield, information that con- tributes to an understanding of a community or culture, or iii. demonstrates or reflects the work or ideas of an archi- tect, artist, builder, designer or theorist who is significant to a community.

Heritage Criteria 3. The property has contextual value because it, i. is important in defining, maintaining or supporting the character of an area, ii. is physically, functionally, visually or historically linked to its surroundings, or iii. is a landmark.

Figure 13 Ontario Heritage Act Criteria. (Ontario Heritage Trust & Ministry of Culture, 2006)

1.2 LCA Analysis:

Corresponding to these translations of the Ontario Heritage Act, the proposed Act seeks to find the appropriate life cycle analysis qualities to merge with these values reinterpreted to form the new hybrid set of criteria for the Act. TTo understand embodied energy, the sum of all energy required to extract raw materials, manufacture, transport, and assemble the materials into a building, we must use building information modeling programs combined with life cycle analysis models. These models give us a range of data that can tell us where carbon is most present in a building.[1] Additionally, the use of circularity tools like the ones described earlier in this thesis can quantify material reuse and recovery rates of buildings' end-of-life scenarios to a relative degree of accuracy. For this proposal's purposes, the analysis used the program One-Click, a Life Cycle Analysis program which uses the seven categories of life cycle analysis, allowing us to understand which stages of the materials life are most important to its total embodied energy (fig.15).

All seven categories contribute to the total energy found in each material, and usually, the most important to carbon contribution are the 1.Product, 4.Maintenance, 6.End of life and 7.Recovery. These categories are the main inspiration for the Act as they describe which materials have the most energy in their extraction and production and the potential condition and recovery the existing material has. LCA allows for a strategic understanding of where to best focus material reuse efforts to reduce the effects of climate change in the building industry. This thesis's main metric is the global warming potential, otherwise known as tCO2e, which tells us the relative measure of how much heat a greenhouse gas traps in the atmosphere. As mentioned in chapter one, a single car emits roughly 4.73tCO2e a year.[2]

1. Benjamin David, E*mbodied Energy and Design: Making Architecture between Metrics and Narratives* (New York: Columbia University GSAPP, 2017), 13-23.
2. "Greenhouse Gases Equivalencies Calculator - Calculations and References." *USEPA*, United States Environmental Protection Agency, last modified: February 16, 2016, https://www.epa.gov/energy/greenhouse-gases-equivalencies-calculator-calculations-and-references.

▾ Life Cycle Analysis (LCA)

1. Product [A1 - A3]
This encompasses the full manufacturing stage, including raw material extraction and processing, intermediate transportation, and final manufacturing and assembly.

2. Transportation [A4]
This counts transportation from the manufacturer to the building site during the construction stage and can be modified by the modeler.

3. Construction Installation [A5] (Optional)
This includes the anticipated or measured energy and water consumed on-site during the construction installation process.

4. Maintenance and Replacement [B2-B5]
This encompasses the replacement of materials in accordance with their expected service life. This includes the end of life treatment of the existing products as well as the cradle to gate manufacturing and transportation to site of the replacement products.

5. Operational Energy [B6] (Optional)
This is based on the anticipated or measured energy and natural gas consumed at the building site over the lifetime of the building, as indicated by the modeler.

6. End of Life [C2-C4]
This includes the relevant material collection rates for recycling, processing requirements for recycled materials, incineration rates, and landfilling rates. The impacts associated with landfilling are based on average material properties, such as plastic waste, biodegradable waste, or inert material. Accounts for waste processing and disposal, i.e., impacts associated with landfilling or incineration.

7. Recovery [D]
This accounts for reuse potentials that fall beyond the system boundary, such as energy recovery and recycling of materials. Along with processing requirements, the recycling of materials is modeled using an avoided burden approach, where the burden of primary material production is allocated to the subsequent life cycle based on the quantity of recovered secondary material.

Figure 14 Life Cycle Analysis Criteria. (Binova, 2020)

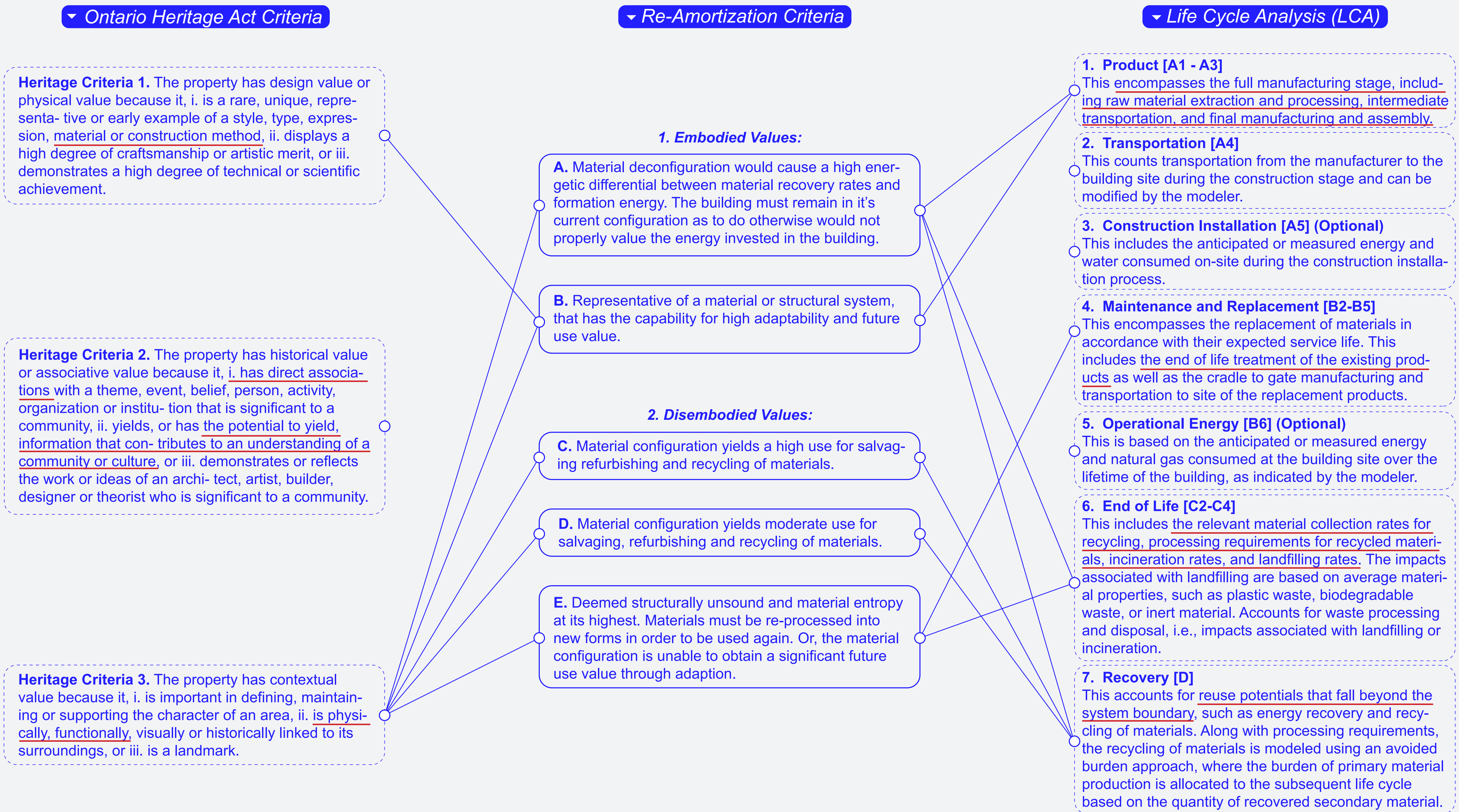


Figure 15 Matrix of Ontario Heritage Act, Life Cycle Analysis, and new combined principles (self authored)

1.3 A Hybrid Model: Re-Amortization

When bringing together the qualitative measures of the Ontario Heritage Act and LCA's quantitative metrics, the proposed Act creates new hybrid criteria set for promoting material duration. There are two types of criteria: **Embodied Values and Disembodied Values** (see figure 16). The Act's embodied values are those criteria that promote a material to remain within its site or context. **Criterion A** focuses the most on end-of-life and material recovery principles. If a building has a high amount of embodied energy that cannot be recaptured through material recovery, it would need to remain in its current configuration. Furthermore, it takes contextual value from the heritage act and interprets "ii. Is physically, functionally, visually or historically linked to its surroundings" as important when linked with the understanding of the immense energy that its product and construction took to make it. **Criterion A** is the most weighted in terms of remain which is why the remaining within its contextual configuration is emphasized. Buildings considered worthy of being placed in **Criterion A** are typical of the modernist era made of a highly conglomerate, not as easily deconfigured material such as cast-in-place concrete.

Criterion B promotes structural reuse of a building's structural system type that is highly adaptable, often from specific building eras. It focuses on the structural properties of the existing building that allow for a high future use-value. Using the heritage acts' design value and physical value principles such as "construction method of an era" combined with LCA's understanding of the product and construction energy it took to make the building's structure, **Criterion B** classifies structures from certain eras as optimal for adaptation. For example, many concrete structural grid buildings with prefabricated infill panels would be ideal for this category as the main structure where most of the embodied energy remains is kept, and only the infill would be replaced. Similarly, hybrid structures such as curtain wall facades and precast panel facades would be appropriate for

▾ Re-Amortization Criteria

1. Embodied Values:

A. Material deconfiguration would cause a high energetic differential between material recovery rates and formation energy. The building must remain in it's current configuration as to do otherwise would not properly value the energy invested in the building.

B. Representative of a material or structural system, that has the capability for high adaptability and future use value.

2. Disembodied Values:

D. Material configuration yields a high use for salvaging refurbishing and recycling of materials.

C. Material configuration yields moderate use for salvaging, refurbishing and recycling of materials.

E. Deemed structurally unsound and material entropy at its highest. Materials must be re-processed into new forms in order to be used again. Or, the material configuration is unable to obtain a significant future use value through adaption.

Figure 16 Re-Amortization Act Criteria.

this category.

The other set of valuation criteria is the building's ability to be deconstructed, resulting in its energy disembodied. This category requires an understanding of the effective yield for building material systems salvaged or recycled. **Criteria C & D** describe the yield potential either from a high to medium yield to a medium to low yield of recycled and salvaged materials. **Criterion E** focuses on high material reprocessing if most materials have reached their highest entropy and are deemed structurally unsound by a professional materials analyst. Professional sets of material auditors would be responsible for making reasonable judgment calls as to a material's ability to be reused based on the use of programs such as One-Click LCA.

As seen in the criteria sheet shown earlier, we can better understand the three categories and their justifications. **Remain (I)** is devoted solely to **Criterion A**, saying buildings with no adaptability, low material recovery rates, and a high amount of embodied energy should remain in place. **Adapt (II)** must show **Criterion B**, a significant structural or component capacity to be adapted, making **Criterion C & D** justify those material recovery rates. Finally, **Disassemble (III)** has neither **Criterion A** nor **B** but must at least two of the three **Disembodied Values**. Central to all classifications is that all materials must remain on-site or return to their regional contexts for material continuity. It ensures that material flows will not be extrapolated outside the city over time but instead develop a unique language and material culture specific to Toronto. This is how buildings are classified in the proposed Act and their material outputs mandated.

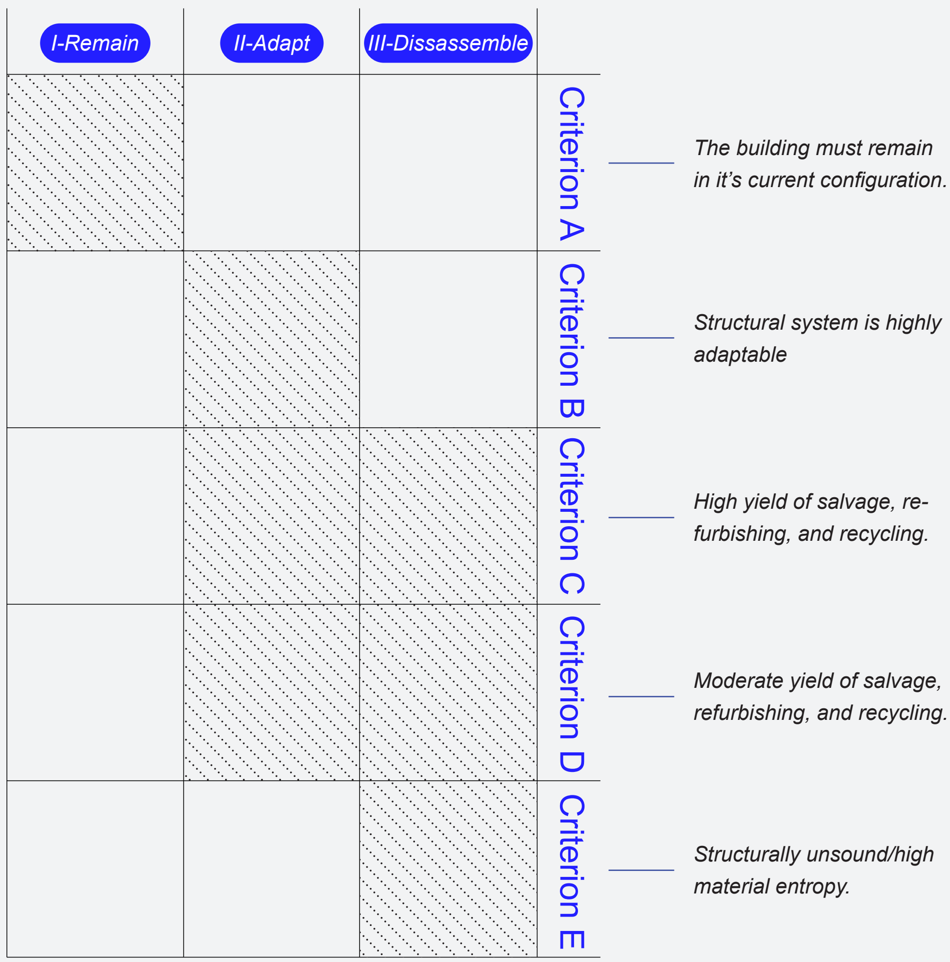


Figure 17 *Required criteria to be met for each category.*

1.4 Material Output: Rules 1 & 2

The three categories of remain, adapt and assemble, arise from the criteria chart, which, as previously mentioned, requires one or more criteria for each building to be classified (see figure 18). These criteria are determined by **Rule 1, which requires a Re-Amortization audit and classification that looks at the adaptation value, tons of carbon dioxide equivalent (tCO2e), and potential circularity of the existing material configuration.** Similar to a heritage report, each report would state why each building would have a strong case for being chosen for each of its criteria resulting from the audit that it undergoes.

After the criteria are selected, **Rule 2 classifies the building under Remain, Adapt, or Disassemble and sets the maximum material output percentages for each category (see figure 19).** The graphic scheme of the percentages runs throughout the documents of this proposal. As seen in each category's sliders in figure 19, **Remain (I)** allows only 20% removal of either recycling or salvage, with 80% required to remain in place. **Adapt (II)** requires that 40% of materials remain in place and has a more generous allowance for salvage and recycling of up to 60%. **Disassemble (III)** is the least restrictive of the three allowing for up to 40% salvage and 60% recycling.

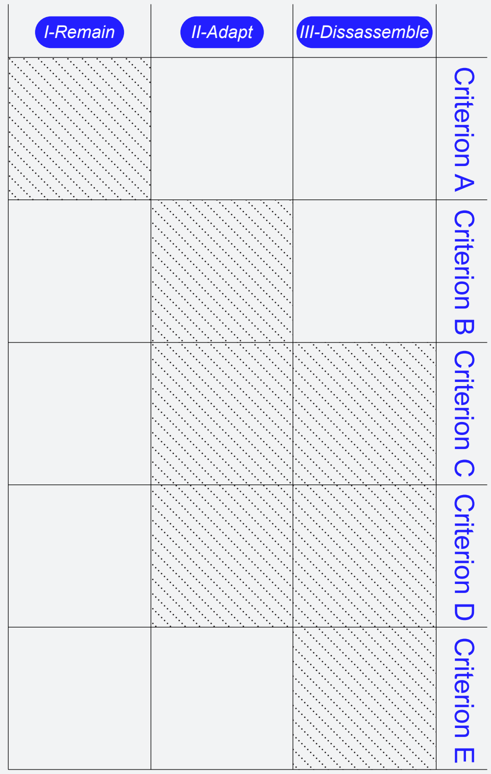


Figure 18 *The Criteria Chart for Building Classification. In the following order: Remain (existing building remains largely in place), Adapt (large portion of the building allowed to be taken down), & Disassemble (All existing materials allowed to leave site).*

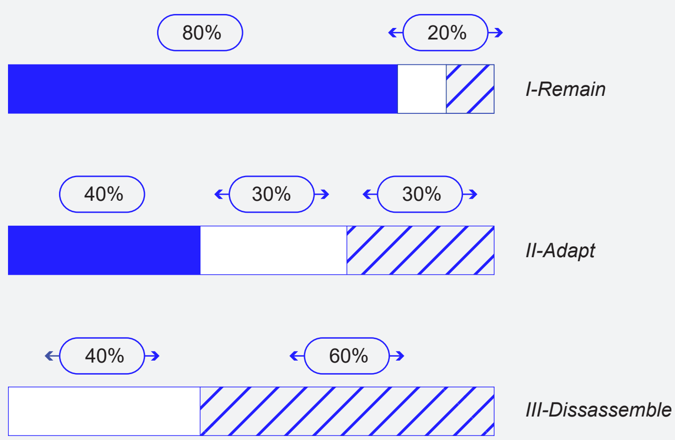


Figure 19 *Percentages of restrictions for each of the three categories: Blue (material must remain in place), Hatch (allowed to be recycled), an white with blue border (salvaged).*

1.5 Material Input: Rule 3

The criteria justify the category the existing building gets placed in and its material output capabilities for future development. Just as important are the future inputs of materials that come to the site. To set a more impactful carbon reduction strategy, there needs to be a balance between the new carbon introduced becoming net with the existing carbon. **Rule 3 mandates future material input must retain an overall Net Embodied Carbon balance with existing materials either on-site or from materials within the urban metabolic system.** No new material input to the site shall supersede the existing amount of carbon on the site, making it net embodied carbon. This Rule will make the rate that Toronto's density increases more matched with the abundance of carbon already present in its built form.

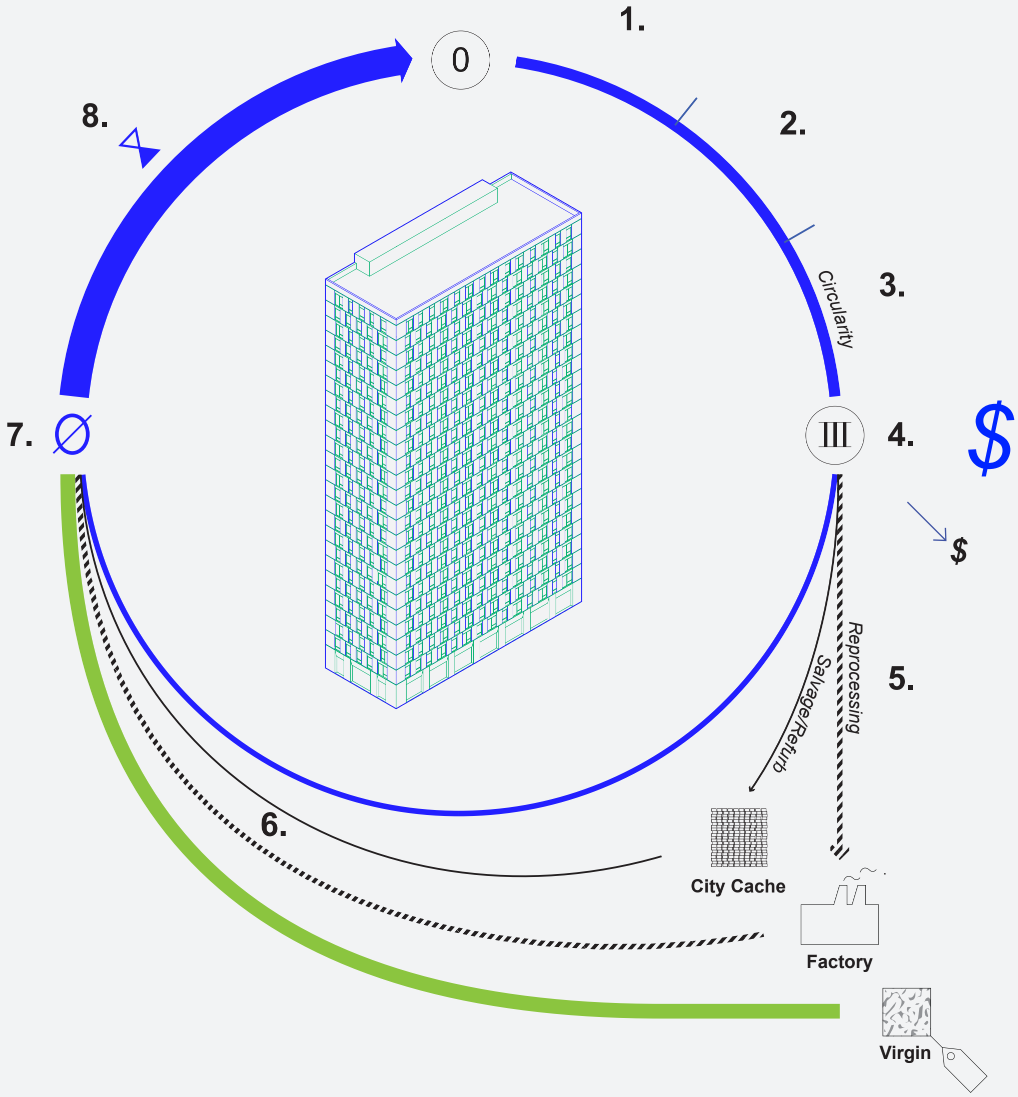
For instance, in a **Disassemble (III)** building where all the materials can leave the site, the new proposed building must include 50% material recycling or reuse to match the 50% new virgin material. **Remain (I) & Adapt (II)** will have a much easier time reaching this net balance because they already contain a significant amount of existing carbon from their material output restrictions put on them by **Rule 2.** To understand graphically how this Rule works, refer to **Step 7** in this insert and all the emblematic precedents in Chapter 3, which show the least extreme to most extreme of **Rule 2.6.1.** In Chapter 3, **Rule 3** is shown across different densities, showing how impactful this Rule will influence new material selection, as it encourages the selection of lower embodied energy materials such as CLT. More importantly, it encourages integrating more material reuse that balances this net embodied equation for future designs that wish to reach a specific density and need to expand their carbon allowance. Instead of seeing the material output and input restrictions as limiting, they can be seen as a force for more creative solutions as architects integrate material reuse into designs and work within the existing constraints of what remains to reduce embodied carbon waste significantly.

Figure 20 *Net Zero Embodied is the goal for the act, making adaptation, and material reuse the key to reaching this zero.*

1.6 Time Limit: Rule 4

The final parameter of this experimental Act is the time limit requirement. **Rule 4 mandates the enforcement of a time limit before a building may be re-classified for a new design after it has undergone the Re-Amortizing process.** This time limit is dependent on the combination of materials, remaining, salvaged, and new which an auditor determines the reasonable amount of time in terms of maintenance that the newly designed material configuration should be unchanged. This restriction avoids any loopholes that a developer could take advantage of in incrementally introducing as much new material as possible by continuously reapplying for building permits under the Act’s conditions. It helps reinforce making long-term decisions for the building’s durability as only minor maintenance is allowed to ensure the building is operational while living out the mandated time limit set on it.

Figure 21 *Example of the time stamp given to each development after it has been completed, materials cannot undergo the development process until this time has been lived out.*



Rule 1	*Step 1 - Use Value Audit* *Step 2 - Embodied Energy Audit* *Step 3 - Material Circularity Audit*
Rule 2	*Step 4 - Re-Amortization Classification I, II, III* *$ - Building Purchase* *Step 5 - Outputs/Material Log* *Step 6 - Remaining Materials Set*
Rule 3	*Step 7 - Net Zero Embodied Energy Cap*
Rule 4	*Step 8 - Time Limit Set*

Figure 22 *Diagram describing steps of the act and the associated rules that those steps take into consideration. (Self Authored)*

1.7 Act Process:

The Act follows an 8 step process (see figure 22) coupled with a flow diagram registering the tCO2e. A series of call-outs illustrate these steps individually, elaborating on the process of each. To clarify **Steps, 1-4 & 8** are completed by city auditors separate from the architects, and **Steps 5-7** are completed by architects & engineers (refer to figure 22 notes).

Step 1 initiates **Rule 1**, beginning with an audit of the use-value, or adaptation value, examining its predominant structural type and ability to change use. This audit would involve a justification that the space is flexible enough to accommodate future use value from easy modification of its current material modification. **Step 2** involves quantifying the tons of Carbon Dioxide (tCO2e) embodied in an existing building and where it sits within its structure, using a Life cycle Analysis program called One-Click LCA. This program uses Environmental Product declarations (EPD's), essentially manufacturing product data, which make assumptions for the auditing of existing buildings and their materials.[1] Finally, **Step 3**, the concluding step of the first three, involves examining the circularity of the existing materials; in other words, the materials yields in terms of recycling, reuse, and waste (refer to figure 24). It allows for accurate material return rates and is useful for looking at the future circularity of newly inputted materials.

Once **Steps 1-3** are complete, the building is finally ready to be categorized into the categories of the Act under **Rule 2**, as either **Remain (I), Adapt (II), or Disassemble (III)**, thus completing **Step 4** (see figure 25). Observation notes are included in the drawing, as seen in the example flow diagram, with an additional breakdown of the carbon in the building directly above. The classification report describing the criteria selected

1. "One-Click LCA." *Binova*, last modified: September 15, 2020, https://www.oneclicklca.com/about-bionova-ltd/.

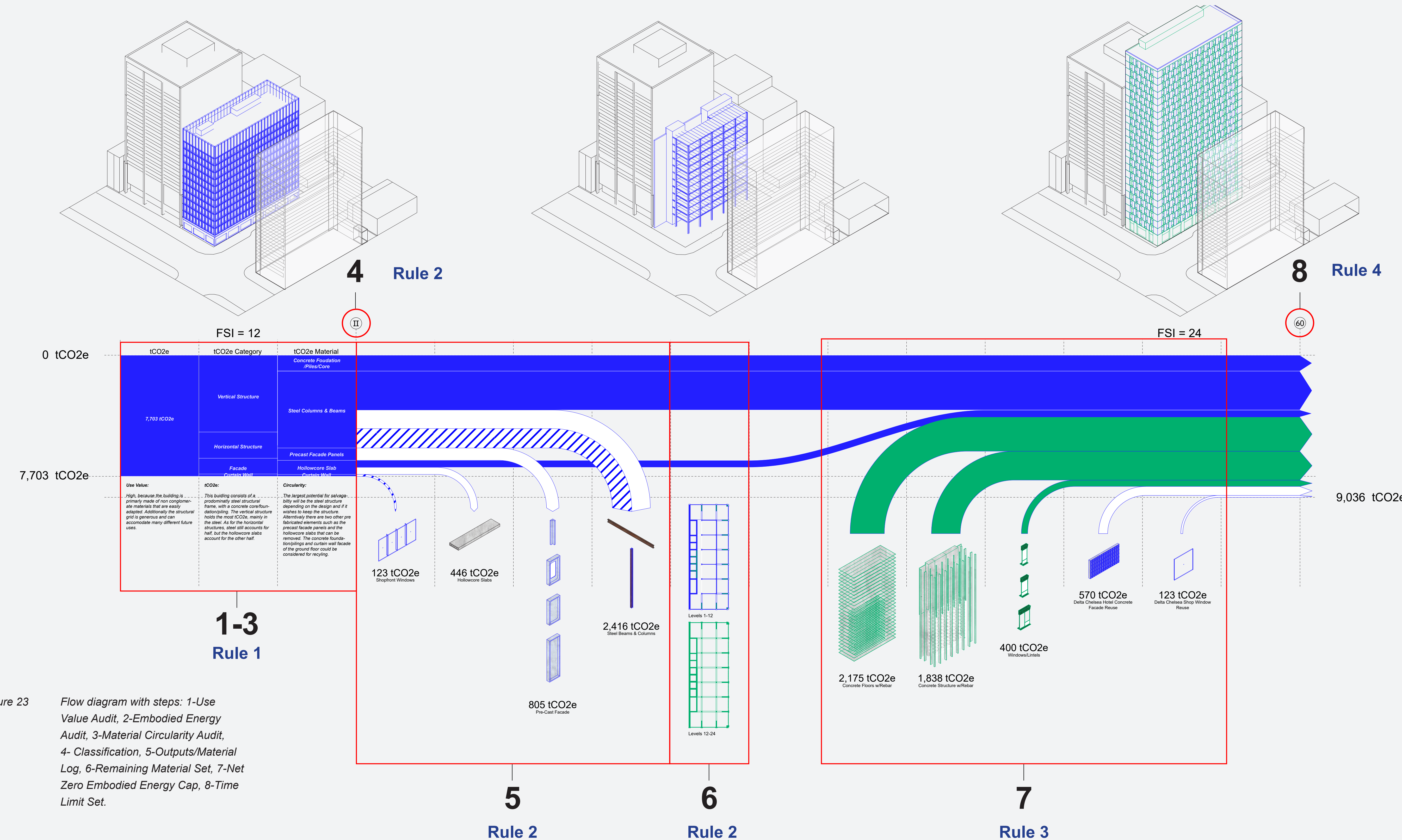


Figure 23 *Flow diagram with steps: 1-Use Value Audit, 2-Embodied Energy Audit, 3-Material Circularity Audit, 4- Classification, 5-Outputs/Material Log, 6-Remaining Material Set, 7-Net Zero Embodied Energy Cap, 8-Time Limit Set.*

is on a separate document and once selected, the drawing is stamped with the categorization of the building. As discussed earlier in this chapter, there are associated guidelines with the maximum amount of removed material allowed and the percentages of material that are to be either recycled or salvaged.

Step 5 is where each category's material output restrictions are applied, making the architects quantify the materials that are remaining or coming out of the system (see figure 26). It follows the same graphic notation as the output chart, which uses a blue fill for remain, a white fill for salvaged materials, and a blue hatch for recycled materials. Below each of the items flowing out, there is also the amount of tCO2e and the material description for cataloging future component or material reuse that will be necessary for material cache storage and integration into other building designs. **Step 6** describes the materials that remain, accompanied by a set of floor plans describing, depending on the design, any removed structure (see figure 27). **Step 7** is where the net embodied energy criteria of **Rule 3** is considered, weighing the new material carbon cost, represented by a green fill against existing materials and integrated material reuse tCO2e, represented by the blue & blue hatch see (figure 28).

Finally, the last step, **Step 8**, brings an official end to the cycle of this metabolic process and Re-Amortizes the building's materials for a set time according to **Rule 4** (see figure 29). Depending on the life span of the combined existing materials, which would be analyzable and given a realistic renewal of life span, auditors of the Act would set the time deemed appropriate for the future configuration to remain in place. After this time has passed, the building on the site can be reviewed for downgraded classification until it is classified into Act III, where all the materials may leave the site.

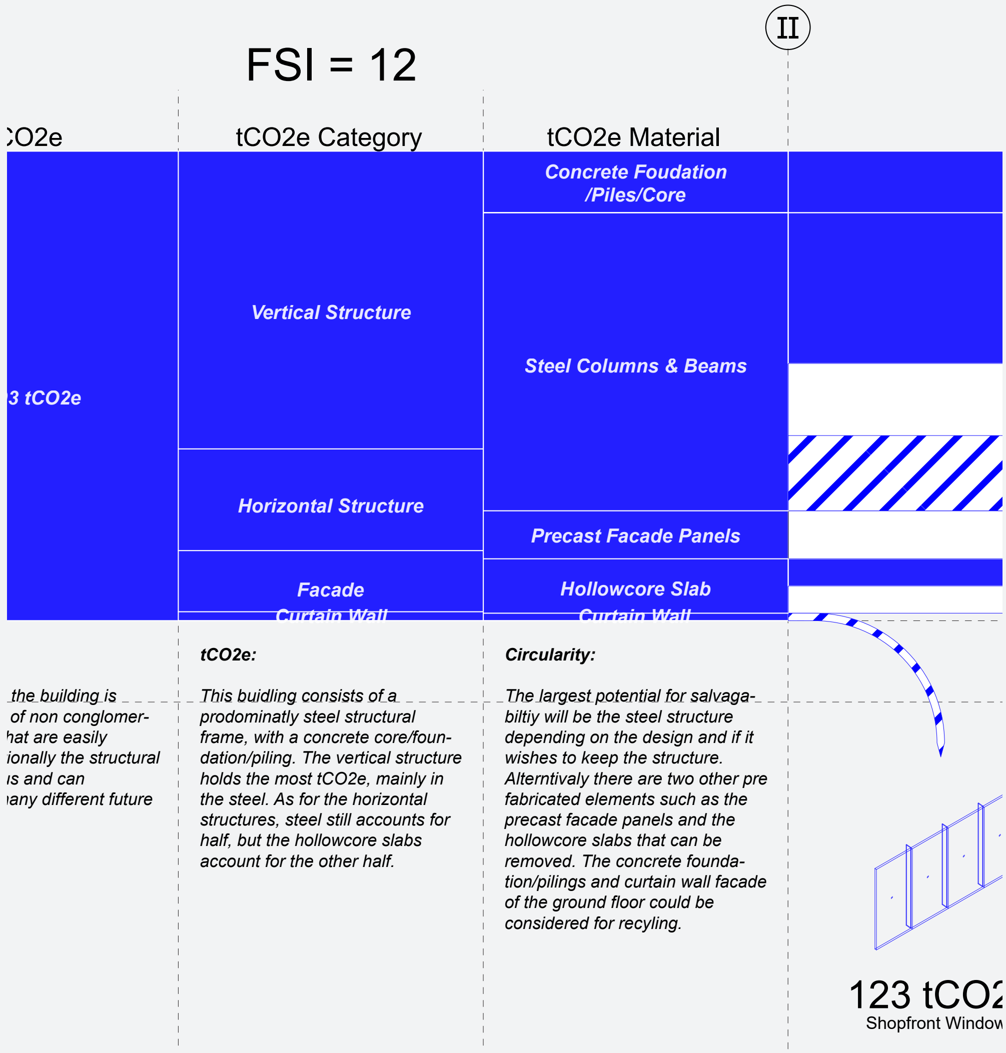
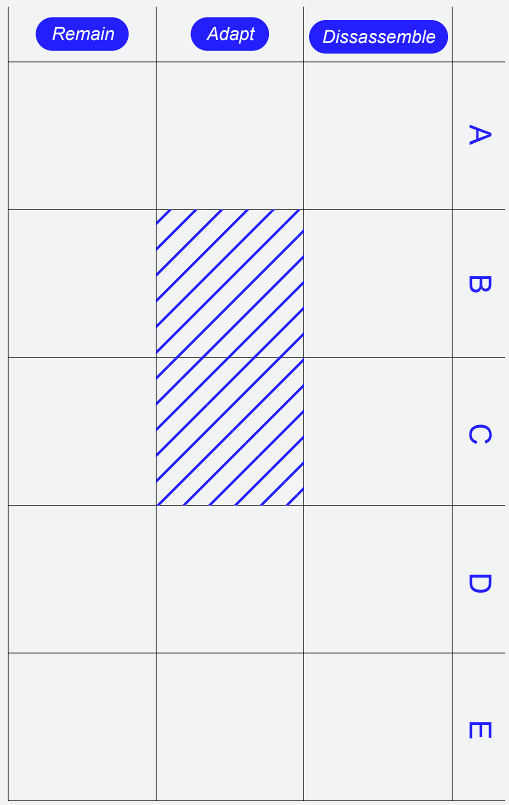


Figure 24 Steps 1-3, required by **Rule 1**, the adaptation, tCO2e, and Circularity Audit all form the observations required for criteria selection (figure shown on following page).



B. 1200 Bay is representative of a material and structural system from the modern era that has a high capability for adaptability. Since the structure is independent from the interior partitions, this building is highly flexible to change use value from office to other forms of development. It's facade systems is also relatively easy to remove for re-skinning of the building and with structural analysis further additions are capable of being added to the existing structure.

D. The yield of 1200 Bay is high as the materials are not conglomerate and the precast facade panels, the hollow-core slabs and the steel frame are easily salvageable. 60% of the embodied energy is located in the steel beams and columns which can be selectively removed.1

1. "One-Click LCA." *Binova*, Accessed September 15, 2020, https://www.oneclicklca.com/about-bionova-ltd/.

Figure 25 *Step 4, a typical criteria report required by **Rule 2**, the classification is denoted on the flow drawing with it's numerical number.*

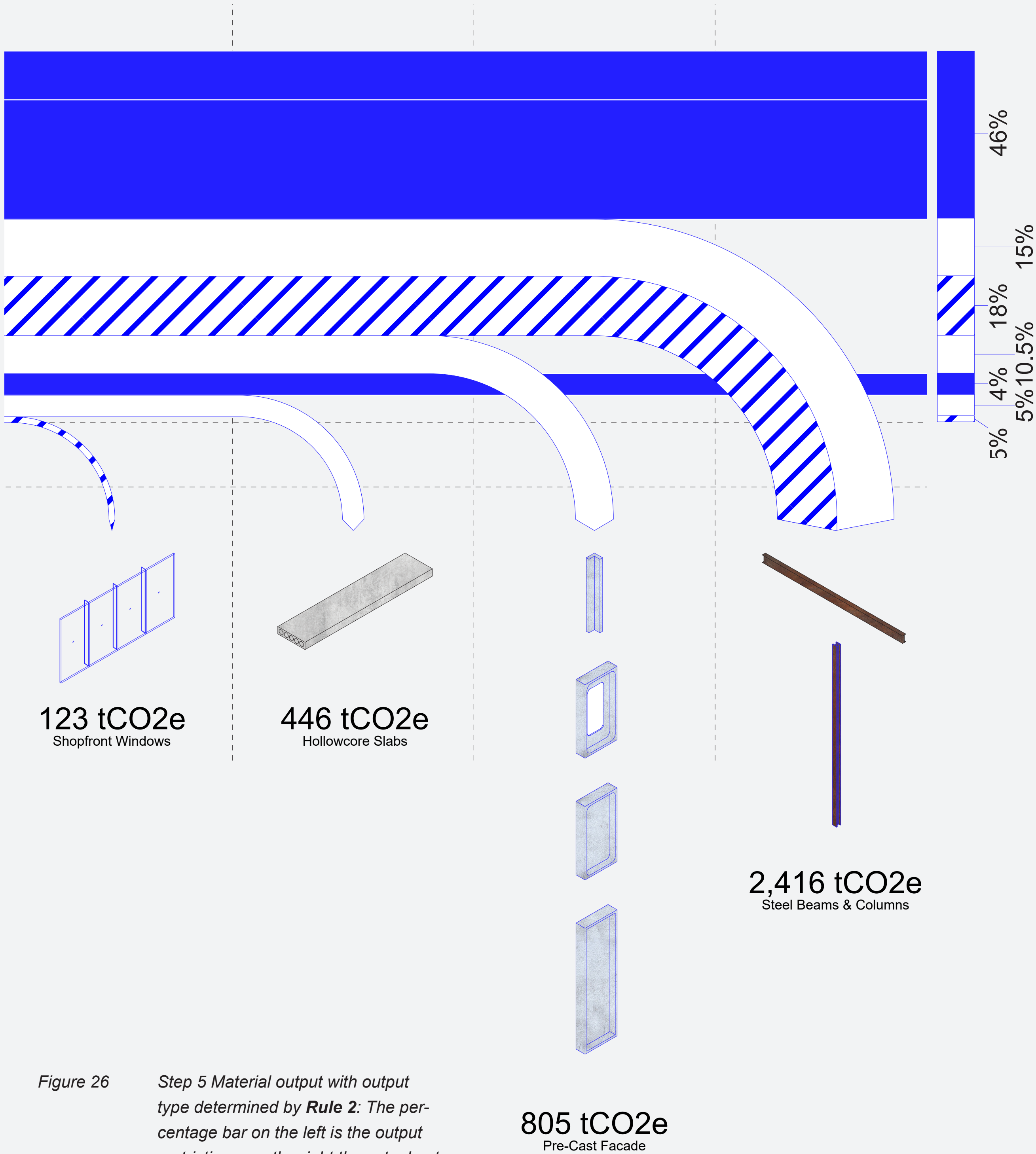
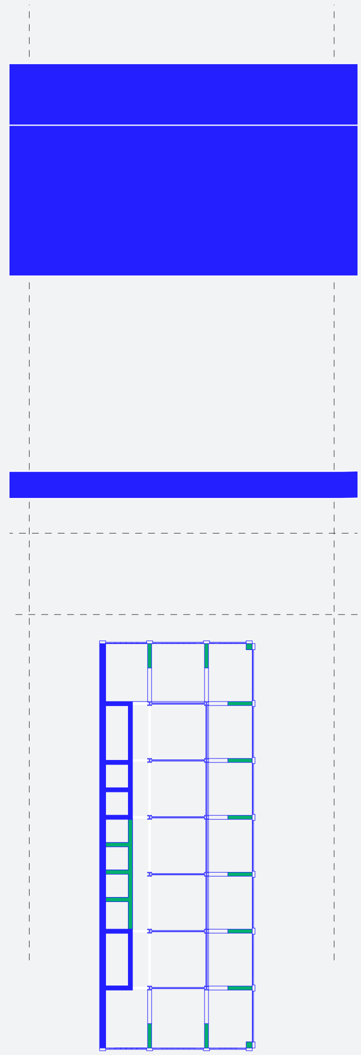
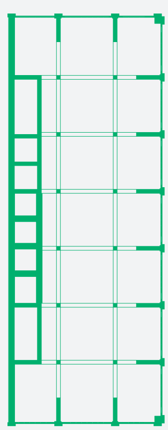


Figure 26 *Step 5 Material output with output type determined by* ***Rule 2****: The percentage bar on the left is the output restrictions, on the right the actual outputs achieved in this design meeting those restrictions.*



Levels 1-12



Levels 12-24

Figure 27 *Step 6 Remaining materials in future design set. Plans included for design understanding.*

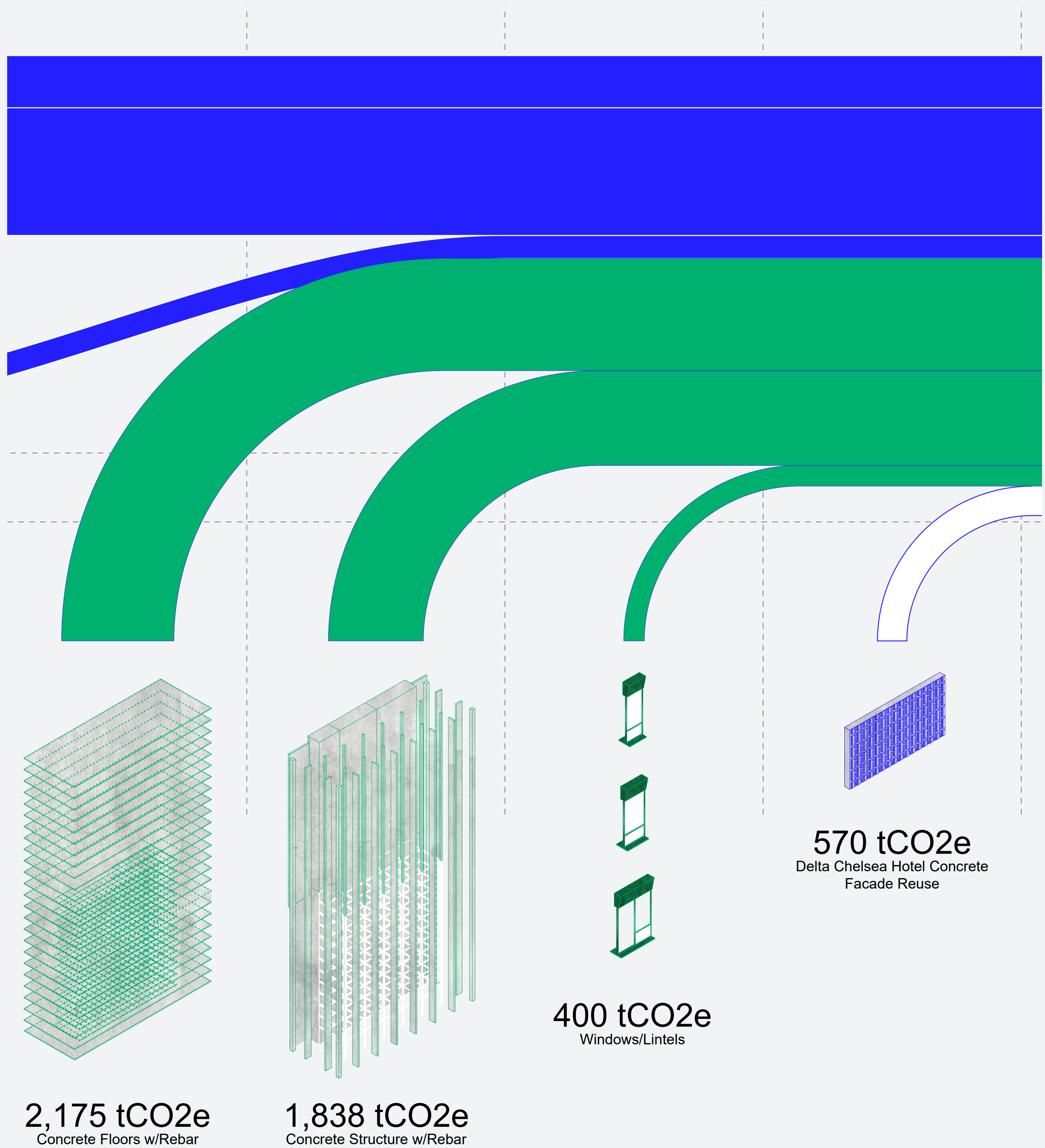


Figure 28 *Step 7 showing net material input required by **Rule 3**, virgin - green and recycled - blue hatch.*

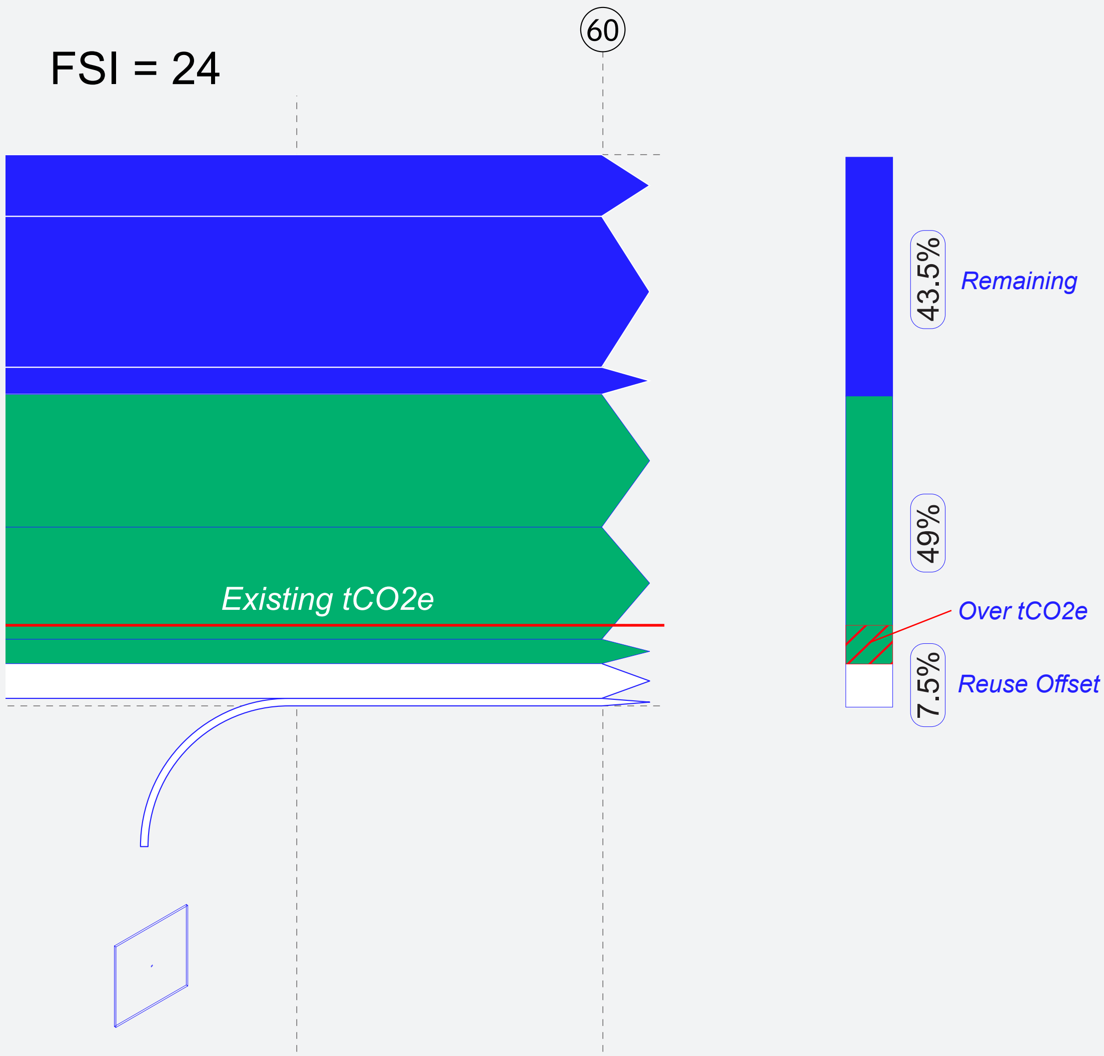


Figure 29 *Step 8 set by **Rule 4**, showing final tCO2e number as well as time restriction of Re-Amortization period. The percentage bar on the right indicates how thie desgin uses material reuse to meet those net embodied energy requiremnts of the Rule.*

03

3.1 - Materials as Agents

The Act itself is simple; however, it fundamentally transforms materials into active agents in the new circular economy. Before the industrial era, material reuse was one of the primary architectural practices. The extraction of new materials and their assembly was economically less viable, and considerable effort was put into the business of material reuse in their urban environments. For example, the Cordoba Mosque in Spain uses marble columns mined from the ruins of Roman buildings, brought them from Italy to Spain, and gave them a new structural function in the Mosque. However, in large capital cities such as Toronto that undergo significant material inputs for future infrastructure, urban mining is less economically viable, costing on average about 17–25 percent more than demolition and taking 2-10 times longer to complete the building.[1]

The Re-Amortization Act would incentivize cyclical processes of designing for deconstruction and would also create opportunities for necessary new building industries centered around reuse. The Re-Amortization Act matches the socio-political will of sustainable material practices with the technological and economic improvements needed to yield more materials from existing buildings. Other barriers aside from economic ones include changing the existing perception of used materials as unsuitable for structural or code reasons. These perceptions could be addressed through more inclusive engineering practices and building codes, like producing the research required to create safety standards for material reuse. When empirical data is gathered for each material case study, material reuse will no longer be considered a hazard but instead a calculated risk that is factored into building practice.

One of the other critical systems activated by The Act would be creating a network of caches of salvaged and recycled materials for de-

1. Mark Gorgolewski, *Resource Salvation: The Architecture of Reuse* (Hoboken, NJ: Blackwell, 2018), 50-51.

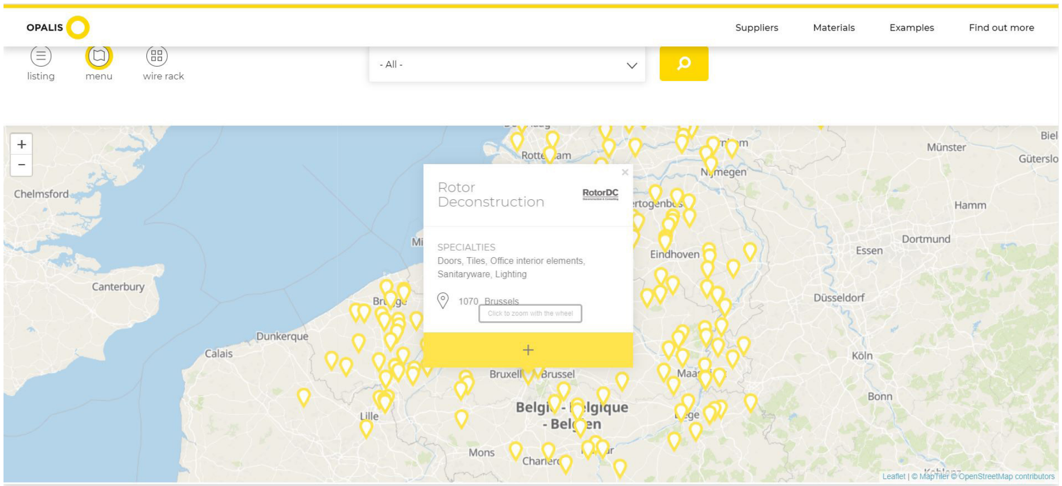


Figure 30 *Example of a salvage network that would cache materials, which is private but can be a part of a larger storage and distribution network for designers to access. (OPALIS, 2019)*

signers and developers to begin to incorporate materials. As one of the prominent Canadian material reuse advocates, Mark Gorgolewski remarks, “waste is sometimes described as material without information.”[2] By providing correct and current information, an existing material stands a better chance for future use. For this reason, The Re-Amortization Act, through the auditing and design processes, seeks to draw and describe this process of material inventorying and tagging.

Although the flow diagrams do not describe where the material is going specifically, this is another layer for further development that would help facilitate a better transition of disembodied materials. Things such as material logs, connection details, structural design, and deconstruction plans are vital for designers to understand both the practical capabilities and historical relevance of each material, enabling them to be brought back to their original regions successfully.

Reused materials from this city cache would have prices set by a government appraiser who would accurately account for the “replacement cost” in determining the fair value of the reused material. The replacement

2 *Ibid., 55-56*

cost factor would take into account an estimate of the new material's cost to replace at fair market value, subtracted from the depreciation of the lifespan & material quality.[3] This reuse cost would give a fairer market appraisal for designers to provide developers a noninflated cost for reused materials. Due to the Act, regulating the reuse market will be important to inflate the value of reused materials to a point where material reuse is considered economically inviable. Inevitably with the shift in the valuation of reused materials, the industries transitioning from demolition to decon-struction practices, such as Ken Kieswetter, will begin to play a prominent role in the circular economy alongside auditors, developers, and archi-tects. Of course, designers & architects will have a new set of constraints placed on them when designing but will work in coordination with these other systems for the sourcing and integration of material reuse in their projects. Instead of the limitless material frontiers that real estate works within, The Act gives existing materials agency, and in doing so, gives the field of design the creative endeavor of integrating material reuse into future projects.

3. Jessica Marschall, *Higher Deconstruction and Reuse Appraiser Standards - Why Internal Regulation Is Criti-cal* (Virgina: The Green Mission Inc, 2020), https://www.thegreenmissioninc.com/assets/deconstruction-and-re-use-appraiser-standards.pdf

3.2 - Deconstruction Technologies

Before jumping into the various emblematic precedents for each part of the act, this section will give a brief overview of the designs' technologies. They are by no means a representation of a kit of parts to be applied to any design. They are specific solutions that have risen from the material configurations that each precedent had. However the technologies give light to how important it is for architects to work and understand the limitations of how much reuse can come from an existing building. These deconstruction agents and other advisors such as engineers can verify the yield of reuse and the integrity of the existing material to maximize the amount of material reuse that is possible.

Chisel, Scraper, Drill, & Pry Bar - These are the tools used at the smaller scale application that are required for cleaning the material or dealing with lighter hardware and adhesives that have bonded materials together. For example materials binded with mortar such as brick and cinder block, need to have this binding agent removed from them so on their next application and have the same consistency when being applied for uniform layout.[1] Another example would be for the removal of a window frame and

1. Ajayabi Atta, REBUILD: Regenerative Buildings and Construction Systems for a Circular Economy (Bristol: IOP Publishing Ltd, 2019), 6-7.

Figure 31 Manuel removal of material is still by and large necessary (Rotor, 2018)

the hardware attaching it to the facade, where these smaller tools can help remove glazing more gently in order to exercise caution due to its fragility as a material.[2]

2. Kim Minjung, *Efficiency and Feasibility of the Disassembly Process for Curtain Wall Systems* (Delft: TU Delft, 2013), 28.

Figure 32 *Electric Hammer (Family Handyman, 2018)*

Reciprocating Saw - Similar to the punching method, the reciprocating saw is the go tool for window frame removal after hardware attaching it to the structure has been removed. However this tool is limited to dealing with window walls and punch windows and is inappropriate for curtain wall systems with permanent connection such as adhesives.[4]

4. Kim Minjung, *Efficiency and Feasibility of the Disassembly Process for Curtain Wall Systems* (Delft: TU Delft, 2013), 29.

Electric Hammer - This tool speeds up significantly the punching method of salvaging modular masonry units in comparison to manually removing with a chisel and hammer. For the punching method, the punch from the electric hammer bit hits through mortar joints and separates adjacent bricks. [3]

3. Ajayabi Atta, REBUILD: Regenerative Buildings and Construction Systems for a Circular Economy (Bristol: IOP Publishing Ltd, 2019), 6-7.

Figure 33 *Reciprocal saw (Family Handyman, 2019)*

Diamond Saw Cutting - For conglomerate materials such as veneered brick as well as cast in place concrete with re-bar, the saw cutting method is used, where a diamond blade runs along a defined track, giving a clean cut to a section of the material.[5] This method can be used for the purposes of subtracting materials for an adaptation purpose as well as modularizing cut materials for future salvage use. The only issue to be mindful of with saw cutting is that corner cuts cannot fully be completed without over cutting. This leaves visible cut lines that extend past the opening. As with all subtractive processes from existing structures, a structural analysis would have to be done before removing material with the saw.

5. Ajayabi Atta, REBUILD: Regenerative Buildings and Construction Systems for a Circular Economy (Bristol: IOP Publishing Ltd, 2019), 6-7.

Figure 34 *Wall sawing is one of the most effective ways to create openings during selective demolition. (True-Line Cut'n Core, 2020)*

Shot Blasting - Concrete that has had carpet or tiles applied to its surface will, once the applied material is removed, leave a residue of the adhesive that was used. One method that effectively removes any epoxies, mastics, paints, glues, plasters, or adhesives is shot blasting the floor. It does this by essentially propelling abrasive media onto the concrete through a rotating drum, sucking back up the stripped content to the hvac system.[6]

6. Joe Nasvik, *Polishing Concrete with Diamonds: Huge Potential for a Brand-New Industry* (Washington: Concrete Construction, 2002), 42-43.

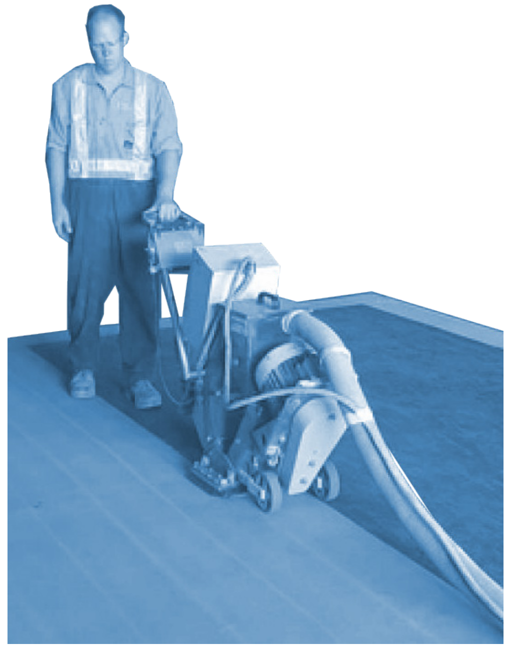


Figure 35 *Shot Blasting of the floor reduces manual removal. (SURFPREP, 2020)*

Figure 36 *Lateral bearing for precast facades. (CMHC, 2002)*

Prefabricated Facade Reuse - To understand the potential for the disassembly of prefabricated facade panels, an understanding of the connecting detail to the structure. Typically for each individual panel there will be a requirement for two gravity connections to take the load of the panel back to columns or the floor slab, as well as two seismic connections that can be incorporated with either the gravity or lateral ties.[7]

7. CMHC, *Architectural Precast Concrete Walls: Best Practice Guide* (Ottawa: Public Works and Government Services Canada, 2002), 19.

In order to salvage the precast facade panel it is simply a process of using cranes to support the removal of them from the facade and unbolting these four connections from the main structure. However, similar to steel bolted connections, the panel connections can also be corroded over time and a process of welding or other operations such as diamond sawing and weld cutting can be used.

Figure 37 *Steam wash for cleaning concrete. (Kaercher, 2020)*

Stain Removal & Re-Sealing - Natural to aging, stains on concrete can cause material deterioration when not maintained properly. There are many different types of stains such as iron rust, mildew, efflorescence and even graffiti and not all can be treated with the same method. For this thesis the simple process of steam cleaning and brushing are applied as it is the most common form of removing stains.[8] To ensure further longevity salvaged concrete such as cast in place or precast should be resealed after this process of cleaning with a sealer that repels the absorption of liquids from penetrating and damaging the material configuration.

8. Dodge Woodson, *Concrete Structures: Protection, Repair and Rehabilitation, 1st ed.* (Oxford: Butterworth-Heinemann, 2009), 85-86.

Oxy Acetylene Cutting Torch - Structural steel can have difficulties when unbolting the existing structure. This can be an occurrence of the ceasing of the bolts due to layers of paint seeping into the threaded joints as well as natural corrosion over time.[9] Which is why the process of Oxy Acetylene cutting allows for more time efficient cutting and delivers more structurally uncompromised lengths of steel for future reuse. It does this through a process that uses fuel gases (Acetylene) and oxygen to cut metal, where pure oxygen instead of air, increases flame temperature to a point where metal can be locally melted at room temperature.[10] The leftover pieces can be recycled and removed from the structure.

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9. Terri Boake, *Understanding Steel Design: An Architectural Design Manual* (Barcelona: Birkhauser, 2015) 220-223.
10. David Lide, *CRC Handbook of Chemistry and Physics, 101st ed.* (New York: CRC Press, 2020), 137.

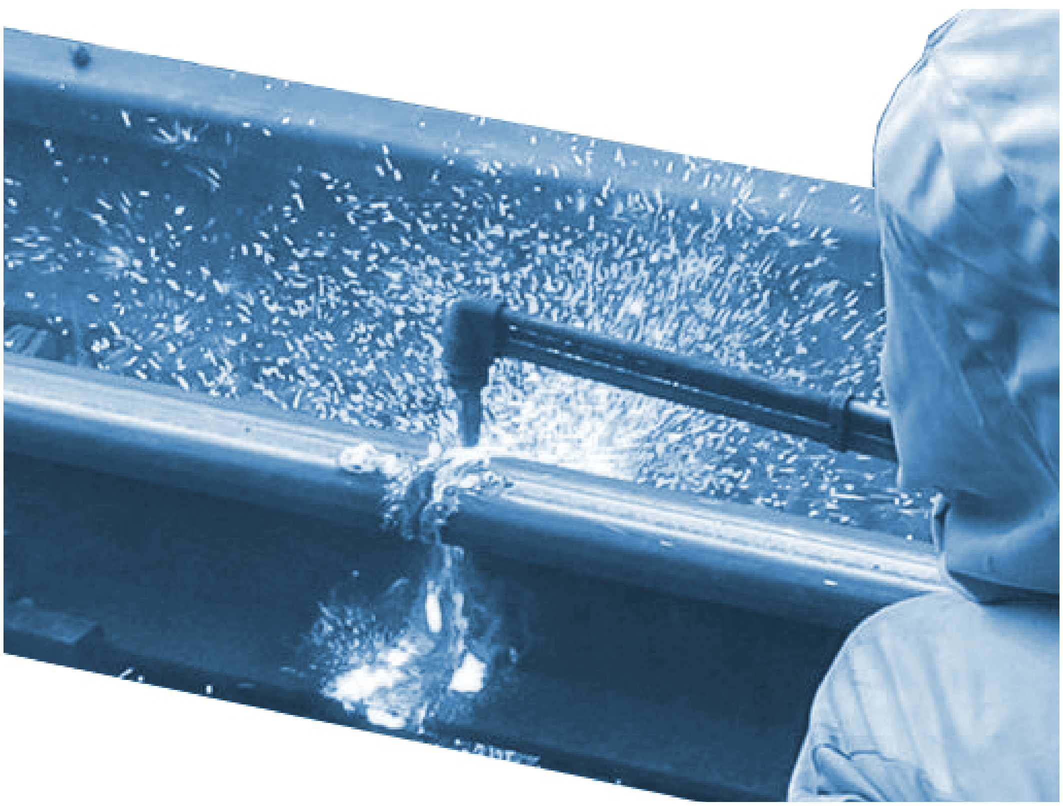


Figure 38 Example of Oxyl-fuel cutting through railway track steel sections. (Oxy-fuel cutting, 2020)

Figure 39 *Mini electric jaw crusher CR series is ideal for the recycling of aggregates from small demolitions. (CM Crusher Machines, 2020)*

Aggregate Crusher - The basic equipment used to process raw material aggregate is very similar to those used to crush, size and stockpile recycled aggregate.[11] For smaller scale applications where other materials such as reinforcing steel aren't involved, an on site aggregate crusher may be used. However a cautionary note for building in areas with high populations would be to set up dust collection screens in order to prevent particulate matter from causing public harm. For larger scale projects with concrete and re-bar, concrete should be taken to a larger crushing machine where metal can be crushed more effectively with the concrete and a series of more intricate sieves, sorting devices and screens can separate the two materials.[12]

11. Vivian Tam, "Recovery of Construction and Demolition Wastes," In Handbook of Recycling - State-of-the-Art for Practitioners, Analysts, and Scientists, edited by Worrel Ernst and Markus (Reuter Amsterdam: Elsevier Inc, 2014), 290.
12. *Ibid., 291.*

3.3 - Material Technologies

Recycled Brick Aggregate - The primary use of recycled aggregate is for infrastructural projects where a large quantity can be incorporated as a small percentage of reuse for very large projects. It is becoming clear that the potential for recycled aggregates such as brick for architectural designs is more likely to be incorporated into aesthetic elements as a recent study showed there was a decrease in compressive strength performance, although minor, when using recycled brick aggregate.[13] Granby Studios in the United Kingdom have created a product that emphasizes the recycled aggregate in a panelized form, resembling that of a terrazzo quality.[14] It would not be a stretch to see the implementation of recycled brick aggregate into precast facade elements as a viable alternative non-structural solution.

13. Paulo Cachim, "Mechanical Properties of Brick Aggregate Concrete." *Construction & Building Materials* 23, no. 3 (2015): 1295.

14. Assemble Architects*, Granby Rock Catalogue* (London: Assemble Architects, 2020). 3.

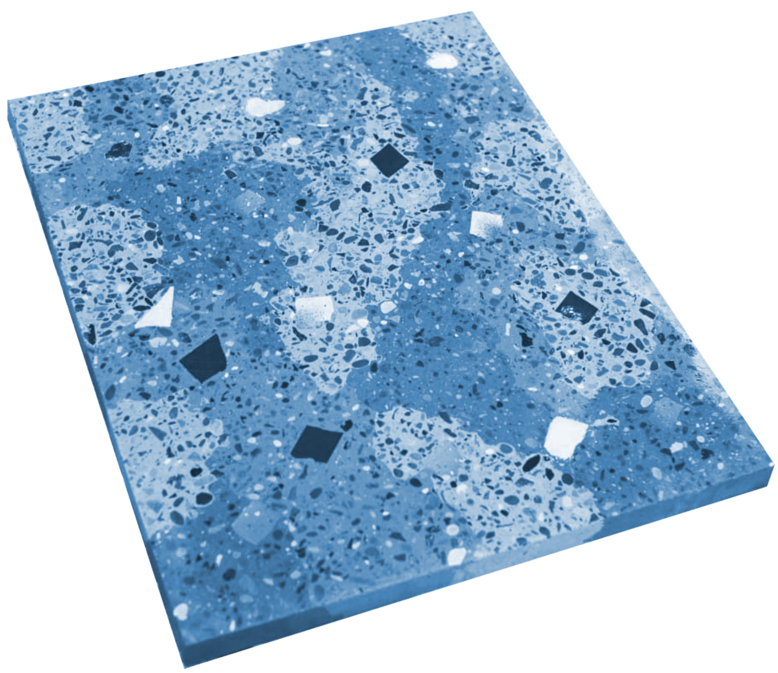


Figure 40 Example of Recycled building rubble product called Granby Rock. (Granby Workshop, 2020)

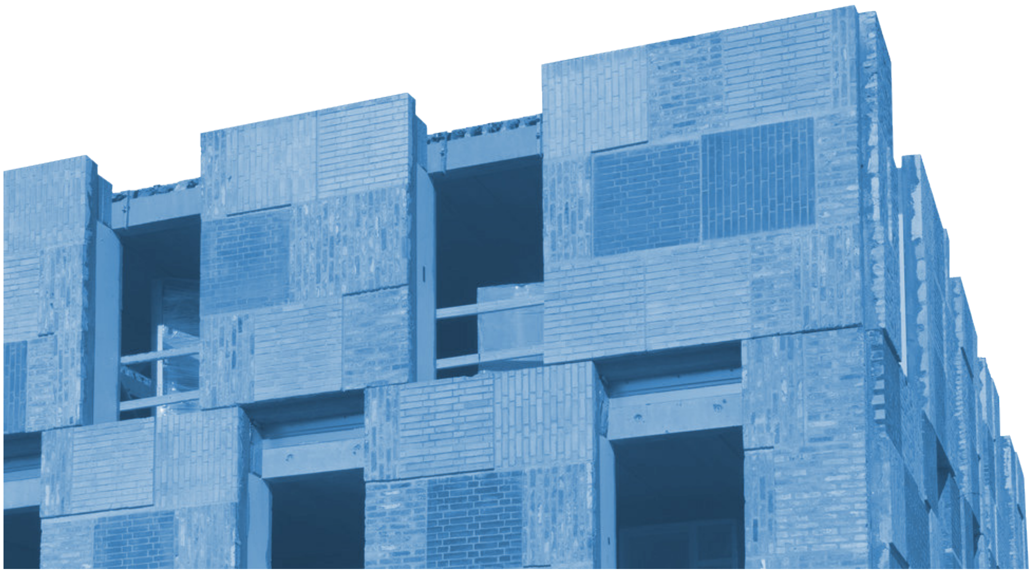


Figure 41 Example of conglomerate facade reuse. (Lendegar Group, 2018)

Facade Reuse - Using the Diamond Saw technology, conglomerate facades such as veneered brick and cast in place concrete can be cut to various modular sizes and attached to structures with bearing plates. Since this type of facade is already hardened cast in place concrete that has been set, post-installed anchors will be necessary to tie it back to the structure. This type of anchor is installed in a hole that is drilled in hardened and cured concrete. Two types of these anchors exists, the first being adhesive anchors which bond the anchor with an epoxy and these are able to reach high bond-stress values for facade application.[15] The second type is mechanical expansion anchors which are inserted into pre-made holes in the concrete, where the anchors expand and bear against the concrete surface.[16] These have less tensile strength than adhesive bonding and would have to be used with another bearing strategy.

15. "Concrete Anchor Bolt Design: Cast-In-Place Anchors vs Post-Installed Anchors." *Material Manufacturing Product Handling*, Next Level, last modified: April 28, 2017, https://nextlevelstorage.com/2017/04/concrete-anchor-bolt-design-cast-in-place-anchors-vs-post-installed-anchors/.
16. *Ibid.*

Engineered Wood Products - Being widely adopted in the building industry for their low embodied energy and aesthetic quality, cross laminated timber (CLT) and glue laminated (Glulam) are great substitutes for steel and concrete structures. In adaptation, they are excellent substitutes for additive structures on top of existing structures as they are lighter weight and add less load. In time the incorporation of the carbon sequestering qualities of mass timber will be incorporated into environmental product decelerations (EPD's), but for this thesis those embodied energy effects were not taken into account by the LCA program used.[17] In a future where building code will allow mass timber able to be used in taller structures this material will be one of the standards for reaching net zero embodied energy.

17. Tall Wood Institute, *Cross Laminated Timer Info Sheets* (Oregon: Tall Wood Institute, 2019) 11-14.

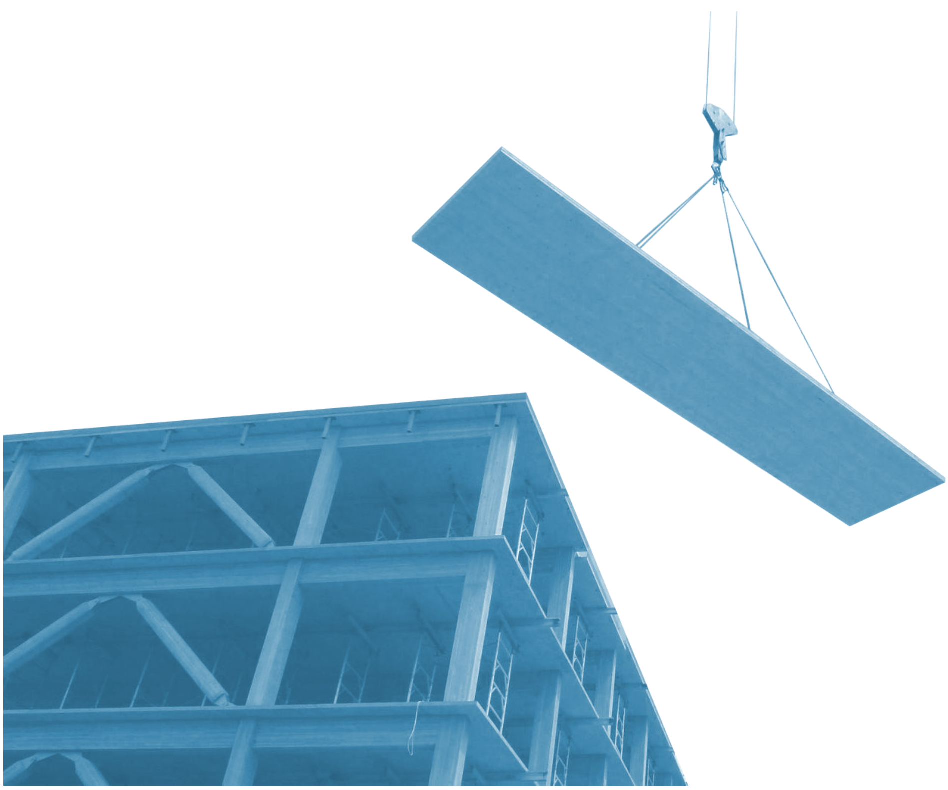


Figure 42 Example of Mass Timber Construction. (Structurelam, 2020)

3.4 - Design Implementation

This thesis has taken six cases from three different buildings to illustrate the Act. They represent a range of restrictions from the most extreme in terms of material output restrictions and the most extreme material reuse to reach net embodied energy to the least for both. The gradient of these six designs shown in this section will illustrate the creative solutions that the Act produces. The use of the building is typically either office or residential to focus on the material application and not major programmatic driven design solutions.

Each case will start by stating the design and technological strategies used, followed by a text describing its implementation. Next to the descriptions are a series of sketches intended to describe the project's three phases. The first is the existing state, largely for reference, the second showcasing the deconstruction methods and technology. Finally, the last will represent the major material reuse inclusions such as recycling and up-cycling. Additionally, there will be warning markers for processes that would require more professional judgment, such as structural and public safety concerns.

Following the set of images will be a flow diagram that will describe the classification audit text, the classification, and the output and input rules described in the insert from Chapter 2. Above the flow diagram in the same sequence as the images, it will go from the existing site to the final proposal annotating the flow of energy and using colour to denote existing materials, salvage, recycling, and new virgin material.

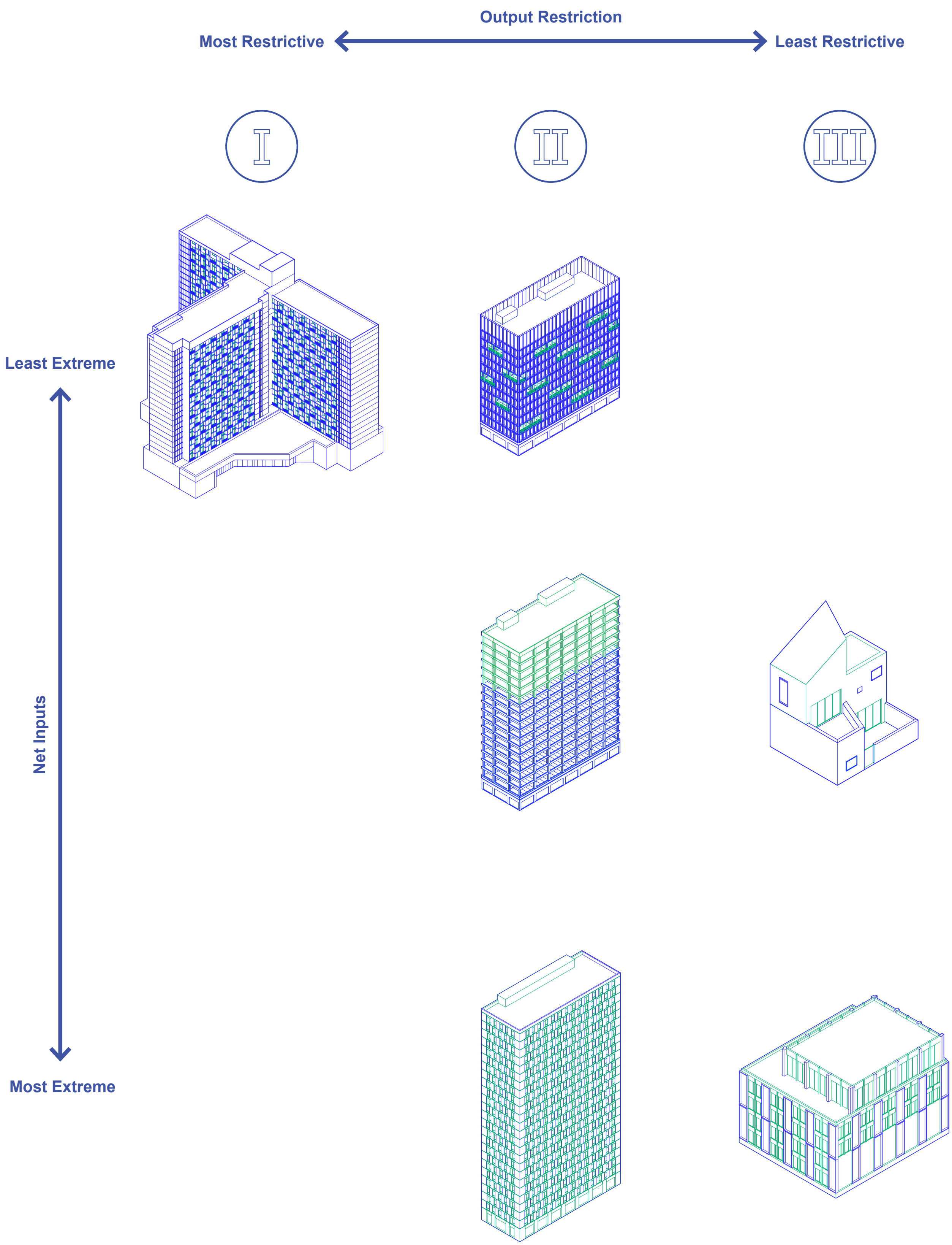
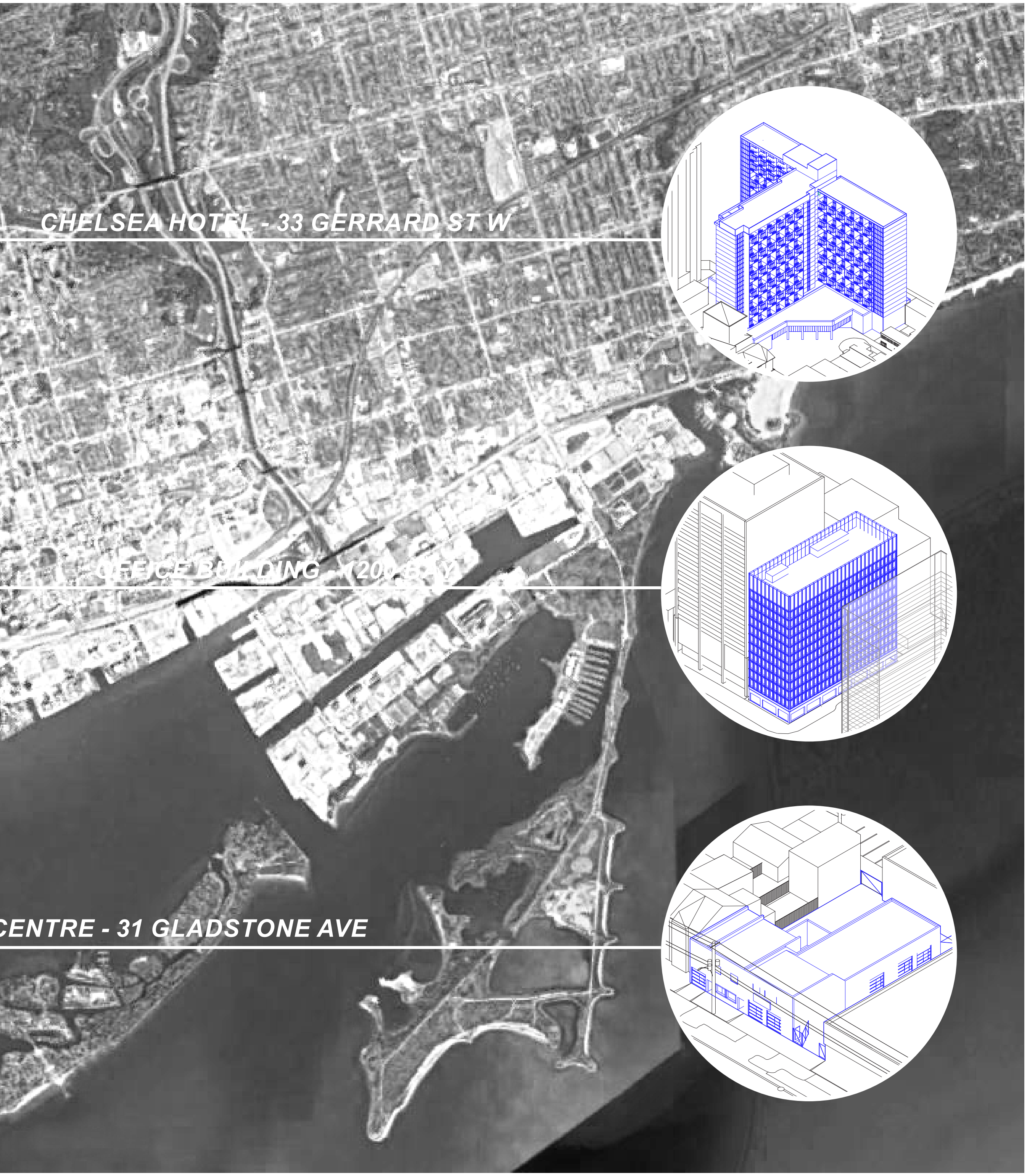

Output Restriction
Most Restrictive
Least Restrictive
I
II
III
Least Extreme
Net Inputs
Most Extreme

Figure 43 Project Locations (Google Maps, 2021)


CHELSEA HOTEL - 33 GERRARD ST W
OFFICE BUILDING - 1200 BAY
CENTRE - 31 GLADSTONE AVE

The Chelsea Hotel was originally designed by Crang and Boake architects in 1975 to become an apartment building with a hostel meant for the University of Ryerson students.[1] Shaped in a “T” bar configuration, its robust construction and modernist form are evocative of Le Corbusier’s mass housing projects and are emblematic of many other housing towers of that era in Toronto. Instead of keeping its original intended use, it was converted into a hotel in 1990 with a further southern wing addition of 600 rooms, thus completing the “T” shape. The deep blocks created over 1,590 units, all of which are all single aspect, making for poorly lit and naturally ventilated units. It towers over its context, standing at 26 stories at its highest point and having an FSI of 9.3. 95% of the building’s embodied energy (tCO2e) is found in the reinforced cast-in-place concrete structure that makes up the floors and walls. Mostly the concrete is just a superstructure without any discerning architectural features. However, there is articulation on the concrete formwork in certain Hotel wings. The building’s other distinguishing features are the picket metal railings and the window wall that encloses each unit. Currently, the Chelsea hotel has not been accepted for Heritage designation and is set to be fully demolished to make way for four towers that will fill the site, the tallest of which will be 84 stories high and an FSI of 18.45, almost double the current density.[2]

1. “Heritage Impact Assessment: Gerrard Street West,” *Architects Alliance*, ERA Architects, last modified: October 1, 2015, http://app.toronto.ca/AIC/index.do.
2. “Chelsea Green - Architectural Plans,” *Toronto: Planning & Development*, Architects Alliance, last modified December 4, 2018, http://app.toronto.ca/AIC/index.do.

Figure 44 Delta Chelsea Hotel (Globe and Mail, 2019)

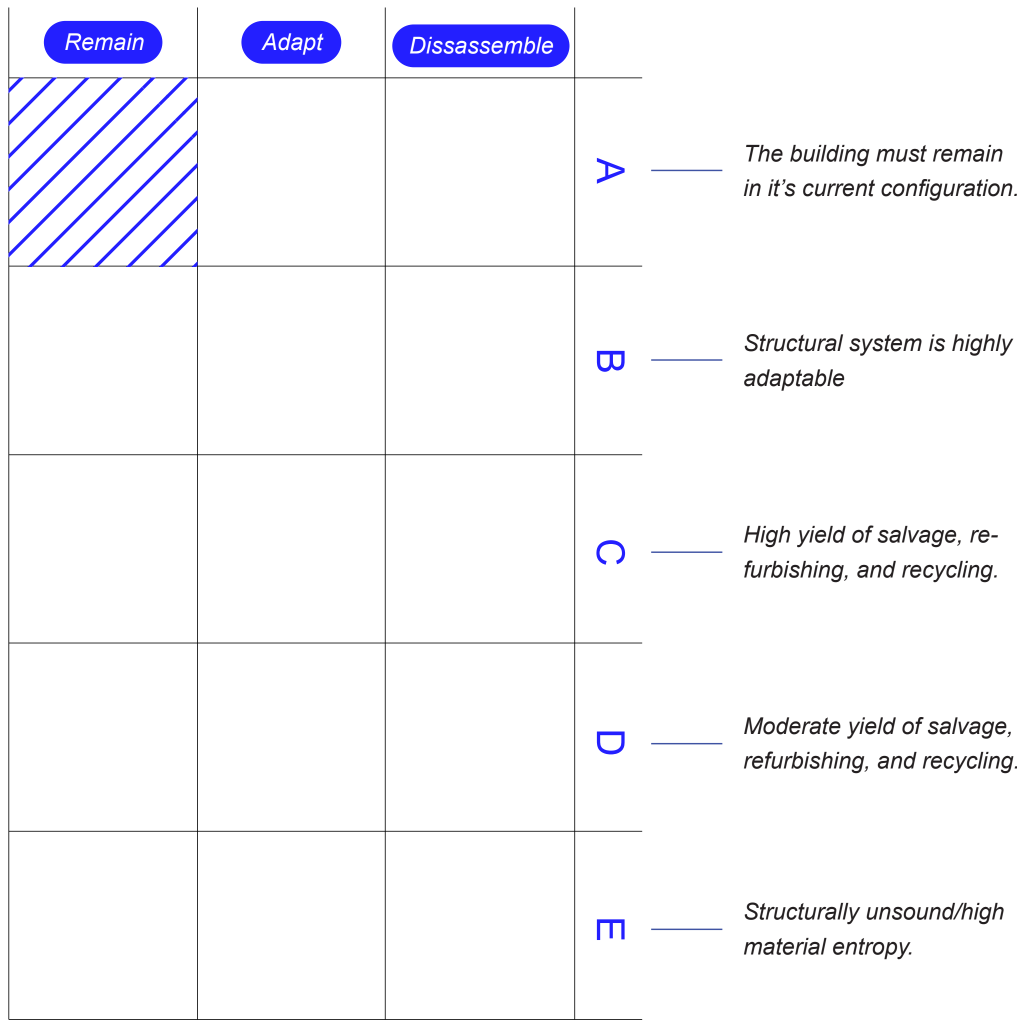


Figure 45 Chelsea Hotel Selected Criteria

A. The Chelsea Hotel represents a building where the material de-configuration would cause high energetic differential between material recovery rates and formation energy because of the conglomerate nature of the cast in place concrete structure which makes it only applicable for aggregate recycling. 95% of the building's embodied energy is in the concrete slabs, structure and foundation. Since this building is only 45 years old, it's structure is still fully functioning, for a renewed lifespan, and must value the massive amount of energy invested in the building.[1]

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1. "One-Click LCA." *Binova*, last modified: September 15, 2020, https://www.oneclicklca.com/about-biono-va-ltd/.

Remain (I) - Case A

Design Strategies - Subtraction, Infill
Technology - Diamond Saw, Manual methods, Shot Blasting

The Chelsea hotel's true identity comes from its modernist superstructure grid, and this design seeks to retain that as much as possible. Processes of subtraction and infill were used in adapting this building back to its original use, that of student accommodation, and creates a generosity in its interior space that is ideal for live and work environments that are becoming more necessary in a Covid world. In particular, this design seeks to address the single aspect issues of ventilation and daylight by subtraction processes, which are limited to only 20% of the existing embodied energy under Act 1 (see figure 50).

The design combines four hotel units into two-bedroom live-work units by subtracting both walls and floors. Cleaning the floors from the residual glue from the carpet is done by using shot blasting technology. Still visible in each unit will be the processes of this subtraction as the Diamond saw will run past the opening to allow for a clean cut leaving for the aggregate in the concrete to be visible and expose a portion of the re-bar. Structural capabilities will have to be reviewed in tandem with the design to ensure that the subtractive process keeps an appropriate ratio between openings and load transfers.

The infill will be used on the double-height space to add a more thermally efficient facade made from recycled concrete blocks with an aluminum cladding on the exterior and add more area to the unit. Using the strategies of subtraction and infill, this project meets the allowed embodied energy required and significantly heightens the quality of space that the existing building had.

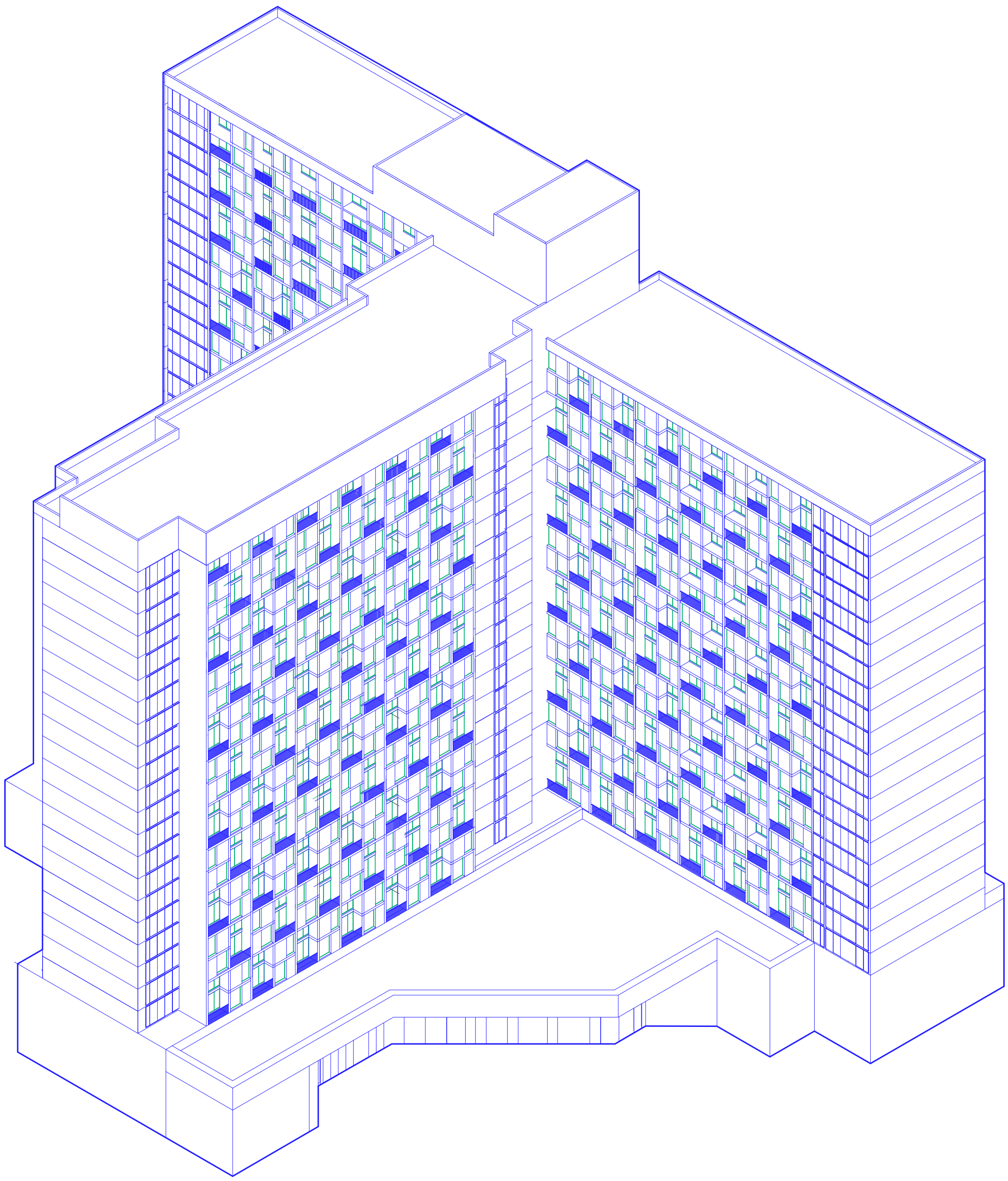

Figure 46 I - A future design (Self Authored)

Figure 47 I-A Existing Material Configuration

1. Removal of interior fittings such as carpet, and drywall. Residual adhesives will be left on carpet.

Figure 48 I-A Material De-configuration

1. Floor slab cut to create double height space using diamond saw cutting. Rebar will be exposed and portion of slab will protrude due to cutting tolerances.
*2. Load bearing wall to be cut, with cut lines running past opening for clean cuts. *Warning* load bearing wall must be studied by structural engineer to ensure they are capable of keeping structural properties with the amount of subtraction from the new design.*
3. Metal picket fence to be cut using reciprocating saw and unbolting top mount from slab.
4. Floor slab to be cleaned of adhesives from carpet with shot blasting technology.

Figure 49 I-A Future Material Configuration

1. Infill recycled CMU wall with new triple glazed windows.
2. Wooden flooring and fixtures to level height difference from diamond cutting processes.

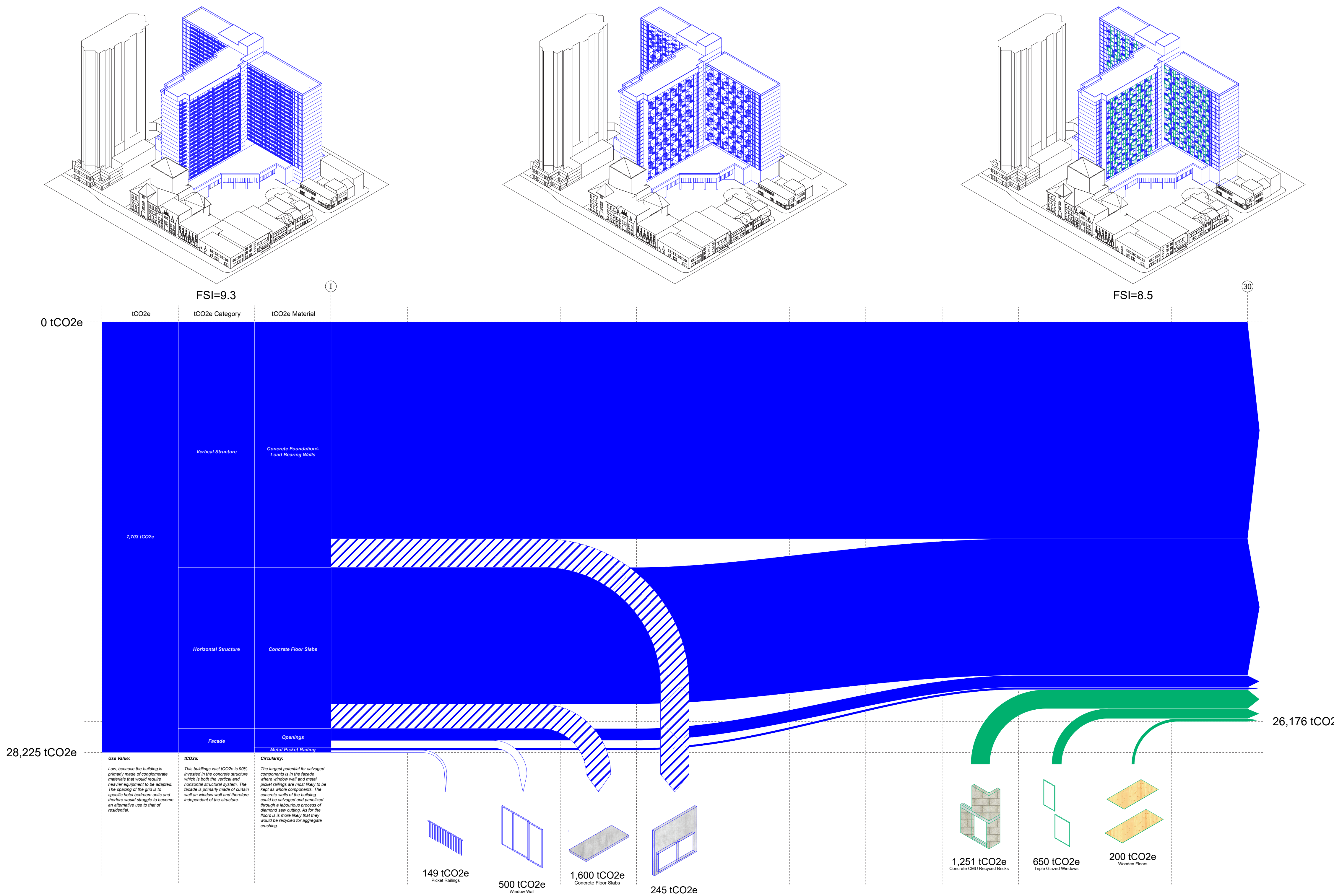

Figure 50 *I-A Flow Diagram*

II - 1200 Bay Street Office

1200 Bay Street was designed by B+H Architects and built-in 1968.[1] The 12 story building is rectangular in mass and consists of commercial retail at grade and 11 stories of office space, with a double-height mechanical space at the penthouse level. It currently sits modestly in its context, having an FSI of 11 due to the lot's constrained dimensions. 60% of the building's embodied energy (tCO2e) is found in the steel structure. Noteworthy on this building is the precast facade with recessed rounded corner windows emblematic of the era. Similarly, the mechanical penthouse and the back alley have precast facade panels without rounded windows but elegant recessed detail. The corner detail also offers a standardized concrete "L" profile that runs along the edge of all four corners of the building. Given the multiple modules of fenestration on this building and the steel structure, this building offers a unique opportunity for reuse. Currently, 1200 Bay is not protected under Heritage designation. It will be fully demolished to make way for an 87 story residential tower, the tallest tower in Toronto if approved, giving it an FSI of 61.67, roughly 9x its original density.[2]

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1. "1200 Bay Street Heritage Impact Assessment," *Kroonenberg Toronto B.B.*, ERA Architects, last modified: June 3, 2020, http://app.toronto.ca/AIC/index.do.
2. "1200 Bay Street - Architectural Drawings." *ProWinko Canada Ltd*, Quadrangle, last modified: June 3, 2020, http://app.toronto.ca/AIC/do.

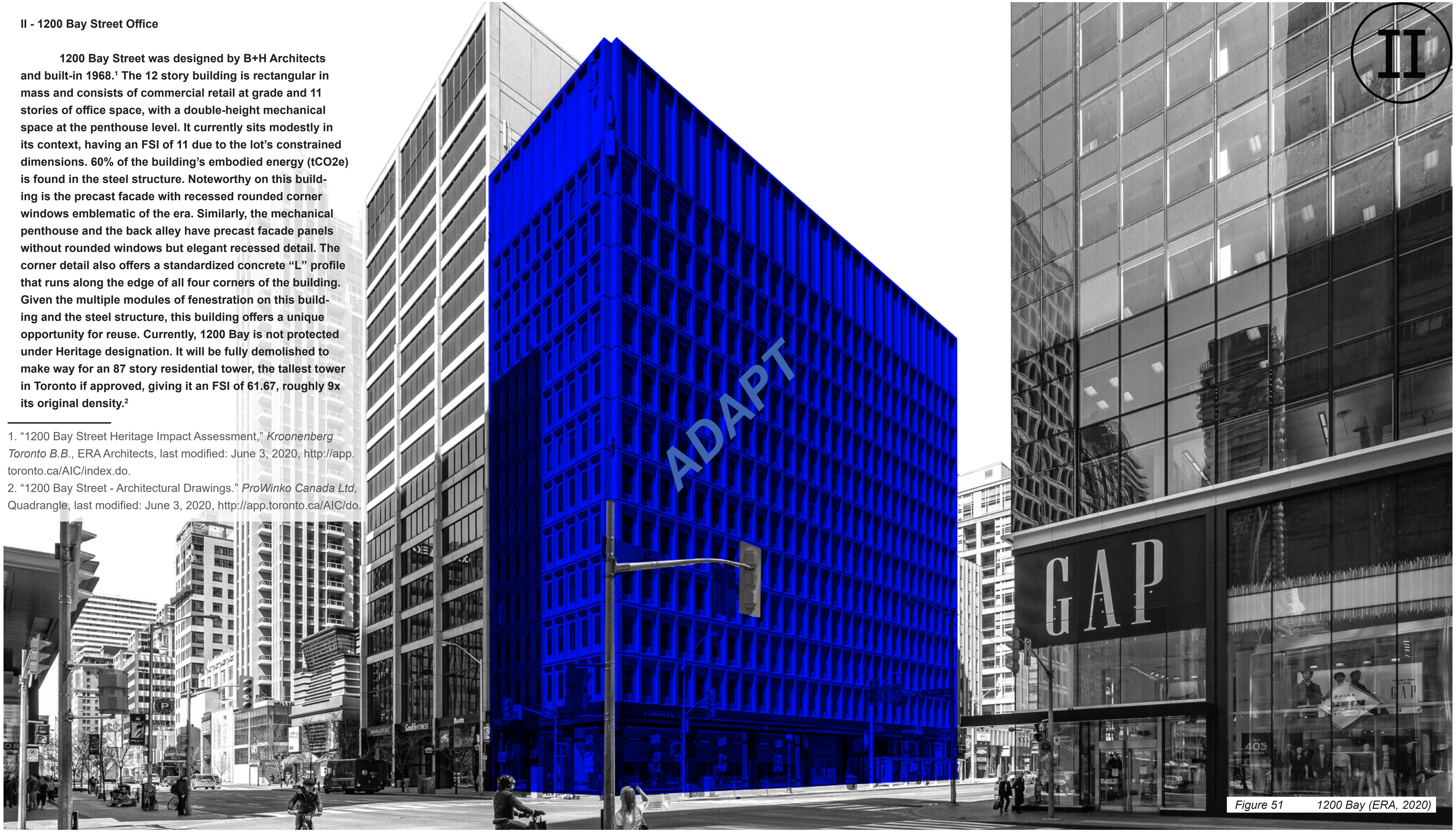


Figure 51 *1200 Bay (ERA, 2020)*

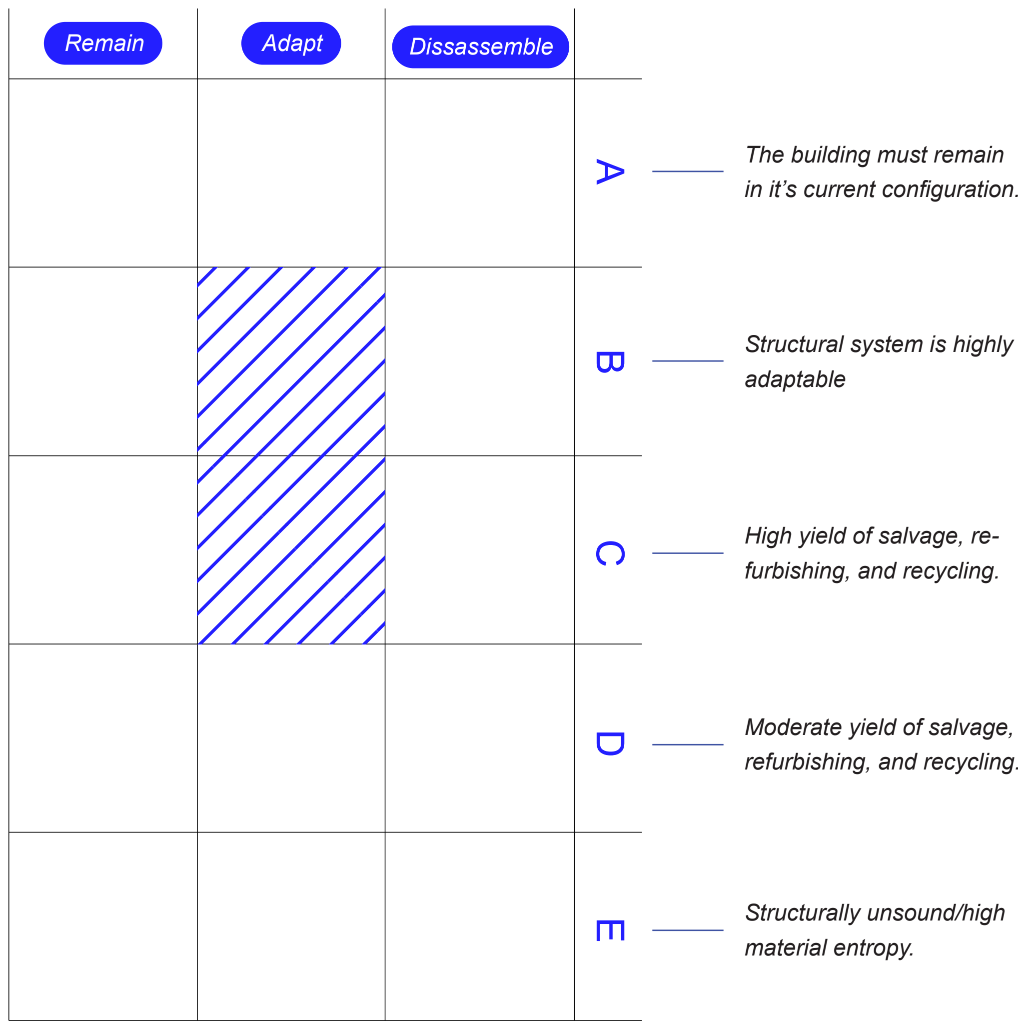


Figure 52 1200 Bay Selected Criteria

B. 1200 Bay represents a material and structural system from the modern era that has a high capability for adaptability. Since the structure is independent of the interior partitions, this building is highly flexible to change use-value from office to other development forms. Its facade systems are also relatively easy to remove for re-skinning of the building, and with structural analysis, further additions are capable of being added to the existing structure.

C. The yield of 1200 Bay is high as the materials are not conglomerate, and the precast facade panels, the hollow-core slabs, and the steel frame are easily salvageable. 60% of the embodied energy is located in the steel beams and columns, which can be selectively removed.[1]

1. "One-Click LCA," *Binova*, last modified: September 15, 2020, https://www.oneclicklca.com/about-bionova-ltd/.

Adapt (II) - Case A

Design Strategies - Subtraction, Renovation, Up-cycling
Technologies - Prefabricated Facade Removal

Working with the original building's modular grid, this design is the least intrusive of the set. Since it removes such a small amount of material, and only introduces a small amount, it is well within it's net embodied energy requirements. It introduces only new material with no material reuse into the future design as shown by it's flow diagram (figure 57).

The design seeks to renovate the building to improve the lack of accessibility to the outside for the users. Precast panels are subtracted from the steel structure by removing the four bearing connections required for each panel starting with the bottom non load bearing connection. This is all done while being lifted by a crane which will support the panel until it's load becomes independent from the structure. The sealants between each precast panel is scraped off using a scraper and each precast facade panel is taken off site to the third party warehouse.

A glass wall is designed behind where the removed precast panels were, leaving a clean surround designed with picket railings inbetween. The existing steel structure, now exposed, has to be fireproofed for exterior conditions.

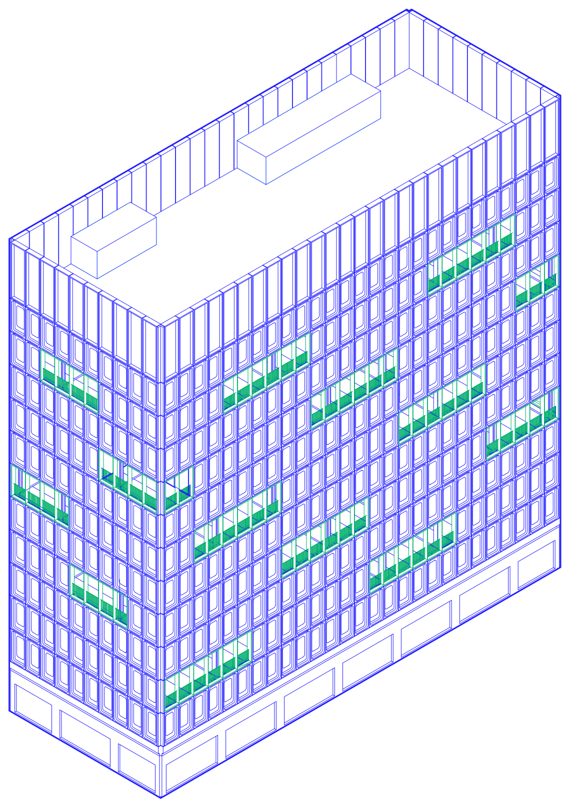


Figure 53 II - A future design (Self Authored)

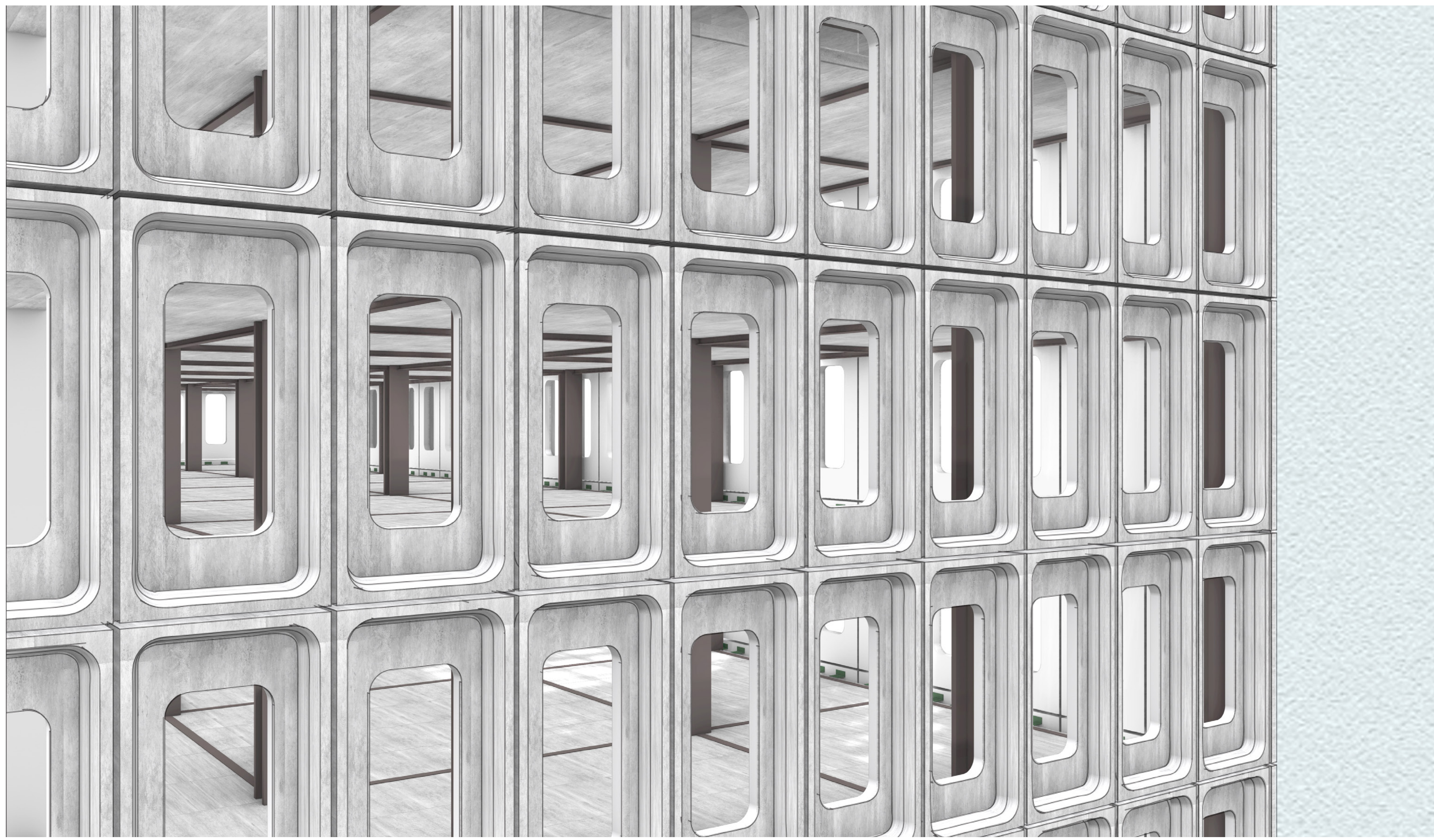


Figure 54 II-A Existing Material Configuration

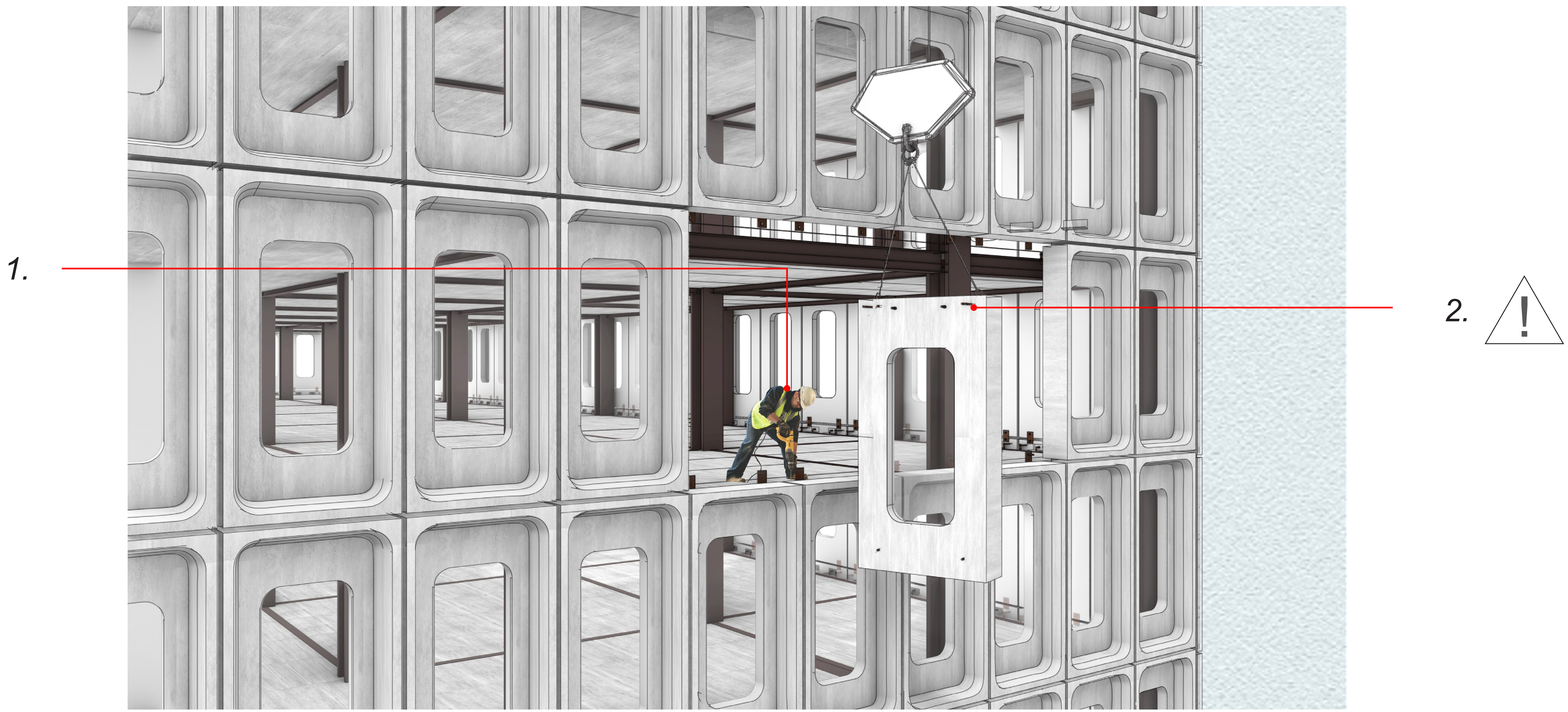


Figure 55 II-A Material De-configuration

1. Removal of bearing connection with deep-well socket drive attached to impact drive drill (hammer drill).
*2. In tandem with bearing connection removal, support with crane ties will be necessary for safety. *Warning* Important for structural to test a panels for structural integrity with age. Extremely dangerous for precast material to break under stress and endanger the street level below.*

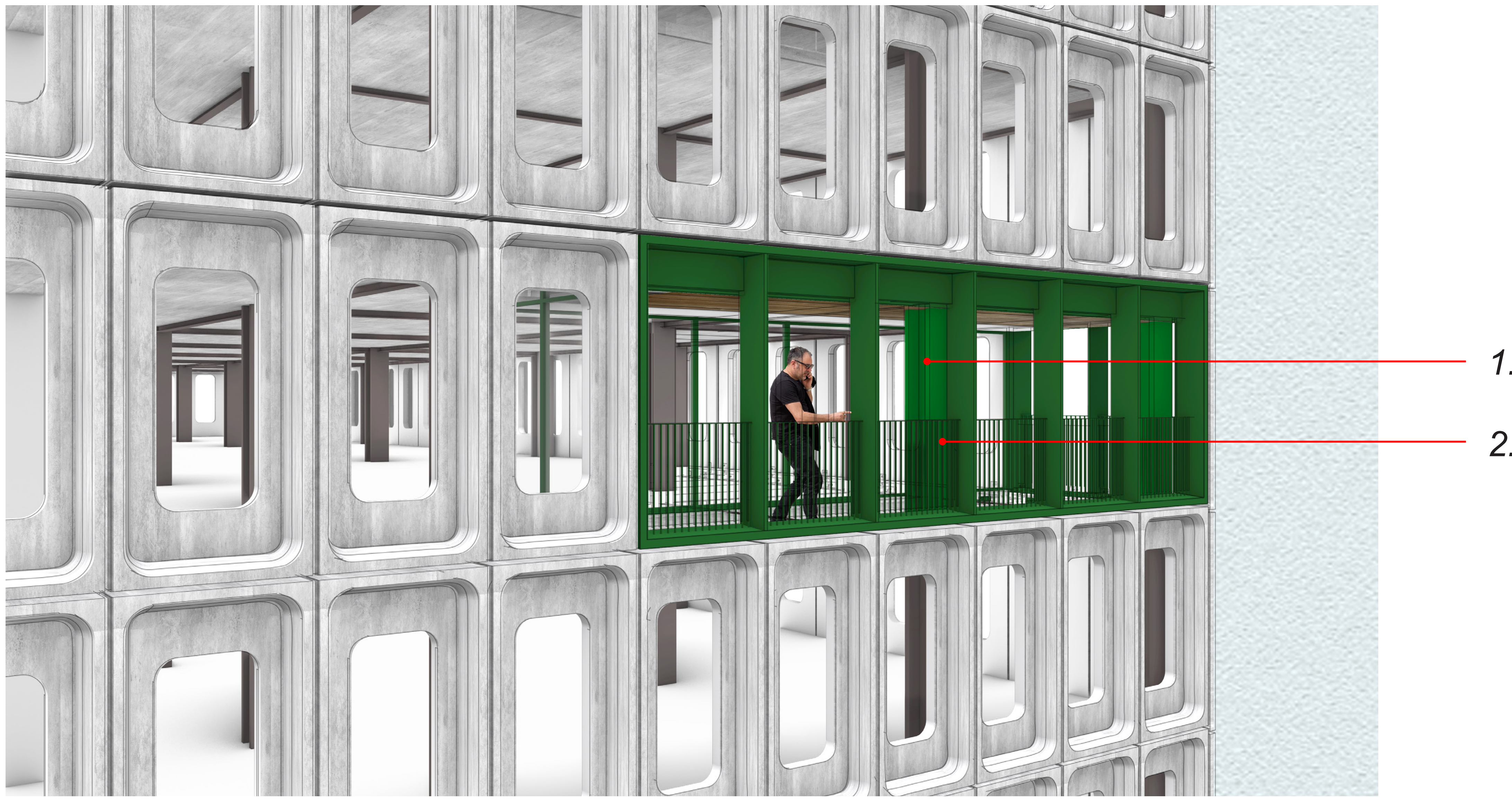


Figure 56 II-A Existing Material Configuration

1. Fireproofing of steel for exterior application necessary as steel becomes exposed.
2. Reuse of Chelsea Hotel picket balconies, cut and re-welded to new size.

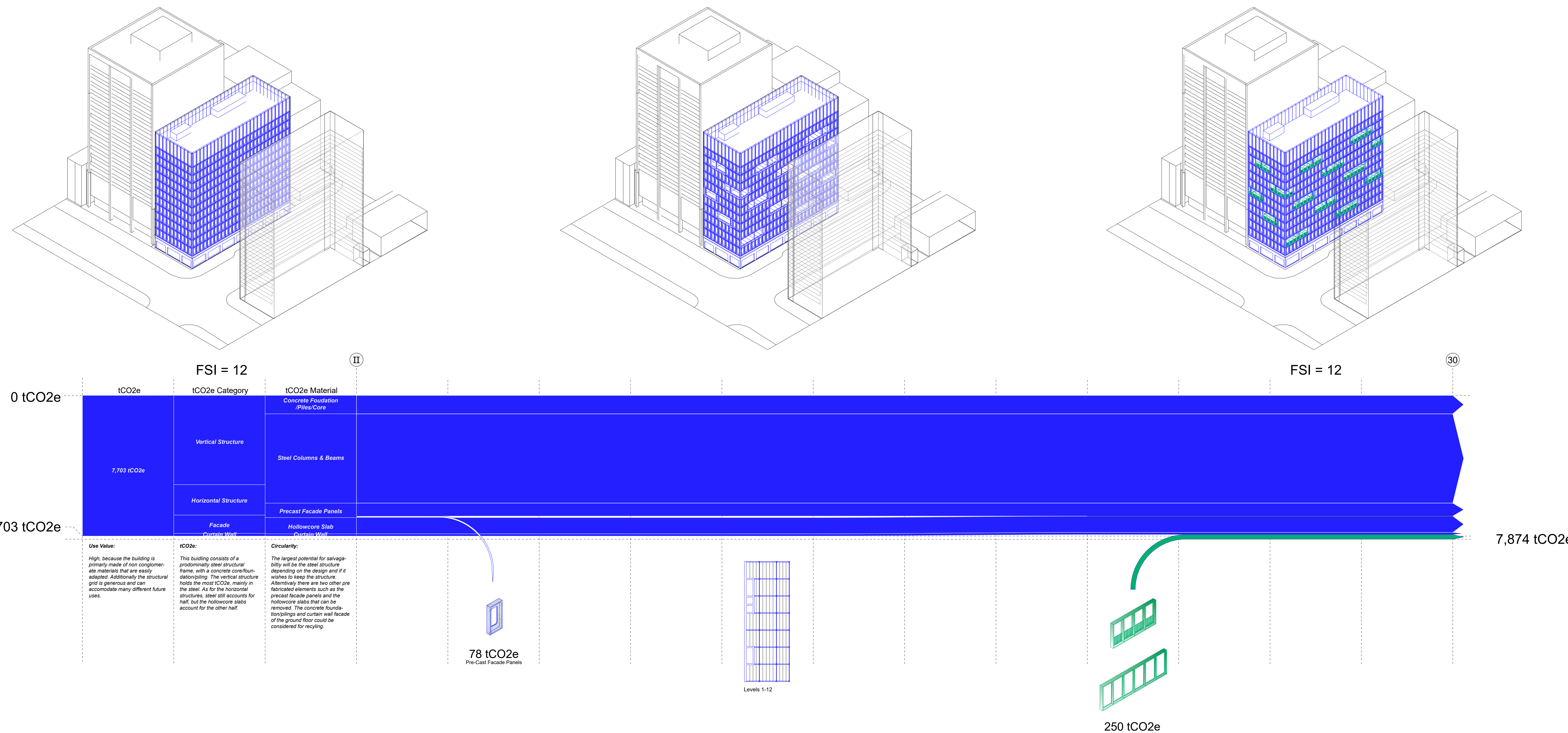


Figure 57 II-A Flow Diagram

Adapt (II) - Case B

Design Strategies - Addition, Redesign, & Recycling
Technologies - Prefabricated Facade Removal, Mass Timber, & Recycled Aggregate Facade

This design is a moderate example of the set. Its main objective is to increase density as much as possible while retaining the majority of the existing structure, where the most carbon is in the building. As seen in the flow diagram for this design (figure 62), this design achieves a significant new density while keeping a substantial amount of the existing building.

Similar to the previous example, precast panels are fully removed and salvaged from the existing building leaving only the steel structure and hollow-core slabs. A small amount of steel and hollow-core slabs are removed to include another elevator in the core for an increase in occupancy as well as removing two of the top floors in order to reduce structural load (CLT has a weight-bearing load of 5KN/m3 versus hollow-core concrete which has 19 KN/m3). On top of the steel structure on the 11th floor, the addition of a further six stories will be added made of CLT to reduce the amount of load. This addition of CLT would need to be reviewed by engineers to understand the reasonable amount of additional stories; for this example, assumed six stories.

The new design will be a full re-cladding of the existing and addition with recycled concrete aggregate precast facade panels, which have a varying thickness in terms of vertical and horizontal elements to give more articulation to the facade. Visible in these precast facade panels will be a terrazzo-like quality made of Toronto's eclectic masonry stock from other demolitions such as brick, concrete, and tile.

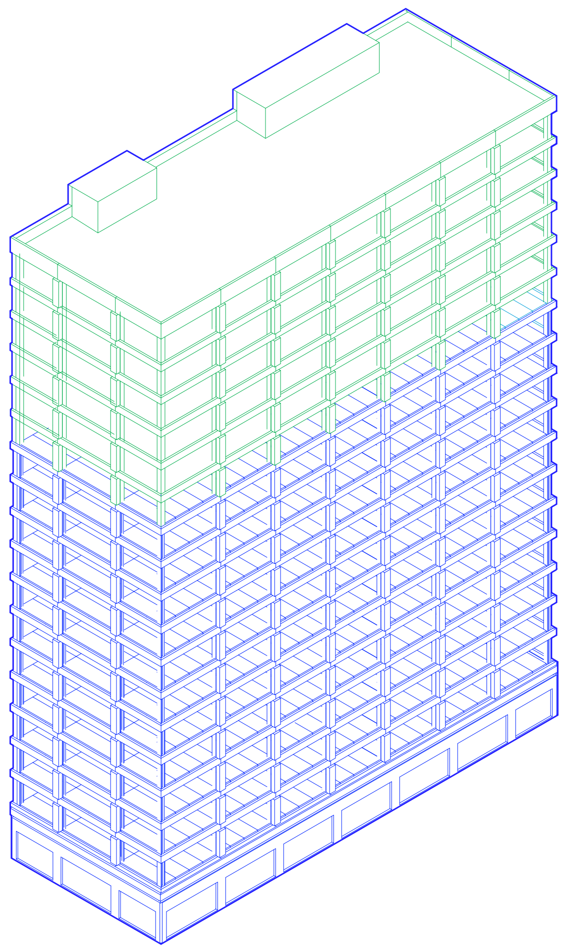


Figure 58 II - B future design (Self Authored)

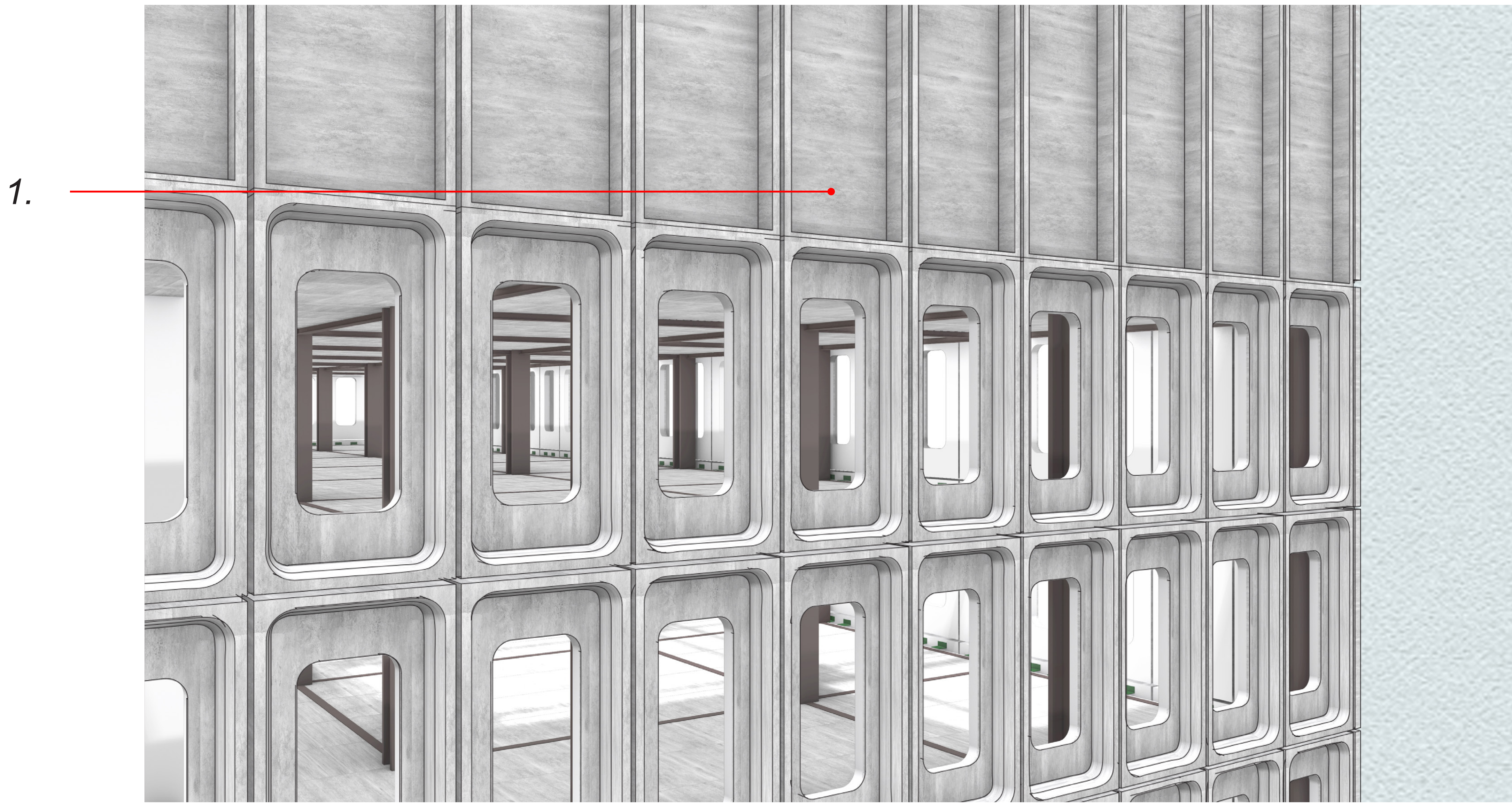
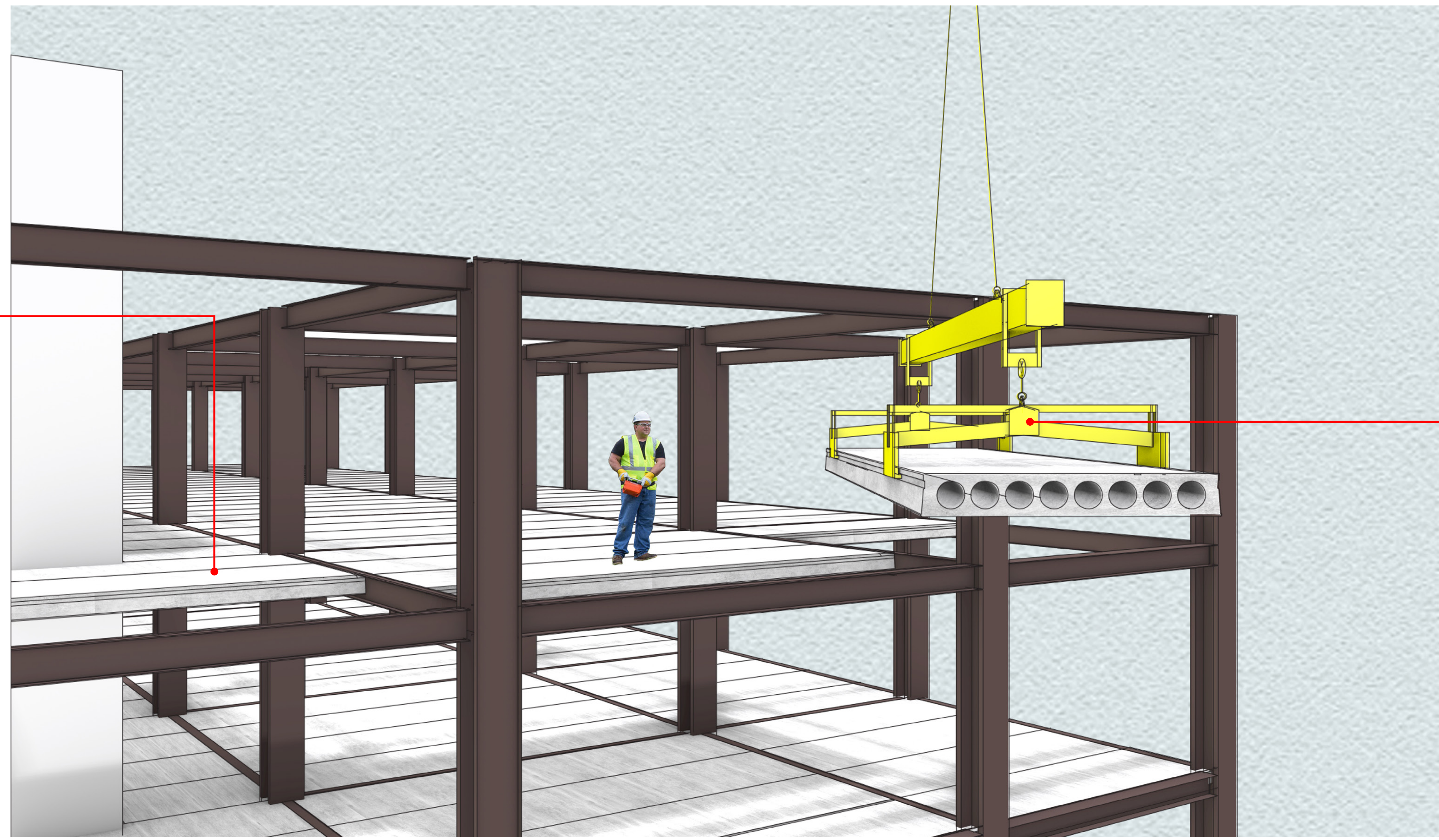


Figure 59 II-B Existing Material Configuration

1. New precast facade panel type will be assumed to have similar connection to other precast assemblies. All precast facade panels will be removed.

1.



2.

Figure 60 II-B Material De-configuration

1. Hollow-core slabs will be diamond sawed in between (much smaller saw) to remove any grout between joints.
2. Removed with a special crane that grabs onto grooves of the profile. *Warning* hollow-core slabs must be tested to ensure they are structurally capable of being lifted without stresses and strains breaking the slabs.

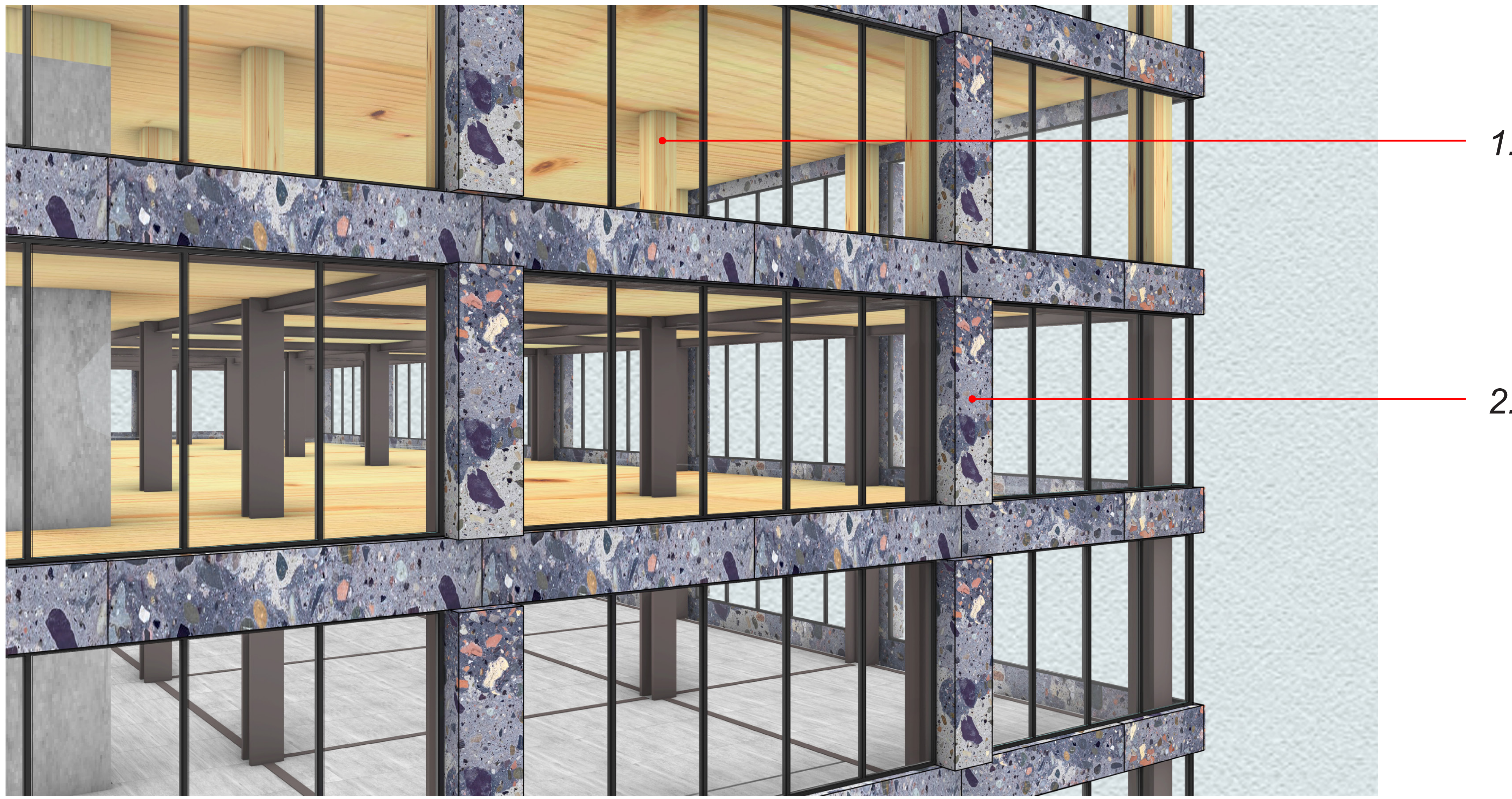


Figure 61 II-B Future Material Configuration

1. Mass timber structural integration will require new steel profiles for proper load transference to the existing steel structure. The CLT panels will have a similar connection detail to the hollow-core slabs.
2. Recycled aggregate precast panels, various sizes, to be sealed for longevity.

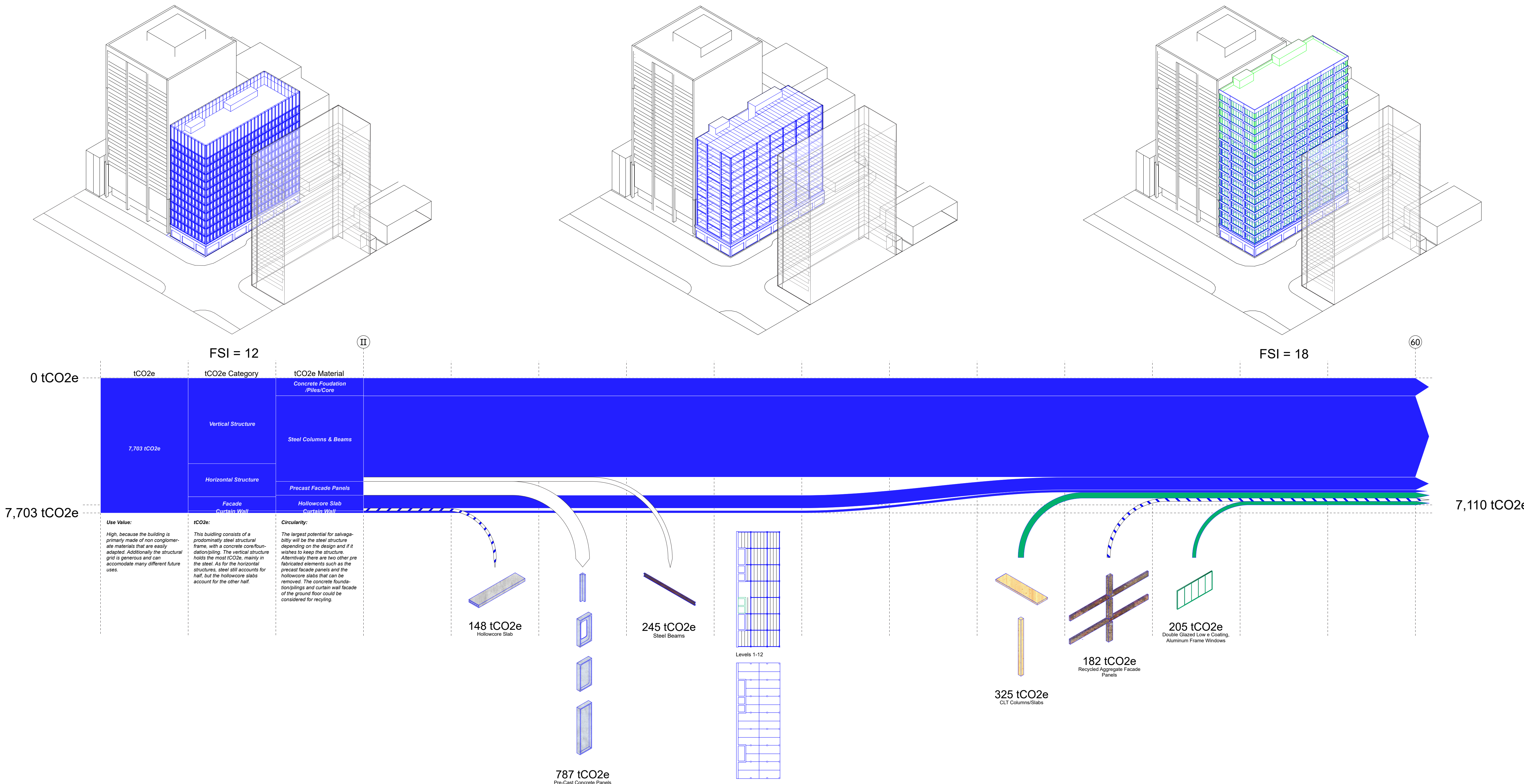


Figure 62 *II-B Flow Diagram*

Adapt (II) - Case C

Design Strategies - Addition, Redesign, Structural Upgrade, Up-cycling
Technologies - Prefabricated Facade Removal, Oxy Acetylene Steel Cutting, & Cleaning/ Sealing

Finally, the last case is the most extreme and is where we see the invocation of the net input that the Act mandates. Of the new build, significant material reuse is used to reach its net embodied energy goals along with the remaining embodied energy from the existing structure, as seen in the flow diagram (figure 67). It will see the addition of a further 12 stories to the existing building giving a total of 24 stories, showing a higher density with net embodied energy goals being met.

All the existing facade will be salvaged, as well as portions of the hollowcore slabs, and the outer structural grid of steel will be salvaged and recycled respectivly to make room for the larger load-bearing structure of columns and an expanded concrete core. This new concrete is made of less carbon-intensive processes that do not use air entrainment as it is not an exposed concrete structure and slag cement instead of fly ash, which greatly reduces the carbon cost of the cast in place concrete.[1]

The existing steel structure will have a new bearing plate to connect to the new concrete core and columns. Oxy-Acetylene cutting will be required to cut the facade's steel columns and beams. The hollow-core slabs will have to be diamond cut if they have grouted connections between them. For both the steel and the hollow-core slabs, a crane will be needed to support them both as they are being deconstructed, similar to the pre-cast facade panels.

In this case, the building's use will become primarily residential. Therefore, it will reduce the amount of glazing on the facade that would be necessary for an office environment. Salvaged diamond saw cut panels from the Chelsea Hotel will be fitted into the new design with the appropriate bearing connections to turn the previous cast-in-place walls into a set of modular precast panels. They will be cleaned beforehand using steam and brush cleaning, stained to a new color, and re-sealed. Between these modular panels, floor-to-ceiling windows of different sizes will create a unique fenestration pattern that breaks from the existing buildings' rigorous modular patterning.

1. CRMCA, *CRMCA Member Industry-Wide EPD for Canadian READY-MIXED CONCRETE* (Ontario: CRMCA, 2013), 4.

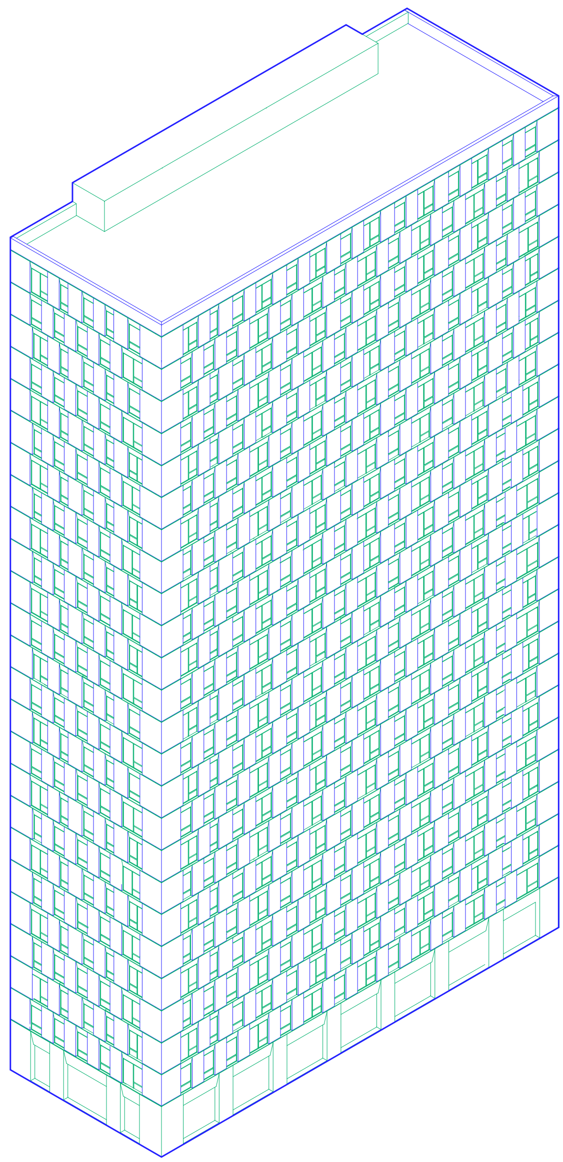


Figure 63 II - C future design (Self Authored)

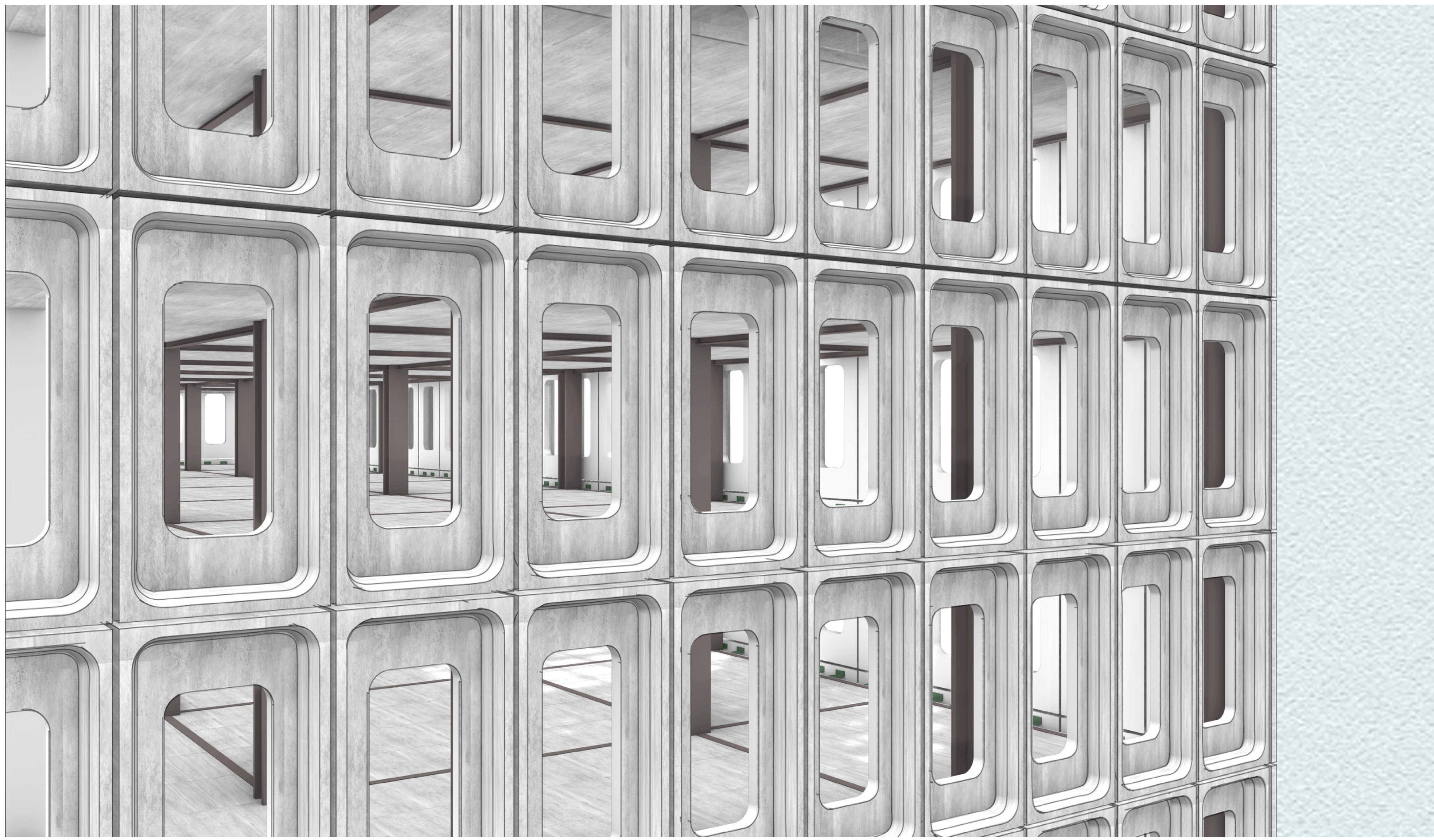


Figure 64 *II-C Existing Material Configuration*

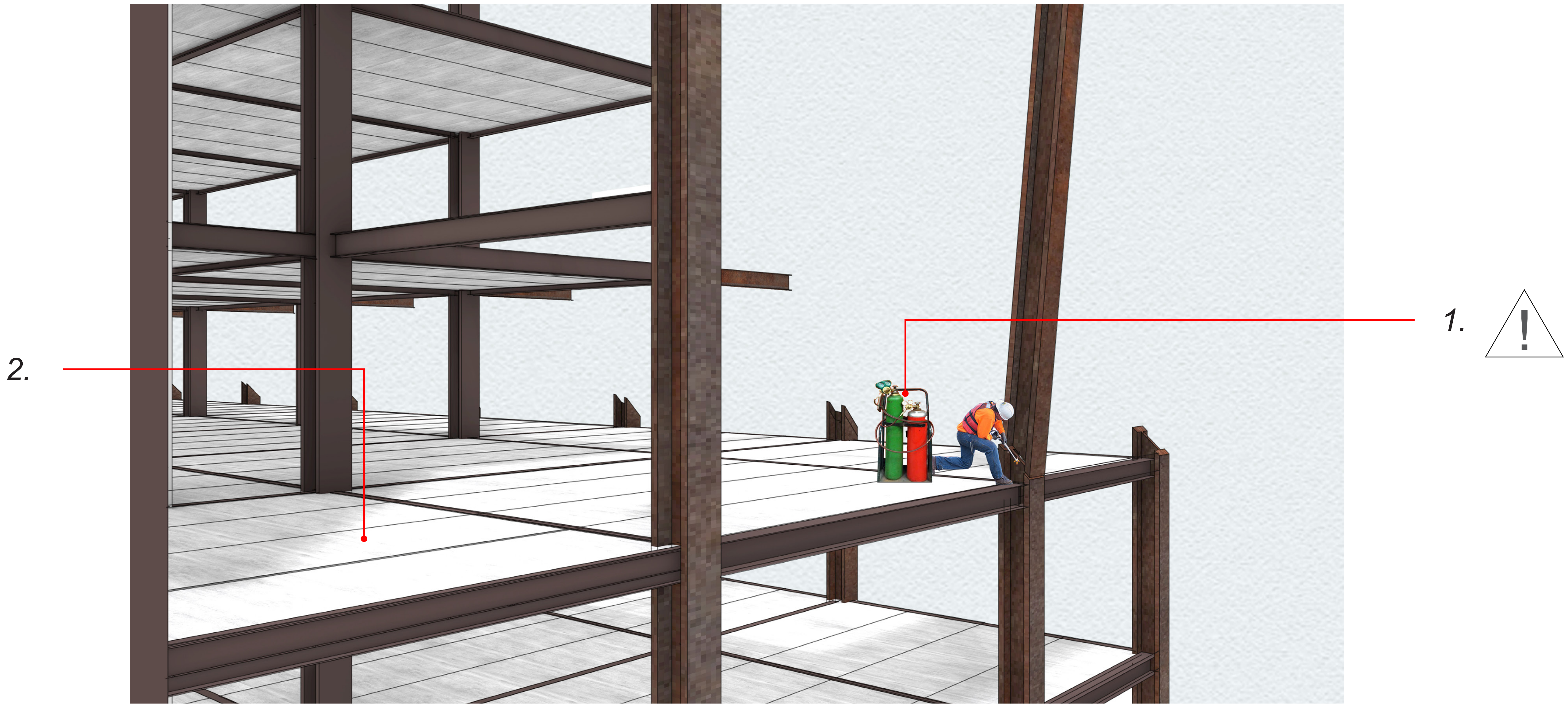


Figure 65 *II-C Material De-Configuration*

*1. Oxy Acetylene weld cut on an angle for a controlled direction of fall.*Warning* Must be attached to crane at top section before cutting to allow for support.*
2. Hollow-core Slabs removed, refer to example B to understand process.

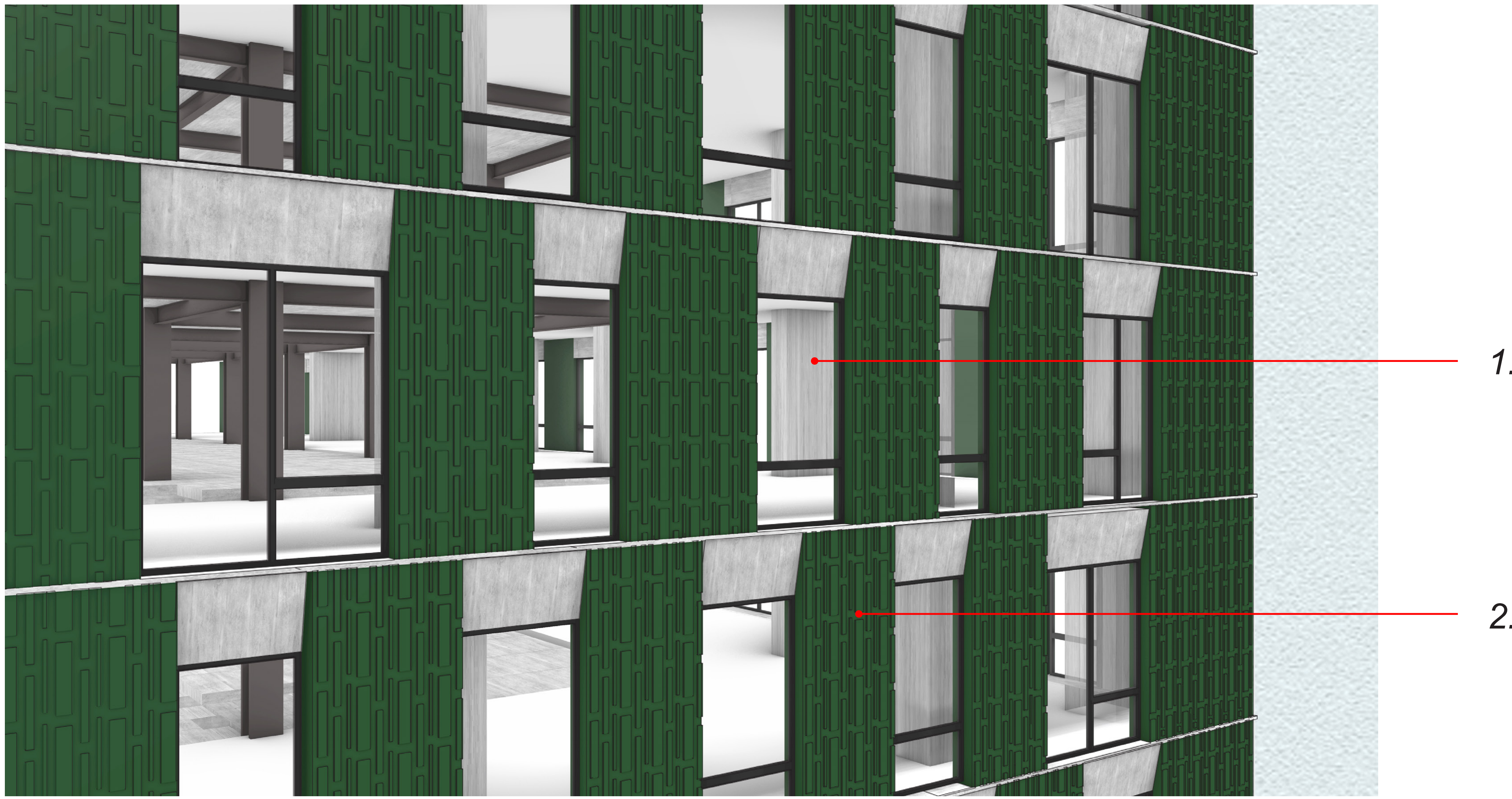


Figure 66 II-C Future Material Configuration

1. Stained and sealed cast in place concrete from Chelsea Hotel.
2. This concrete outer structure will pick up the majority of load for the additional 12 floors. It is made from a mixture with slag cement and very little fly ash, as well as no air en-treatment which significantly reduces the amount of tCO2e.

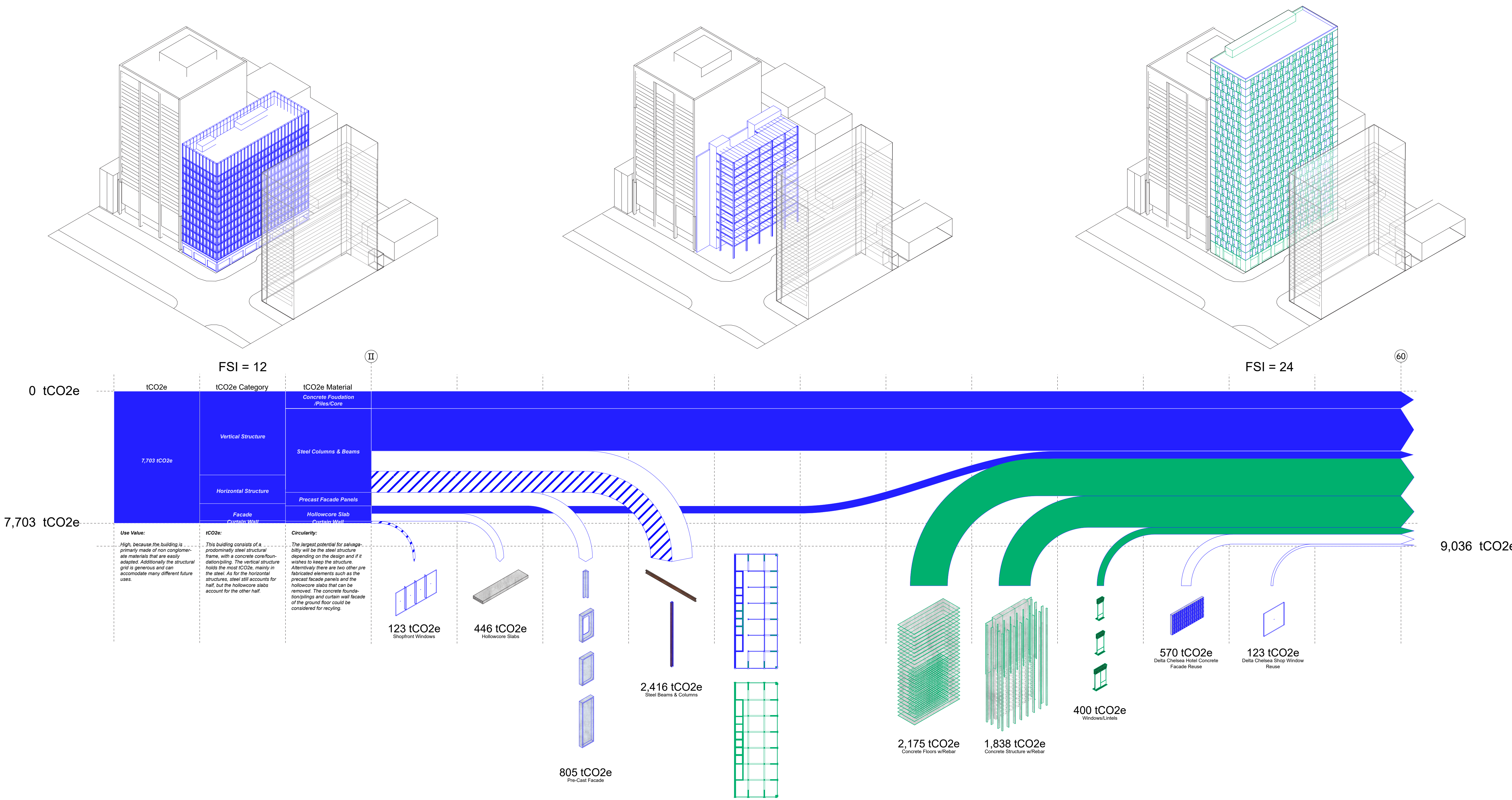


Figure 67 *II-C Flow Diagram*

III

III - A - Bianchi Auto Collision Repair

Not much is documented historically as to the Bianchi collision center's historical character located on 31-37 Gladstone Avenue, except that it seems to have been built in the mid-1950s, replacing a series of house form buildings. From the heritage impact statement for the proposed development on this site, it is clear that the only influencing factor in terms of heritage for this new development would be the Gladstone hotel's presence and creating a view corridor to that, effectively reducing the height of the proposal.[1] The existing buildings are auto repair garages consisting of one brick building and the larger of the two auto garages made predominantly of concrete block. Both buildings on the block account for a small FSI of 0.68 as the auto body shop set back most of the lot for traffic flow. Facades of both of the buildings have a masonry veneer on them, one of them being of veneered brick and the alternative consisting of a ceramic tile. The garages themselves have many easily dis-mountable components such as windows, trusses, doors, and garage doors. The buildings on 31-37 Gladstone are not considered at all for heritage status since they have a minimal aesthetic value that would be considered worth keeping. Proposed is a six-story building with an FSI of 3.5, roughly 5x its original density.[2]

1. "31 GLADSTONE AVENUE HERITAGE LETTER," *Condoman Realty Inc.* ERA Architects, last modified: July 2, 2020, http://app.toronto.ca/AIC/index.do.
2. Standard Practice Inc. "31-37 Gladstone Avenue Toronto ON - Architectural Drawing Set," *Condoman Developments*, Last modified: July 23, 2020, http://app.toronto.ca/AIC/index.do.

Figure 68 Bianchi Collision Centre 31-37 Gladstone Ave. (Google Maps, 2020)

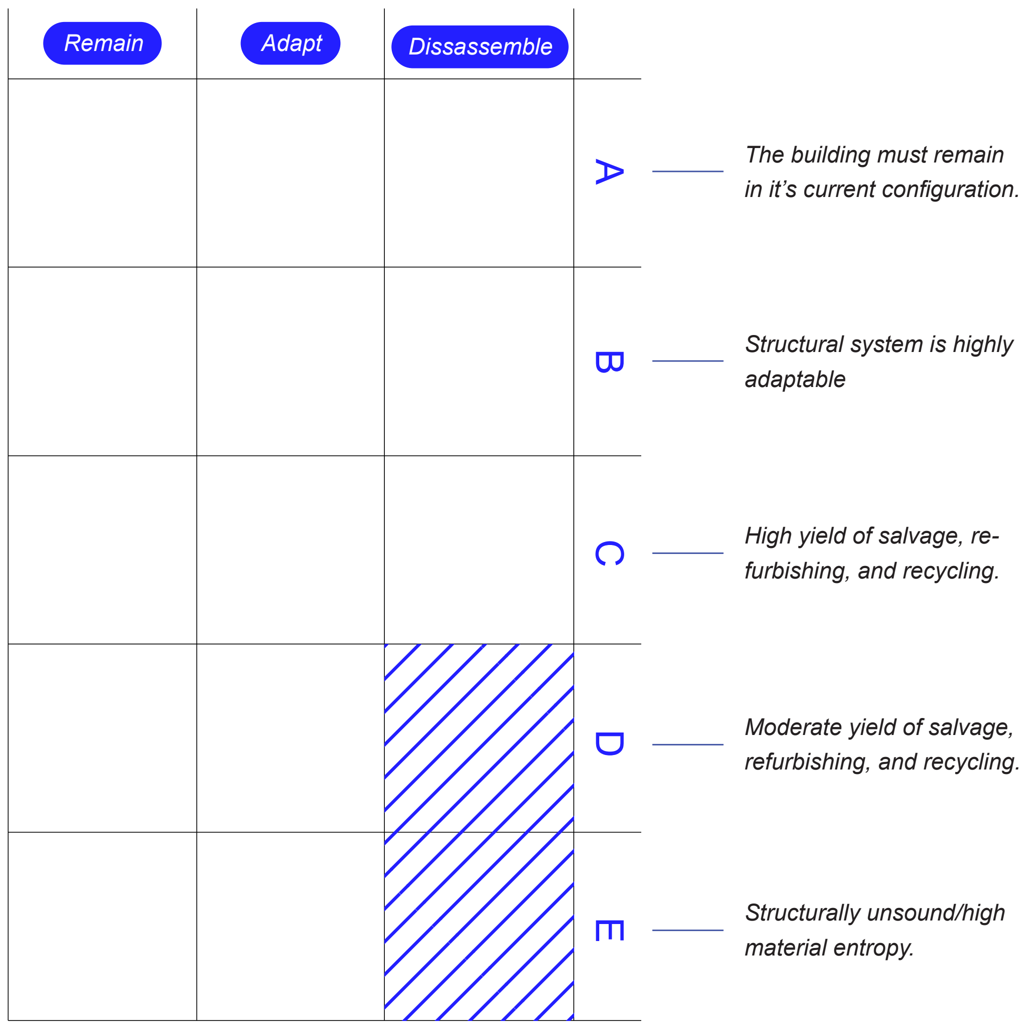


Figure 69 Bianchi Collision Centre Selected Criteria

D. Has a high salvage and recycling value, particularly in the brick veneered walls, concrete masonry units, and all other components such as windows, aluminum trusses, and garage doors. All these materials can find a form of reuse if deconstructed carefully.

E. Bianchi Collision Centre is deemed structurally unsound because the foundation has subsided over time and puts at risk the concrete masonry units tied to it. Furthermore, the way the two buildings are attached to one another means that the structural partition wall would too significantly restain the future form and use the site.

Disassemble (III) - Case A

Design Strategies - Recycling, Up-cycling
Technologies - Electric Hammer, Reciprocating Saw, Diamond Saw Cutting

This option represents a lower density application of material reuse where there is no major structural sink of energy needed to be balanced (see figure 74). However, this small-scale development of 7 terraced houses shows the effect of the net embodied energy input rule 2.6.1 in the role of new development and material recycling and minor use of salvage to avoid paying fees for new carbon that would exceed the existing carbon.

In this case, the existing garages are more carefully deconstructed, starting with the removal of the doors, garage doors, windows, & signage using manual methods and the reciprocating saw. Once that is done, the wooden structure on the roof and floors' interior is removed along with the other materials adhered to it to be recycled. With only the masonry now standing, either cutting can happen in the front where the veneered facades are, and the electric hammer can be used for punching through the remaining brick and concrete block. In some instances, a small crane or scaffolding pulley will have to be used to bring down the cut material. As many of these examples, structural integrity must be kept in mind when punching or sawing to ensure that the structure does not collapse.

The new residential mews will consist of a staggering set of terraces giving each property access to natural daylight and outdoor space. The lower half of the building acts as the work zone with a garage aesthetic to it, emphasized by the salvaged concrete blocks from the site and the existing windows and garage doors that open onto the ground floor patio. The upper terraces wrap over the concrete block are made of wood frame construction and are clad in a cedar shingle to contrast the ground floor's grittiness.

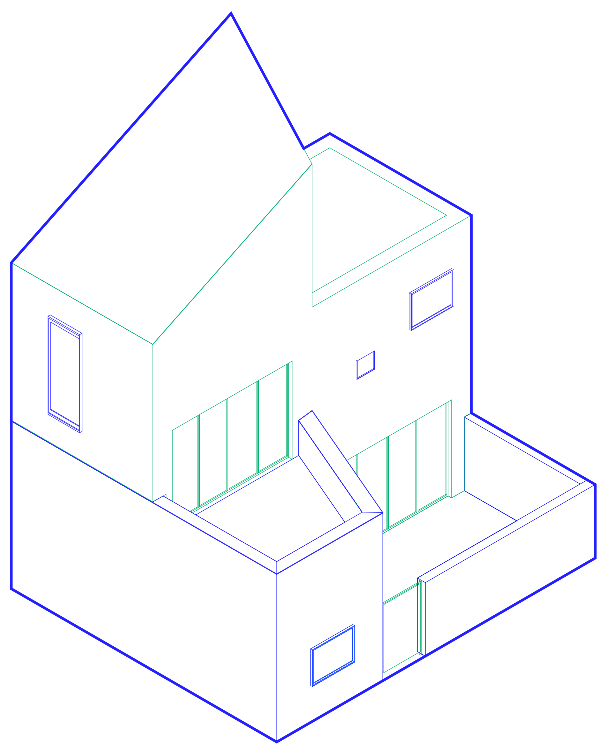


Figure 70 III - A future design (Self Authored)

Figure 71 III-A Existing Material Configuration

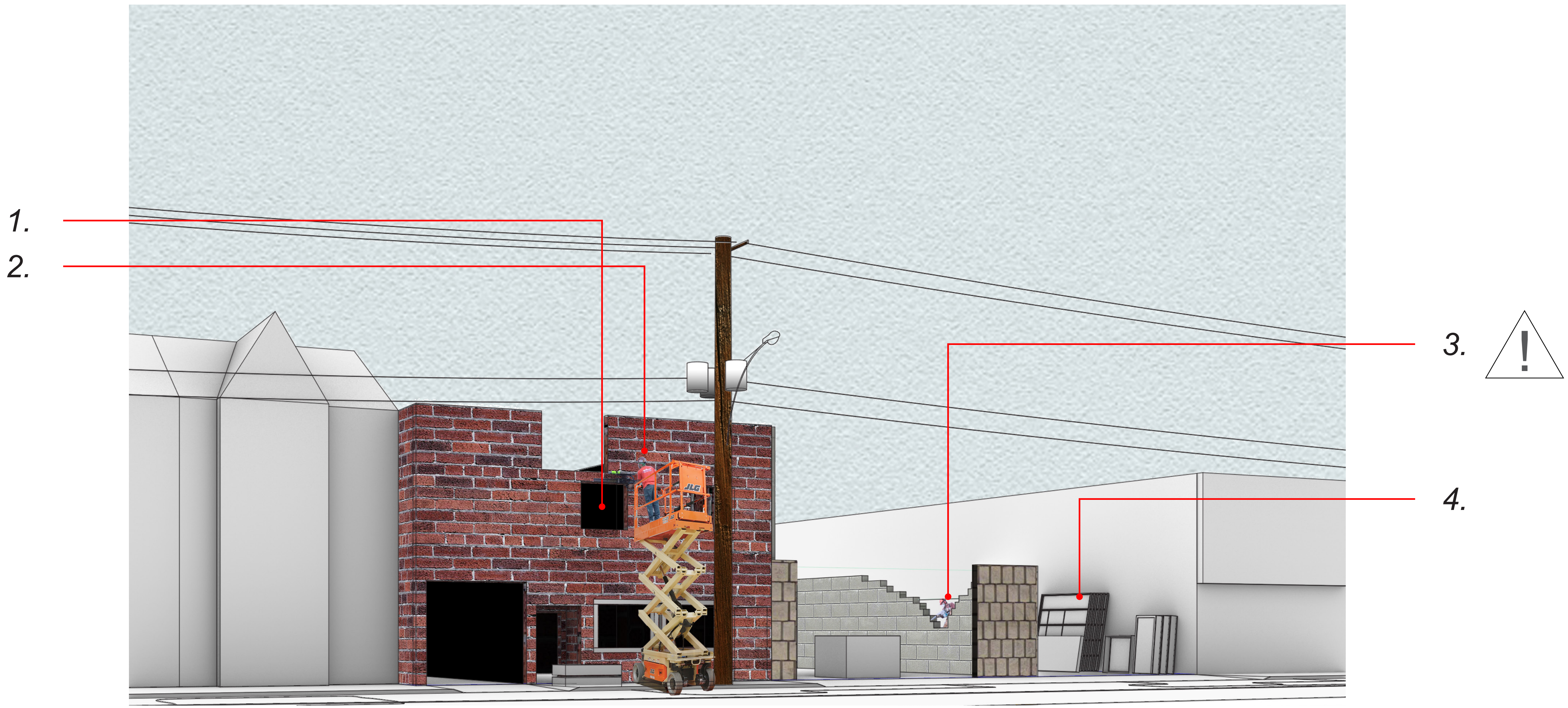


Figure 72 III-A Material De-Configuration

1. Existing windows removed through cutting out with reciprocating saw, unscrewing of aluminum frame, and finally prying out of window.
2. Diamond saw cutting on track of brick veneer and ceramic tile veneer wall.
*3. Punching method with electric hammer to salvage as many concrete blocks as can be yielded. *Warning* removal of cinder blocks to be done with structural integrity in mind, the use of bracing may be necessary for health and safety.*
4. Windows cut using Reciprocating Saw - Salvaged windows restored.

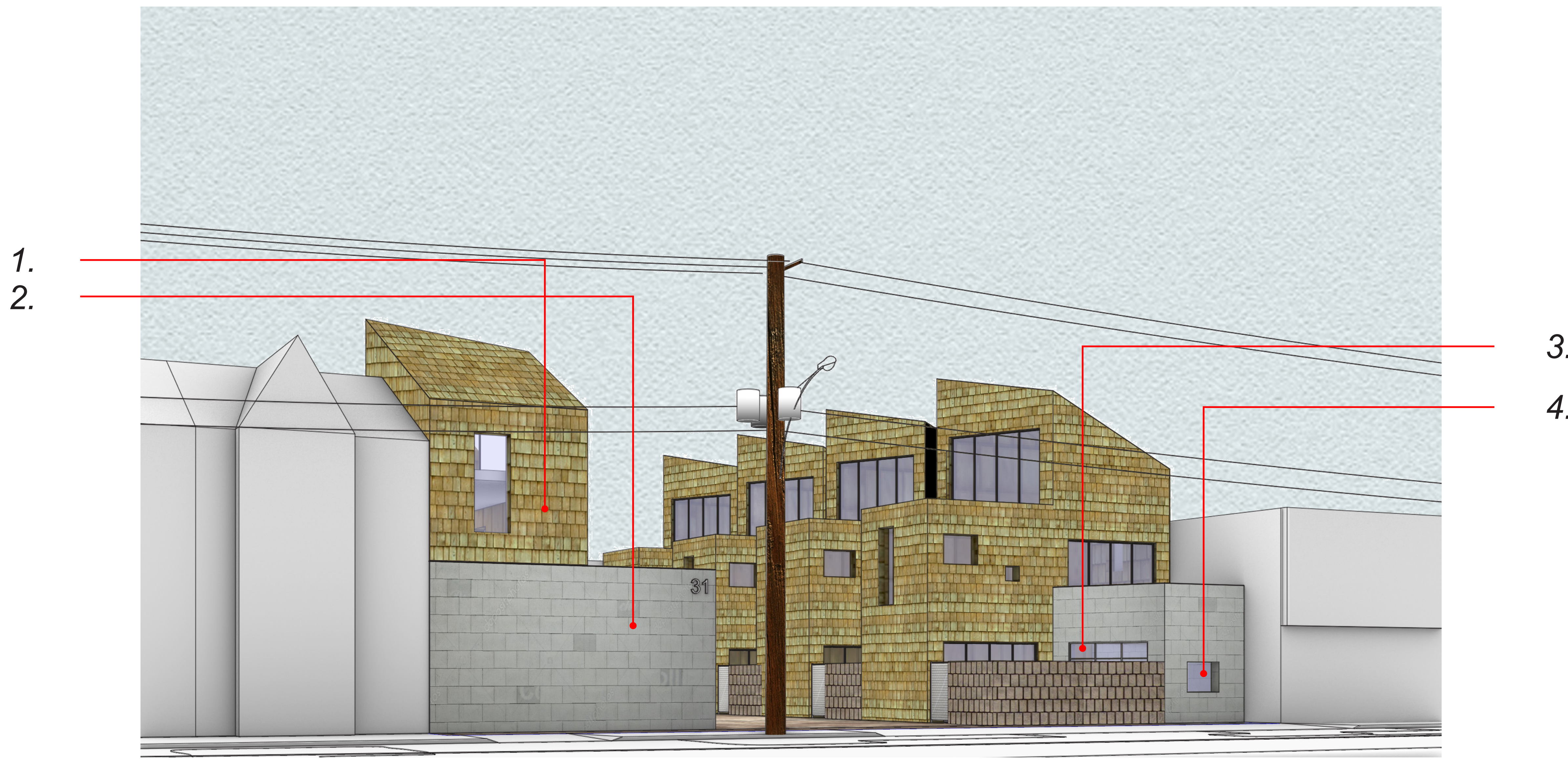


Figure 73 III-A Future Material Configuration

1. Ceder shingles & wood frame construction.
2. Recycled Concrete Block.
3. Garage door reuse from original Bianchi Collision Centre.
4. Existing window reuse.from original Bianchi Collision Centre.

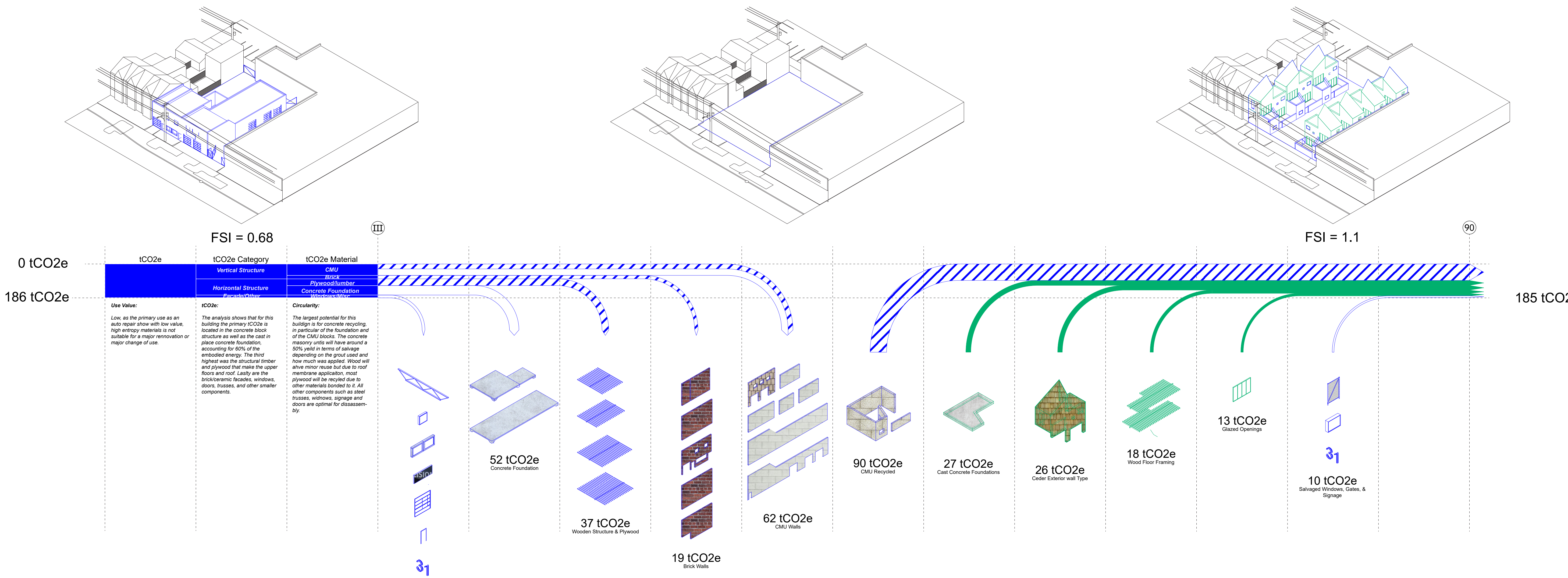


Figure 74 III-A Flow Diagram

Disassemble (III) - Case B

Design Strategies - Up-cycling
Technologies - Reciprocating Saw, Diamond Cut Saw, Aggregate Crusher

The second option represents a medium-density application of material reuse. The larger-scale application of up-cycled materials helped meet the net-zero input targets (see figure 79). It shows a similar scale to what is currently being proposed in the five stories' planning application.

Parallel to the previous case, the building's smaller components are removed and stored on-site until they are distributed to the third-party warehouse for others to buy. However, instead of selective demolition in the previous example, this example chooses to bring down the structure more rudimentary with mechanical demolition from an excavator. The leftover rubble on the site is crushed on-site and used in the new concrete structure for recycled aggregate, saving on carbon used for manufacturing elsewhere since the rubble scale can be managed on-site. It is necessary to address the potential hazard of using the aggregate crusher on-site and the particulate matter that can be hazardous. It would be important to address this particulate matter with a screen to trap dust either surrounding the site or immediately surrounding the crusher itself.

The final residential project will have up-cycled the precast mechanical penthouse panels from the 1200 bay project, reusing the same bearing connections. It will design with the module to determine the bay of each unit. Concrete will be the main new structure, supplemented with recycled aggregate for less intensive carbon, and the floors will up-cycle the hollow core slabs that were also from 1200 bay. These hollow-core slabs will have to be diamond saw cut to match the structure's new spacing.

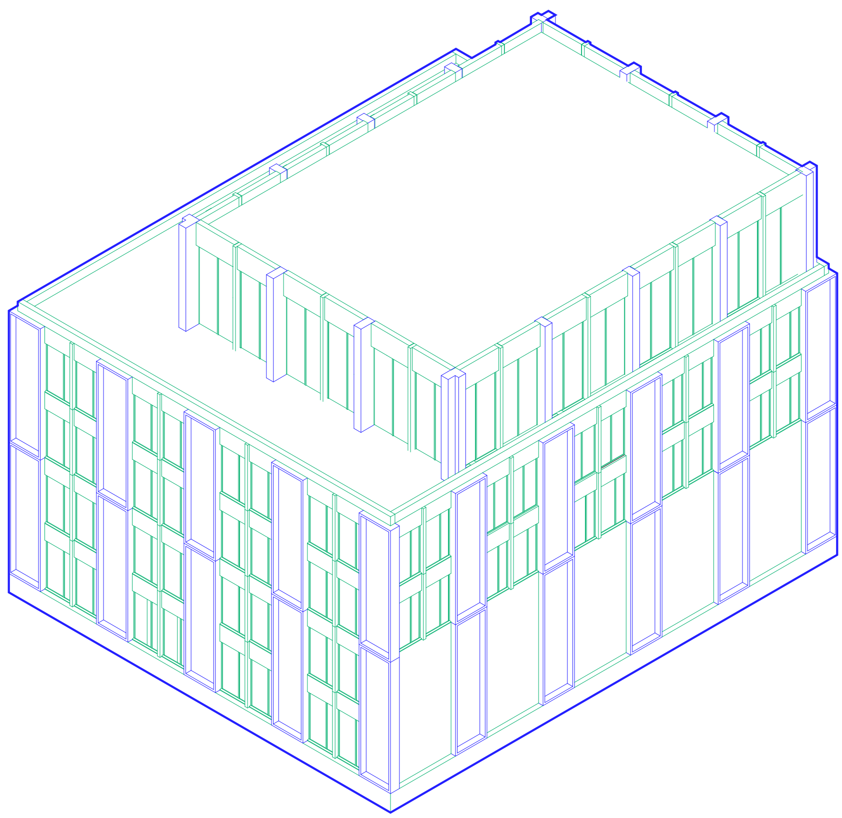


Figure 75 III - B future design (Self Authored)

Figure 76 III-B Existing Material Configuration

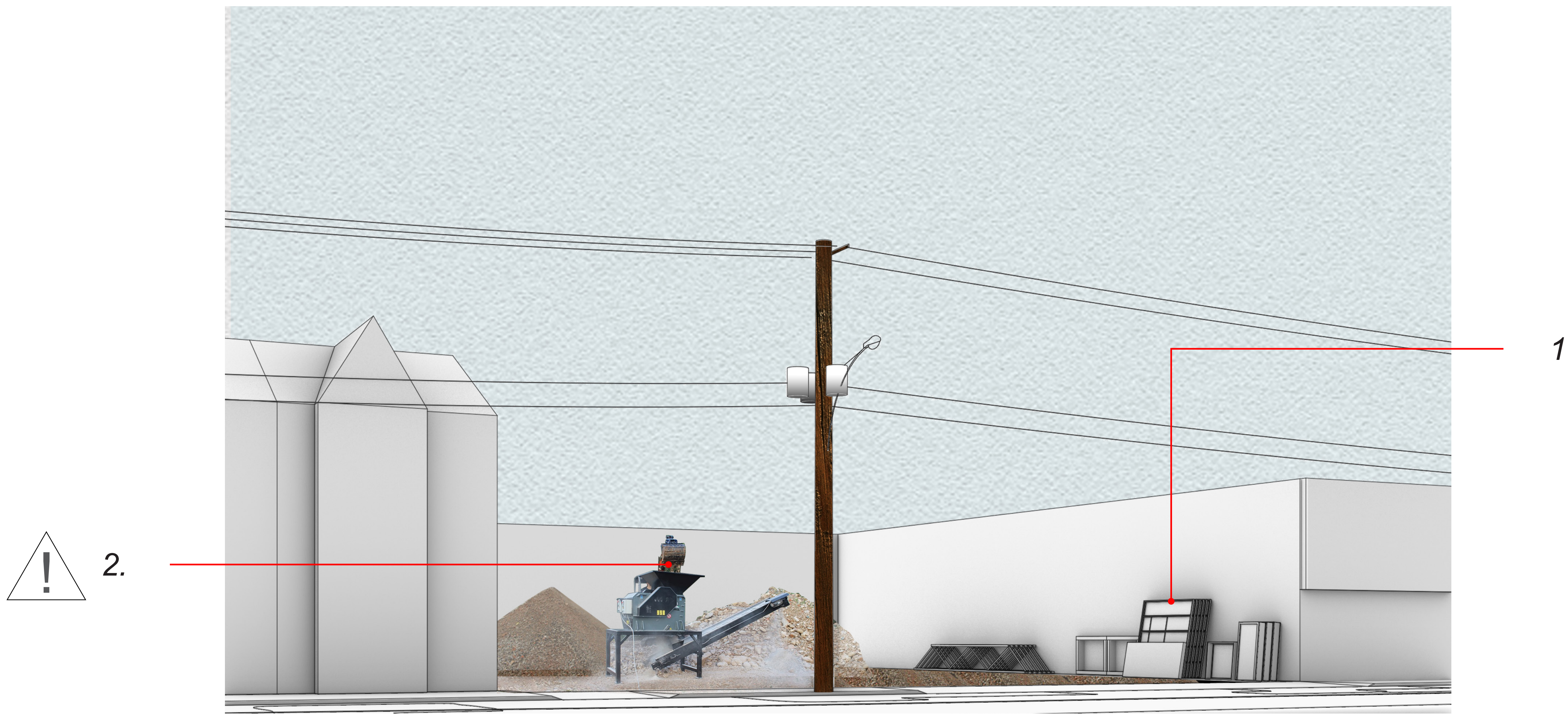


Figure 77   III-B Material De-configuration

1. All windows, doors, trusses and other components salvaged in same manner as example A of this Act.
2. All other masonry recycled on site in aggregate crusher, to be integrated into concrete foundations and structure (20%). Leftover concrete will be added to a recycled aggregate depot.

Figure 78 III-B Future Material Configuration

1. Floor structure will consist of hollow-core slabs from the 1200 Bay project which will be diamond cut to fit the new grid of the project.
2. Precast mechanical penthouse facade reuse from 1200 Bay. All precast panels cleaned and resealed during installation.

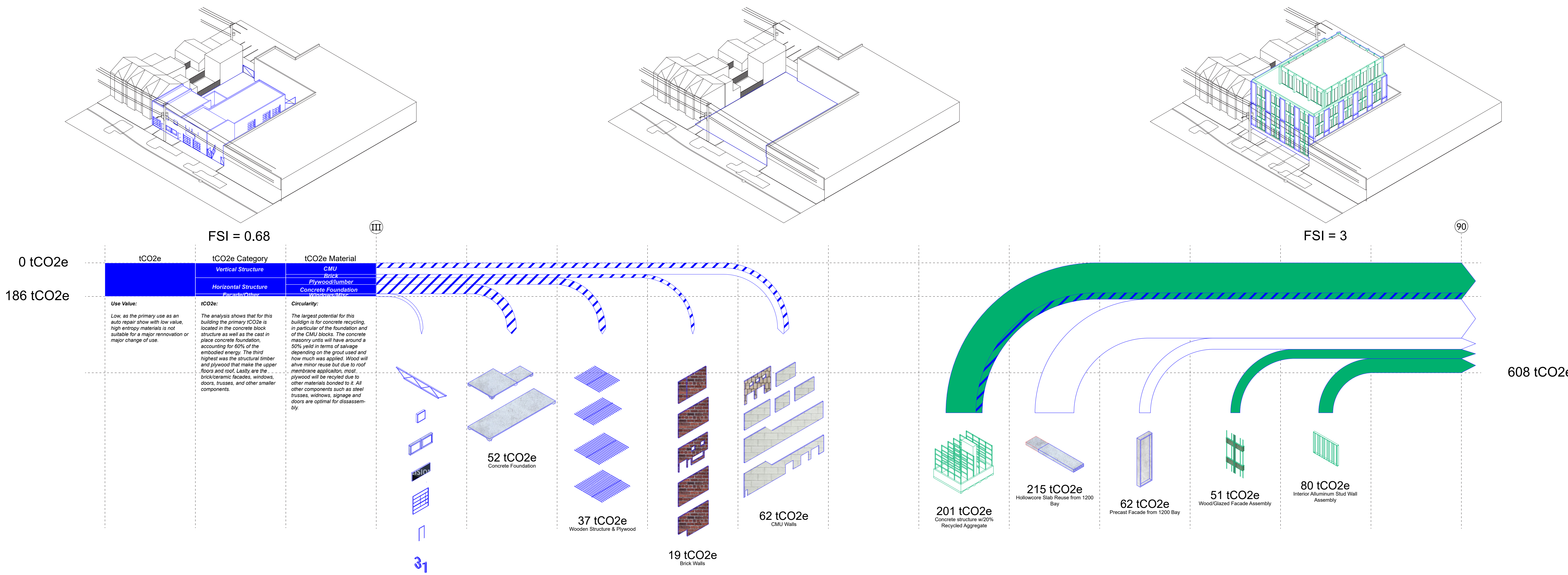


Figure 79 III-B Flow Diagram

Conclusion:

Incorporation of this experimental Act would have many other barriers to deal with, in particular incorporation into existing density measures imposed by the city of Toronto. In the experimental alternative reality that has been created in the thesis, density is relative to the ability to reach the net embodied energy standard imposed by the act, essentially making any site able to achieve any density as long as it meets that net requirement. However, inevitably this would have to work with the context in terms of building height, and street continuity. Perhaps the ability to reach any density while reaching net-zero carbon is an excellent incentive for developers to justify the material restrictions put on sites economically. However, since this Act works in a closed material metabolic system, further study will be required to understand the rate that a city could grow with this net material cap put on it. Inevitably the amount of available material for new developments will ebb and flow depending on which buildings come into the legislation and at what time.

Furthermore, this Act could be considered with other carbon-reducing principles such as energy performance and energy generation that other technologies could bring to a new design. Over the typical lifespan of a building, the cumulative operational emissions eclipse the initial embodied ones, leading to embodied energy only consisting of a fifth or less of the building's total energy consumed.[1] However, projections show that between now and 2050, as building operational performance gets better and better, that 80-90 percent of a building's life span energy profile will be embodied, which means that although not accounted for in this thesis, materials that improve operational performance such as insulation must be taken into account for their embodied energy impacts as well as the majority of energy shifts towards embodied energy.[2] Other operational perfor-

1. Bruce King, *The New Carbon Architecture: Building to Cool the Climate* (Gabriola Island, BC: New Society Publishers, 2017), 20.
2. *Ibid., 21.*

mances such as mechanical systems, energy production, and water usage are important, but the material cost should also be taken into account. Not to discount operational energy efficiency entirely, but it seems more likely that cities will have to strike a balance between lowering the embodied energy and improving operational performances of buildings so that they can reach a truly net carbon zero building.[3] The complexities of considering energy production and building performance would have made this thesis a much longer journey, which is why it chose to focus only on embodied energy.

Another large barrier that has been touched upon briefly in this thesis is risk and liability for adaptation and reused material specification. Inevitably the material risks and liability in terms of adaption and reuse must become standardized by sets of material decay studies incorporated into engineering standards. This set of standard practices will allow engineers and architects to have legitimate claims for the safety of reused materials and adapted buildings that insurance will allow as an appropriate assumed risk. Just as engineers will need standards, the building code will also have to be updated to incorporate reused materials in studies such as flame spread ratings and fire resistance. Without material reuse being integrated into code, material reuse will struggle to be widely adopted as unique variances will have to be issued. These integrations into law are not a part of the proposed Act but will nevertheless be one of the larger and slower challenges necessary for the larger incorporation of building adaptation & material reuse.

Similarly, another legal issue will be in terms of health and safety associated with deconstruction, particularly the toxicity that old materials can have. It is then important to advocate for regulation of safe working conditions as this burgeoning industry begins to have more prominence for both workers and the public at large since airborne toxins span outside

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3. *Ibid., 21.*

of the construction site into neighborhoods. Addressing the practice of deconstruction can be a part of addressing more significant issues within new construction as well, which can also carry dangerous toxins, trying to make all construction be upheld to better labor equality and pollution standards.

Regardless of incorporating other city policies, operational energy, and legal issues, the exercise of testing the possibilities of an Act like this is beneficial for beginning to understand the qualitative and quantitative methodologies that need to be incorporated and visualized in future designs. Architectural practices need to understand the future relevance of material reuse and the beneficial impact on reducing the effects of climate change. At the end of the day, if legislation similar to this does not become integrated into policy, it will be up to the profession to convince clients to factor in the actual cost of materials in terms of their carbon and the economic pragmatism reuse allows without limiting design capabilities. Suppose adaptation and material reuse can be presented as a cost-benefit to developers by saving money on keeping existing structures and sourcing more uncostly salvaged materials. In that case, there is a solid argument to be made until significant city policy changes to suit this agenda. Suppose architects position themselves now as not just the broker between the city and client in the building industry but also as the critical logistical force for material reuse integration. In that case, we will have more resilience in the practice as our skillset expands to include the capability of rising to the challenges of reaching zero carbon. The architect can be the hub of this information and live up to the practice's responsibility for the public good.

In conclusion, gaps in conservation and heritage must be addressed to promote and be inclusive of a material's ecological value and not only limited to safeguarding the diverse set of cultural values that it currently uses.[4] When considering materials that remain, a more flexible inclusion of what is considered 'character defining' will be necessary, promoting all materials to remain and be translated back into Toronto's fabric. With this newfound awareness re-valuing all existing materials in relation to conservation and heritage, the experimental proposal of the Re-Amortization Act seeks to show us the possibilities for material duration to address both the urgency of the climate crisis as well as our cultural struggle to maintain our collective memory when faced with building obsolescence caused by financial decay. A more flexible sense in terms of materiality allows the processes of the present and future environmental and cultural crises to also play a role in the material duration of our cities.

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4. Susan Ross, "Re-Evaluating Heritage Waste: Sustaining Material Values through Deconstruction and Reuse." *Historic Environment: Policy and Practice* 00, no.1 (February 2020): 17.

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