MATERIAL WORKS:
Optimizing Material Circularity through Reversing Architecture

by
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AUTHOR'S 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.

MATERIAL WORKS

ABSTRACT

"Material Works" posits the largest abandoned industrial landscape in the Niagara region — the former General Motors Plant site — as a key infrastructure to circulate the existing building stocks for city-scale reuse in St. Catharines, Ontario. The city's building permits issued in 2023-2024 were analyzed to examine buildings registered for demolition and to build a database of materials to be reused if deconstructed. This initial study informed the design of the facility, in its scale, aesthetics and programmatic organization.

The half-demolished GM structure, with a former building footprint of 38,000m^2, is transformed to a circularity hub to address the city's potential reusable building material stock. The architecture provides spaces for people to train in deconstruction, salvaged materials to be processed for resale, and designers to demonstrate their potential for architectural re-application. With circulation of materials as the central motif, agencies essential in facilitating circular activities are imagined to co-exist in one physical site to develop approaches to create more sustainable, closed-loop metabolic systems of materials.

The building industry constitutes nearly a quarter of the global waste stream, and with Ontario's landfills projected to reach capacity by 2032, the movement and uncertain destination of materials remain critical environmental concerns. In the quest for a sustainable architectural future, where construction's inherent destructiveness contrasts with the demand for densification, focus shifts toward assessing the residual value of existing urban building stocks within the Anthropogenic landscape. This paradigm shift from the current linear to a circular construction model protects the architectural heritage of our urban fabric from rapid erasure while optimizing resource efficiency.

This thesis explores design interventions and industry practices that replace the 21st century's planned-obsolescence-thinking with reuse, contributing to the discourse of material circularity to address the environmental and cultural resiliency in architecture.

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I am deeply grateful to the University of Waterloo, located on the traditional territory of the Neutral, Anishinaabeg, and Haudenosaunee peoples. It has been my privilege to study here for the past seven years, maturing as a member of the architectural community and a visitor to this land. Watching the Grand River flow and witnessing the surrounding landscape change with the seasons has been a constant reminder of time's passage. To all the people I have met on this journey—through shared conversations, critiques, struggles, and laughter—you have shaped this pivotal chapter of my life. Monica Gutierrez and Simon Peiris, my Master's years would not have been the same without you by my side.

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DEDICATION

I dedicate this thesis to my (친) grandfather—whom I've never met, but who is remembered by my family in Korea, and whose humble contributions to the world live on through his buildings. There may no longer be any traces of your devotion in the field, even a single drawing, yet I find myself inspired and honoured that our curiosity in architecture has crossed paths—and that you would have, perhaps most definitely, been a role model I could look up to.

I also dedicate this to my (외) grandfather, who provided me a home at birth in this foreign land of Canada, made home by my parents for us. It was sometime in 2010, shortly after I had moved back to Canada from Korea, when you drove me past the thesis site and casually mentioned the closure of the General Motors plant that same year. The thesis took root in this distant memory, revisited over a decade later with a deeper curiosity and aspiration for architecture.

TABLE OF CONTENTS

	AUTHOR'S DECLARATION	ii
	ABSTRACT	iii
	ACKNOWLEDGMENTS	iv
	DEDICATION	v
	BIBLIOGRAPHY/LIST OF FIGURES	viii-xxxi
00	INTRODUCTION	1-8
	CHAPTER 01: THE LINEARITY OF THE 21ST-CENTURY BUILDING ECONOMY	
1.1	**Obsolescence of Buildings and the Myth of Fate**	**9-40**
1.1.1	Obsolescence	13-18
1.1.2	Mechanics and Culture of Clearance	19-20
1.1.3	Incentivization of Demolition over Reuse in Canada	21-30
1.1.4	Limited Capacity for Preservation	31-40
	CHAPTER 02: SYSTEM-BUILDERS OF THE URBAN FABRIC	
2.1	**Reversing Architecture**	**41-56**
2.2.1	(Re)discovering Value in the Forgotten	45-50
2.2.2	Shearing (deconstructing) Layers	51-56
2.2.3	Technical Barriers (considerations) in Deconstruction: Brick by Brick	57-61
2.2	**Emergence of Regulatory Changes**	**62-65**
2.3	**Case Studies**	**66-86**
2.3.1	Ouroboros	67-72
2.3.2	Re:Purpose Savannah	73-78
2.3.3	RotorDC	79-84

	CHAPTER 03: CONVERGENCE OF TECHNOLOGY, SOCIETY AND ARCHITECTURE	
3.1	**Story of the Site**	**87-124**
3.1.1	The Industrial Structure of Niagara	91-92
3.2.1	History, Present, Future of the Former GM Plant	93-124
3.2	**Inventory of the Material Bank**	**125-130**
3.3	**St. Catharines' Material Assets**	**131-172**
	CHAPTER 04: DESIGN	
4.1	**Design Strategies**	**173-186**
4.1.1	Design Principals	177-178
4.1.2	Adaptive Reuse	179-180
4.1.3	Programming	181-182
4.1.4	Materials Movement	183-184
4.1.5	Idea Exchange	185-186
4.2	**Proposal: Hub to Facilitate Circular Economy**	**187-198**
4.3	**More about the Machine**	**199-216**
4.4	**The Architecture**	**217-246**
4.5	**Future Speculation**	**247-248**
	CONCLUSION	249-250
	APPENDICES	251-318
A.	Training Module	253-278
B.	Initial Sketches	279-290
C.	Model Photos	291-304
D.	Conference Notes	305-308
E.	Deconstruction Experience	309-310
F.	Final Presentation	311-318
	GLOSSARY	320

BIBLIOGRAPHY

Andrew, Robbie M. 'Global CO2 Emissions from Cement Production', 16 August 2018. https://doi.org/10.5194/essd-2018-90.

Banham, Reyner. *Theory and Design in the First Machine Age*. Second. London: Architectural Press, 1960.

Bates, Zebuliah, Dave Bennink, Robert Falk, Jonathan Klane, Matt McKinney, Anne Nicklin, and Dirk Wassink. *Introduction to Deconstruction: A Comprehensive Training Workbook*. Oregon State edition., 2017.

Baum, Martina, and Kees Christiaanse. *City as Loft: Adaptive Reuse as a Resource for Sustainable Urban Development*. Zürich: GTA Verlag, 2012.

Bergman, Richard, Hongmei Gu, Robert Falk, and Tom Napier. 'Using Reclaimed Lumber and Wood Flooring in Construction: Measuring Environmental Impact Using Life-Cycle Inventory Analysis', 2010.

Brand, Stewart. *How Buildings Learn: What Happens after They're Built*. New York, NY: Viking, 1994.

Brunner, Paul. 'Urban Mining A Contribution to Reindustrializing the City'. *Journal of Industrial Ecology - J IND ECOL* 15 (1 June 2011). https://doi.org/10.1111/j.1530-9290.2011.00345.x.

'By Reversing the Construction Process, Ouroboros Reduces Waste'. Accessed 18 June 2024. https://storeys.com/ouroboros-deconstruction-demolition/.

Canada, Environment and Climate Change. 'Reducing Municipal Solid Waste'. Guidance, 18 February 2010. https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/municipal-solid/reducing.html.

'Capital Project Planning for a Circular Economy: Construction Management and Economics: Vol 36 , No 6'. Accessed 11 April 2024. https://www.tandfonline.com/doi/full/10.1080/01446193.2018.1435895.

'Deconstruction Ordinance – City of Palo Alto, CA'. Accessed 19 September 2024. https://www.cityofpaloalto.org/Departments/Public-Works/Zero-Waste/Zero-Waste-Requirements-Guidelines/Deconstruction-Ordinance.

'Deconstruction Ordinance Expansion | Portland.Gov', 19 November 2019. https://www.portland.gov/bds/news/2019/11/19/deconstruction-ordinance-expansion.

Deleuze, Gilles. 'Postscript on the Societies of Control' 59 (1992).

Devlieger, Lionel. 'Reverse Architecture—The Virtues of Unbuilding and Reassembling'. *Rewriting Architecture, 10+1 Actions: Tabula Scripta*, 1 January 2020.

———. 'The Raw, the Cooked, and the Overdone on What Makes Building Materials Salvageable (or Not) in North Western Europe'. *FAKTUR*, no. 03 (2020).

Gorgolewski, Mark. *Resource Salvation*. 1st ed. John Wiley & Sons, Ltd, 2018. https://doi.org/10.1002/9781118928806.

'GREEN DEMOLITION BY-LAW NO. 11023.' City of Vancouver British Columbia, 2014.

Hahn, Barbara. *Technology in the Industrial Revolution*. New Approaches to the History of Science and Medicine. Cambridge: University Press, 2020.

Heuvel, Dirk van den. 'D E C O N S T R U C T I O N'. Accessed 16 October 2023. http://deconstructionconference.nl/.

'Homepage | Opalis'. Accessed 27 February 2024. https://opalis.eu/en.

'Issued Permits', 3 October 2023. https://www.stcatharines.ca/en/building-and-renovating/issued-permits.aspx.

Hradil, Petr. 'Barriers and Opportunities of Structural Elements Re-Use'. VTT Technical Research Centre of Finland, 2014.

Jacobs, Jane. *Systems of Survival: A Dialogue on the Moral Foundations of Commerce and Politics*. 1st Vintage Books ed. New York: Vintage Books, 1994.

JRPass.com. 'Ise Grand Shrine: Everything You Need to Know about Japans Most Sacret Shinto Shrine'. Accessed 11 February 2025. https://www.jrpass.com/blog/ise-grand-shrine-everything-you-need-to-know-about-japans-most-sacret-shinto-shrine.

Kanters, Jouri. 'Design for Deconstruction in the Design Process: State of the Art'. *Buildings* 8, no. 11 (November 2018): 150. https://doi.org/10.3390/buildings8110150.

Kennedy, Christopher, John Cuddihy, and Joshua Engel-Yan. 'The Changing Metabolism of Cities'. *Journal of Industrial Ecology* 11, no. 2 (2007): 43–59. https://doi.org/10.1162/jie.2007.1107.

Madaster Global. 'Madaster: The Cadastre for Materials and Products'. Accessed 9 September 2024. https://madaster.com/.

Mah Hutton, Jane, and Alison Creba. 'Taking Apart Buildings and Systems: In Conversation with Mae Bowley of Re:Purpose Savannah' 92, no. 1 (2022).

March 05, Adam Redling Published and 2018. 'Construction Debris Volume to Surge in Coming Years'. Construction & Demolition Recycling. Accessed 9 February 2025. https://www.cdrecycler.com/news/global-volume-construction-demolition-waste/.

Marcus, J. S. 'A French Château Could Be Your Dream Home—If You Can Put It Back Together'. WSJ, 21 November 2023. https://www.wsj.com/real-estate/luxury-homes/a-french-chateau-could-be-your-dream-homeif-you-can-put-it-back-together-59b824ed.

Moe, Kiel, and Ryan E. Smith. *Building Systems: Design, Technology, and Society*. Abingdon, Oxon [England] ; New York, NY: Routledge, 2012.

'Municipal Solid Waste and Construction & Demolition Debris | Bureau of Transportation Statistics'. Accessed 11 April 2024. https://www.bts.gov/archive/subject_areas/freight_transportation/faf/faf4/debris.

Museum Chat The Official Blog of the St. Catharines Museum & Welland Canals Centre. 'History from Here: Garden City Arena', 24 October 2023. https://stcatharinesmuseumblog.com/2023/10/24/history-from-here-garden-city-arena/.

Niagara Falls Review. 'Demolition Permit Requested for Old St. Catharines General Hospital', 23 June 2017. https://www.niagarafallsreview.ca/news/niagara-region/demolition-permit-requested-for-old-st-catharines-general-hospital/article_94c36613-5a09-593c-8829-eab879d64d99.html.

N. Jackson, John, and Carol White. *The Industrial Structure of the Niagara Peninsula*. Department of Geography, Brock University, 1971.

Okwuosa, Ashley. 'A Former GM Plant in St. Catharines Is Leaking Toxic Chemicals'. *The Narwhal* (blog). Accessed 16 March 2024. https://thenarwhal.ca/st-catharines-former-gm-plant/.

'Ontario Street Corridor Secondary Plan Study | EngageSTC'. Accessed 16 March 2024. https://www.engagestc.ca/ontariostreetstudy?tool=survey_tool#tool_tab.

Praxes of Care - Ecology and Deconstruction, 2023. https://www.youtube.com/watch?v=7OrAIlrTHxo.

Price, Cedric, Samantha Hardingham, Architectural Association London, and Canadian Centre for Architecture, eds. *Cedric Price Works 1952-2003: A Forward-Minded Retrospective*. London: Architectural Association, 2016.

Rau, Thomas. *Material Matters: Developing Business for a Circular Economy*. London ; Routledge, Taylor & Francis Group, 2023.

'Re-Designation of Ontario Street Property Approved', 1 December 2020. https://www.stcatharines.ca/en/news/redesignation-of-ontario-street-property-approved.aspx.

Sennett, Richard. *The Craftsman*. New Haven: Yale University Press, 2008.

Sorensen, Jon R., and Joseph P. Ritz. 'ST. CATHARINES IN MOURNING FOR LOST JOBS RIPPLE EFFECT OF GM'S CUTBACKS LEAVES CITY REELING'. Buffalo News, 13 December 1992. https://buffalonews.com/news/st-catharines-in-mourning-for-lost-jobs-ripple-effect-of-gms-cutbacks-leaves-city-reeling/article_9956e40c-335b-54fa-871f-8b06c6391e76.html.

Standard, Grant LaFleche Spectator Reporter, The St Catharines. 'St. Catharines Hospital Demolition Reveals Hidden Tunnels, Underground Swimming Pool'. Niagara Falls Review, 27 November 2019. https://www.niagarafallsreview.ca/news/niagara-region/st-catharines-hospital-demolition-reveals-hidden-tunnels-underground-swimming-pool/article_5c2c7587-3db0-5ae1-9a06-2c74fd5eb37d.html.

'Sustainable Deconstruction Requirements | City of Boulder'. Accessed 19 September 2024. https://bouldercolorado.gov/services/sustainable-deconstruction-requirements.

Tatiya, Amol, Dong Zhao, Matt Syal, George H. Berghorn, and Rex LaMore. 'Cost Prediction Model for Building Deconstruction in Urban Areas'. *Journal of Cleaner Production* 195 (10 September 2018): 1572–80. https://doi.org/10.1016/j.jclepro.2017.08.084.

Tingley, Danielle Densley. 'Design for Deconstruction: An Appraisal'. *The University of Sheffield*, 2012.

'Your Home Our City: The 1904 Fire'. City of Toronto, 23 November 2017. Toronto, Ontario, Canada. https://www.toronto.ca/explore-enjoy/history-art-culture/online-exhibits/web-exhibits/web-exhibits-community-neighbourhoods/your-home-our-city/your-home-our-city-the-1904-fire/.

Walter, Karena. '$250M Plan for GM Site'. *St. Catharines Standard*, DEVELOPMENT, 12 December 2014.

———. 'Game over: Demolition Starts on Garden City Arena'. St. Catharines Standard, 4 July 2023. https://www.stcatharinesstandard.ca/news/niagara-region/game-over-demolition-starts-on-garden

LIST OF FIGURES

CHAPTER 00

Figure 0.1 Thesis Site Context Plan (former GM site) at 1:15 000. *Drawing by Author.*

Figure 0.2 Former GM Plant site, 2023. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 0.3 Former St. Catharines General Hospital site, 2023. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 0.4 Former Garden City Arena site, 2023. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 0.5 Current state of the GM site, 2023. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 0.6 Archival image of the McKinnon Industries (later the GM plant), 1937. *St. Catharines Museum & Welland Canals Centre. Retrieved from https://museum cityofstcatharines.msappproxy.net/objects/21546/mckinnon-industries?ctx=2ef9d9960b040bb74c6afd7f-6fe0e86051d3b8df&idx=39.*

Figure 0.7 "GM Plant Demolition, St. Catharines, Ontario – Drone", 2016. *Drone shot by Essence Media. Retrieved from https://www.youtube.com/watch?v=MGjAwD0C1Yk.*

Figure 0.8 Demolition activity at the GM plant, 2022. *Photo by Julianna D'intino. Retrieved from https://juliannadintino.com/Connecting-Rods.*

Figure 0.9 Current state of the GM plant building, 2023. *Photo by Author.*

Figure 0.10 Archival image of the St. Catharines General Hospital, 1929. *Brock University Library. Retrieved from https://exhibits.library.brocku.ca/s/arthur-a-schmon/item/7340#?c=&m=&s=&cv=&xywh=-30%2C-1%2C923%2C650.*

Figure 0.11 "St. Catharines General Hospital – Demolition", 2019. *Drone shot by Mike Duyn. Retrieved from https://www.youtube.com/watch?v=rg0OjPNNd3I.*

Figure 0.12 Demolition activity at the St. Catharines General Hospital, 2019. *Photo by Richard Hutton (Metroland). Retrieved from https://www.niagarathisweek.com/news/whats-going-on-here-st-catharines-general-hospital/article_cc2d6c10-a4b7-52d9-92f4-4ceaa256ff6e.html.*

Figure 0.13 Current state of the St. Catharines General Hospital building, 2024. *St. Catharines Standard. Retrieved from https://www.stcatharinesstandard.ca/news/niagara-region/were-not-one-to-sit-on-our-hands-new-owner-takes-on-former-st-catharines/article_545d5bd6-7d73-517c-979c-7e570c69a541.html.*

Figure 0.14 Archival image of the Garden City Arena, 1974. *Brock University Library, Retrieved from https://exhibits.library.brocku.ca/s/st-catharines-standard-niagara-falls-review-photograph-collection/media/16194.*

Figure 0.15 "Game over: Demolition starts on Garden City Arena", 2023. *St. Catharines Standard. Retrieved from https://www.stcatharinesstandard.ca/news/niagara-region/game-over-demolition-starts-on-garden-city-arena/article_04895566-9319-5784-bdd2-23721afd2d13.html.*

Figure 0.16 Demolition activity at the Garden City Arena, 2023. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 0.17 Current state of the Garden City Arena site, 2024. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 0.18 St. Catharines Plan at 1:50000, showing three major demolition sites discussed in text. *Drawing by Author.*

CHAPTER 01

Figure 1.1 A demolition site in downtown Toronto, surrounded by the rapid urbanization of high-rises (1), 2024. *Photo by Author.*

Figure 1.2 A demolition site in downtown Toronto, surrounded by the rapid urbanization of high-rises (2), 2024. *Photo by Author.*

Figure 1.3 STRUCTUEAL DEGENERATION: HYPOTEHTICAL CURVES, 1964. *Diagram by Peter Cowan, 'Studies in the Growth, Change and Ageing of Buildings', Ekistics 18, no. 105 (1964): 102–6.*

Figure 1.4 FUNCTIONAL OBSOLESCENCE, 1964. *Diagram by Peter Cowan. 'Studies in the Growth, Change and Ageing of Buildings', Ekistics 18, no. 105 (1964): 102–6.*

Figure 1.5 OPEN-PLAN (Berlin National Gallery, Mies van der Rohe, 1968), 1969. Photo by *Domus. Retrieved from https://www.domusweb.it/en/from-the-archive/2011/03/28/less-is-forever.html.*

Figure 1.6 CONCRETE BRUTALISM (Salk Institute, Louis Kahn, 1965), n.d. *Photo by Liao Yusheng. Retrieved from https://www.archdaily.cl/cl/02-209774/clasicos-de-arquitectura-salk-institute-louis-kahn-louis-kahn.*

Figure 1.7 MODULAR MEGASTRUCTURES (Nakagin Capsule Building, Kisho Kurokawa, 1972), n.d. *Photo by Arcspace. Retrieved from http://architecture-history.org/schools/METABOLISTS.html.*

Figure 1.8 EMBODYING OBSOLESCENCE AESTHETICS (Potteries Thinkbelt, Cedric Price, 1964-66), 1964-66. *Drawing by Cedric Price. Retrieved from https://www.moma.org/collection/works/849*

Figure 1.9 Rust Belt parameter across the border. It's worth noting that the Rust Belt has no fixed boundary, as it is a broad term encompassing diverse economic experience rather than by natural borders. Drawing by Author. P*arameter derived from: Yolande Pottie-Sherman, 'Immigration Policy and Less-Favoured Regions and Cities: Comparing Urban Atlantic Canada and the US Rust Belt', Springer, IMISCOE Research Series, 2024, https://doi.org/10.1007/978-3-031-55680-7_6.*

Figure 1.10 Bulldozer patent, 1932.

Figure 1.11 A demolition site in downtown Toronto, 2024. *Photo by Author.*

Figure 1.12 Total Approved Capacity of Landfill sites vs Remaining, and expected year for reaching capacity. *Graph by Author. Data derived from https://open.canada.ca/data/en/dataset/c7c19fd6-d004-46d1-83cf-cdd687c3588e.*

Figure 1.13 Estimate travel path from Ontario to U.S. landfills for cheaper tipping fees. *Drawing by Author.*

Figure 1.14 Niagara Waste Systems Limited Walker South Landfill, 2023. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 1.15 Humberstone – Niagara Region, 2023. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 1.16 Niagara Regional Road 12 – Niagara Region, 2023. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 1.17 St. Catharines Plan at 1:50000, showing heritage designated districts against three major demolition sites discussed in Chapter 00: Introduction. *Drawing by Author.*

Figure 1.18 Queen Street Heritage Conservation District Boundary, 1989. *Retrieved from: 'The Queen Street Heritage Conservation District Study: District Plan", David Cuming and Associates, Unterman McPhail Heritage Resource Consultants, and Wendy Shearer Landscape Architect Limited, 1989.*
Figure 1.19 Yates Street and Area Heritage Conservation District Boundary, 1994. *Retrieved from: 'Yates Street and Area Heritage Conservation District Study: Background Report', The City of St. Catharines Planning Department, 1994.*

Figure 1.20 Port Dalhousie Heritage Conservation District Boundary, 2000. *Retrieved from: 'Heritage Conservation District Study: Port Dalhousie Heritage Conservation District City of St. Catharines', Heritage Resources Centre University of Waterloo, 2012.*

Figure 1.21 Power Glen Heritage Conservation District Boundary, 2010. *Retrieved from: 'Power Glen: Heritage Conservation District Plan', The City of St. Catharines, Planning Services Department and the St. Catharines Heritage Committee, in Association with the Power Glen Community, 2010.*

Figure 1.22 30-32 Academy Street. Yellow highlighting architectural elements described for the heritage registration. *Street Image. Retrieved from https://earth.google.com/web/.*

Figure 1.23 "City of St. Catharines Register", 2024. *Retrieved from https://www.stcatharines.ca/en/building-and-renovating/heritage-properties-and-conservation-districts.aspx.*

Figure 1.24 A demolition site in downtown Toronto: an example of facadism, 2014. *Photo by Author.*

Figure 1.25 Facadism diagram. *Drawing by Author.*

CHAPTER 02

Figure 2.1 Re:Purpose Savannah's outdoor storage space, 2024. *Photo by Author.*

Figure 2.2 Catalytic diagram representative of the systemic networked relation of forces and factors contingent on architects, the work of architecture and architectural works. *Retrieved from: Kiel Moe and Ryan E. Smith, 'Building Systems: Design, Technology, and Society', Routledge, 2012.*

Figure 2.3 Plan and elevation of Ise Shrine. *Retrieved from https://www.jrpass.com/blog/ise-grand-shrine-everything-you-need-to-know-about-japans-most-sacret-shinto-shrine.*

Figure 2.4 Roman Forum, 2022. *Photo by Author.*

Figure 2.5 Bordeaux château disassembled and stored in warehouse, 2023. *Retrieved from A French Château Could Be Your Dream Home—If You Can Put It Back Together - WSJ.*

Figure 2.6 Dismantled marble slabs. *Retrieved from: Lionel Devlieger, 'The Raw, the Cooked, and the Overdone on What Makes Building Materials Salvageable (or Not) in North Western Europe', FAKTUR, no. 03, 2020.*

Figure 2.7 Salvaged bricks displayed at Re:Purpose Savannah's yard, 2024. *Photo by Author.*

Figure 2.8 Building life cycle stages with layered information. *Diagram by Author.*

Figure 2.9 Stewart Brand's "Shearing Layers" diagram. *Diagram by Author informed by: Stewart Brand, 'How Buildings Learn: What Happens After They're Built', Viking Press, 1994.*

Figure 2.10 Example of brick building deconstruction. *Diagram by Author.*

Figure 2.11 Comparison between building demolition and deconstruction. *Retrieved from: A. Tatiya et al., 'Cost prediction model for building deconstruction in urban area', Journal of Cleaner Production, 2017.*

Figure 2.12 Essential parts of a house. *Retrieved from: Vincent Phelan, 'The Care and Repair of the House' United States Government Printing Office, Washington, 1931.*

Figure 2.13 Types of tools used for salvaged and deconstruction. *Diagram by Author informed by: 'Introduction to Deconstruction: A Comprehensive Training Textbook', Oregon State Edition, Building Materials Reuse Association, 2017.*

Figure 2.14 North American Cities mandating deconstruction. *Ordinance paused in Milwaukee as of October 2023 due to challenges of limited markets for reclaimed materials. Drawing by Author.

Figure 2.15 Building life cycle stages with layered information. *Diagram by Author.*

Figure 2.16 Erin house deconstruction site, 2020. *Retrieved from https://www.ouroborosdecon.com/projects/erin-4643e.*

Figure 2.17 Ouroboros facility 1 to 1000. *Drawing by Author.*

Figure 2.18 Distance from deconstruction sites to facility. *Drawing by Author.*

Figure 2.19 Image of the Ouroboros warehouse, 2023. *Photo by Author.*

Figure 2.20 Image of the Ouroboros warehouse, 2023. *Photo by Author.*

Figure 2.21 Crest Hill bungalow deconstruction site, 2021. *Photo by Jesse Kellem.*

Figure 2.22 Re:Purpose Savannah facility 1 to 1000. *Drawing by Author*

Figure 2.23 Distance from deconstruction sites to facility. *Drawing by Author.*

Figure 2.24 Image of the Re:Purpose Savannah "yard", 2024. *Photo by Author.*

Figure 2.25 Image of the Re:Purpose Savannah "yard", 2024. *Photo by Author.*

Figure 2.26 Lebeau building deconstruction site, 2020. *Retrieved from: Lionel Devlieger, 'The Raw, the Cooked, and the Overdone on What Makes Building Materials Salvageable (or Not) in North Western Europe', FAKTUR, no. 03, 2020.*

Figure 2.27 RotorDC facility 1 to 1000. *Drawing by Author*

Figure 2.28 Distance from deconstruction sites to facility. *Drawing by Author.*

Figure 2.29 Image of the RotorDC facility. *Retrieved from https://rotordc.com/.*

CHAPTER 03

Figure 3.1 Conceptual sketch of an imaginary industrial site illustrating the contingent relationship of technological development and the urban fabric, both in socially and physically. *Drawing by Author.*

Figure 3.2 "Typologies". *Retrieved from: Bernd and Hilla Becher, 'Typologies', 2024. (from left to right, top to bottom: 1-Baltimore, Maryland, USA (1981), 2-Gutehoffnungshütte, Oberhausen, D (1972), 3-Aliquippa, Pennsylvania, USA (1986), 4-Bloomdale, Ohio, USA 1977, 5-Liège, B (1968), 6-Hayange, Moselle, F 1980, 7-Aiseau Presle, Charleroi, B (1977), 8-Siège Espérance, Borinage, B (1971), 9-Fosse Dourges no. 4, Hénin Liétard, Nord, F (1978), 10-Zeche Zollverein, Essen, D (1998), 11-Zeche Eiberg, Essen, D (1968), 12-Zeche Concordia, Oberhausen, D (1968)).*

Figure 3.3 TABLE I.B. Annual Employment Change in Manufacturing, 1965-1970. *Retrieved from: John N. Jackson and Carol White, 'The Industrial Structure of the Niagara Peninsula', Department of Geography, Brock University, 1971.*

Figure 3.4 Canal and Road Transport and Settlement, 1825-50. *Retrieved from: John N. Jackson and Carol White, 'The Industrial Structure of the Niagara Peninsula', Department of Geography, Brock University, 1971.*

Figure 3.5 Ariel drawing of the McKinnon Industry factory. *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.6 GENERAL MOTORS OF CANADA LIMITED ST. CATHARINES. *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.7 TABLE IV.A MANUFACTURING EMPLOYMENT IN ST. CATHARINES - THOROLD, 1970, BY DETAILED INDUSTRIAL GROUP. *Retrieved from: John N. Jackson and Carol White, 'The Industrial Structure of the Niagara Peninsula', Department of Geography, Brock University, 1971.*

Figure 3.8 St. Catharines Region Manufacturing Employment 1970. *Chart by Author informed by John N. Jackson and Carol White, 'The Industrial Structure of the Niagara Peninsula', Department of Geography, Brock University, 1971.*

Figure 3.9 Newspapers related to GM gathered by St. Catharines Museum and Welland Canals Centre. *Retrieved from St. Catharines Public Library.*

Figure 3.10 Potential Proposed Draft Plan by Bayshore Groups, 2015. *Retrieved from St. Catharines Public Library.*

Figure 3.11 Site plan of the former GM Plant site. *Drawing by Author.*

Figure 3.12 South Elevation (as-found). *Drawing by Author.*

Figure 3.13 East Elevation (as-found). *Drawing by Author.*

Figure 3.14 1934: When the property was first purchased by McKinnon in 1900 it was a single building on 54.7 acres of land. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.15 1954: Much of the area around the original building is still farmland. Looking past the GM plant, there has been much development yet. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.16 1965: Prosperity and development continue for the GM industry. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.17 2000: Continued growth of buildings and parking lots with more development added to the area. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.18 2010: The year General Motors officially closed. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.19 2013: Condemned property with nothing but grand, vacant buildings and parking lot. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.20 2018: Drastic change of landscape. 75% of the plant demolished. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.21 2020: The site has been left in its half-demolished state to this day. *Satellite image. Retrieved from https://earth.google.com/web/*

Figure 3.22 GENERAL MOTORS OF CANADA LTD. ST. CATHARINES AXLE PLANT. *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.23 AXLE PLANT WEST SIDE. *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.24 AXLE PLANT EAST SITE. *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.25 Construction document (A). *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.26 Construction document (B). *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.27 Construction document (C). *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.28 Construction document (D). *Retrieved from the St. Catharines Museum and Welland Canals Centre. Archival Drawing.*

Figure 3.29 View of the West Plant, 2023. *Photo by Author.*

Figure 3.30 View of the East Plant, 2023. *Photo by Author.*

Figure 3.31 View of the West Plant with leftover debris from demolition beyond (A), 2023. *Photo by Author.*

Figure 3.32 View of the West Plant with leftover debris from demolition beyond (B), 2023. *Photo by Author.*

Figure 3.33 View of the West Plant from Ontario Street (A), 2023. *Photo by Author.*

Figure 3.34 View of the East and West Plant from Ontario Street (A), 2023. *Photo by Author.*

Figure 3.34 View of the East and West Plant from Ontario Street (B), 2023. *Photo by Author.*

Figure 3.36 View of the West Plant from Ontario Street (B), 2023. *Photo by Author.*

Figure 3.37 OPALIS website. Example of the search engine showing available providers for salvaged bricks. *Retrieved from https://opalis.eu/en.*

Figure 3.38 Building stocks within St. Catharines' urban fabric. *Drawing by Author.*

Figure 3.39 Urban agencies in charge of circulating material matters in St. Catharines. Materials constantly circulate through our cities, taking various forms, whether as products, resources, or debris. Recognizing the urban ecology is crucial in assigning the appropriate agency to improve this movement and ensure its circularity. *Drawing by Author.*

Figure 3.40 Example of exploded (deconstructed) 3D model for material quantification. *Drawing by Author.*

Figure 3.41 St. Catharines Building Permit Analysis: 2023-2024 (A). *Graphics by Author.*

Figure 3.42 St. Catharines Building Permit Analysis: 2023-2024 (B). *Graphics by Author.*

Figure 3.43 Salvageable Material Profiles. *Graphics by Author.*

Figure 3.44 Typical single detached dwelling. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.45 Typical multi-housing. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.46 Typical commercial building. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.47 Typical detached garage. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.48 Typical mid-rise building. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.49 Typical industrial building. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.50 Typical institutional building. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.51 Typical high-rise building. *Satellite image. Retrieved from https://earth.google.com/web/.*

Figure 3.52 Overview of the total material volume with residual value in St. Catharines placed on the thesis site. *Drawing by Author.*

CHAPTER 04

Figure 4.1 View of the proposed Material Works building from the field. *Visual by Author.*

Figure 4.2 Conceptual sketches (A). *Drawing by Author.*

Figure 4.3 Building waste hierarchy. *Drawing by Author.*

Figure 4.4 Overall site plan diagram. *Drawing by Author.*

Figure 4.5 Programming diagram. *Drawing by Author.*

Figure 4.6 Materials movement diagram. *Drawing by Author.*

Figure 4.7 Idea exchange diagram. *Drawing by Author.*

Figure 4.8 View of the warehouse. *Visual by Author.*

Figure 4.9 Context view. *Drawing by Author.*

Figure 4.10 Context plan 1:5000. *Drawing by Author.*

Figure 4.11 Site plan 1:750. *Drawing by Author.*

Figure 4.12 Ground floor plan 1:750. *Drawing by Author.*

Figure 4.13 Second floor plan 1:750. *Drawing by Author.*

Figure 4.14 Third floor plan 1:750. *Drawing by Author.*

Figure 4.15 Conceptual sketches (B). *Drawing by Author.*

Figure 4.16 Deconstruction equipment sketches. *Drawing by Author.*

Figure 4.17 Activities within the warehouse and material storage area. *Drawing by Author.*

Figure 4.18 Isometric section of the warehouse. *Drawing by Author.*

Figure 4.19 DIFFERENT USAGE OF SCAFFOLDING BAYS. *Drawing by Author.*

Figure 4.20 EMPTY FAÇADE. *Drawing by Author.*

Figure 4.21 SCENARIO: 22 SINGLE DETACHED DWELLINGS DECONSTRUCTED ALL AT ONCE (100% OF THE DIMENSIONAL LUMBER RECLAIMED). *Drawing by Author.*

Figure 4.22 Stewart Brand's "Shearing Layers". *Drawing by Author.*

Figure 4.23 Warehouse exterior shelving capacity. *Drawing by Author.*

Figure 4.24 Conceptual sketches (C). *Drawing by Author.*

Figure 4.25 GRID. *Drawing by Author.*

Figure 4.26 Design development models (A). *Photo by Author.*

Figure 4.27 GROUND FLOOR. *Drawing by Author.*

Figure 4.28 Design development models (B). *Photo by Author.*

Figure 4.29 SECOND FLOOR. *Drawing by Author.*

Figure 4.30 Design development models (C). *Photo by Author.*

Figure 4.31 THIRD FLOOR. *Drawing by Author.*

Figure 4.32 Design development models (D). *Photo by Author.*

Figure 4.33 Elevations and sections of the edu corridor (East elevation_01, West elevation_01, Section A-A). *Drawing by Author.*

Figure 4.34 Elevations and sections of the warehouse building (East elevation_02, West elevation_02, Section B-B). *Drawing by Author.*

Figure 4.35 Elevations and sections of the application building and the overall site (South elevation, North elevation, Section C-C). *Drawing by Author.*

Figure 4.36 Edu corridor wall section detail 1:50. *Drawing by Author.*

Figure 4.37 Warehouse wall section detail 1:50. *Drawing by Author.*

Figure 4.38 Materials might first arrive at Material Works as what appears to be a pile of debris - not unlike the rubble scattered around any waste management site. But once these piles are not only sorted, but processed, organized and arranged, their status is reinstated and their lost value once again recognized. This work goes beyond mere material management - it is an act of curation, possible with significant time investment, an eye for details and the appreciation for the art of balancing aesthetics and efficiency. *Visual by Author.*

Figure 4.39 The warehouse architecture functions as an urban machine, embracing the efficiency of its industrial nature. Permeable circulation system allows for continuous movement across the entire body. The bay doors fold and unfold from all sides of the building, facilitating the arrival, departure, and the transfer of materials. *Visual by Author.*

Figure 4.40 The vast volume of the warehouse accommodates countless activities. The vibrant sounds of equipment, shifting materials, and people in motion echoes across the open void. Along with sound, light permeates through the building freely, filling each bay with a soft, diffused glow. *Visual by Author.*

Figure 4.41 With no fixed program, the education corridor invites learners to a space that must be activated to take shape. Collaboration is essential, and exchange of knowledge is encouraged. This is not a place for individuals to passively acquire information but a dynamic environment where agencies inform each other, driving the progression of circular building practices. The visual connection from this corridor to the courtyard and the warehouse beyond, along with staircases leading to the ground-floor workshop spaces supports the collaborative nature of these initiatives. *Visual by Author.*

Figure 4.42 At first glance, the Material Works might appear to be a park. Beyond the gabion wall filled with building materials, the large open field of vegetation is carved with paths revealed through the movement of people across the site, with curated material stocks placed along the way. There is great dynamism that can be observed even from the street. The glass panels, seemingly irregular, come together as an elegant facade running along the entire corridor. Looking toward the brick building at the back, it becomes clear that even a single bay is composed of multiple brickworks, most likely sourced from various existing buildings. The experimentation wall embodies this diverse organization - an assembly that appears incomplete, yet deliberately composed with intention. *Visual by Author.*

Figure 4.43 Future speculation by phases. *Drawing by Author.*

00 INTRODUCTION

MATERIAL WORKS: Optimizing Material Circularity through reversing Architecture

Introduction

Alarmed by the rapid transformation and erasure of our architectural heritage and accumulation of material waste, this thesis questions the 21st-century norms of the linear construction industry. It examines contemporary circular building practices including policy making, salvaged material markets, and deconstruction work, advocating for a paradigm shift– starting from what already exists within our built environment.

"Just like the limited surface of the earth is charted in a land registry, we need to register the limited material supplies of our planet in a material registry" [1]

Thomas Rau (Material Matters: Developing Business for a Circular Economy, 7)

1 Thomas Rau, Material Matters: Developing Business for a Circular Economy (London ; Routledge, Taylor & Francis Group, 2023). 7.

Any individual who's lived in St. Catharines probably knows the former GM plant between Highway 406 and the Queen Elizabeth Way. Just outside of the city's growing downtown, this industrial landscape has been fenced up since 2015 when the demolition work of the former GM Plant began on site. Visible from the satellite imagery, the enormity of the building footprint speaks to the significance of its operation at the time [Fig. 0.2]. If it wasn't for the proximity of the highways, or the Geographic Information System mapping, a visitor could easily miss it even if they were to drive right through the Ontario Street corridor that splits the East and West site. The fences do a decent job containing the half-demolished structure hidden away from street view. However, its prominence covering the entire block, the accumulation of no-trespassing signs over the years and the broken rubble from the unfinished demolition work seeps through the steel mesh border, while the future of the site remains uncertain as it has been for the past decade. The physical evidence of the ephemerality of architecture and constant change in our urban landscape can be witnessed in our every day travels.

In the same years that the GM Plant demolition began, another emblematic 19th century brick structure – the St. Catharines General Hospital – was taken down [Fig. 0.3]. Since its opening in 1870 and closure in 2013, the site awaits a new residential development.[2] While Panoramic Properties purchased the building in 2017 with a plan to reuse the existing structure, most of the building was demolished.[3] All patients and medical staffs were relocated to the new hospital building in west St. Catharines on Fourth Avenue; the only architectural element preserved on-site from the existing structure – the "arch" – stands alone behind the construction fence while the bricks are said to have been sold during the demolition phase.

2 Grant LaFleche Spectator Reporter Standard The St Catharines, 'St. Catharines Hospital Demolition Reveals Hidden Tunnels, Underground Swimming Pool', Niagara Falls Review, 27 November 2019, https://www.niagarafallsreview.ca/news/niagara-region/st-catharines-hospital-demolition-reveals-hidden-tunnels-underground-swimming-pool/article_5c2c7587-3db0-5ae1-9a06-2c74fd5eb37d.html.

3 'Demolition Permit Requested for Old St. Catharines General Hospital', Niagara Falls Review, 23 June 2017, https://www.niagarafallsreview.ca/news/niagara-region/demolition-permit-requested-for-old-st-catharines-general-hospital/article_94c36613-5a09-593c-8829-eab879d64d99.html.

Fig. 0.1

Thesis Site Context Plan (former GM site) 1 : 15 00

The Garden City Arena from the 1930's, like many other sports arenas in the city, was also demolished to make way for new development, despite the absence of clear plans in place since its demolition work in 2023.[4] [Fig. 0.4] The grand structure once welcomed visitors on the east side of downtown St. Catharines, just off the Ontario Highway 406. Built in response to the city's growing love for sports, it is now entirely untraceable, buried beneath the grass field covering the site today. Possible uses of a high-density residential development, or a new location for the fire services HQ, is in discussion for the property, while the structure itself is known to have been decommissioned due to the cost of fixing mechanical, structural, functional and aesthetic issues.[5]

4 'History from Here: Garden City Arena', Museum Chat The Official Blog of the St. Catharines Museum & Welland Canals Centre, 24 October 2023, https://stcatharinesmuseumblog.com/2023/10/24/history-from-here-garden-city-arena/.

5 Karena Walter, 'Game over: Demolition Starts on Garden City Arena', St. Catharines Standard, 4 July 2023, https://www.stcatharinesstandard.ca/news/niagara-region/game-over-demolition-starts-on-garden-city-arena/article_04895566-9319-5784-bdd2-23721afd2d13.html.

In St. Catharines, similar to many metropolitan cities across North America, existing building stocks diminish into thin air, and the remnants of the urban fabric—holding historic, environmental, and economic value—are demolished into rubble to make way for an uncertain future. The three cases mentioned: GM Plant, St. Catharines General Hospital, and Garden City Arena, are large and significant, and so the public and the local press notice their appearance. Such demolition is continual, for all types of buildings, although their causes of abandonment and the rate at which they're demolished vary.

The transformation of the physical architecture post-demolition does not stop there. Demolition rubble scattered on the same site then travels to an available facility to be either recycled or dumped in the landfill. This movement is often hard to trace due to insufficient regulatory frameworks, fragmented accountability among contractors, and the absence of standardized tracking systems. Consequently, the movement of debris often occurs through unregulated channels, with little to no documentation of its final destination. This linear movement of materials is, however, a rather recent phenomena rooted in the 21st century planned obsolescence-ideologies, in which demolition is incentivized by tax systems that prioritize rapid development rather than preservation of the built structure. Demolition is a quick and cheap way to provide the real estate a clean slate for new development. Through this process, the value of all physical matter which initially was manufactured to form the building, is lost. It's an act of violence and erasure that has major environmental and cultural consequences to our urban fabric.

Blinded by today's standards, it is easy to forget that what was once built, can be un-built, dis-mantled, deconstructed and stored for future usage. Reusing today's urban building material stock is highly dependent on the treatment of buildings post-use. Demolition turns them into useless debris, and deconstruction allows for individual material blocks to be salvaged for meaningful reapplication. While circulating second-hand materials does occur today, it's often on a small scale and done informally due to the lack of systemic structure that supports

1

2

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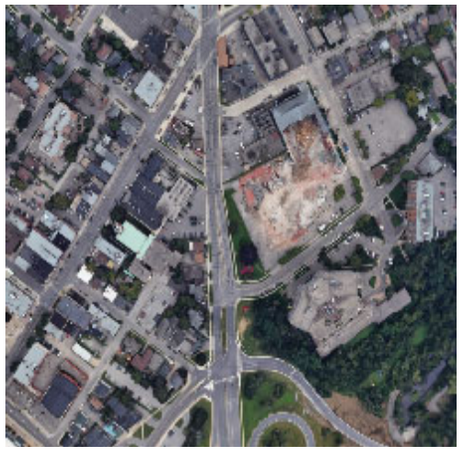


Fig. 0.2
Former GM Plant site

Fig. 0.3
Former St. Catharines General Hospital site

Fig. 0.4
Former Garden City Arena site

Satellite images
NTS.

Fig. 0.5

Satellite image of the current state of the former GM site. (Google Earth, 2023)

this process. There has been little to no effort in building a database of the urban metabolism when it comes to building materials, in contrast to water and food waste management which moves much more quickly and continuously. With no incentives and systematic procedures for deconstruction work, only a handful of buildings are dismantled, meaning the volume of salvaged materials remain low, and therefore challenging to grow market demand to continue the circulation of second-hand materials.

As deconstruction practices and corresponding regulatory changes are emerging in support of this paradigm shift, there is a key missing piece in speculating a circular future: the absence of infrastructure capable of streamlining the movement of these materials. In response, this thesis posits the largest abandoned industrial landscapes in the Niagara region – the former GM Plant site – as a key architecture intended to facilitate the circularity of existing building materials in the city of St. Catharines by processing, storing, and selling 'mined' building components, thereby adding value to the extension of the physical assets of the built environment. The hub imagines educational programs, a salvaged material handling warehouse, and a box store designed to commercialize and circulate the building assets of St. Catharines in one site; the cooperative nature of these initiatives is actualized through the physical architecture. The industrial landscape presents us with an opportunistic site, in which the mass rubble of building materials from the constant demolition throughout the city is re-imagined to be carefully salvaged through deconstruction, collected and recorded as a means to preserve our built environment at the scale of both an urban landscape, down to individual building materials.

In order to estimate the quantity of annual materials coming out of demolition or deconstructed buildings in St. Catharines, building permits – key formal documents for recording building stock – were analyzed. Through this legal record required to commence any significant building projects, including demolition, we can examine the constant changes occurring to the city's building assets. Different building types are constructed and demolished at different rates, with various materials invested into or broken down with them. St. Catharines' permits issued in 2023-2024 were analyzed to quantify and identify material types that could be reused if deconstructed instead of demolished in a one year span. While the number is subject to change, this methodology provides insight to how such legal document can be utilized to build a database for city scale reuse. This study informs the design of the new reuse-facility, in its scale, aesthetics and programmatic organization, exploring the potential of an abandoned industrial site to be transformed into a new infrastructure to meet today's social, environmental and cultural need.

1:
(FORMER) GM PLANT SITE

Fig. 0.6

Fig. 0.7

Fig. 0.8

Fig. 0.9

2:
(FORMER) ST. CATHARINES GENERAL HOSPITAL SITE

Fig. 0.10

Fig. 0.11

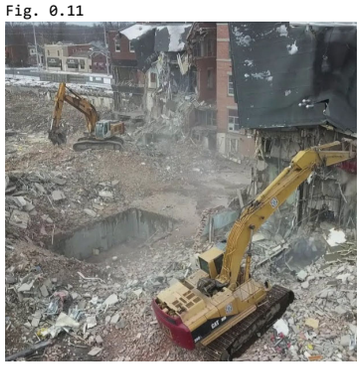


Fig. 0.12

Fig. 0.13

3:
(FORMER) GARDEN CITY ARENA SITE

Fig. 0.14

Fig. 0.15

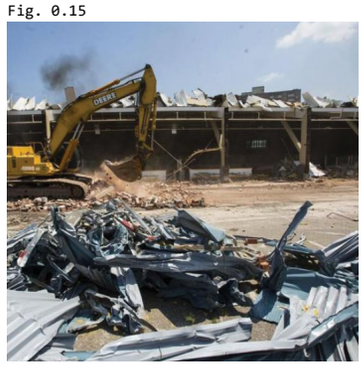


Fig. 0.16

Fig. 0.17

Fig. 0.18

St Catharines Plan
1 : 50 000

Fig. 1.1

A demolition site in downtown Toronto, surrounded by the rapid urbanization of high-rises (photo by author, 2024)

01 THE LINEARITY OF THE 21ST-CENTURY BUILDING ECONOMY

1.1 Obsolescence of Buildings and the Myth of Fate

The cases of the former GM Plant, St. Catharines General Hospital, and Garden City Arena exemplify the phenomenon of architectural obsolescence–the sudden devaluation and expendability of the existing. Once the architecture's initial purpose no longer met the city's demand, the structures were abandoned, demolished, and their site left vacant for an unknown future.

Evolving out of early-twentieth-century US capitalist real estate development, the paradigm of obsolescence spread globally in the mid-century urban and social realms before impacting architecture directly, leading to the sudden loss of value and utility of buildings and cities.[6] Daniel M. Abramson begins his book, "Obsolescence", with a visual depiction of the demolition work of the Gillender building in New York, after only 13 years of operation since its completion in 1897. He quotes the real estate executive, Cecil Evers, claiming that the building had reached the "limit of its commercial life no longer able to earn a proper return on the land it stands on." Many buildings in the late 19th to 20th century in New York and Chicago followed the trend of obsolescence, as they were demolished between 5-28 years of usage, including landmarks of industrial civilization: Grand Central Terminal (1903), Plaza Hotel (1906), and Western Union Building (1914).

6 Daniel M. Abramson, *Obsolescence: An Architectural History* (Chicago ; The University of Chicago Press, 2016). 2.

Chapter 1 introduces the foundation of the "obsolescence" theory, tracing its emergence in the early 20th century and its establishment as a doctrine of rapid (presumed) building devaluation by the 1960s. This set the stage for the modern linear construction industry model and incentivized demolition. During the progression of the U.S. federal income tax code following the enactment in 1909, corporations found leeway to maximize their income from deduction allowances. Like income-producing equipment, it was recognized that buildings' value declined with time as they went through physical wear and tear, and was affected by economic obsolescence. The deductible costs soon allowed obsolescence-related losses of value, "apart from physical depreciation," as the Supreme Court noted in 1932, shaping American business practices and building politics. The losses of value were reflected in the depreciation allowances in the tax code, driven by evolving technology, rising property values, and changing land use, where the new inevitably outpaces and devalues the old. Retail typologies change every ten to fifteen years, hotels are vulnerable to quick changes in style and taste and industrial landscapes evolve and decline based on current business trends.[7] Investors can also benefit financially from obsolescence within the depreciation allowances of the U.S. corporate income tax code by writing off the building investment as rapidly as possible to decrease tax liability. Business plans, immediate economic interests, and aesthetic preferences have come to conjunctly shape and determine buildings' shortened lifespan.

7 Maya Przybylski and Lola Sheppard, eds., *At Extremes*, Bracket, almanac 3 (Barcelona: Actar, 2015).

Fig. 1.2

A demolition site in downtown Toronto, surrounded by the rapid urbanization of high-rises (photo by author, 2024)

1.1.1. Obsolescence

The 1960s marked an era of intense confrontation with obsolescence. Peter Cowan, director of the Hospital Research Project at University College London, published *Studies in the Growth, Change, and Ageing of Buildings* in 1964. His diagrams: "Structural Degeneration" [Fig. 1.3] and "Functional Obsolescence" [Fig. 1.4], illustrate the inevitability of architectural devaluation imposed by the obsolescence theory, where performance in both structural and programmatic relevancy constantly declines while this process can only be temporarily mitigated through rebuilding or adaptation. The rate of this process, however, cannot be predicted. He states, "To impose patterns of natural growth upon buildings is not only irrelevant but wrong".[8] While all too complex and contingent to be understood as a projection, architectural function and worth became minimized to be quantifiable, and was necessarily decreased in theory to ensure economic growth above all else. The fate of buildings came to be determined by tax rules, further encouraging the economic thinking to the built environment.

8 Peter Cowan, 'Studies in the Growth, Change and Ageing of Buildings', *Ekistics* 18, no. 105 (1964): 102–6.

Designing with obsolescence in mind first involves anticipating its degrading affect on a building, ensuring a building's lifespan was not determined by programmatic functional change. By pre-empting this process, architects can focus on minimizing its effects by creating adaptable structures that can accommodate changing functions, ultimately extending their lifespan. In the case obsolescence's deformations has already begun, strategic design application can stabilize the architectural form, ensuring aesthetic continuity. Lastly, obsolescence can be accepted entirely, and rather be taken as an opportunity to form a new architectural expression. In comparison to the two previous examples of repair or stabilization, this strategy embodies the temporality of architecture in the aesthetic itself. Those horrified by its implications of ephemerality and waste sought to reverse the phenomena through tactics of preservation, adaptive reuse, and ecologism[9].

9 Abramson, *Obsolescence*. 4.

Such ideologies were manifested in architectural designs globally, of open-plan interior with flexibility accepting of the changefulness of obsolescence, modular megastructures joining together long and short-life components, and concrete brutalist buildings which reasserted traditional values of permanence and durability. Mies van der Rohe's Berlin National Gallery featured a factory-shed design for flexibility in changing conditions [Fig. 1.5]. Louis Kahn's Salk Institute introduced the interstitial system, layering factory loft spaces [Fig. 1.6]. Megastructures, often tied to the Japanese Metabolists, balanced different rates of change and replacement [Fig. 1.7]. Experimental designs like Peter Cook's Plug-In City and Cedric Price's Potteries Thinkbelt visualized obsolescence in architecture itself, typically manifested with embracing the industrial aesthetics while embodying the versatile functionality of the speculative architecture [Fig.

Fig. 1.3

STRUCTURAL DEGENERATION: HYPOTHETICAL CURVES (Peter Cowan, 1964)

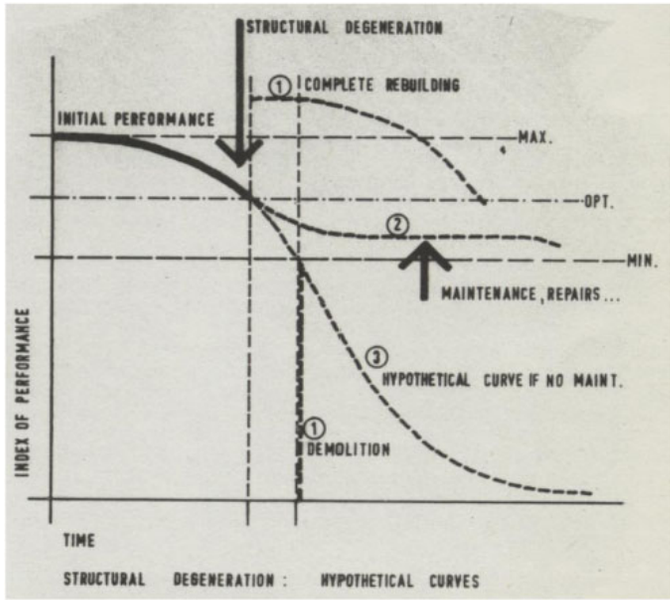
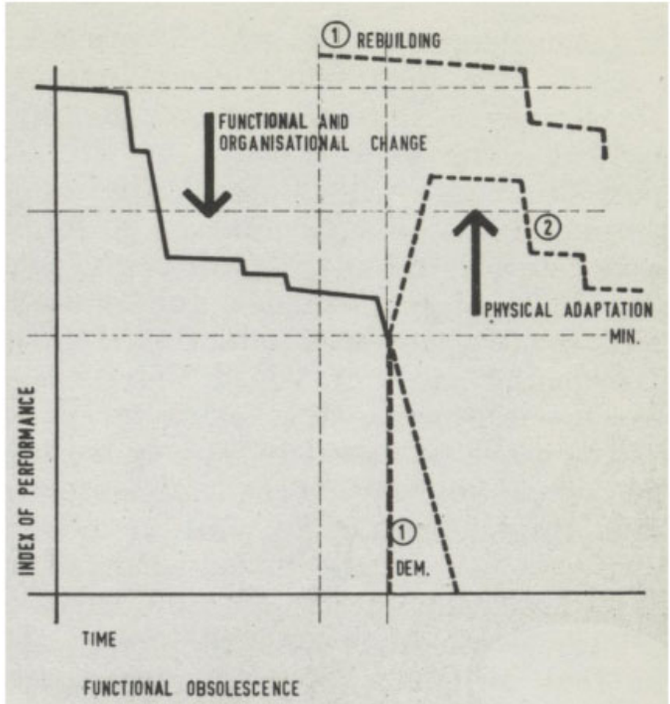


Fig. 1.4

FUNCTIONAL OBSOLESCENCE (Peter Cowan, 1964)



1.8]. The works of Sim Van der Ryn is emblematic of the era's emerging interest of sustainability in architectural discourse in the mid-1980s. He claimed that cities are a part of a complex ecosystems, and that objectives around resource conservation can be directly applied to the scale of individual buildings by using low-tech, salvaged materials[10]. The overarching motif of these collective rise of design strategies, whether accepting or less accepting of obsolescence's logic, was valuing conservation and adaptability over expendability.

10 Sim Van der Ryn, *Sustainable Communities: A New Design Synthesis for Cities, Suburbs and Towns*, New Catalyst Books ed. (Gabriola Island, BC: New Catalyst Books, 2008).

Fig. 1.5

OPEN-PLAN
(Berlin National Gallery, Mies van der Rohe, 1968)

Fig. 1.7

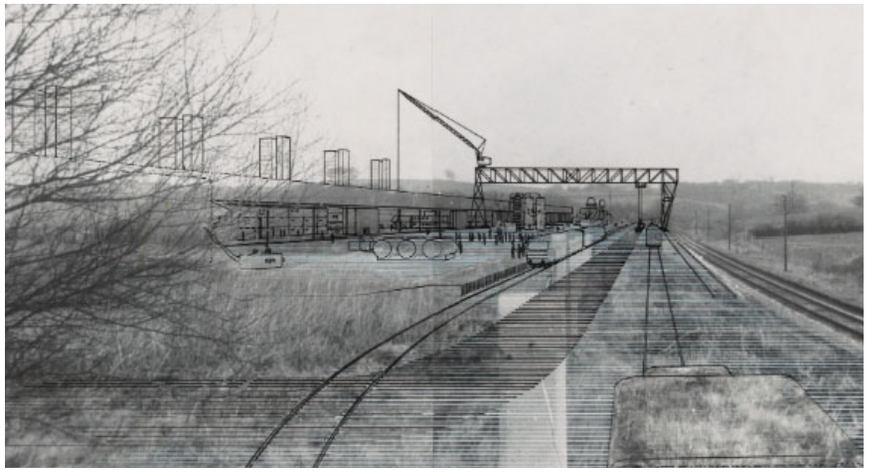
MODULAR MEGASTRUCTURES
(Nakagin Capsule Building, Kisho Kurokawa, 1972)

Fig. 1.6

CONCRETE BRUTALISM
(Salk Institute, Louis Kahn, 1965)

Fig. 1.8

EMBODYING OBSOLESCENCE AESTHETICS
(Potteries Thinkbelt, Cedric Price, 1964-66)



By today's industry standards, market value declines faster than a building's lifespan, and buildings become prone to abandonment followed by demolition in favour of the real estate market. The phenomenon was observed not only from presumption of shortened lives of individual buildings, but also in the broader principles of urban planning.[11] Coupled with the rapid destruction of buildings driven by fluctuating property values, the functional obsolesce of post-war industrial landscapes in North America led to the growth of abandoned architectural entities. In cities which relied on manufacturing industries in particular, factory typologies, which once facilitated the operation, became obsolete as the supported industry trends waned and the industry no longer met the immediate economic interest of the city.

11 Abramson, *Obsolescence*. 3.

This was the most evident in cities that saw great economic prosperity in the late 19th century with the boom of the steel industry. Entering mid-20th century, North American cities stretching from New York to the Midwest were shrinking with accelerating de-industrialization in vast landscapes of obsolescence. Notably named the "Rust Belt", this growing patterns of vacancy was among the most visible manifestations of industrial restructuring, a period marked by the abandonment of urban-industrial districts and expansion of the service sectors[12]. [Fig. 1.9]

12 Nicholas Lynch, 'Remaking the Obsolete: Critical Geographies of Contemporary Adaptive Reuse', *Geography Compass* 16, no. 1 (2022): e12605, https://doi.org/10.1111/gec3.12605. 3.

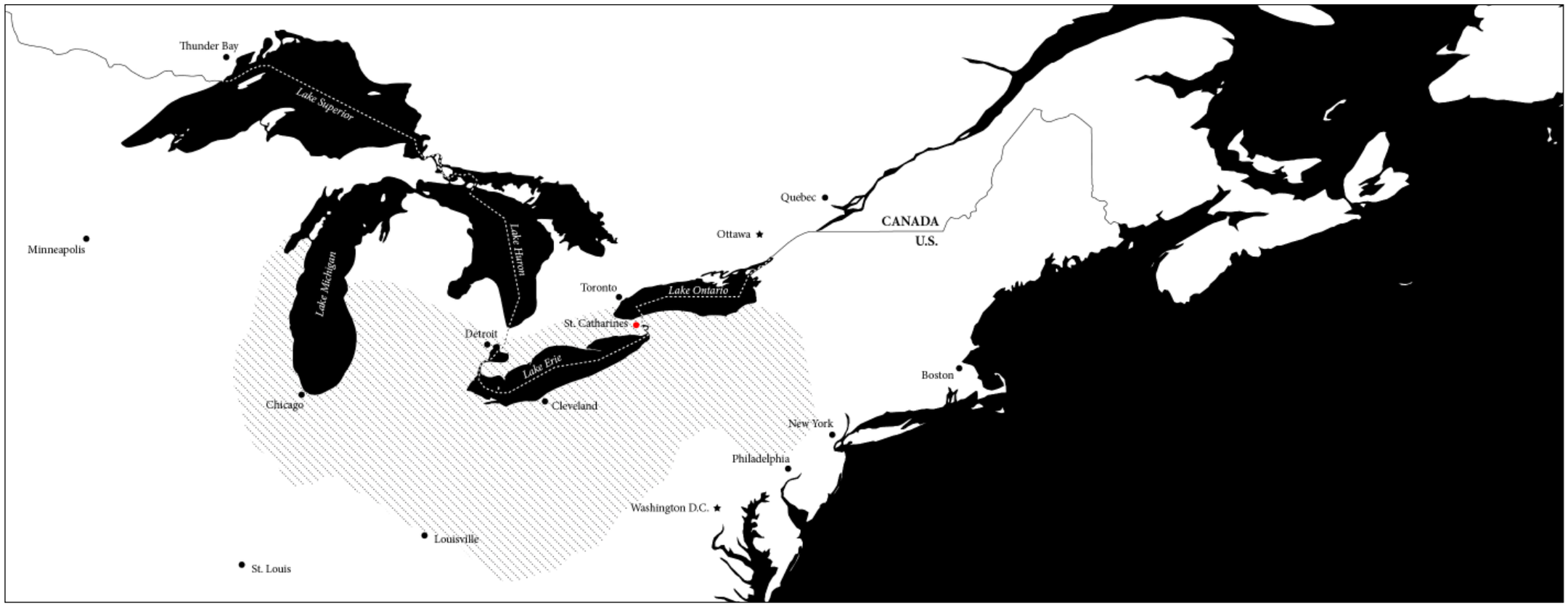
Following this array of vacant properties is the Niagara Peninsula, St. Catharines – a city just across the border that experienced great economic growth from various related industry including automobile manufacturing. The geographical expansion of the Rust Belt eventually arrived to St. Catharines, leading to the closure and long-term abandonment of the city's emblematic structures of the century including the Hayes-Dana plant, Ontario Paper Company, and the GM plant.

Fig. 1.9

Rust Belt parameter across the border.

It's worth noting that the Rust Belt has no fixed boundary, as it is a broad term encompassing diverse economic experience rather than by natural borders.

Parameter derived from "Immigration Policy and Less-Favoured Regions and Cities: Comparing Urban Atlantic Canada and the US Rust Belt" by Yolande Pottie-Sherman (2024)



1.1.2 Mechanics and Culture of Clearance

Alongside the continual assumption of functional obsolescence of buildings was the development of technology in aiding the process of urban erasure and rapid development. Construction (and destruction) equipment evolved, as with any machines, in scale, efficiency and speed. As another means of speeding up process, the treatment of buildings after its usage was replaced with demolition over reuse. Wrecking companies demolished buildings and earthmoving contractors cleared land at an unprecedented pace and scale. Bulldozer became a symbol of, not mere industrial tool, but a friendly model capable of providing metropolitan cities a clean canvas for future development, made quite familiar to all through its frequent self-promotion in advertisements, journalism, and children's literature.[13] Amongst the many medias highlighting the equipment's symbolism of American growth, Francesca Russello Ammon recalls the conclusion of the 1951 novel, "Bulldozer" by Stephan Meader about an entrepreneurial youth and the machine: "He looked ahead. More equipment in the years to come. Big tractors, scrappers, motor graders. Bigger contracts-highways-dams-airfields-there was no limit to what they could do with those touch machines."

13 Francesca Russello Ammon, *Bulldozer*, 2016. 1.

Introduction of mechanized systems and streamline assembly in the 19th century also completely reshaped the workforce – significantly eliminating labour work and strengthening our reliance on technology. Through Fordism, we have been conditioned to embrace the benefits of mass production and consumerism and to forget about its wastefulness.[14] An early critic was Aldous Huxley, who in Brave New World (1932) mocked the cultural indoctrination that favours newness. Youth, in his portrait of a fictionalized totalitarian society, is put to bed with slogans such as: 'ending is better than mending' or 'the more stitches, the less riches'.[15] With the introduction of streamlined manufacturing processes focussed on machinery, mass production took precedence. This shift occurred alongside an increase in labour costs and a predominant replacement of human labour by machinery – this also meant the loss of craftmanship when it came to the making of building materials. As labour costs rose, and material costs cheapened, building materials continued to be devalued, further fueling the wasteful nature of the building industry model.

14 Lionel Devlieger, "'Reverse Architecture. The Virtues of Unbuilding and Reassembling'", *Rewriting Architecture, 10+1 Actions: Tabula Scripta*, 1 January 2020, 150.

15 Devlieger. 150.

A historically specific "culture of clearance," rooted in wartime ideology, technology, policy, and large-scale destruction practices, enabled such rapid and dramatic urban transformations with the public's support. This often led to the slow violence of clearance, manifesting in ongoing physical, social, and environmental injustices. Influenced by a long tradition of American environmental exploitation, wartime engineers and other stakeholders adopted a militarized view of the landscape, treating it as an obstacle to be overcome in the pursuit of new construction.[16] The

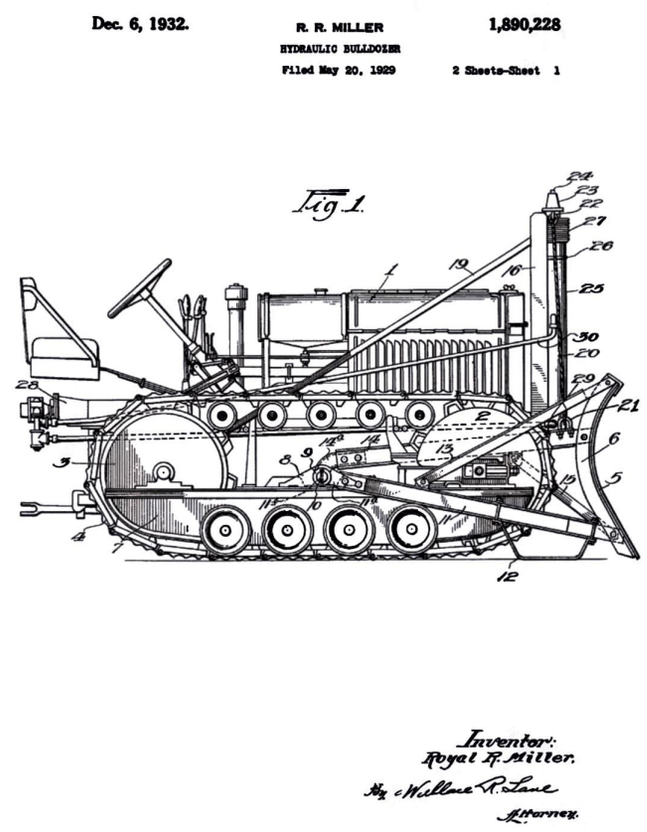
16 Ammon, *Bulldozer*. 6.

narrative around the destructive nature of C&D was changing, and most importantly, this linear building industry model emerged to become the new norm in the 21st century, standardized to optimize financial growth in architecture and the entirety of cities[17]. Equipment like the wrecking ball, bulldozer and excavators stands today as the front-line vehicle to facilitate new construction.

17 Abramson, *Obsolescence*. 3.

Fig. 1.10

Bulldozer patent (1932)



1.1.3 Incentivization of Demolition over Reuse in Canada

Canada's tax system has, like the US, favoured destruction of buildings since the 1940s, incentivizing destruction over reuse. The current system fails to sustain our existing building stock within our urban fabric. In the context of global policy, Canada is the only G7 nation without national law protecting such assets.[18]

18 'Legal Protection Needed for Historical Places Under Federal Jurisdiction' (Heritage Canada Foundation, 2008).

Federal policies began to favour demolition over reuse during William Clifford Clark's tenure as deputy minster of finance (1932-1952). This was the heyday of planned obsolescence, and his redesign of Canada's tax systems in the 1940s reflected his contempt for existing buildings. The revised *Income Tax Act* offered substantial tax benefits to property owners who chose demolition, including:

- *Tax deductions based upon the presumption that commercial, industrial and rental residential buildings lost two-thirds of their value within 10 years (today that would be about half their value, measured in constant dollars)*
- *Avoidance of tax recapture: if it was later revealed that the cumulative deductions exceeded what the building actually lost in the market value, the owner wouldn't have to pay them back (called "recapture") if the building was demolished; and*
- *Deduction of any remaining book value after depreciation: The owner could also claim whatever building value remained on the books as a tax-deductible loss because the building was no longer there and must have gotten lost (called "terminal loss")*

The consequences of this change was disastrous for built heritage, establishing a market dynamic that prioritized demolition over preservation in favour of short-term economic gains, significantly influencing the fate of Canadian buildings. Canada's "built environment" of over 15 million buildings is valued at approximately $6.5 trillion, making it the country's largest collection of privately owned physical assets.[19] Under policies rooted in the ideology of planned obsolescence, the destruction of such assets represents an inefficient use of resources—financial, labour, and materials. Canada destroyed so many buildings in the 20th century that one-third of Canadian landfill deposits consisted of construction material.[20] Even with the higher tipping fees, it was only reduced to 27 percent in 2012.[21]

19 Denhez and Grafton.

20 Denhez and Grafton.

21 'An Overview of Construction and Demolition Waste Management in Canada: A Lifecycle Analysis Approach to Sustainability | Clean Technologies and Environmental Policy', accessed 22 May 2024, https://link.springer.com/article/10.1007/s10098-012-0481-6.

Based on the available open data sources reported in 2011, 11 out of 31 large landfills in Ontario are over half full and many are expected to reach capacity by 2032 [Fig. 1.12].[22] Meanwhile, Canada has been taking advantage of America's

22 Government of Ontario, 'Ontario Landfills - Open Government Portal', accessed 9 September 2024, https://open.canada.ca/data/en/dataset/c7c19fd6-d004-46d1-83cf-cdd687c3588e.

Fig. 1.11

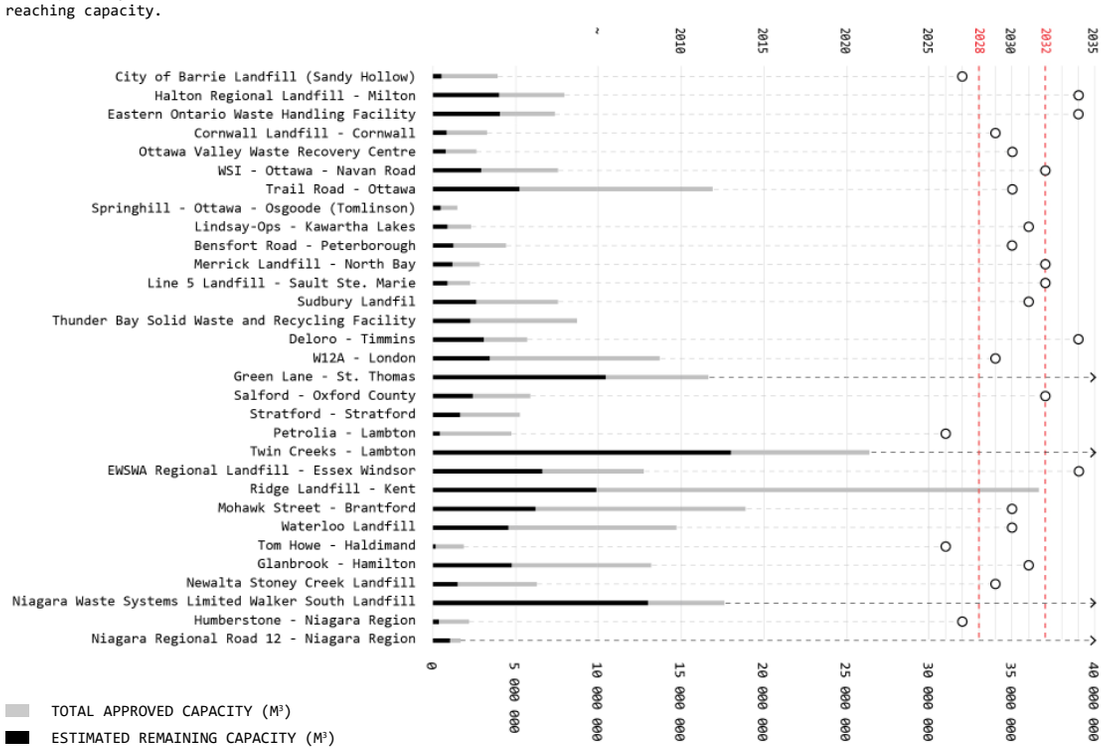
A demolition site in downtown Toronto (photo by the author, 2024)

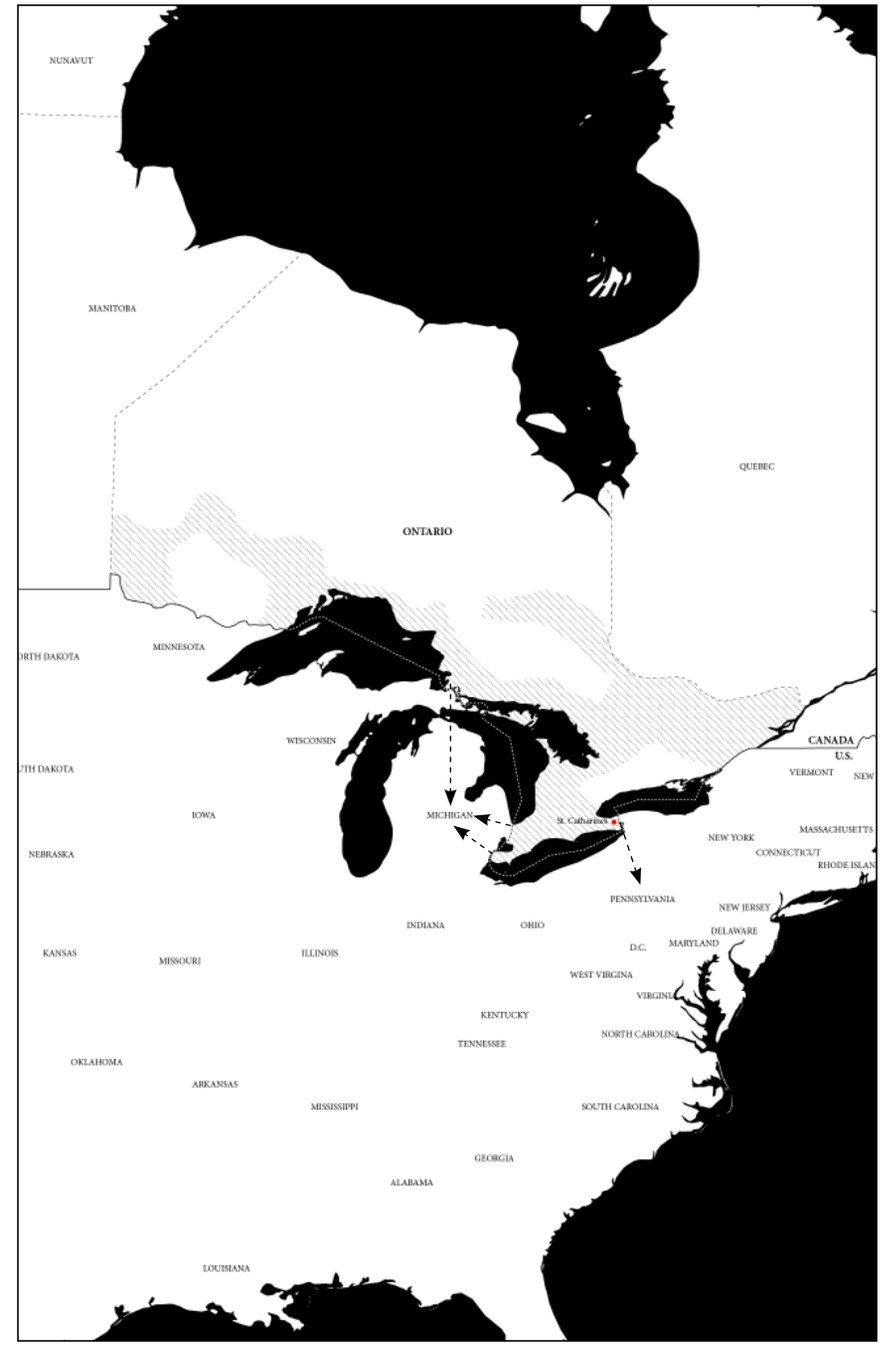
cheaper tipping fee. Disposal costs in Michigan and New York are so low that it is economically viable for Ontario companies and large institutions to cover the expenses of long-distance trucking.[23] [Fig. 1.13] If the United States prohibited Ontario waste from crossing the border, Ontario's landfill capacity would be depleted by 2028. In Niagara, two out of three landfill sites are nearing their approved capacity, yet the data has not been updated since 2011, leaving the status in 2024 uncertain and unmonitored. Policies incentivizing demolition over reuse of buildings has resulted in not only the eraser of architectural heritage but also the growing mass of construction materials in landfills, further streamlining the linear construction process.

23 Fatima Syed April 8 and 2024 7 Min Read, 'Ontario Could Run out of Landfill Space in Nine Years. Then What?', *The Narwhal* (blog), 8 April 2024, https://thenarwhal.ca/ontario-landfill-explainer/.

Fig. 1.12

Total Approved Capacity of Landfill sites vs Remaining, and expected year for reaching capacity.





Concentration of landfill sits

Fig. 1.14

FACILITY:
Niagara Waste
Systems Limited
Walker South
Landfill

ADDRESS:
3081 Taylor Road;
Lots 31, 29, 50
and 66

100m

Fig. 1.15

FACILITY:
Humberstone -
Niagara Region

ADDRESS:
235 Humberstone
Road, Feeder/
Humberstone
Road, Lots 26-27,
Concession 5

100m

Fig. 1.16

FACILITY:
Niagara Regional
Road 12 - Niagara
Region

ADDRESS:
Lots 6-7, Conces-
sion 7 and Part
of Unopened Road
Allowance between
Lots 6-7, Conces-
sion 7

100m

1.1.4 Limited Capacity for Preservation

While Canada's Federal taxation incentives demolition, other avenues for building preservation – such as the Ontario Heritage Act – have limited capacity to preserve. This provincial legislature is informed by Parks Canada's Standards and Guidelines for the Conservation of Historic Places in Canada and devolves most responsibility for built-heritage protection to municipalities. It focuses on a limited scope of aesthetic values. It's three criteria for selection are design value or physical value, historical or associated value, and contextual value, all making a qualitative argument for the historical narrative of keeping a building.[24]

24 'Law Document English View', Ontario.ca, 24 July 2014, https://www.ontario.ca/laws/view.

The city of St. Catharines currently has over 1000 properties included in the Ontario Heritage Register.[25] Most properties fall under the following 4 districts: Queen Street and Area Heritage District, Yates Street and Area Heritage District, Port Dalhousie Heritage District and Power Glen Heritage District. When put into perspective, the registry protects less than 5% of the city property and the buildings on it from demolition [Fig. 1.17]. This has resulted in its inability to address the large stock of post-industrial and modernist buildings, as well as typical residential houses which account for most of the city's as-built assets, classified as not worthy of keeping with pressure to densify the city.

25 'Heritage Properties and Conservation Districts', 5 July 2023, https://www.stcatharines.ca/en/building-and-renovating/heritage-properties-and-conservation-districts.aspx.

The properties are protected under the Ontario Heritage Act, in one of three ways[26]: designated individually under Part IV of the OHA ("Conservation of property of cultural heritage value or interest"), designated as part of the Heritage Conservation District under Part V of the OHA ("Heritage conservation district"), or listed on the City's Heritage Register.

26 'Heritage Properties and Conservation Districts'.

Even within the registration period, the buildings are not safe from erasure. While a property is on the Heritage Register, before its official designation is approved, the owner must give Council 60 days' notice if you wish to demolish or remove a building or structure on the property. This allows the City to review the demolition application and evaluate the property's cultural heritage value to determine if the property meets the criteria for designation under the Ontario Heritage Act. If the property meets the criteria for designation, the property can be designated by the City and protected from demolition. This 60-day rule is often a loophole taken advantage of by developers to demolish a building before it becomes designated.

1: Queen Street and Area Heritage District

2: Yates Street and Area District

3: Port Dalhousie Heritage District

4: Power Glen Heritage District

Fig. 1.17

St Catharines Plan
1 : 50 000

Fig. 1.18

Queen Street Heritage
Conservation District
Boundary

Fig. 1.19

Yates Street and Area
Heritage Conservation
District Boundary

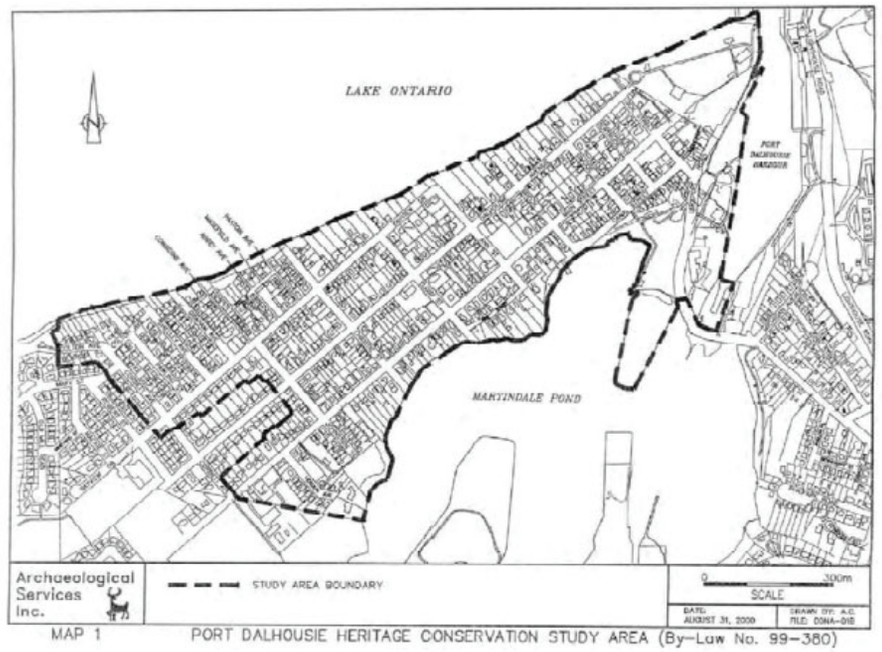


Fig. 1.20

Port Dalhousie Heritage Conservation District Boundary

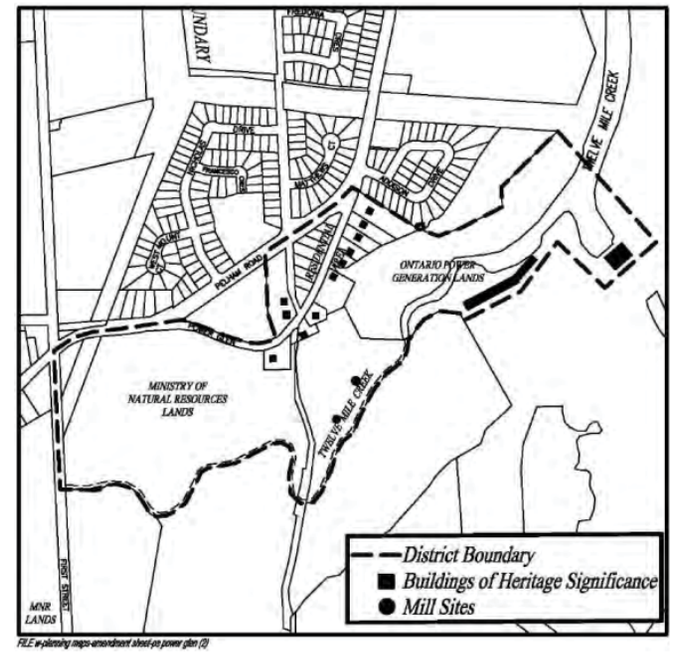


Fig. 1.21

Power Glen Heritage Conservation District Boundary

The City of St. Catharines heritage registration prioritizes aesthetic values built on historical, nostalgic narrative which fails to address any related environmental catastrophe caused by failure to protect it. Public and institutional buildings such as churches and museums are commonly designated as heritage sites due to their cultural, historical, and architectural significance, as well as their communal function and visibility. These public structures often symbolize collective identity and showcase notable designs, attracting advocacy for preservation. In contrast, houses—city's largest building assets—are typically private, lack the same level of public interest, and pose economic and practical challenges for owners to maintain heritage standards. Despite the challenges, these buildings are also designated as heritage in St. Catharines, when they contribute significantly to the city's historical character, particularly reflecting the late 19th-century expansion during a period of prosperity leading up to World War I. Within the description of Cultural Heritage Value and Potential Attributes[27], the Heritage Register report describes pre-war residential dwellings of heritage interest as those having pebble-dash façade, dentils incorporated within the trim, and decorative weaved brickwork. [Fig. 1.23]

27 'Heritage Properties and Conservation Districts'.

Fig. 1.22

30-32 Academy Street.

Yellow highlighting architectural elements described for the heritage registration.

Fig. 1.23

City of St. Catharines Register accessed 2024 (https://www.stcatharines.ca/en/building-and-renovating/heritage-properties-and-conservation-districts.aspx)

City of St. Catharines Register (updated Octover 1, 2024)

ADDRESS/ DATE ADDED	DESCRIPTION OF CULTURAL HERITAGE VALUE AND POTENTIAL ATTRIBUTES
30-32 Academy Street July 13, 2009	Built c.1870, this two and one-half storey, semi-detached, stucco home is notable for its two front bay windows, two side entrances, and second storey window design. The one storey high bay windows have shelves with decorative friezes and brackets. The second floor windows are placed on the facade in pairs. Above the centre mullions are semi-circular ornaments. The side entrances are composed of decorative friezes and brackets similar to the ones on the bay window. The doors are panelled with a glazed section. The roof is a four sided, bellcast mansard with several dormers trimmed with a boxed cornice, frieze and brackets. The building contributes to the historical character of downtown St. Catharines.
27 Academy Street September 14, 2020	The 2-storey residential building contributes to the historical character of downtown St. Catharines. The brick building has a bay window on the front façade and rounded arched windows.
3 Adie Place September 14, 2020	The residence is well-preserved example of a vernacular, residential dwelling from the late-19th century with early 20th century (pre-1913) additions. Simple in design, the house's most prominent feature is the porch that stretches across the front of the house.
85 Albert Street September 14, 2020	Constructed in the 1870s, the residence does not appear to have been heavily altered. The house had a long, 80-year period of ownership with the Daniel Woodhouse family. Woodhouse was a former lock-tender on the 3rd Welland Canal. The Albert Street neighbourhood formed part of the late 19th century expansion of the city north of Welland Avenue during the decades of prosperity prior to the start of World War I.
95 Albert Street September 14, 2020	The residence represents a well-preserved example of a vernacular, residential dwelling from the turn of the century. The residence has a pebble dash façade and a front porch which stretches across the front of the house. The Albert Street neighbourhood formed part of the late 19th century expansion of the city north of Welland Avenue during the decades of prosperity prior to the start of World War I.
96 Albert Street September 14, 2020	A late-19th century one-storey brick residence with a wide porch across the front façade. There is a transom above the front entrance. The Albert Street neighbourhood formed part of the late 19th century expansion of the city north of Welland Avenue during the decades of prosperity prior to the start of World War I.
105 Albert Street September 14, 2020	One-storey late-19th Century residence. The residence has an enclosed porch. The windows on the front façade have dentils incorporated within the trim. A porch can also be found on the side of the residence. The Albert Street neighbourhood formed part of the late 19th century expansion of the city north of Welland Avenue during the decades of prosperity prior to the start of World War I.

28 Facadist Toronto Heritage Vat Face Value, Zhen (Janet) Li, 2023

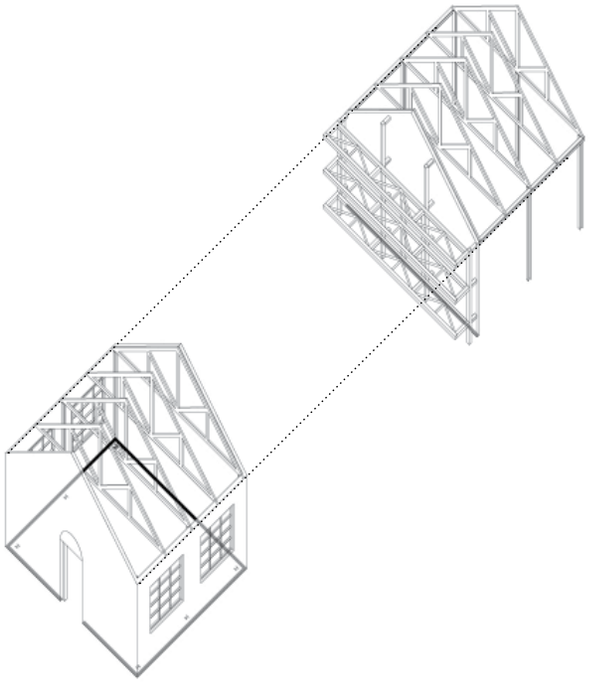
Fig. 1.24

A demolition site in downtown Toronto: an example of facadism (photo by the author, 2024)

The significance of aesthetic in conservation work is also evident in "facadism": a preservation method where only a building's facade is retained during demolition, often framed as heritage preservation. As Janet Li's thesis work examines, such performative act of maintaining only the veneer of a historic structure serves as another development tool, benefiting developers by capitalizing on valuable locations and appealing the public.[28] Although it may appear indistinguishable from fully preserved buildings—particularly through approaches like adaptive reuse—facadism is not heritage preservation, but a practice that facilitates ongoing demolition under the guise of aesthetic continuity.

Fig. 1.25

Facadism diagram



The limited characterization of buildings and their corresponding valuation for preservation fails to address the large stock of post-industrial buildings due to their era-specific focus. However, if building policies were re-imagined to embrace a more adaptable and flexible framework—possibly one that incorporates the dynamic material life cycle of buildings as a strategy to address climate challenges—they could better integrate the evolving material remnants of the urban fabric, offering a more inclusive and sustainable approach to heritage preservation. This creates opportunities to address the conservation of extensive building stocks and their materials, expanding beyond the current limited scope. Preserving elements such as brickwork not only protects historical character of a city but also helps mitigate carbon emissions associated with the manufacturing of these material layers. Systematic rules within building construction such as OHA, LEED, Income Tax Act have great effect on the maintenance of our current urban fabric and sets a framework for its development as well as the overall construction industry model.

The mid-19th century saw great economic shift in North America, where the building value presumed by fantastical prophecies could not compete with property value through tax systems incentivizing demolition. The building industry collectively shaped its model to follow this trend which devalued existing structures, and recklessly demolishing them into debris. The linearity of such industry model results in a waste of planetary resources and labour, and fixes demolition to be at the end of the life cycle of a building as the 21st century default. As climate change continues to escalate and natural resources deplete, it's crucial to question these norms established only in the past half-decade, and prioritize alternatives to handling buildings to prolong the existing material stocks and resources.

Fig. 2.1

Re:Purpose Savannah's outdoor storage space (photo by the author, 2024)

2.1 Reversing Architecture

Architects are one of many system-builders in today's building industry and society. While manifested in the physical form of a building, the development of the building system – or architecture - reflects broader immaterial social desires and the complex network of sociopolitical forces required to sustain it.[1] In the midst of a climate crisis, the recognition of the role of an architect within this network is crucial, taken the significant casualties caused by the wasteful nature of the construction industry [Fig. 2.2].

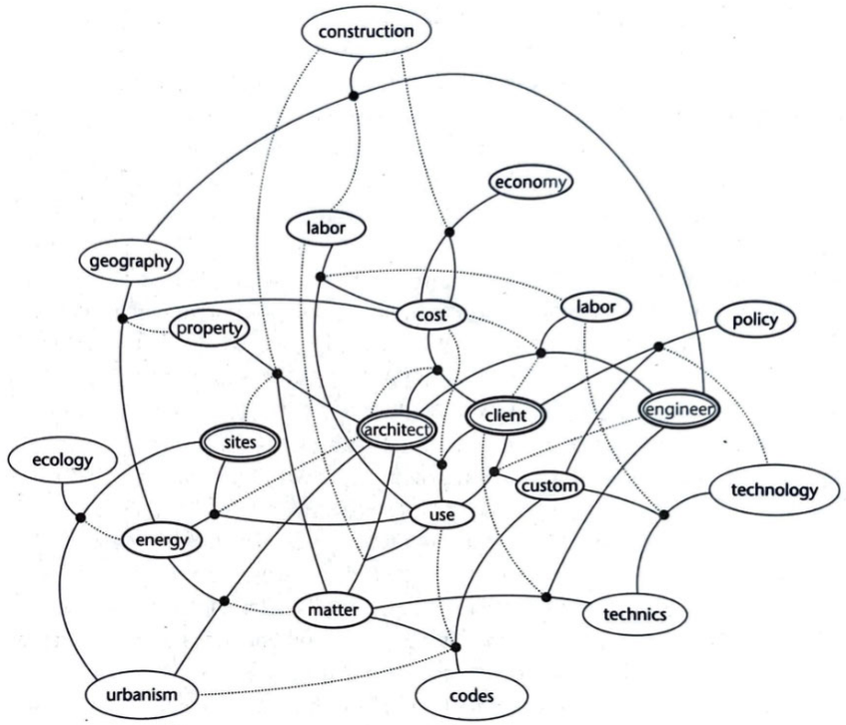
1 Kiel Moe and Ryan E. Smith, *Building Systems: Design, Technology, and Society* (Abingdon, Oxon [England] ; New York, NY: Routledge, 2012). 1.

From this perspective, the paradigm shift from a linear process to a circular one should be seen as a part of a broader network of interconnected forces. This network is also prefigured by social desires, such as ecological needs for preservation, resource stewardship, valuing cultural heritage, maintaining a sense of community, which shape and influence these processes in advance. There is no doubt that a hierarchy of change exists: without a system in place to guide and structure it, large-scale transformation and reform cannot occur. Within the systematic and profound challenges, architects re-center their strengths alongside other system-builder, drawing on their expertise in building construction and the nuanced understanding of materials. If the building itself cannot be preserved as a whole post-occupancy, could we retrieve reusable components through dismantling to prolong its usage in parts?

Chapter 2 focuses on the process of deconstruction, examining the material realities and challenges inherent in this fieldwork. It explores valuation in material reuse, technical aspects of building deconstruction, contemporary practices engaged in deconstruction and emerging regulatory changes that promote unbuilding as a sustainable alternative to traditional demolition.

Fig 2.2

Catalytic diagram representative of the systemic networked relation of forces and factors contingent on architects, the work of architecture and architectural works.



2.1.1 (Re)discovering Value in the Forgotten

Long before the 20th century, buildings have always been tested against time. Structural degradation from eroding effects of time on buildings begin from the moment it's built, and requires maintenance (whether by repair, renovation, or rebuilding) throughout the duration of the building's lifespan.

Different cultures developed region-specific strategies which allowed them to preserve architectural vernacular. For example, the Shinto shrine in Ise, Japan, has been reconstructed every 20 years since its initial construction in 690 A.D. and remains standing to this day.[2] [Fig. 2.3] The wooden dowels and interlocking joints allow for easy dismantling, and the wood components to be reused in other shrines. In the case of Rome, the entire city, which embodies ancient romans' intelligence and craftmanship developed throughout the era, have survived for two millennia; the built assets are now officially registered and protected under UNESCO as of 1980. [Fig. 2.4] Rebuilding with existing materials and prioritizing conservation is not an innovative idea, but rather an ancient practice driven by care and willingness to prolong historical artifact.

2 'Ise Grand Shrine: Everything You Need to Know about Japans Most Sacret Shinto Shrine', JRPass.com, accessed 11 February 2025, https://www.jrpass.com/blog/ise-grand-shrine-everything-you-need-to-know-about-japans-most-sacret-shinto-shrine.

Stone has long maintained its desirability due to its durability and aesthetics, factors that also benefited the 19th-century Bordeaux château. In November 2020, Paris-based antiques dealer Alisanne Frew discovered a disassembled château—5,389 pieces of limestone from Bordeaux's historic center—stored in a warehouse. She paid $2.25 million, invested $650,000 in preparing the pieces for resale, and is asking $7.5 million.[3] [Fig. 2.5] Materials considered worth such time-consuming and costly process of disassembling buildings, cleaning, and storing are quite limited in today's market unless they are qualified to be protected under legislative acts. The disappearance of traditional practices, which valued conservation over expendability, accelerated exponentially with the capitalist growth of cities. By the 20th century in North America, they were nearly erased due to a combination of factors: increased real estate pressure, an obsession with rapid demolition, the availability of powerful machinery and explosives, and fiscal policies that encouraged accelerated building obsolescence.[4]

3 J. S. Marcus, 'A French Château Could Be Your Dream Home—If You Can Put It Back Together', WSJ, 21 November 2023, https://www.wsj.com/real-estate/luxury-homes/a-french-chateau-could-be-your-dream-homeif-you-can-put-it-back-together-59b824ed.

4 Dirk van den Heuvel, 'D E C O N S T R U C T I O N', accessed 16 October 2023, http://deconstruction-conference.nl/. 11.

Assessment of reuse value in architecture remains uncertain, as value itself is socially constructed and extends beyond the fixed numerical indications typically associated with commerce. With many hidden layers of environmental, cultural, and economic significance embedded in each building material, the industry demands multidisciplinary expertise to accurately (re)discover the value of these often-overlooked resources, assess their suitability for deconstruction and salvage, and prevent their value from being lost.

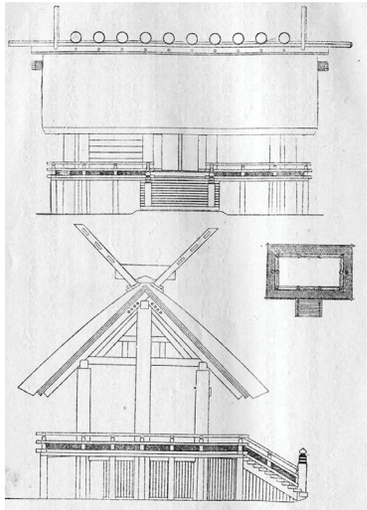


Fig. 2.3

Plan and elevation of Ise Shrine

Fig. 2.4

Photograph of the Roman Forum by Author

Fig. 2.5

Photograph of the Bordeaux château disassembled and stored in warehouse

Market Value

The concept of salvage value is often considered to be a material resale potential for either its original function or an alternative use.[5] This valuation is typically established through market comparisons with similar materials in comparable conditions, or by determining its fair market value.

The calculation of salvage value must encompass all expenses associated with handling, transportation, storage, and the preparation of retrieved materials for subsequent reuse or resale. The primary cost shift when reusing building materials is in reduction of material costs, and higher labor costs.[6] Therefore, a comprehensive understanding of building science, assembly techniques, and life cycle assessment (LCA) of materials, as well as selective dismantling, is essential.

Lionel Devlieger from Rotor, a deconstruction organization based on Brussel, uses marble as an example to demonstrate how the rarity and fame of a product can be a compelling narrative for competing with the new, and growing demands in the market. He states that operators in the second-hand building component market have been concentrating on so-called "architectural antiques" prioritizing materials that are pre-WW2 with characteristic or traditional building typologies and techniques.[7] Carved natural stone, ancient bricks, oak beams and terra-cotta tiles are examples of such components which hold cultural value, residing within the skills of the craftsmen who shaped them. The preference comes from the market favouring 'old' things, for sentimental and durability of the materials. This, however, also simultaneously devalues industrially produced post-Second World War building materials, deeming them unworthy of conservation.

But if marble, a geological heritage material that takes an incredible amount of time to form naturally, then bricks and tiles, baked by humans in the past, may share a similar heritage[8] – one that is rooted in the idea of formation with great time and energy. The emissions generated during their production long ago should be seen as contributing to a cumulative human footprint, thus creating a burden that we must collectively acknowledge and account for.

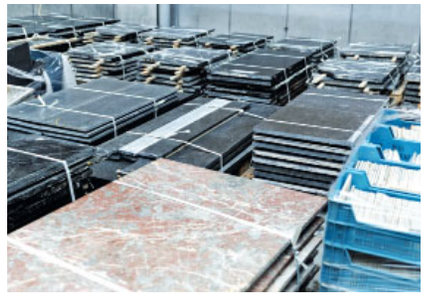


Fig. 2.6
Dismantled marble slabs (RotorDC, 2020)

Resource scarcity and its relationship to its social perception plays a critical role in establishing a material's market value. This concept frames the emerging term of "urban mining"; re-discovering the recoverable quality from buildings of the last decades of the 20th century beyond its assembled form.

5 Zebuliah Bates et al., *Introduction to Deconstruction: A Comprehensive Training Workbook*, Oregon State edition, 2017. 13.

6 'Capital Project Planning for a Circular Economy: Construction Management and Economics: Vol 36 , No 6', accessed 11 April 2024, https://www.tandfonline.com/doi/full/10.1080/01446193.2018.1435895. 307.

7 Lionel Devlieger, 'Reverse Architecture—The Virtues of Unbuilding and Reassembling', *Rewriting Architecture, 10+1 Actions: Tabula Scripta*, 1 January 2020. 151.

8 Lionel Devlieger, 'The Raw, the Cooked, and the Overdone on What Makes Building Materials Salvageable (or Not) in North Western Europe', *FAKTUR*, no. 03 (2020). 40.

Handmade Value

Shadowed by the great appeal of mechanization—its speed, tirelessness, and superior computational capabilities—was the loss of manual craftsmanship.

The Industrial Age in the eighteenth century embraced the virtue of abundance and the mechanically produced, gradually adopting the view of rational improvement and progress, modeled on the efficiency of new machinery like James Watt's steam engine.[9] Craftsmen underwent a shift socially, as Watt's eighteenth-century steam engine evolved from workshop conditions to mass production. This reflects a broader shift in nineteenth-century engineering, as seen in the history of the blueprint: a transition from hands-on knowledge to the centralized ownership and control of explicit knowledge, which was used to establish institutions in production– often materializing in architectural form of factories.

Against the rigorous perfection of the machine, the positive values derived from the irregularities and flaws in handwork remained as an emblem of human individuality. When metal, wood, and clay were crafted by hand, the maker's stamp served as a mark of their presence. The long history of crafting clay, which dates to nearly ten thousand years to the discovery of pure-clay bricks in Jericho, illustrated three ways humans engage consciously with materials: altering, marking or identifying them with ourselves. Immanuel Kant's famous remarks, "The hand is the window on to the mind", encapsulates the science behind how these motions and the sense of touch, affect how we think.

Here, physical intelligence is directly translated into materialistic knowledge, a school of thought quite removed from the modern understanding of building material production processes. Through demolition, each of these carefully crafted, irreplaceable urban blocks are reduced to rubble.

Fig. 2.7
Salvaged bricks displayed at Re:Purpose Savannah's yard (Author, 2024)

Environmental Value

Annual construction and demolition (C&D) waste is expected to reach 2.2 billion tons globally by the current year 2025, and according to EPA it has increased 342% from 1990.[10] In Canada, C&D constitutes to 12% of national waste stream[11], while the number goes up to 23% (nearly ¼) in USA[12]. These numbers are significant when understanding its equivalency to 6,000,000 homes being landfilled annually in Canada and USA alone from C&D.

9 Richard Sennett, *The Craftsman* (New Haven: Yale University Press, 2008). 83.

10 Adam Redling Published March 05 and 2018, 'Construction Debris Volume to Surge in Coming Years', Construction & Demolition Recycling, accessed 9 February 2025, https://www.cdrecycler.com/news/global-volume-construction-demolition-waste/.

11 Environment and Climate Change Canada, 'Reducing Municipal Solid Waste', guidance, 18 February 2010, https://www.canada.ca/en/environment-climate-change/services/managing-reducing-waste/municipal-solid/reducing.html.

12 'Municipal Solid Waste and Construction & Demolition Debris | Bureau of Transportation Statistics', accessed 11 April 2024, https://www.bts.gov/archive/subject_areas/freight_transportation/faf/faf4/debris.

Building construction is also very material intensive, with 40-50% of all extracted raw materials being transformed into building products.[13] The destructive extraction practices results in natural habitat loss, further contributing to the accelerating climate crisis of the 21st century.

Steel and concrete manufacturing account for 16% of global carbon emissions, while cement production alone – a key ingredient for concrete – increased almost 30 folds since 1950.[14] Marketed as the prime sustainable material, our extensive use of lumber too may need to be reassessed. Forests are becoming low on wood fiber from fires, pine beetle and logging regulatory changes. In the last few years in British Columbia, a prime resource of lumber in Canada, there's been multiple lumber mills closing due to their lack of wood fiber to produce lumber or plywood – only 2% of these trees standing today.[15] Returning to the definition of "value," the embodied carbon measurement provides a tangible numerical value for understanding the environmental significance of materials. While somewhat simplified, this tool enables meaningful comparisons between existing materials and newly manufactured ones.

Planning of energy-efficient buildings with a low environmental impact have evolved in numerous ways – from implementation of renewable energy systems to passive strategies. It has now become increasingly important to ensure that buildings have a low embodied energy, since it could equal the same amount of energy as the building's operational energy use for 50 years[16]. With the increasing focus on calculating embodied carbon emissions, there is an opportunity to translate sustainability advocacy into the implementation of systematic procedures, such as carbon taxes and incentive structure, as effective mechanisms for promoting sustainability in the industry.

In addition to the industry's shift from focusing on operational to embodied energy, there is a growing emphasis on moving away from recycling, to reuse. When tracing back the roadmap of recycling, materials are typically crushed and melted, resulting in further devaluation of materials; a process that still consumes significant energy, emphasizing its distinctive differences compared to reuse[17]. This distinction between recycling and reuse prompts a critical examination of the standardized green strategies embedded in current practices, encouraging a reassessment of the various green initiatives implemented for managing existing building stocks.

13 Petr Hradil, 'Barriers and Opportunities of Structural Elements Re-Use' (VTT Technical Research Centre of Finland, 2014).

14 Robbie M. Andrew, 'Global CO2 Emissions from Cement Production', 16 August 2018, https://doi.org/10.5194/essd-2018-90.

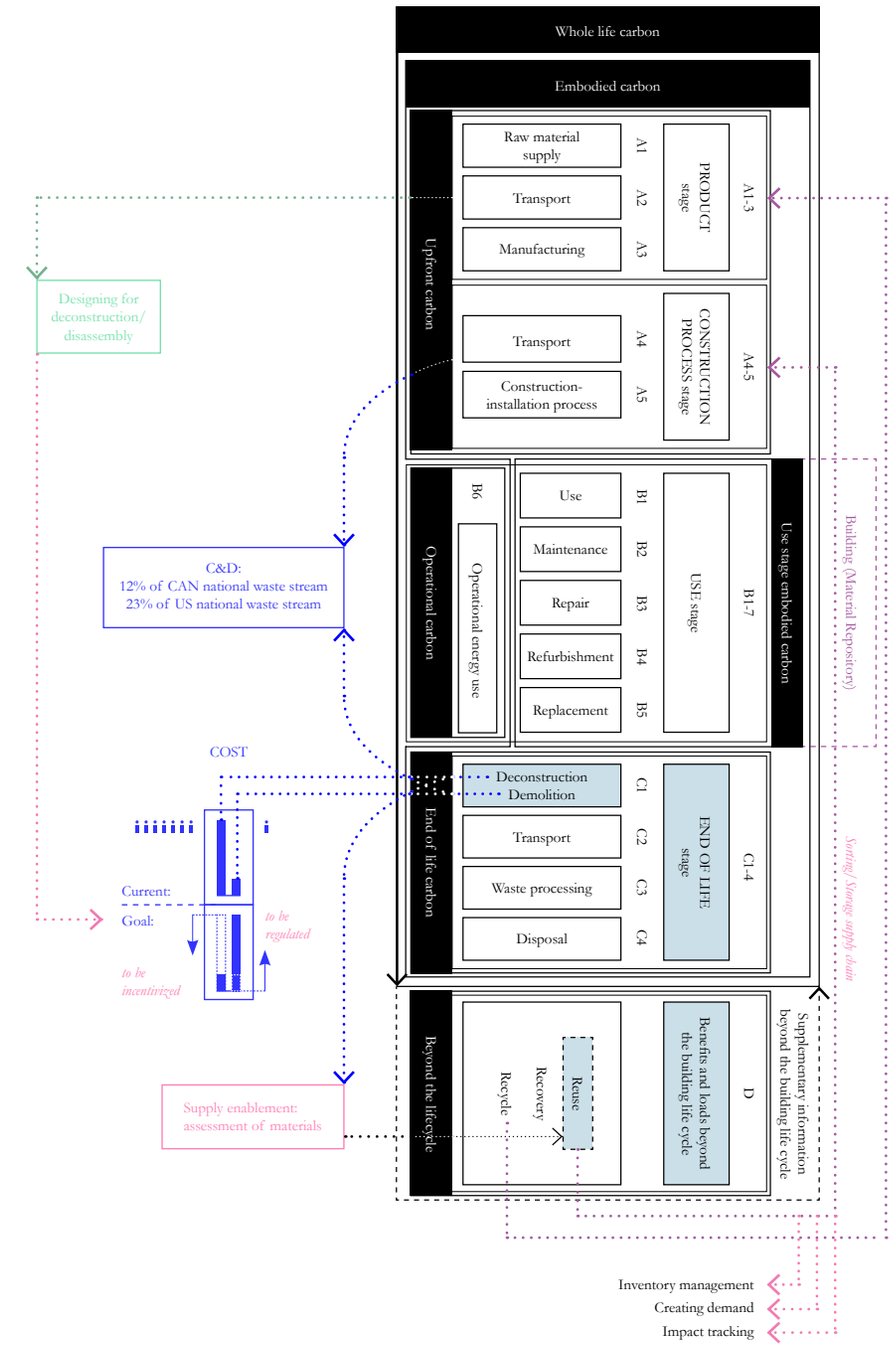
15 *Praxes of Care - Ecology and Deconstruction*, 2023, https://www.youtube.com/watch?v=7OrAllrTHxo.

16 Jouri Kanters, 'Design for Deconstruction in the Design Process: State of the Art', *Buildings* 8, no. 11 (November 2018): 150, https://doi.org/10.3390/buildings8110150.

17 Devlieger, 'Reverse Architecture. The Virtues of Unbuilding and Reassembling'. 148.

Fig. 2.8

Building life cycle stages with layered information.



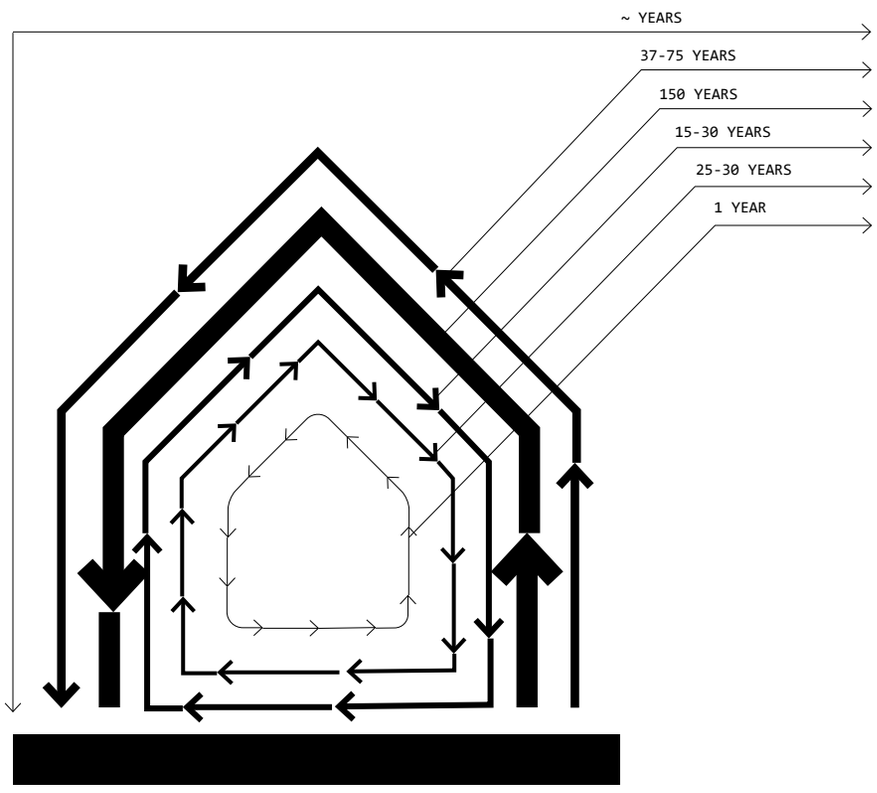
2.1.2 Shearing (deconstructing) Layers

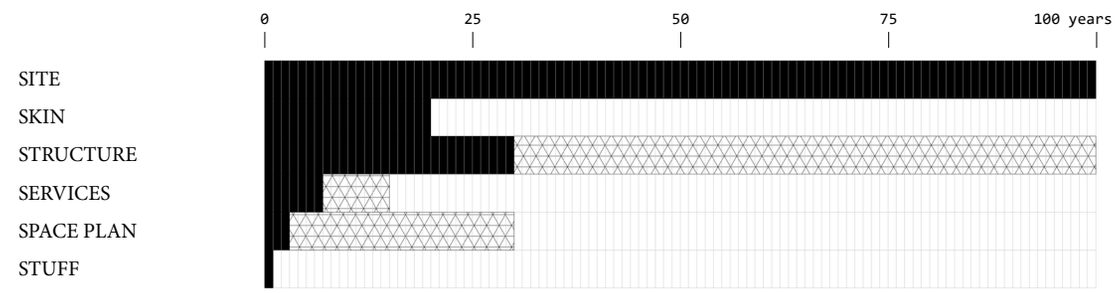
Understanding a building in layers, both theoretically and physically, helps us not only build and un-build but also to ultimately reverse the now-systematized linear process of the construction industry. In 1994, Stewart Brand released *How Buildings Learn: What Happens After They're Built*, challenging the notion of architecture's permanence by highlighting the continuous evolution of buildings. Drawing from the ideas of British architect Frank Duffy, Brand introduced the concept of "shearing layers" — encompassing site, structure, skin, services, space plan, and stuff — to illustrate how buildings change over time in layers. [Fig. 2.9] This theory encouraged architects, construction professionals, clients, and occupants to rethink how decisions are made about buildings, taking into account their long-term adaptability and performance beyond the immediate programmatic needs of the user.[18]

18 Stewart Brand, *How Buildings Learn: What Happens after They're Built* (New York, NY: Viking, 1994).

Fig. 2.9

Brand's "Shearing Layers" from *How Buildings Learn: What Happens After They're Built* (1994)





Site: This is the geographical setting, the urban location, and the legally defined lot, whose boundaries and context outlast generations of ephemeral buildings. "Site is eternal," Duffy agrees

Structure: The foundation and load-bearing elements and perilous and expensive to change, so people don't. These are the building. Structural life ranges from 30 to 300 years (but new buildings make it past 60, for other reasons)

Skin: Exterior surfaces now change every 20 years or so, to keep up with fashion or technology, or for wholesale repair. Recent focus on energy costs has led to re-engineered Skins that are air-tight and better insulated

Services: These are the working guts of a building: communications wiring, electrical wiring, plumbing, sprinkler system, HVAC (heating, ventilating, and air conditioning), and moving parts like elevators and escalators. They wear out or obsolesce every 7 to 15 years. Many buildings are demolished early if their outdated systems are too deeply embedded to replace easily

Space plan: The interior layout – where walls, ceilings, floors, and doors go. Turbulent commercial space can change every 3 years or so; exceptionally quiet homes might wait 30 years

Stuff: Chairs, desks, phones, pictures; kitchen appliances, lamps, hair brushes; all the things that twitch around daily to monthly. Furniture is called mobilia in Italian for good reason.

This concept of shearing the building layers is actualized in the physical world through the act of deconstruction – a form of reversing physical architecture. [Fig. 2.10] A literal translation from the word, deconstruction describes a process of selective disassembly of a building at the end of its life to recover materials and components for potential reuse or recycling.[19] It is an approach to building removal that can extract resources so they can be used for high value future uses, opposed to demolition, which is defined as destroying, or wrecking of any building, structure, or part thereof. [Fig. 2.11] Deconstruction, therefore, can be re-inserted into the construction phase at the end of a building's lifespan in lieu of demolition, potentially altering the fate of building materials which otherwise would be sent to the landfill. Just like the significant amount of time invested in getting a building erected, the process of how it comes down post-occupancy deserves a similar level of planning and care. Such physical reversal work is possible only through careful dismantling of structure and processing, and typically done by hand with limited current technology available.

19 Mark Gorgolewski, *Resource Salvation*, 1st ed. (John Wiley & Sons, Ltd, 2018), https://doi.org/10.1002/9781118928806.

"It is at times through the slower speed of gradually taking a building a part that allows for a reassessment of a building's future and identify what can be mined."[20]

Mae Bowley
(Taking Apart Buildings and Systems:
In Conversation with Mae Bowley
of Re:Purpose Savannah, 74)

20 Jane Mah Hutton and Alison Creba, 'Taking Apart Buildings and Systems: In Conversation with Mae Bowley of Re:Purpose Savannah' 92, no. 1 (2022). 74.

Fig. 2.10

EXAMPLE OF DECONSTRUCTING A BRICK BUILDING

❶ brick wall-sectional removal:

tools/technique used: diamond saw cutting

❷ salvaging (individual) bricks:
tools/technique used:
chisel, scraper, drill, pry bar, electric hammer

brick typically reclaimable twice before complete loss of structural integrity

❸ Broken brick aggregates during deconstruction can be recycled into aesthetic elements, or sent to landfill

❹ construction material processing facilities: recycle/fabrication/waste management

❺ storage

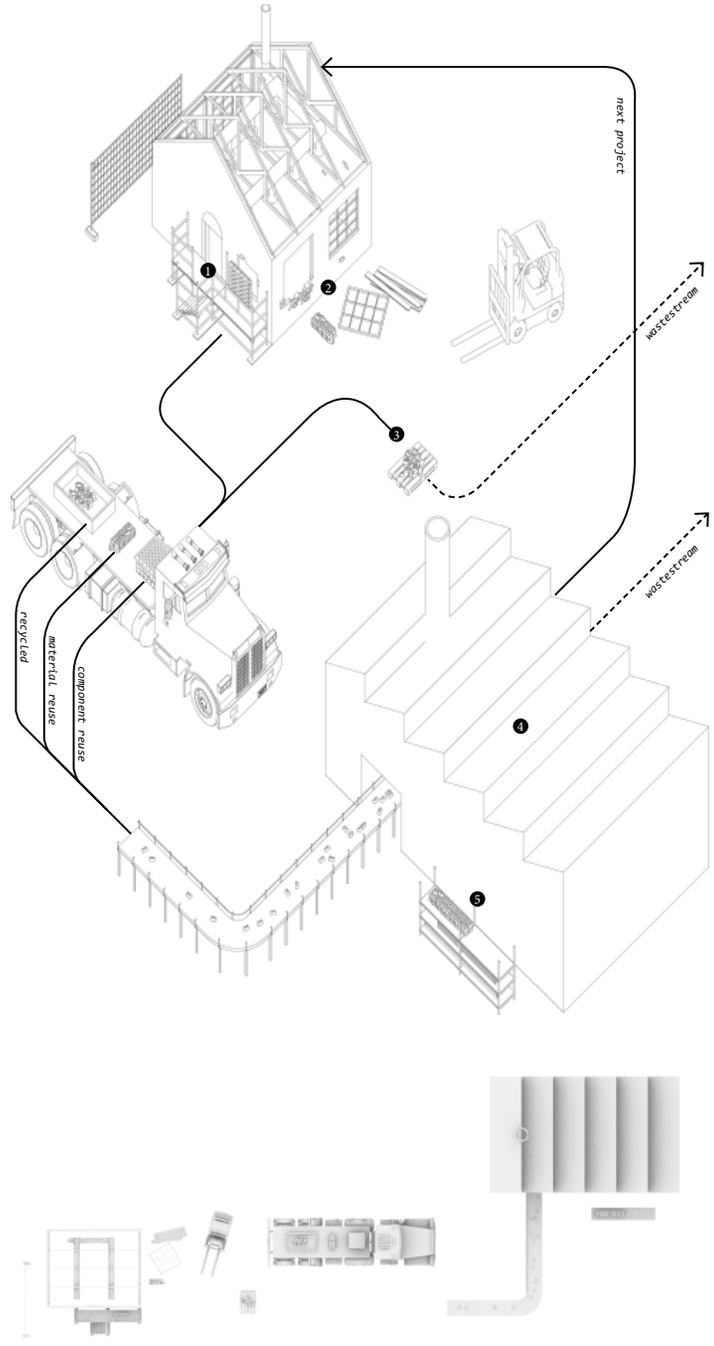


Fig. 2.11

Comparison between building demolition and deconstruction from "Cost prediction model for building deconstruction in urban area" (2017)

ATTRIBUTE	DEMOLITION
Definition	Activities to destroy a building or structure to a pile of debris and mixed rubble most of which are hauled to landfills.
Environmental impact	Heavy impact on the environment due to disposal of material to landfills and wastage of resources. Care must be taken during planning and operations to prevent the spread of hazardous materials, including lead and asbestos.
Community employment	Socially does not benefit communities as it is heavily dependent on use of machinery.
Community education	Community needs to be educated about noise, dust, and machinery operations
Cost and time impact	Quickly executed, often more economic for contractors and owners who want the site cleared quickly for investment.
Planning site survey	Intensive machine operation planning.
Safety plan	Includes structure, material, method of construction, adjoining properties, utilities, hazardous material, location, neighborhood, access, etc.
Tools and equipment	Heavy and large machines and tools used for quick operations,
Labour	Less labor intensive, depend on heavy machine operations.
Material handling	Machine-based sorting for recycle, hauling and disposal.
Material disposal	A large amount of waste produced which is sent to landfills. Hauling and tipping costs are higher.
Structure's suitability	All structures can be demolished and turned into rubble.
Site security	Focus on workers safety and the general public and adjoining structures safety.
Asbestos containing material	If asbestos containing material presents in the building, wet demolition can be used without having to remove the material.
Pollution	Creates more waste during site clearance. More noise and dust with the use of heavy machinery and operations.

ATTRIBUTE	DECONSTRUCTION
Definition	Activities to systematically disassemble components and materials from a building or structure.
Environmental impact	Environmentally beneficial due to reuse of material and preserving maximum construction material. Avoids depletion of energy and new material and promotes conservation of natural resources.
Community employment	Creates new employment opportunities for local workforce as it is largely dependent on labor.
Community education	Communities should be educated about the process and duration of deconstruction. Residents in neighborhoods with substantial abandonment may be expecting a quick demolition/cleanup operation.
Cost and time impact	Operationally costs more and takes longer but adds the benefits of incentives and salvaged material value which may result in reduced cost.
Planning site survey	Intensive labor training and working plans.
Safety plan	Requires more intensive survey of structure, material classification for reuse, recycle and disposal, components and connections, hazardous material, location, access, etc.
Tools and equipment	Smaller hand tools and equipment used to remove material in good condition.
Labour	Highly labor intensive operation.
Material handling	All material separated as deconstructed into different
Material disposal	Reduces the amount of waste by up to 75% as most material is aimed for reuse and recycle
Structure's suitability	Not all buildings are good candidates for deconstruction.
Site security	Asbestos containing material, if present in the buildings, require large cost and time investment to remove.
Asbestos containing material	Besides workers' safety, material security on-site is important because salvaged material is vulnerable to theft.
Pollution	Greater protection of the local site. Creates less dust and noise.

2.1.3. Technical Barriers (considerations) in Deconstruction: Brick by Brick

A key barrier in deconstruction work lies in the technical realities of buildings: they are not designed to be dismantled. Construction practices often prioritize waste management due to the inherent challenges posed by non-deconstructable elements within buildings. Notably, structural components such as TGI joists, engineered products, and SPF exhibit minimal resale value in the market. Certain building elements, such as sub-floors, flooring systems, and related materials, present challenges in their separation due to the construction techniques employed, compounded by the application of spray foam, and caulking during their installation processes.[21] The methods used to joint these components (whether by nails, mortar or welding) play a pivotal role in determining their viability for reuse and influence their salvageability. [Fig. 2.13] Some materials simply have too low of a market value for salvage. The following section explores the economic considerations concerning material value in relation to a building's salvage potential, taking into account its specific construction attributes.

21 *Praxes of Care - Ecology and Deconstruction.*

First, is the material selection criteria. Trees up to 2000 years old were harvested to produce lumber for typical wooden framed buildings until 1970s. Their prominence on the landscape quickly declined with clearcutting to meet the growing demand, becoming a scarce resource. This process is accelerated with every demolition – a procedure that fails to acknowledge the generations of time required for regrowth. Benefits of old growth lumber include 92% less embodied carbon and its structural integrity, equivalent to 3 times higher than new lumber.[22] In younger major cities, such as Vancouver which was only found in 1886, forests predates its urban fabric – the history not necessarily preserved in the building themselves but the materials which were stewarded and protected by the First Nations before the colonial times.[23] Wood dominated the construction industry until its flammability was proven, notably altering our urban scape after the Great Fire of 1904 in Toronto. This event led to the enforcement of using more robust materials in construction through the Building Code, along with specific regulations regarding wood applications.[24]

22 Richard Bergman et al., 'Using Reclaimed Lumber and Wood Flooring in Construction: Measuring Environmental Impact Using Life-Cycle Inventory Analysis', 2010.

23 *Praxes of Care - Ecology and Deconstruction.*

24 City of Toronto, 'Your Home Our City: The 1904 Fire', City of Toronto (City of Toronto, 23 November 2017), Toronto, Ontario, Canada, https://www.toronto.ca/explore-enjoy/history-art-culture/online-exhibits/web-exhibits/web-exhibits-community-neighbourhoods/your-home-our-city/your-home-our-city-the-1904-fire/.

Masonry, typically manufactured in the forms of bricks and blocks, highlights the adaptability of standardized component assembly. However, its construction method causes major challenges when it comes to deconstruction – lime mortar is easier to separate and clean, while cement-based mortar makes it much more difficult to separate.[25] Understanding its limited processing capabilities when it came to working with individual bricks, modern salvage methodology for harvesting modules of brick walls from existing buildings has broadened their re-application in architecture – exemplified by projects like the *Resource Row House* by Lendager. Concrete is rarely ever reused as

25 Danielle Densley Tingley, 'Design for Deconstruction: An Appraisal', *The University of Sheffield*, 2012. 15.

its jointing materials, often by means of cement, make it impossible to dismantle. The steel reinforcement in typical modern cast-in-place structures poses greater unpredictability during the deconstruction process.[26]

26 Bates et al., *Introduction to Deconstruction*. 36.

27 Bates et al., *Introduction to Deconstruction*. 37.

28 Tingley, 'Design for Deconstruction: An Appraisal'. 16.

Steel is not often reused, although not impossible, but is recycled to a high extent. Its nature as project-specific with structural integrity and sizing geared towards specific designs limits its re-application, in addition to the costly process of regrading in the case it's reintroduced as structural members.[27] Reusing steel is highly dependant on the used steel quality, but also on the connection method where bolts are preferred. Additionally, the addition of fire protection around steel could make deconstruction harder.[28]

Fig. 2.12

Essential parts of a house by Vincent Phelan (The Care and Repair of the House, 1931)

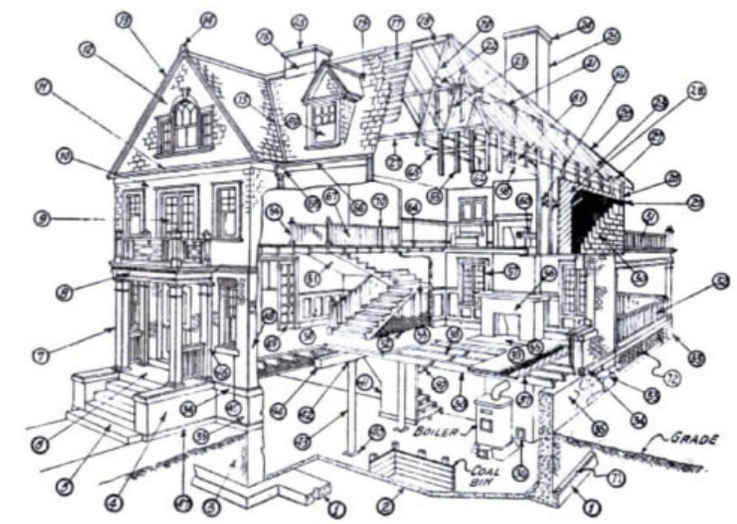


FIGURE 1.—*Essential parts of a house*

1. Footings.
2. Basement floor.
3. Foundation wall.
4. Buttress.
5. Steps.
6. Platform.
7. Porch column.
8. Porch cornice.
9. French doors.
10. Frame wall.
11. Eaves cornice.
12. Gable end.
13. Rake cornice.
14. Finial.
15. Valley.
16. Chimney flashing.
17. Shingle battens.
18. Ridge board.
19. Common rafter.
20. Hip rafter.
21. Purlin.
22. Collar beam.
23. Jack rafter.
25. Chimney.
26. Corner post.
27. Plate.
28. Diagonal sheathing.
29. Sheathing paper.
30. Shingle.
31. Balcony.
32. Veranda.
33. Piers.
34. Water table.
35. Underpinning.
36. Clean-out door.
37. Subfloor.
38. First-floor joists.
39. Finish floor.
40. Column base.
41. Plaster partition.
42. Column cap.
43. Iron column.
44. Girder.
45. Window sill.
46. Pilaster.
47. Ground course.
49. Sliding door.
50. Wainscoting.
51. Stair soffit.
52. Metal lath.
53. Platform.
54. Newel post.
55. Hearth.
56. Fireplace.
57. Casement window.
58. Rough head.
59. Bridging.
60. Rough sill.
61. Truss over opening.
62. Ceiling joists.
63. Studding.
64. Second floor joists.
65. Ribbon board.
66. Gutter.
67. Balustrade.
68. Leader head.
69. Dormer window.
70. Handrail.
71. Drain.

Fig. 2.13

Tool list from “Introduction to Deconstruction”

Types of tools for salvage/deconstruction:

A. Cutting tools
1. Utility knife
2. 5-in-1 tool
3. Hand saws
4. Reciprocating saws
5. Circular saws
6. Multi-Use Tools (Mini-router and Oscillating Multi-tool)
7. Chainsaw
8. Angle grinder

B. Prying tools
1. Flatbars
2. Crowbars and other long prybars
3. Cat’s paw type prybars
4. Specialty prybars and prybar systems
5. Roofing shovel

C. Wedging and chiseling
1. Shims and wedges
2. Hand chisels
3. Power chisels

D. Nail removal
1. Claw hammers
2. Prybars
3. Nail nipper
4. Nail Jack
5. NailKicker
6. Crescent 56 Nail Puller and similar nail extracting tools

E. Tools for bolts, screws and other threaded items
1. Screwdrivers
2. Pliers
3. Wrenches

F. Hammers
1. Claw hammers
2. Sledge hammers
3. Soft head mallets
4. Specialty hammers

G. Material bundling and packaging tools & supplies
1. Sawhorses
2. Banding tools
3. Ratchet straps
4. Shrink wrap
5. Pallets
6. Specialty racks

H. Material moving tools
1. Hand trucks
2. Carts
3. Pallet jack
4. Forklift
5. Wheelbarrow
6. Rope and straps
I. Tools for accessing hard to reach areas
1. Ladders
2. Scaffolding
3. Mechanical lifts

J. Cleaning tools
1. Brooms and brushes
2. HEPA Vacuum and HEPA Air Filter
3. Wet cleaning tools

Secondly, the type of construction must be identified. Residential buildings in North American suburbs are mainly constructed with wood frames, possible to be deconstructed by stripping out selective non-structural and structural for full deconstruction. In comparison, commercial and institutional structures introduce structural steel frames and CMU in addition to wood frames. Industrial structures typically require even heavier, durable materials and construction methods such as CIP concrete and masonry exterior. Development of complex building envelopes create more challenges for deconstruction. Large project sizes often raises questions on insurance coverage due to its higher potential for accidents.[29] For such reasons, selective deconstruction is more common for commercial structures in modern practices, and mining of architectural components such as tiles, furniture and service-based products is focused.

Lastly, the buildings' age plays a huge role in determining the salvage potential, both in its quality of individual materials and the construction methods employed during the time of construction. Solid stone walls were once a common construction method which hold great market value today. Older structures typically have higher quality interior frames such as wood trims; ornamental features no longer found in modern buildings. Common issues here include navigating deconstruction of balloon framing from the early 1800s which is difficult for dismantling, framing often sizes differently than contemporary standards, hazardous materials including lead paint and asbestos, safety concerns including rotten structural members or flooring, pest damages and mold.[30] In contemporary buildings, key benefits include uniform construction methods, standardized sizes for framing elements, and easily removable fixtures. In contrast, common drawbacks involve subpar materials, prominent use of non-reusable or low-value materials like plastics, prefabricated systems that are challenging to deconstruct, and adhesives and fasteners that hinder disassembly.[31]

Technical understanding of a building's layers is the first step in deconstruction work and an avenue for assessing the residual value of building stock. Due to the technical barriers inherent in the fieldwork, the focus is often put on waste management. This, however, simultaneously condemn the intrinsic value of existing materials to obsolescence. Architecture stands as a primary physical record of the time, knowledge, labour, and energy invested in building our urban fabric –values worthy of remembrance, preservation, and continuation.

29 Bates et al., *Introduction to Deconstruction*. 15.

30 Bates et al., *Introduction to Deconstruction*. 35.

31 Bates et al., *Introduction to Deconstruction*., *Introduction to Deconstruction*. 34.

2.2 Emergence of Regulatory Changes

Arguably, the greatest challenges encountered by the reuse sector today are not technological but legal – including procurement procedures, building material certification processes, insurance policies – which was all written with the linear (not circular) economy as a backdrop.[32] This work demands collaboration not just from architects and engineers, but also from lawyers, highlighting the interdisciplinary nature of the effort.

As discussed in Chapter 1, Canadian taxation have favoured demolition over reuse since the 1940s, and have standardized the procedure as the end/first phasing of any typical construction projects. By the mid-1980s, the industry gained more consciousness of the buildings' role in excessive energy consumption and material waste, and saw adoption of the term "sustainability" in architectural discourse. The notion of sustainable design came to be systematized through establishing evaluation systems like LEED (Leadership in Energy and Environmental Design) for resource efficiency. Even within this system, however, reuse it ranked low, and there continues to be a lack of support especially in commercializing salvaged materials to be re-introduced to the product-line – this is essentially the final step is closing the loop of the circular economy. The economy is often in tension with policy, as regulations force companies to comply under threat of punishment, but they seldom reward commerce for taking initiatives.[33] It's a crucial factor which structures the framework of deconstruction work, ultimately impacting the scale at which deconstruction field can grow and more materials salvaged.

On the contrary of its conflicting nature of the government and business, positive trends emerge in North America in the building policy sector. Many of the current policies adopted within North America apply at the C1-4 "End of Life" and D "Beyond the Building Life Cycle" stage of a building, including Portland's 2016 deconstruction ordinance[34], CA municipalities' C&D recycling ordinances[35], Boulder's 75% weight diversion[36], and Vancouver's green demolition bylaw requiring 75-90% material recycling[37] [Fig. 2.14, 2.15]. This collective initiative underscores the significance of not solely penalizing but also incentivizing such ordinances to propel the advancement of this movement toward reuse.

In summary, several best practices can be consolidated as follows: mandate a salvage assessment or material reuse plan, provide a list of approved contractors, develop a workforce training program which can be funded by a demolition fee, include commercial buildings beyond residential, and initiative grants and incentives. In today's global economic climate, efficiency in resource use yields competitive advantages.

32 Devlieger, 'Reverse Architecture. The Virtues of Unbuilding and Reassembling'. 150.

33 Jane Jacobs, *Systems of Survival: A Dialogue on the Moral Foundations of Commerce and Politics*, 1st Vintage Books ed (New York: Vintage Books, 1994).

34 'Deconstruction Ordinance Expansion | Portland.Gov', 19 November 2019, https://www.portland.gov/bds/news/2019/11/19/deconstruction-ordinance-expansion.

35 'Deconstruction Ordinance – City of Palo Alto, CA', accessed 19 September 2024, https://www.cityofpaloalto.org/Departments/Public-Works/Zero-Waste/Zero-Waste-Requirements-Guidelines/Deconstruction-Ordinance.

36 'Sustainable Deconstruction Requirements | City of Boulder', accessed 19 September 2024, https://bouldercolorado.gov/services/sustainable-deconstruction-requirements.

37 'GREEN DEMOLITION BY-LAW NO. 11023', n.d.

Fig. 2.14

North American Cities Mandating Deconstruction

*Ordinance paused in Milwaukee as of October 2023 due to challenges of limited markets for reclaimed materials.

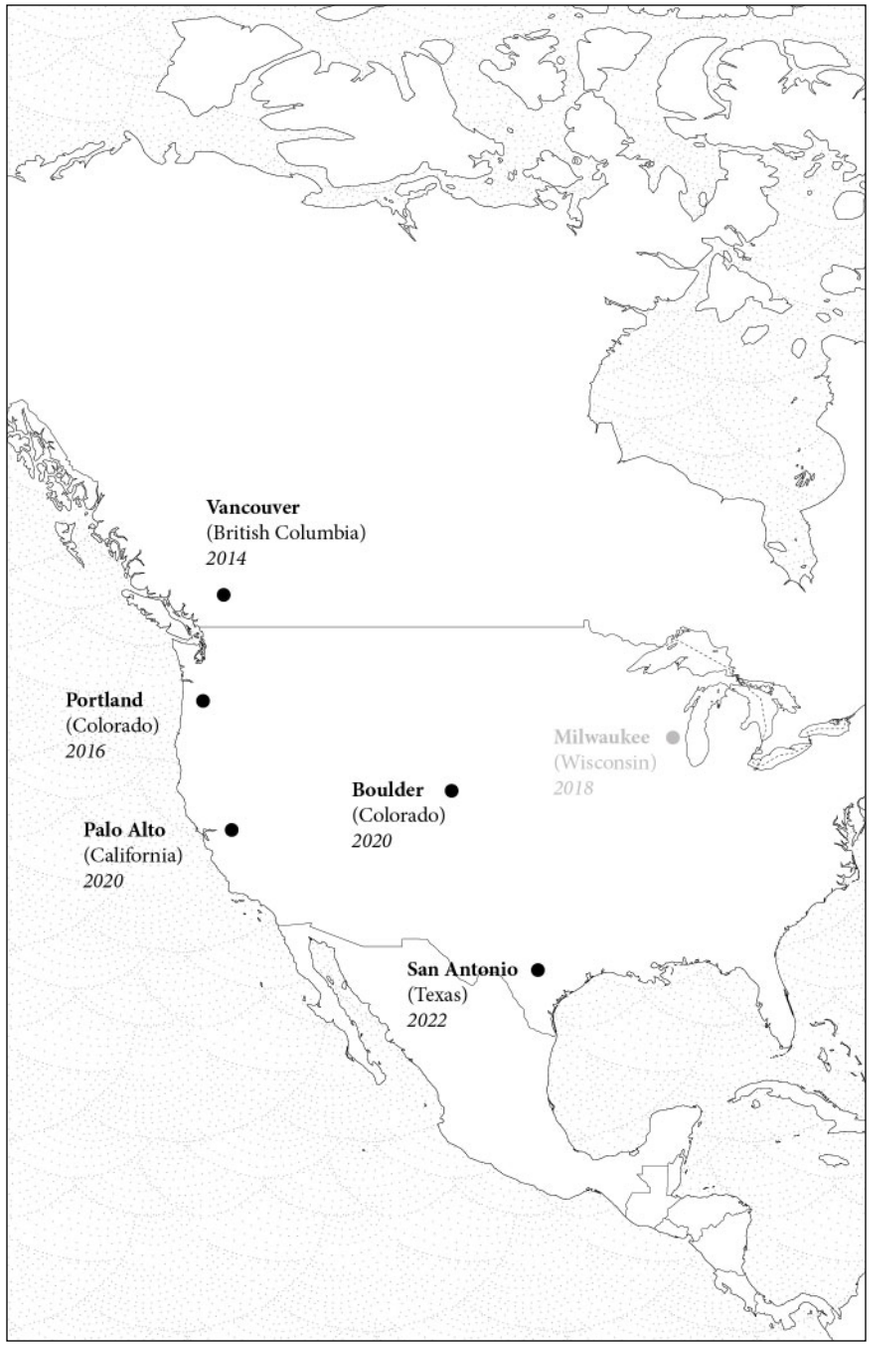
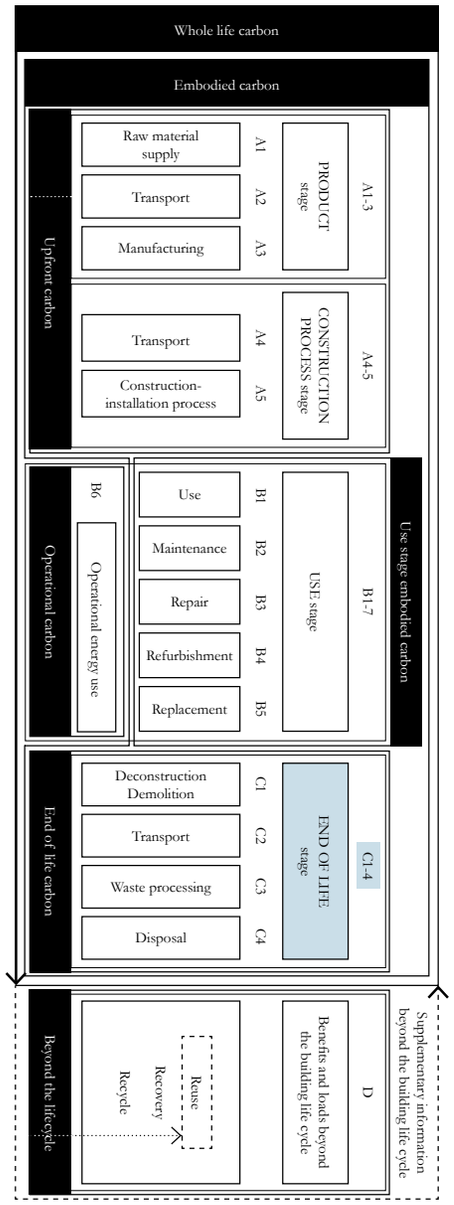


Fig. 2.15

Building's life cycle stages



INFORMATION FROM ORIGINAL LIFE-CYCLE CHART

AREAS AFFECTED BY THE MENTIONED MANDATES

Economic attributes of regulations on deconstruction work can be understood using Eq. (1) (modified from "Cost prediction model for building deconstruction in urban areas")[38]:

38 Amol Tatiya et al., 'Cost Prediction Model for Building Deconstruction in Urban Areas', *Journal of Cleaner Production* 195 (10 September 2018): 1572–80, https://doi.org/10.1016/j.jclepro.2017.08.084.

$$Cn = Cr + Cd + Pf - Vs - Vt \quad (1)$$

Where,
Cn = net cost
Cr = cost of activities for removal
Cd = cost of activities for debris disposal
Pf = (penalty) fees
Vs = value added from salvage
Vt = tax credits and incentives

The source text of the equation above claims that deconstruction can have a lower net cost than demolition, highlighting the importance of cost prediction that considers case-based reasoning including the building's age, design complexity, hazardous materials, location, etc[39]. The constructed formula should by no means be considered the definitive method for assessing the cost of demolition or deconstruction work. Rather, it serves as a tool to help understand the interplay of various factors that contribute to the overall cost estimation. This model provides a framework to guide further analysis and refinement, allowing stakeholders to consider diverse variables such as removal activities, disposal costs, salvage value, and financial incentives when choosing deconstruction as an alternative to demolition.

39 Tatiya et al.

2.3 Case Studies

The following case studies of contemporary initiatives in the field of deconstruction examine the business model structure of each organization, their testimony on deconstruction work, and their approach to curating user experience through deliberate material display to foster commerce work.

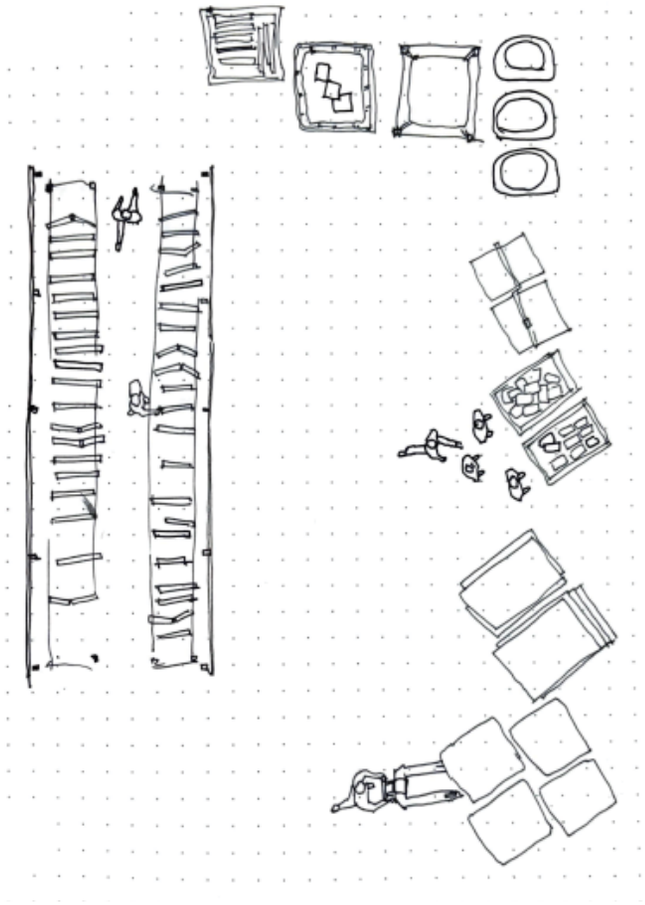
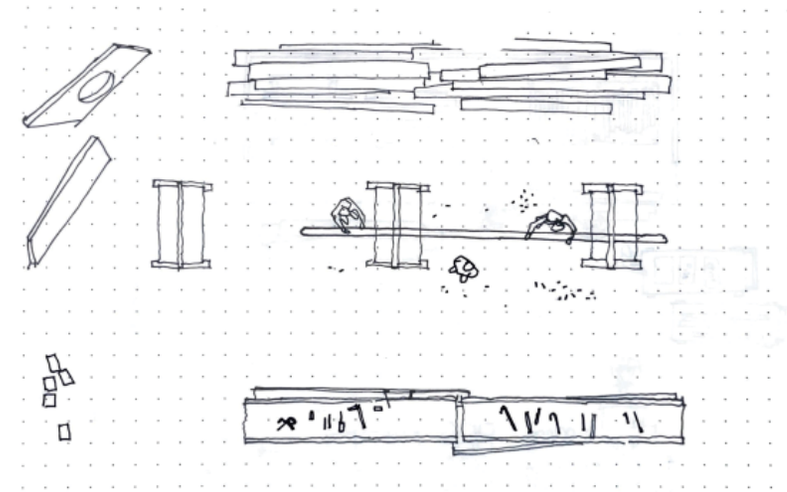


Fig. 2.16

Erin house decon-
struction site

Erin*, Canada

*moved to Toronto as of 2024



2.3.1 Ouroboros

Ouroboros situates itself in Toronto, a metropolitan city in a state of constant demolition and rapid development, with virtually any street seeing a major construction project on any given day. Frustrated by the throw-away culture prevalent in contemporary North American society, Meredith Moore launched Ouroboros in 2022 in response.

Ouroboros deconstructs and salvages valuable building materials across Ontario, with a portfolio that includes buildings in Toronto, Guelph and Erin. Offered services include deconstruction/demolition audits, salvage work, and partial/structural deconstruction. Originally operating from a remote warehouse in Erin, Ontario, Ouroboros relocated to Toronto in 2024 as part of its business expansion.

Meredith explains deconstruction as an envision of construction in reverse. Items that are installed last during construction such as light fixtures, doors, and trims, are typically the first to come out in a deconstruction. Ouroboros takes as much pride and care removing the materials from the home as the initial trade did upon installation, so they can be preserved to be reused as opposed to being dumped as trash.[40]

Moore argues that most of the construction and demolition waste in today's landfills could be repurposed and diverted. A typical deconstruction project can divert more than 45 tonnes of reusable materials from landfills while recovering valuable old-growth lumber and unique architectural elements. Beyond reducing construction waste, deconstruction also helps lower the release of airborne pollutants and dust generated by traditional construction practices.

40 'By Reversing the Construction Process, Ouroboros Reduces Waste', accessed 18 June 2024, https://storeys.com/ouroboros-deconstruction-demolition/.

The largest project taken on by Ouroboros was the deconstruction of the Erin house, a 9,850 sf home which was left vacant for 7 years. After purchasing the property in 2019, the current owner sought advice from various specialists to determine the best approach for the aging structure. Aiming to minimize the building's overall footprint and operational carbon, they concluded that retrofitting the structure would be both more expensive and less effective than starting anew. With this decision, the client approached Ouroboros to explore how deconstruction could support their goal of reducing the project's environmental impact.

The original structure, built in 1969 with later additions in 1980 and 1989, contained high-quality materials, including first-generation Douglas fir beams and joists, dimensional lumber, rosso levanto and Verias Green marble, local granite, interior and exterior cedar panelling, and clean cedar trim—all materials which were salvaged. Ouroboros' expertise in carefully deconstructing the structure and preserving the existing concrete foundation for reuse in the new build played a key role in receiving the bid. The preservation of the main structures, including the expansive concrete foundation and several stone masonry walls, led to saving roughly 110 tonnes of CO2e emissions, equivalent to the amount of carbon sequestered by 1,800 tree seedlings grown for a decade.

Meredith actively advocates for a paradigm shift in the construction industry, encouraging government bodies and building professionals to adopt approaches that challenge regulations rounded in the linear economy. This could inverse the cost of tipping fees, making deconstruction work more competitive with demolition and introduce incentives beyond the tax credits her works currently deliver to the homeowners. The company's goal is to make deconstruction more cost-effective and accessible so that it becomes more widely adopted, and for sourcing and specifying a salvaged piece of lumber to become as easy as walking into a big box store and picking up a load of 2x4s.

As the industry and the Ouroboros network grows, Moore hopes to help clients deconstruct larger buildings and very importantly, commercial projects as they're some of the largest contributors to C&D waste.

"In my opinion, the most under-utilized and wasted material of demolition is the old growth lumber many of our city's buildings are comprised of. It is an irreplaceable resource, largely unavailable today, that embodies the history, beauty and enduring strength of Canada." – Meredith Moore

Fig. 2.17

Ouroboros facility
1 to 1000

A: MATERIAL PROCESSING
B: WOOD WORKING AREA
C: LARGER COMPONENTS: DIMENSIONAL LUMBER, ARCHITECTURAL MEMBERS, ETC
D: SMALLER COMPONENTS: MISCELLANEOUS, TRIM, WINDOWS, ETC
E: EQUIPMENT STORAGE

1: MATERIAL LOADING DOCK

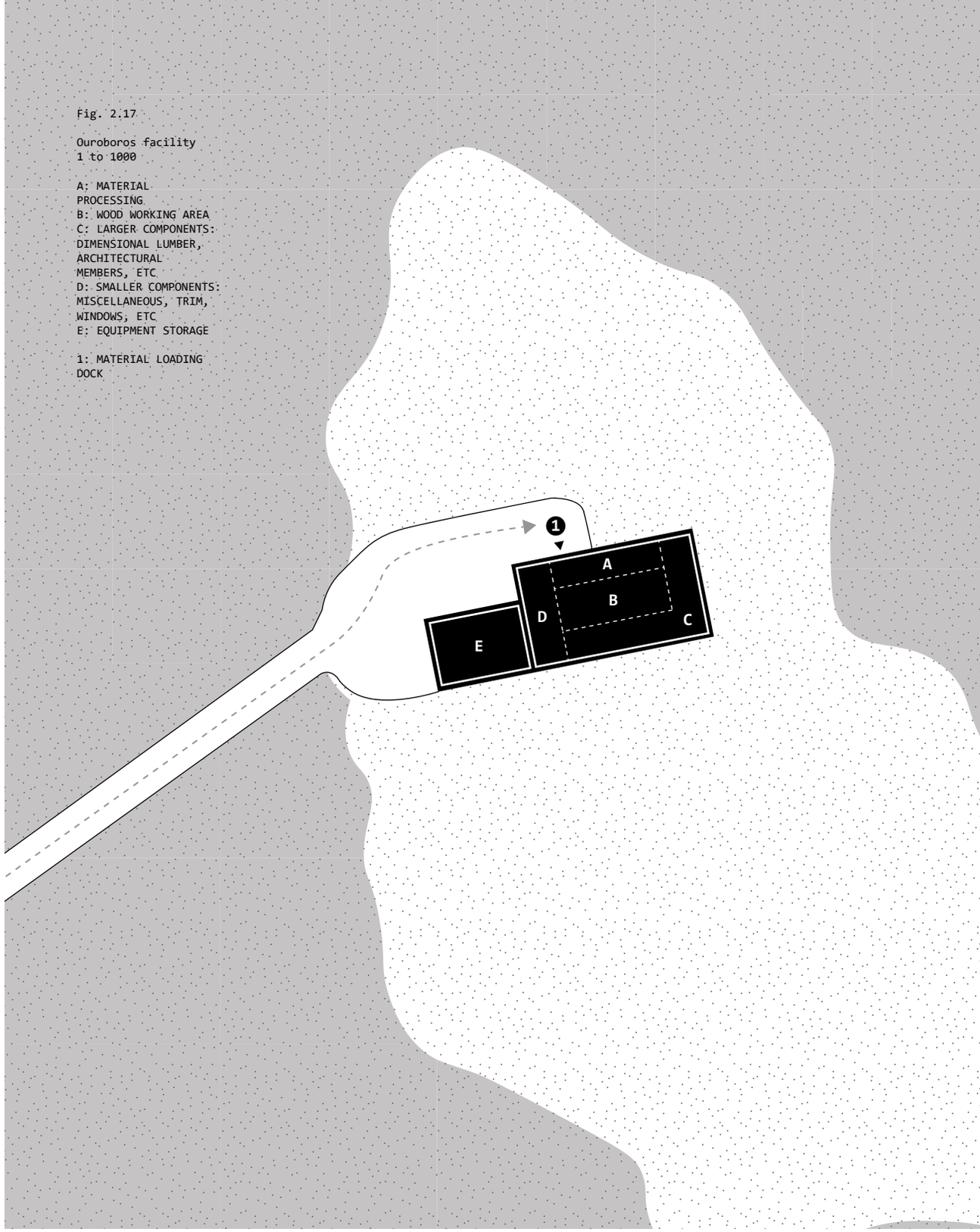
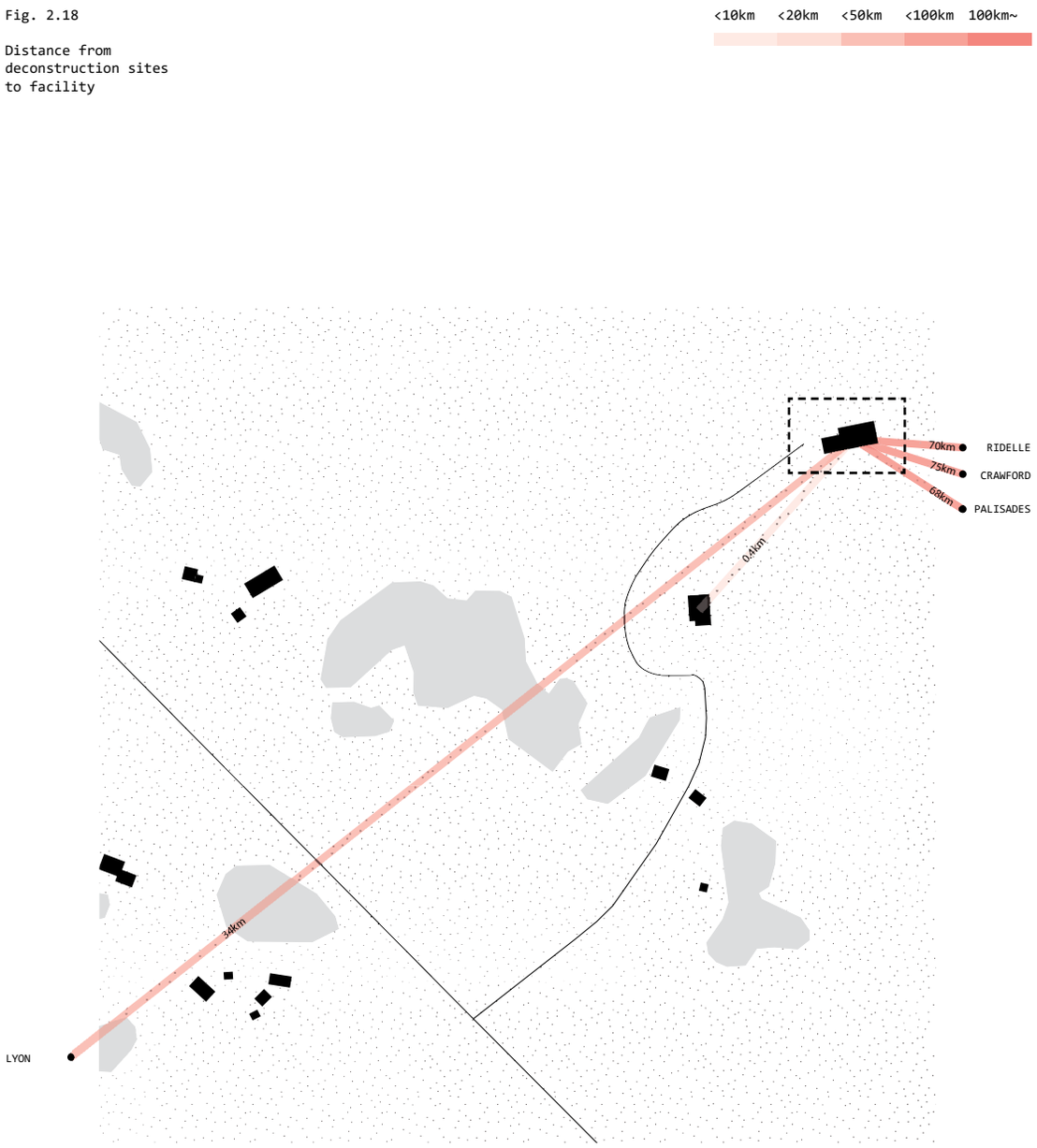


Fig. 2.18

Distance from
deconstruction sites
to facility



DISTANCE	DECONSTRUCTION SITES:
34km	LYON (GUELPH)
0.4km	ERIN (ERIN)
70km	RIDELLE (TORONTO)
75km	CRAWFORD (TORONTO)
68km	PALISADES (TORONTO)

Fig. 2.19, 2.20

Images of the
Ouroboros warehouse
(Photos by author)

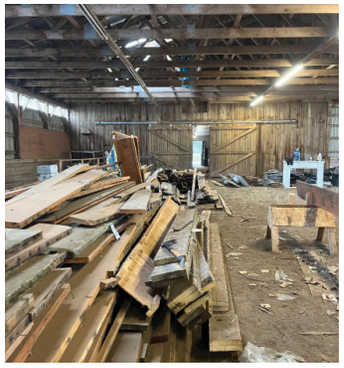
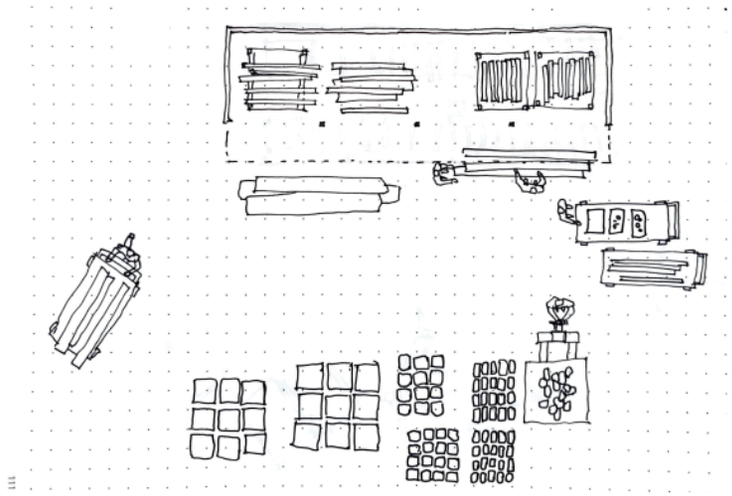


Fig. 2.21

Deconstruction site in Savannah (photo by Jesse Kellem)

Savannah, USA



2.3.2 Re:Purpose Savannah

For Re:Purpose Savannah, deconstruction is a form of stewardship that integrates environmental and land care with a matriarchal vision of community. This non-profit, women-run organization trains women in deconstruction practices aimed at dismantling buildings and selling salvaged materials in Savannah, Georgia. The work performed by these women uncovers the complex layers of history embedded in buildings—layers that are typically erased during demolition, leading to the loss of materials and the valuable knowledge, labor, and natural history they embody.

In "Taking Apart Buildings and Systems," Jane Mah Hutton and Alison Creba discuss the practice of deconstruction with Mae Bowley, director of Re:Purpose Savannah. Bowley advocates for three key interventions to disrupt harmful construction and demolition systems: first, incentivizing deconstruction while regulating demolition; second, increasing landfill fees, as low disposal costs incentivize waste in a sector that contributes significantly to landfill waste; and third, raising the minimum wage to ensure fair compensation for the labor involved in deconstruction work.

According to Bowley, deconstruction is a caretaking work that emphasizes the safety of workers, the careful handling of materials, and the reduction of waste destined for landfills. She highlights the preciousness of these materials, noting that each piece has a history and value.

For example, markings on old wood, commonly found in late 18th-century buildings, reveal the careful craftsmanship of millworkers who custom-cut wood to maximize yield and minimize waste. This wood, sourced from ancient

forests that have been almost entirely harvested by European settlers, is not only more carbon-dense than modern alternatives but also holds historical significance, which is lost when discarded in landfills.

Savannah Grey bricks also serves as an emblematic material of how the deconstruction industry intersects with social history, resource dilemmas, gentrification, and uneven urban development. Once considered inferior and crafted by enslaved individuals on plantations, these bricks have now become some of the most expensive on the national market.[41] As she points out, the connection between building materials and social status runs deep. In the past, building owners often covered their Savannah Grey brick structures with stucco, ashamed of not being able to afford the more prestigious imported bricks. Today, however, these bricks are so sought after that people are stripping away the stucco to proudly display them—exposing not just the bricks but also the fingerprints of those who made them.

After Re: Savannah cleared debris from the burned Webb House in 2019, original architectural features were revealed, prompting the owner to restore the building rather than demolish it. This example illustrates how deconstruction can serve as a catalyst for architectural preservation and innovation.

Bowley further notes the potential for reclaimed C-grade wood to be repurposed into cross-laminated timbers (CLTs), offering a more sustainable alternative to concrete and steel in mass timber structures. The growing demand for CLTs presents a significant opportunity for large-scale deconstruction to become an essential part of the supply chain.[42]

Re: Savannah dedicates considerable time and resources to transforming what appears to be waste into well-organized, aesthetically appealing merchandise, encouraging people to recognize and reuse salvaged materials. Bowley emphasizes that how materials are presented influences not only sales but also how people perceive their value and respect their potential for reuse. These women's advocacy for a circular future extends beyond their on-site work to their participation in conferences, where they share their stories, teach, and collaborate with other system builders in the field.

"How many tonnes have we recycled and how many tonnes have we diverted from the landfill? I think about overlaying those numbers on the national system and the immediate impact this would have on climate change, the workforce, women – you name it. The construction and demolition industry is so vast, and if we scaled-up deconstruction efforts to even a sixteenth of that, it would be massive."– Mae Bowley

41 Mah Hutton and Creba, 'Taking Apart Buildings and Systems: In Conversation with Mae Bowley of Re:Purpose Savannah'. 72.

42 Mah Hutton and Creba. 75.

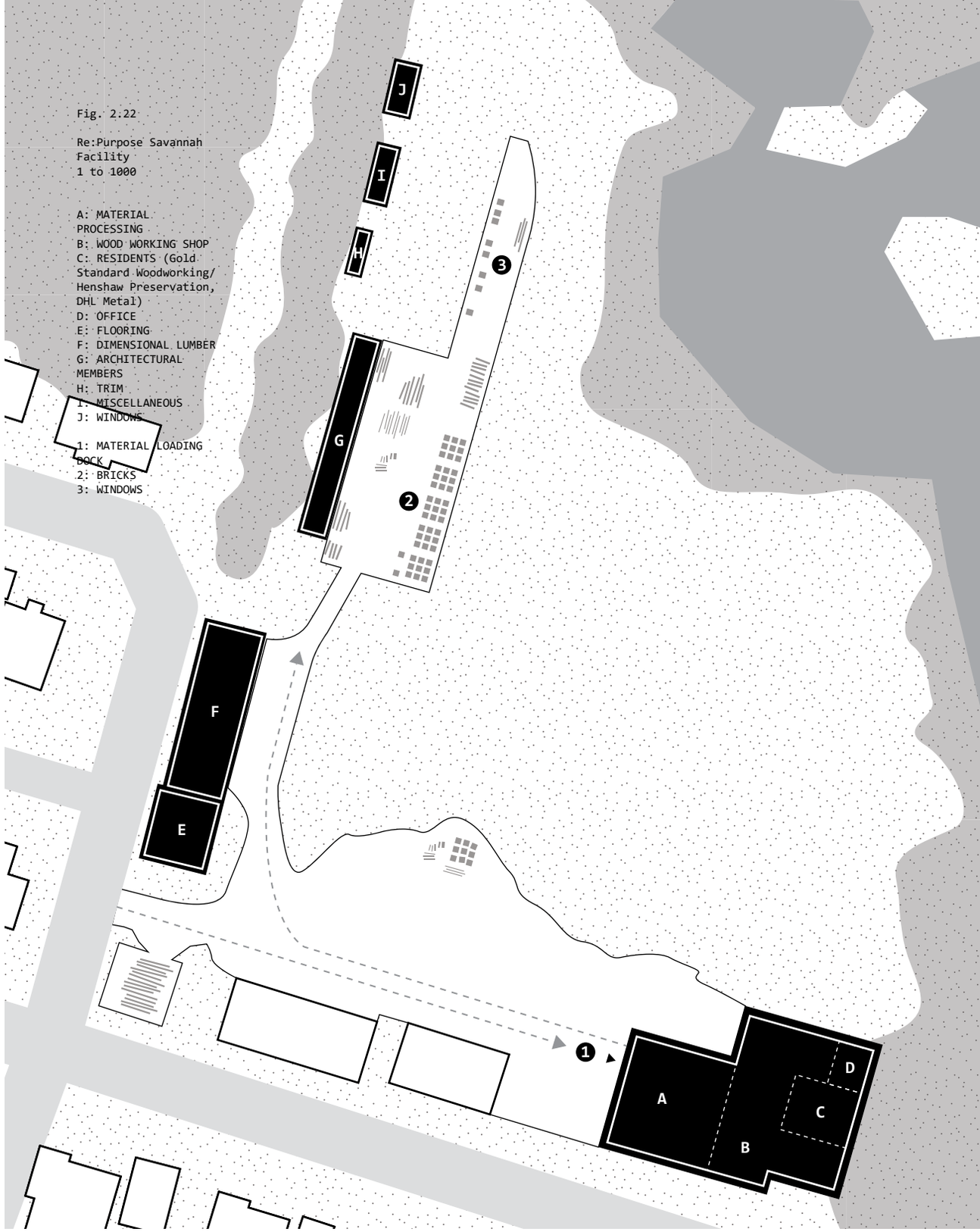


Fig. 2.22

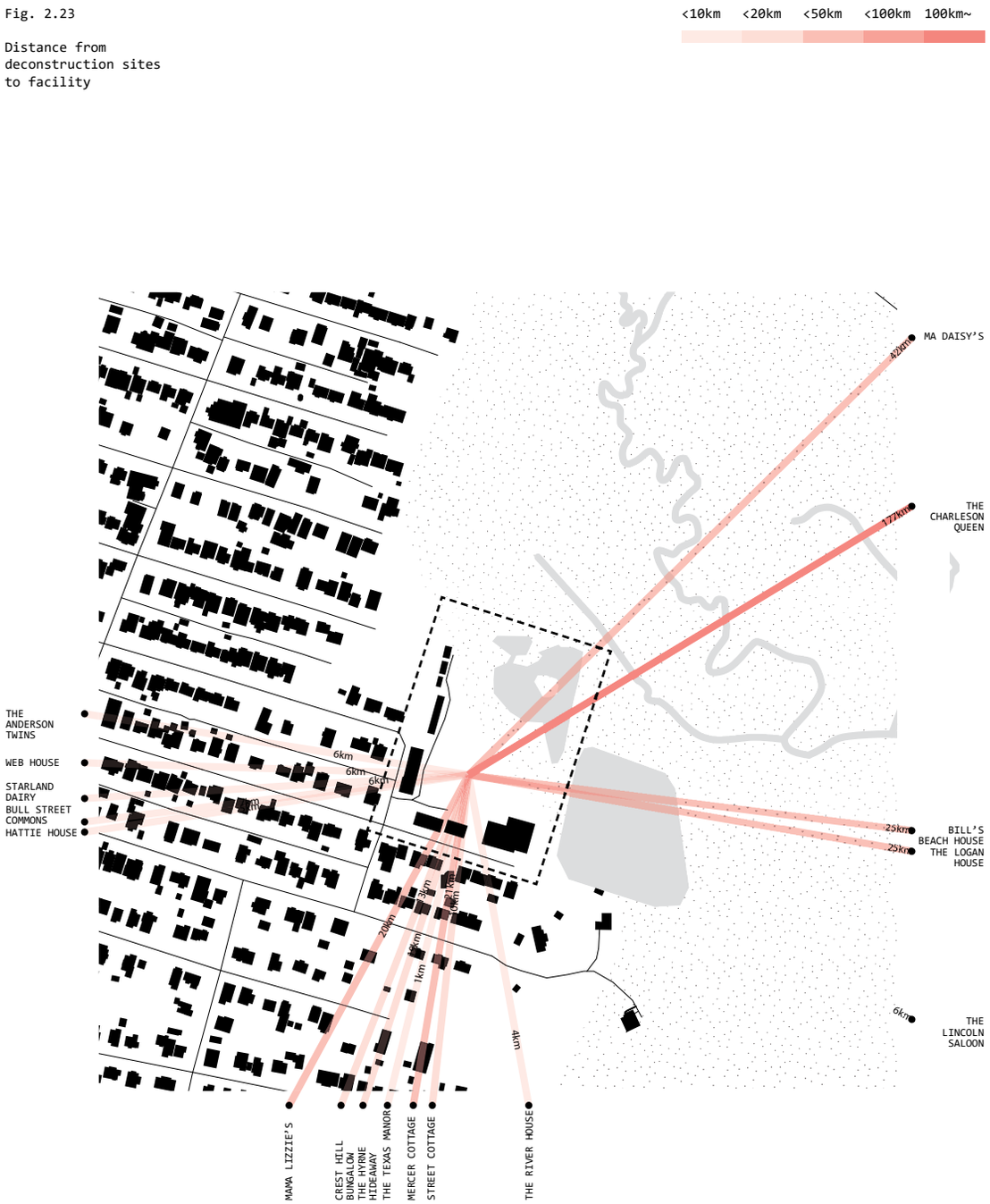
Re:Purpose Savannah Facility
1 to 1000

A: MATERIAL PROCESSING
B: WOOD WORKING SHOP
C: RESIDENTS (Gold Standard Woodworking/ Henshaw Preservation, DHL Metal)
D: OFFICE
E: FLOORING
F: DIMENSIONAL LUMBER
G: ARCHITECTURAL MEMBERS
H: TRIM
I: MISCELLANEOUS
J: WINDOWS

1: MATERIAL LOADING DOCK
2: BRICKS
3: WINDOWS

Fig. 2.23

Distance from
deconstruction sites
to facility



DISTANCE	DECONSTRUCTION SITES:
42km	MA DAISY'S (BLUFFTON, SC)
7km	BULL STREET COMMONS (BINGVILLE, GA)
1km	THE TEXAS MANOR (EAST SAVANNAH, GA)
25km	BILL'S BEACH HOUSE (TYBEE ISLAND, GA)
10km	STREET COTTAGE (ISLE OF HOPE, GA)
4km	THE RIVER HOUSE (THUNDERBOLT, GA)
6km	STARLAND DAIRY (STARLAND ARTS DISTRICT, GA)
6km	THE LINCOLN SALOON (NATIONAL LANDMARK DISTRICT, GA)
177km	THE CHARLESTON QUEEN (OLD CITY CHARLESTON, SC)
25km	THE LOGAN HOUSE (TYBEE ISLAND, GA)
19km	THE HYRNE HIDEAWAY (VERNON RIVER, GA)
13km	CREST HILL BUNGALOW (CHATHAM COUNTRY, GA)
20km	MAMA LIZZIE'S (COFFEE BLUFF, GA)
6km	WEBB HOUSE (THOMAS SQUARE, STREETCAR HISTORIC DISTRICT, GA)
5km	HATTIE HOUSE (MIDTOWN, GA)
21km	MERCER COTTAGE (BURNSIDE ISLAND, GA)
6km	THE ANDERSON TWINS (HISTORIC VICTORIAN DISTRICT, GA)

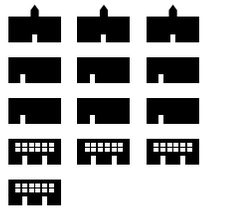
Fig. 2.24, 2.25

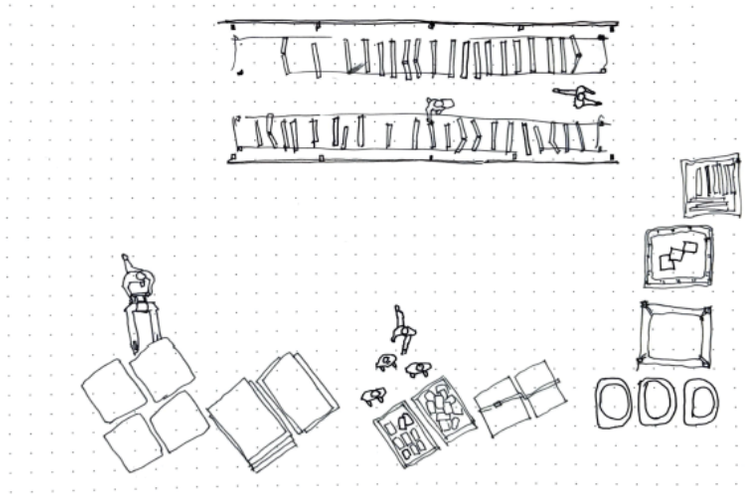
Images of the
Re:Purpose Savannah
"yard" (Photos by
author)

Fig. 2.26

"Lebeau" building deconstruction site

Brussels, Belgium





2.3.3 RotorDC

Rotor was co-founded in 2006 as a non-profit organization and design collective based in Brussels, focusing on promoting a more resource-efficient materials economy. The team has since engaged in research, curatorial projects, architecture, deconstruction, and material markets. In 2014, the spin-off cooperative Rotor DC (Deconstruction and Consultancy) was established, primarily focusing on dismantling and reusing materials from buildings. Rotor DC, a horizontally-managed cooperative, aims to demonstrate the feasibility of running an independent company active in dismantling and reselling contemporary building materials in metropolitan areas.

In 2006, when incorporated as a non-profit, the organization was relatively isolated—though not alone—in advocating for the off-site reuse of building parts. With the concept of component reuse gaining traction in larger circles, circularity is moving from the margins to the center stage in architectural discourse. Over the years, Rotor DC has managed the selective dismantling and refurbishment of several hundred tons of building materials annually, primarily sourced from large-scale service buildings slated for demolition or undergoing major renovations that require the removal of interior finishes and equipment.

Rotor specializes in dismantling floor and wall tiles, particularly ceramic tiles produced by successful French and Belgian companies that were widely used in buildings constructed in the 1930s to 1950s. Rotor DC has invested significant time and money in research, equipment, and machinery to streamline the cleaning and salvaging process. Years of hands-on experience with a progressively skilled team of

dismantling workers, along with close collaboration with a growing network of demolition contractors, city officials, designers, builders, and artisans, have revealed both the opportunities and challenges of reusing building materials.

The philosophy of Rotor DC is simple: when the demolition of the whole is inevitable, at least some parts should be preserved.[43] Lionel Devlieger, co-founder of Rotor, explains deconstruction work is personal and subjective. Every operator in the trade naturally develops a unique, idiosyncratic identity, much like a vintage clothing shop forms its style through the assortment of reclaimed garments it offers.[44] Similarly, the selection of materials and goods results from a curating process guided by three levels of constraints. First, due to economic and spatial limitations, only the most valuable and profitable materials can be dismantled and stored. Storage costs necessitate that every item in the warehouse must sell at a decent price. Second, access to demolition sites is limited. Geographically, Rotor's focus remains on Brussels, and only a certain number of sites provide opportunities to extract materials. Lastly, the team gravitates toward certain materials based on their quality, scarcity (such as marbles from depleted quarries), or versatility, ensuring they can be easily reused[45] Ultimately, the process is also influenced by aesthetics and personal taste.

The "Lebeau" project involved the deconstruction of a 1950s-60s modernist building that once housed Belgium's national telephone company. Despite facing tight deadlines and an initial refusal of access by the building's new owner, the team successfully salvaged materials including the rare Belgian marble: "Bleu Belge". A veined black marble quarried in southern Belgium, this marble was a signature of high-end art-deco architecture but became scarce after its quarries were exhausted in the mid-20th century. The project also recovered red Belgian marble—a material that is still quarried although the most vibrant and exceptional varieties are now rare. Both the black and red marbles have deep geological histories, with the black marble formed from ancient marine animal skeletons and the red marble originating from petrified coral reefs. The recovery of these valuable materials was accompanied by a range of challenges. Outdated installation methods, such as the use of Portland cement mortar, complicated the extraction process. Yet, the skilled team managed to salvage intact glazed blue ceramic tiles and marble slabs with careful handling.[46]

Rotor advocates for extending the same level of care given to marble, a material naturally formed over time, to other building materials. The emissions generated during the production of these materials, regardless of when they were created, contribute to the cumulative human footprint. This environmental burden should be collectively acknowledged and accounted for in modern construction and deconstruction practices.

"For designers, building professionals, and building owners, this knowledge suggests the desirability of taking great care of the incredible fruits that this process bore, and making them available for future generations by avoiding unmindful mortars which create joints that are too sticky." – Lionel Devlieger

43 Devlieger, 'The Raw, the Cooked, and the Overdone on What Makes Building Materials Salvageable (or Not) in North Western Europe'. 34.

44 Devlieger, 'Reverse Architecture. The Virtues of Unbuilding and Reassembling'. 152.

45 Devlieger. 152.

46 Devlieger, 'The Raw, the Cooked, and the Overdone on What Makes Building Materials Salvageable (or Not) in North Western Europe'. 34.

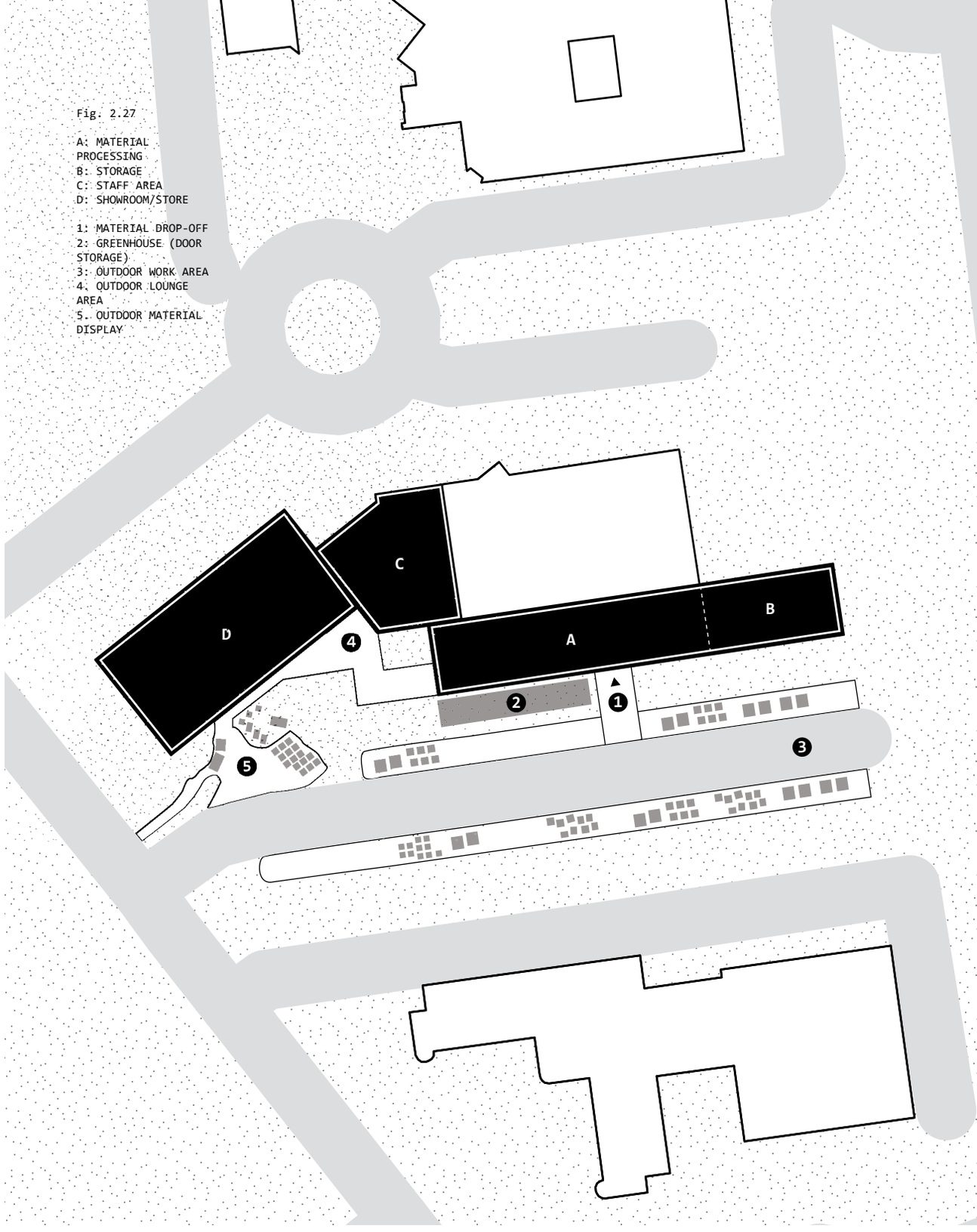


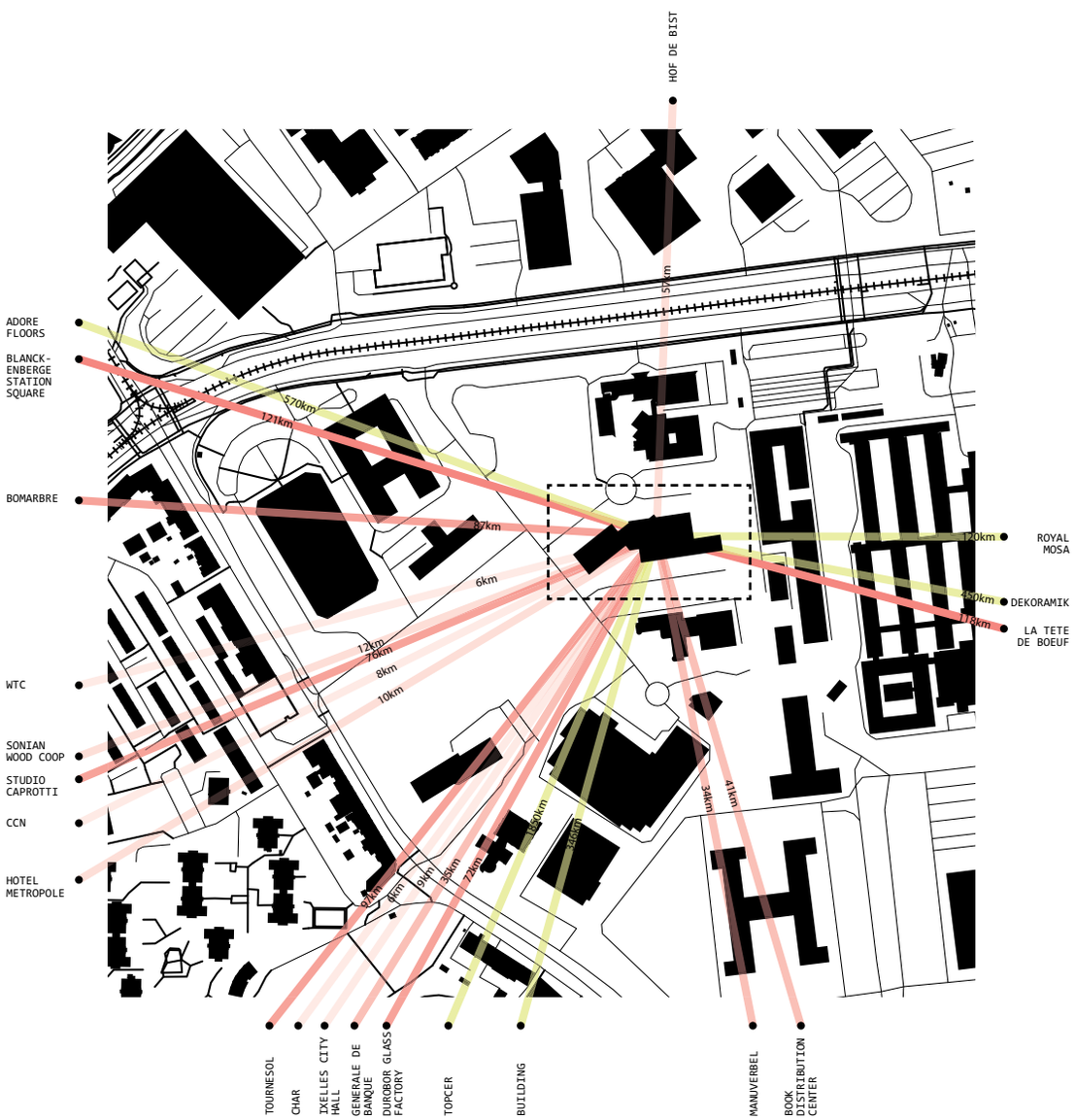
Fig. 2.27

A: MATERIAL PROCESSING
B: STORAGE
C: STAFF AREA
D: SHOWROOM/STORE

1: MATERIAL DROP-OFF
2: GREENHOUSE (DOOR STORAGE)
3: OUTDOOR WORK AREA
4: OUTDOOR LOUNGE AREA
5: OUTDOOR MATERIAL DISPLAY

Fig. 2.28

Distance from
deconstruction sites
to facility



DISTANCE	DECONSTRUCTION SITES:
8km	CENTRE DE COMMUNICATION NORD (BELGIUM)
72km	DUROBOR GLASS FACTORY (SOIGNIES, BELGIUM)
35km	GENERALE DE BANQUE (BEERSEL, BELGIUM)
76km	HARDWARE STORE-STUDIO CAPROTTI (LESSINES, BELGIUM)
118km	LA TETE DE BOEUF (AYWAILLE, BELGIUM)
34km	MANUVERBEL (BOOM, BELGIUM)
6km	WTC (BRUSSELS, BELGIUM)
10km	HOTEL METROPOLE (BRUSSELS, BELGIUM)
9km	IXELLES CITY HALL (ELSENE, BELGIUM)
57km	HOF DE BIST (ANTWERP, BELGIUM)
1850km	TOPCER (PORTUGAL)
450km	DEKORAMIK (GERMANY)
120km	ROYAL MOSA (HOLLAND)
6km	CHARLEMAGNE BUILDING (BRUSSELS, BELGIUM)
12km	SONIAN WOOD COOP (BRUSSELS, BELGIUM)
121km	BLANCKENBERGE STATION SQUARE (BLANCKENBERGE, BELGIUM)
346km	BUILDING (PARIS)
570km	ADORE FLOORS (UK)
87km	BOMARBRE (ZULTE, BELGIUM)
41km	FORMER BOOK DISTRIBUTION CENTER (WALLON BRABANT, BELGIUM)
97km	TOURNESOL SOCIAL HOUSING (CUESMES, BELGIUM)

*not all sites noted**

Fig. 2.29, 2.30

Images of the RotorDC
facility (From the
RotorDc website)

The cases of Ouroboros, Re:purpose Savannah, and Rotor DC reveal several critical barriers to the broader adoption of deconstruction and material reuse:

1. **Structural Integrity of Salvaged Materials:** Maintaining the integrity of materials during deconstruction is a challenge. Older installation techniques, such as the use of Portland cement, complicate material recovery, as seen in Rotor DC's efforts to salvage rare marble, where improper handling often led to damage. A major technical challenge of reusing construction materials in a building is being able to know and rely upon their structural integrity. This re-assessment process adds time and cost to the overall construction phase.

2. **Economic Viability and Spatial Constraints:** High storage and operational costs limit the economic feasibility of deconstruction. Both Ouroboros and Rotor DC emphasize the need to prioritize the most valuable materials, as storage space and profitability are major constraints. Additionally, tipping fees and cheaper demolition options, further restrict deconstruction's competitiveness.

3. **Regulatory and Policy Barriers:** The lack of supportive regulations is a significant obstacle. Ouroboros and Re:purpose Savannah advocates for increased landfill fees, government incentives, and policy changes to make deconstruction more financially viable. Current regulations favour demolition, leaving deconstruction at an economic disadvantage.

4. **Inventory Management:** The challenge of tracking salvaged materials limits scalability. Meredith Moore of Ouroboros stresses the need for more advanced inventory software to streamline the sale and distribution of reclaimed materials, which remains underdeveloped and inefficient.

5. **Labor and Time Costs:** Deconstruction is labor- and time-intensive compared to demolition. Re:purpose Savannah highlights the need for higher wages to fairly compensate workers, as the meticulous nature of deconstruction increases costs, making it less attractive to the stakeholders.

6. **Cultural and Aesthetic Perception:** Cultural attitudes toward salvaged materials present a major social barrier. Re:purpose Savannah emphasizes the importance of reframing reclaimed materials as aesthetically valuable to increase public and industry acceptance. Without changing perceptions, demand for these materials remains limited.

Fig. 3.1

Conceptual sketch of an imaginary industrial site (drawn by author)

03 CONVERGENCE OF TECHNOLOGY, SOCIETY AND ARCHITECTURE

3.1 Story of the Site

The intersection of technology, society and buildings is more contingent than deterministic. Tools always presuppose a machine, and the machine is always social before it materializes in technical form.[1] This philosophy is derived from Gilles Deleuze, who stated that, "Types of machines are easily matched with each type of society–not that machines are determining, but because they express those social forms capable of generating them and using them".[2] From the invention of watermills during the agricultural revolution, to the steam engine innovation in 1764, and later the development of the first assembly line during the Second Industrial Revolution, industrial typologies and infrastructural architecture evolved to accommodate production activities and meet the social demands of each era.[3]

Chapter 3 outlines the historical context of the thesis site – the former GM plant – within the broader industrial structure of the Niagara Peninsula. Like many areas that experienced rapid economic growth throughout the 20th century with the boom of the steel and automobile industries, and the decline in the latter half, St. Catharines' largest industrial site remains vacant in 2025, since the demolition work started in 2016. This abandoned site presents an opportunity to invite a new emerging form of industrial assembly: an infrastructure that facilitates the circular flow of building materials. The city's urban landscape is examined through the lens of material metabolism to understand reusable resources within the existing building stock, and to meet today's demand for a circular building economy.

1 Kiel Moe and Ryan E. Smith, *Building Systems: Design, Technology, and Society* (Abingdon, Oxon [England] ; New York, NY: Routledge, 2012). 159.

2 Gilles Deleuze, 'Postscript on the Societies of Control' 59 (1992). 6.

3 Barbara Hahn, *Technology in the Industrial Revolution*, New Approaches to the History of Science and Medicine (Cambridge: University Press, 2020).

Fig. 3.2

"Typologies", Bernd & Hilla Becher (2004)

1. Baltimore, Maryland, USA (1981)
2. Gutehoffnungshütte, Oberhausen, D (1972)
3. Aliquippa, Pennsylvania, USA (1986)
4. Bloomdale, Ohio, USA 1977
5. Liège, B (1968)
6. Hayange, Moselle, F 1980
7. Aiseau Presle, Charleroi, B (1977)
8. Siège Espérance, Borinage, B (1971)
9. Fosse Dourges no. 4, Hénin Liétard, Nord, F (1978)
10. Zeche Zollverein, Essen, D (1998)
11. Zeche Eiberg, Essen, D (1968)
12. Zeche Concordia, Oberhausen, D (1968)

3.1.1. The Industrial Structure of Niagara

The industrial structure of the Niagara peninsula was constructed based on the region's social needs. A study by John N. Jackson and Carole White examined the patterns of industrial development, focusing on how the significance of various factors influenced industry location decisions over time.[4] The historical, economic and statistical data on manufacturing industries in the area describes the region to have local specialization in wine production, flour milling, pulp and paper mills, steel pipe and tube mills, metal smelting and refining, certain metal fabricating industries, motor vehicle parts manufacturing, boatbuilding, and abrasives manufacturing.

4 John N. Jackson and Carol White, *The Industrial Structure of the Niagara Peninsula* (Department of Geography, Brock University, 1971).

At the time of the 1970 study, 11.5% of the industries studied had declining employment. Those industries, which emerge from Table 1B as slow growth industries, account for 59% of the manufacturing industries in Ontario, while they account for 69% of manufacturing employment in the study area [Fig. 3.3]. This was, however, shortly after the boom in the primary metals and machinery industries which still accounted for 46% of the entire labour force, making the Niagara region one that gained significant economic power through such industries.

During the late eighteenth and early nineteenth centuries, the industrial structure of the Niagara Peninsula was closely tied to its waterways, with rivers and lakes serving as the primary transportation routes. [Fig. 3.4] Early industries developed in response to the needs of settlers, mainly farmers, while the construction and expansion of the canal system in the 1870s facilitated long-distance transport. As railways and electric power gained importance, the canal's role shifted from a transport hub to a source of water for industrial processes and effluent disposal. This transition helped retain existing industries along the canal and attracted new ones. By the late nineteenth century, the Niagara Peninsula had become an attractive industrial center due to its transportation infrastructure and access to power. The rise of the railway system, the electrification of lines, and the growing auto industry further spurred the region's industrial growth, establishing the foundation for a diversified manufacturing economy. Though the factors driving industrial development have evolved over time, the region's geography and transportation networks left a lasting impact on its urban-scape and economic structure.

Fig. 3.3

TABLE I.B. Annual Employment Change in Manufacturing, 1965-1970 (The Industrial Structure of the Niagara Peninsula, 1971)

TABLE I. B.

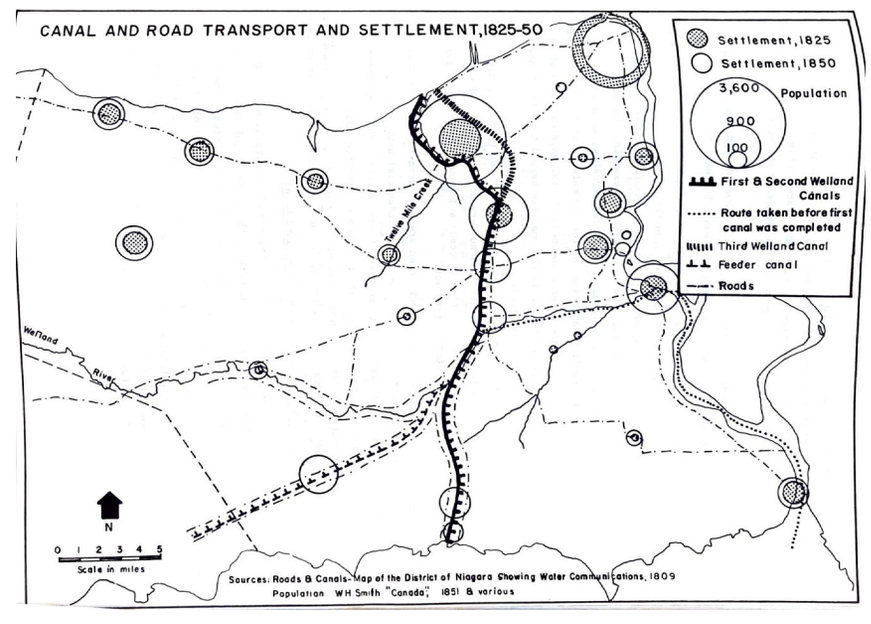
ANNUAL EMPLOYMENT CHANGE IN MANUFACTURING, 1965-1970

Industrial Groups:	Ontario 1965-1967		Regional Municipality of Niagara 1965-1970		St.Catharines - Thorold 1967-1970		Welland 1965-1970		Niagara Falls 1965-1970	
	+	-	+	-	+	-	+	-	+	-
Food and Beverages	3.59		0.41		6.62		1 07		1.58	
Tobacco Products Industries	6.31									
Rubber Industry	3.22			3.13		12.35		2.67		
Leather Industry		2.64	9.34			2.02			76.00	
Textile Industry	4.56			3.37		9.69		4.08	2.67	
Knitting Mills		5.13	2.30		3.30		2.96			
Clothing	1.37		0.20			33.33	17.04			
Wood Products	3.08			3.39		0.60	0.71		52.73	
Furniture and Fixtures	5.17		3.05		3.17			8.33	3.0	
Pulp and Paper		1.59		4.41		4.56				16.61
Printing and Publishing	4.07		1.99		4.22			1.55	2.72	
Primary Metals	3.05		4.19			7.05	3.93		5.14	
Metal Fabrication	2.36		0.76			1.89	0.82		5.65	
Machinery	0.72		3.74		1.14		4.21		5.02	
Transport Equipment	1.95		2.16		3.46					
Electrical Products	7.84		1.29			1.95	10.00			6.00
Non-metallic Mineral Products		2.07	1.71			4.27	2.59		6.92	
Petrol and Coal Products	77.71		4.85		6.67					
Chemicals	5.76			0.74	1.28		3.24			0.93
Miscellaneous	5 .90		3.49		5.72		8.57		2.21	
TOTAL MANUFACTURING INDUSTRY	3.68		1.21		0.80		2.26		1.19	

Source: D.B.S., ANNUAL CENSUS OF MANUFACTURES, 1967.
D.B.S., CENSUS OF MANUFACTURING INDUSTRIES, Section D, Province of Ontario, 1965.
Industrial Directory of Municipal Data, 1965 and 1967.

Fig. 3.4

Canal and Road Transport and Settlement, 1825-50 (The Industrial Structure of the Niagara Peninsula, 1971)



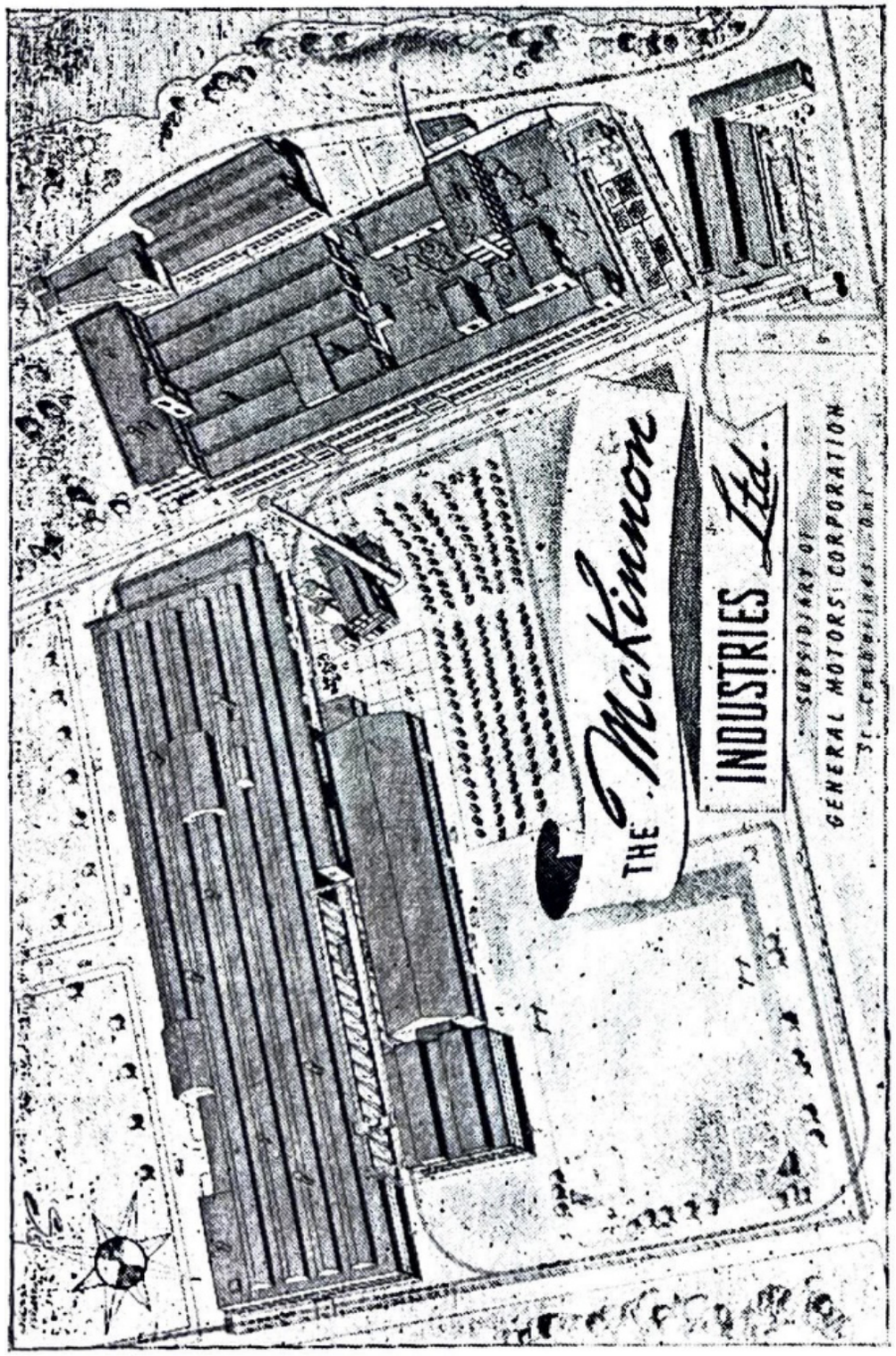


Fig. 3.5

Aerial drawing of the McKinnon Industry factory

3.1.2. History, Present and Future of the Former GM Plant

The demolished GM plant, formerly one of the great historical economic beacons of St. Catharines, holds a significant narrative of manufacturing, labour and construction.

The origins of McKinnon Industries Limited trace back to 1878 when Mr. McKinnon and Mr. Mitchell partnered in a hardware store on St. Paul Street. By 1900, known then as the McKinnon Dash Company, the business had thrived to the point of requiring a larger space, leading to the establishment of Plant 1 at the intersection of Ontario and Carleton Street. [Fig. 3.6] As the First World War erupted in 1914, the company saw significant growth, employing 650 individuals. The era of the horse-drawn vehicle was fading fast as the automobile replaced the former mode of transportation from the street and highways. The McKinnon Company found that it too must change with the times, and so with 1,200 employees it embarked on the manufacture of a line of automotive products. General Motors acquired McKinnon in 1929, employing 1,450 workers. The company evolved further post-Depression, with modern facilities and increased employment reaching 1,800 by 1939 – due to World War II demands, peaking at 4,500 employees by 1942. The post-war years saw continuous expansion, prompting the construction of a new foundry at Plant 2 in 1950 on 140 acres of land. Leadership changes in 1957 marked a new phase, with E. J. Barbeau appointed as President and General Manager.

Over the decade from 1954 to 1964, McKinnon manufactured around 40 different products and served as the equivalent of 27 U.S. divisions. In January 1965, McKinnon-St. Catharines began streamlining its operations to meet the greatly increased demand for engines, axles, and automotive electrical components as a result of the Canada–U.S. Automotive Trade Agreement. By this time, McKinnon Industries Limited was composed of three plants: Plant 1 on Ontario Street in St. Catharines, Plant 2, and the Administration Building, located on the east bank of the Welland Ship Canal, and Plant 3 in Windsor, Ontario. The milestone of McKinnon history delineates the aims and the accomplishments of the company from its humble beginning to this date.

The year 1969 marked the amalgamation of McKinnon Industries with General Motors of Canada Limited, testifying McKinnon's continual contributions to the advancement of Canadian process in the specialized industry for 92 years.[5] The industrial structure was in the process of continual evolution and change by managerial decision. At its peak in the 1970s during the boom of transportation equipment industry, GM employed approximately 9,700 people in manufacturing jobs at its two St. Catharines factories – on Ontario Street and Glendale. [Fig. 3.6]

Out of the total regional labour manufacturing industry of 47,351 in Niagara, the largest proportion employed was by the transport equipment industries at 28%. Within this industry, 12,227 out of the total 13,308 were employed by

5 N. Jackson and White.

manufacturers of motor vehicle parts and accessories. [Fig. 3.7] The next most important industrial group was the primary metals industry, employing 18% of the total, mainly in the production of iron and steel. Together the two largest industrial groups in the area employed a total of 46% of the labour force.[6] Within St. Catharines, this figure surpassed half, with the transportation equipment industry alone accounting for 55% of the labour force. [Fig. 3.8]

Shortly after, the industry's decline began. Headlines beginning with "GM Lay Off of Workers" made its appearance on newspapers as early as 1973. [Fig. 3.9] The slump in demand for large cars led to the announcement of laying off 2,500 of its 6,500 hourly-rated workers at the St. Catharines plant. Similar lay off rates of nearly 50 percent were seen in Oshawa during the same period. The responsibility on the survival of the industry jumped between the company and the people, with the company's expansions plans expected to create thousands of new jobs and the workers' union strikes, accommodating for their employment status and working conditions. The annual regional unemployment rate was estimated to be 12.2 percent for 1992, surpassing Ontario's 10.8 percent rate and the Canadian average of 11.3 percent, as it continued to suffer from severe industrial decline and layoffs.[7] Following the trends of Buffalo and Detroit, St. Catharines quickly became another shrinking city plagued with

6 N. Jackson and White.

7 Jon R. Sorensen and Joseph P. Ritz, 'ST. CATHARINES IN MOURNING FOR LOST JOBS RIPPLE EFFECT OF GM'S CUTBACKS LEAVES CITY REELING', Buffalo News, 13 December 1992, https://buffalonews.com/news/st-catharines-in-mourning-for-lost-jobs-ripple-effect-of-gms-cut-backs-leaves-city-reeling/article_9956e40c-335b-54fa-871f-8b06c6391e76.html.

Fig. 3.6

GENERAL MOTORS OF CANADA LIMITED ST. CATHARINES

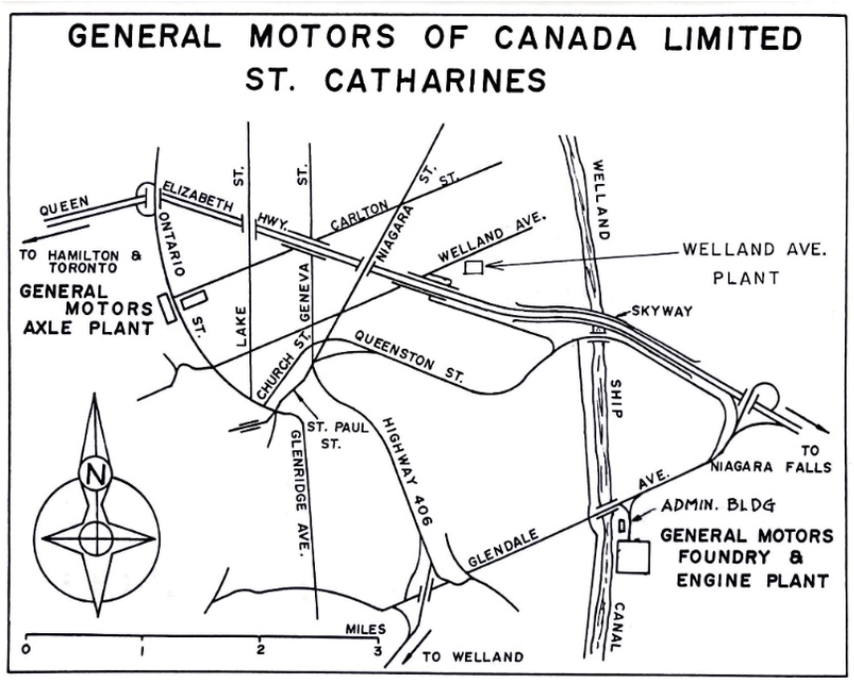


Fig. 3.7

TABLE IV.A MANUFACTURING EMPLOYMENT IN ST. CATHARINES - THOROLD, 1970, BY DETAILED INDUSTRIAL GROUP (The Industrial Structure of the Niagara Peninsula, 1971)

TABLE IV.A

MANUFACTURING EMPLOYMENT IN ST. CATHARINES - THOROLD, 1970, BY DETAILED INDUSTRIAL GROUP.

Industrial Group		St. Catharines - Thorold Employment	% of Total	L.Q.
101-147	Food & Beverages	1,225	5.43	0.49
101-3	Meat Products	30	0.13	0.08
105-7	Dairy Products	357	1.58	0.94
112	Fruit & Vegetable Canning	521	2.31	1.49
123-5	Grain Mills	7	0.03	0.07
128-9	Bakeries	134	0.59	0.31
131-9,111	Other food proc.	60	0.27	0.14
141	Beverages (Soft drinks	8	0.04	0.05
	(Wineries	108	0.48	6.94
151-3	Tobacco Products	-	-	-
161-9	Rubber Industries	34	0.15	0.06
172-9	Leather Industries	31	0.14	0.08
172	Tanning	28	0.12	0.38
	Other	3	0.01	0.03
183-229	Textile Industries	144	0.64	0.17
183	Cotton Yarn & Cloth	30	0.13	N/A
211-16	Other Primary Textiles	105	0.47	0.90
221-9	Other	9	0.04	0.01
231-9	Knitting Mills	300	1.33	1.24
231	Hosiery	150	0.67	2.39
232-9	Other	150	0.67	0.83
242-9	Clothing Industries	-	-	-
251-9	Wood Industries	164	0.73	0.30
261-8	Furniture & Fixtures	46	0.20	0.08
271-4	Paper & Allied Industries	3,271	14.51	2.70
271	Pulp & Paper Mills	2,974	13.19	4.85
272-4	Other	297	1.32	0.50
286-9	Printing, Publishing Ind.	267	1.18	0.22
291-8	Primary Metals	544	2.41	0.28
294	Iron Foundries	449	1.99	1.65
296	Copper rolling, casting & extruding	76	0.34	1.05
298	Other rolling casting etc.	19	0.08	0.22
301-9	Metal Fabricating	1,882	8.35	0.82
301	Boiler & Plate Works	555	2.46	4.83
302	Structural Metal Fab.	257	1.14	0.96
303	Ornamental & Architectural Metal	25	0.11	0.12
304	Metal Stamping & Coating	172	0.76	0.35
305	Wire & Wire Products	518	2.30	1.74
306	Hardware & Tools	122	0.54	0.42
307	Heating Equipment	82	0.36	0.91
308	Machine Shops	61	0.27	0.45
309	Miscellaneous	90	0.40	0.22
311-18	Machinery Industries	392	1.74	0.28
315	Miscellaneous	376	1.67	6.64
316	Commercial Refrig. Equip.	16	0.07	0.08
321-9	Transportation Equipment	12,478	55.35	4.53
321	Aircraft & Parts Mfgrs.	60	0.27	0.13
323	Motor Vehicles	31	0.14	0.03
326	Vehicle Parts	12,227	54.23	13.04
327	Shipbuilding & Repairs	150	0.67	2.21
328	Boatbuilding & Repairs	10	0.04	0.27
331-8	Electrical Products Inds.	563	2.50	0.26
336	Industrial Equipment	563	2.50	1.00
341-59	Non-Metallic Mineral Products	503	2.23	0.70
347	Concrete	69	0.31	0.47
348	Ready Mix Concrete	122	0.54	1.70
349-51	Clay Products	42	0.19	0.47
357	Abrasives	255	1.13	3.42
359	Other	15	0.07	0.04
365-9	Petrol & Coal Products	60	0.27	0.64
371-9	Chemicals	81	0.36	0.07
375	Paint & Varnishes	50	0.22	0.45
377	Toilet Preparations	18	0.08	0.22
378	Industrial Chemicals	13	0.06	0.04
381-99	Miscellaneous Mfg. Ind.	560	2.48	0.46
381	Scientific Equipment	39	0.17	0.15
TOTAL MANUFACTURING INDUSTRIES		22,545		

Sources: 1970 Survey
1968 Niagara College of Technology Survey.

Fig. 3.8

St. Catharines Region Manufacturing Employment 1970

FOOD & BEVERAGES

PAPER

PRIMARY METALS

METAL FABRICATING & MACHINERY

TRANSPORT EQUIPMENT

NON-METALLIC MINERAL PRODUCTS

ALL OTHER MANUFACTURING

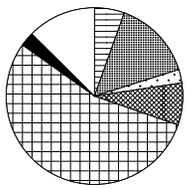
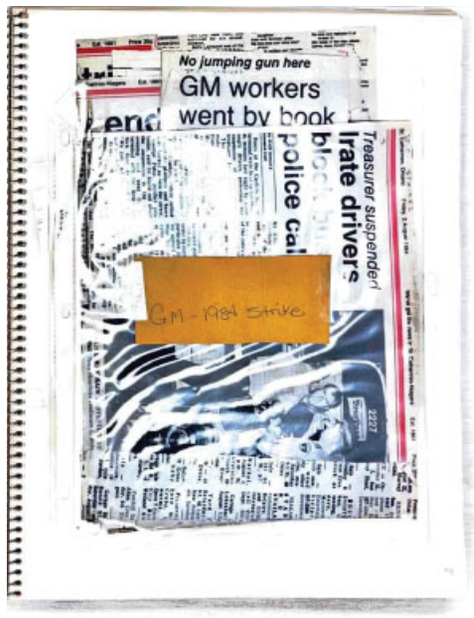
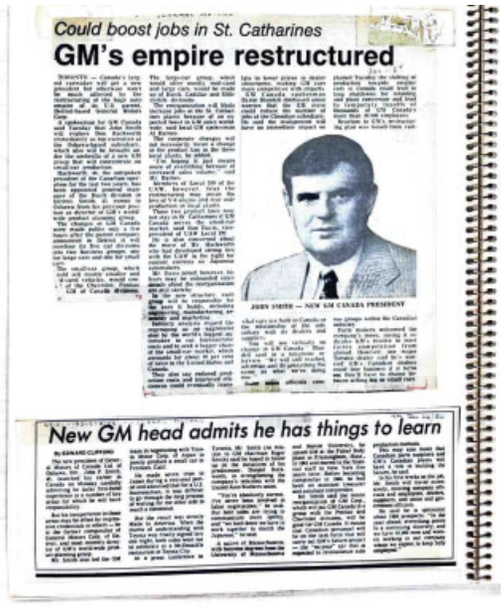


Fig. 3.9

Newspapers related to GM gathered by St. Catharines Museum and Welland Canals Centre





unemployment. The continuous struggle of maintaining the business during the industry's decline finally came to an end in 2010, with its permanent closure after a few decades of downsizing. The local impact of the business decline was significant – affecting not only the people once employed by the firm, but all neighbouring businesses including restaurant workers serving autoworkers and their families, supermarket workers and other retail store employees. Additionally, the real estate market faced challenges with little demand for commercial space, making it more difficult to sell land and secure lease agreements.

In 2015, the site was purchased by BayShore Groups for 12.5 million dollars, and demolition on the factory began in 2016. Simultaneously, GM once again made its frequent appearances on the news, but this time, evoking optimistic opportunities of its future development. The company unveiled its ambitious $250-million plan for the 54.66 acres that included a mix of retirement residences, apartment lofts, commercial business, a technical trade school and more.[8] [Fig. 3.10] Despite numerous statements of reassurance, the construction process came to an abrupt halt in 2018, leaving the site in a half-demolished state and surrounded by its own debris, abandoned by the former owner. Initial problems they were running into included a union certification vote with which the company took issue and uncertainty over the city's tax incentive plan that helps developers cover cleanup costs of brownfield projects. It is said that the city sued Bayshore over alleged infractions under the Building Code, Fire Code Act, and waste disposal violations which the company pleaded guilty to. In addition to the demolition waste remaining on the site for half a decade, becoming an eye-sore to the public, several health concerns rose as the residents spoke up of their illness and its potential connection to the brownfield toxins nearby.[9]

The largest unanswered question among residents was regarding responsibility: who is responsible for the abandoned site and its future? Responses from all levels of government only fueled residents' beliefs that no one was taking the issue seriously while the blame shifted onto each other. As of 2024, the site was known to be a privately owned property, with the city undertaking a land use study called, "Ontario Street Corridor Secondary Plan Study". The Ontario Street Corridor stretches from the QEW in the north to Welland Avenue in the south, which leads into the downtown core. The study is focused on redeveloping the former GM lands for future use and follows the approval of Official Plan Amendment 26 (OPA 26) to re-designate the lands for such purposes.[10]

Today, the only remaining structure is a linear brick strip running right along Ontario Street, measured at around 230m, and the three storey concrete assembly, once used as storage for the plant. [Fig. 3.11] Such essence of architectural identity emerges as a fundamental and lasting presence within

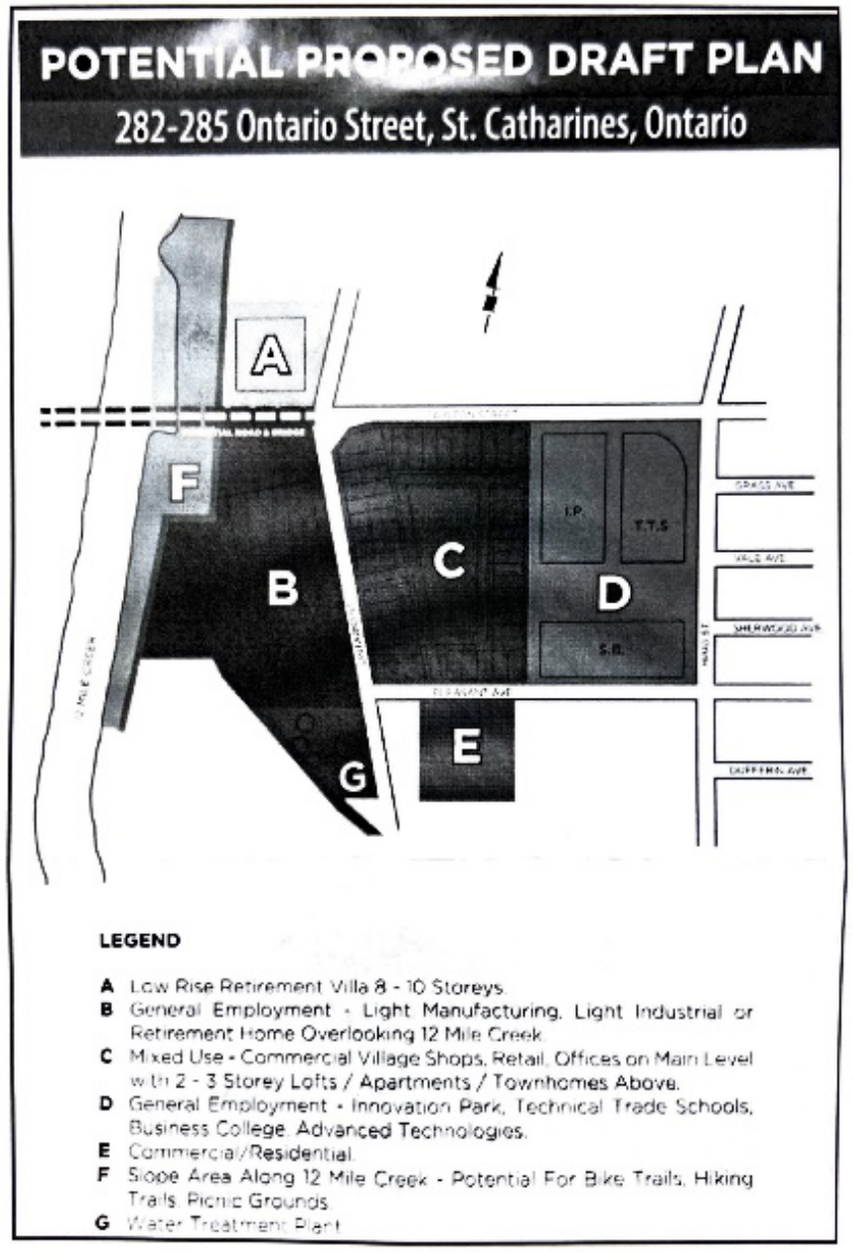
8 Karena Walter, '$250M Plan for GM Site', *St. Catharines Standard*, DEVELOPMENT, 12 December 2014.

9 Ashley Okwuosa, 'A Former GM Plant in St. Catharines Is Leaking Toxic Chemicals', *The Narwhal* (blog), accessed 16 March 2024, https://thenarwhal.ca/st-catharines-former-gm-plant/.

10 'Ontario Street Corridor Secondary Plan Study | EngageSTC', accessed 16 March 2024, https://www.engagestc.ca/ontariostreetstudy?tool=survey_tool#tool_tab.

Fig. 3.10

Potential Proposed Draft Plan by Bayshore Groups, 2015



industrial landscape. The enduring nature of industrial buildings reflects their structural integrity and liberating open-floor plans, designed to accommodate heavy machineries and production.

They can accept both programmatic and systematic changes, and this adaptable nature allows them to remain living, dynamic and also unique components in the city's structure. With their generous size and open ground plans, these buildings allow for extreme flexibility and evolving needs. They can be translated into architectural structures with a legacy deeply intertwined with industrialization's impact on cities and lifestyles. In addition to the economic, ecological and social aspects of sustainable development, there's another relevant consideration to reusing such structure: stabilizing functional relevancy through reprogramming. If conversion approaches allow users to appropriate the locations and the areas continue to be living components of everyday urban life, then they can make an important contribution to sustainable urban development that goes well beyond closed materials cycles and CO^2 balances. The transformation of industrial production sites into living urban components is a global phenomenon observed in many countries transitioning from an industrial society to a knowledge-based and service-based society.[11]

Drawing inspiration from its history and its architectural prominence in the urban fabric, this study remodels the industrial site of the former GM Plant to host activities meeting one of modern day's immediate ecological needs: optimizing material circularity and diverting construction debris from the waste stream.

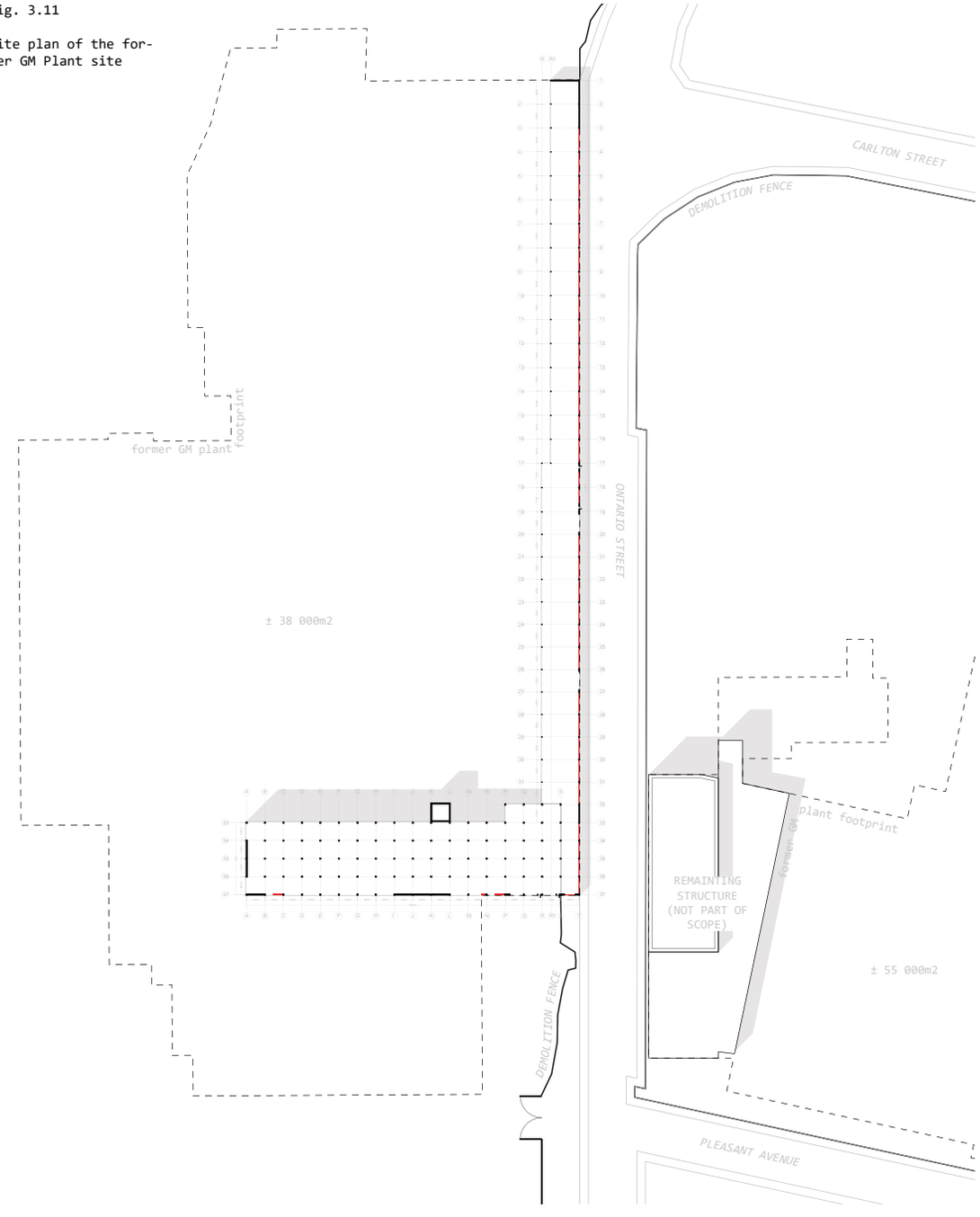
The re-imagination of the former industrial site builds upon the idea of remediating the loss of economic development in a city, and the corresponding architectural obsolescence. Visionary approaches seen in Cedric Price's Potteries Thinkbelt (1965) and Peter Cook's Plug-In City (1964) are pioneering projects that lays the groundwork for imagining the process of obsolescence in design itself – truly the products of the heyday of obsolescence in the 20th century. These examples combine aesthetic appreciation for abandoned industrial landscapes with the repurposing of industrial buildings, the activation of public spaces, and the exploration of these areas as catalysts for technological and social innovation (and learning). This integrated approach revitalizes abandoned spatial entities, turning wastelands into vibrant hubs of activity through material agency.

In an era where resources are depleting and the C&D materials reaching the capacity of landfills, the value of modern architecture requires reassessment beyond its built form through the act of dissection, both physically and conceptually, perhaps even down to the individual building blocks to broaden our understanding of optimized usage possibilities of our existing urban fabric.

11 Martina Baum and Kees Christiaanse, *City as Loft: Adaptive Reuse as a Resource for Sustainable Urban Development* (Zürich: GTA Verlag, 2012).

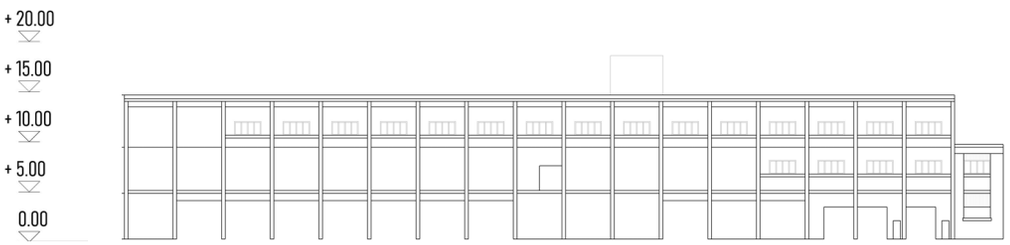
Fig. 3.11

Site plan of the former GM Plant site



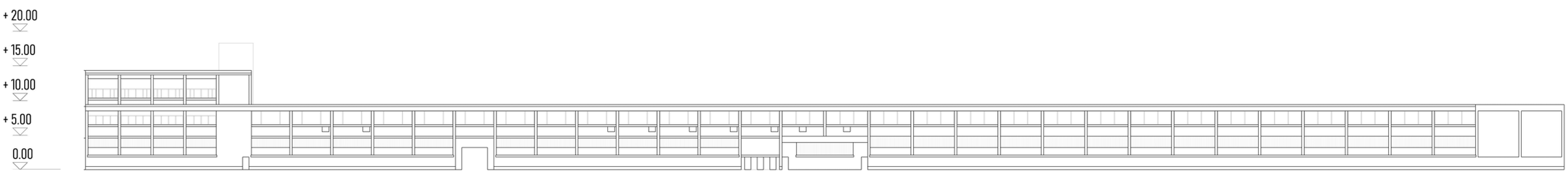
Before we ask where else the waste could go once the landfill sites become full, perhaps a better question would be: *how much of it is truly waste? How much of our once-valuable building assets have become waste?*

Fig. 3.12



SOUTH ELEVATION (AS-FOUND)

Fig. 3.13



EAST ELEVATION (AS-FOUND)

1934

Fig. 3.14 When the property was first purchased by McKinnon in 1900 it was a single building on 54.7 acres of land.

1954

Fig. 3.15 Much of the area around the original building is still farmland. Looking past the GM plant, there has been much development yet.

1965

Fig. 3.16 Prosperity and development continue for the GM industry.

2000

Fig. 3.17 Continued growth of buildings and parking lots with more development added to the area.

2010

Fig. 3.18 The year General Motors officially closed.

2013

Fig. 3.19 Condemned property with nothing but grand, vacant buildings and parking lot.

2018

Fig. 3.20 Drastic change of landscape. 75% of the plant demolished.

2020

Fig. 3.21 The site has been left in its half-demolished state to this day.

ARCHIVAL IMAGES AND SITE DOCUMENTATION

The following pages feature scans of archival blueprint copies and additional drawings of the McKinnon Industries factory building (later the GM Plant by the time of the demolition), sourced from the St. Catharines Museum and Welland Canals Centre. Due to the lack of digital drawings of the factory building, the scans became a crucial reference for producing drawings and 3d models for the entirety of the project. With the museum staff's generosity, and curiosity, the blueprint copies were scanned in high quality and now part of the institution's archival digital database.

The film photographs were taken by the author during site visits.

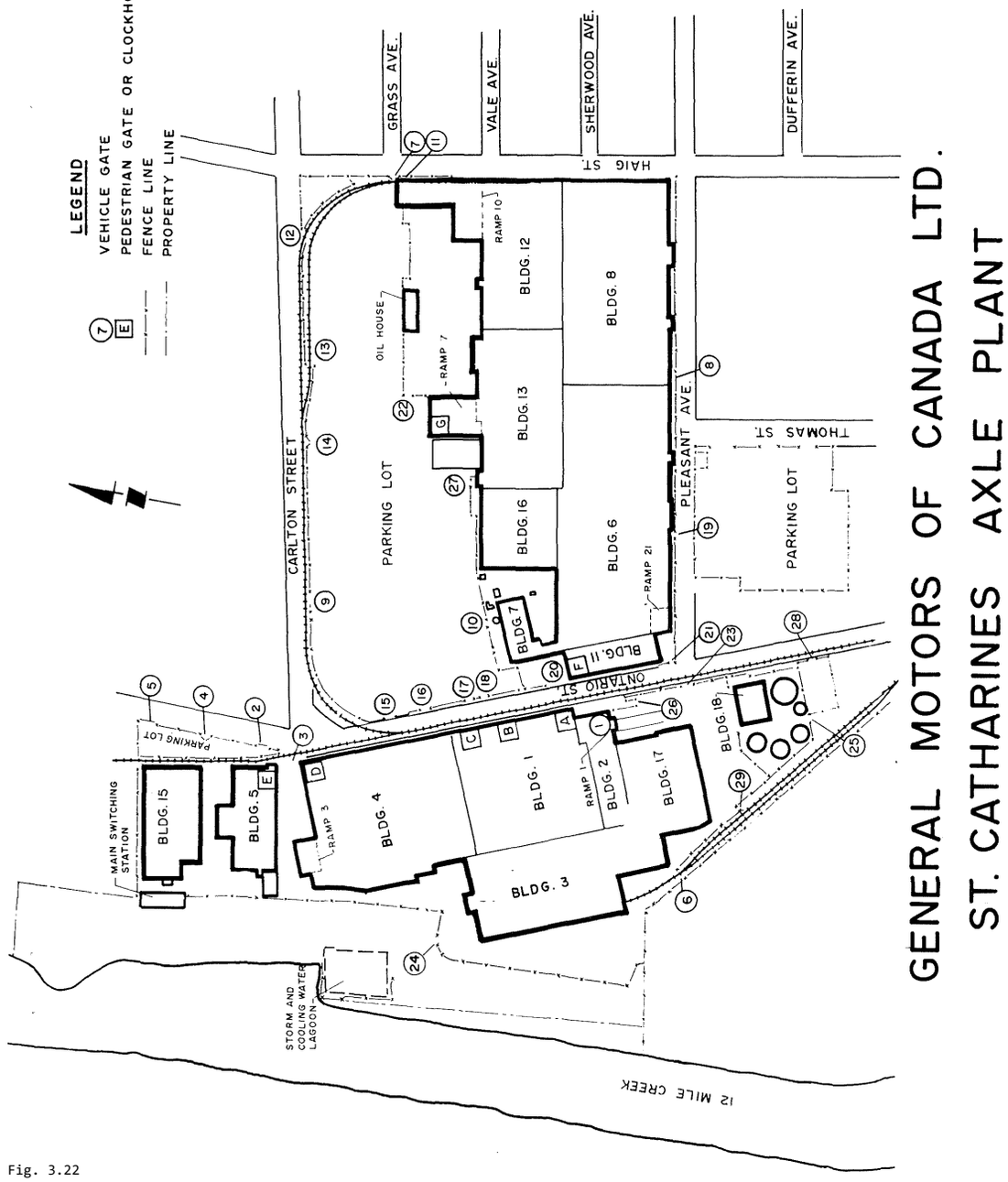


Fig. 3.22

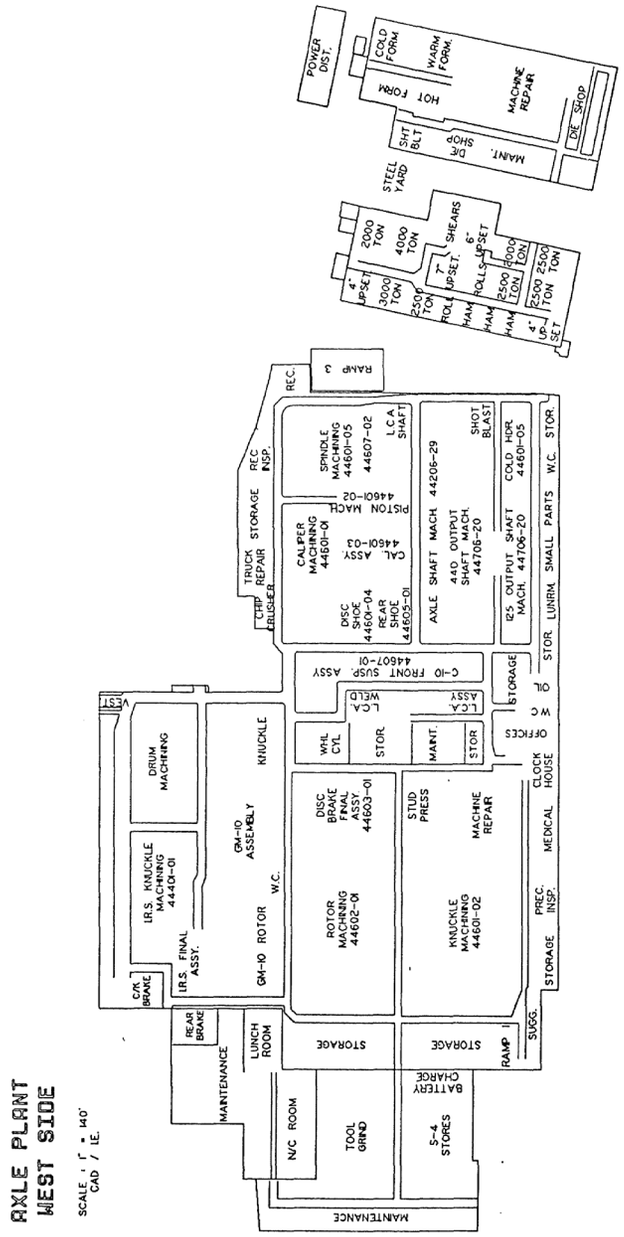


Fig. 3.23

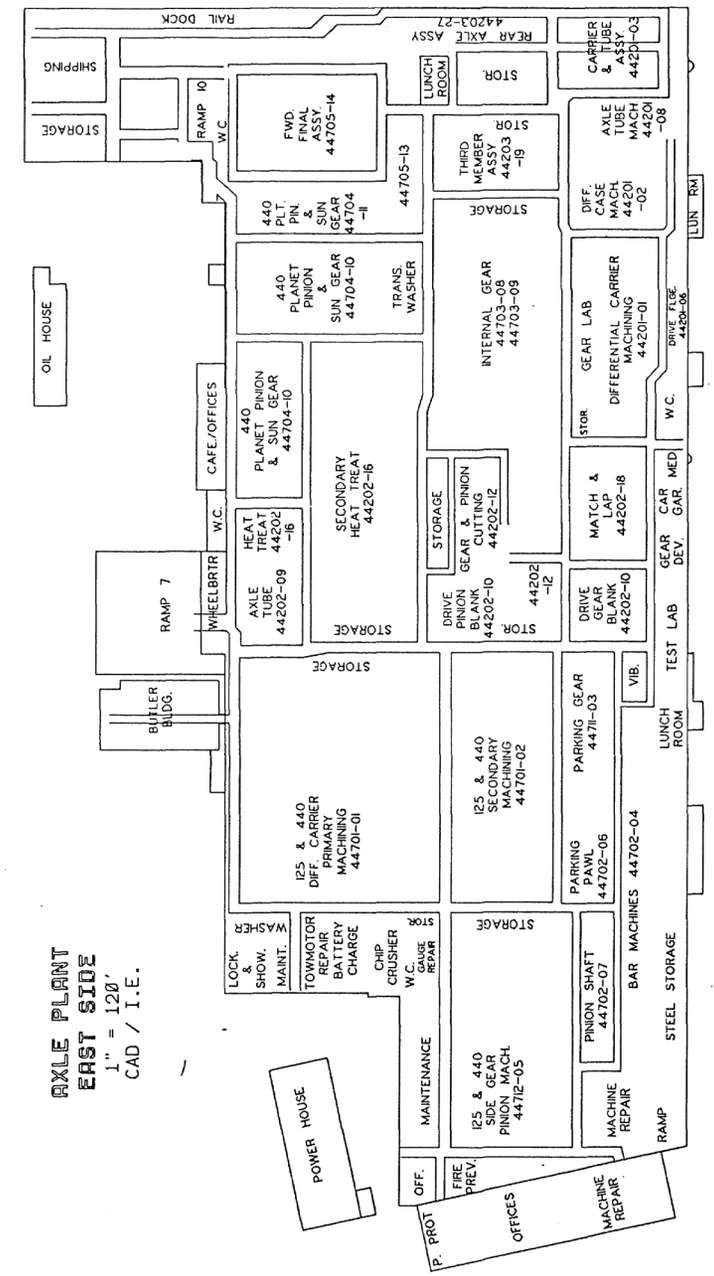


Fig. 3.24

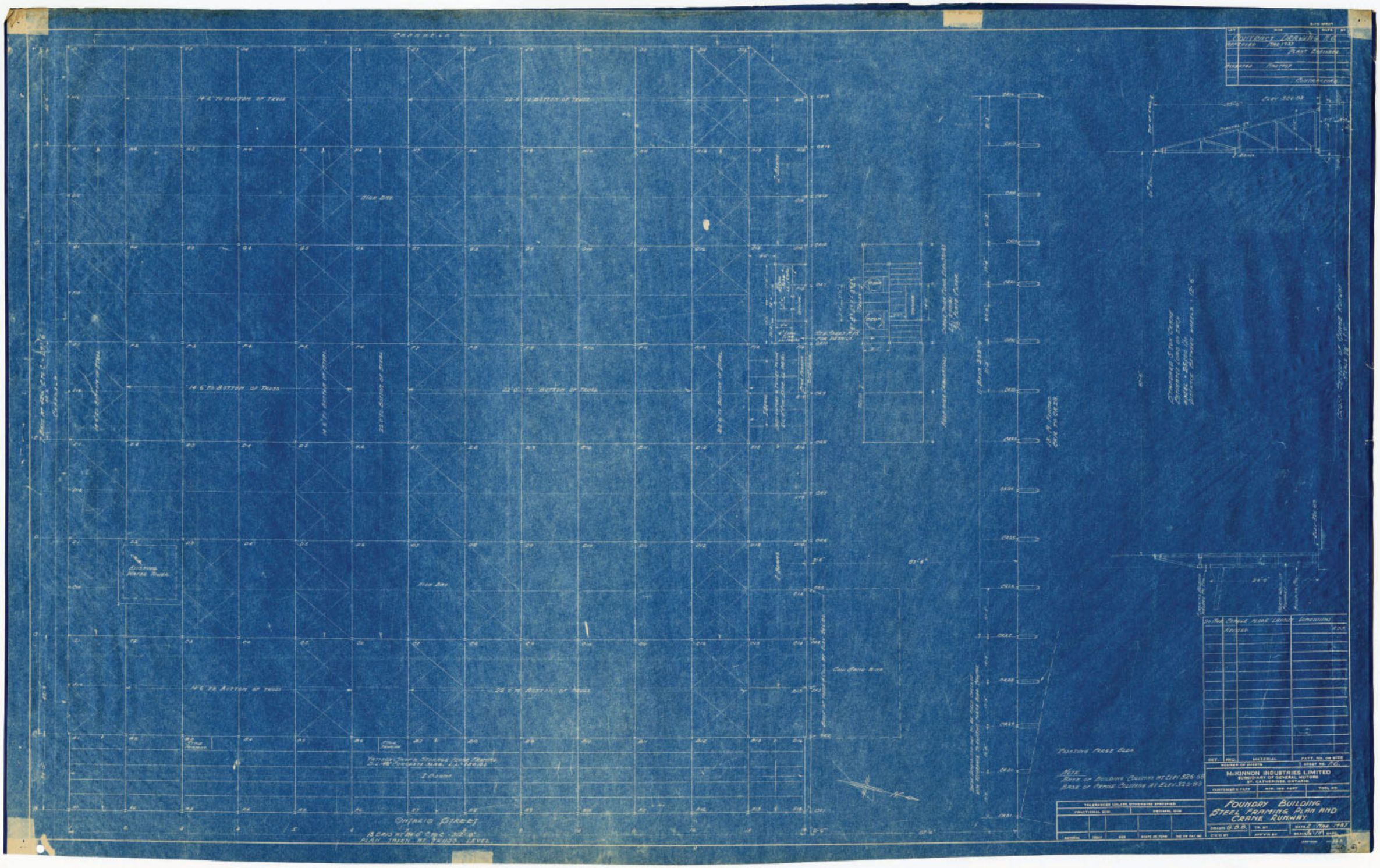

McKINNON INDUSTRIES LIMITED
FOUNDRY BUILDING
STEEL FRAMING PLAN AND
CRANE RUNWAY
ONTARIO STREET

Fig. 3.25

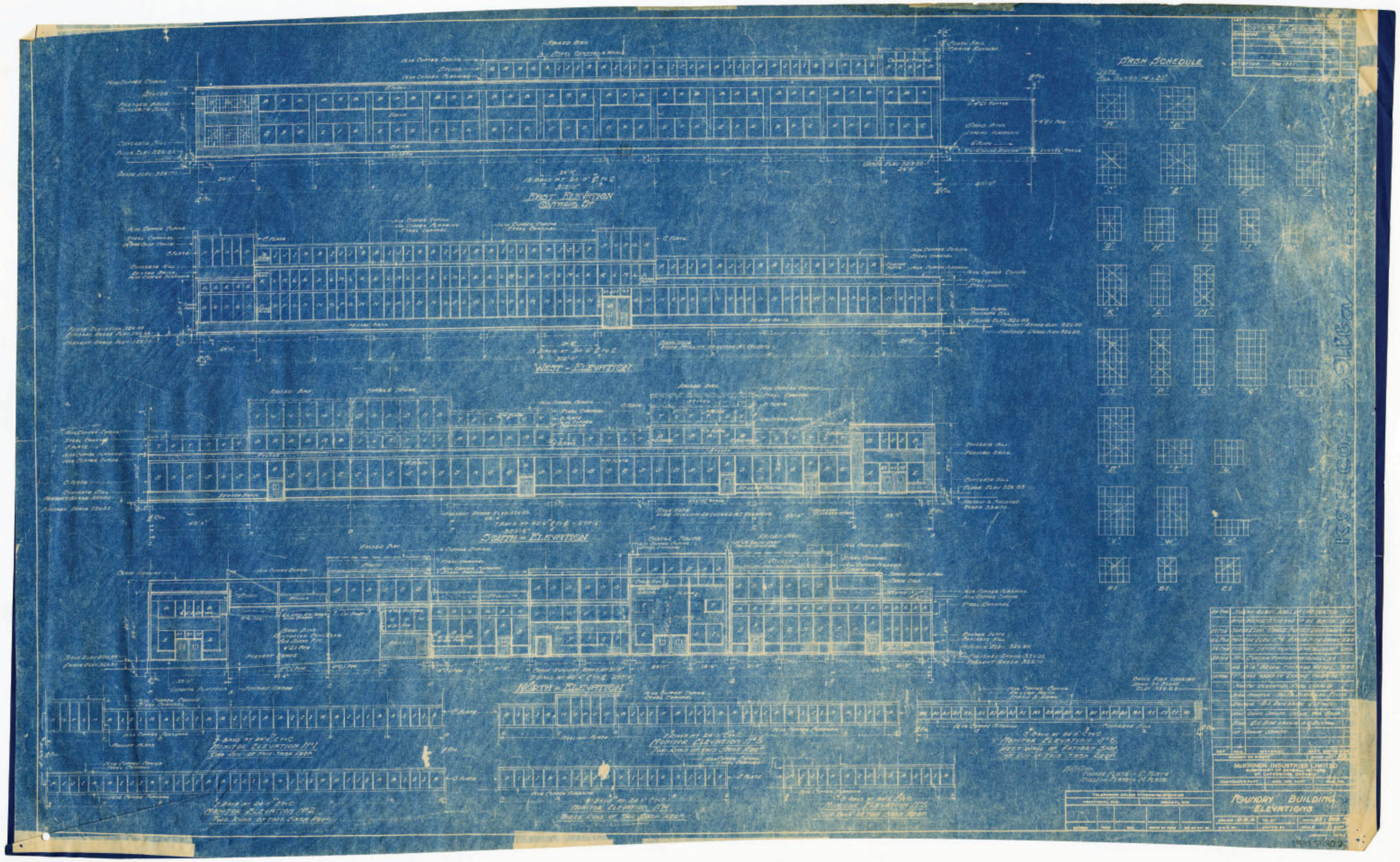

SASH SCHEDULE
EAST ELEVATION
WEST - ELEVATION
SOUTH = ELEVATION
NORTH = ELEVATION
MONITOR ELEVATION No 1
MONITOR ELEVATION No 2
MONITOR ELEVATION No 3
MONITOR ELEVATION No 4
MONITOR ELEVATION No 5
McKINNON INDUSTRIES LIMITED
FOUNDRY BUILDING ELEVATIONS

Fig. 3.26

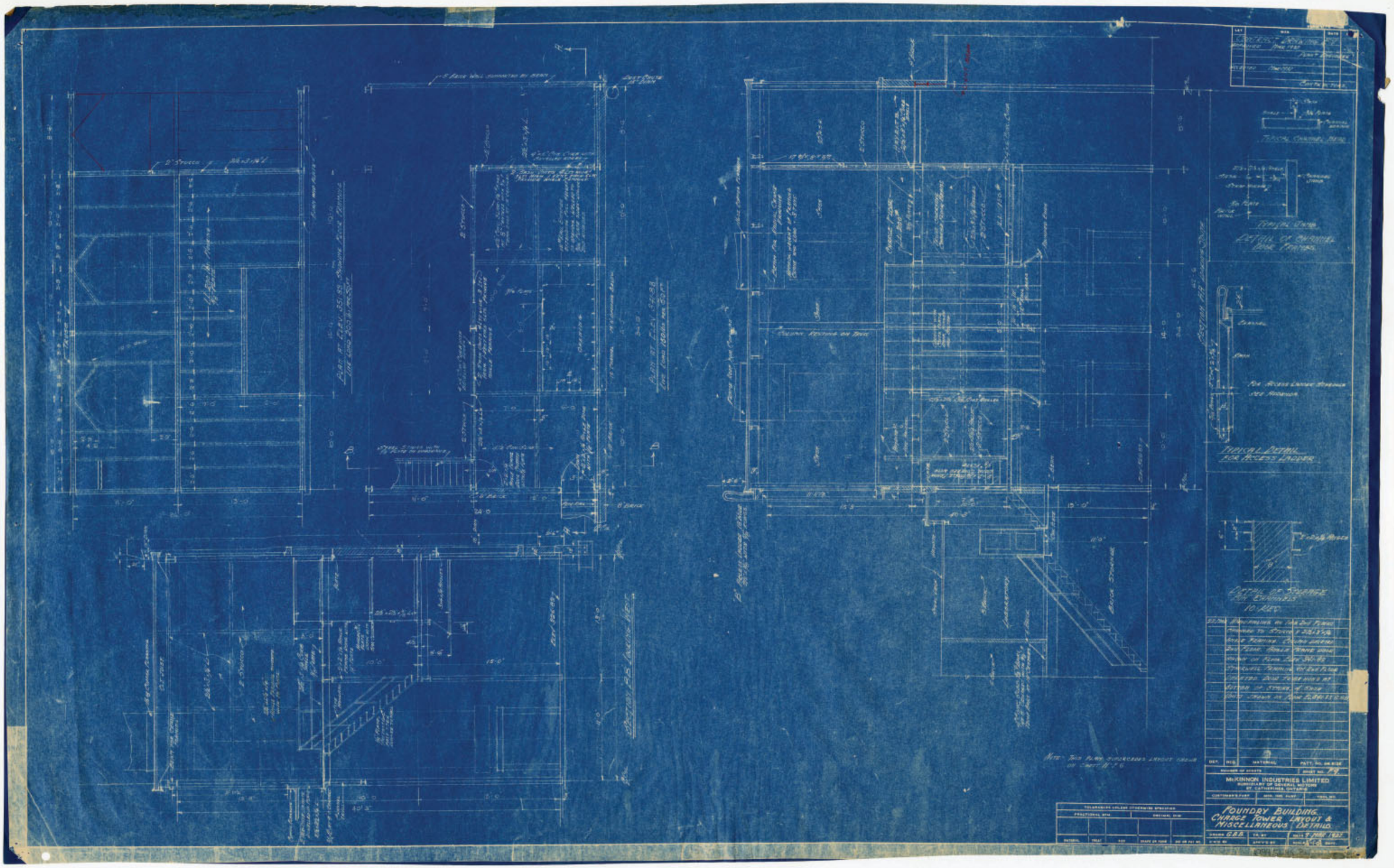

McKINNON INDUSTRIES LIMITED
SUBSIDIARY OF GENERAL MOTORS
ST. CATHERINES, ONTARIO
FOUNDRY BUILDING
CHARGE, POWER, LAYOUT &
MISCELLANEOUS DETAILS
TYPICAL DETAIL
FOR ACCESS LADDER
DETAIL OF STORAGE
FOR CYLINDERS
10 REQ.

Fig. 3.27

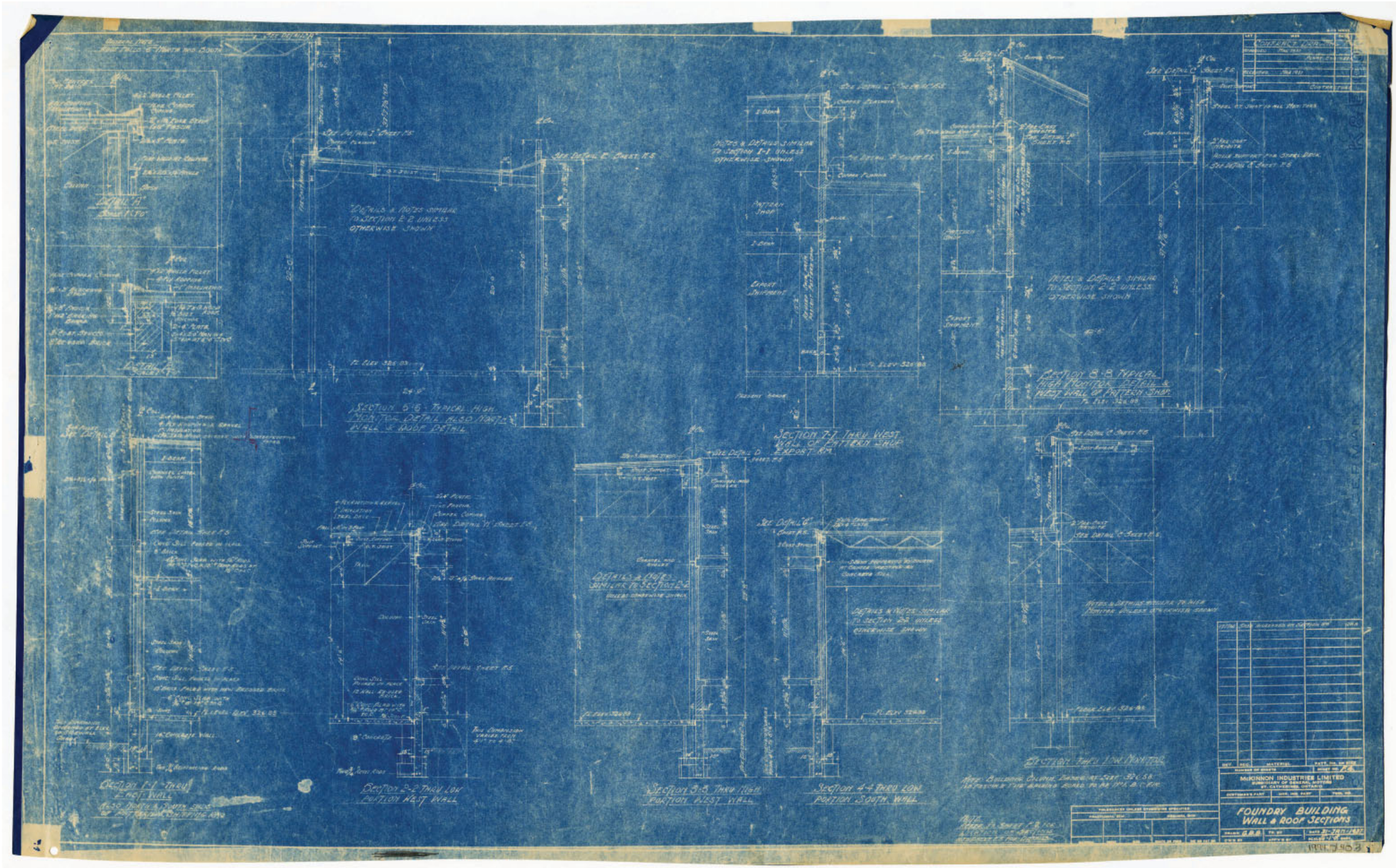

SECTION 5-5 TYPICAL HIGH MONITOR DETAIL ALSO NORTH WALL & ROOF DETAIL
SECTION 7-7 THRU WEST WALL OF PATTERN SHOP EXPORT RM.
SECTION 8-8 TYPICAL HIGH MONITOR DETAIL & WEST WALL OF PATTERN SHOP
SECTION 1-1 THRU EAST WALL
SECTION 2-2 THRU LOW PORTION WEST WALL
SECTION 3-3 THRU HIGH PORTION WEST WALL
SECTION 4-4 THRU LOW PORTION SOUTH WALL
SECTION THRU LOW MONITOR
McKINNON INDUSTRIES LIMITED
SUBSIDIARY OF GENERAL MOTORS
ST. CATHERINES, ONTARIO
FOUNDRY BUILDING
WALL & ROOF SECTIONS

Fig. 3.28

Fig. 3.29

Fig. 3.30

Fig. 3.31

Fig. 3.32
Fig. 3.33

Fig. 3.34
Fig. 3.35

Fig. 3.36

3.2 Inventory of the Material Bank

"After all, waste is in fact simply a collection of material without an identity"[12]

Thomas Rau
(Material Matters:
Developing Business for
a Circulation Economy, 6)

12 Thomas Rau, *Material Matters: Developing Business for a Circular Economy* (London ; Routledge, Taylor & Francis Group, 2023). 6.

Today's stock of materials within the built infrastructure of a city will become tomorrow's waste and could serve as a future resource. Whether the assets become waste or resource rely on the treatment of the physical matter at the end of the building's life. "Urban mining", as explained in "Material Matters" by Thomas Rau, refers to a method of retrieving resources from what has been discarded as waste, recognizing the value of underused materials within urban environments and advocates for their systematic reuse.[13] This practice, common before the industrial era and practiced in many "developing" regions, involves recovering materials, food, water, and energy that are currently wasted in cities. It aims to exploit the large stocks of resources in urban settings, particularly in buildings, infrastructure, and landfills. Urban mining can systematically utilize Anthropogenic stocks, urban reservoirs, and waste streams to promote long-term environmental sustainability, conserve resources, and generate economic advantages.

13 Rau. 123.

Effective urban mining requires research to quantify material stocks and flows, with urban metabolism studies providing valuable data.[14]. This concept, grounded in systems theory and thermodynamics, is defined by Kennedy et al. as, "the sum total of the technical and socioeconomical processes that occur in cities, resulting in growth, production of energy and elimination of waste".[15] Urban metabolism principles help analyze the interrelations between environmental, sociological, and economic factors, showing how resources move through cities and their surrounding areas. Using material flow analysis (MFA) from industrial ecology, these studies account for resource flows and stocks over time. While most analyses focus on input and output flows, understanding the existing internal stocks is crucial for studying city-scale reuse potential. They suggest that waste management practices like reuse and recycling, which focus on existing stocks, promote cyclical material flows and increase resource efficiency, unlike landfilling, which necessitates more raw resource inputs and creates more waste outputs.

14 Mark Gorgolewski, *Resource Salvation*, 1st ed. (John Wiley & Sons, Ltd, 2018), https://doi.org/10.1002/9781118928806. 46.

15 Christopher Kennedy, John Cuddihy, and Joshua Engel-Yan, 'The Changing Metabolism of Cities', *Journal of Industrial Ecology* 11, no. 2 (2007): 43–59, https://doi.org/10.1162/jie.2007.1107.

Tools of optimizing material movement have manifested itself in many creative ways – including bulldozers and urban infrastructures such as highways. As we continuously move towards a digital future, systematic approaches to collecting data, crucial to streamlining the process of the intakes and outflows of second-hand materials, are being adopted by many individuals. Most demolition material collections, transfers, and sales occur informally through online marketplaces; the

most notable ones being Kijiji, Facebook marketplaces, and Etsy. Such marketplace encourages local material network as its search engine primarily focuses on the proximity of the seller to the customer. Most items, whether construction materials or miscellaneous items, are described to have been salvaged from an existing home. The greatest limitation to streamline the sale on these platforms is the limited quantity, informal inventory, unstandardized sizes and nicheness of the items.[16]

16 Gorgolewski, *Resource Salvation*. 240.

In efforts to formalize and ground such networks of material flows, digital online platforms are becoming more developed. A notable example is OPALIS, an atlas of building resources founded by Rotor which generates harvest maps that outline the available supply of useful waste, surplus, and other unused materials in select regions of Europe.[17] [Fig. 3.35] As a means to enhance predictability of these building components, there's been collective initiative to improve ways which technical specifications of building materials could be recorded and stored for future generations. Parallel to the constant development of BIM models, is our ability to record data, hence, a system that could be translated into a book-keeping tool of materials. Obtaining a detailed 3D inventory of building components would allow for both the quality and the conditions of the individual elements to be recorded, monitored, updated in real time, efficiently and effectively facilitating the deconstruction processes.[18] Some have even established cadastre for materials

17 'Homepage | Opalis', accessed 27 February 2024, https://opalis.eu/en.

18 Lionel Devlieger, 'Reverse Architecture—The Virtues of Unbuilding and Reassembling', *Rewriting Architecture, 10+1 Actions: Tabula Scripta*, 1 January 2020. 149.

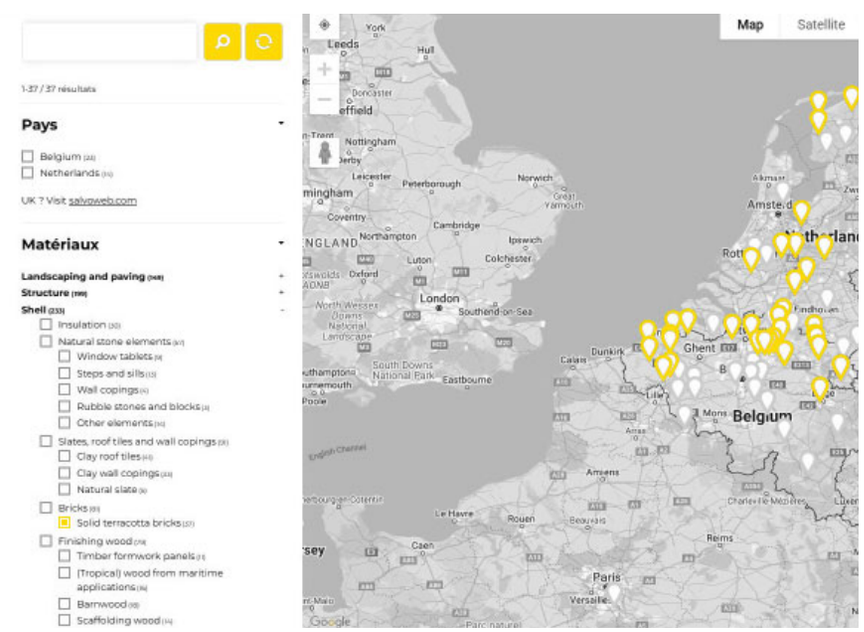


Fig. 3.37

OPALIS website.

Example of the search engine showing available providers for salvaged bricks.

("Madaster", "OneClick LCA") which generates and stores material passports for buildings, focused on creating a comprehensive database for your assets to facilitate future reuse and responsible end-of-life management.[19] The capabilities of such tools extend beyond merely quantifying and cataloging the volume and types of materials in a building. They function as integrated systems that enable the assessment of environmental impacts, often through comprehensive life-cycle analyses and evaluations of embodied carbon. These business models are grounded in building-specific knowledge, drawing inspiration from the local industrial ecology, and establishing material inventories for future projects. This approach helps bring secondary materials to the forefront of architectural catalogues, positioning them as a primary resource rather than an afterthought.

19 'Madaster: The Cadastre for Materials and Products', Madaster Global, accessed 9 September 2024, https://madaster.com/.

Construction materials are usually durable and long lasting, so their accumulation in the urban fabric and the corresponding stocks grow slowly overtime. A significant quantity of the total extracted natural resource stock used for producing such materials resides as stock in the current urban fabric and forms a potential resource that can offset new materials coming into the system. There are many opportunities for these resources to be treated in a circular way in order not to burden the virgin (and non-renewable) resources.

The demand for increased flows of resources depends on the age and stage of a city's development. New and growing cities have large and expanding inflows of new construction materials to create the new buildings and infrastructure. Conversely, they have small stocks within the urban fabric and small outflows of construction materials, as there is little demolition. New cities also have growing energy needs with potential to integrate efficiency and renewable energy sources.[20] For example, fast-growing Asian cities have an input–output ratio for solid materials greater than 10:1.[21] For such cities, the potential for recovery of materials from the urban stocks is low due to small stocks. In contrast, old established cities have less need for new materials to create infrastructure, so they have reduced inflows; however, they have large stocks within their fabric and greater outflow of demolition waste that offers potential for reuse.[22]

20 Paul Brunner, 'Urban Mining A Contribution to Reindustrializing the City', *Journal of Industrial Ecology - J IND ECOL* 15 (1 June 2011), https://doi.org/10.1111/j.1530-9290.2011.00345.x.

21 Gorgolewski, *Resource Salvation*. 47.

22 Gorgolewski. 48.

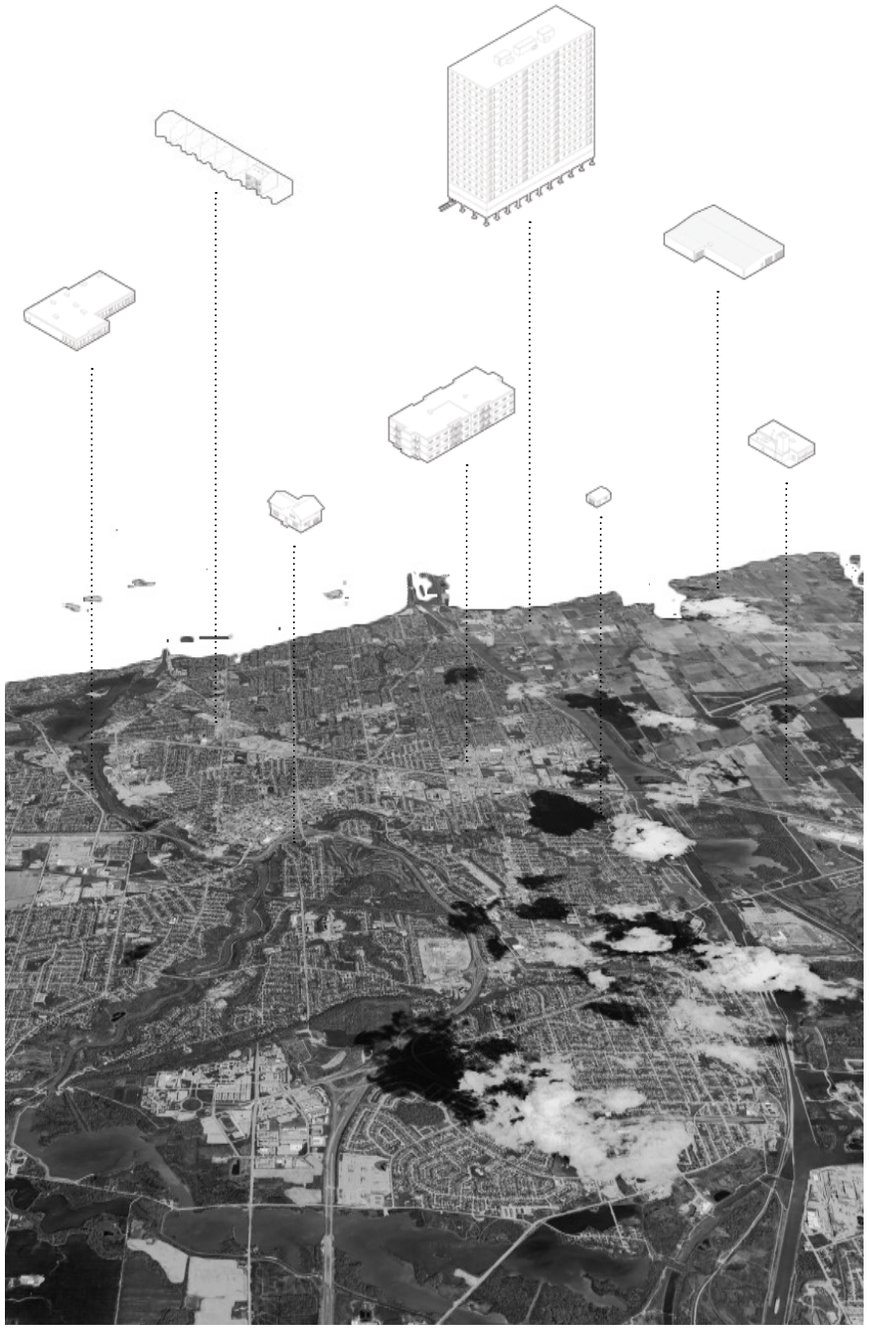
Paul H. Brunner's study, "Urban Mining A Contribution to Reindustrializing the City", suggests that for cities in a steady state, it is conceivable that 80% or more of primary resources could be substituted by secondary resources found within the city.[23] St. Catharines falls under this scale umbrella of urban development, with the city expecting to grow by roughly 31,000 people by 2041, which according to the Land Needs Assessment will require over 14,000 new dwelling units and 18,000 new jobs to accommodate that growth.[24]

23 Brunner, 'Urban Mining A Contribution to Reindustrializing the City'.

24 'Re-Designation of Ontario Street Property Approved', 1 December 2020, https://www.stcatharines.ca/en/news/redesignation-of-ontario-street-property-approved.aspx.

Fig. 3.38

Building stocks within St. Catharines' urban fabric.



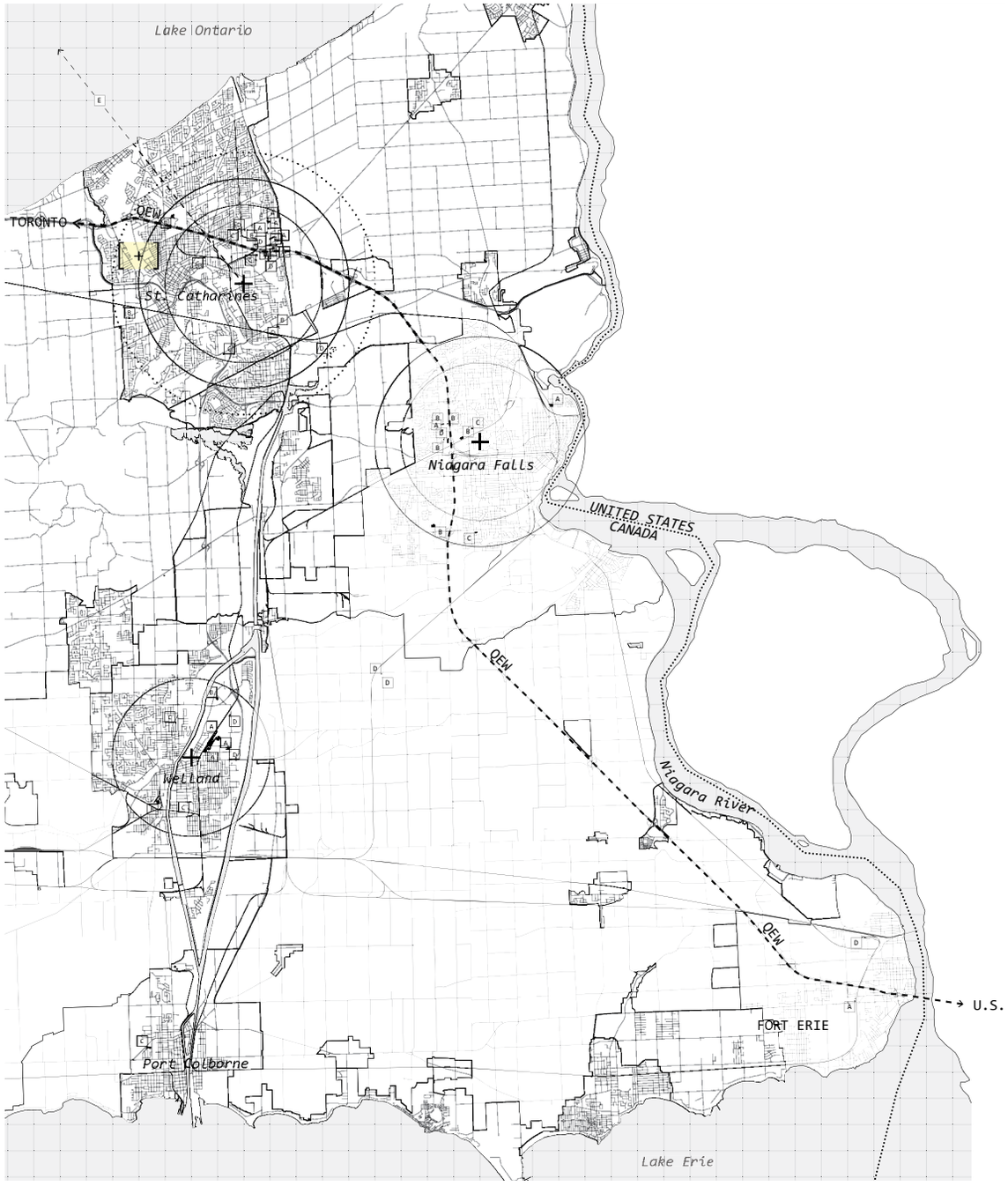


Fig. 3.39

Urban agencies in charge of circulating material matters in St. Catharines.

Materials constantly circulate through our cities, taking various forms, whether as products, resources, or debris. Recognizing the urban ecology is crucial in assigning the appropriate agency to improve this movement and ensure its circularity.

A: BUILDING MATERIAL MANUFACTURER/FABRICATOR

Tora Inc (15 Cushman Rd, St. Catharines, ON L2M 6S7) • Colbey Custom Fabricating (14 Cushman Rd, St. Catharines, ON L2M 6S8) • Hingston Metal Fabricators (490 Eastchester Ave E, St. Catharines, ON L2M 6S3) • Cushman Steel (514 Eastchester Ave E, St. Catharines, ON L2M 7P3) • LinerWerx Inc. (18 Seapark Dr Unit 6, St. Catharines, ON L2M 6S6) • Niagara Metal Finishers & Supply (21 Seapark Dr, St. Catharines, ON L2M 6S5) • Triangle Die & Tool Co Limited (604 Welland Av, St. Catharines, ON L2M 5V6) • Concordia Steel Fab Inc(4746 Montrose Rd, Niagara Falls, ON L2H 1K3) • Ironworks Niagara (4746 Montrose Rd, Niagara Falls, ON L2H 1K3) • Niagara Energy Products (4749 Buttrey St, Niagara Falls, ON L2E 7K7) • Kit Steel Inc. (100 Downs Dr, Welland, ON L3B 5N6) • Niagara Ornamental Iron Works Limited (57 Eastchester Ave, St. Catharines, ON L2P 2Y6) • Valbruna ASW Inc. (42 Centre St, Welland, ON L3B 0E5) • Salit Steel Welland (8-48 Centre St, Welland, ON L3B 0B9) • CanForge - Canada Forgings (166 Major St, Welland, ON L3B 3T4)

B: HOME IMPROVEMENT STORES/BUILDING MATERIALS SUPPLIER

NiagaraFloors.ca (464 Glendale Ave, St. Catharines, ON L2P 3Y3) • RONA St.Catharines (250 Dunkirk Rd, St. Catharines, ON L2P 0C5) • Niagara Block Inc (5000 Montrose Rd, Niagara Falls, ON L2H 1K5) • Altieri Building Supplies Ltd (4564 Montrose Rd, Niagara Falls, ON L2H 1K2) • CBM-Canada Building Materials Co • WeTrans Building Supplies • St. Amands Landscape Depot Inc • Metal Supermarkets Niagara (113 Cushman Rd #43, St. Catharines, ON L2M 6S9) • Patene Building Supplies (39 Seapark Dr, St. Catharines, ON L2M 6S5) • St. Catharines Building Supplies (176 Bunting Rd, St. Catharines, ON L2M 3Y1) • U-Cart Concrete (23 Neilson Ave, St. Catharines, ON L2M 5V9) • Turkstra Lumber - Niagara Falls (4555 Kent Ave, Niagara Falls, ON L2H 1J1) • Stark Lumber (379 Vansickle Rd, St. Catharines, ON L2R 6W8) • Vesuvius Canada Inc (333 Prince Charles Dr S, Welland, ON L3B 5N4) • RONA+ Niagara Falls (7959 McLeod Rd, Niagara Falls, ON L2H 0G5) • The Home Depot (20 YMCA Dr, St. Catharines, ON L2N 7R6) • Fort Erie RONA (584 Garrison Rd, Fort Erie, ON L2A 1N4) • The Home Depot (7190 Morrison St, Niagara Falls, ON L2E 7K5) • Welland RONA (165 Primeway Dr, Welland, ON L3B 0A1)

C: SECOND HAND MARKETS

ReStore-Habitat For Humanity (150 Bunting Rd, St. Catharines, ON L2P 3G5) - NON-PROFIT • ReStore-Habitat For Humanity (2499 ON-20, Fonthill, ON L0S 1E6) • Goodwill (495 Welland Ave, St. Catharines, ON L2M 5V9) • Goodwill (36 Page St, St. Catharines, ON L2R 4A7) • Goodwill (271 Ridley Rd W, St. Catharines, ON L2S 0B3) • Goodwill (228 Glendale Ave, St. Catharines, ON L2T 3Y6) • Goodwill (6777 Morrison St, Niagara Falls, ON L2E 6M8) • Goodwill (6840 McLeod Rd, Niagara Falls, ON L2G 3G6) • Goodwill (572 Niagara St, Welland, ON L3C 6T8) • Goodwill (1 Churchill Ave, Welland, ON L3B 4Y5) • Goodwill (53 West Side Rd #45, Port Colborne, ON L3K 3W7)

D: RECYCLING FACILITY/SALVAGE YARD

SLM Recycling (555 Brown Rd, Welland, ON L3B 5N4) • Green-Go Recycling (139 Atlas Ave, Welland, ON L3B 6J2) • International Metal Salvage (25 Invertose Dr, Port Colborne, ON L3K 5V5) • Attar Metals Inc. (177 Dunlop St, Fort Erie, ON L2A 2N4) • Lion Auto Recycling Inc (9274 Carl Rd, Port Robinson, ON L0S 1K0) • Niagara Region Recycling Centre (5030 Montrose Rd, Niagara Falls, ON L2H 1J5) • Ken’s Salvage Co Ltd (310 Allanburg Rd, Thorold, ON L2V 1A4) • Walker (3081 Taylor Rd, Allanburg, ON L0S 1A0) • Glendale Metal Company (424 Glendale Ave, St. Catharines, ON L2P 3Y3) • Davidson Environmental (242 Dunkirk Rd #1, St. Catharines, ON L2R 7K6) • TKC Metal Recycling Inc. (20 Cushman Rd, St. Catharines, ON L2M 6S8) • AIM Recycling St. Catharines (17 Seapark Dr, St. Catharines, ON L2M 6S5) • Garden City Salvage (492 Welland Ave, St. Catharines, ON L2M 5V5)

E: DECONSTRUCTION

Amwell Demolition & Deconstruction (155 Nipissing Rd, Milton, ON L9T 1R3) • Kieswetter Demolition (235 Madison Ave. S. Kitchener, ON N2M 3H5) • MAGCOR Demolition (82 Advance Rd., Etobicoke, ON M8Z 2T7) • Ouroboros Deconstruction (Toronto)

3.3 St. Catharines Material Assets

This research is deeply rooted in the question of scale –both in terms of material quantities and systems of governance. Building permits, required for any significant construction, renovation, or demolition activity, operate at a municipal scale but collectively reveal broader patterns of urban transformation. As publicly accessible records, they offer a unique lens through which to analyze the urban metabolism of building materials. By aggregating this data, the research constructs an inventory of mineable materials embedded within the built fabric of St. Catharines, demonstrating how small-scale administrative tools can inform large-scale strategies for circular urbanism. The City of St. Catharines operates an open data source with a collection of issued permits from 2021 to year of 2024.[25] Provided information include the address, permit file number, date issued, building type, floor area, estimated construction value, and a brief project description. The search engine was used to define the scope of the study, focusing on projects registered within a one-year period from 2023 to 2024, examining approximately 1,000 projects in total. This quantification serves as the datum for the city's material inventory, with the numbers extrapolated to predict the accumulation of resources over time.

25 'Issued Permits', 3 October 2023, https://www.stcatharines.ca/en/building-and-renovating/issued-permits.aspx.

As the statistics show in the later pages, demolition works happen at a much slower pace than new construction, while renovation projects remain the most common type of building activity. This contrast is typical in cities, where densification often occurs through large-scale, block-wide developments, while demolition tends to proceed incrementally on a site-by-site basis. The inflows and outflows of building materials occur at all stages of a building's lifecycle, highlighting the need to examine a range of building projects beyond full demolition (or deconstruction). The scope of this thesis quantifies materials extracted from listed demolition projects as a starting point for the broader investigation.

Eight main building types were identified: single detached dwelling, single detached garage, multi-housing, commercial building, mid-rise, high-rise, industrial and institutional buildings. Each building typology was 3D modelled in detail, primarily focused on the structure and envelope. Further investigation of the assembly and materialistic properties of the identified buildings was based on the imageries and data found through geographic information systems (GIS). The digital models were exploded, grouped into common building components, and then quantified by mass and volume.

The following pages summarizes the "St. Catharines Building Permit Analysis (2023-2024)", followed by building profiles of each typologies examined which lists out the construction factors taken into considerations for this speculative study of

materials. It's worth noting that the "Percentage of Salvageable Materials" chart contains percentage number for "Reuse": directly reuseable materials; "Recycle": materials that cannot be reused but can be recycled; and "Remain": foundation mass. Due to the significant mass of concrete foundation in all buildings (from 35-72% according to the study), this building layer was extrapolated as a separate category in order to gain better understanding of assessing above-ground building elements that can be dismantled. This simultaneously alludes to the possibility of reutilizing the foundation structure as a design strategy for the next project to eliminate the large use of concrete and reduce the highest carbon-intensive procedure in construction. 1-5% of the total mass accounts for the omitted building layers that have low volume such as plastic building membranes, that is expected to be disposed.

Assumptions made on the construction types and architectural attributes were informed by personal knowledge, the research conducted in this thesis, largely based on the "Introduction to Deconstruction: A Comprehensive Training Textbook", published by the Building Materials Reuse Association. This initial investigation into the inventory of building materials and components served as a foundation for identifying valuable assets within the existing urban fabric of St. Catharines, while also informing design decisions for a circularity hub that addresses contemporary social demands presented in Chapter 4.

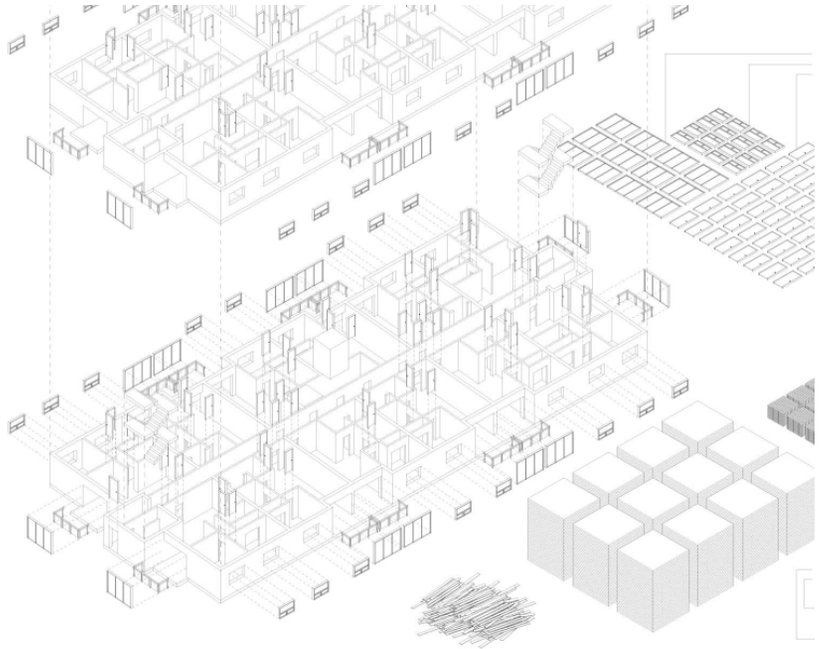


Fig. 3.40

Example of exploded (deconstructed) 3D model for material quantification.

Fig. 3.41

St. Catharines Building Permit Analysis: 2023-2024 (A).

PROCEDURE

1. St. Catharines Issue Building permits accessed through public portal: *https://www.stcatharines.ca/en/building-and-renovating/issued-permits.aspx*

2. Search engine used to narrow down scope to permits issued between 2023-2024

3. Relevant information excerpted and logged into Excel (Address, File Number, Date Issued, Building Type, Floor Area (Square feet), Estimated Construction Value, Project Description)

4. List of permits categorized by building types: Single detached dwelling, Multi-housing, Commercial, Single detached garage, Mid-rise, Institutional and High-rise

5. List of permits categorized by project types: Demolition, Partial demolition, Renovation, New Build, Additions)

525 Welland Avenue	23 103309 000 00 A	5/10/2023	Gymnasia	0	$35,000	Alteration to existing NFPA 13 Sprinkler System for new tenant Planet Fitness
525 Welland Avenue	23 105865 000 00 N	6/9/2023	Stores	0	$15,000	Alterations to Repair Vehicle Impact Damages to 'Walmart'
526 Welland Avenue	23 108854 000 00 N	8/10/2023	Stores	0	$49,000	Alteration of Unit 4 for a UPS store.
528 Niagara Street	23 112719 000 00 RI	10/24/2023	Single	0	$50,000	Replace Basement Stairs, Finish Portion of Basement in Single Detached Dwelling
528 Scott Street	23 103394 000 00 F	9/26/2023	Apartment Bldg <= 6 stories	0	$6,000	Alterations to rear stairs.
53 George Street	23 105548 000 00 F	5/19/2023	Drains And/Or Water	0	$0	Replace Waterline to Street
53 Lowell Avenue	23 109177 000 00 R	8/9/2023	Single	0	$6,000	Demolish Front Porch
53 Prince Philip Drive	23 102411 000 00 RI	3/23/2023	Single	630	$40,000	Construct Attached Garage
53 York Street	23 100858 000 00 F	1/25/2023	Drains And/Or Water	0	$0	Remove Builders Trap And Install 2 Cleanouts
54 Elderwood Drive	23 101756 000 00 R	3/27/2023	Single	560	$100,000	Covered Patio Addition to Existing Single Dwelling Unit
54 Francis Creek Boulevard	23 105099 000 00 E	6/12/2023	Detached Carport	228	$18,000	Construct 14' x 20' Aluminum Pergola
54 Hamilton Street	23 102578 000 00 F	3/14/2023	Drains And/Or Water	0	$0	Spot Repair Outside About 10ft. Front Foundation and Install a Clean Out
54 Hillview Road N	23 100405 000 00 F	5/1/2023	Single	0	$100,000	Construct Second Floor Addition, Interior Alterations & New Rear Deck
540 Lake Street	23 110740 000 00 R	9/19/2023	Single	0	$30,000	Interior Alterations, Remove Load Bearing Wall Between Kitchen/Dining and Living
541 Glenridge Avenue	23 110118 000 00 IS	8/17/2023	Hospitals	0	$20,000	Replace existing fire alarm control panel (no devices) at Hotel Dieu Shaver Hospital
541 Lake Street	23 101399 000 00 A	3/25/2023	Schools/ Colleges- Non Residential	0	$750,000	Interior Renovations to Existing Secondary School
541 Lake Street	23 107621 000 00 A	7/28/2023	Classrooms, New Portable	0	$0	Demolish Portable Classroom (8)
541 Lake Street	23 107624 000 00 A	7/28/2023	Classrooms, New Portable	0	$0	Demolish Portable Classroom (9)
541 Lake Street	23 107625 000 00 A	7/28/2023	Classrooms, New Portable	0	$0	Demolish Portable Classroom (10)
541 Lake Street	23 107627 000 00 A	7/28/2023	Classrooms, New Portable	0	$0	Demolish Portable Classroom (11)
541 Lake Street	23 107628 000 00 A	7/28/2023	Classrooms, New Portable	0	$0	Demolish Portable Classroom (12)
548 Ontario Street	23 113980 000 00 R	11/27/2023	Duplex	0	$200,000	repair fire damage to basement accessory dwelling unit
55 Lloyd Street	23 104070 000 00 F	8/2/2023	Duplex	46	$50,000	Alter Interior of Basement to Create Accessory Dwelling Unit
559 Vine Street	23 111773 000 00 RI	10/16/2023	Single	0	$35,000	Finish Basement of Single Detached Dwelling
56 Chelsea Street	23 101565 000 00 B	2/27/2023	Detached Garage	0	$0	Demolish Detached Garage
56 Chelsea Street	23 102303 000 00 E	4/24/2023	Detached Garage	288	$20,000	Construct 12' x 24' Detached Garage
56 Hillview Road N	23 115403 000 00 R	12/18/2023	Single	0	$64,638	Foundation Repair - Helical Pier Installation
56 Leaside Drive	23 110059 000 00 R	8/28/2023	Single	0	$13,000	Alteration to Replace Chimney (Going from Wood to Gas)
56 St Paul Street W	23 112770 000 00 A	11/7/2023	Schools/ Colleges- Non Residential	0	$2,500	Upgrades to the Existing Fire Alarm System
56 Tecumseh Street	22 104530 000 00 F	7/20/2023	Duplex	827	$65,000	Construct a Two Storey Addition Create an Accessory Dwelling Unit Above the Garage
57 Carlisle Street	21 118149 000 00 RN	7/20/2023	Apartment Bldg > 6 stories	10,572	$45,750,000	Construct Super Structure Only (above elev. 109.60 m) for 19 Storey Mixed Use Apartment Building - 'Carlisle Square'. Separate tenant permits required for commer
57 Carlisle Street	22 114585 000 00 R	7/18/2023	Apartment Bldg > 6 stories - Condomini	0	$0	Alternative Solution for Standpipe
57 Carlisle Street	22 114616 000 00 RI	3/3/2023	Apartment Bldg > 6 stories	0	$0	Alternative Solution for Delta Beams
57 Carlisle Street	22 114828 000 00 R	4/14/2023	Apartment Bldg > 6 stories - Condomini	0	$0	Alternative Solution for 'Fire Pump Room'
57 Carlisle Street	23 102243 000 00 F	3/2/2023	Apartment Bldg > 6 stories	0	$0	PERMIT REVISED: to remove Conditional Permit status (22-114632 CP file closed). *Conditional Permit for the Structural Frame of the 18 Story Building subject to Al
57 Lorne Street	23 110435 000 00 R	9/1/2023	Single	0	$30,000	to partially construct a finished basement
57 Parkview Road	23 108146 000 00 R	7/27/2023	Duplex	0	$50,000	Alteration to Duplex to Repair Fire Damage.
579 Bunting Road	23 102374 000 00 D	3/13/2023	Solar Collectors	0	$27,223	Install Rooftop Solar Panels
58 Lake Street	23 110549 000 00 P	8/28/2023	Drains And/Or Water	0	$0	Replace Waterline
58 Seymour Avenue	23 105888 000 00 A	6/22/2023	Classrooms, New Portable	0	$100,000	Construct new portable classroom.
58 Trelawne Drive 0000	23 111839 000 00 RI	10/26/2023	Single	340	$90,000	Construct One Storey Addition with Finished Basement, Alter Interior of Ground Floor
58 Welland Avenue	23 101482 000 00 R	5/3/2023	Apartment Bldg <= 6 stories	0	$200,000	Repairs to Existing Unit Balconies
581 Lake Street	23 111327 000 00 M	10/20/2023	Stores	0	$10,000	Alterations to existing grocery store to install security gates.
585 Niagara Street	23 110138 000 00 TS	8/29/2023	Tents	0	$12,000	Construct Temporary Tents from Aug. 30 to Sept. 5. (20'x100', 2-10'x60',30'x60', 2- 40'x60', 40'x40')
588 Carlton Street	23 109796 000 00 N	9/22/2023	Stores	0	$0	Demolish Existing Store
59 Church Street	23 105986 000 00 IS	7/21/2023	Courtrooms	0	$150,000	Install Generator on Roof, Alteration for Structural Support
59 Church Street	23 106931 000 00 IS	8/17/2023	Courtrooms	0	$25,000	Alteration to existing NFPA 13 sprinkler system in ROBERT S.K. WELCH COURTHOUSE.
59 Parker Street	23 100661 000 00 R	2/15/2023	Duplex	0	$15,000	Alter Interior of Basement and Ground Floor to Create an Accessory Dwelling Unit
59 Rykert Street	22 115135 000 00 RI	1/4/2023	Row Housing	0	$75,000	Interior Renovations to Repair Fire Damage Unit 102
59 Rykert Street	23 113110 000 00 RN	10/31/2023	Row Housing	32	$114,000	Repair Front and Rear Foundation Wall of Rowhouse (Unit 65)
591 Lake Street	23 113949 000 00 R	11/23/2023	Single	0	$10,000	Construct 18' x 42' Irregular Deck
594 Niagara Street	23 113668 000 00 R	12/7/2023	Multiple	2,422	$50,000	Interior Alterations to Construct Two Accessory Dwelling Units (3 Units Total)
595 Carlton Street	23 112151 000 00 MI	11/7/2023	Restaurants < 30 Persons	0	$70,000	Interior Alterations / Tenant Fit-out - Unit 24
5A Bradley Street	23 105499 000 00 F	6/20/2023	Duplex	0	$70,000	Alter Interior of Ground Floor
5B Wilholme Drive	23 103076 000 00 F	4/11/2023	Single	0	$75,000	Alteration to Enclose Existing Deck
6 Charlotte Street	23 111621 000 00 RN	11/13/2023	Multiple	1,448	$350,000	Construct New Triplex
6 Chessington Street	23 104331 000 00 B	5/11/2023	Inground Pool	0	$55,000	Install 10' x 20' Inground Pool
6 Marmora Street	22 114409 000 00 B	3/2/2023	Detached Garage	225	$25,000	To Construct A Detached Garage In The Rear Yard
6 Matthews Crt	23 113146 000 00 RI	11/20/2023	Single	1,600	$200,000	Interior Alterations to Ground Floor, New Powder Room and Reconfigured Kitchen
6 Pine Street (Demo)	23 101224 000 00 B	2/14/2023	Detached Garage	0	$0	Demolish Detached Garage
6 Pine Street (Garage)	23 101226 000 00 B	3/14/2023	Detached Garage	252	$20,000	Construct 21' x 11' Detached Garage
6 Tara Court	23 112490 000 00 B	10/23/2023	Inground Pool	0	$70,000	Construct 14' x 40' Inground Pool
6 Woodglen Drive	23 114786 000 00 B	12/7/2023	Shed	0	$12,000	Construct new 12' x 16' shed.
60 Duncan Drive	23 105361 000 00 B	5/26/2023	Detached Garage	391	$45,000	Construct New Detached Garage
60 Windward Street	23 107106 000 00 R	7/14/2023	Apartment Bldg > 6 stories	0	$35,000	Replace Existing Generator
600 Ontario Street	23 108987 000 00 N	8/30/2023	Restaurants < 30 Persons	0	$500	Alteration to Unit 4 to Create Bakery attached to Units 5 & 6.
600 Vine Street	23 109730 000 00 A	8/25/2023	Schools/ Colleges- Non Residential	0	$1,150,000	Alterations to 'Prince Philip Elementary School' for HVAC Upgrades and BAS Work.
61 Dorothy Street	23 111221 000 00 BS	11/23/2023	Detached Garage	1,391	$40,000	Construct 26' x 53'-6" Detached Garage
61 Dorothy Street	23 113930 000 00 B	11/23/2023	Detached Garage	0	$0	Demolition of Existing Detached Garage.
61 Duncan Drive	23 105853 000 00 A	7/19/2023	Schools/ Colleges- Non Residential	0	$250,000	Install new LULA Lift in Dalewood Public School.
61 Glen Park Road	23 102475 000 00 F	3/24/2023	Single	470	$114,000	One Storey Addition and Covered Deck
61 Mountain Street	23 112051 000 00 RI	10/13/2023	Single	0	$40,000	Alter Interior of Ground Floor of Single Detached Dwelling
61 Sovereign Drive	23 105363 000 00 E	7/25/2023	Shed	264	$10,000	Construct New Cabana Shed 22 x 12
610 Niagara Street 0000	23 111006 000 00 RI	11/10/2023	Duplex	0	$65,900	Interior Alterations to Create Basement Accessory Dwelling Unit
616 Scott Street	23 109171 000 00 RI	8/10/2023	Single	165	$45,000	Demolish Existing Sunroom & Construct New Unheated Sunroom
618 Vine Street	23 106170 000 00 B	6/8/2023	Inground Pool	0	$75,000	Construct 14' x 30' Inground Pool
62 Currie Street	23 105088 000 00 F	6/8/2023	Duplex	0	$70,000	Interior Alterations to Existing Duplex, Relocate Kitchen
62 Currie Street	23 110013 000 00 RI	11/14/2023	Duplex	217	$10,000	Addition/Replacement of Front and Rear Decks.
62 Kinsey Street	23 111086 000 00 DS	10/3/2023	Solar Collectors	0	$20,000	Install 39 Solar Collectors on Roof of Single Detached Dwelling
620 Bunting Road	22 114871 000 00 RI	1/10/2023	Single	485	$30,000	Addition of Attached Carport
63 Carlton Street	23 110390 000 00 R	11/28/2023	Apartment Bldg <= 6 stories	0	$75,000	Repair and Reinstate portion of the building due to Fire Damage (Unit 2).
63 Church Street	22 114931 000 00 BI	2/13/2023	Offices > 6 stories	0	$200,000	Replace Emergency Generator
63 Glen Park Road	23 113742 000 00 R	11/27/2023	Single	0	$25,000	Waterproofing to Single Detached Dwelling
63 York Street 0000	23 113253 000 00 R	11/15/2023	Semi	0	$800	Block Up Window in South Elevation of Right Side of Semi-Detached Dwelling
64 Ontario Street	23 107294 000 00 T	7/12/2023	Tents	0	$0	Erect Five Temporary Tents for 'Ribfest' from August 3, 2023 to August 8, 2023 (40 x 30, 40 x 60, 20 x 60, 2 - 40 x 45)

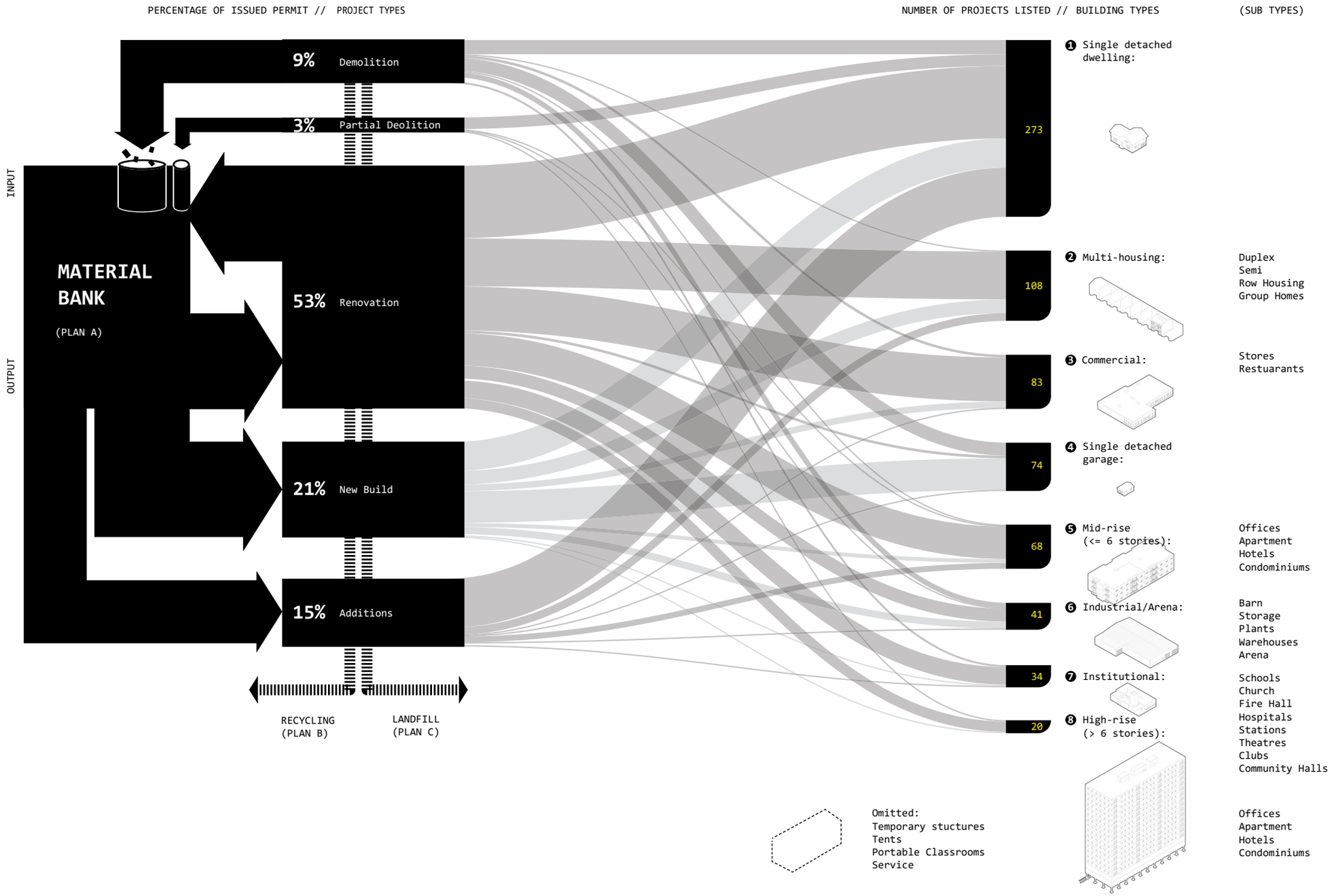
Fig. 3.42

St. Catharines Building Permit Analysis: 2023-2024 (B).

Demolition accounted for 9% of issued building permits in St. Catharines, while new construction made up 21%, resulting in an approximately 1:2 ratio of demolitions to new builds. Although deconstruction alone may not fully meet the city's densification demands, it can supply a substantial amount of second-hand materials, significantly reducing the need for virgin resources.

Renovation projects represent over 50% of permits, highlighting the ongoing circulation of materials throughout a building's lifespan.

In this study, any materials expected to be removed from a project are first directed to the Material Bank (Plan A) for future reuse. If reuse is not viable, recycling serves as Plan B, with disposal in landfills as the last resort (Plan C), minimizing overall waste.



* Project types that didn't have inflows/outflows of physical materials (typically service upgrades) were omitted in the calculation
* Temporary installation projects were omitted

Fig. 3.43

Salvageable Material
Profiles.

TYP. MANUFACTURED/
FABRICATED FORM

MATERIAL NAME

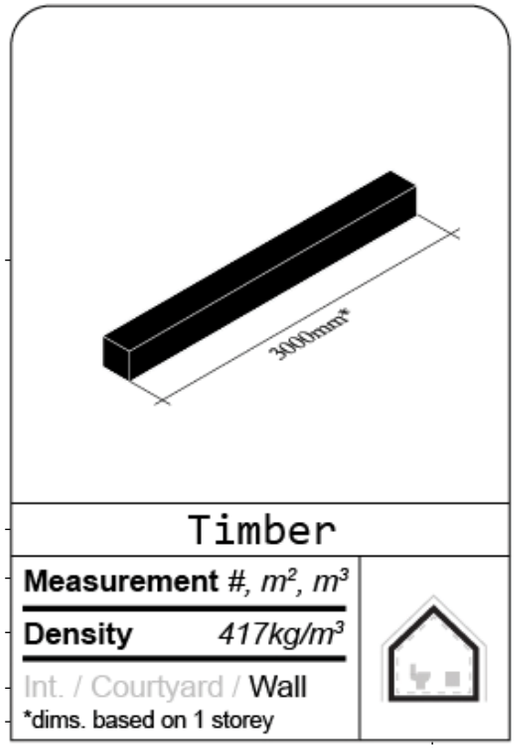
MEASUREMENT METHOD(S):
by unit(#)/area(m2)/
volume(m3)

MATERIAL DENSITY

STORAGE METHOD(S)

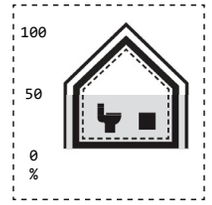
SPECIFIC CONSIDER-
ATIONS

SOURCE (BASED ON THE
SHEARING LAYERS)



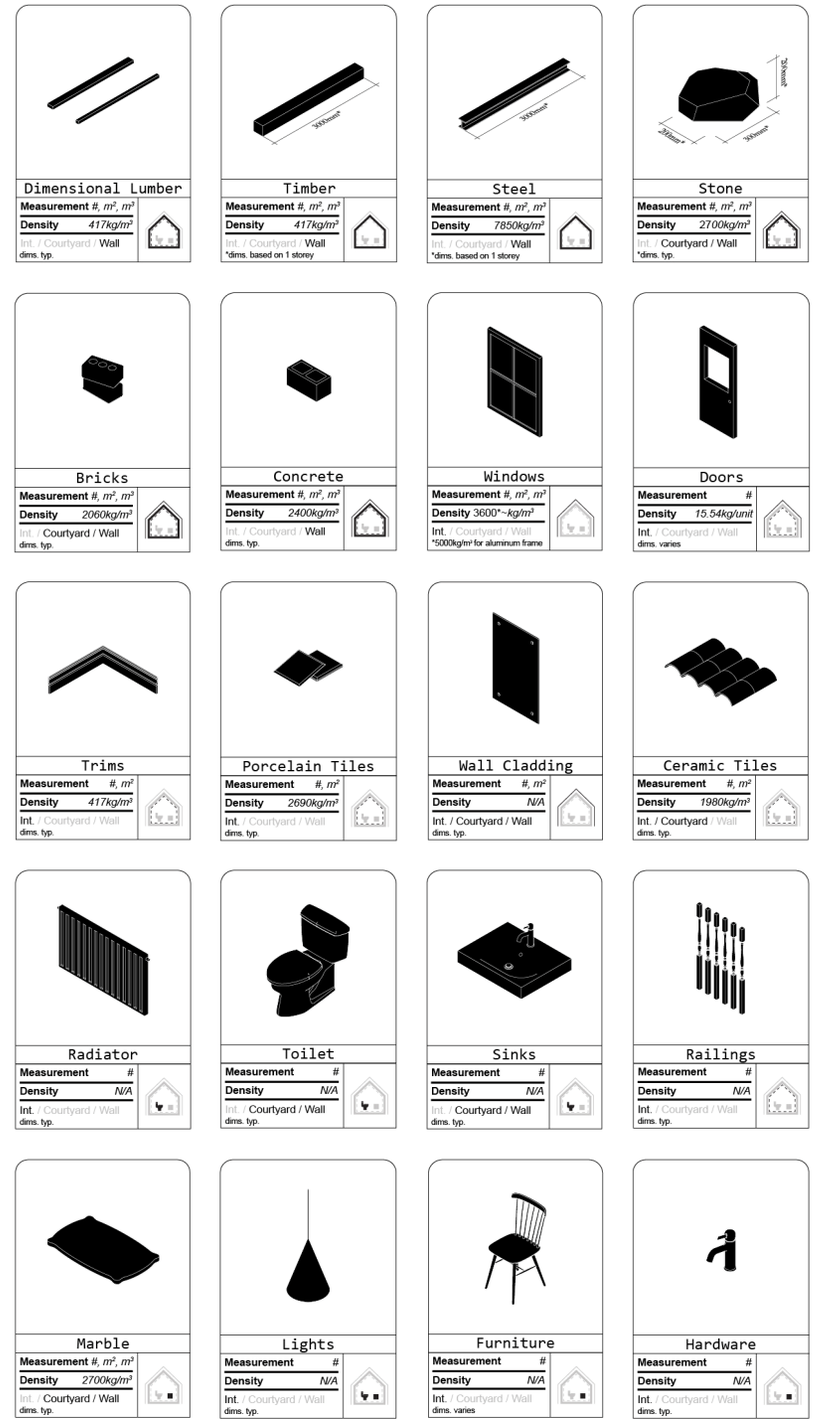
MATERIAL DENSITY
DETAILS (SOURCE: ONE-
CLICK LCA)

DIMENSIONAL LUMBER: Dried timber, conifer (Canadian Wood Council)
WOOD FLOORING: Oriented strand board (OSB), 613.4 kg/m3 (Canadian Wood Council)
OSB SHEATHING: Oriented strand board (OSB), 613.4 kg/m3 (Canadian Wood Council)
CONCRETE: Concrete, ready mix, 4001 - 5000 psi (C30/35), 5000-00-FA/SL (NRMCA (2022))
ALUMINUM WINDOW FRAME: Anodized aluminium extrusions (Aluminum Extruders Council (AEC 2016))
FIBERGLASS WINDOW FRAME: Fiberglass windows, 1.5m x 1.3 m, 40 mm frame thickness, 1.42 m2 glazing area, 42.6 kg/m2, 300 Series Tilt and Turn, 300 Series Fixed, 325 Series Awning/Casement, 325 Series Fixed, 400 Series (Inline)
GLASS: Laminated glass, two or more sheets, 28.4 kg/m2, 10.9 mm (Multiver)
GYPSUM BOARD: Gypsum plaster board, regular, 40% recycled gypsum, 6.5-25 mm (0.25-0.98 in), 10.725 kg/m2 (2.20 lbs/ft2) (for 12.5 mm/0.49 in), 858 kg/m3 (53.6 lbs/ft3) (One Click LCA)
VINYL SIDING: Horizontal vinyl siding, T: 0.04 inches, L: 12 ft, W: 0.75 ft, 89.27 lbs/ft3 (VSI)
INSULATION:Fiberglass insulation board, R = 1m2K/W, 45.3 mm, 2.61 kg/m2, 57.62 kg/m3 (NAIMA)
STEEL STRUCTURE: Fabricated hollow structural steel sections, unpainted, 7850 kg/m3 (487 lb/ft3) (CISC)
STEEL STUDS: Solid sheet steel for studs, industry average US and CN, 1ft 5/8in-14in x1ft 1/4in x 3ft 1/2in x0.0188in-0.1242in (SRI)
STEEL SIDING: Steel sheets, generic, 60% recycled content, S235, S275 and S355 (One Click LCA)
BRICKS: Clay bricks, 2060 kg/m3, 15.70% moisture content (Shaw Group)
DOORS: MDF door and lining, 1981x838x44 mm, 15.54 kg/unit (Staircraft Group Ltd)
ASPHALT SHINGLES: Asphalt roofing shingles, 9.26 kg/m2, Supreme® (Owens Corning)
NATURAL STONE: Natural stone, Finnish average, 2700 kg/m3 (KIVI ry)
PORCELAIN TILE: Porcelain tile, 0.24-0.41in, nominal facial area 3-36in, 4.55 lb/ft2 (Crossville)
CERAMIC TILE: Ceramic tile, US average, 0.287-0.433in, 0.5x0.5in - 24x24in, planks max. 36in, 3.5-7.0 lb/ft2, Industry average, North America (TCNA)



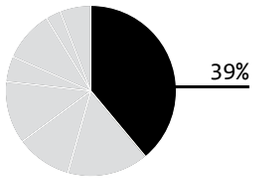
TOTAL VOLUME
OF REUSABLE
MATERIALS

TOTAL VOLUME OF
BUILDING MATERI-
ALS PER STUDIED
BUILDING

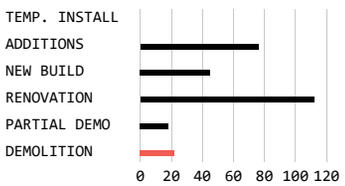


Single Detached Dwelling

Permits Issued by Building Type (%)



Categorization of Activities Listed



Case Study Building:
306 Vine Street, St. Catharines
Building footprint: 150m²
Storeys: 2
(REGISTERED FOR DEMOLITION)

CONSIDERATIONS:

- Platform construction
- Wood as main structural material
- Exterior finish is 1/2 brick veneer and 1/2 vinyl siding
- Wood studs installed at 16” O.C. with 2x4” and 2x10” dimensional lumber
- PVC window frame
- no basement

Percentage of Salvageable Materials

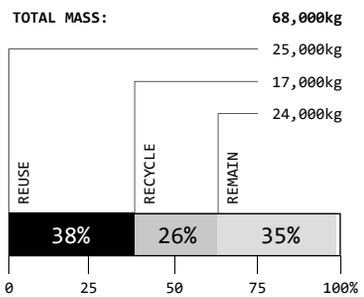
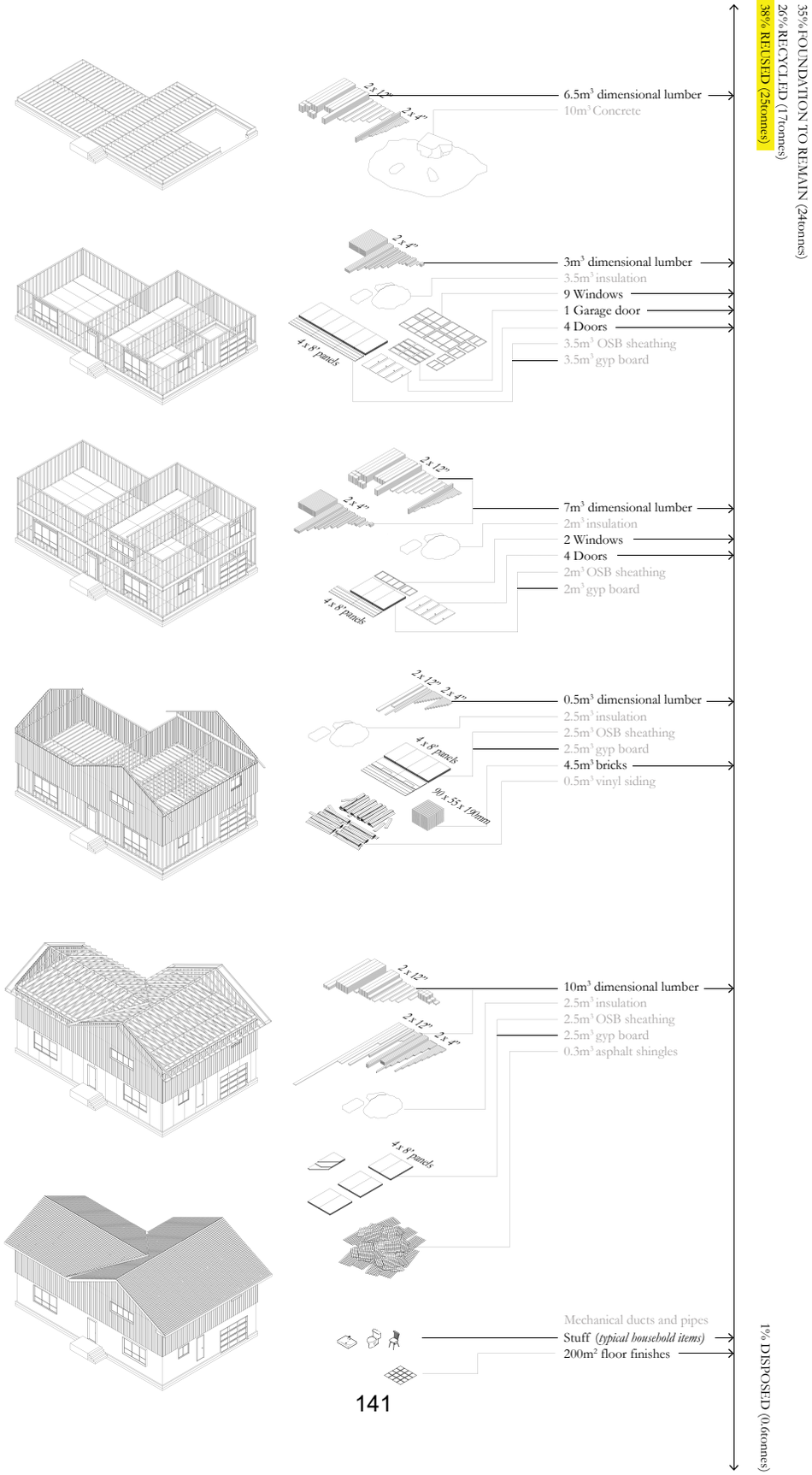


Fig. 3.44

Typical single detached dwelling.



Reclaimed Material Inventory: Single Detached Dwelling

TOTAL MASS OF BUILDING MATERIALS: 68,000kg
TOTAL MASS OF REUSABLE MATERIALS: 25,000kg

x 22 (demolitions)
= 550 tonnes of reusable materials

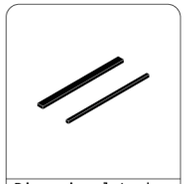
TOTAL VOLUME OF BUILDING MATERIALS: 100m³
TOTAL VOLUME OF REUSABLE MATERIALS: 50m³

x 22 (demolitions)
= 1,100m³ of reusable materials

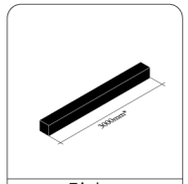
Single-family residential buildings—comprising the majority of structures registered for demolition—represent the primary source for "urban mining" within the city of St. Catharines. These structures predominantly appear in satellite imagery from post-1965 development. Homes constructed during this period were typically built using platform wood framing, a method that, compared to the balloon framing common in the 1940s, allows for easier deconstruction.

Old-growth timber was commonly used for structural framing up until the 1970s and is assumed to still be present in portions of the city's remaining building stock. Despite the variation in structural types across different eras, dimensional lumber remains the largest contributing material for this building typology.

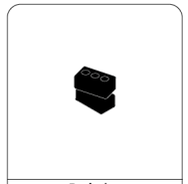
While brick façades are still visible across the urban landscape, these are most often non-structural veneer applications. Load-bearing brick construction is largely confined to pre-20th-century buildings, which are now relatively scarce within the contemporary urban fabric.



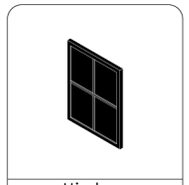
Dimensional Lumber
Measurement #, m², m³
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.



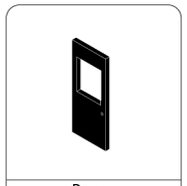
Timber
Measurement #, m², m³
Density 417kg/m³
Int. / Courtyard / Wall
*dims. based on 1 storey



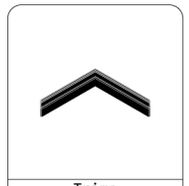
Bricks
Measurement #, m², m³
Density 2060kg/m³
Int. / Courtyard / Wall
dims. typ.



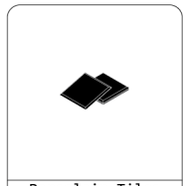
Windows
Measurement #, m², m³
Density 3600*~kg/m³
Int. / Courtyard / Wall
*5000kg/m³ for aluminum frame



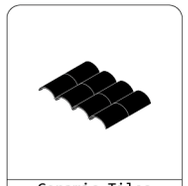
Doors
Measurement #
Density 15.54kg/unit
Int. / Courtyard / Wall
dims. varies



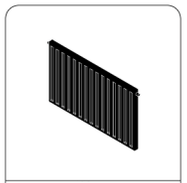
Trims
Measurement #, m²
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.



Porcelain Tiles
Measurement #, m²
Density 2690kg/m³
Int. / Courtyard / Wall
dims. typ.

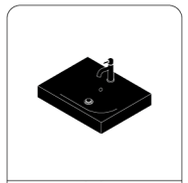


Ceramic Tiles
Measurement #, m²
Density 1980kg/m³
Int. / Courtyard / Wall
dims. typ.



Radiator
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Toilet
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Sinks
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Railings
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Marble
Measurement #, m², m³
Density 2700kg/m³
Int. / Courtyard / Wall
dims. typ.

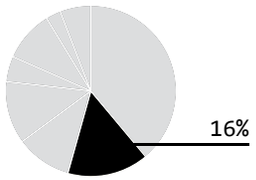
Lights
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Furniture
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. varies

Hardware
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

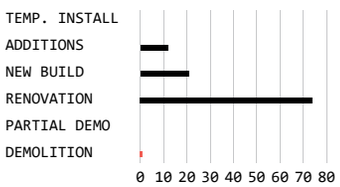
Multi-housing

Permits Issued by Building Type (%)



Duplex
Semi
Row Housing
Group Homes

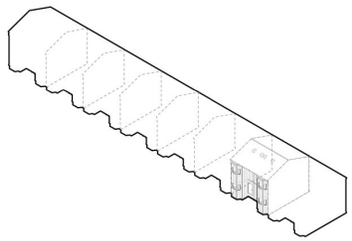
Categorization of Activities Listed



Case Study Building:
234 Oakdale Avenue, St. Catharines
Building footprint: 500m² (60m² X 8)
Storeys: 2

CONSIDERATIONS:

- Platform construction
- Wood as main structural material
- Brick veneer (not structural)
- Exterior finish is 1/4 brick veneer and 3/4 vinyl siding
- Wood studs installed at 16” O.C. with 2x4” and 2x10” dimensional lumber
- PVC window frame
- no basement



Percentage of Salvageable Materials

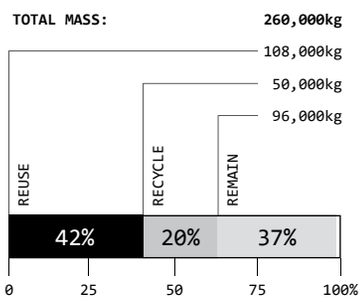
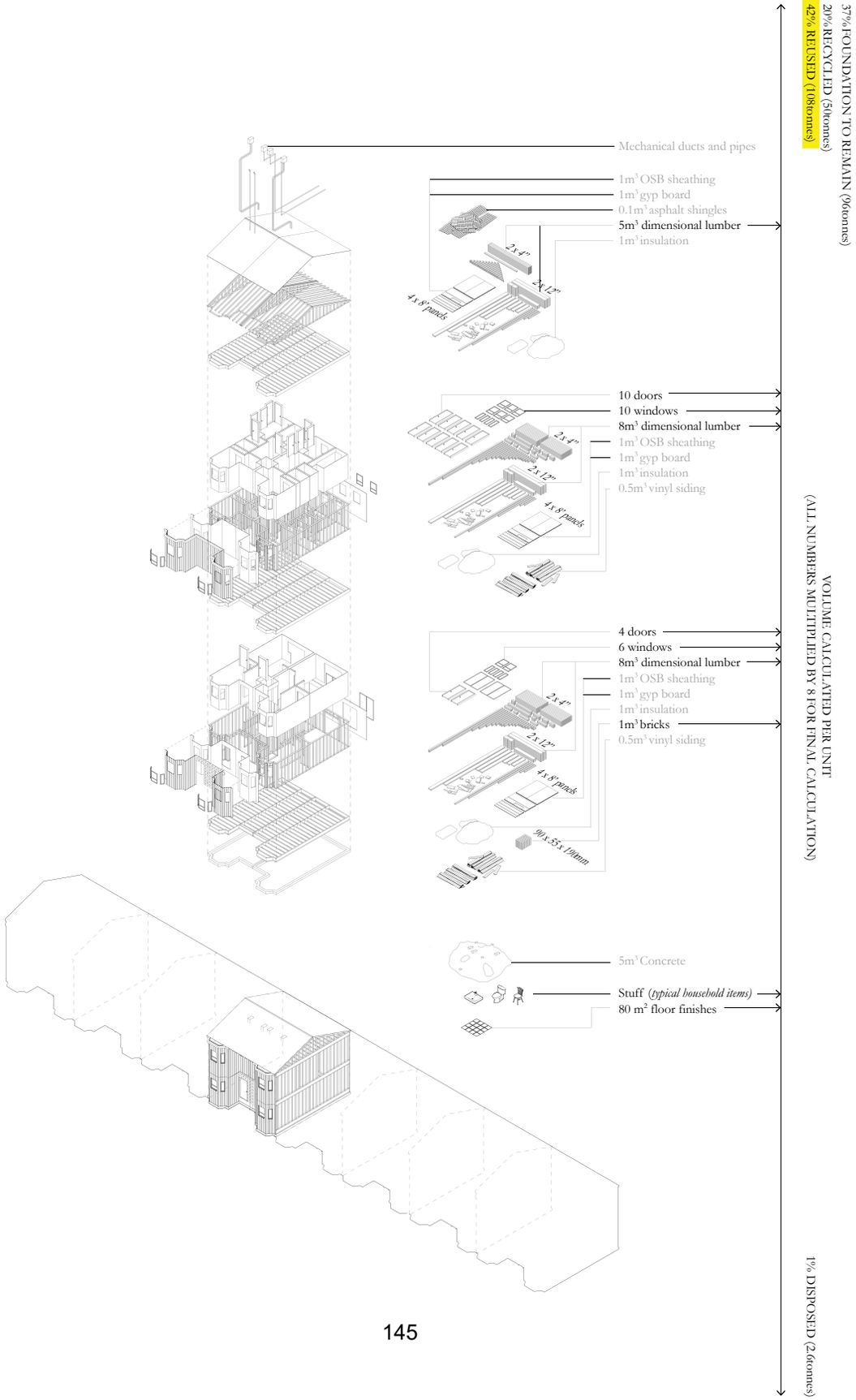


Fig. 3.45

Typical multi-housing.



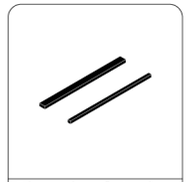
Reclaimed Material Inventory: Multi-housing

TOTAL MASS OF BUILDING MATERIALS: 260,000kg
TOTAL MASS OF REUSABLE MATERIALS: 108,000kg x 1 (demolitions) = 108 tonnes of reusable materials

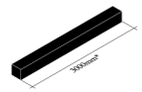
TOTAL VOLUME OF BUILDING MATERIALS: 750m³
TOTAL VOLUME OF REUSABLE MATERIALS: 400m³ x 1 (demolitions) = 400m³ of reusable materials

Similar to the single detached dwelling buildings, dimensional lumber constitutes the greatest percentage of the overall materials quantity, while the quality and type of the wood will depend of the year of construction.

The only main distinction derived from the calculation is that the reusable materials mass is slightly greater in relation to the total mass. Due to the increased occupancy, household items' mass is expected to be much higher than single detached houses per m².



Dimensional Lumber
Measurement #, m², m³
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.



Timber
Measurement #, m², m³
Density 417kg/m³
Int. / Courtyard / Wall
*dims. based on 1 storey

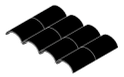
Bricks
Measurement #, m², m³
Density 2060kg/m³
Int. / Courtyard / Wall
dims. typ.

Windows
Measurement #, m², m³
Density 3600*~kg/m³
Int. / Courtyard / Wall
*5000kg/m³ for aluminum frame

Doors
Measurement #
Density 15.54kg/unit
Int. / Courtyard / Wall
dims. varies

Trims
Measurement #, m²
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.

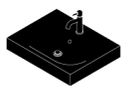
Porcelain Tiles
Measurement #, m²
Density 2690kg/m³
Int. / Courtyard / Wall
dims. typ.



Ceramic Tiles
Measurement #, m²
Density 1980kg/m³
Int. / Courtyard / Wall
dims. typ.

Radiator
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Toilet
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Sinks
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Railings
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Marble
Measurement #, m², m³
Density 2700kg/m³
Int. / Courtyard / Wall
dims. typ.

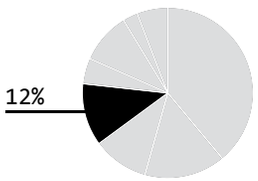
Lights
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Furniture
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. varies

Hardware
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

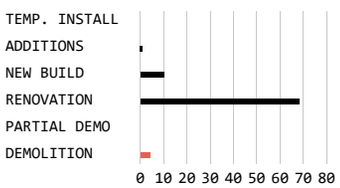
Commercial Building

Permits Issued by Building Type (%)



Stores
Restaurants

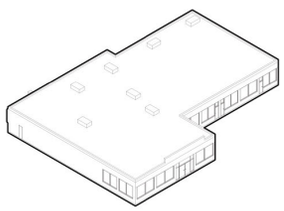
Categorization of Activities Listed



Case Study Building:
588 Carlton Street, St. Catharines
Building footprint: 850m²
Storeys: 1
(REGISTERED FOR DEMO)

CONSIDERATIONS:

- Steel and concrete as main structural material
- Exterior finish is painted stucco
- Steel studs installed at 16” O.C.
- Aluminum window frame/curtain wall
- no basement



Percentage of Salvageable Materials

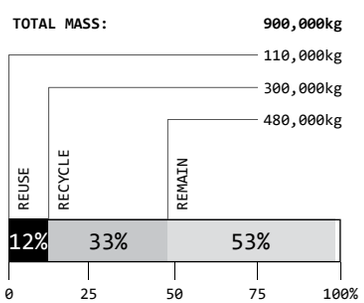
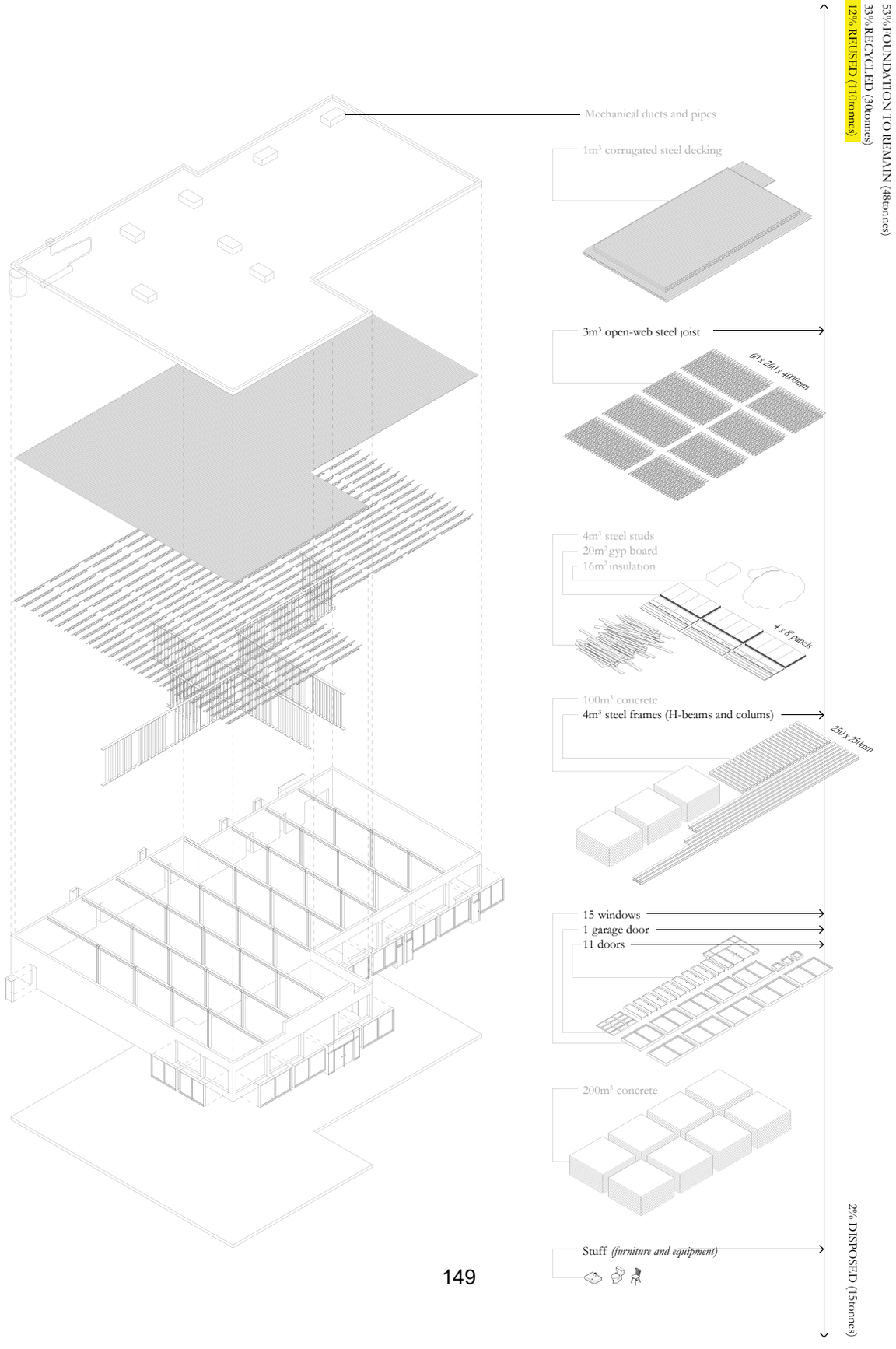


Fig. 3.46

Typical commercial building.



Reclaimed Material Inventory: Commercial Building

TOTAL MASS OF BUILDING MATERIALS: 900,000kg
TOTAL MASS OF REUSABLE MATERIALS: 110,000kg

x 4 (demolitions)
= 440 tonnes of reusable materials

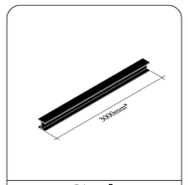
TOTAL VOLUME OF BUILDING MATERIALS: 500m³
TOTAL VOLUME OF REUSABLE MATERIALS: 50m³

x 4 (demolitions)
= 200m³ of reusable materials

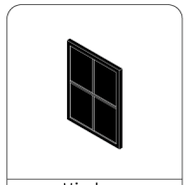
Commercial building typology contains the lowest salvage value. While steel structural members have potential to be deconstructed for reuse, the exterior walls are often built of CMUs which can be recycled but is not reused.

The floor area-to-height ratio significantly drives the salvage percentage. While the concrete foundation covers the entirety of the floor area, the constructed structure above ground (that can be deconstructed) is only erected at one storey. The exterior of the case study building was finished with stucco and paint, which has no residual value.

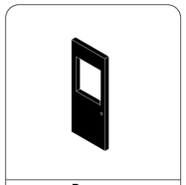
With the main structural materials being concrete (nearly not reusable) and steel (reusable through re-certification), items with the highest potential and value in salvage are architectural components such as windows, curtain walls, doors, as well as furniture. Additionally, commercial buildings have high usage of aluminum frames, and based on their significant embodied carbon, reusing these components would mean restoring a great amount of emissions.



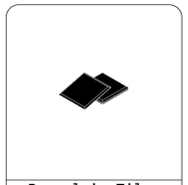
Steel
Measurement #, m², m³
Density 7850kg/m³
Int. / Courtyard / Wall
*dims. based on 1 storey



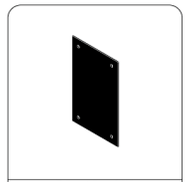
Windows
Measurement #, m², m³
Density 3600*~kg/m³
Int. / Courtyard / Wall
*5000kg/m³ for aluminum frame



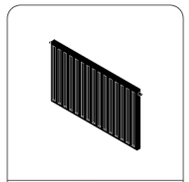
Doors
Measurement #
Density 15.54kg/unit
Int. / Courtyard / Wall
dims. varies



Porcelain Tiles
Measurement #, m²
Density 2690kg/m³
Int. / Courtyard / Wall
dims. typ.

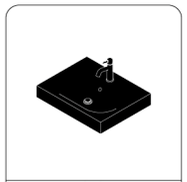


Wall Cladding
Measurement #, m²
Density N/A
Int. / Courtyard / Wall
dims. typ.



Radiator
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Toilet
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Sinks
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

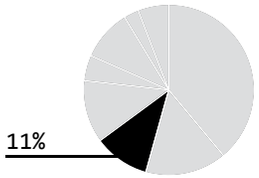
Lights
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Furniture
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. varies

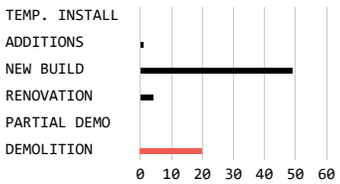
Hardware
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Single detached garage

Permits Issued by Building Type (%)



Categorization of Activities Listed



Case Study Building:
15 Keele Street, St. Catharines
Building footprint: 30m²
Storeys: 1
(REGISTERED FOR DEMO)

CONSIDERATIONS:
- Wood as main structural material
- Exterior finish is vinyl siding

Percentage of Salvageable Materials

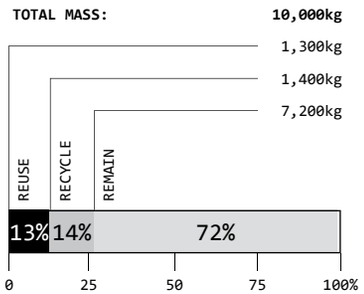
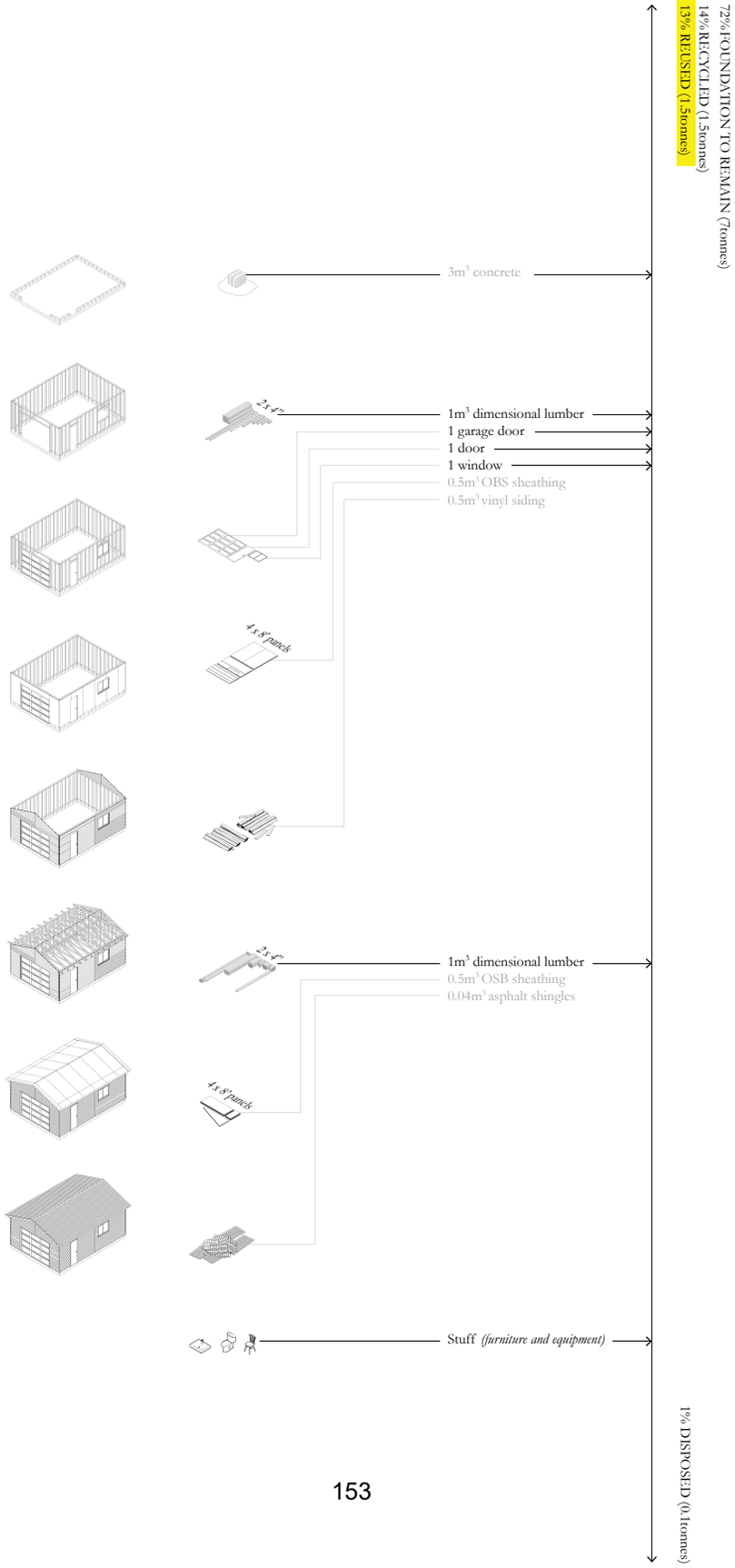


Fig. 3.47

Typical detached garage.



Reclaimed Material Inventory: Single Detached Garage

TOTAL MASS OF BUILDING MATERIALS: 10,000kg
TOTAL MASS OF REUSABLE MATERIALS: 1,300kg

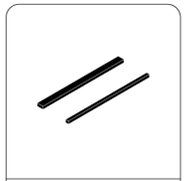
x 20 (demolitions)
= 26 tonnes of reusable materials

TOTAL VOLUME OF BUILDING MATERIALS: 10m³
TOTAL VOLUME OF REUSABLE MATERIALS: 5m³

x 20 (demolitions)
= 100m³ of reusable materials

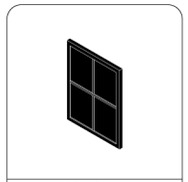
With little to no partition walls beyond the parameter structure, this typology has the lowest overall salvage percentage, while foundation accounts for over 70% of the total building mass.

The number of single detached garage demolitions is similar to that of single detached dwelling, many coming down together under one property.



Dimensional Lumber

Measurement *#, m², m³*	
Density *417kg/m³*	
Int. / Courtyard / Wall	
dims. typ.	



Windows

Measurement *#, m², m³*	
Density 3600*~*kg/m³*	
Int. / Courtyard / Wall	
*5000kg/m³ for aluminum frame	

Doors

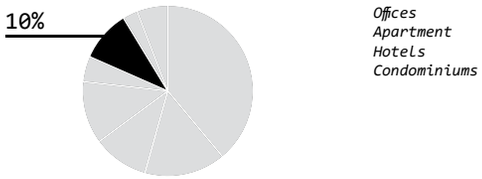
Measurement *#*	
Density *15.54kg/unit*	
Int. / Courtyard / Wall	
dims. varies	

Furniture

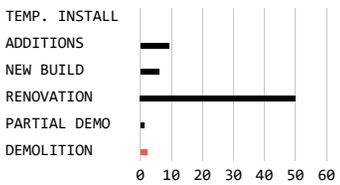
Measurement *#*	
Density *N/A*	
Int. / Courtyard / Wall	
dims. varies	

Mid-rise (<= 6 stories)

Permits Issued by Building Type (%)



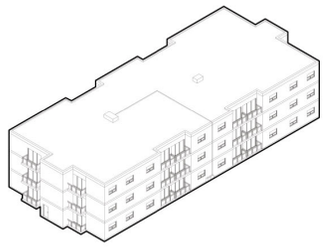
Categorization of Activities Listed



Case Study Building:
234 Oakdale Avenue, St. Catharines
Building footprint: 900m²
Storeys: 3

CONSIDERATIONS:

- Platform construction
- Wood as main structural material
- Brick veneer (not structural)
- Exterior finish is brick veneer
- Wood studs installed at 16” O.C. with 2x4” and 2x10” dimensional lumber
- no basement



Percentage of Salvageable Materials

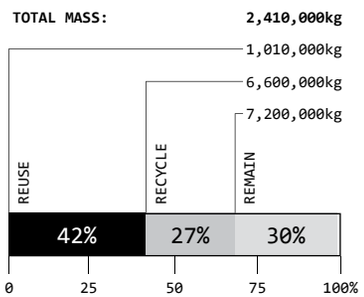
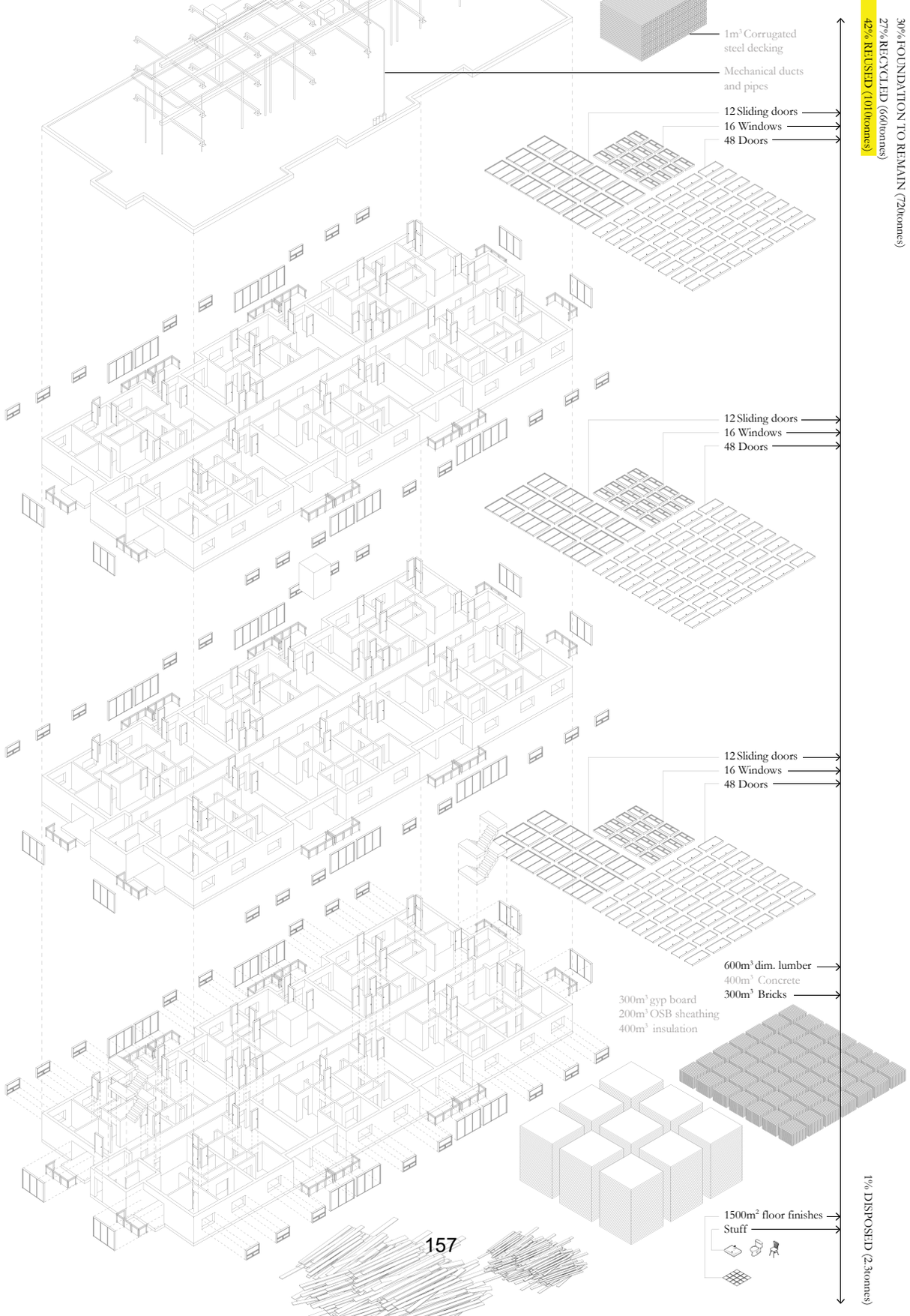


Fig. 3.48

Typical mid-rise building.



Reclaimed Material Inventory: Mid-rise (<=6 stories)

TOTAL MASS OF BUILDING MATERIALS: 2,410,000kg
TOTAL MASS OF REUSABLE MATERIALS: 1,010,000kg x 2 (demolitions)
= 2,020 tonnes of reusable materials

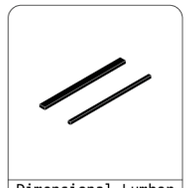
TOTAL VOLUME OF BUILDING MATERIALS: 3,000m³
TOTAL VOLUME OF REUSABLE MATERIALS: 1,500m³ x 2 (demolitions)
= 3,000m³ of reusable materials

The case study building chosen for the mid-rise typology shows the highest salvageable percentage at nearly 70%, with 42% of it having direct reuse potential.

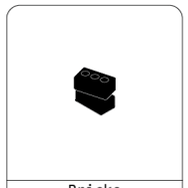
Key drivers for this includes its high level of occupancy and "mid-rise" building height. In such buildings with high occupancy, multiple units are present on every floor, each containing typical housing components such as windows, doors, fixtures, and furniture. The subdivision of floor spaces to accommodate multiple units necessitates numerous partitions, thereby requiring a large quantity of dimensional lumber. Because the study building is an apartment with rentable units, the building naturally embodies a level of aesthetic desirability. To achieve this, higher quality materials such as bricks and stone cladding can be seen in many mid-rise housing typologies.

Additionally, the higher the building, installation (and dismantling) and maintenance of these surface material becomes more difficult and labour intensive due to its size and limited access to them.

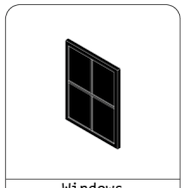
The height of mid-rises also encourages wood construction as it can be achieved with typical dimensional lumber.



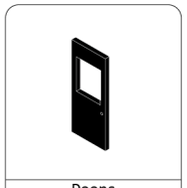
Dimensional Lumber
Measurement #, m², m³
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.



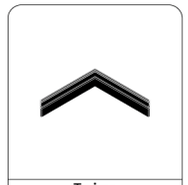
Bricks
Measurement #, m², m³
Density 2060kg/m³
Int. / Courtyard / Wall
dims. typ.



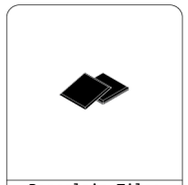
Windows
Measurement #, m², m³
Density 3600*~kg/m³
Int. / Courtyard / Wall
*5000kg/m³ for aluminum frame



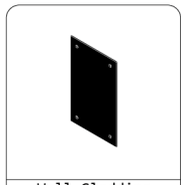
Doors
Measurement #
Density 15.54kg/unit
Int. / Courtyard / Wall
dims. varies



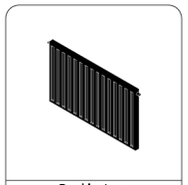
Trims
Measurement #, m²
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.



Porcelain Tiles
Measurement #, m²
Density 2690kg/m³
Int. / Courtyard / Wall
dims. typ.

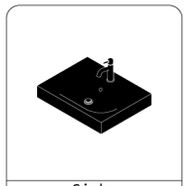


Wall Cladding
Measurement #, m²
Density N/A
Int. / Courtyard / Wall
dims. typ.



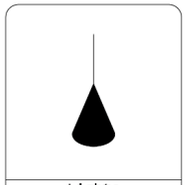
Radiator
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Toilet
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Sinks
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Marble
Measurement #, m², m³
Density 2700kg/m³
Int. / Courtyard / Wall
dims. typ.



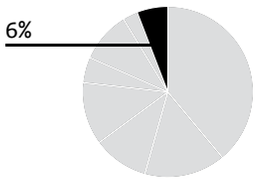
Lights
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Furniture
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. varies

Hardware
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

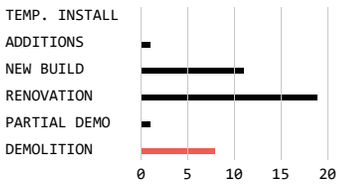
Industrial buildings

Permits Issued by Building Type (%)



Barn
Storage
Plants
Warehouses
Arena

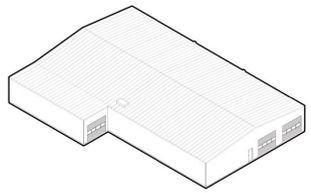
Categorization of Activities Listed



Case Study Building:
14 Keefer Road, St Catharines:
Building footprint: 800m²
Storeys: 1

CONSIDERATIONS:

- Steel and concrete as main structural material
- Exterior finish is steel siding
- Steel studs installed at 16” O.C.
- Vinyl window frame
- no basement



Percentage of Salvageable Materials

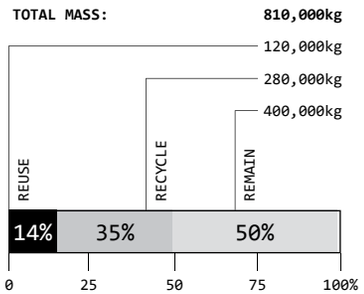
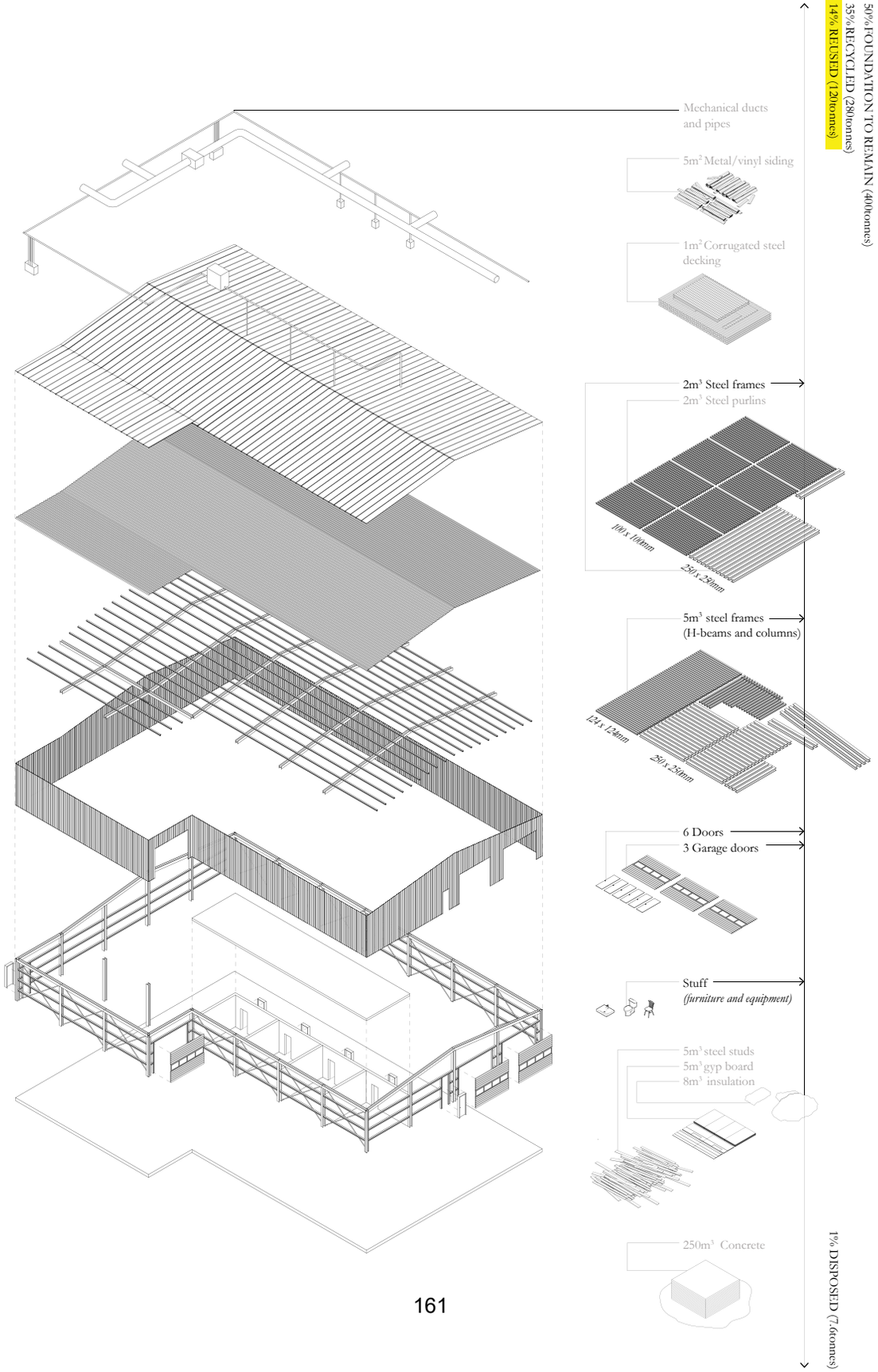


Fig. 3.49

Typical industrial building



Reclaimed Material Inventory: Industrial Buildings

TOTAL MASS OF BUILDING MATERIALS: 810,000kg
TOTAL MASS OF REUSABLE MATERIALS: 120,000kg

x 6 (demolitions)
= 720 tonnes of reusable materials

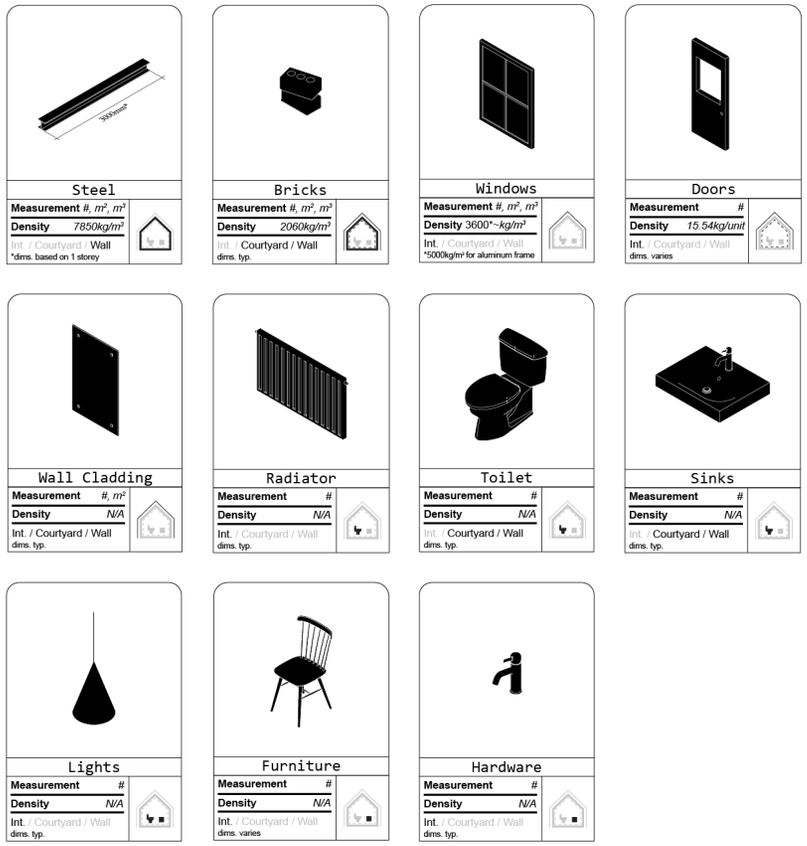
TOTAL VOLUME OF BUILDING MATERIALS: 350m³
TOTAL VOLUME OF REUSABLE MATERIALS: 20m³

x 6 (demolitions)
= 120m³ of reusable materials

Similar to the commercial building typology, contemporary industrial buildings have low salvage value due to its high usage of concrete - both for wall and foundation construction.

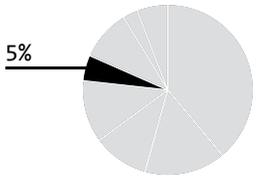
With the building construction's priority to have large spans, steel structural members are expected to be the most common material for salvage.

Possible contamination from the industrial activity can higher hinder the reuse of any materials deconstructed from these structures.



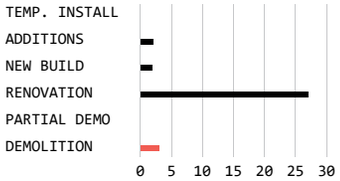
Institutional buildings

Permits Issued by Building Type (%)



Schools
Church
Fire Hall
Hospitals
Stations
Theaters
Clubs
Community Halls

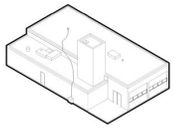
Categorization of Activities Listed



Case Study Building:
192 Linwell Road, St. Catharines
Building footprint: 300m²
Storeys: 1
(REGISTERED FOR DEMO)

CONSIDERATIONS:

- Steel and concrete as main structural materials
- Exterior finish is brick veneer
- Steel studs installed at 16” O.C.
- Vinyl window frame
- no basement



Percentage of Salvageable Materials

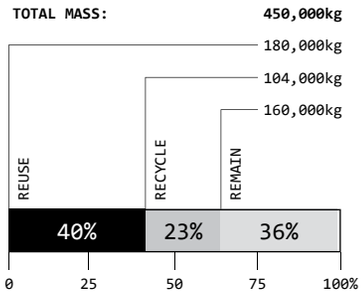
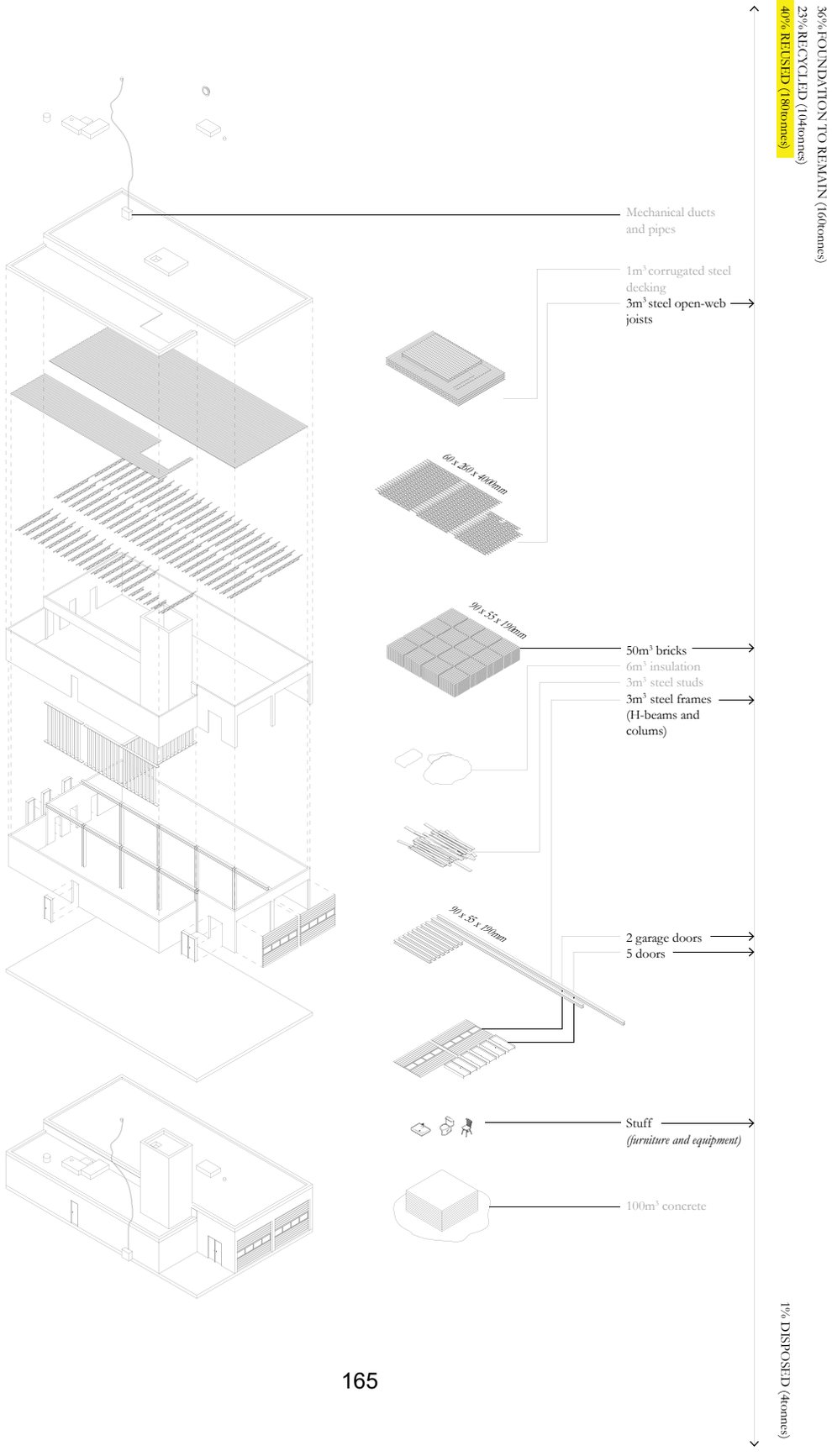


Fig. 3.50

Typical institutional building



Reclaimed Material Inventory: Institutional Buildings

TOTAL MASS OF BUILDING MATERIALS: 450,000kg
TOTAL MASS OF REUSABLE MATERIALS: 180,000kg

x 3 (demolitions)
= 540 tonnes of reusable materials

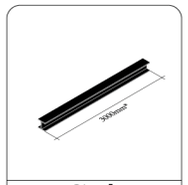
TOTAL VOLUME OF BUILDING MATERIALS: 200m³
TOTAL VOLUME OF REUSABLE MATERIALS: 100m³

x 3 (demolitions)
= 300m³ of reusable materials

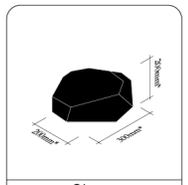
Institutional buildings are considered the highest in status amongst the typologies, reflective of their architectural attributes.

As they are expected to last up to a century, compared to commercial or residential buildings that are redeveloped within 20-40 years, the construction materials themselves reflect the program's need for longevity. Durable and long-lasting materials such as stone and brick that have lasted the test of time are found the most on these buildings (ex: we see more banks, schools, churches made of these materials than houses partly since residential buildings are more prone for replacement, and structures originally constructed are most likely now demolished). Also a projection of stability, prestige and permanence, architectural integrity in style and performance is prioritized over ROI (return on investment. Public funding (whether driven by religious beliefs, cultural doctrine, or government-based ownership) also allows for higher upfront cost for construction.

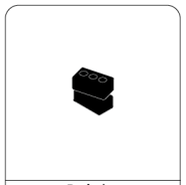
Pre-war industrial and infrastructural buildings also share many similarities, however, are no-longer prominent within the St. Catharines urban fabric.



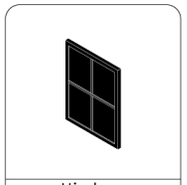
Steel
Measurement #, m², m³
Density 7850kg/m³
Int. / Courtyard / Wall
*dims. based on 1 storey



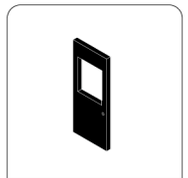
Stone
Measurement #, m², m³
Density 2700kg/m³
Int. / Courtyard / Wall
*dims. typ.



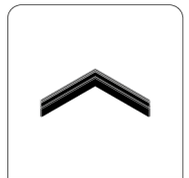
Bricks
Measurement #, m², m³
Density 2060kg/m³
Int. / Courtyard / Wall
dims. typ.



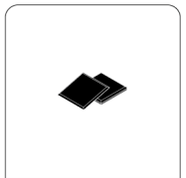
Windows
Measurement #, m², m³
Density 3600*~kg/m³
Int. / Courtyard / Wall
*5000kg/m² for aluminum frame



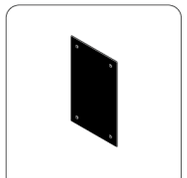
Doors
Measurement #
Density 15.54kg/unit
Int. / Courtyard / Wall
dims. varies



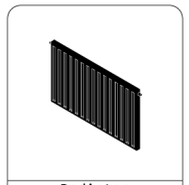
Trims
Measurement #, m²
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.



Porcelain Tiles
Measurement #, m²
Density 2690kg/m³
Int. / Courtyard / Wall
dims. typ.

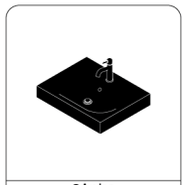


Wall Cladding
Measurement #, m²
Density N/A
Int. / Courtyard / Wall
dims. typ.

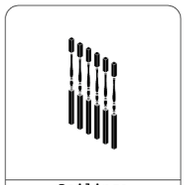


Radiator
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Toilet
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Sinks
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Railings
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Marble
Measurement #, m², m³
Density 2700kg/m³
Int. / Courtyard / Wall
dims. typ.

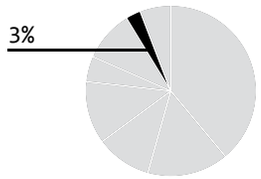
Lights
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Furniture
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. varies

Hardware
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

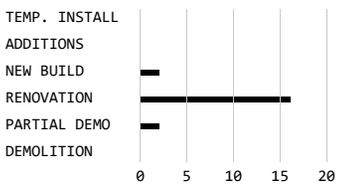
High-rise (> 6 stories)

Permits Issued by Building Type (%)



Offices
Apartments
Hotels
Condominiums

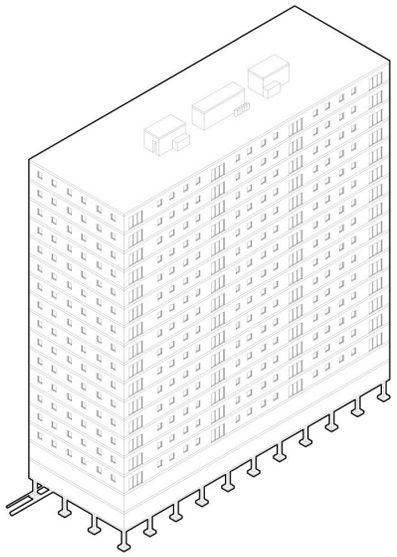
Categorization of Activities Listed



Case Study Building:
57 Carlisle Street, St. Catharines
Building footprint: 1100m²
Storeys: 15

CONSIDERATIONS:

- Steel and concrete as main structural material
- Exterior finish is steel panels
- Steel studs installed at 16” O.C.
- Aluminum window frame
- 2 underground levels



Percentage of Salvageable Materials

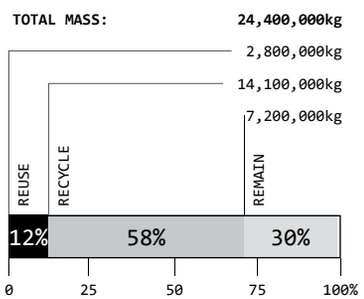
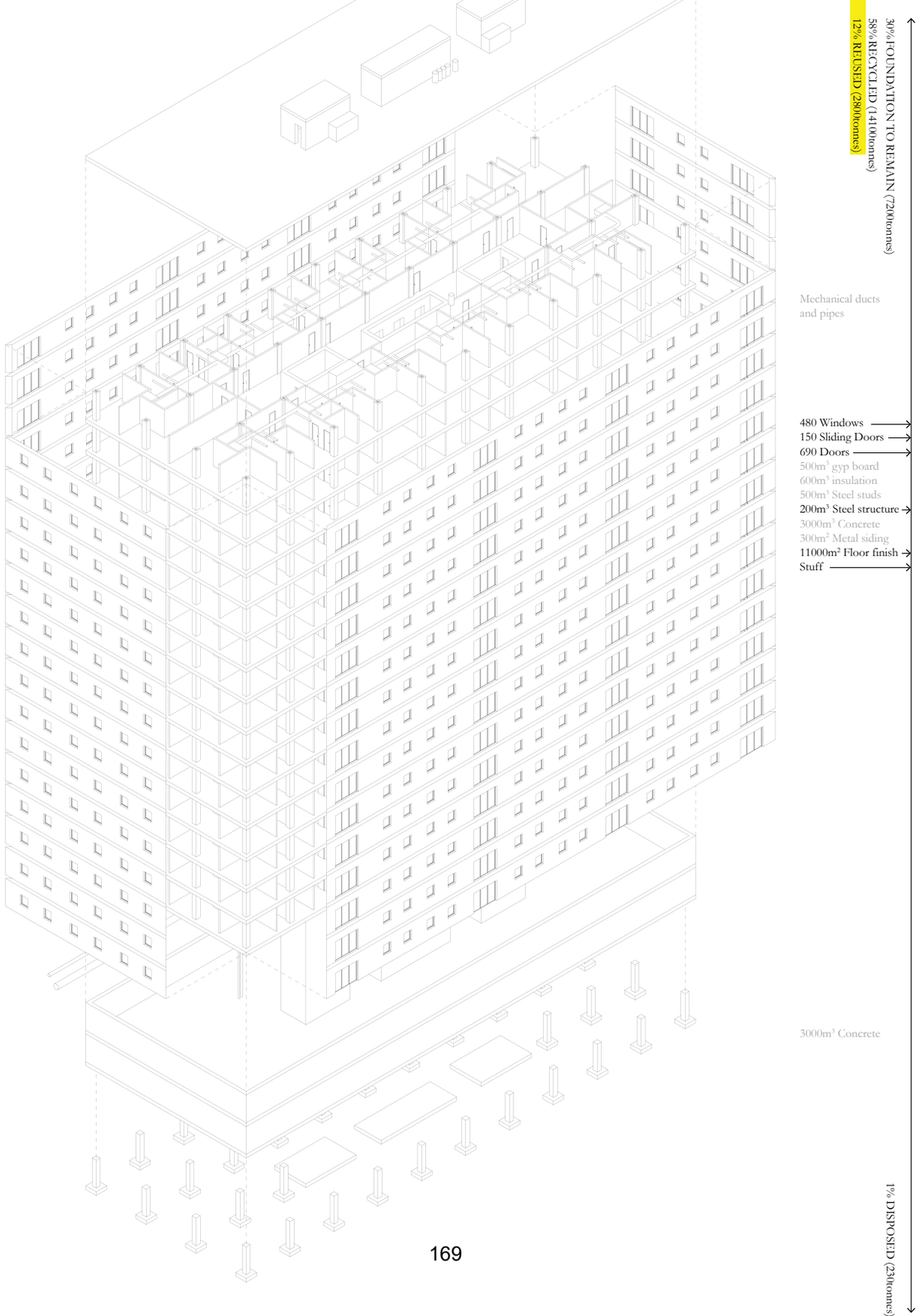


Fig. 3.51

Typical high-rise building



Reclaimed Material Inventory: High-rise (> 6 stories)

TOTAL MASS OF BUILDING MATERIALS: 24,000,000kg
TOTAL MASS OF REUSABLE MATERIALS: 2,800,000kg x 0 (demolitions) = 0 tonnes of reusable materials

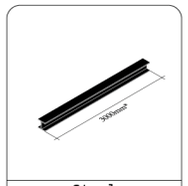
TOTAL VOLUME OF BUILDING MATERIALS: 10,800m³
TOTAL VOLUME OF REUSABLE MATERIALS: 1,200m³ x 0 (demolitions) = 0m³ of reusable materials

St. Catharines has a small number of high-rise buildings. The "Carlisle Square" is the single highest condo that is planned to finish construction in 2025.

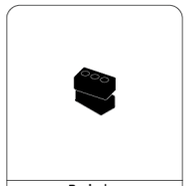
At 3% contribution in the city's 2023-2024 building permit, high-rises see the slowest rate of change in the city. There are a couple new projects registered to be constructed, while the remainder is for renovation of the existing.

For the tallest building typology, its structure has the greatest mass, mainly made of concrete and steel. The height and scale of this typology highly restrict structural deconstruction potential.

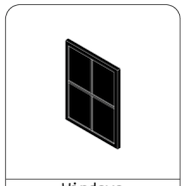
Similar to the mid-rise case study building, the high concentration of occupants reflect a high number of typical residential-building components including fixtures, furnitures, doors and windows. While case study building shows low-salvage value materials (stucco and steel cladding) higher-quality materials such as masonry panels which is also easier to dismantle, will higher determine the building's overall mining potential.



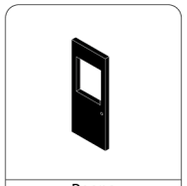
Steel
Measurement #, m², m³
Density 7850kg/m³
Int. / Courtyard / Wall
*dims. based on 1 storey



Bricks
Measurement #, m², m³
Density 2060kg/m³
Int. / Courtyard / Wall
dims. typ.



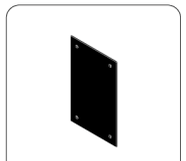
Windows
Measurement #, m², m³
Density 3600*~kg/m³
Int. / Courtyard / Wall
*5000kg/m² for aluminum frame



Doors
Measurement #
Density 15.54kg/unit
Int. / Courtyard / Wall
dims. varies

Trims
Measurement #, m²
Density 417kg/m³
Int. / Courtyard / Wall
dims. typ.

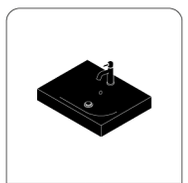
Porcelain Tiles
Measurement #, m²
Density 2690kg/m³
Int. / Courtyard / Wall
dims. typ.



Wall Cladding
Measurement #, m²
Density N/A
Int. / Courtyard / Wall
dims. typ.

Radiator
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Toilet
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.



Sinks
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Marble
Measurement #, m², m³
Density 2700kg/m³
Int. / Courtyard / Wall
dims. typ.

Lights
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

Furniture
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. varies

Hardware
Measurement #
Density N/A
Int. / Courtyard / Wall
dims. typ.

In a span of just one year, 67 structures were issued to be demolished in St. Catharines. This approximates to 12,500m^3 of building stock, equivalent of a 40 storey 1m^2 tower - which 75% of this is estimated to hold residual value.[25] [Fig. 3.47]

26 'An Overview of Construction and Demolition Waste Management in Canada: A Lifecycle Analysis Approach to Sustainability | Clean Technologies and Environmental Policy'.

Through full deconstruction, 4000m^3 - 15 storeys high - of this volume of materials can be reclaimed for direct reuse. This quantity only grows when considering the accumulation of matter over time. Whether this tower of material resources is lost through demolition or restored through deconstruction is ultimately dependent on how the existing building stock are treated moving forward.

From the perspective of reusing from the existing, all resources have already been produced. All that is needed for minimal waste and resource efficiency is facilitating its continual circulation.

Fig. 3.52

Overview of the total material volume with residual value in St. Catharines placed on the thesis site.

Fig. 4.1

View of the proposed Material Works building from the field.

04 DESIGN

4.1 Design Strategies

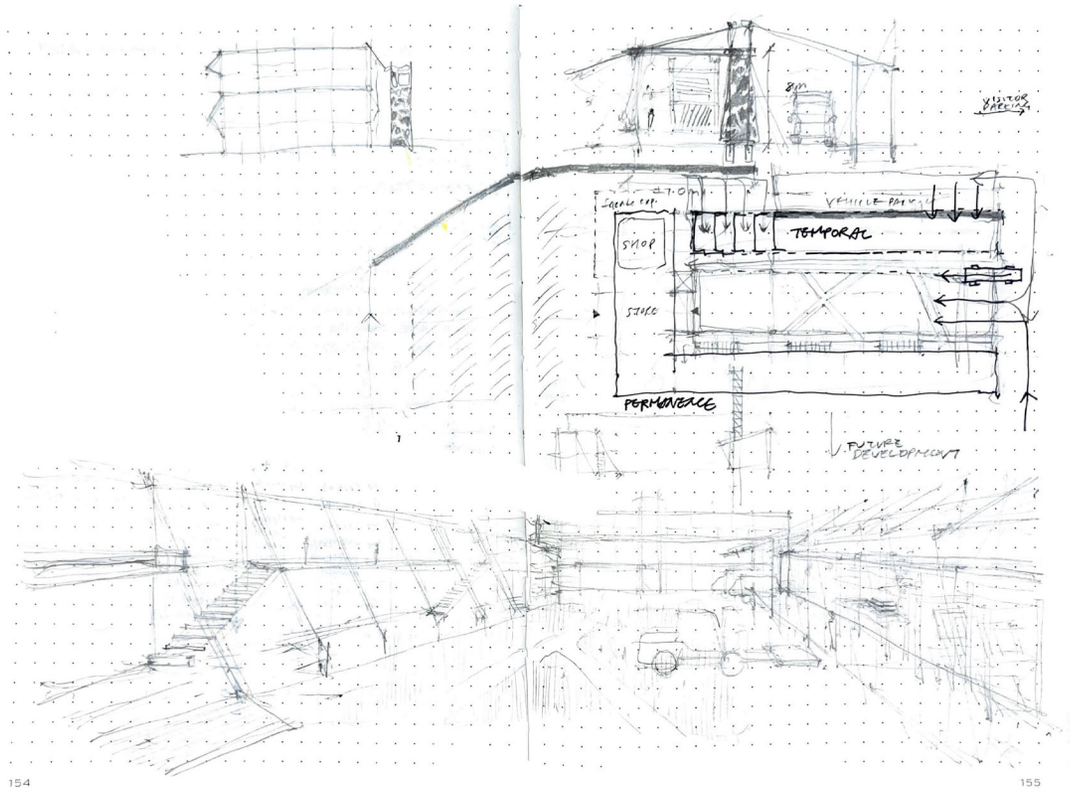
As of the current year, 2025, the linearity of the building industry remains prominent, inherently transforming the materials embed within the North American urban fabric into rubble, while only a hnadful are preserved under the pressure of densification. However, we are seeing continual efforts to restructuring this linearity, to a circular building economy, where the existing material assets are rather dismantled, as opposed to demolished, to prolong its usage. Acknowledging the impermanence of architecture, buildings can be re-imagined as temporal repository of materials, beyond the overall built form. Whether the physical volume encompassing valuable material blocks is broken down to useless debris or reintroduced to the existing urban metabolism of resources is ultimately dependent on the treatment of these physical assets at the end of their lifetime through choosing deconstruction over demolition.

Amongst the social, technical, and political barriers existing in the industry's pursuit of a circular future, the research posits the absence of such architecture in modern cities as a main thesis question that needs to be addressed in streamlining the process of in/outflows of building materials. The remains of the existing factory structure speak to the rationally-formed functionalism, exemplary of typical post-war industrial buildings, once an economic beacon of the city. All proposed new additions are built on the existing grid, utilizing the orderly form in the new context of a circular hub. This initiative aims to revitalize the site, fostering sustainable practices and community engagement in St. Catharines through material agency.

The proposal for the conversion of the former GM Plant 1 into a circularity hub is seen as an opportunity to develop the Material Works as a site to demonstrate circular practices within the building industry in the context of St. Catharines. The hub includes educational programs, a warehouse for processing deconstructed building materials, and a box store designed to commercialize the selling of second-hand materials. Additionally, a circularity lab and an architectural office is situated over the box store.

Fig. 4.2

Conceptual sketches
(A).



4.1.1 Design Principles

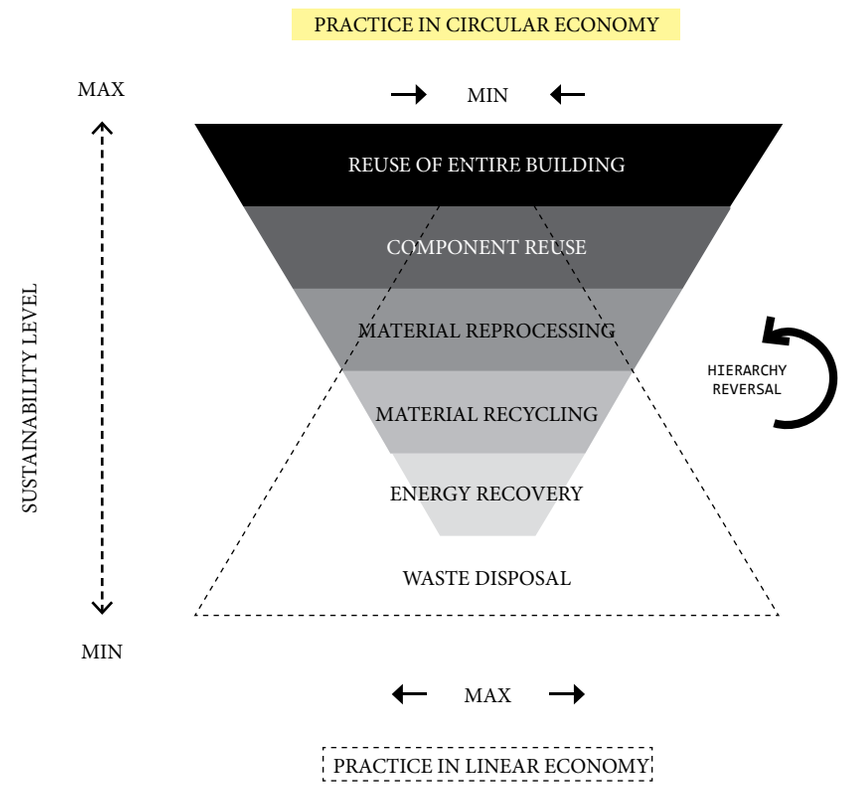
The design of the Material Works begins with reflecting on architect's role in circular design. While policy, regulation, and social perception must evolve, architects hold a central position in this transition, as we possess the expertise to reintegrate salvaged materials into new construction through design.

The following list summarizes key design principles architects can adopt to support circular building practices:

- *Buildings should not be received as static structures, but as dynamic and open ones that can easily adapt to changing requirement*
- *The transformation capacity of buildings and systems needs to be extended by considering the whole life cycle of the building and building systems*
- *Treat building materials as long-term valuable assets through their whole life cycle using reconfiguration, reuse, and re-manufacturing options at the building, systems, and material levels*
- *Consider waste and demolition as a design error*
- *Decouple the fixed function-material relationship in buildings via the design of reconfigurable systems*
- *Involve the construction industry in the whole life cycle of the building and building systems*

Fig. 4.3

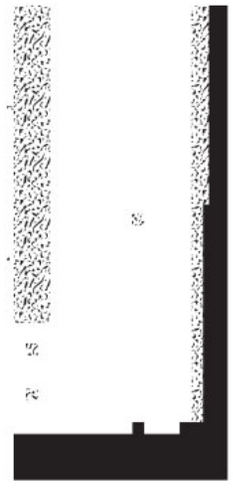
Building waste hierarchy.



4.1.2 Adaptive Reuse

Ultimately, circular design aims to inverse the building waste hierarchy. Following these principles, the entire remainder of the structure on site was kept for adaptive reuse, or renewal, with minimal new additions to improve spatial functionality, and many components of the new construction have been designed with salvaged materials. Inspired by the linearity of the brick structure running parallel to its sole public interface, Ontario Street, the longitudinal section is designated as the "Education Corridor," serving as a space for various learning activities. The three-storey latitudinal concrete volume, oriented perpendicular to the street, accommodates "application" programs in the following order: a box store on the ground, a circularity lab on the second floor, and an architecture office on the third floor.

The "warehouse" is the only fully new-built structure, positioned separately to the west. The overall form and scale mirrors the edu corridor across the yard, built on the same structure grid of the existing. These 3 volumes are connected by gates along the north and west perimeters of the site, enclosing the remainder of the open field to form a courtyard.



OLD VS. NEW

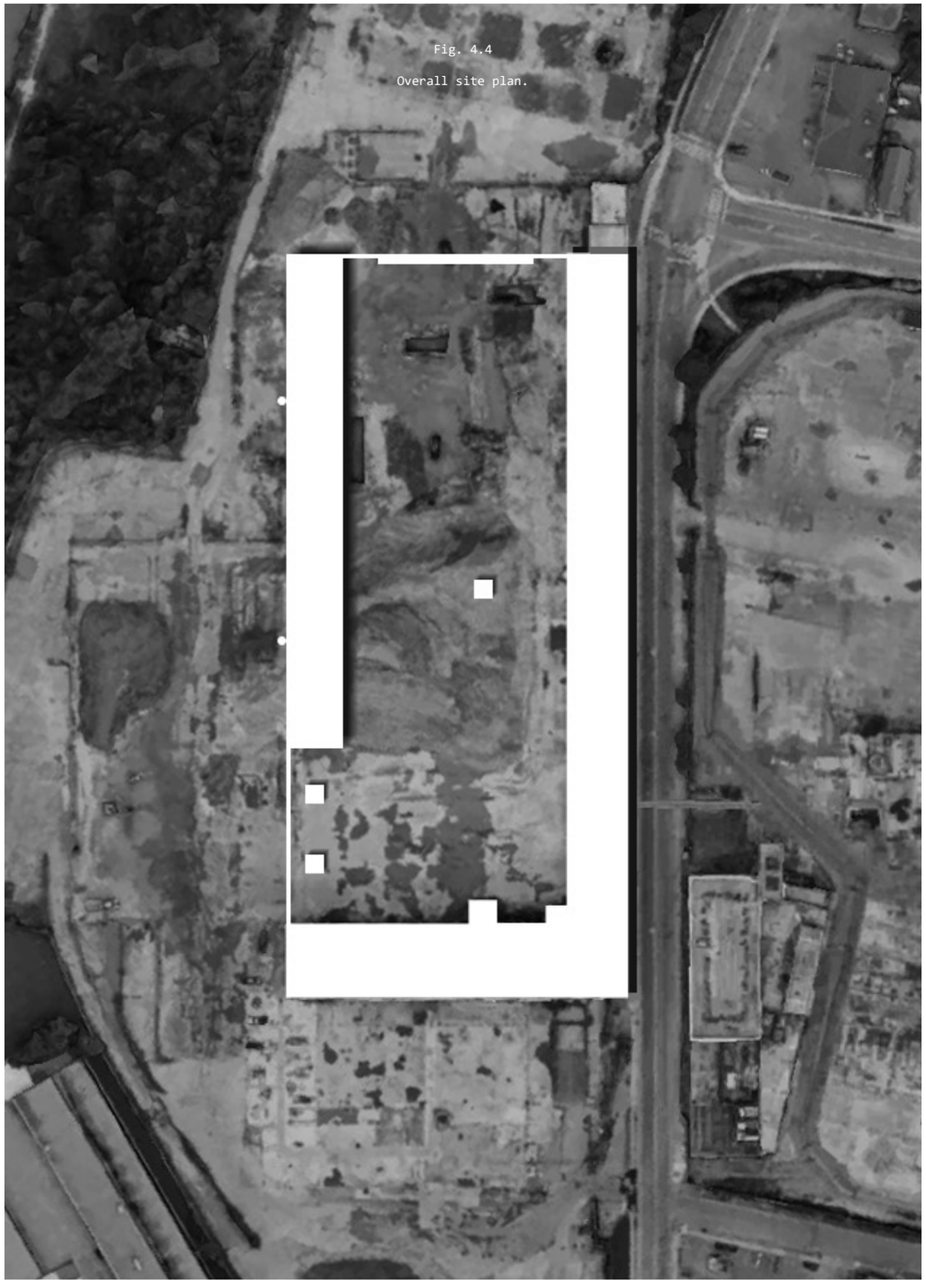


Fig. 4.4

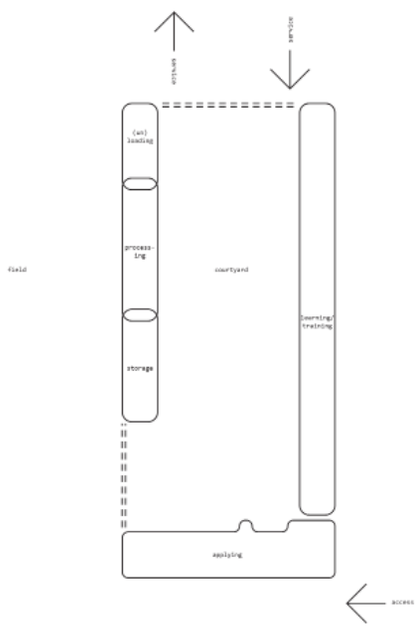
Overall site plan.

4.1.3 Programming

Agencies in the realm of education, contractor work, commerce and design were identified and imagined to co-exist in one physical site where the optimization of material circularity bridges these programs as their collective central motif.

The project envisages itself as the main facilitating infrastructure within the existing network of material flow of the city, influencing the city's economic and social development around material reuse.

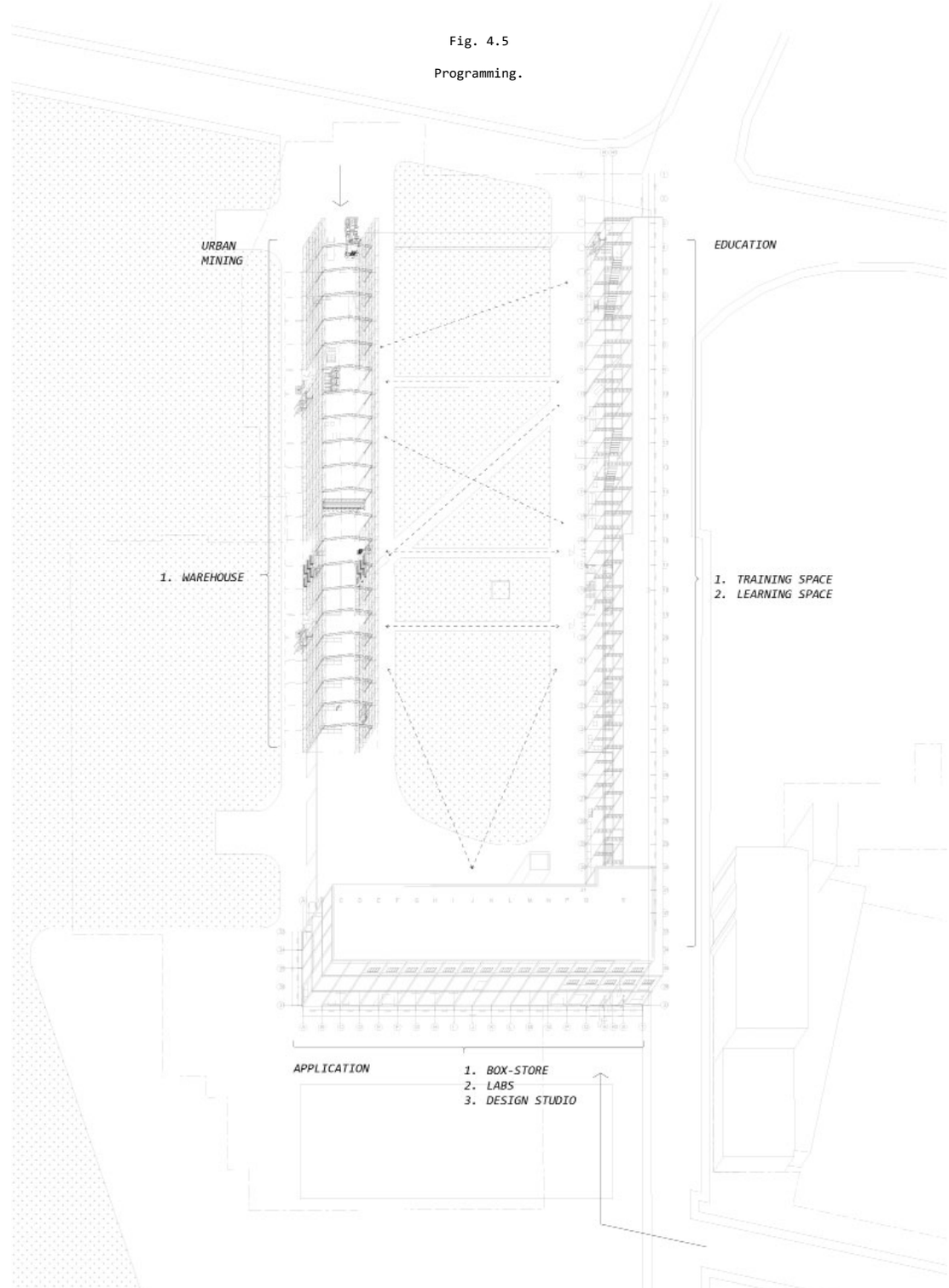
Every aspect of the design: including the treatment of the existing (adaptive reuse), programming (assigning key agencies in circularity work), material choice (implementation of salvaged materials), and courtyard configuration, embody material circularity, envisaged to cultivate through collaborative initiative. Through this speculation of the future where deconstruction and reuse replaces demolition, secondary materials are given a new narrative in which aesthetics is not compromised, rather, experimented with to reinstate the value of salvaged materials.



PROGRAM

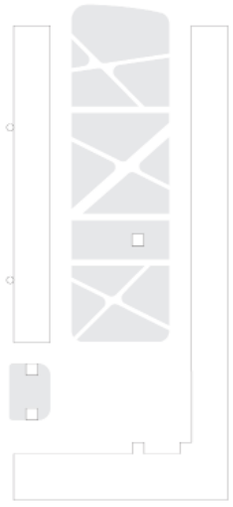
Fig. 4.5

Programming.



4.1.4 Materials Movement

The entirety of the architecture was designed to facilitate material movement. The processing procedure of items is dependent on their as-found states. In most cases, a degree of cleaning, cutting and processing is required, therefore, will be first dropped off at the warehouse north entrance, before being transferred to the material-processing zone. For a a bundle of materials where a large sorting job is needed prior to processing, the "field" to the west of the warehouse is used. Commercialization of these materials begins from how they are stored. The facade of the warehouse was designed specifically to store items along the entire exterior elevation of the building, making the stored materials an integral part of the architecture itself. On the opposite side, a demonstration wall—using a similar facade system—is dedicated to architects and researchers for testing new architectural systems with salvaged materials. Once materials are ready for sale or exhibition, they are transported to the main box store/showroom. Salvaged materials are also integrated into the facility proposal: the edu corridor's new additions feature reclaimed wood frames, the south building's missing surfaces are patched with reclaimed bricks, and the gates are made of gabion walls filled with leftover aggregate.



LANDSCAPE

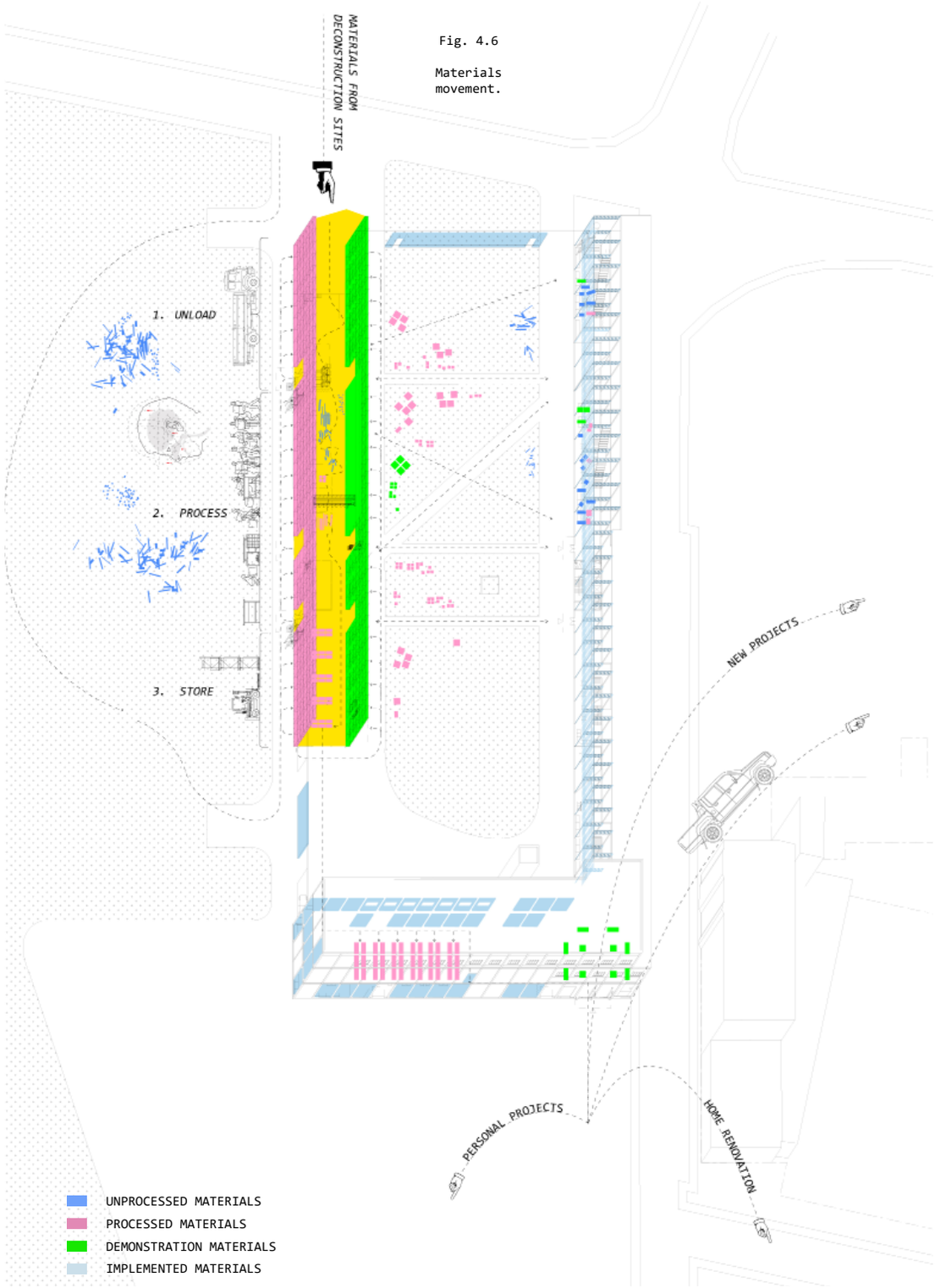


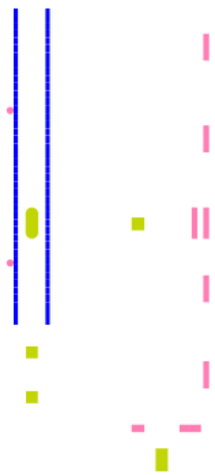
Fig. 4.6

Materials movement.

4.1.5 Idea Exchange

With every material movement, there is an exchange in matter, ideas, information and knowledge. Thus, circulation becomes a key design motif, materialized in architectural features, facilitating the movement of people, equipment and materials. Some appear in the built forms of typical staircases, lifts, and corridors, others exist as a means of transportation equipment such as traveling cranes, forklifts and vehicles, while the soft-landscaping of the outdoors reveal the convergence of the complex, active network of movements the hub facilitates. Recognizing the importance of both theoretical learning and hands-on experience, the workshop spaces on the ground floor and the classrooms upstairs are vertically connected by staircases that runs along the Education Corridor longitudinally.

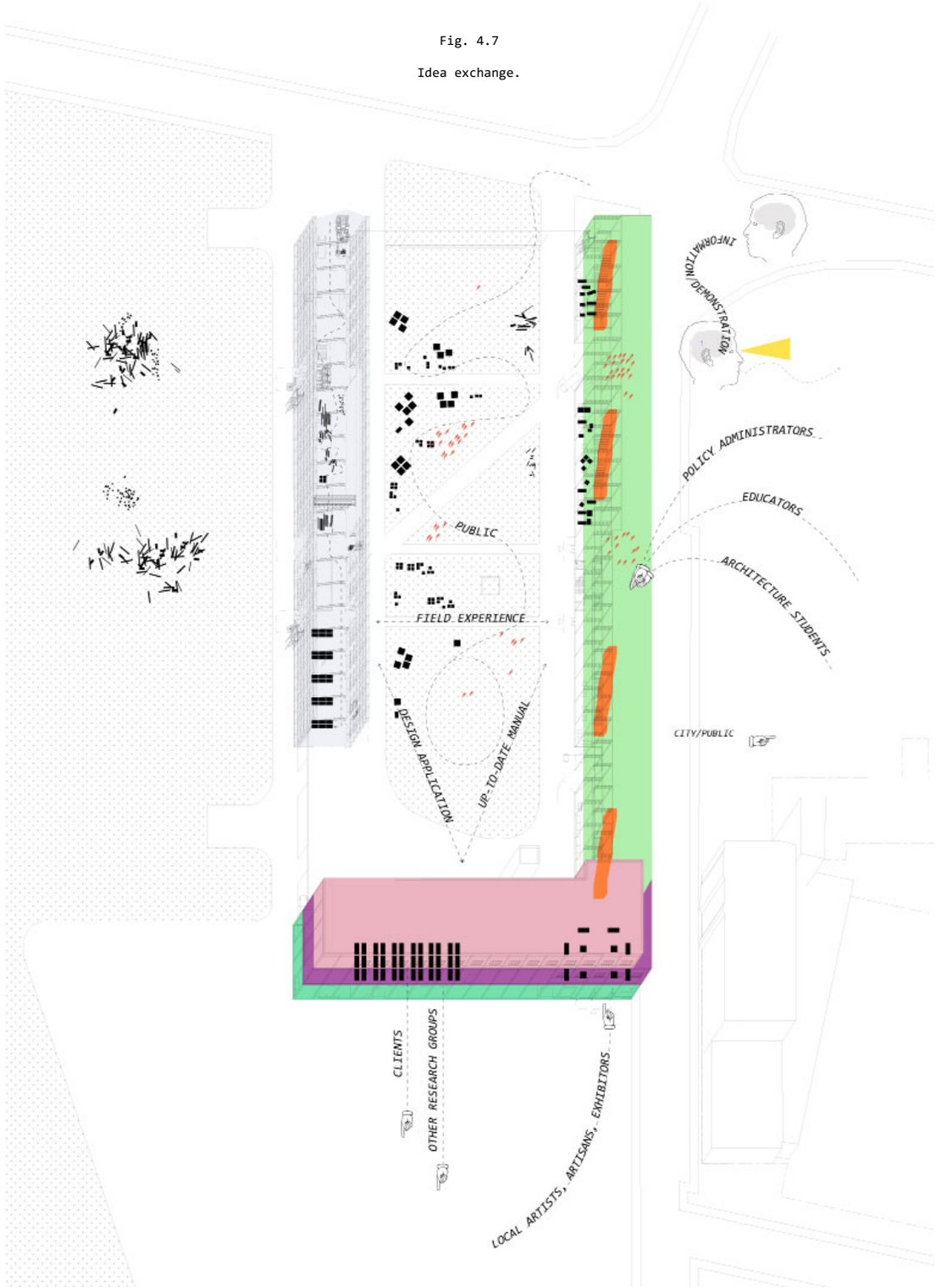
Both the programming and spatial configuration facilitate the coexistence of agencies that typically have limited direct communication, fostering collaboration within a shared physical space to advance a circular building economy.



SERVICES

Fig. 4.7

Idea exchange.



4.2 Proposal: Hub to Facilitate Circular Economy

PROJECT INFORMATION

ORIGINAL INSTITUTION:
GENERAL MOTORS OF CANADA, PLANT 1, ST. CATHARINES
ORIGINAL ALTERNATE NAMES:
GENERAL MOTORS OF CANADA, PLANT 1, ST. CATHARINES
GENERAL MOTORS 1 MCKINNON INDUSTRIES

NEW INSTITUTION:
MATERIAL WORKS

ADDRESS: 285 ONTARIO STREET, ST. CATHARINES, ONTARIO, L2R 5L5

Fig. 4.8

View of the
warehouse.

0 10 20 50 100m

Chapter 04:
Design

Fig. 4.9

CONTEXT VIEW

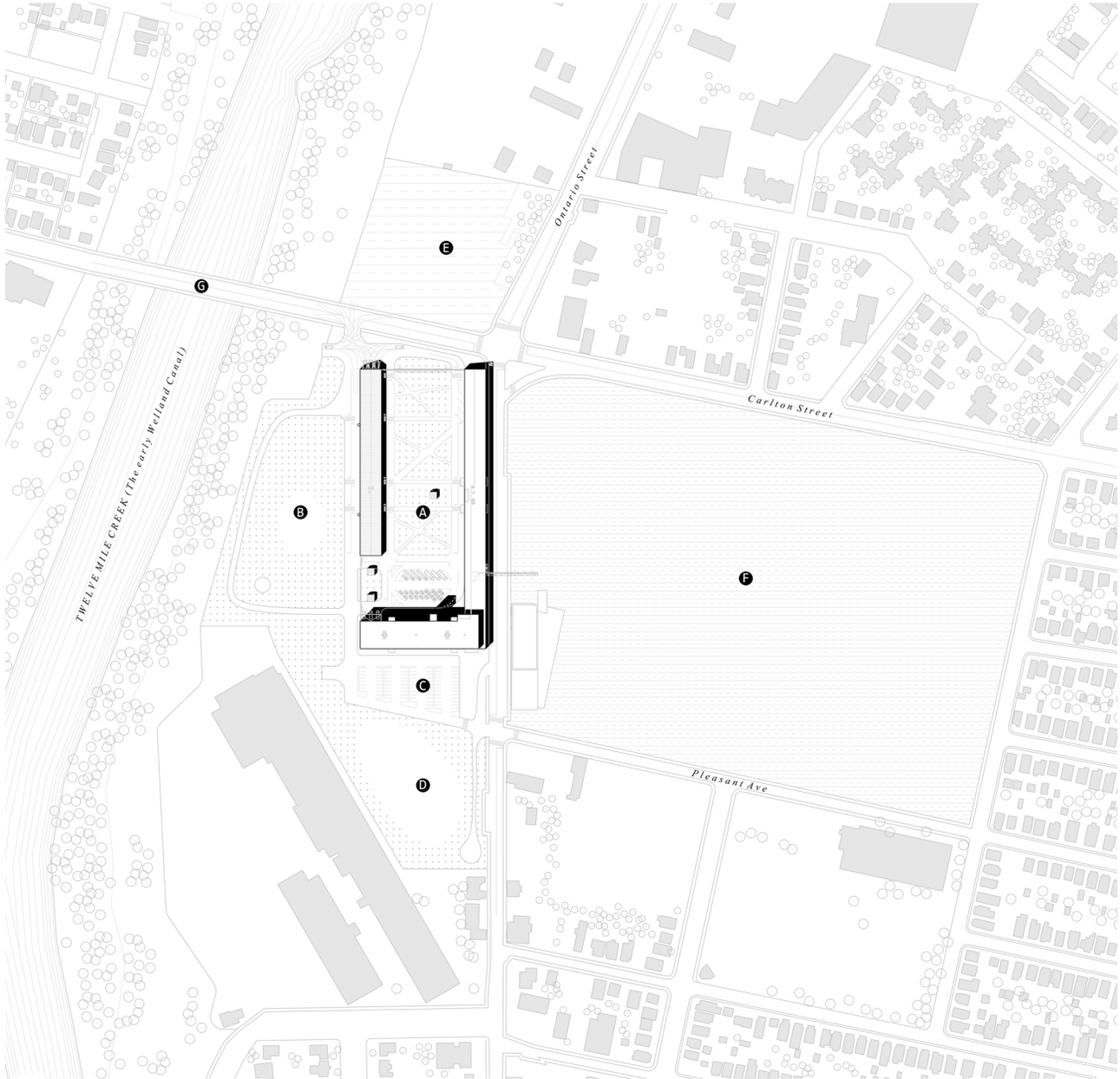


Fig. 4.10

CONTEXT PLAN
1:5000

A. Courtyard
B. Field
C. Customer parking
D. Public park
E. Remaining vacant land_NORTH
F. Remaining vacant land_EAST
G. Proposed extension of Carlton Street and bridge

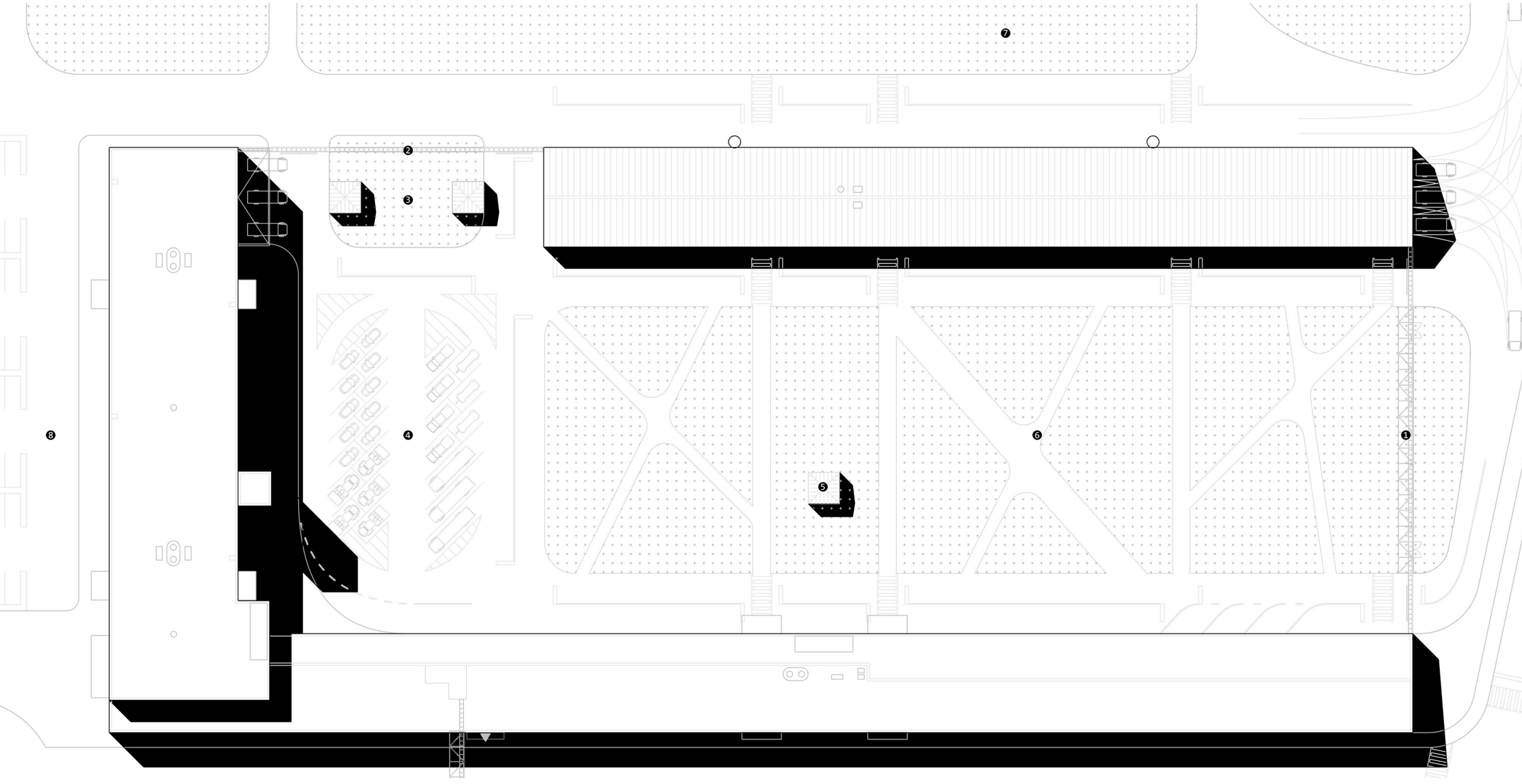


Fig. 4.11

SITE PLAN
1: 750

1. Gate_01
2. Gate_02
3. Gate keeper
4. Large vehicle parking
5. Tool storage
6. "Courtyard"
7. "Field"
8. Customer parking lot

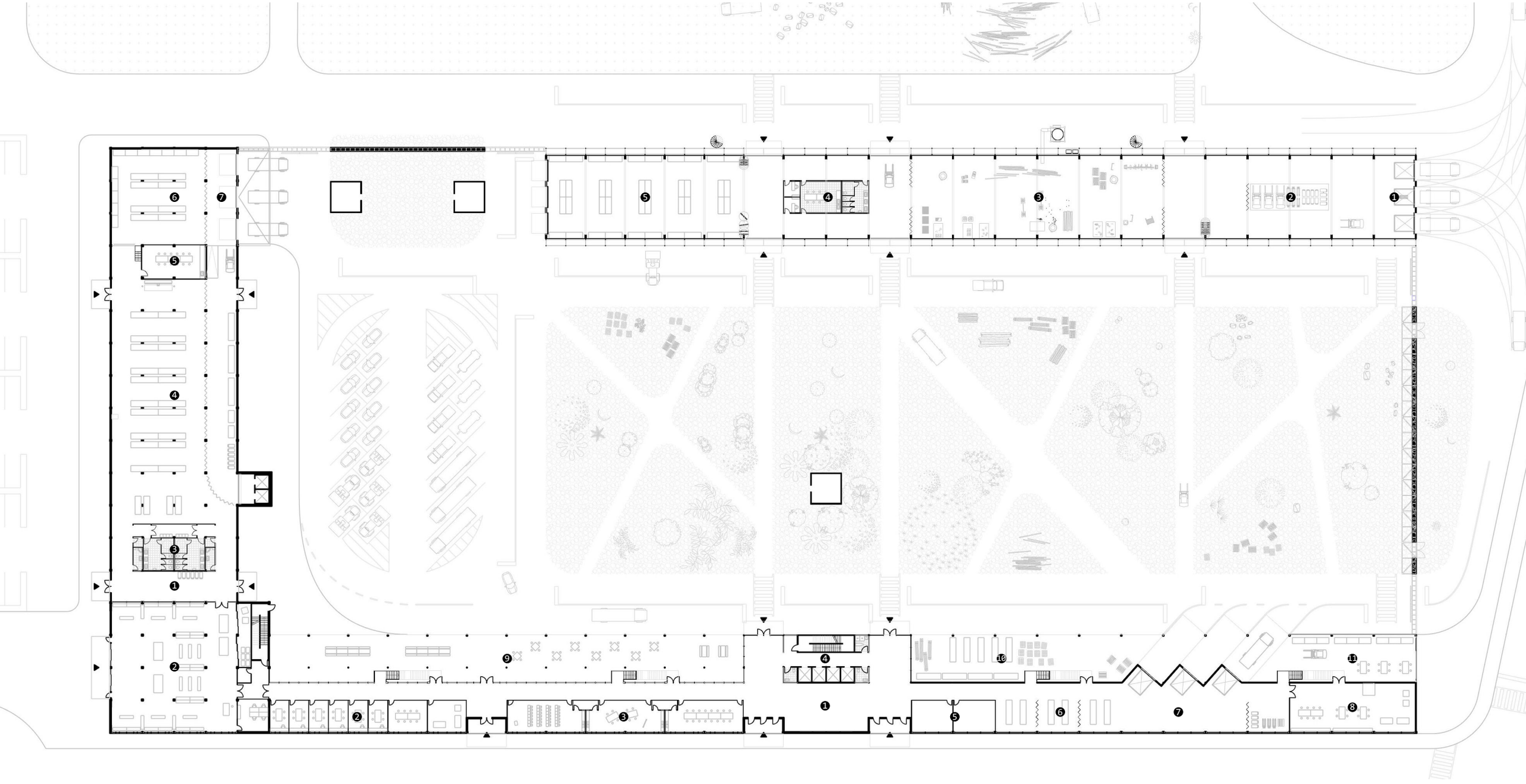


Fig. 4.12

GROUND FLOOR PLAN
1: 750

EDU CORRIDOR
1. Lobby
2. Admin
3. Meeting rooms
4. Services core
5. Locker rooms
6. Shelving
7. Loading/unloading
8. Woodshop
9. Outdoor seating area
10. Outdoor storage area
11. Outdoor work area

WAREHOUSE
1. Loading/unloading
2. Indoor equipment
3. Indoor work area
4. Services core
5. Covered storage area

APPLICATION_BOX STORE
1. Lobby
2. Showroom
3. Services core
4. Store
5. Break room
6. Storage
7. Loading/unloading

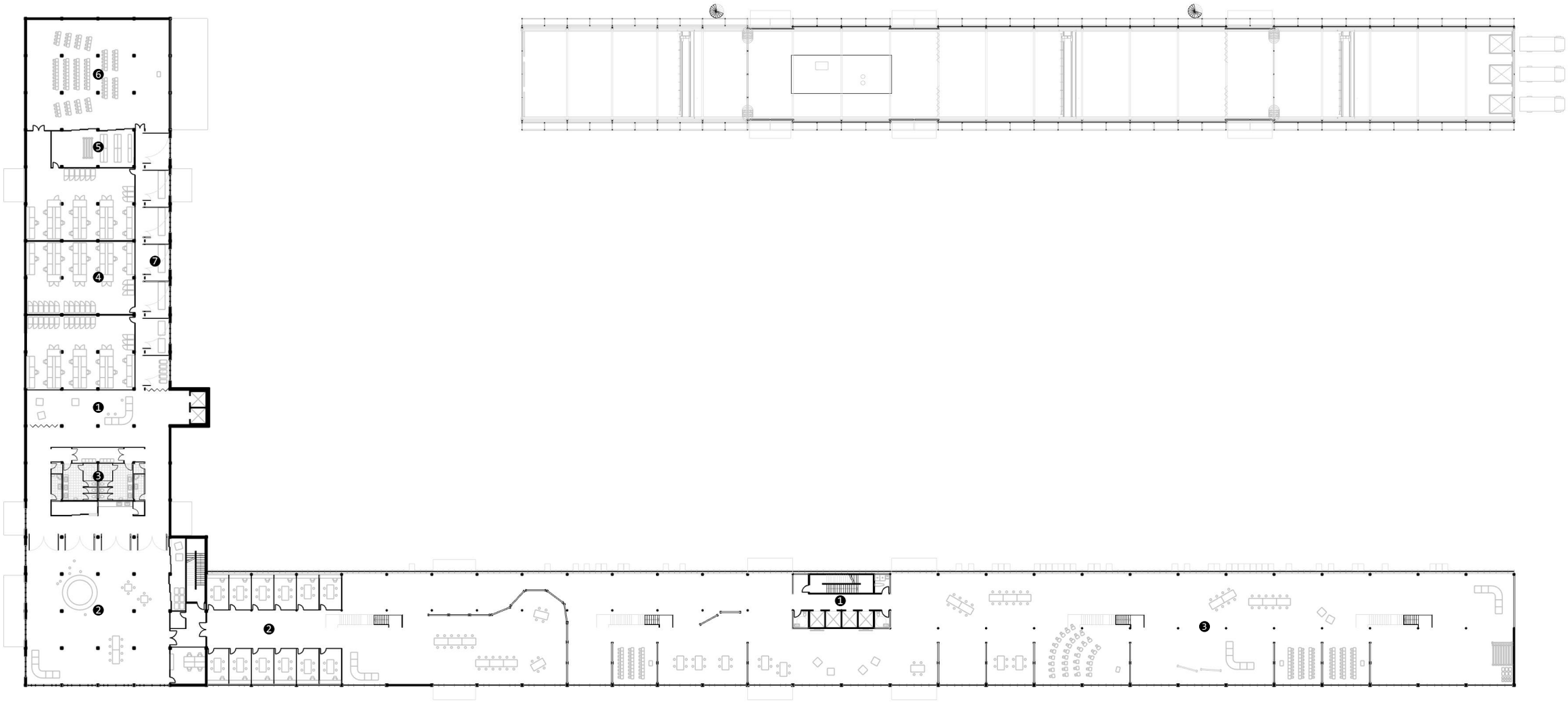


Fig. 4.13

SECOND FLOOR PLAN
1: 750

EDU CORRIDOR
1. Services core
2. Admin
3. Learning space

APPLICATION_RESEARCH LAB
1. Lobby
2. Lounge area
3. Services core
4. Labs
5. Storage
6. Conference room
7. Open work area

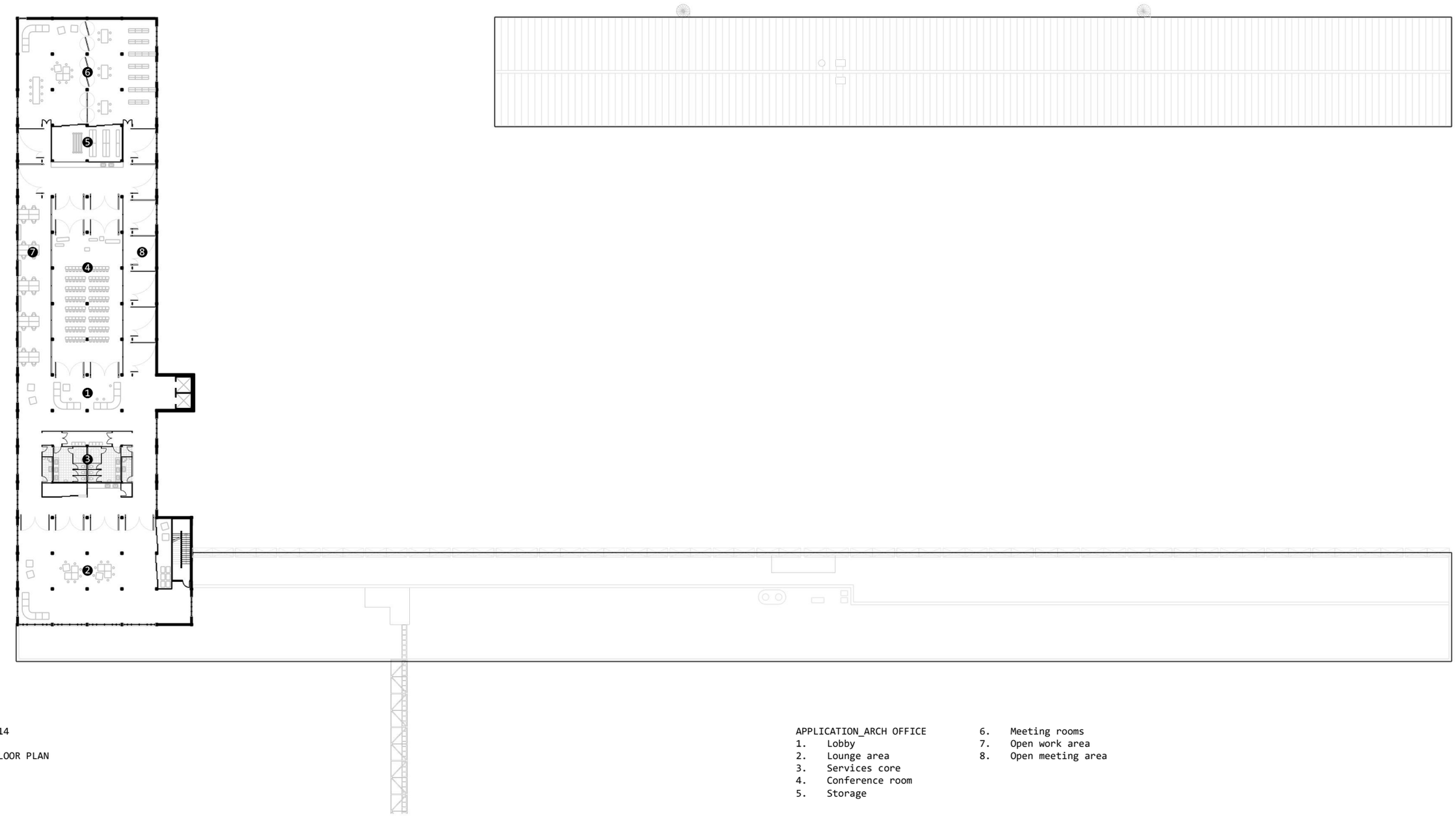


Fig. 4.14

THIRD FLOOR PLAN
1: 750

APPLICATION_ARCH OFFICE

1. Lobby
2. Lounge area
3. Services core
4. Conference room
5. Storage
6. Meeting rooms
7. Open work area
8. Open meeting area

4.3 More about the Machine

The definition of a machine within the discourse of architecture extends far beyond simple technical tools developed to perform a singular function. For postwar architects of the 1960s like Cedric Price, the future of the urban fabric could not be separated from the consideration of technological advancement.

The Material Works exemplify what Cedric Price coins as "anticipatory architecture", in which the design empowers users and societal changes as collaborators.[1] As the materiality of the urban fabric continues to change, the quality, type and scale of what could be extracted from "urban mining" remains contingent. Therefore, spatial flexibility and technical adaptability became a key design motif.

28 Cedric Price, *Cedric Price Works 1952-2003*: A Forward-Minded Retrospective, Vol. 2: Articles & Talks, ed. Samantha Hardingham (London: Architectural Association and Canadian Centre for Architecture, 2016), 460–67, 461.

The works of Reyner Banham is reflected in making technology part of a larger synthesis of architecture rather than a mere byproduct of building maintenance. According to his philosophy, technological performance should be prioritized over aesthetic permanence, challenging architecture's fixation on longevity. In contrast, industries like automobile manufacturing embrace built-in obsolescence to accommodate continual change—whether due to structural degradation, functional obsolescence, or shifts in style.[2]

29 Reyner Banham, Theory and Design in the First Machine Age (London: Architectural Press, 1960), 329.

The Pompidou Centre also served as a significant architectural precedent in its radical exposure of mechanical systems and structural functionality on the exterior of the building. By externalizing elements traditionally concealed within the architectural envelope (ducts, piping, circulation, and structural supports), the design not only celebrated industrial aesthetics but also redefined the visual language of high-tech architecture. This deliberate move challenged conventional notions of architectural composition, shifting the focus from formal expression to performance and infrastructure. In doing so, the project blurred the disciplinary boundaries between architecture and engineering, highlighting a collaborative design process wherein technical systems were no longer subordinate to form, but rather integral to the building's identity and expression.

Architecture's ephemerality inspired the overall thesis project, leading to the development of a visual narrative for the warehouse facade system; intentionally left incomplete and adaptable to the ongoing transformation of the urban fabric. Given the unprecedented nature of anticipatory architecture, the arbitrary presentation of the overall-built form speaks to the planned obsolescence inherent in the 21st century, and the project becomes an iteration of experiential architecture , shaped by material movement and informed by technical support.

Fig. 4.15

Conceptual sketches (B).

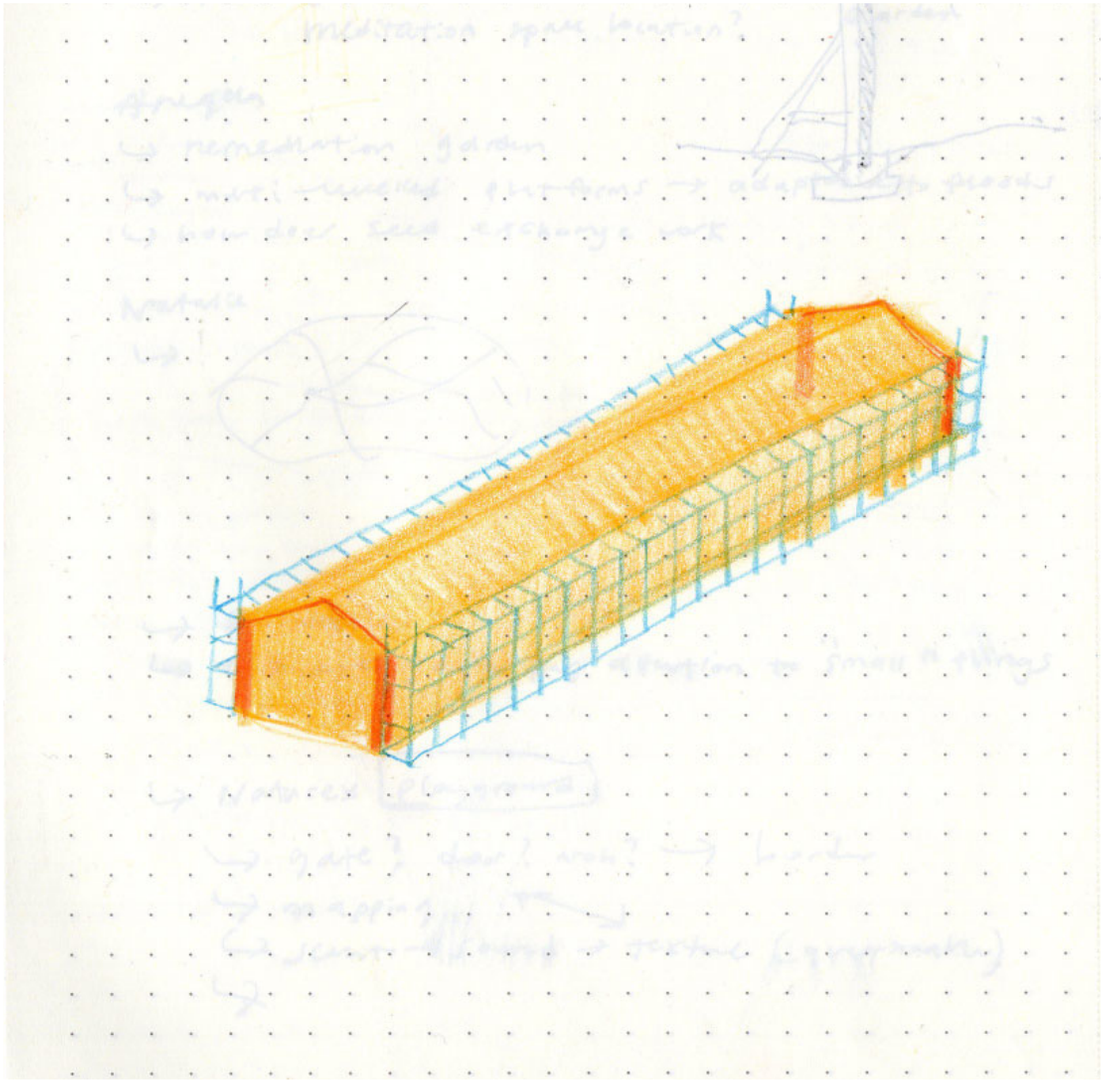


Fig. 4.16

Deconstruction equipment sketches.

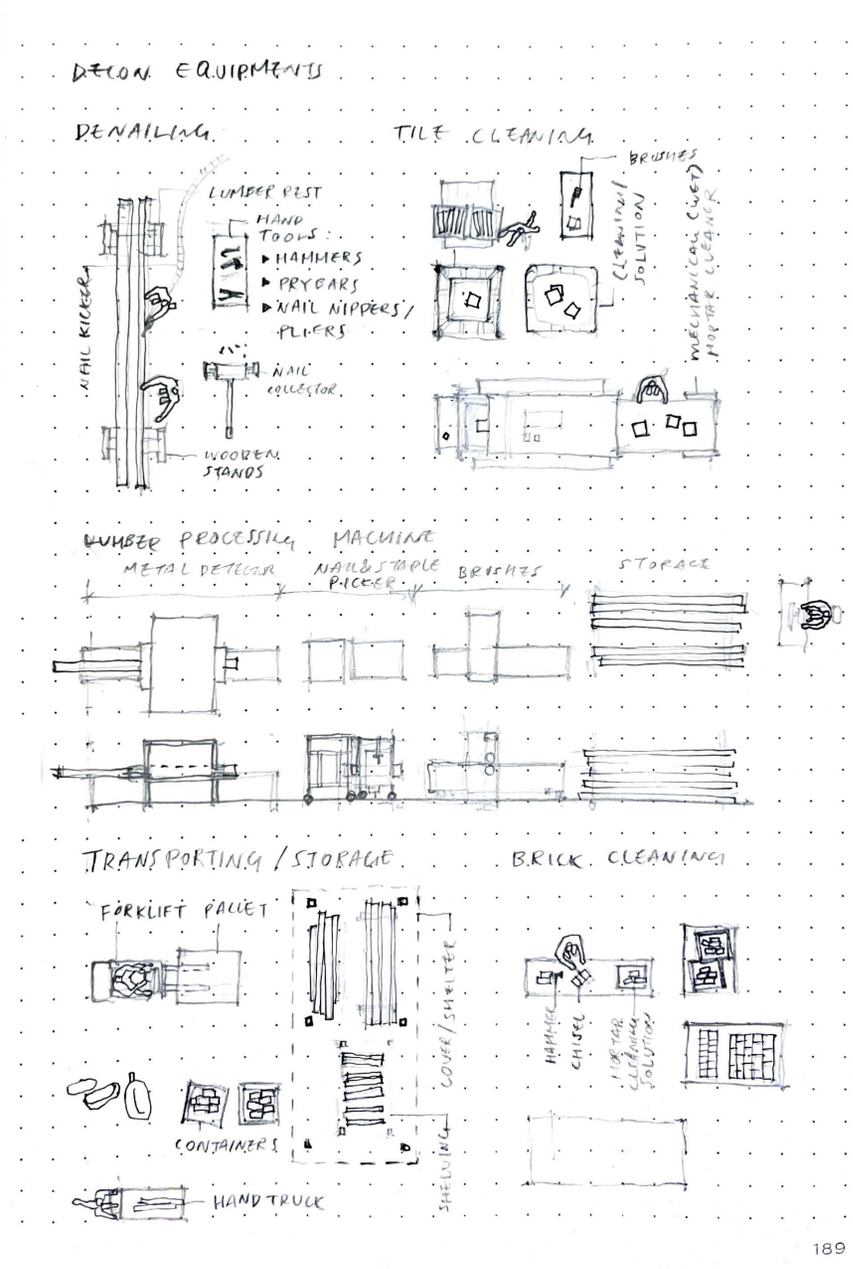
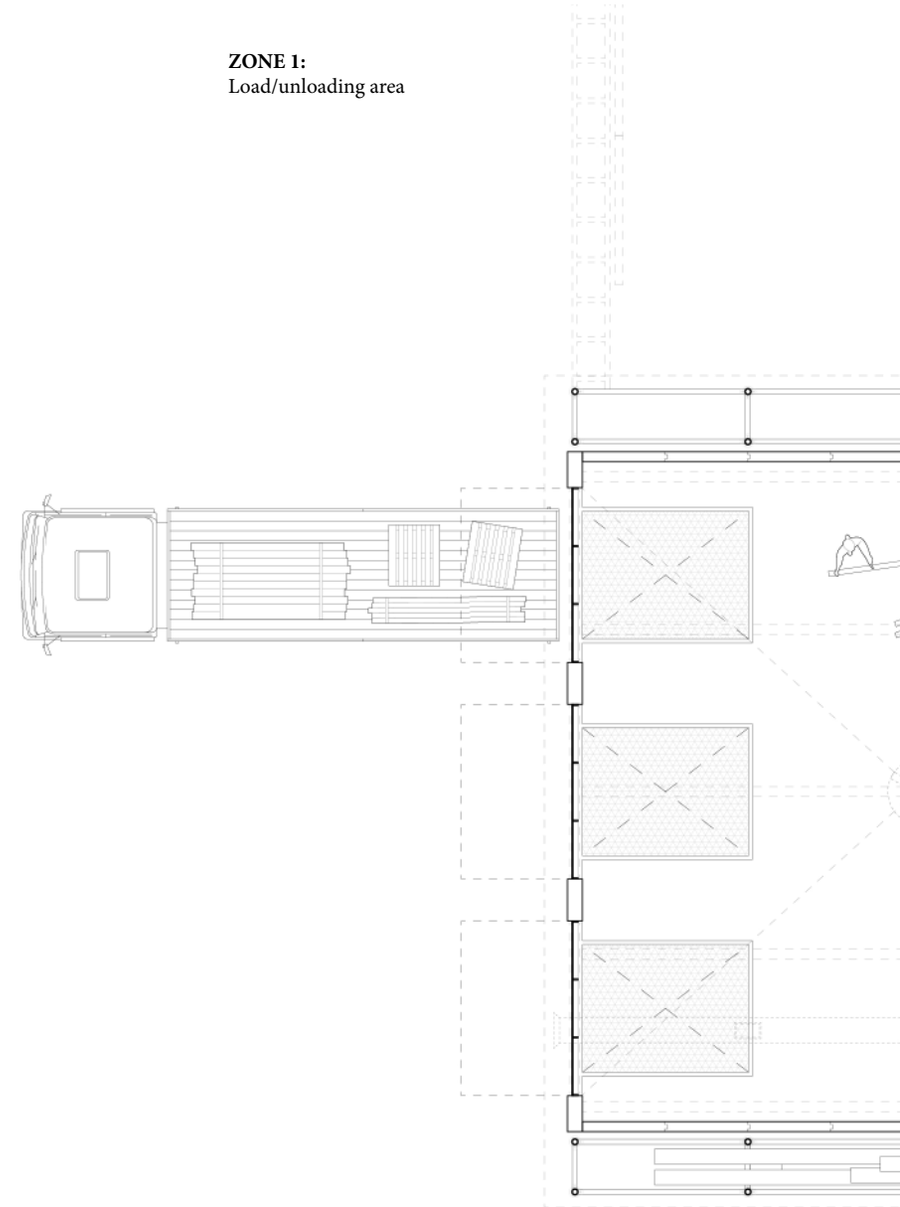


Fig. 4.17

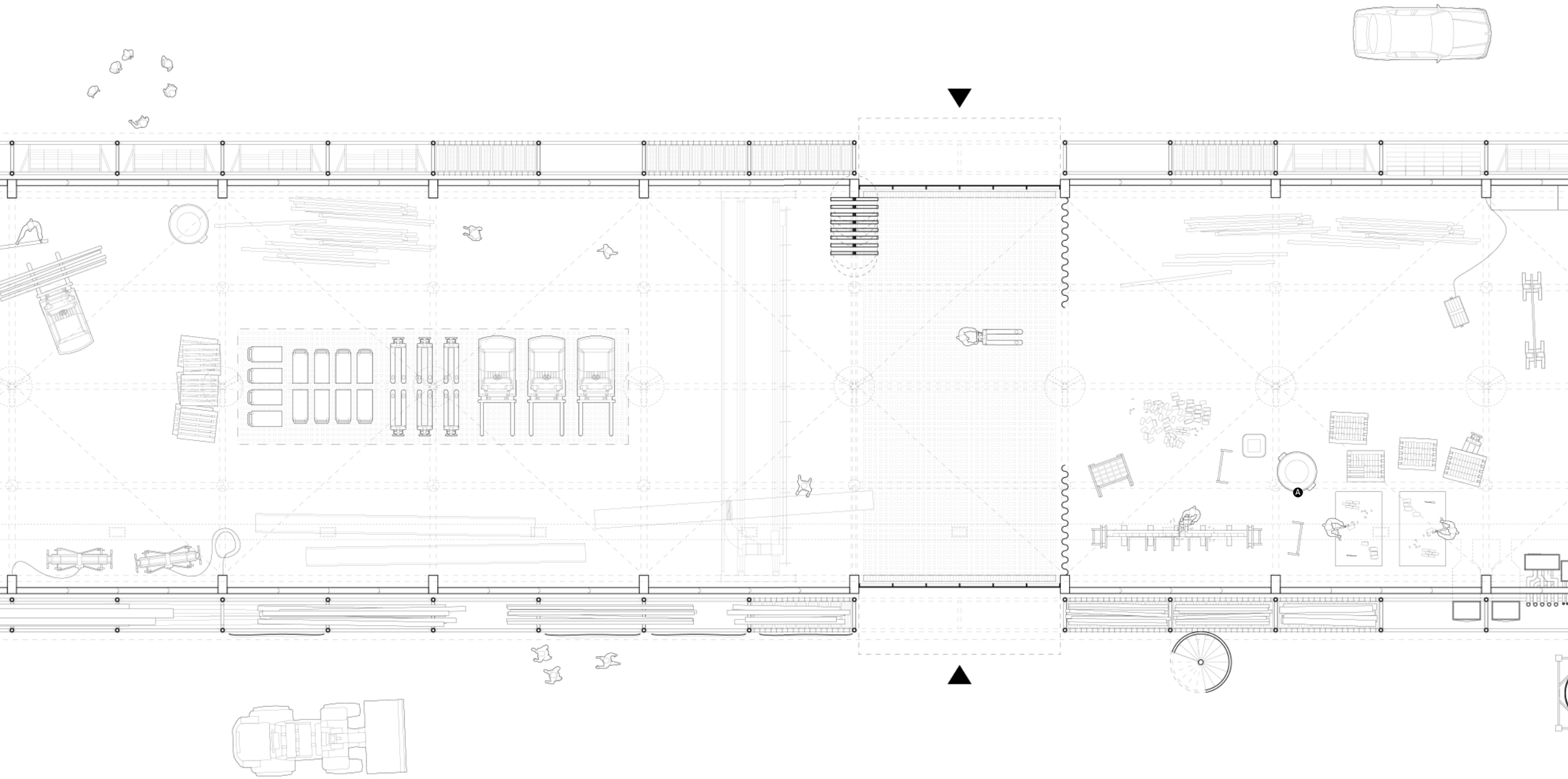
Activities within the warehouse and material storage area.

ZONE 1:
Load/unloading area

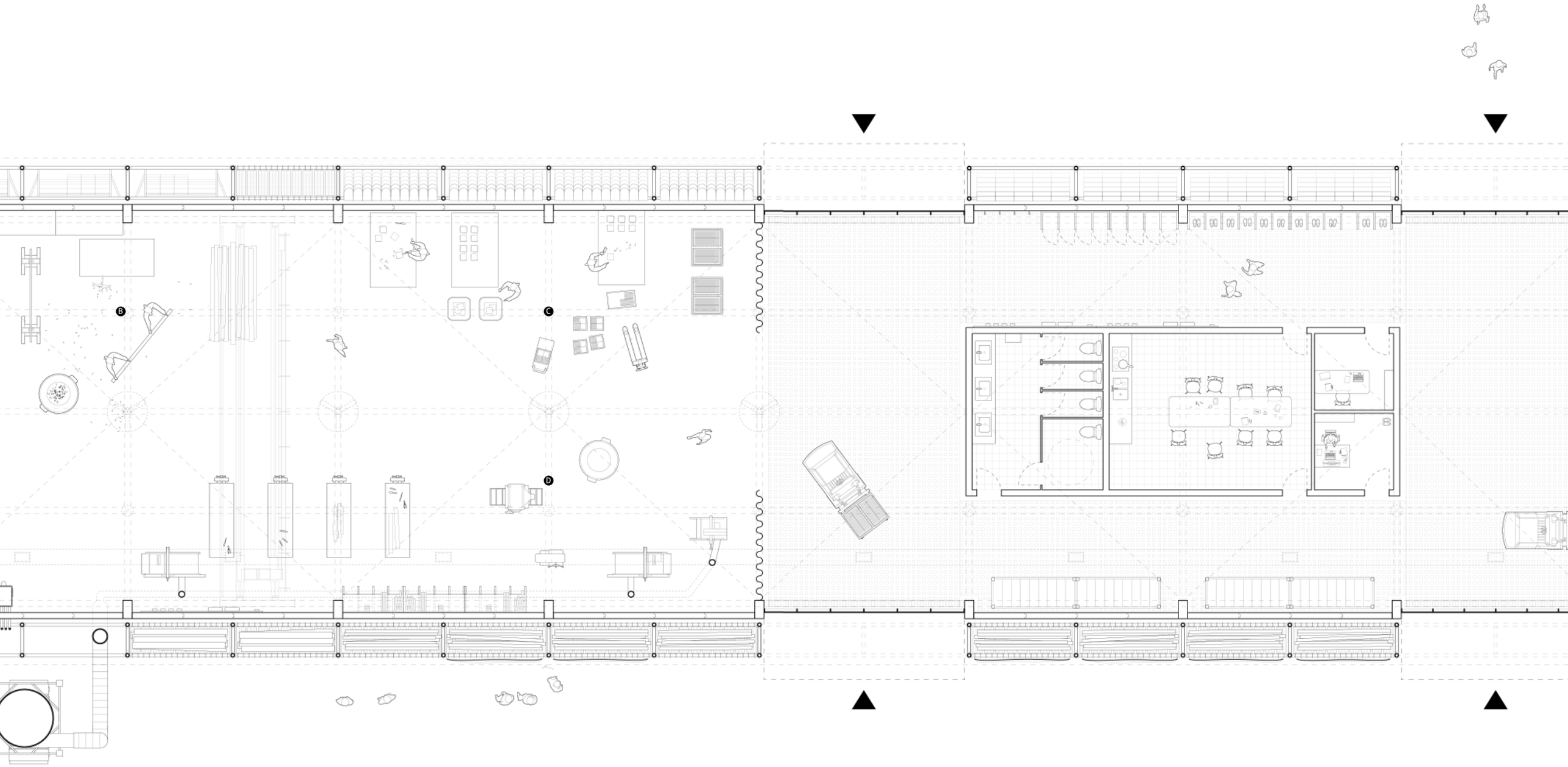


ZONE 2:
The first open space beyond the drop-off zone. For material assortment and organization. Contains equipment park area.

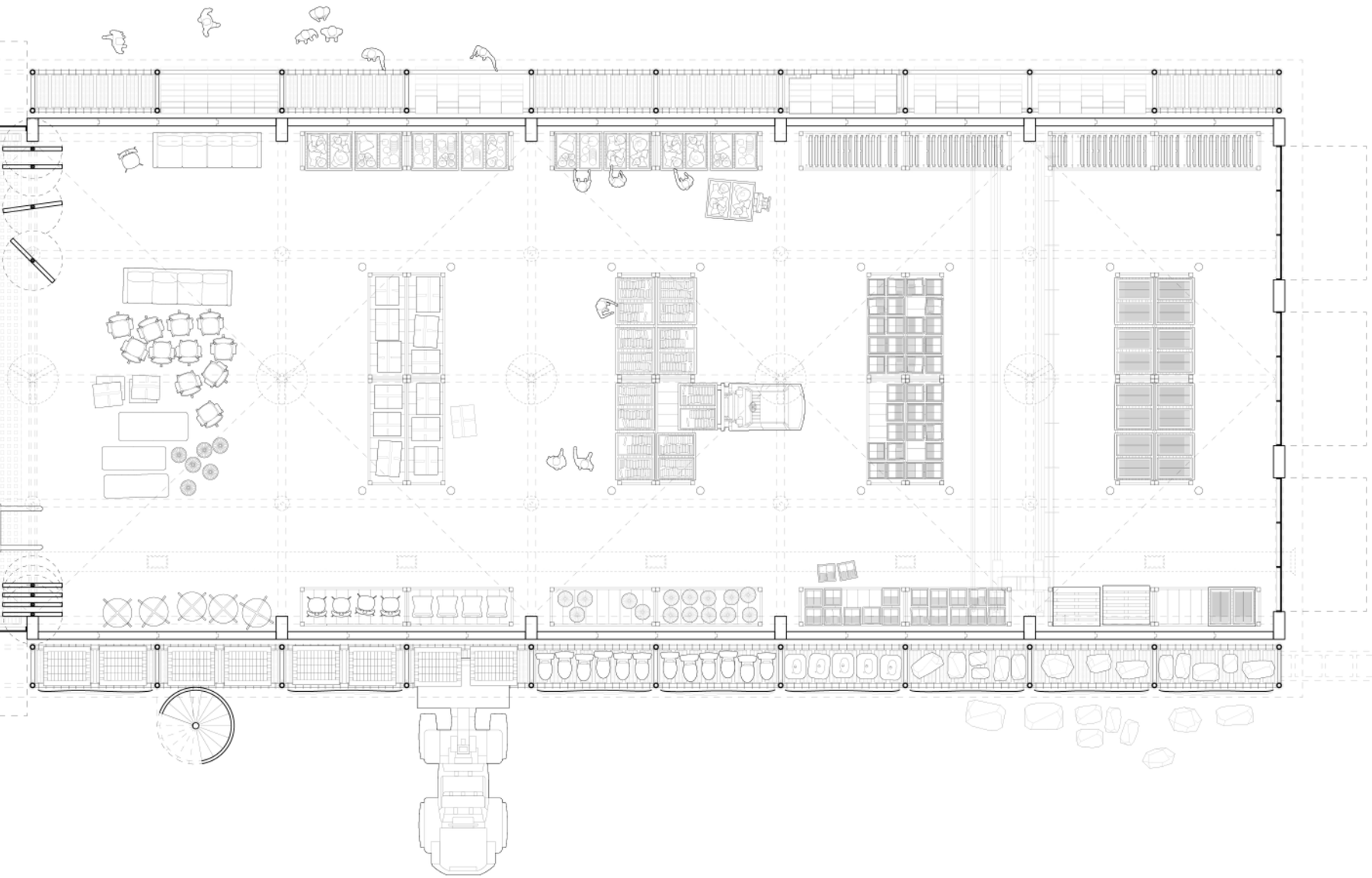
ZONE 3:
The main material-processing area. Holds 3 specific stations: brick cleaning (A), de-nailing (B), and tile cleaning (C); and a woodshop (D).



ZONE 4:
Admin spaces containing washrooms, lunchroom, and offices.



ZONE 5:
Indoor storage area.



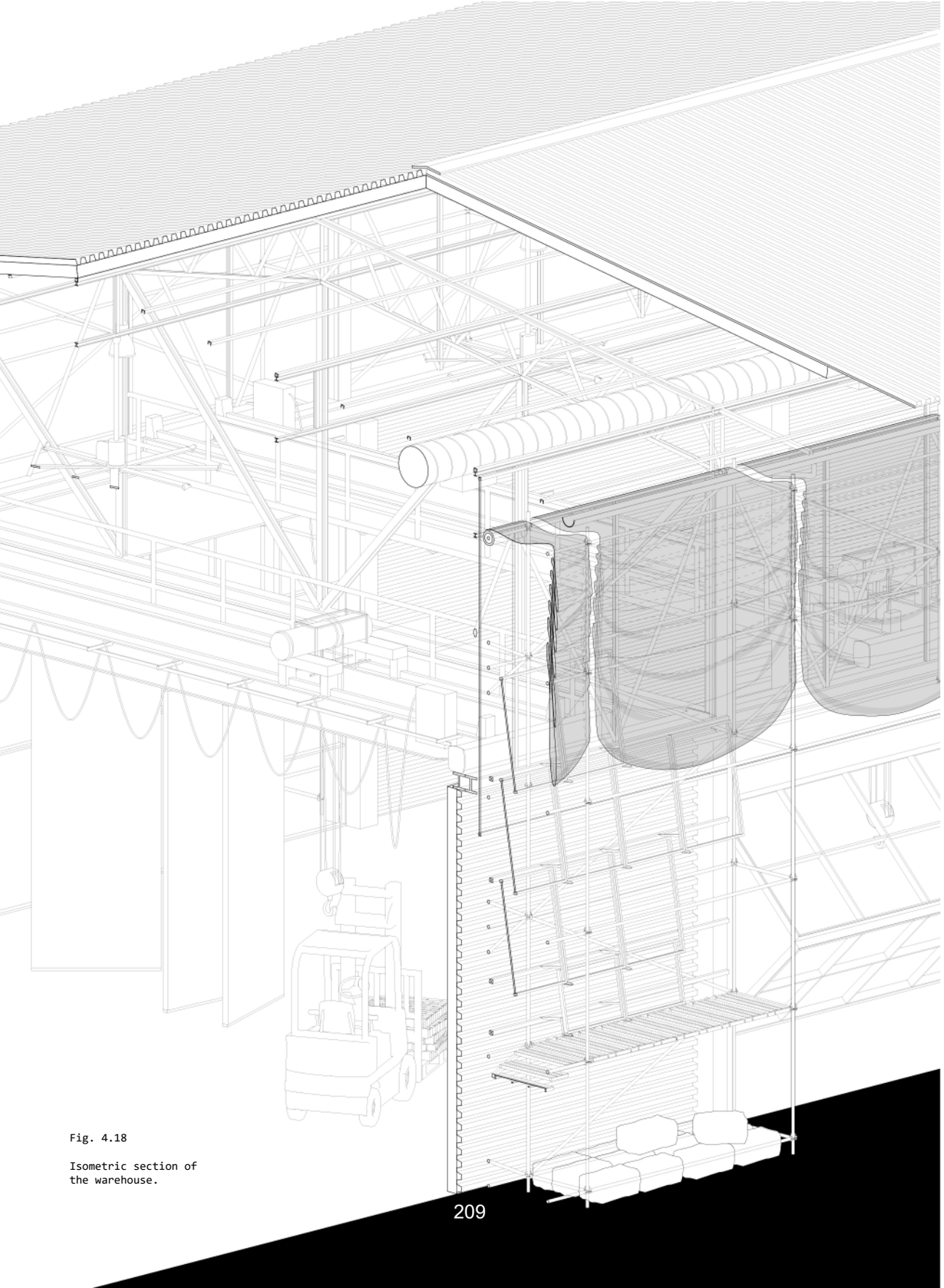


Fig. 4.18

Isometric section of the warehouse.

The scaffolding bay is 1m deep, with spans ranging from 6.5-7m, correspondent to the structure grid of the existing building across the courtyard. This wall system runs along the entire west and east elevation of the warehouse building at approximately 140m.

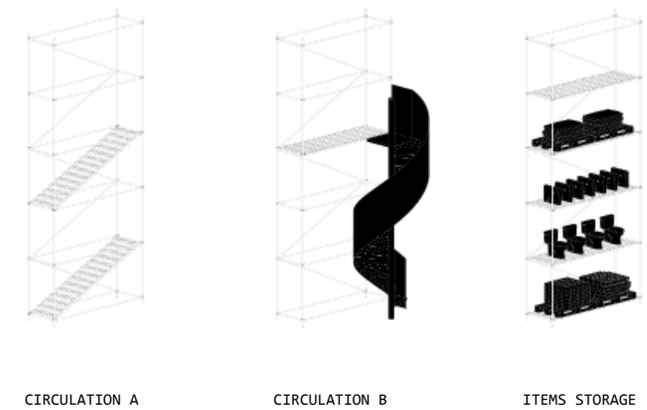
Learning from the case studies of contemporary deconstruction organizations, display of materials proved to be a major factor in commercializing salvaged materials. Taking the time and effort to curate items - like any typical commercial merchandise - affects how people value them.

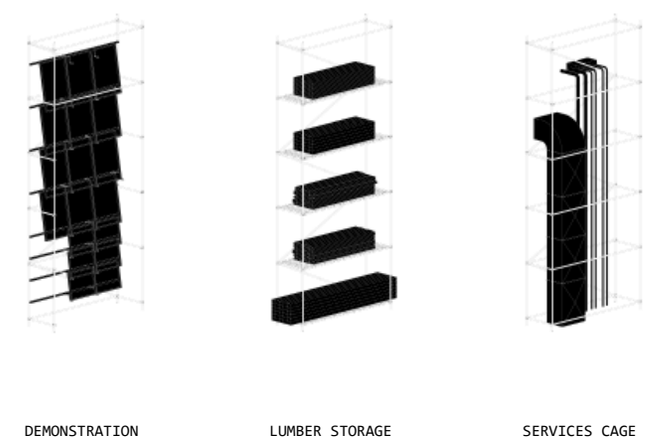
As a result, the design of the main material handling architecture revolved around presenting these array of materials on the exterior of the building. The collection of materials integrated into the facade system, which its form, configuration and aesthetics are intended to change depending on the types of materials coming down throughout the city. The continuous evolution of this system embodies the unprecedented nature of anticipatory architecture, and its iteration is intentionally left incomplete.

Since these bays are essentially a series of frames, they serve multiple purposes: circulation, demonstration, storage, and services cage.

Fig. 4.19

DIFFERENT USAGE OF SCAFFOLDING BAYS





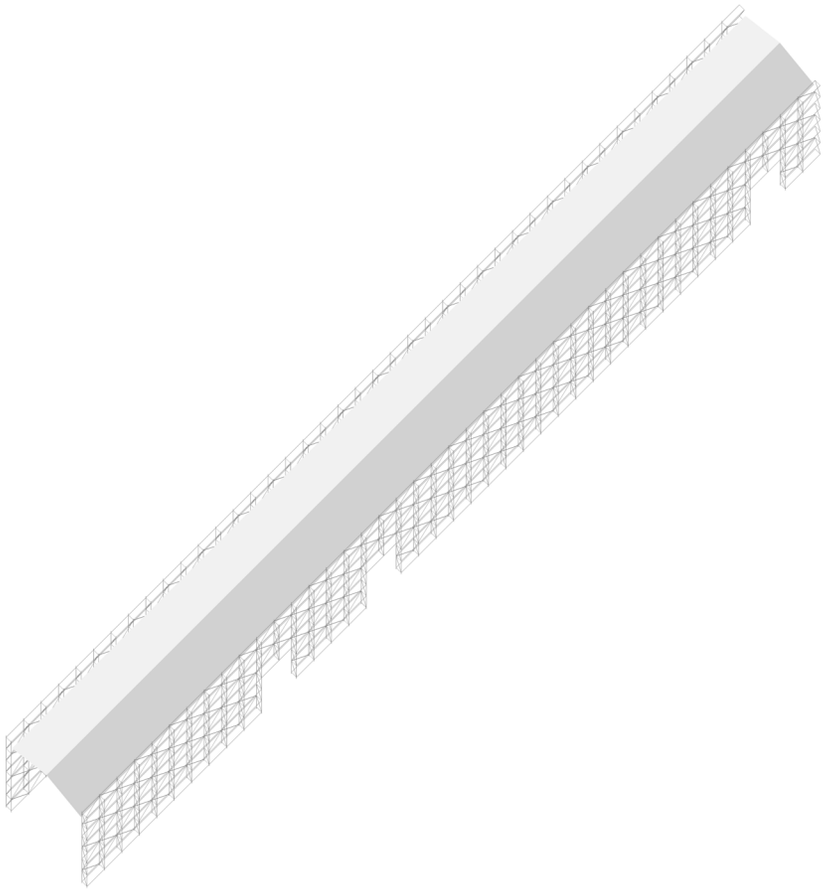


Fig. 4.20

EMPTY FACADE

SHELVING CAPACITY: 580M³

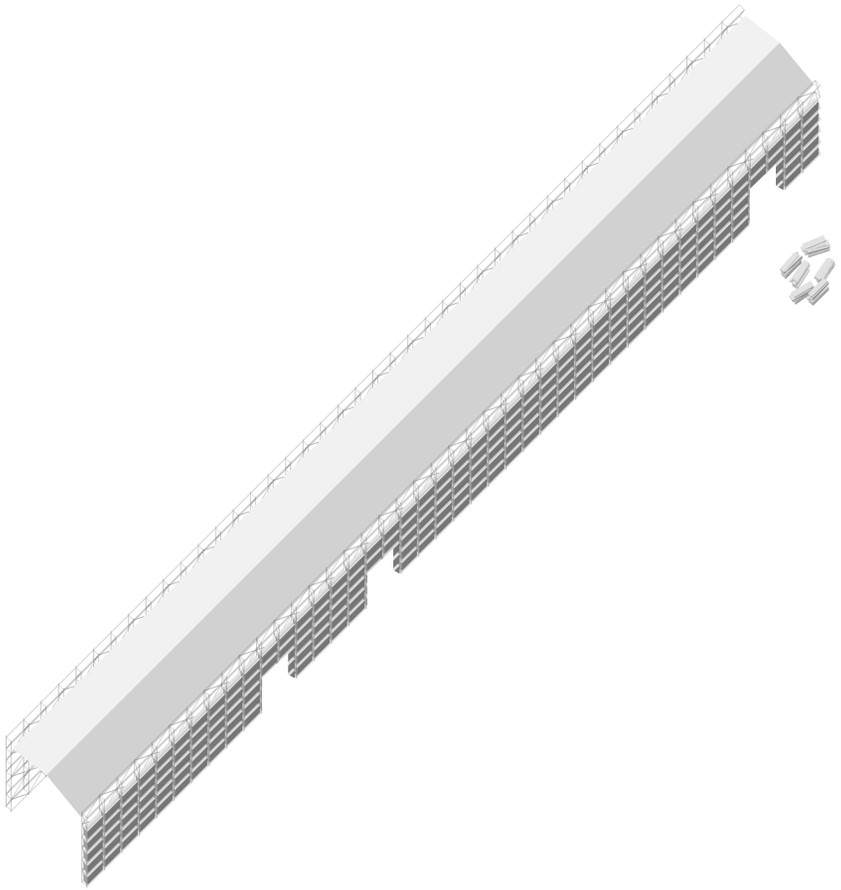


Fig. 4.21

SCENARIO: 22 SINGLE DETACHED DWELLINGS DECONSTRUCTED ALL AT ONCE
(100% OF THE DIMENSIONAL LUMBER RECLAIMED)

DIMENSIONAL LUMBER FROM (22) SINGLE DETACHED DWELLINGS: 594M³

CALCULATION: $(6.5M^3+3M^3+7M^3+0.5M^3+10M^3)x22=594M^3$

Learning from Brand's "Shearing Layers", we understand that degration in buildings happens in layers, with varying years of ageing. Considering that building maintenance projects happen accordingly to this timeline, we can anticipate material inflows and outflows at the facility to reflect these rhythms.

By visualizing the same shearing diagrams as a sequential graph over 100 years, we can begin to imagine how the warehouse facade might evolve over time, making visible the data-driven patterns of material change through the architecture itself.

Fig. 4.22

Stewart Brand's "Shearing Layers".

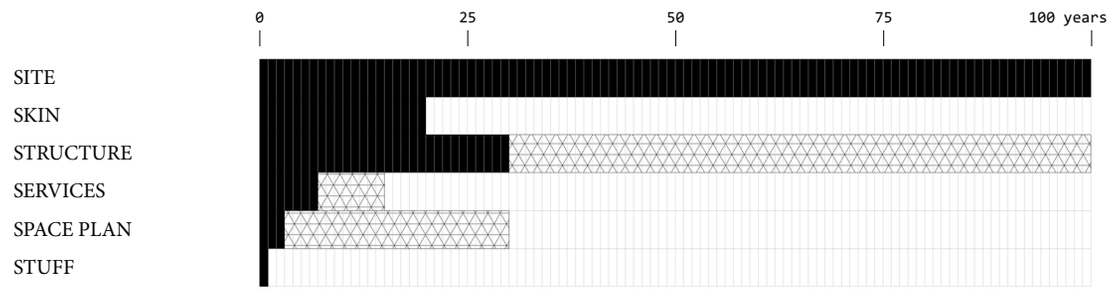
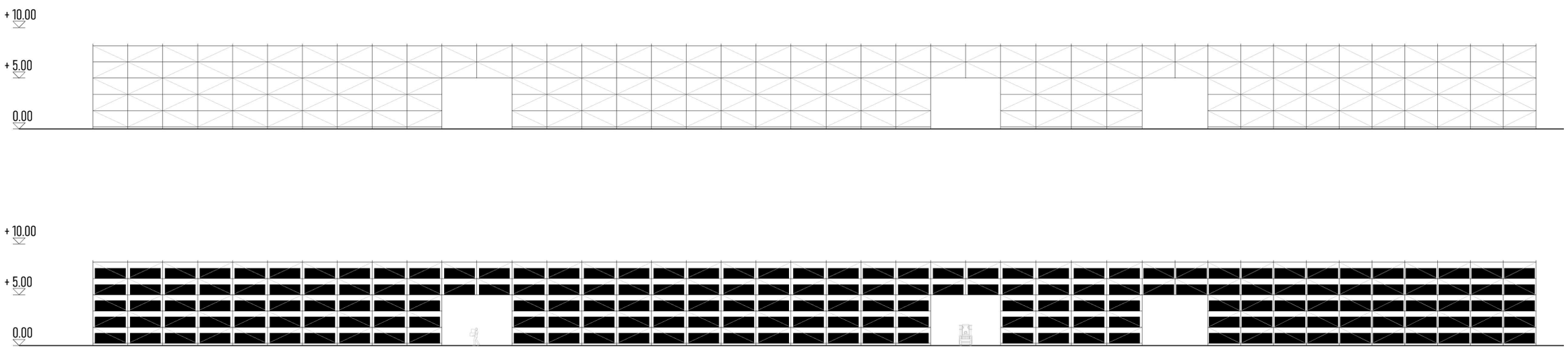


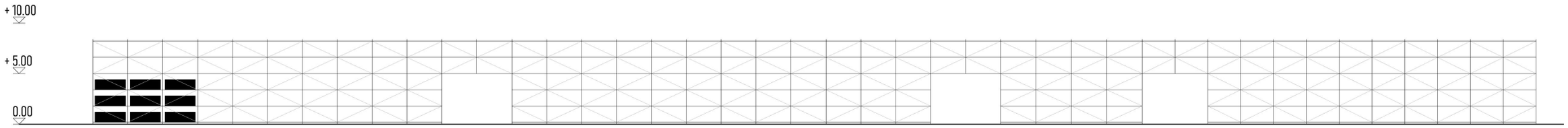
Fig. 4.23

Warehouse exterior shelving capacity.



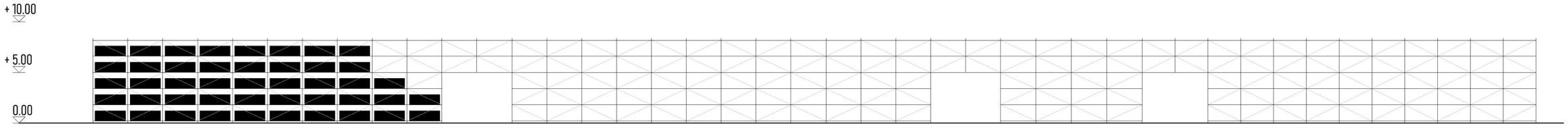
SHELVING CAPACITY: 580M³

MORE ABOUT THE MACHINE



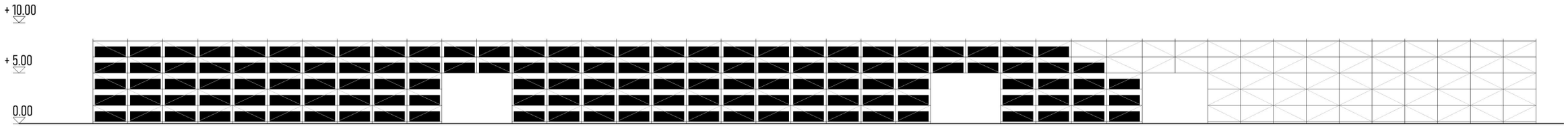
DIMENSIONAL LUMBER FROM (1) SINGLE DETACHED DWELLINGS: 27M³

CALCULATION: (27M³)x1=27M³



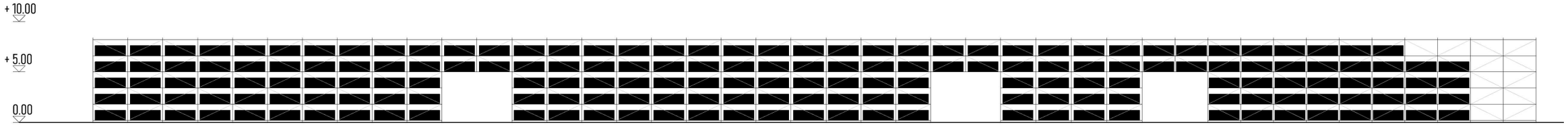
DIMENSIONAL LUMBER FROM (5) SINGLE DETACHED DWELLINGS: 135M³

CALCULATION: (27M³)x5=135M³



DIMENSIONAL LUMBER FROM (15) SINGLE DETACHED DWELLINGS: 405M³

CALCULATION: (27M³)x15=405M³



DIMENSIONAL LUMBER FROM (20) SINGLE DETACHED DWELLINGS: 540M³

CALCULATION: (27M³)x20=540M³

4.4 The Architecture

LIST OF DRAWINGS:

00 GRID

01 GROUND FLOOR

02 SECOND FLOOR

03 THIRD FLOOR

04 EAST ELEVATION_01 (EDU CORRIDOR)

05 WEST ELEVATION_01 (EDU CORRIDOR)

06 SECTION A-A (EDU CORRIDOR)

07 EAST ELEVATION_02 (WAREHOUSE)

08 WEST ELEVATION_02 (WAREHOUSE)

09 SECTION B-B (WAREHOUSE)

10 SOUTH ELEVATION (BOX STORE & OTHERS)

11 NORTH ELEVATION (BOX STORE & OTHERS)

12 SECTION C-C (BOX STORE & OTHERS)

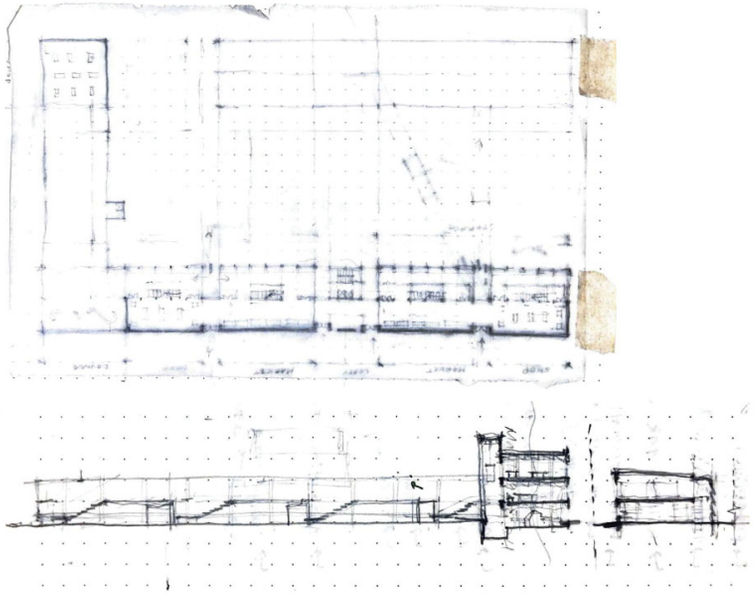
13 EDU-CORRIDOR DETAILED WALL SECTION

14 WAREHOUSE DETAILED WALL SECTION

15 RENDERS

Fig. 4.24

Conceptual sketches (C).



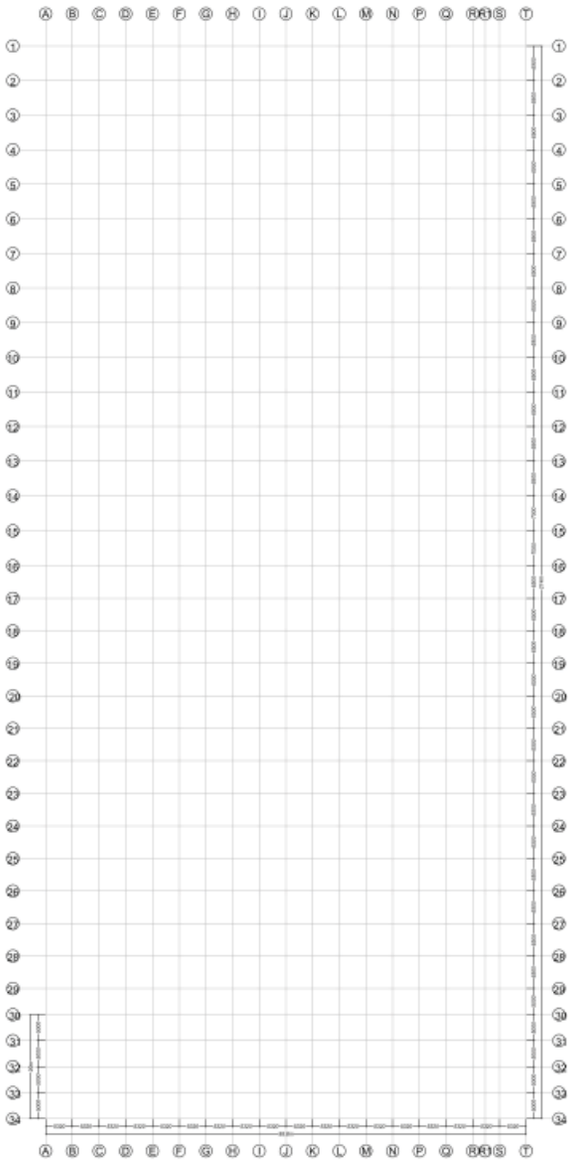


Fig. 4.25

GRID

Fig. 4.26

Design development models (A).

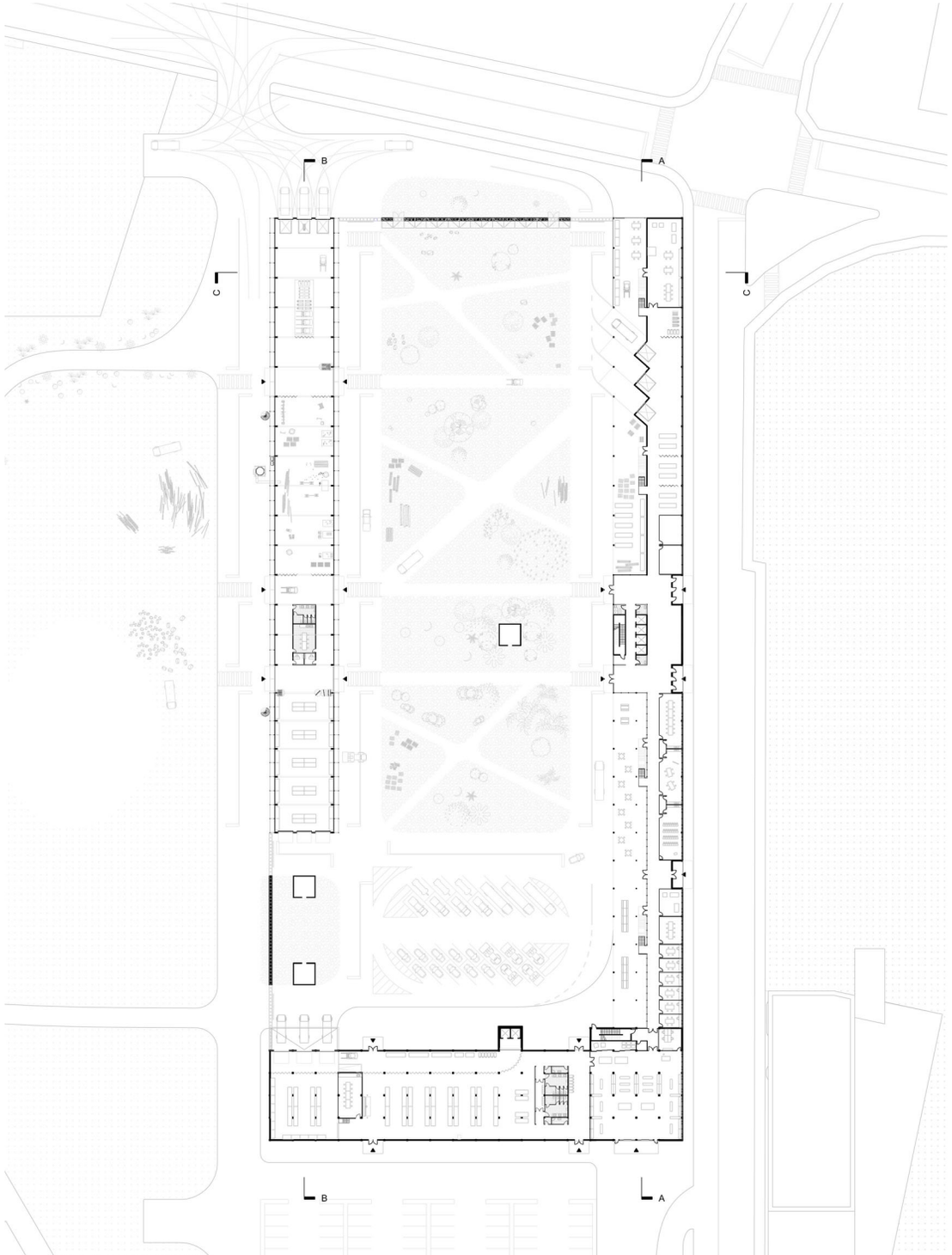


Fig. 4.27

GROUND FLOOR

Fig. 4.28

Design development models (B).

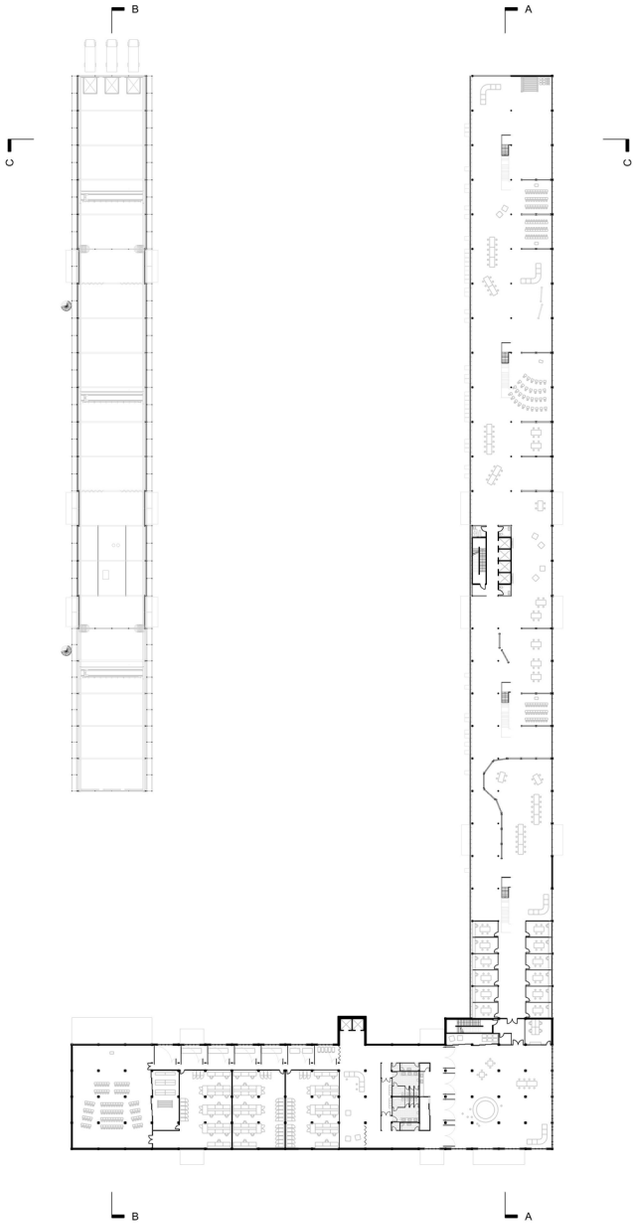


Fig. 4.29

SECOND FLOOR

Fig. 4.30

Design development models (C).

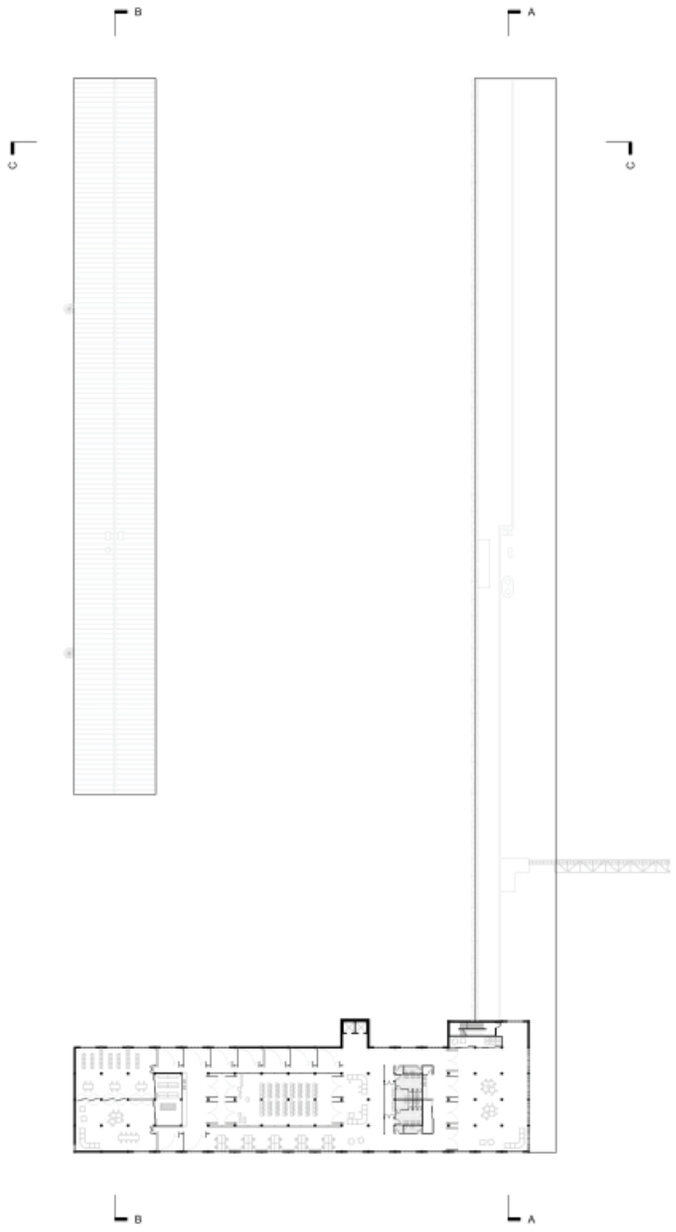
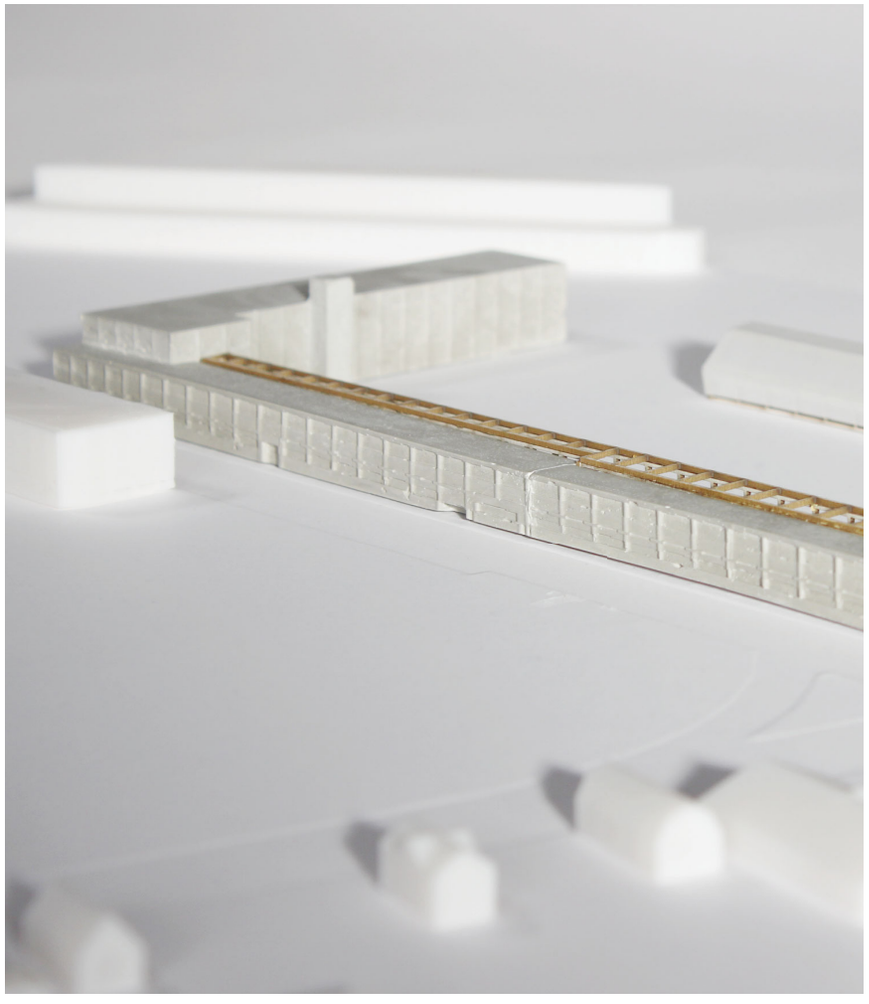


Fig. 4.31

THIRD FLOOR

Fig. 4.32

Design development models (D).



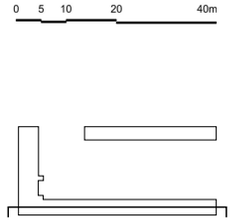
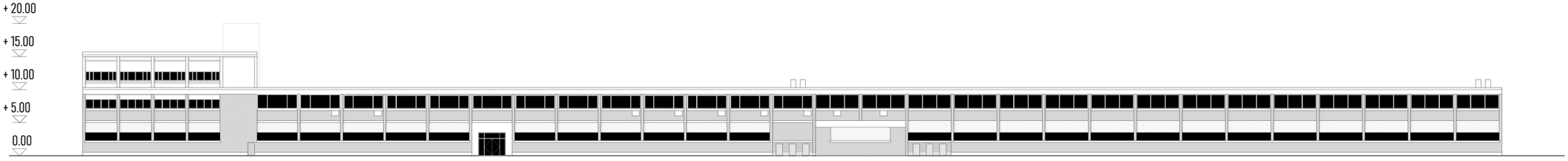
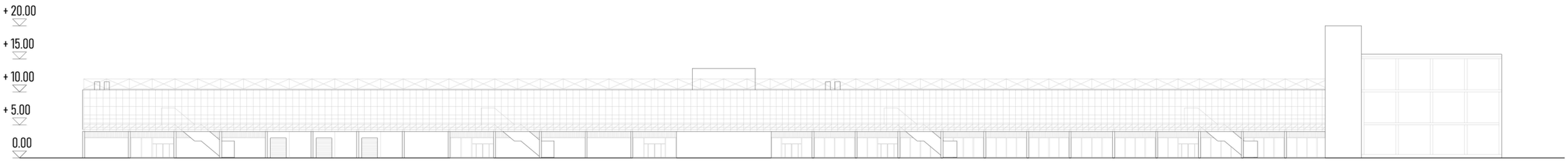


Fig. 4.33

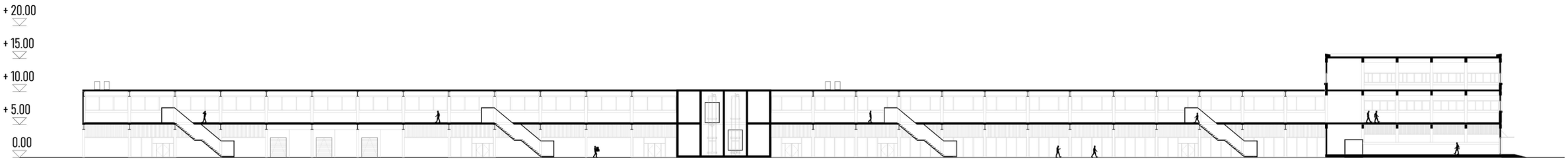
Elevations and sections of the edu corridor.



EAST ELEVATION_01



WEST ELEVATION_01



SECTION A-A

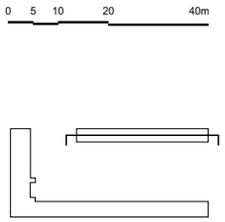
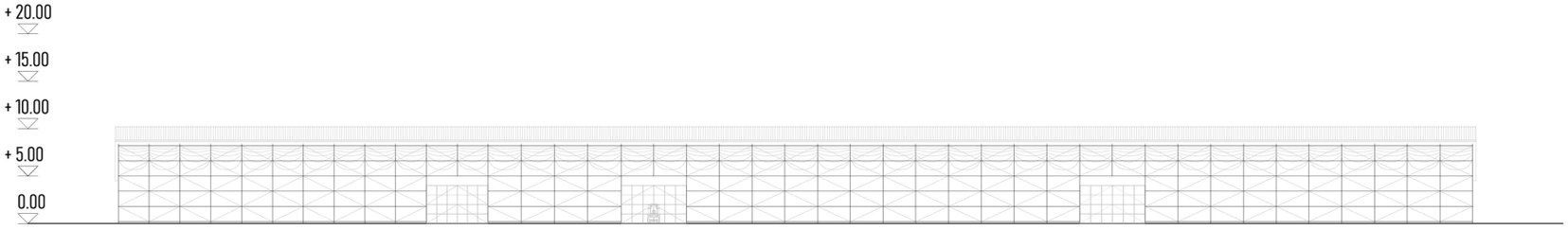
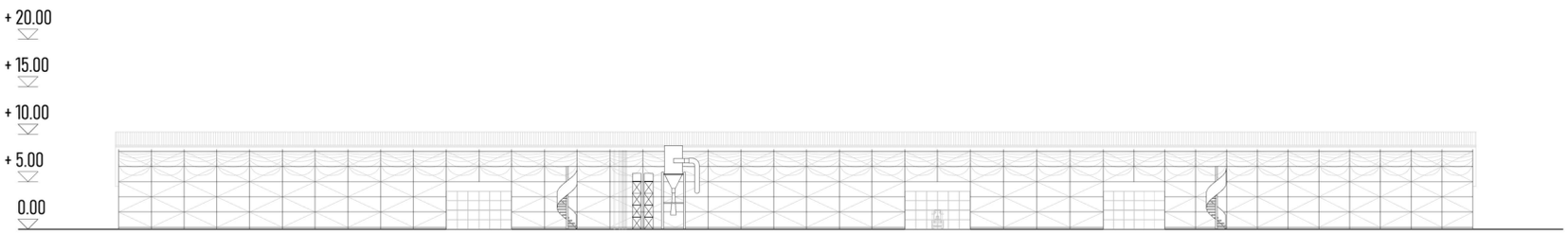


Fig. 4.34

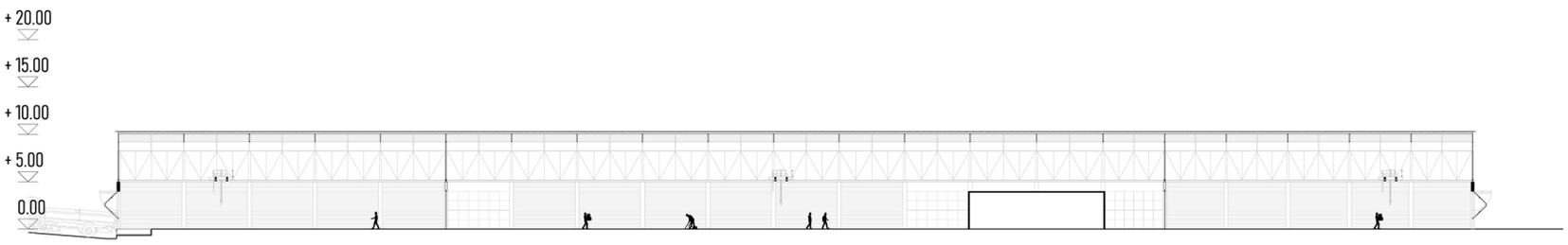
Elevations and sections of the warehouse.



EAST ELEVATION_02



WEST ELEVATION_02



SECTION B-B

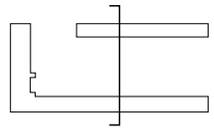
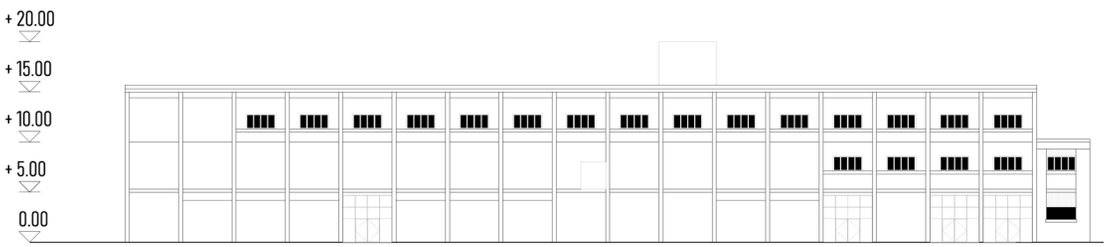


Fig. 4.35

Elevations and sections of the application building and the overall site.



SOUTH ELEVATION

NORTH ELEVATION

SECTION C-C

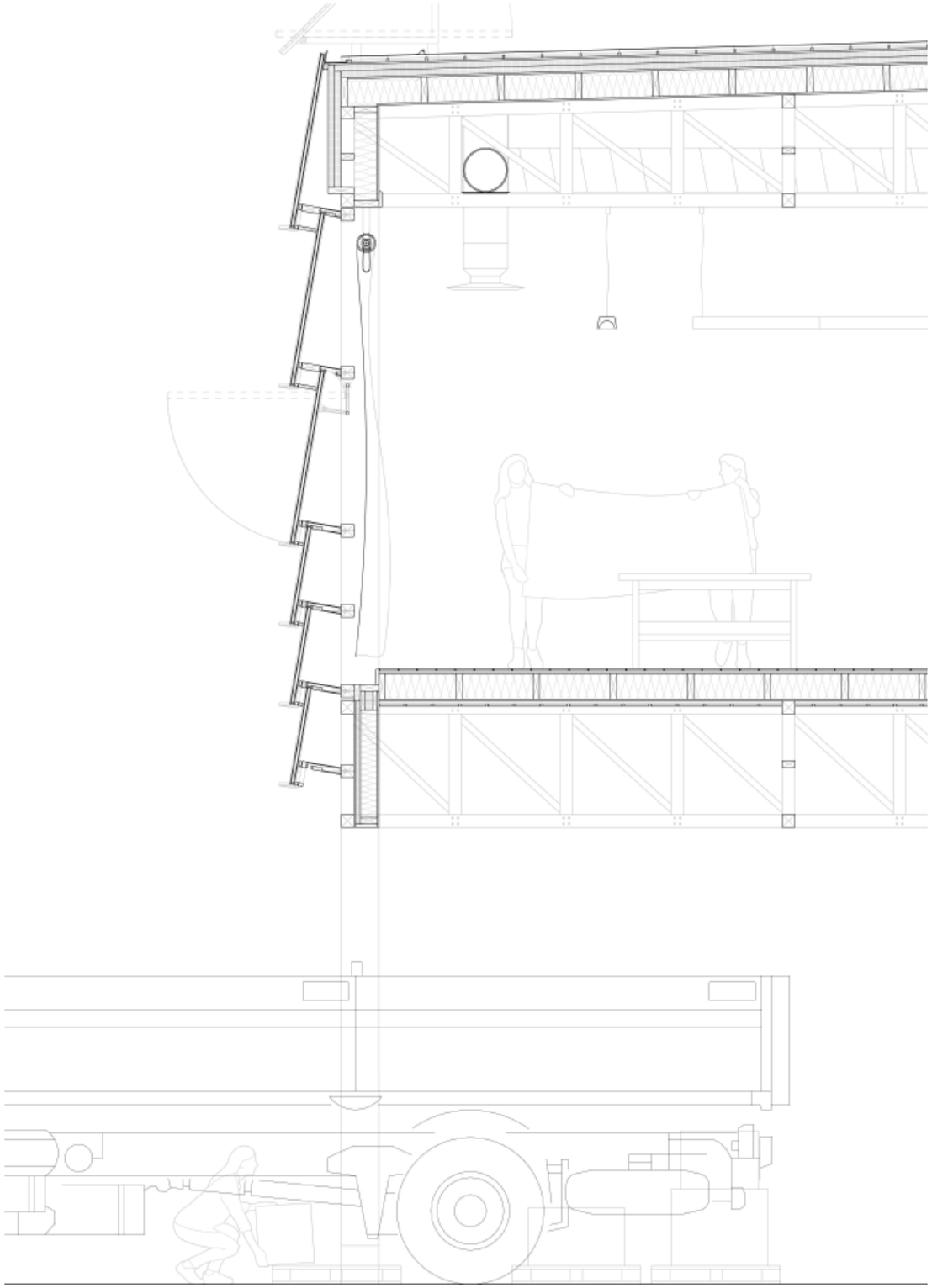


Fig. 4.36

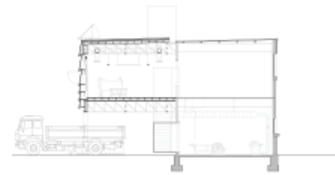
Edu corridor wall section detail. 1:50

ROOFTOP
1. Gutter
2. Rotating solar PV Panels
3. Snow guard

ROOF
4. Parallel chord wood floor truss made with salvaged dimensional lumber (4x4" top and bottom chord, 2x4" webs)
5. 1/2" plywood
6. 2x8", 24" O.C. wood joist with mineral wool batt-insulation, R-32
7. 1/2" OSB sheathing
8. (2) 2" mineral wool insulation board
9. 1" plywood
10. polyethylene membrane
11. Counter battens
12. Roof panel clip
13. Roof underlayment
14. Standing seam metal panels roof covering

FLOOR
15. 1/2" salvaged wood flooring
16. Radiant heating with self-leveling gypcrete
17. Salvaged 2x8", 24" O.C. wood joist with mineral wool batt-insulation, R-32
18. 38mm trimmer joist
19. 19mm plywood sheathing
20. 1" heavy duty T-grid
21. Salvaged ceiling wood tiles
22. Parallel chord wood floor truss made with salvaged dimensional lumber 4x4" top and bottom chord, 2x4" webs

GLASS FACADE
23. Double glazed units made of salvaged glass planes refilled with argon
24. Timber frame made of salvaged dimensional lumber
25. Aluminum bar
26. Silicone seal
27. Deadload bracket
28. Loadbearing timber transom
29. Threaded U-bolt
30. CLT column 300x300mm
31. Interior curtain installed at ea. bay



The education corridor expansion is constructed with nearly 90% salvaged materials, including the wood trusses, wood joists, wood tiles, and the glass facade system. The only new materials introduced are CLT columns, sheathing materials and steel connections between the members. To accommodate for the various length of salvaged glass, the facade system was designed as shingles that can overlap, optimizing their use by minimizing the re-cutting of them. The irregularity of these pieces become an aesthetic language, unique to these reused components.

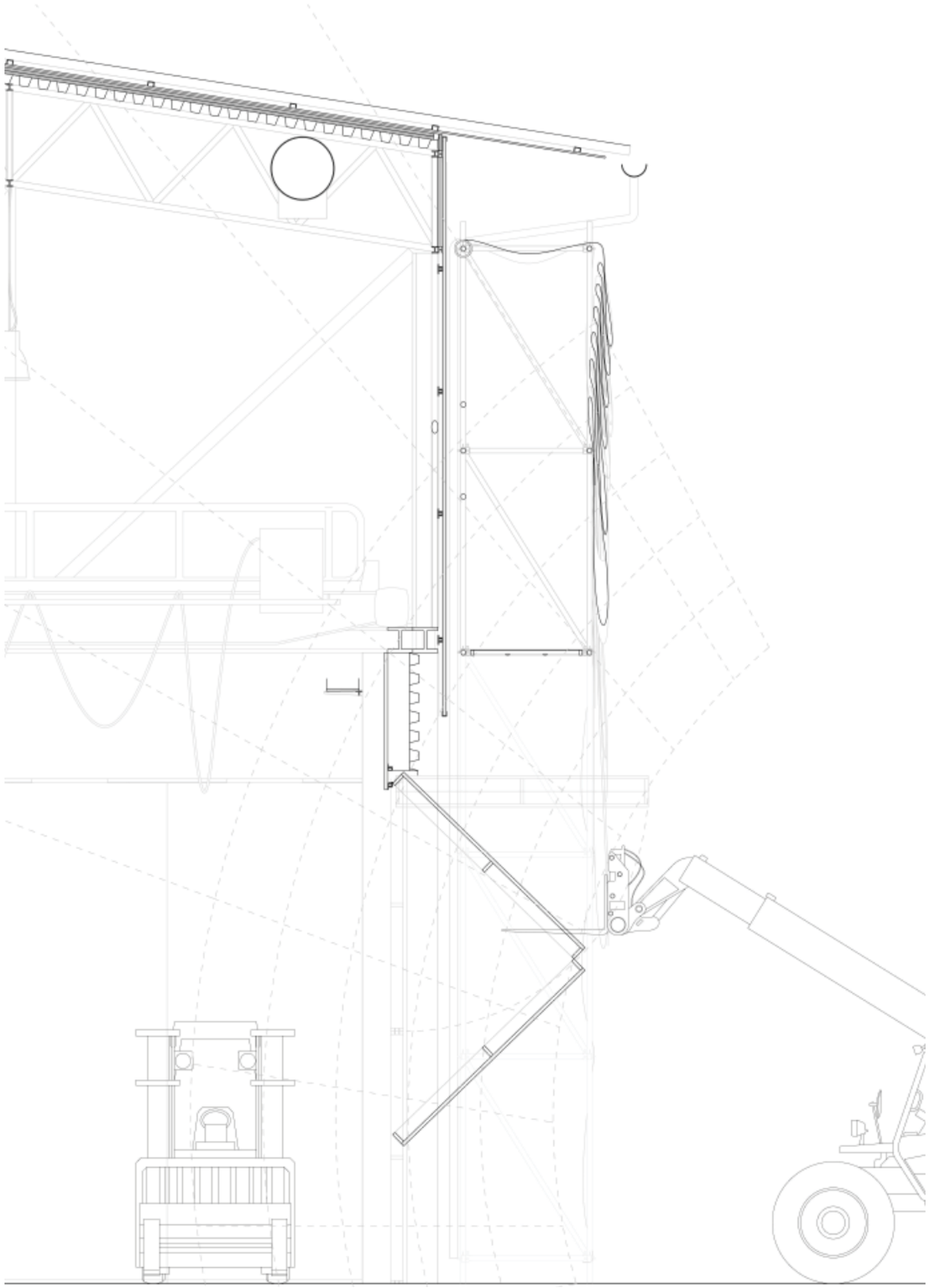


Fig. 4.37

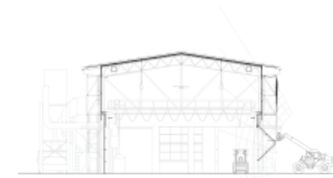
Warehouse wall section detail. 1:50

ROOF
1. Parallel chord vaulted steel roof truss
2. Roof beam
3. Trapezoidal profile sheeting, load-bearing, connected with self-tapping screw and sealing strip
4. Polyethylene sheet
5. (2) 2" mineral wool board, R-8.4
6. Roofing seal, bitumen sheathing
7. Spacer section
8. Trapezoidal profile sheeting, roof covering
9. Ventilation grille
10. Drip profile
11. Gutter

SCAFFOLDING SYSTEM
12. Anchor bolt
13. Standard
14. Ledgers Braces
15. Couplers at joints
16. Outdoor curtain installed at each day
17. Toe board (min 150mm high)
18. Motor for curtains
19. Work/walk platform

UPPER SCREEN
20. Transparent polycarbonate corrugated sheet with UV-resistant coating, 175x51x3mm
21. Steel rectangular hollow section 70x50x-4mm, galvanized
22. Steel column, HEA 120, galvanized
23. Steel circular hollow section bracing
24. Motor for horizontal slide windows

LOWER WALL
25. Building columns
26. Vertical girts (locate girts outboard of main structure to clear columns, across bracing and fire proofing)
27. Liner panels with thermal insulation
28. Sub girt
29. Trapezoidal profile sheeting, metal wall panels



As the only construction with the use of steel and concrete, the warehouse structure ensures a life-long durability of over a century. The proposed design of large open spans allow for large equipment movement including the overhead crane and forklifts. In the case the warehouse is no longer used, the flexible floor plan allows for other programs to be easily adapted. The scaffolding system is independent of the main warehouse construction, with industrial fabric protecting materials from the weather.

Fig. 4.38

Materials might first arrive at Material Works as what appears to be a pile of debris - not unlike the rubble scattered around any waste management site.

But once these discarded piles are not only sorted, but shaped, arranged, and given order, their values are rediscovered in the eyes of the visitors—their once lost status renewed, and their presence no longer overlooked.

This work goes beyond mere material management —it is an act of curation, possible with significant time investment, an eye for details and the appreciation for the art of balancing aesthetics and efficiency.

Fig. 4.39

The warehouse architecture functions as an urban machine, embracing the efficiency of its industrial nature.

Permeable circulation system allows for continuous movement across the entire body. The bay doors fold and unfold from all sides of the building, facilitating the arrival, departure, and the transfer of materials.

Fig. 4.40

The vast volume of the warehouse accommodates countless activities.

The vibrant sounds of equipment, shifting materials, and people in motion echoes across the open void.

Along with sound, light permeates through the building freely, filling each bay with a soft, diffused glow.

Fig. 4.41

With no fixed program, the education corridor invites learners to a space that must be activated to take shape.

Collaboration is essential, and exchange of knowledge is encouraged. This is not a place for individuals to passively acquire information but a dynamic environment where agencies inform each other, driving the progression of circular building practices.

The visual connection from this corridor to the courtyard and the warehouse beyond, along with staircases leading to the ground-floor workshop spaces supports the collaborative nature of these initiatives.

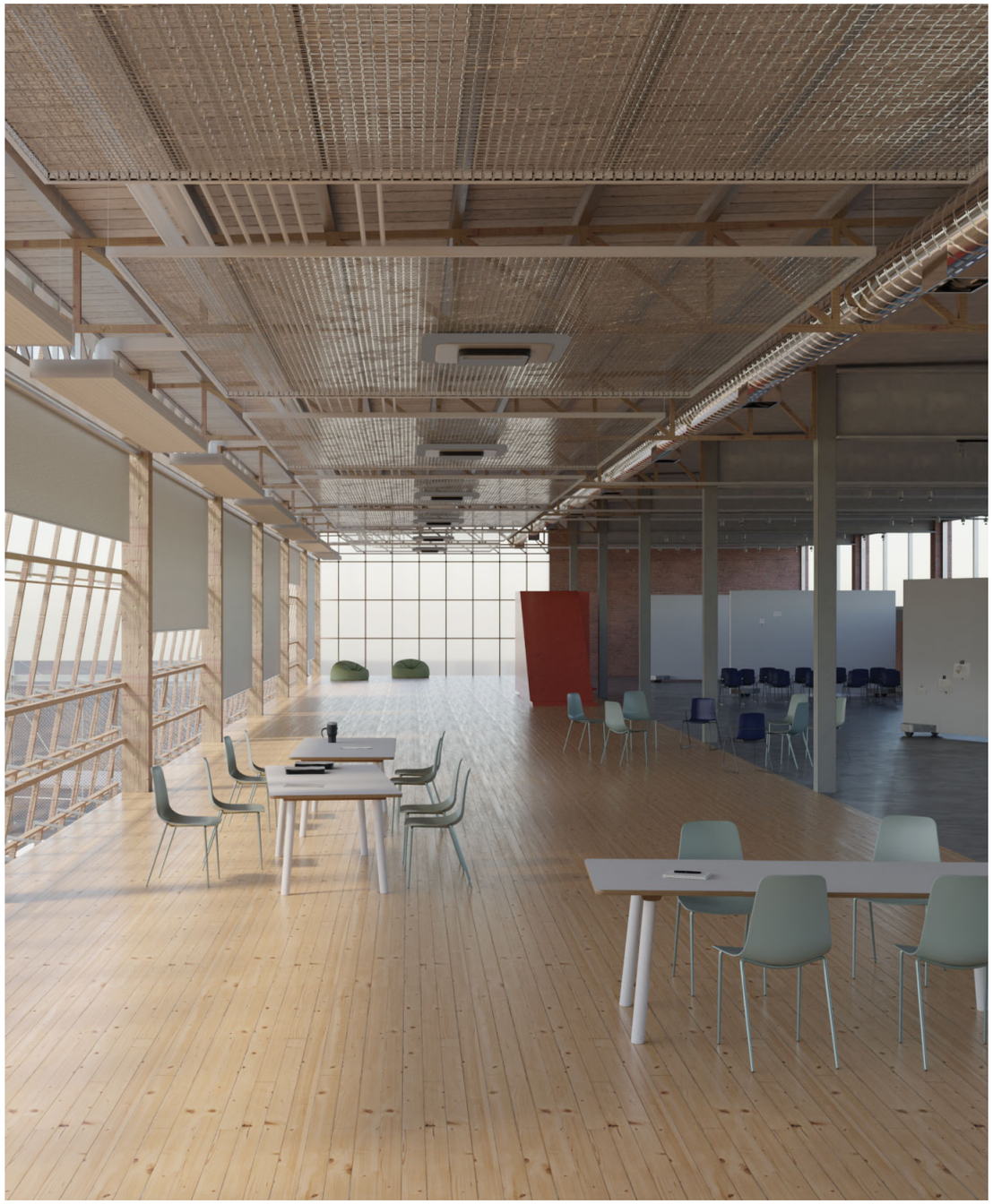


Fig. 4.42

At first glance, the Material Works might appear to be a park.

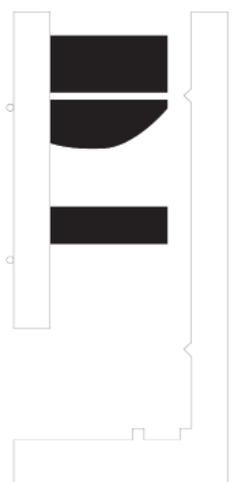
Beyond the gabion wall filled with building materials, the large open field of vegetation is carved with paths revealed through the movement of people across the site, with curated material stocks placed along the way.

There is great dynamism that can be observed even from the street. The glass panels, seemingly irregular, come together as an elegant facade running along the entire corridor. Looking toward the brick building at the back, it becomes clear that even a single bay is composed of multiple brickworks, most likely sourced from various existing buildings.

The experimentation wall embodies this diverse organization—an assembly of material matter that appears incomplete, yet deliberately composed with intention.

4.5 Future Speculation

Beyond the 67 buildings that were registered for demolition in 2023-2024, the city of St. Catharines will continue the process of renewal, demolition (or deconstruction), and densification. With emergence of regulatory changes incentivizing deconstruction across the globe, the project speculates a future beyond the proposed design, where temporary structures are added to the main warehouse building for additional storage spaces. This speculation adds another usage to the yard space intended to be used primarily as a circulation circuit.



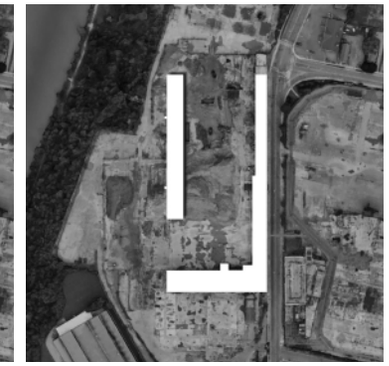
FUTURE ADDITIONS

Fig. 4.43

Future speculation by phases.

2023
Existing condition.

PHASE 1
Existing building to be renovated for adaptive reuse.



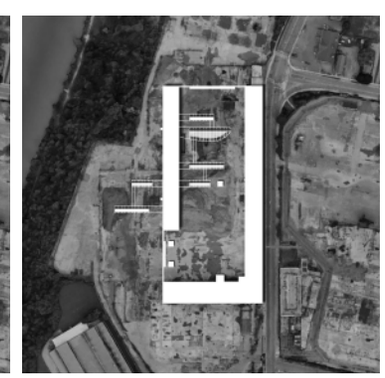
PHASE 2
New warehouse building constructed on the west side of the site.

PHASE 3
Education corridor extension.

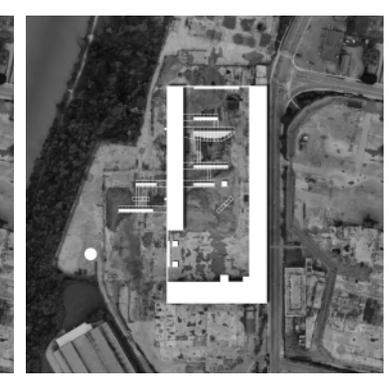
PHASE 4
Gates constructed on the north and west of site.

PHASE 5
Interior storage is at capacity: additional storage built.

PHASE 3
Continual expansion of storage units.



PHASE 4
Bridges connecting storage units to be constructed.



PHASE 5
Additional infrastructure to be constructed to accommodate growth.

CONCLUSION

Chapter 1 introduced the foundation of the North American building economy, constructed based on the capitalistic ideologies of planned of obsolescence which devalues the existing structures and incentives demolition through tax systems: determining the fate of buildings. While Canada's Federal taxation too incentives demolition, other avenues for building preservation—such as the Ontario Heritage Act—have limited capacity to preserve based on era-specific aesthetic narrative. Any buildings deemed unworthy of conservation is reduced to rubble and sent to landfills, which are reaching capacity at an alarming rate with all Ontario sites expected to be full by 2032. The inadequate preservation of the urban fabric, evidenced by increasing landfill waste and vacant sites such as the former GM plant, highlights the urgent need for improved material circularity within the planet's limited surface area.

A key strategy to move towards a circular building economy is to replace demolition with deconstruction as society once favoured. Chapter 2 delved into the inherent challenges in this type of fieldwork. Since buildings aren't typically designed and built with disassembly in mind, they are technically challenging to deconstruct. The types of materials a building is composed of, the type of construction and the building age all determine whether deconstruction is appropriate. The case studies of three contemporary deconstruction organizations—Ouroboros, Re:purpose Savannah, RotorDC—examined business model structures, operational considerations and priorities in their work. Each organization has developed region-specific strategies tailored to the local urban fabric, as the materials harvested are shaped by each city's unique history and development. Deconstruction being a highly intensive labour work, economic viability is constantly addressed through efficient use of storage space, selective harvesting, and attention to the curation work for commerce. Aesthetics in this practice extends beyond the selection of materials during salvage work; it also serves as a tool to shift cultural attitudes towards second-hand materials thereby increasing commercial demand. While the low tipping fees, high minimum wages and the lack of a systematic procedure continue to limit reuse, we are witnessing a wave of regulatory changes across North America specific to deconstruction - a small yet crucial step for deconstruction work to make scaled impact.

In order to obtain a tangible understanding of available material assets embedded in our built fabric, an urban metabolism analysis was conducted within St. Catharines using issued building permits. This understanding re-enforced the ephemerality of architecture, while allowing buildings to be re-imagined as a repository of valuable materials. In the case all buildings currently registered for demolition under the city's permits were instead deconstructed, approximately 4,500 tonnes of materials can be salvaged, and re-introduced to the city's metabolism.

Material flows are in constant motion within our cities today, taking various forms. In the context of reuse, people tend to sell and purchase second-hand items off on-line platforms at an individual scale. On a much larger scale, materials are manufactured, distributed to home improvement stores, and sometimes re-enter the material ecology through second hand markets, or recycling facilities. Both examples, while capable of re-utilizing existing building resources, remain too subtle to make significant impact. A paradigm shift—from the modern linear construction economy to a circular one, from recycling to reuse, and from demolition to deconstruction—must be supported by a more radical tool: an infrastructure capable of streamlining the deconstruction process.

The ***Material Works,*** in the simplest form, is a infrastructural hub for facilitating circular economy work within the existing network of city's material flow. Agencies in the realm of education, contractor work, commerce and design were identified as key system-builders capable of reversing the now-standardized linear construction. While practioners globally advocate for circularity, the thesis imagines these rather independent agencies to co-exist in one physical site where the optimization of material circularity bridges these programs as their collective central motif.

Every aspect of the design: including the treatment of the existing (adaptive reuse), programming (assigning key agencies in circularity work), material choice (implementation of salvaged materials), and courtyard configuration, embody material circularity, envisaged to cultivate through collaborative initiative. From training contractors in deconstruction to handling and processing salvaged materials, commercializing these materials, and advancing research on their reapplication, Material Works' aims to influence the city's economic and social development around, and through, material reuse. With this speculation of the future where deconstruction and reuse replaces demolition, secondary materials are given a new narrative in which aesthetics is not compromised, rather, experimented with to reinstate the value of salvaged materials.

From tracing its history of a forgotten practice shadowed by the 21st-century obsolescence ideologies, material optimization through reuse remains a significant avenue for a sustainable architectural future—one that recognizes and remembers the past, and resists the erasure of the urban fabric.

APPENDICES

A. **Training Manual**
B. **Initial Sketches**
C. **Model Photos**
D. **Conference Notes**
E. **Deconstruction Experience**
F. **Final Presentation**

A. Training Manual

The *Training Manual: HANDLING DECONSTRUCTED MATERIALS* was created as an example of a training module that could be used as the main textbook at Material Works. The book presents guidance and practical safety measures to be taken at any reuse-facility. Such practice structure contributes to the development of training/education curriculum for handling deconstructed materials which as of the current year, 2025, is yet to exist in Canada.

Just like any typical fieldwork, handling deconstruction materials requires precision, safety, and technical expertise to execute the work, upon training. Proper training is essential, as working with materials involves handling hazardous substances, working at heights, and use of specialized equipment. Workers must be proficient in hazard identification, personal protecting equipment (PPE) usage, and site-specific protocols. Exposure risks to asbestos, concrete dust, and other toxic chemicals necessitates compliance with safety regulations.

Operating specialized tools and heavy machinery, as well as handling large materials, demands skill and certification. Training covers hand tools, fastener removal systems, de-nailing, and machinery such as forklifts, telehandlers, and overhead crane, ensuring efficiency and compliance with licensure requirements.

This manual serves as a comprehensive guide to best practices, technical knowledge, and safety standards in handling deconstruction materials.

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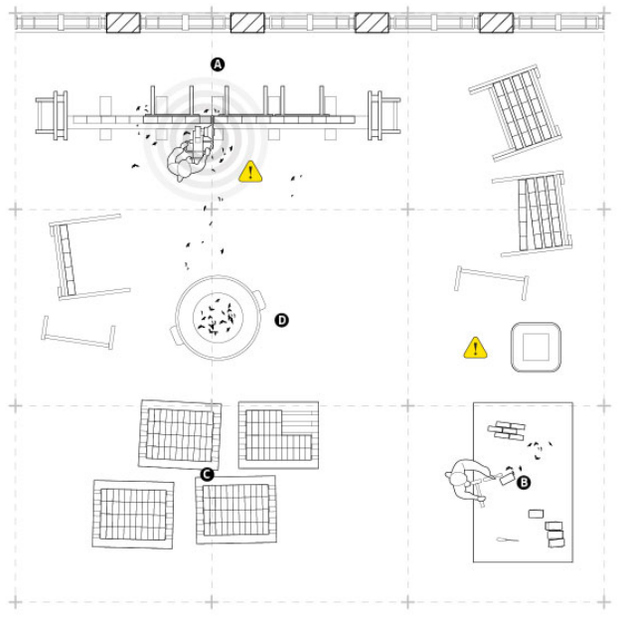
Meredith Moore (Ouroboros Deconstruction)

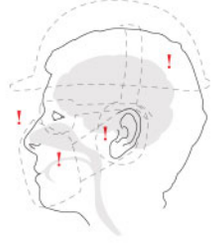
Sources:
Forklift with small turning radius and its efficiency (Journal of Physicals: Conference Series), 2022
Introduction to Deconstruction: A Comprehensive Training Textbook (BMRA), 2017.
PARTS MANUAL for VR522/524 Telescopic Material Handler, 1997
https://www.craneskit.com
https://www.ford.ca
https://www.unitedequipment.com.au
https://www.catlifttruck.com
https://warehousewiz.com
https://www.lxhausys.com
https://archi-monarch.com
https://catalog.uline.ca

TRAINING MANUAL:

HANDLING DECONSTRUCTED MATERIALS

Volume 1.





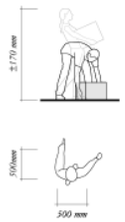
MATERIAL WORKS

A Human

Weight Capacity	*±80kg*
	±170lbs
Height Capacity	2000mm

Shelving / Transport

*Req. cert: N/A

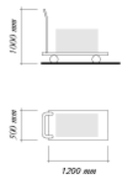


B Carts

Weight Capacity	*900kg*
	2000lbs
Height Capacity	N/A

Shelving / Transport

*Req. cert: N/A

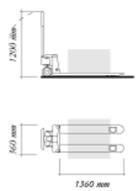


C Pallet Jack

Weight Capacity	*2500kg*
	5500lbs
Height Capacity	N/A

Shelving / Transport

*Req. cert: N/A

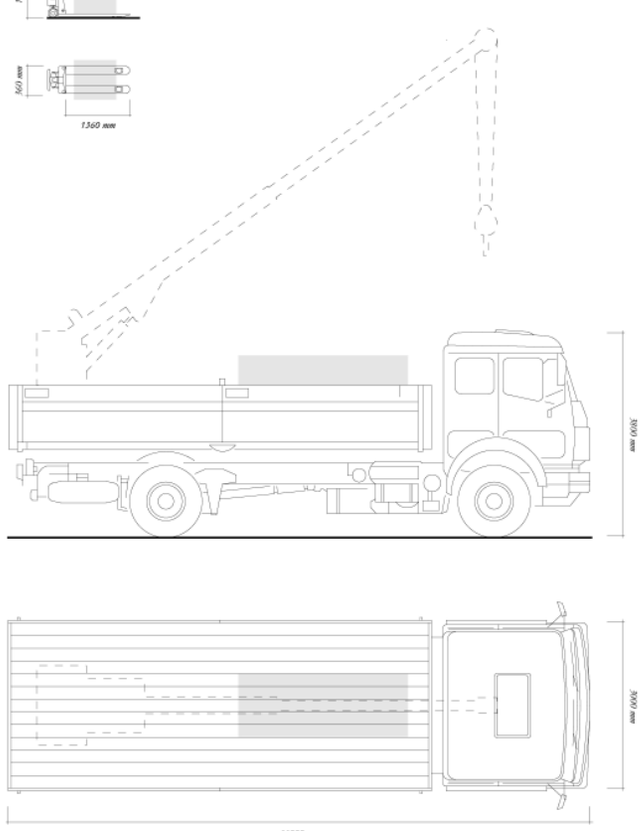


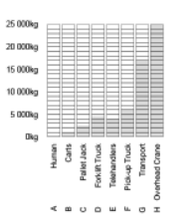
G Transport

Weight Capacity	*17000kg*
	37000lbs
Height Capacity	N/A

Shelving / Transport

*Req. cert: Class G / Class A / Class D



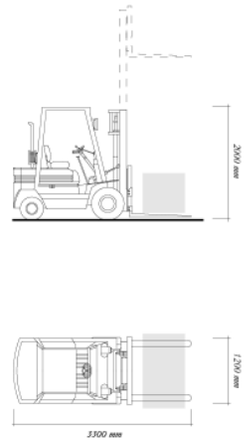


D Forklift Truck

Weight Capacity	*4500kg*
	10000lbs
Height Capacity	3000mm

Shelving / Transport

*Req. cert: Training and certification

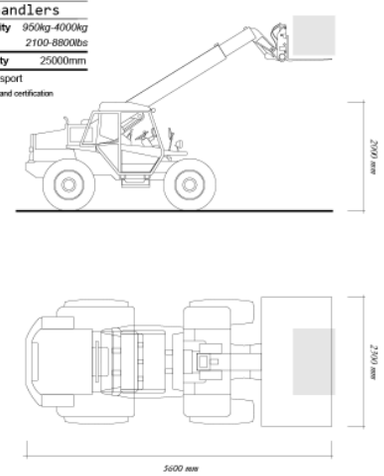


E Telehandlers

Weight Capacity	*950kg-4000kg*
	2100-8800lbs
Height Capacity	25000mm

Shelving / Transport

*Req. cert: Training and certification

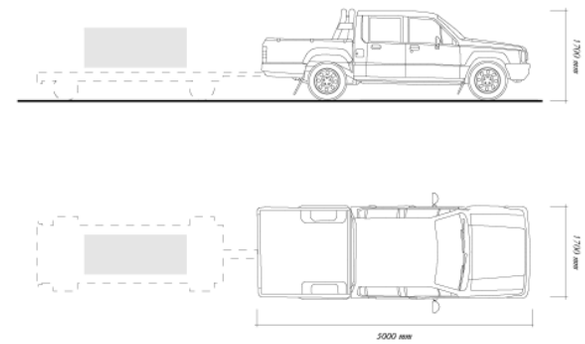


F Pick-up Truck

Weight Capacity	*6100kg*
(including towing)	*13500lbs*
Height Capacity	N/A

Shelving / Transport

*Req. cert: Class G

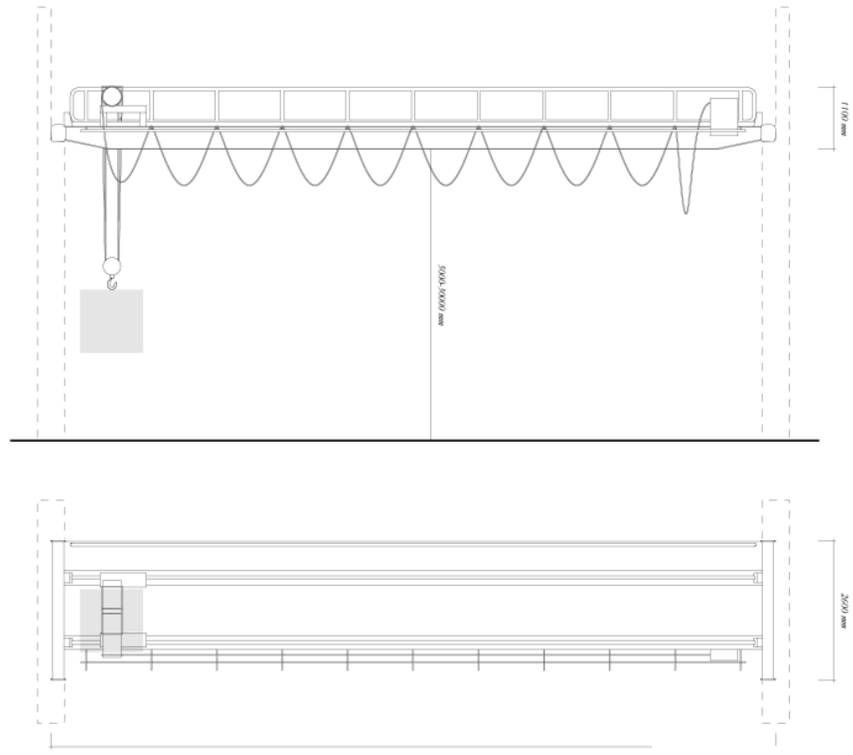


H Overhead Crane

Weight Capacity	*25000kg*
	55000lbs
Height Capacity	30000mm

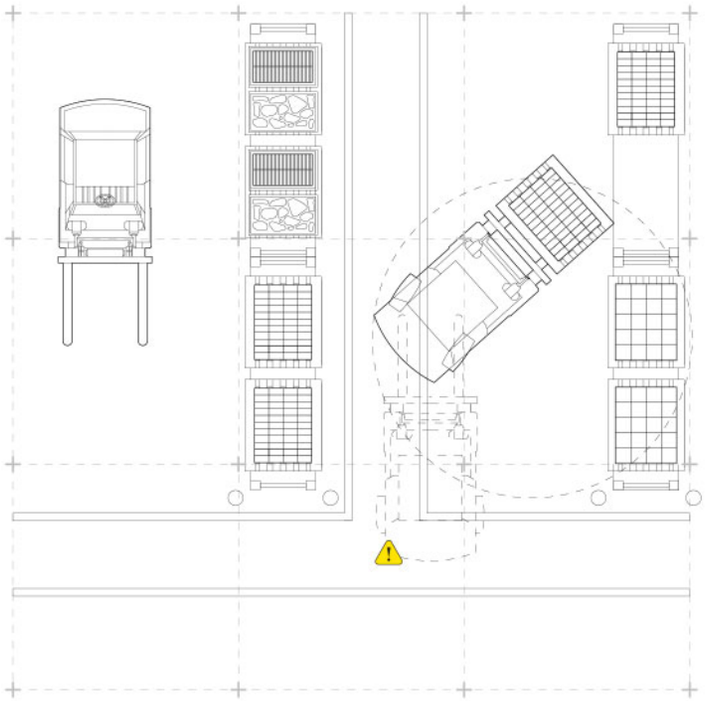
Shelving / Transport

*Req. cert: Training and certification

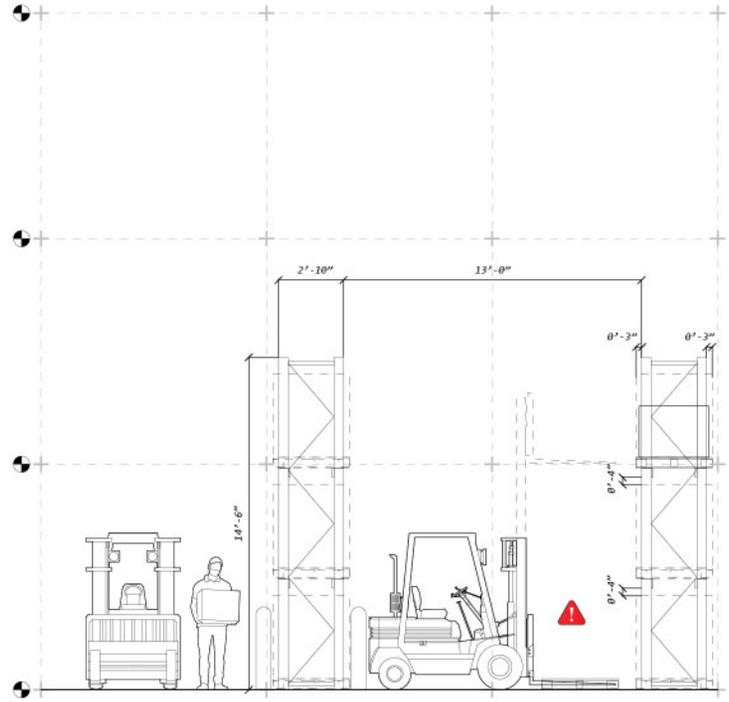


STORAGE - TYPE. A

PLAN



ELEVATION

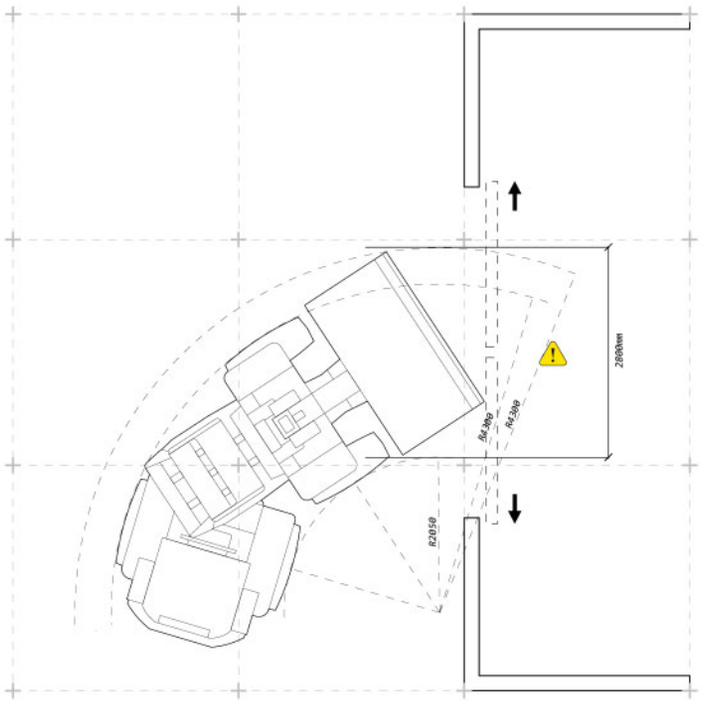


GENERAL HAZARDS:
1. Heavy traffic area of both workers and equipment

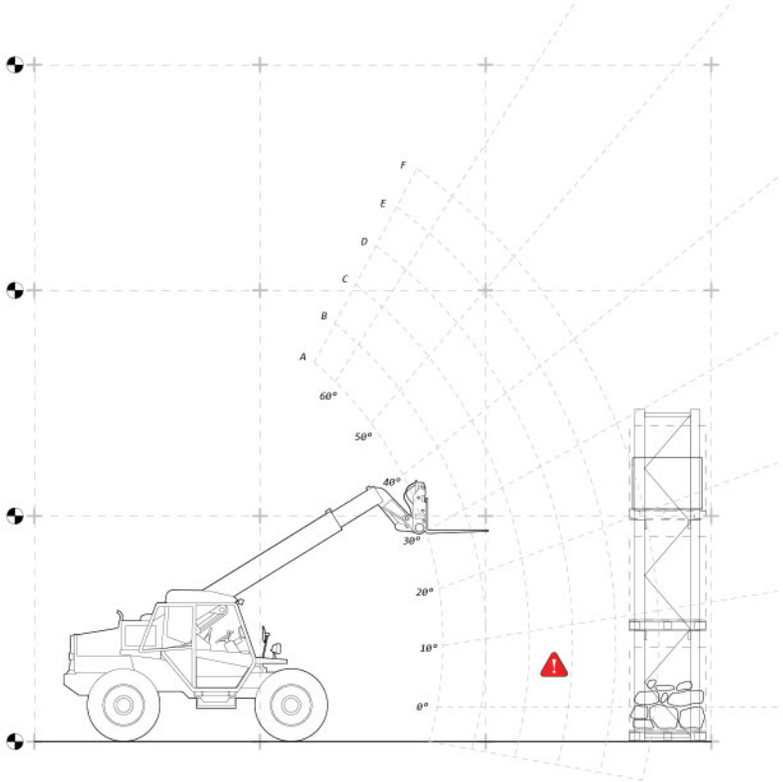
CATIOUNARY ZONES:
1. Look both ways when exiting aisles

STORAGE - TYPE. B

PLAN



ELEVATION

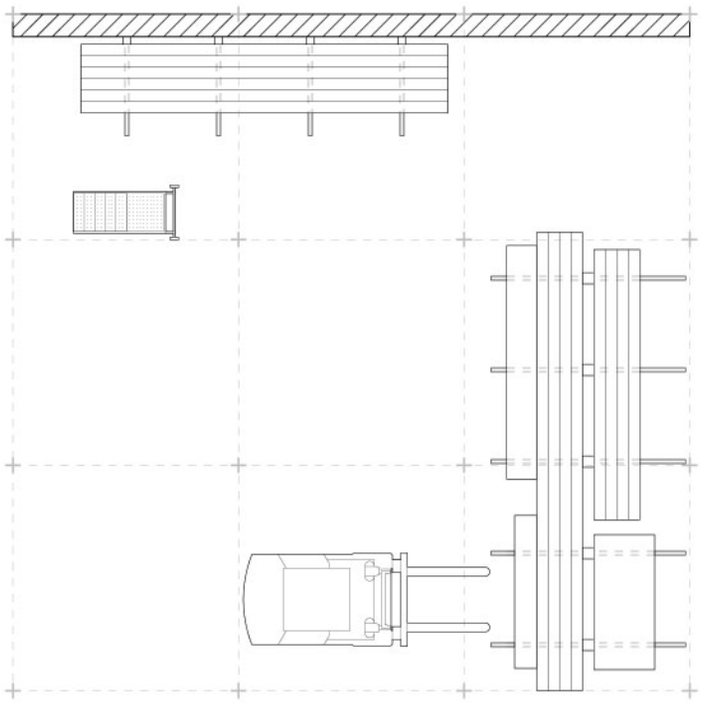


GENERAL HAZARDS:
1. Telehandlers are able to extend in both X and Y-axis, therefore, requires great clearance when in motion

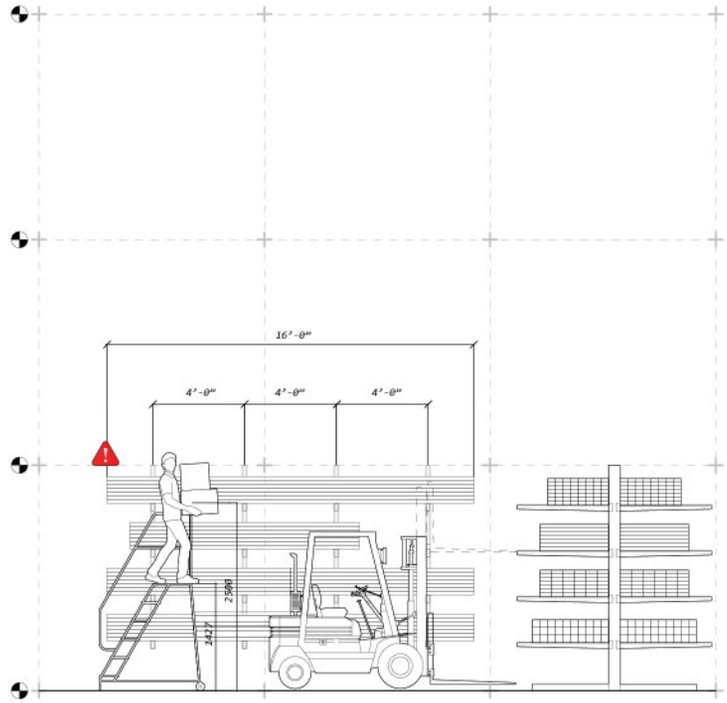
CATIOUNARY ZONES:
1. Clear entry ways for incoming vehicles

STORAGE - TYPE. C

PLAN



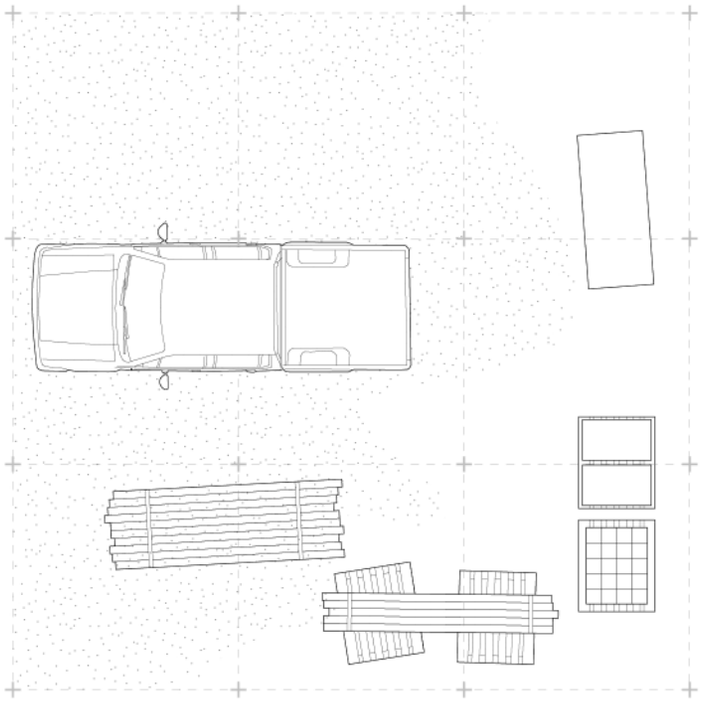
ELEVATION



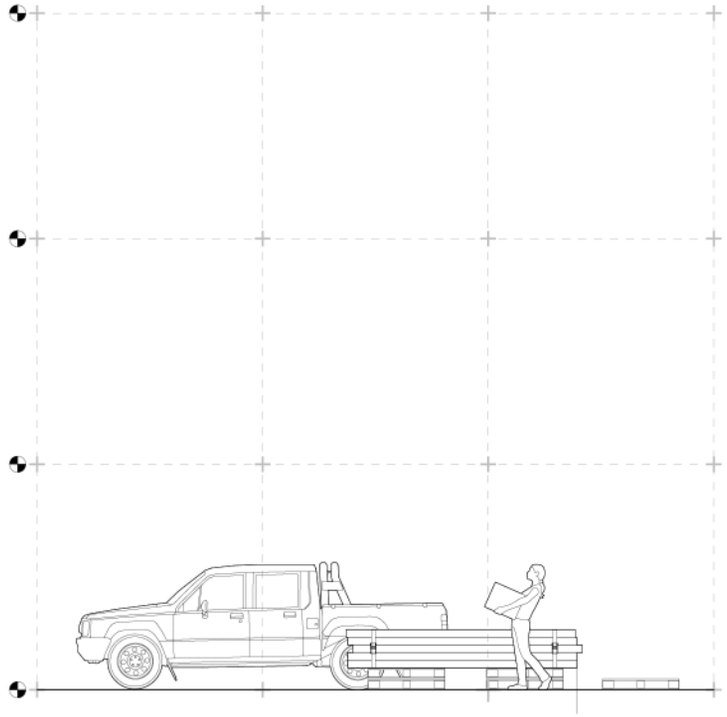
GENERAL HAZARDS:
1. Fall hazard when reaching high shelving

MATERIAL TRANSFER/PACKAGING

PLAN

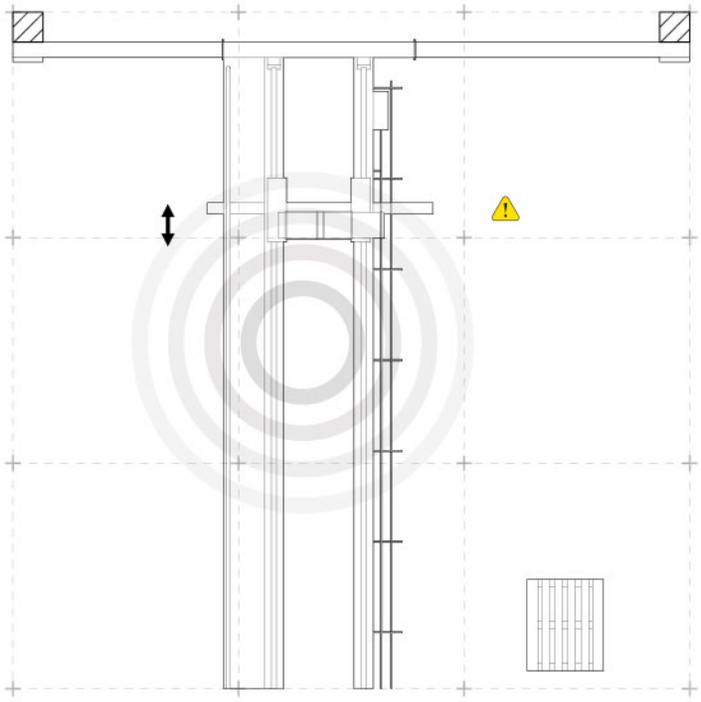


ELEVATION

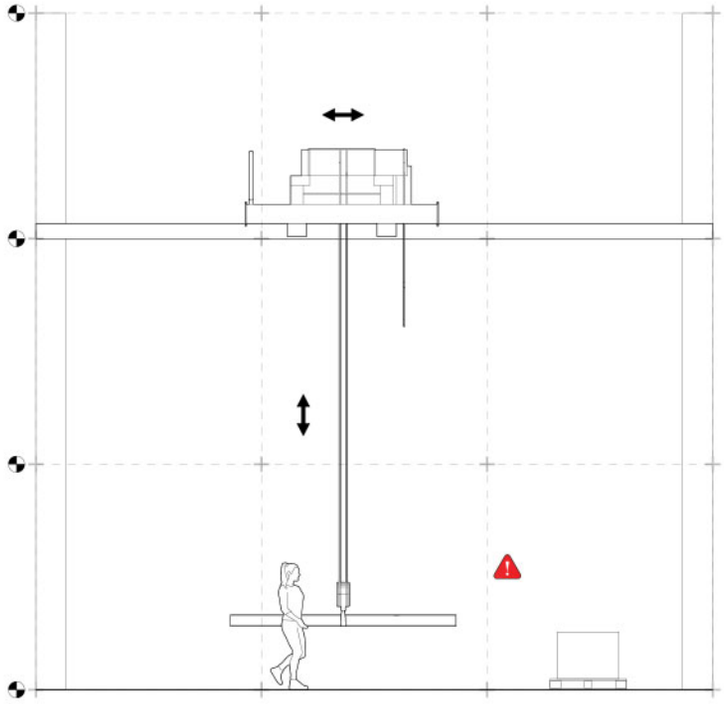


MATERIAL TRANSFER (XL)

PLAN



ELEVATION

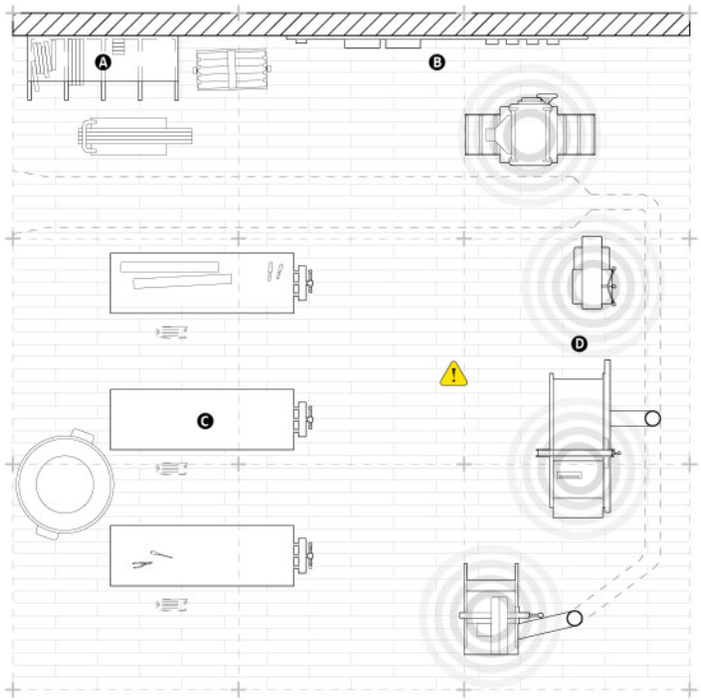


GENERAL HAZARDS:
1. EOT capable of moving large and heavy materials active

CATIOUNARY ZONES:
1. Path of EOT to be clear at ground level

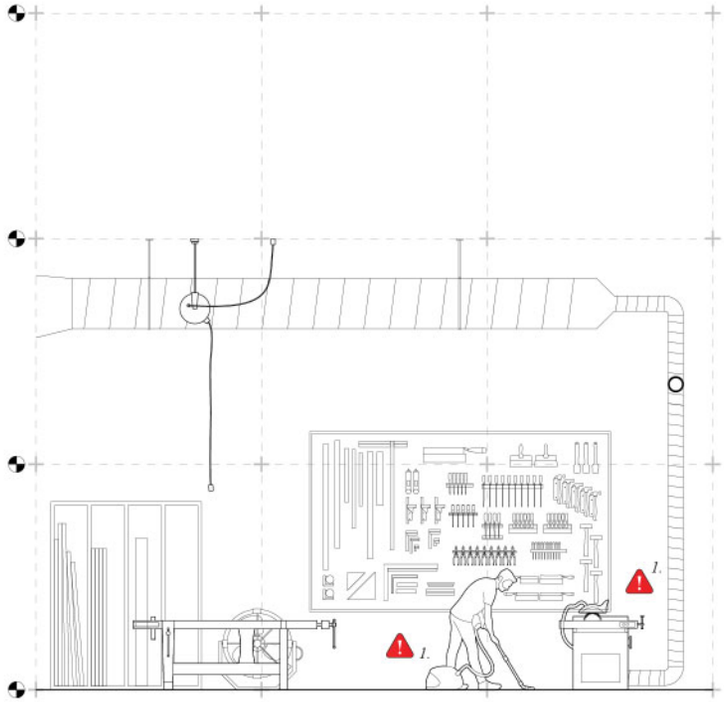
WOOD-SHOP

PLAN



STATIONS:
A. Storage
B. Tool shelf
C. Work bench
D. Shop machinery
(planer / drill press /
sliding table saw /
band saw / etc)

ELEVATION



GENERAL HAZARDS:
1. Large powertools: to be never left unattended
2. Collection of saw dust on floor: to be maintained clean

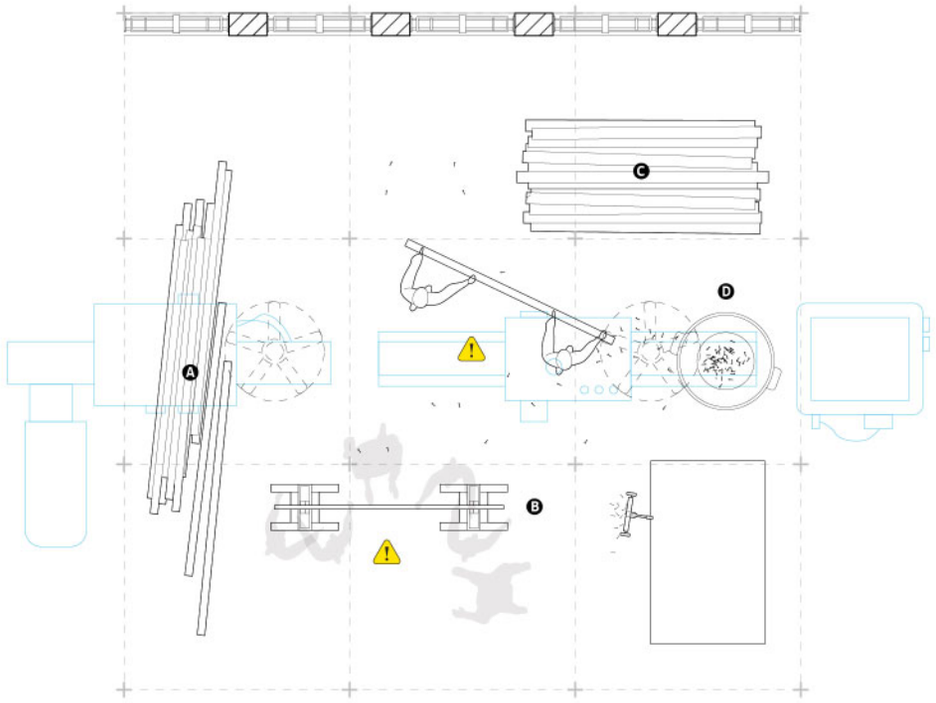
AREAS TO PROTECT:
1. Eyes
2. Repository systems
3. Ears

CATIOUNARY ZONES:
1. Main machining area

SAFETY MEASURES (PPE):
- Mask
- Headphones
- Saftey glasses

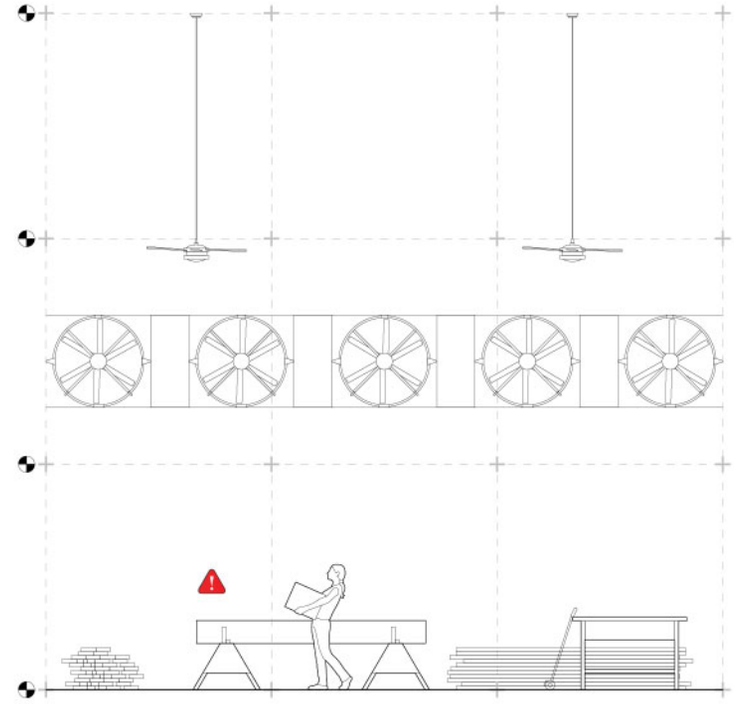
MATERIAL PROCESSING AREA - LUMBER

PLAN



STATIONS:
A. Pre-processed lumber
B. De-nailing
C. Post-processed lumber
D. Nail/debris disposal

ELEVATION



GENERAL HAZARDS:
1. Denailing by hand with pry bars and hammers can lead to unexpected release of nails. Safety measures to be taken to protect face

AREAS TO PROTECT:
1. Eyes

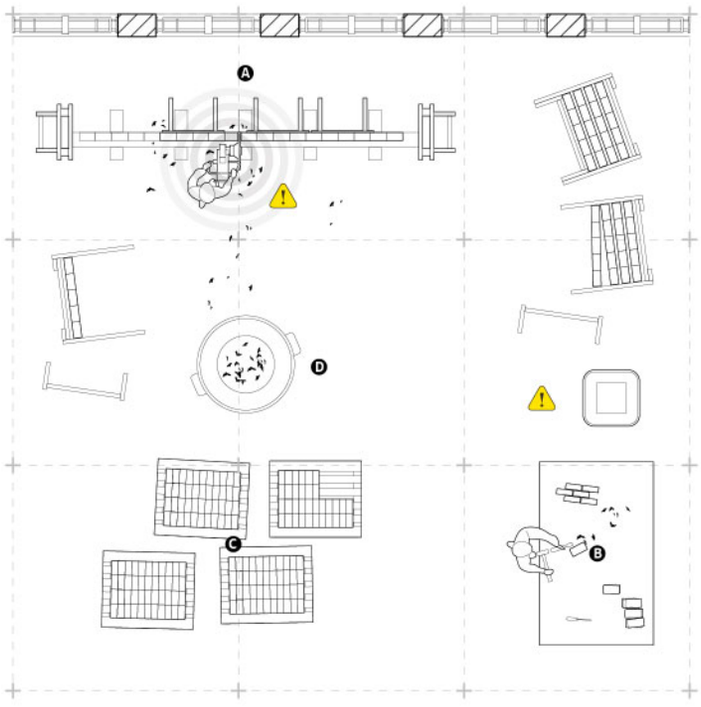
CATIOUNARY ZONES:
1. Denailing area
2. Circulation (ensure there's enough room to turn while moving long wood members)

SAFETY MEASURES (PPE):
- Saftey glasses
- Steeltoe boots

OPPORTUNITIES:
- Introduction of robotic system capable of streamlining the process of inspection and removal of nails (ex: Urabn machine)

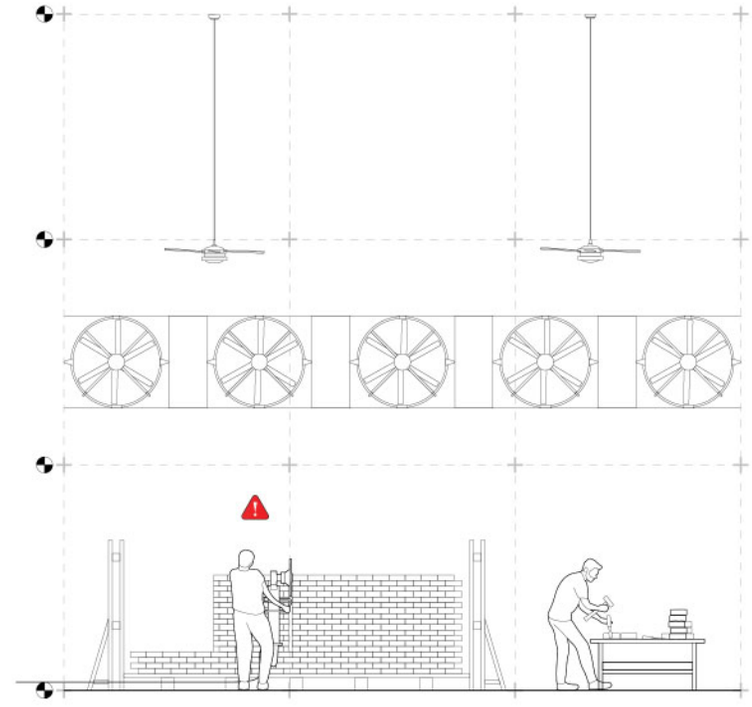
MATERIAL PROCESSING AREA - BRICK

PLAN



STATIONS:
A. Panelization of pre-processed bricks
B. Mortar removal (hand-tools + chemical)
C. Post-processed bricks
D. Mortar/debris disposal

ELEVATION



GENERAL HAZARDS:
1. Mortar removal, both with power-tool or by hand, release fine powder that is harmful. Using hand-helf circular saw on brick wall can result in small, sharp brick pieces to fly out. Safety measured to be taken not to inhale, consume or get in eyes.

AREAS TO PROTECT:
1. Eyes
2. Repository systems
3. Ears
4. Head

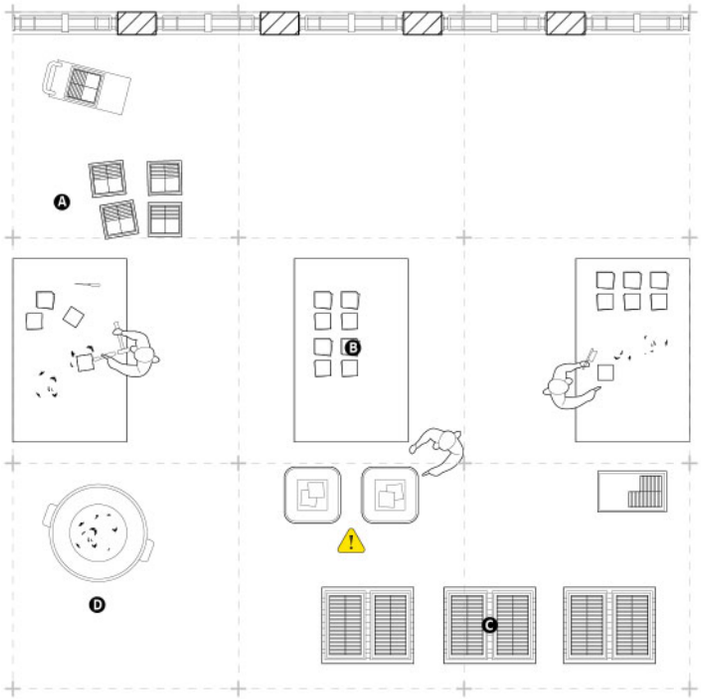
CATIOUNARY ZONES:
1. Main machining area
2. Toxic mortar dissolver

SAFETY MEASURES (PPE):
- Safety helmet
- Mask
- Headphones
- Saftey glasses
- Steel toe boots

OPPORTUNITIES:
- Introduction of robotic system capable of streamlining the process of removing mortar and cleaning of bricks

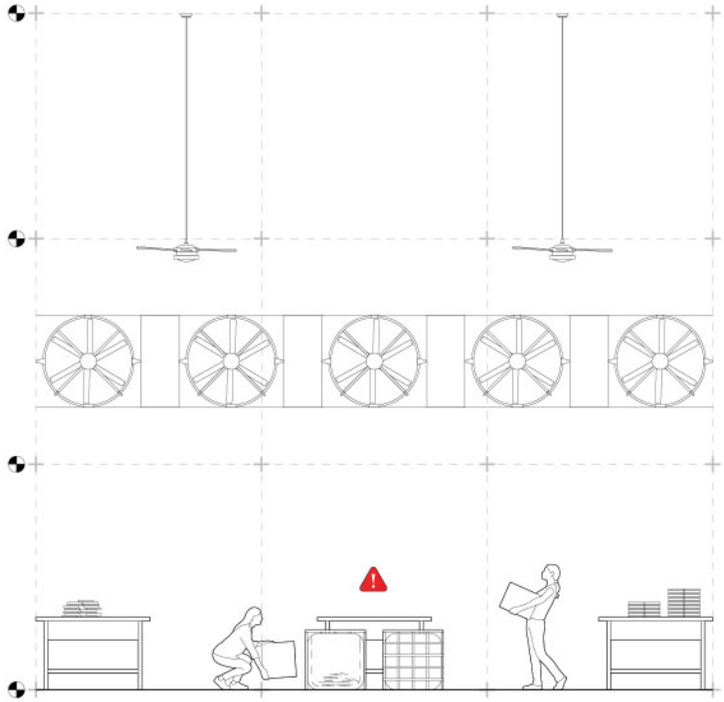
MATERIAL PROCESSING AREA - TILE

PLAN



STATIONS:
A. Pre-processed tiles
B. Mortar removal
(hand-tools + chemical)
C. Post-processed tiles
D. Mortar/debris disposal

ELEVATION



GENERAL HAZARDS:
1. Toxic mortar dissolver used. Saftey measured to be taken to avoid inhale, contact with skin or eyes

AREAS TO PROTECT:
1. Eyes
2. Repository systems

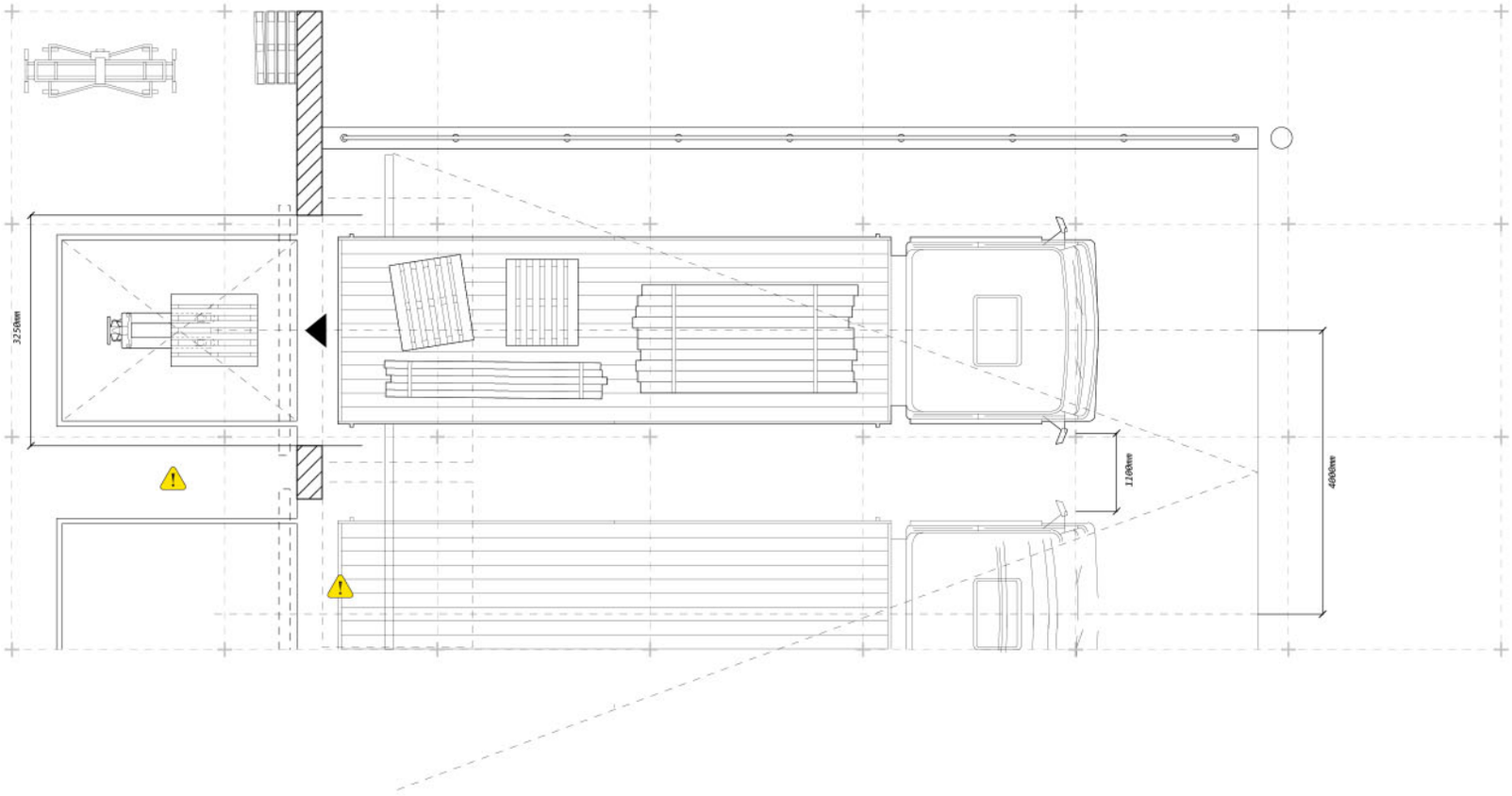
CATIOUNARY ZONES:
1. Eyewear to be worn - nails filying
2. Toxic mortar dissolver

SAFETY MEASURES (PPE):
- Mask
- Saftey glasses
- Steel toe boots

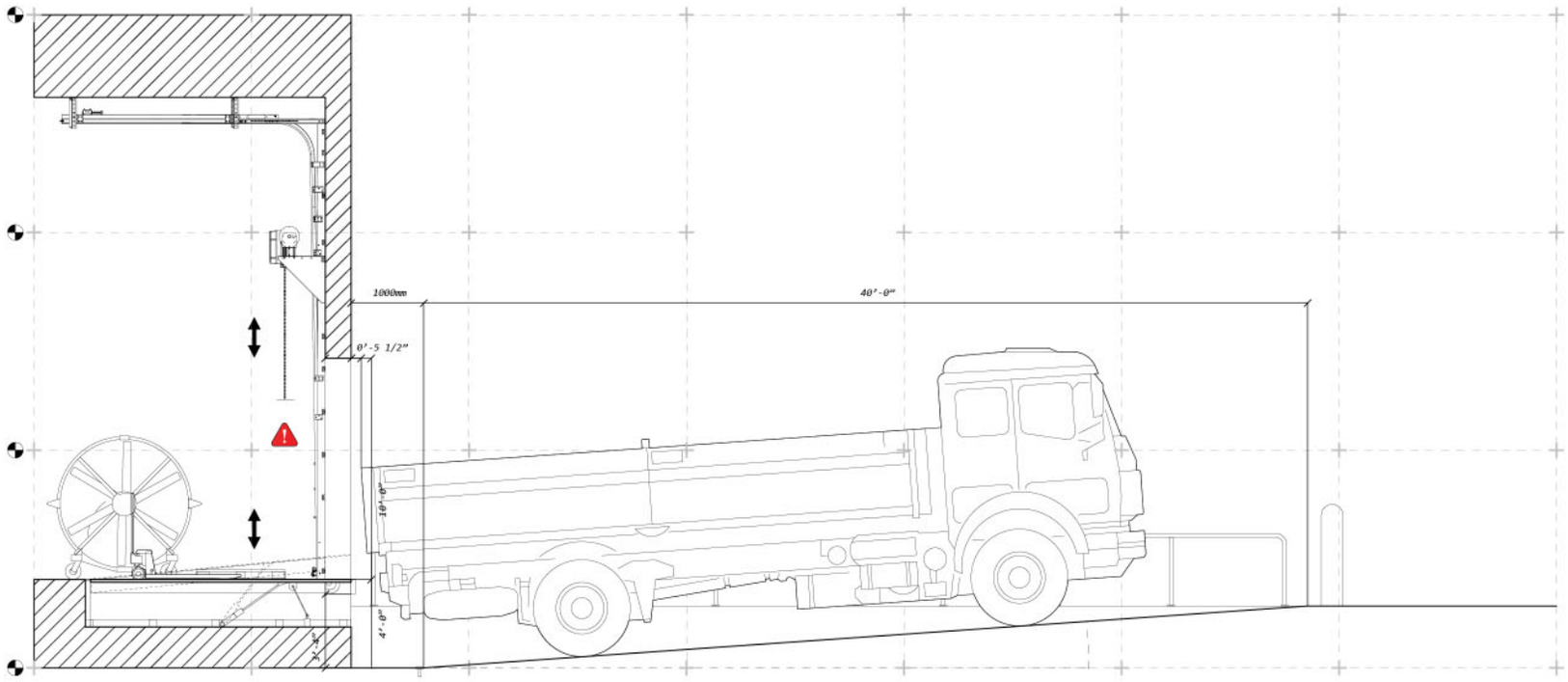
OPPORTUNITIES:
- Introduction of robotic system capable of streamling the process of removing mortar and cleaning of tiles

LOADING/UNLOADING

PLAN



ELEVATION



GENERAL HAZARDS:
1. Fall hazard due to level change from interior to exterior

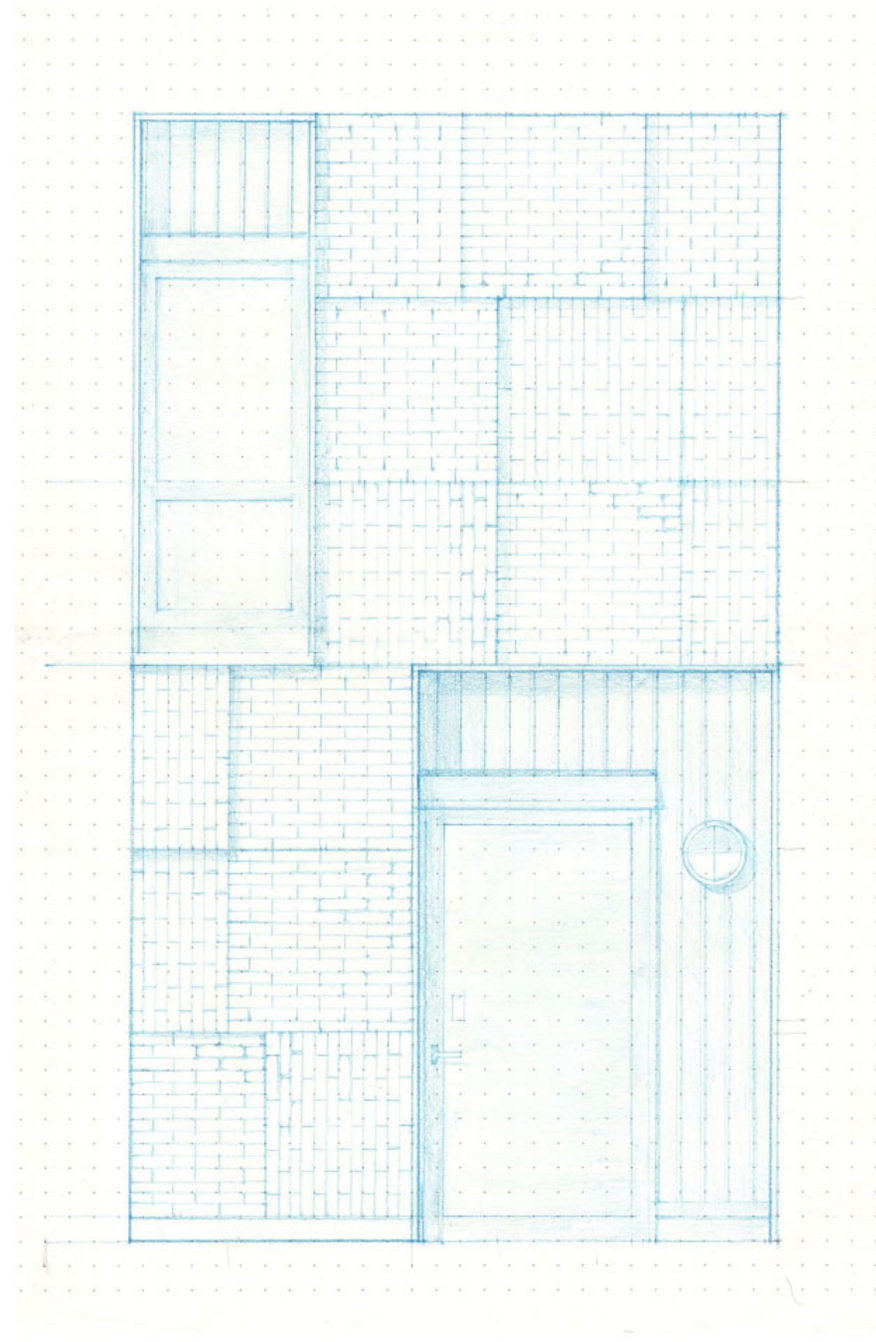
CATIOUNARY ZONES:
1. Loading/unloading areas to maintain clearance to avoid overcrowding of materials, equipments and people

B. Initial Sketches

The initial design development involved numerous sketches and hand-crafted drawings, both to communicate the architectural vision and develop a profound understanding of materials aesthetics.

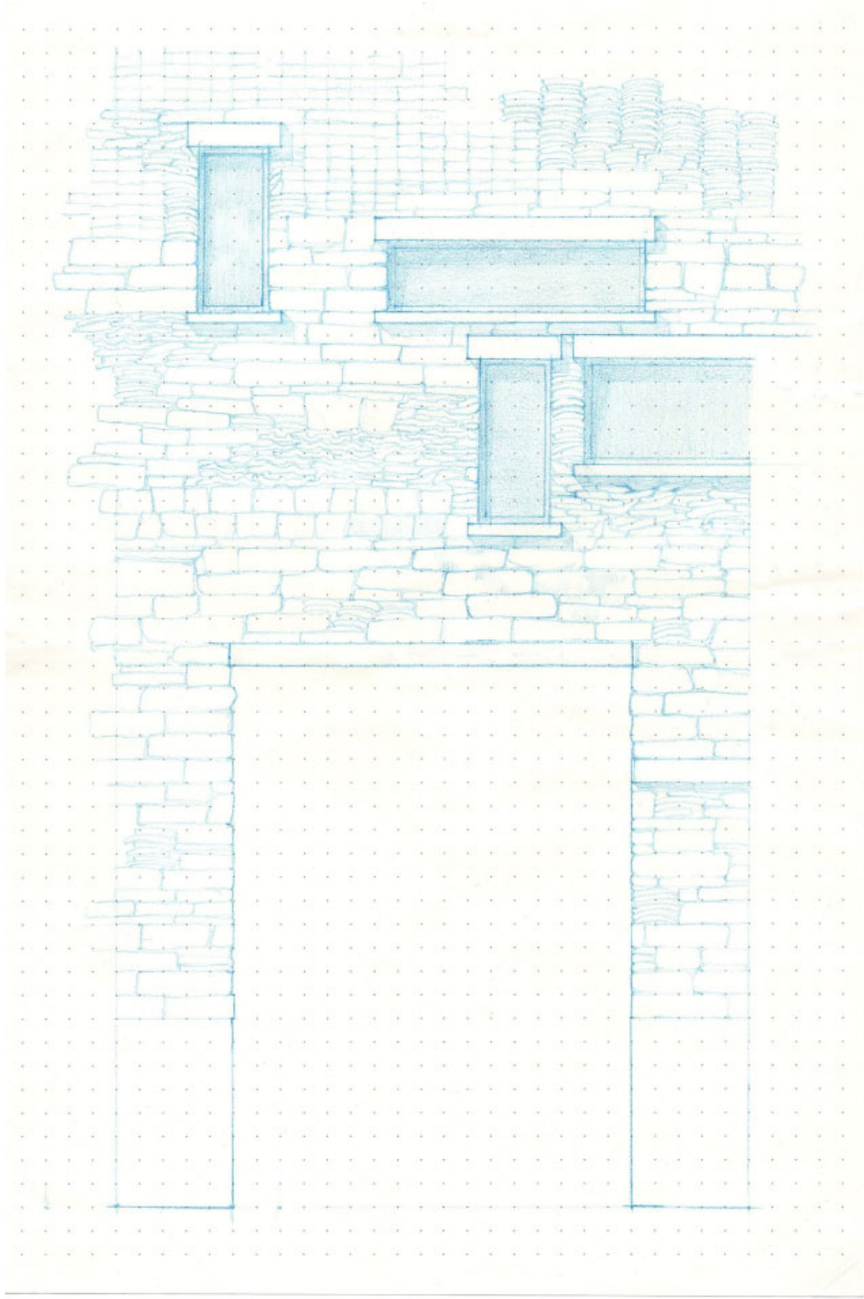
Resources Row Housing (Lendager Group)
Partial facade drawing

Materials: Reused 1m x 1m brickwork panels from abandoned rural houses.



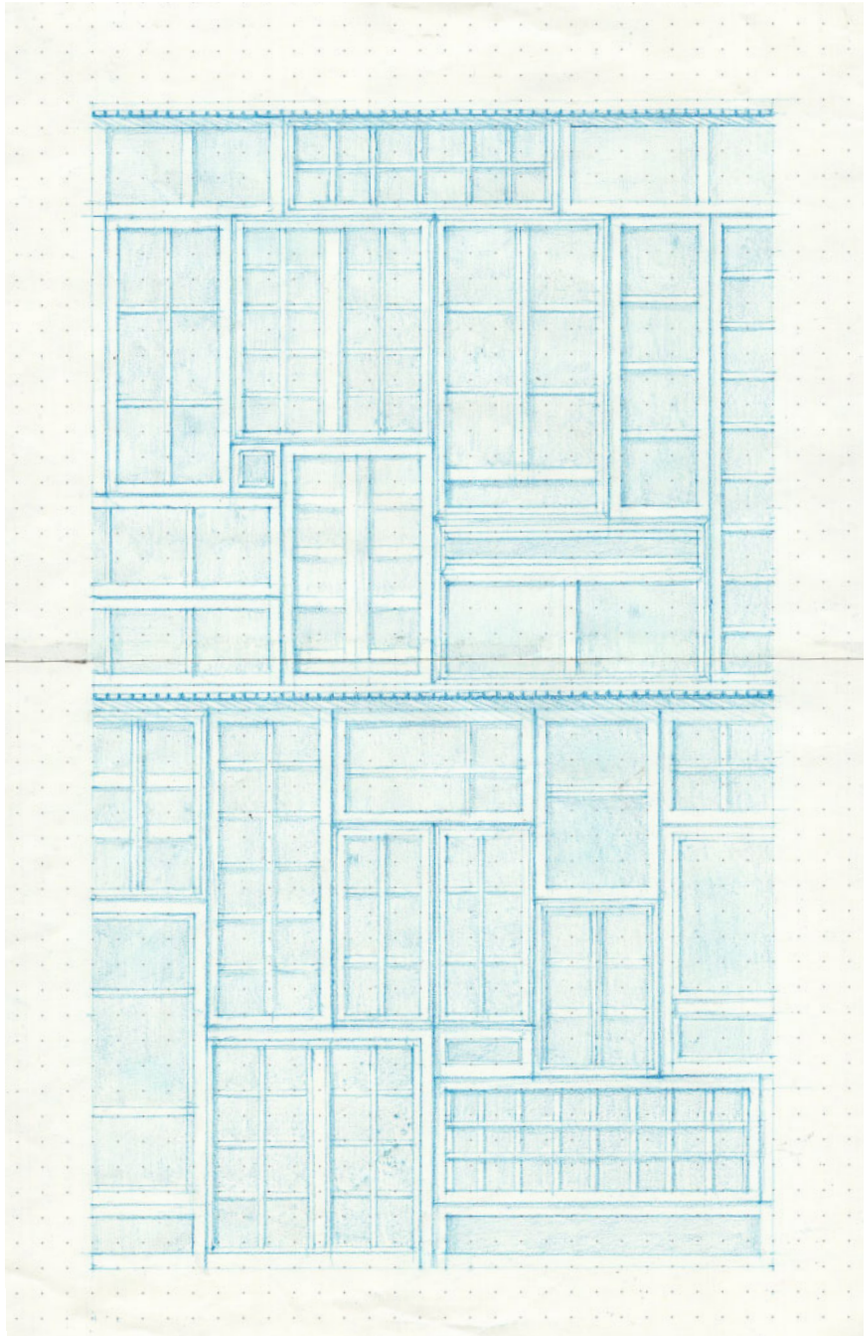
Ningbo Museum
(Wang Shu)
Partial facade drawing

Materials: salvaged masonry parts (tiles, bricks, etc) from local villages.

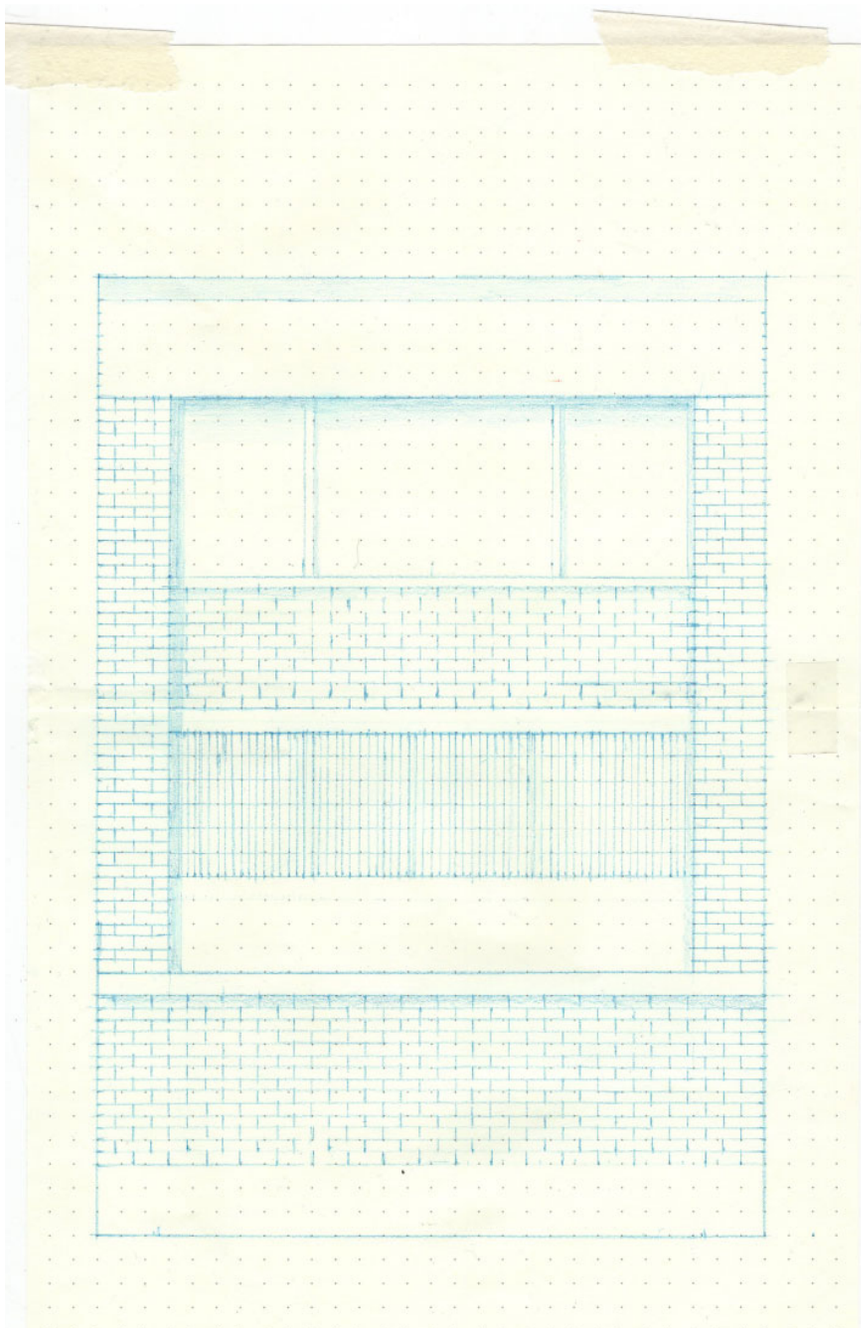


Headquarters of the European Council and Council of the European Union (Philippe Samyn and Partners architects & engineers, Studio Valle Progettazioni architects, Buro Happold Ltd engineers)
Partial facade drawing

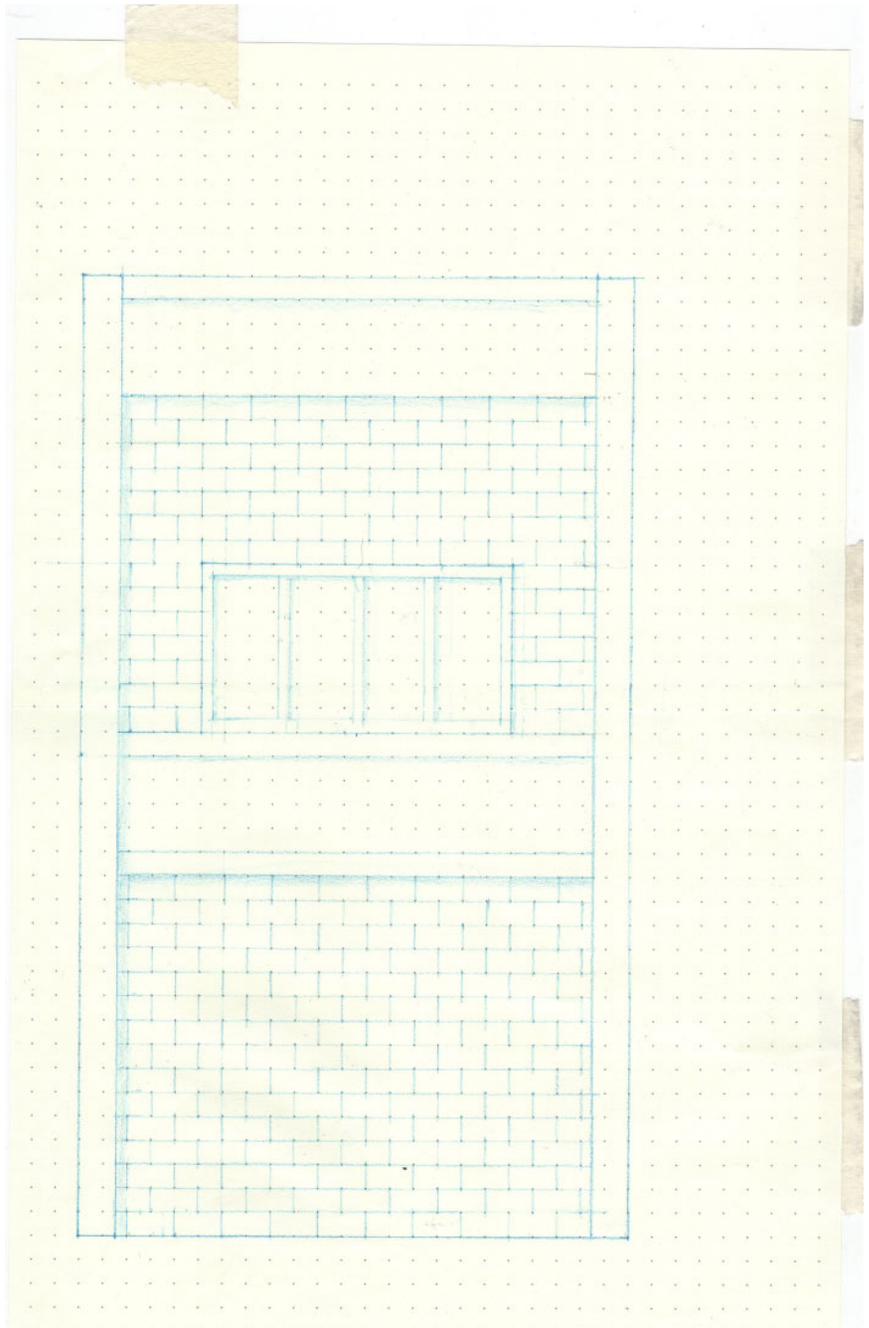
Materials: repurposed old windows soured from various European countries.



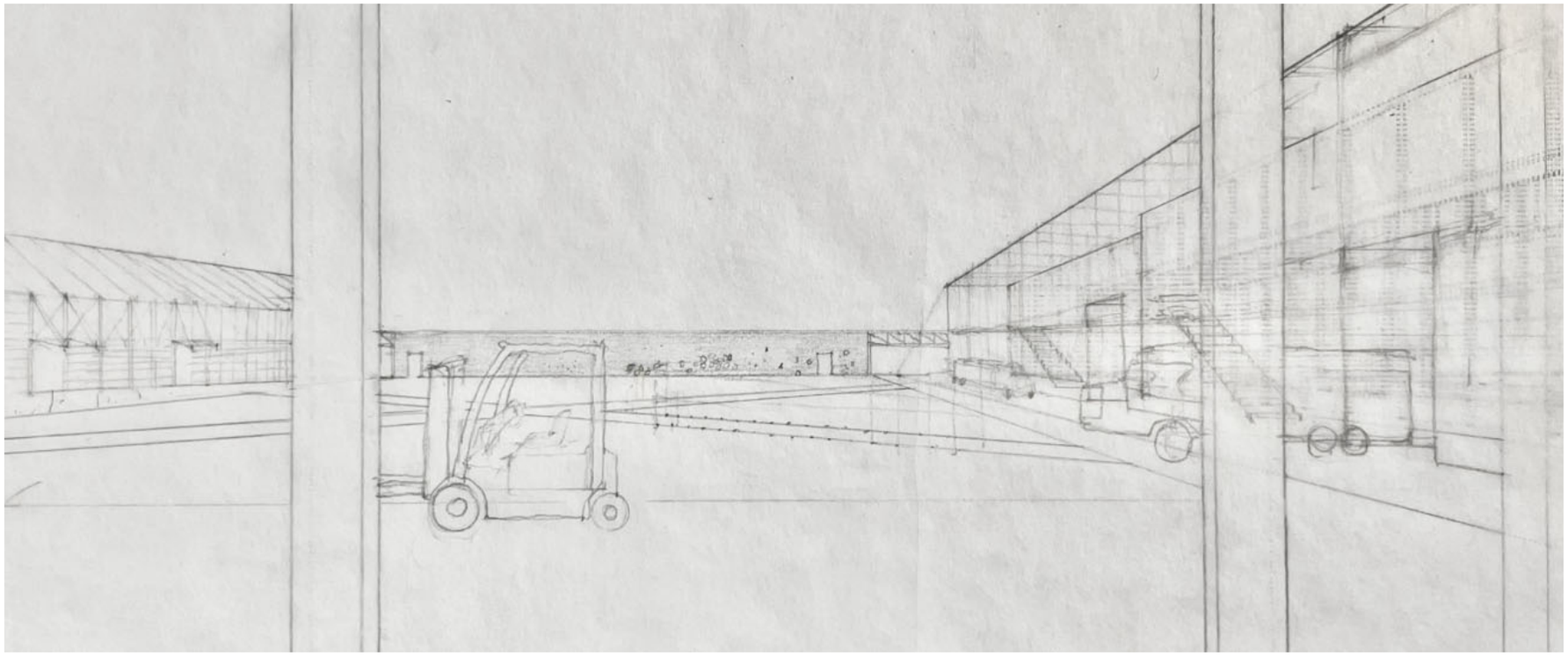
EXISTING GM PLANT STRUCTURE
Partial east elevation

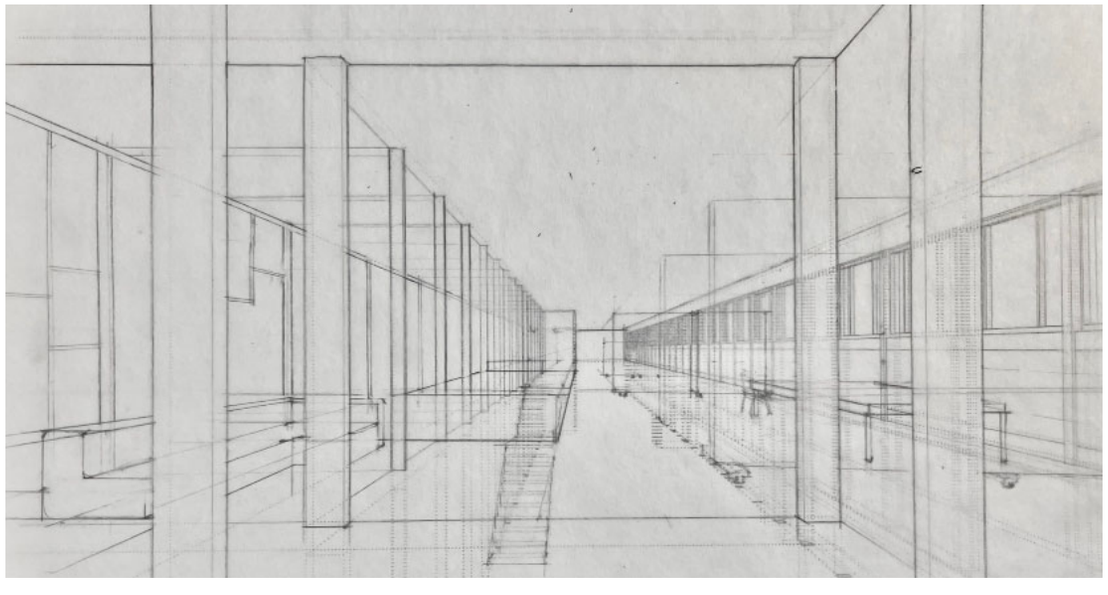


EXISTING GM PLANT STRUCTURE
Partial south elevation

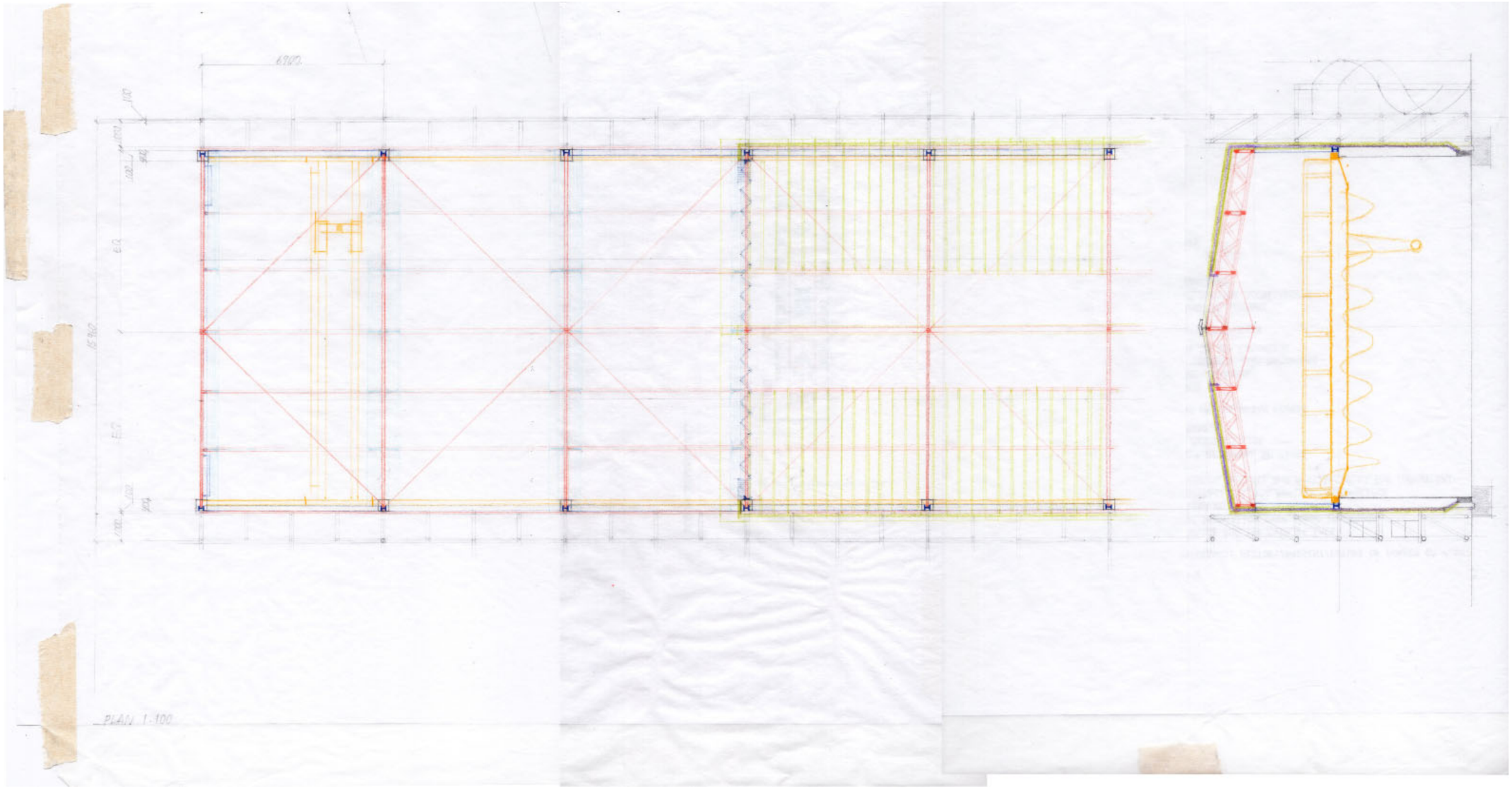


COURTYARD (TOP)
CLASSROOM (BOTTOM)
Initial sketches

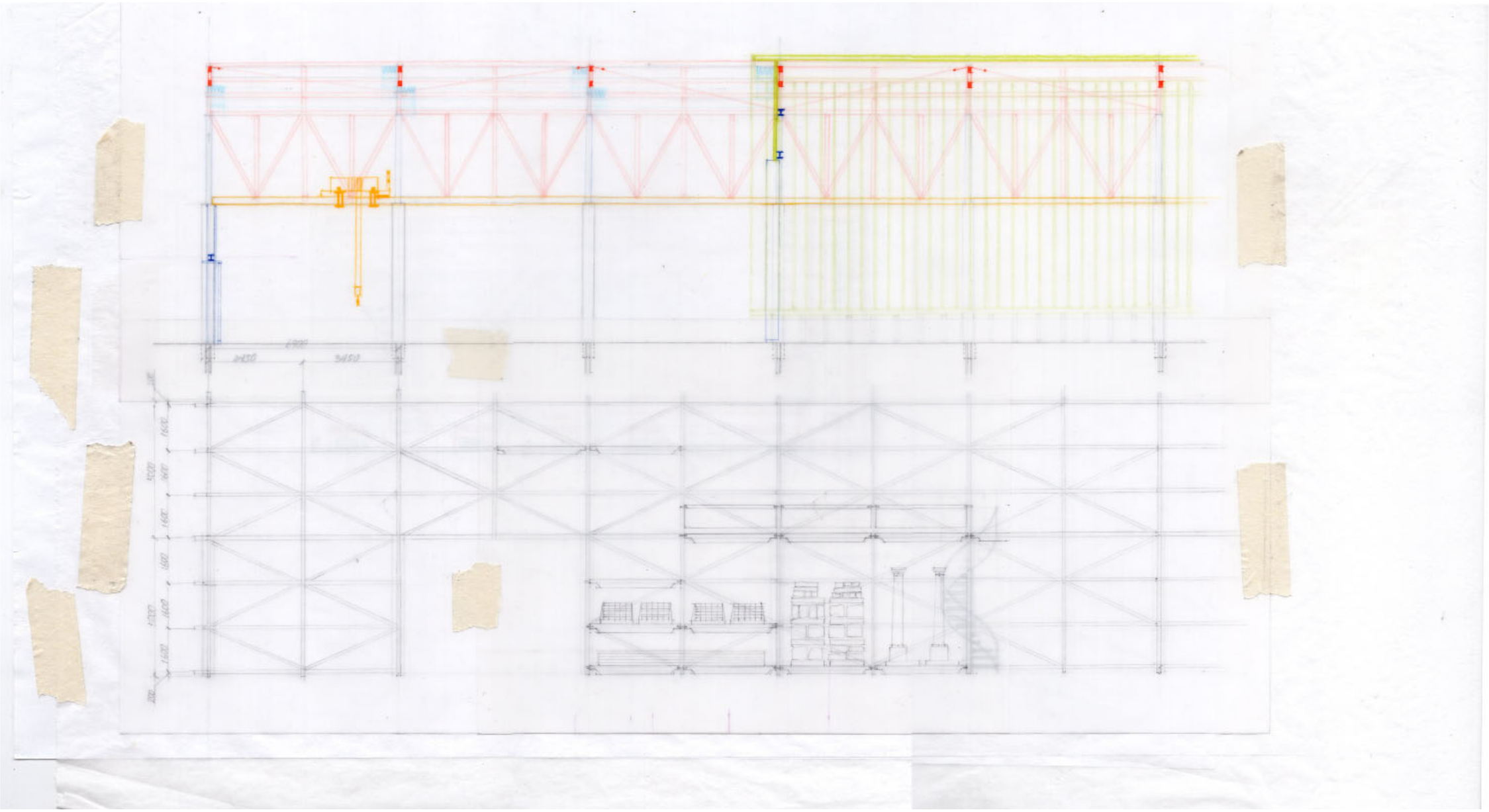




WAREHOUSE
Typical plan and section



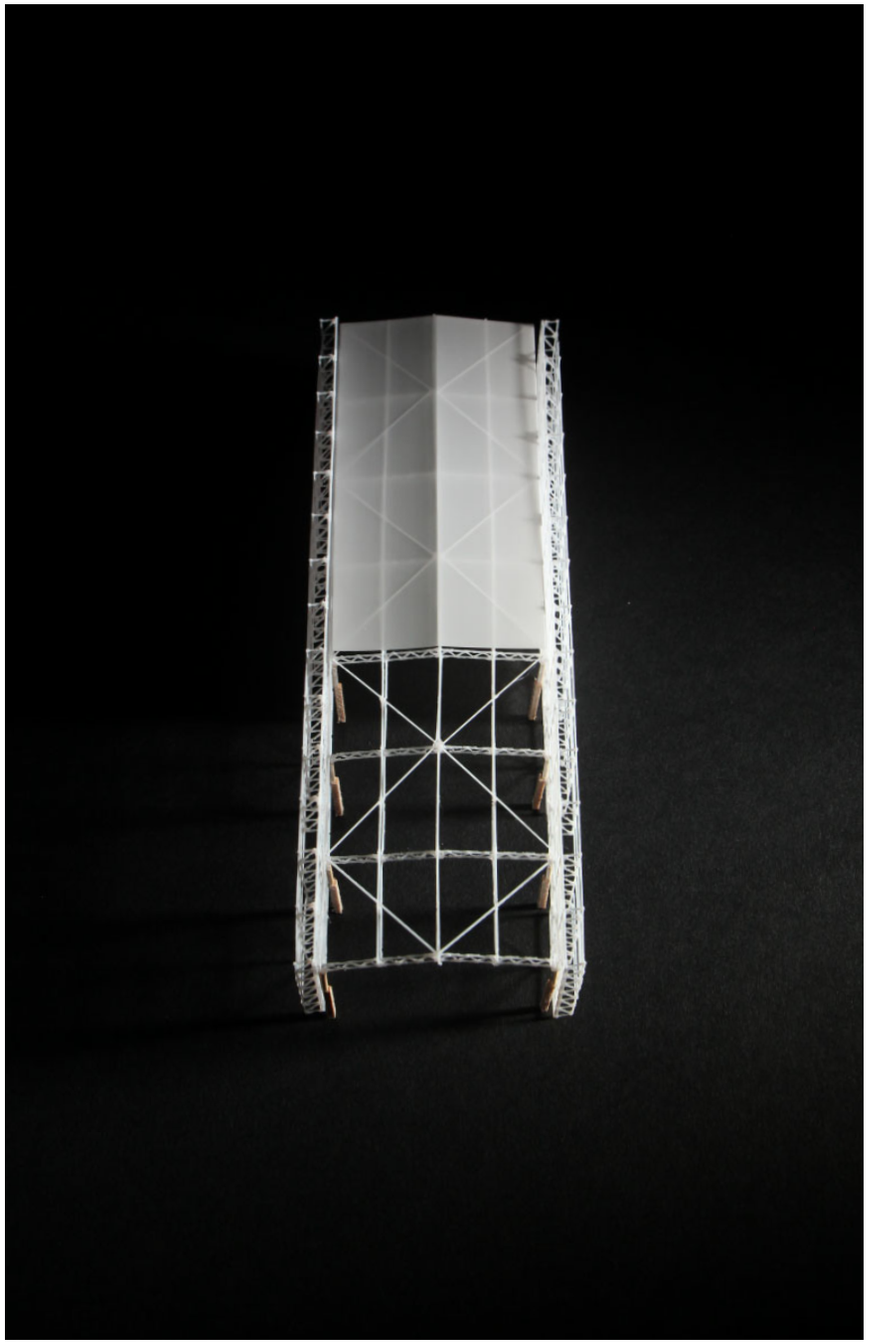
WAREHOUSE
Typical elevation and section

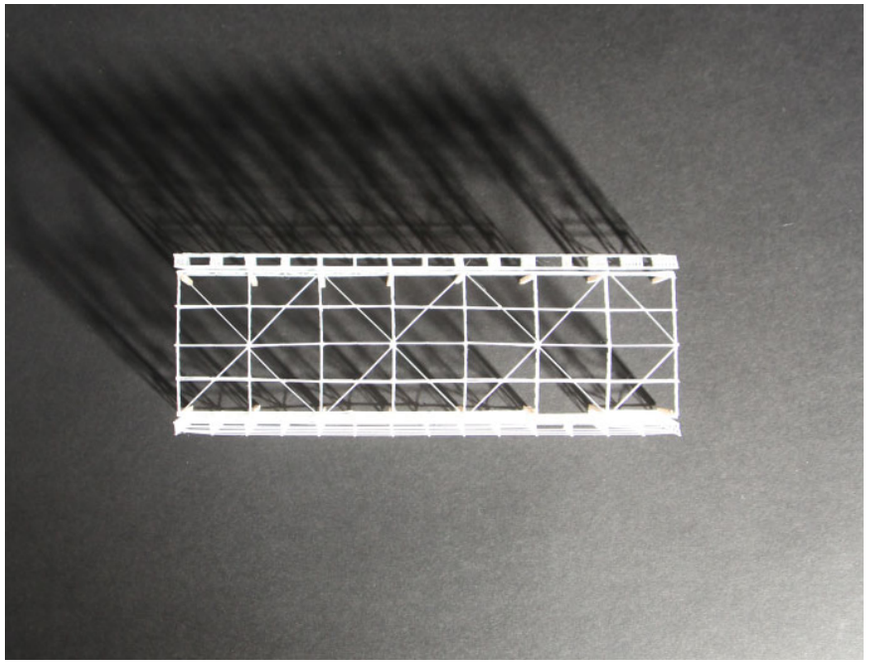


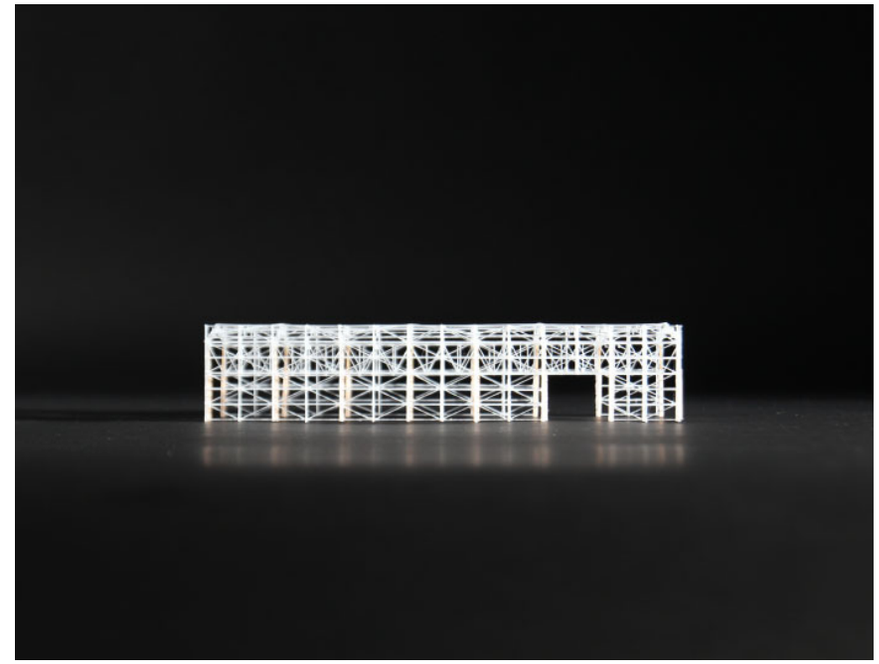
C. Model Photos

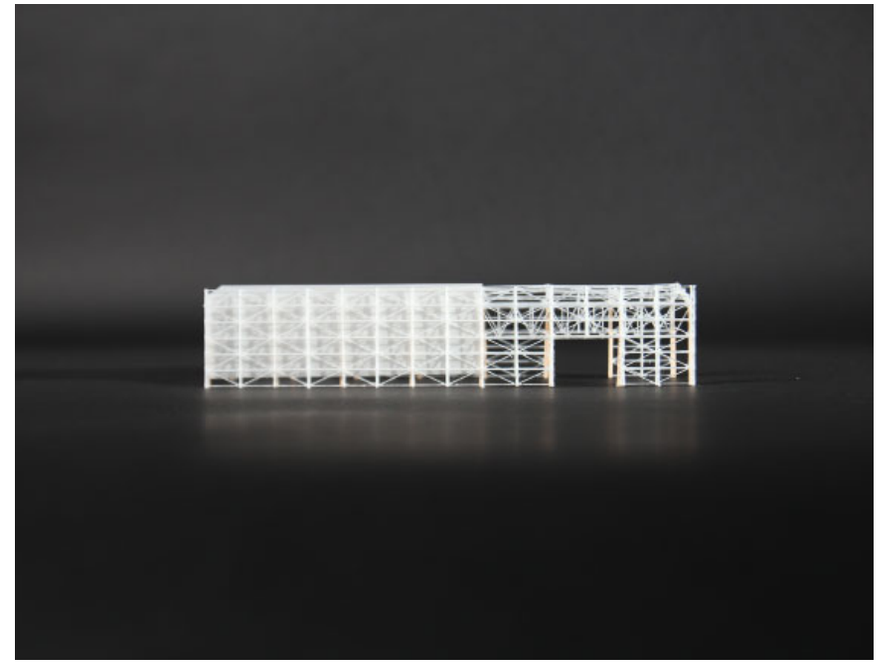
Physical models made during design development and for the final presentation.

Materials: basswood, mylar, PLA, museum board, acrylic









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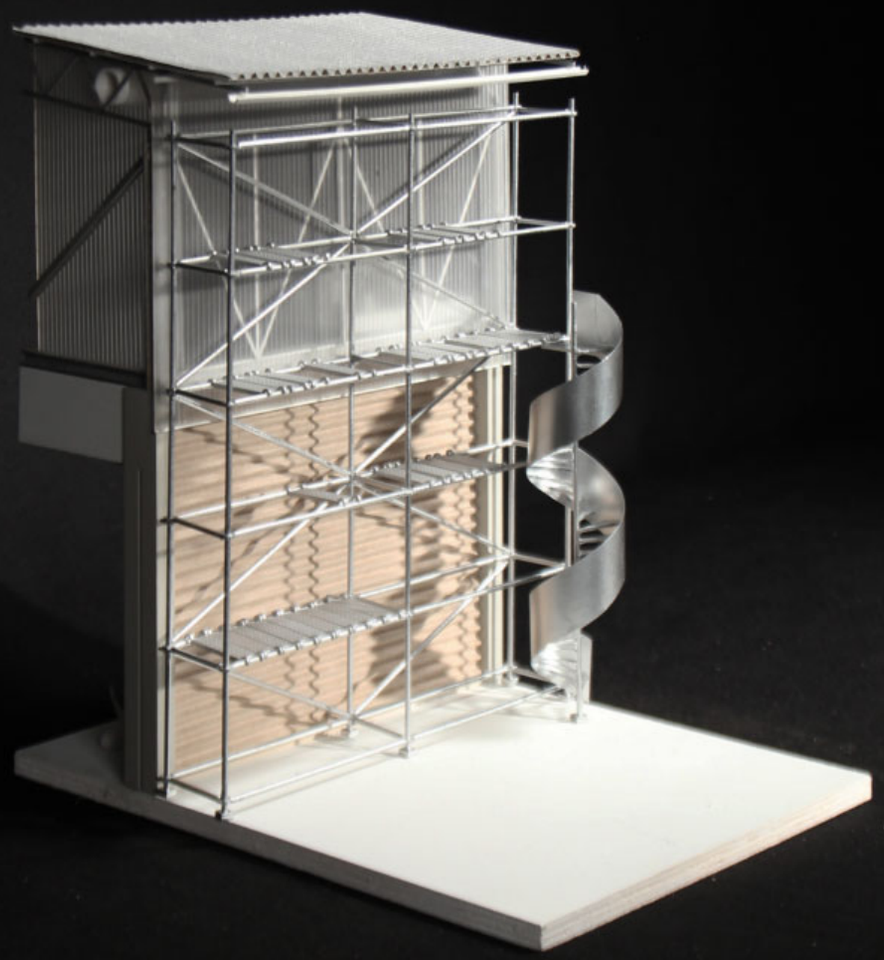
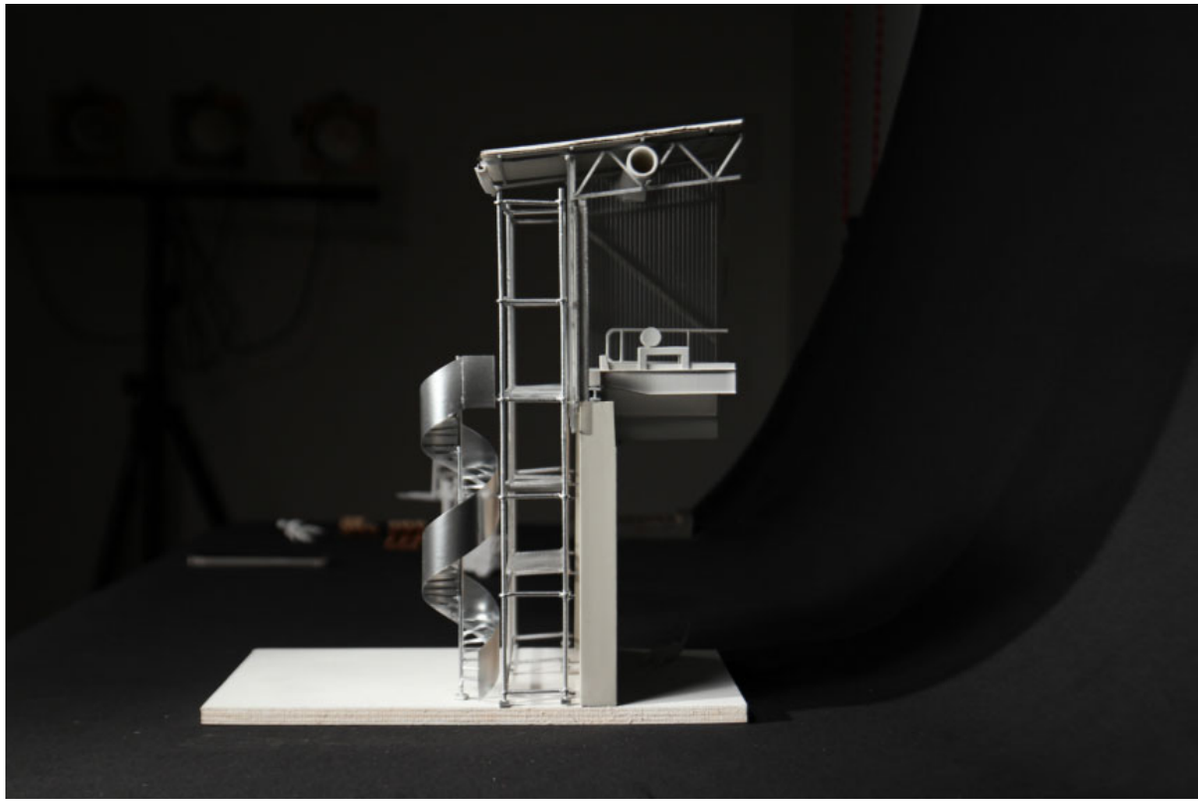
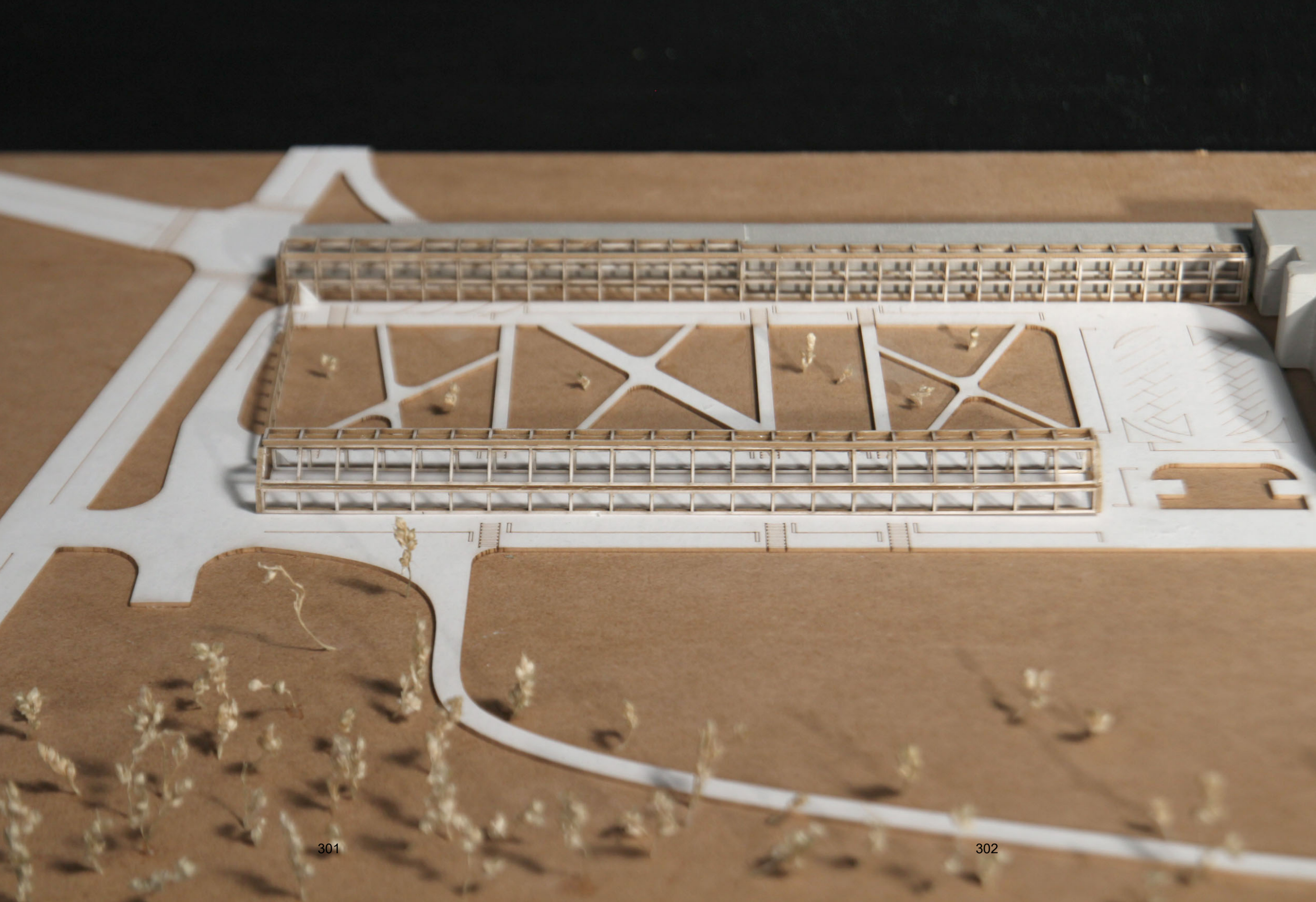


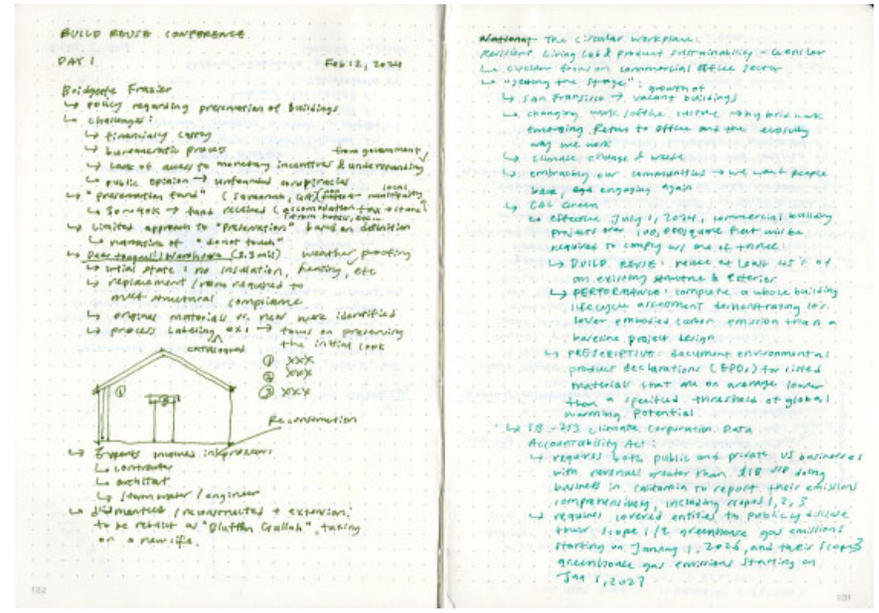


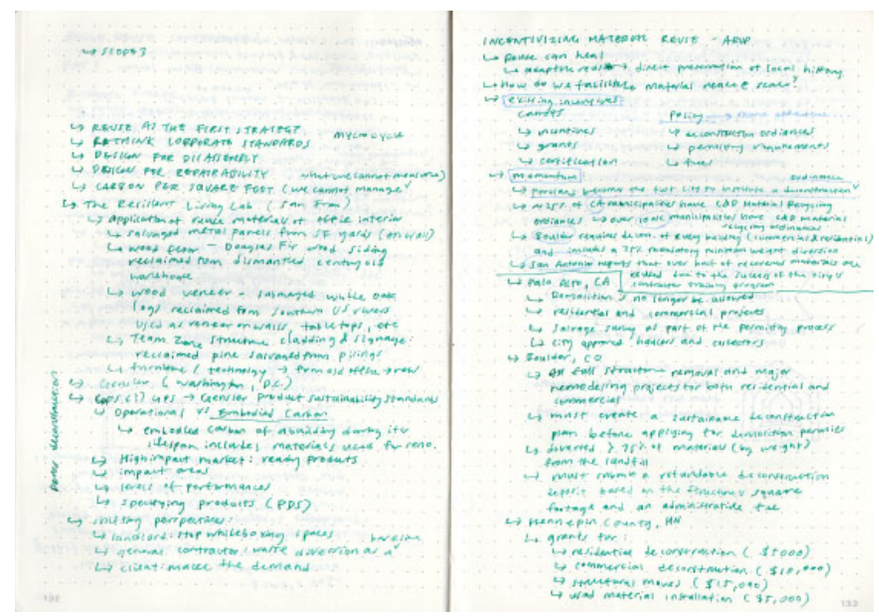


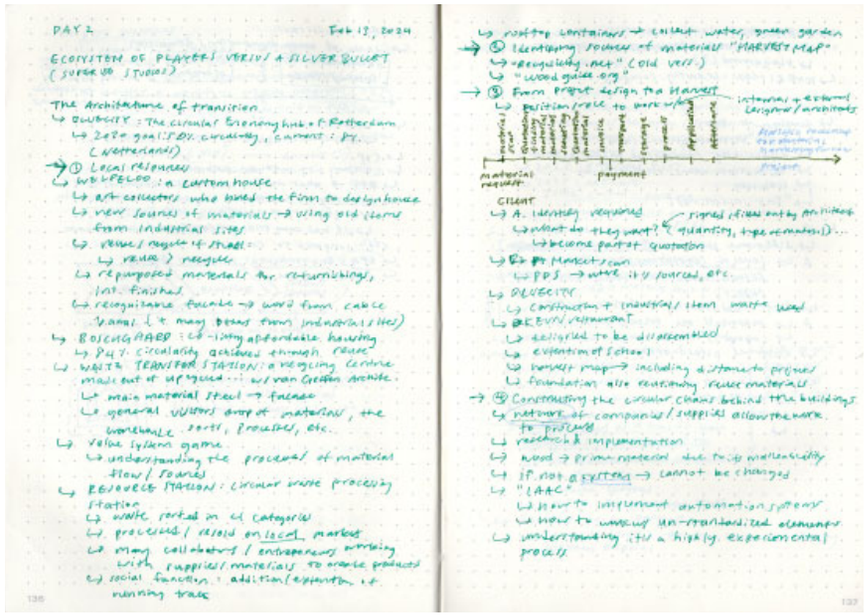
D. Conference Notes

I had the pleasure of attending the 2024 Deconstruction + Reuse Conference in Savannah, Georgia, hosted by Re:Purpose Savannah, one of the three case studies featured in my thesis.

The event brought together policymakers, practitioners, contractors, practitioners, and designers—key stakeholders in the field of deconstruction—to exchange knowledge and engage in meaningful discussions about advancing sustainable building practices.







DAY 2 — Feb 13, 2024

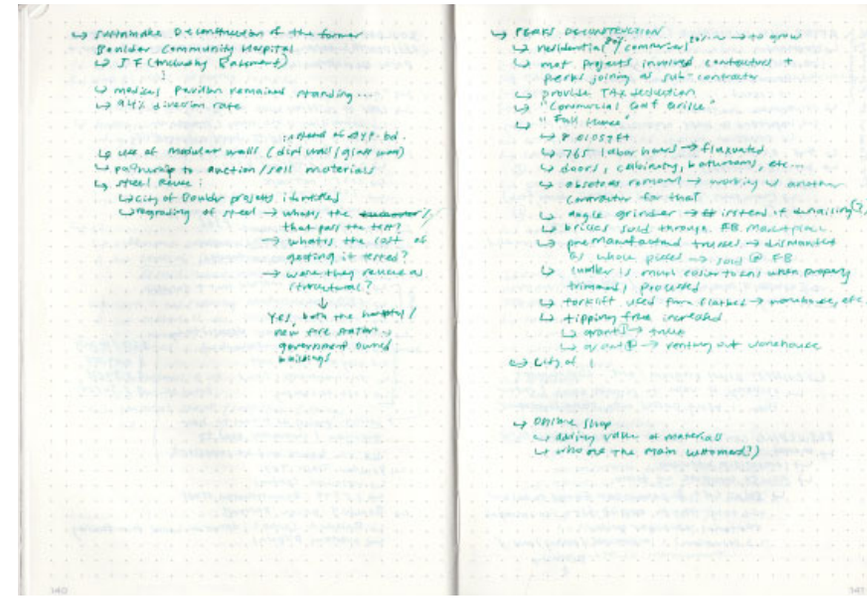
ECOSYSTEM OF PLAYERS VERIV + SILVER BULLET (SUPERLOO STUDIOS)

The Architecture of transition

↳ OVERCITY : The circular Greening hub of Rotterdam
↳ 2020 goal: 50% circularity, current : 4%. (Netherlands)
→ ① Local resources
↳ WOKPELOO : a custom house
↳ art collectors who hired the firm to design house
↳ new sources of materials → using old items from industrial sites
↳ reuse / recycle of steel:
↳ reuse) recycle
↳ repurposed materials for refurnishings, incl. finishes
↳ recognizance funds → word from cabec (name, & may come from industrial sites)
↳ BOSCHGRAAF : 68-story affordable housing
↳ 94% circularity achieved through reuse
↳ WASTE TRANSFER STATION: a recycling centre made out of upcycled ... w/ van Gerven Architects.
↳ main material steel → frames
↳ general visitors drop off materials, the warehouse sorts, processes, etc.
↳ value systems game
↳ understanding the process of material flow / source
↳ RESOURCE STATION : circular waste processing station
↳ waste sorted in 4 categories
↳ processed / resold on local markets
↳ many collaborators / entrepreneurs working with supplies / materials to create products
↳ social function : addition / expansion of running trails

↳ rooftop containers → collect water, grown garden
→ ② Identifying sources of materials "HARVEST MAP"
↳ reequality.net" (old vers.)
↳ "wood guide.org"
→ ③ From project design to harvest
↳ position / role to work with — internal + external designers / architects

CLIENT
↳ A. identify requirements — signed off/sent only by architect
↳ what do they want? (quantity, type, remanufacture)...
↳ become part of quotation
↳ Market scan
↳ PDS → where it's sourced, etc.
↳ SILVERCITY
↳ Construction + industrial / item waste wood
↳ BREVIN restaurant
↳ delighted to be disassembled
↳ extension of kitchen
↳ market map → including distance to project
↳ foundation also retaining reuse materials
→ ④ Constituting the circular chains behind the buildings
↳ network of companies / suppliers allow the work to proceed
↳ research & implementation
↳ wood → primary material due to its malleability
↳ if not a system → cannot be changed
↳ "LAAC"
↳ how to implement automation systems
↳ how to unscrew un-standardized elements
↳ understanding it's a highly experimental process

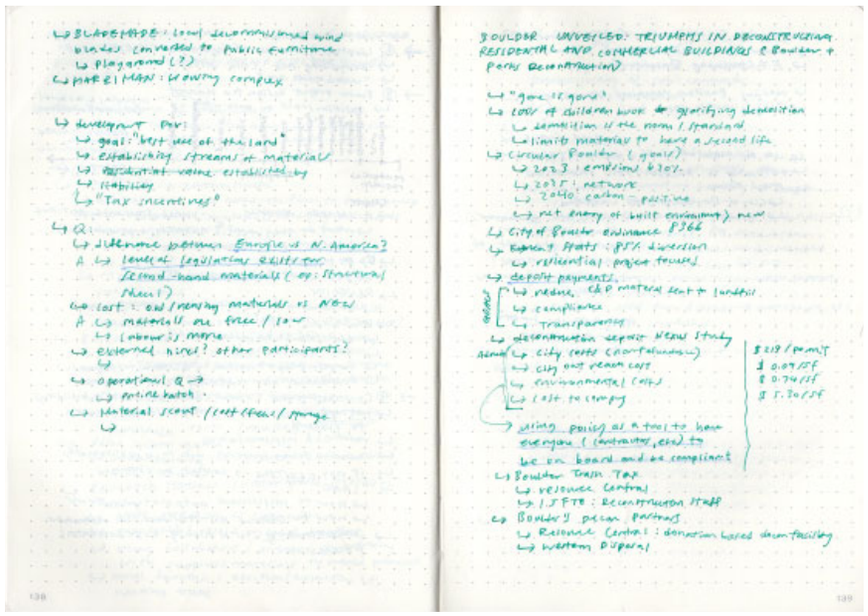


↳ Sustainable Deconstruction of the former Boulder Community Hospital
↳ J.F. (McCarthy Basement)
↳ medical pavilion remained standing...
↳ 94% diversion rate

↳ use of modular walls (dirt wall / gland wall)
↳ pathway to auction / sell materials
↳ steel reuse:
↳ City of Boulder projects identified
↳ regrading of steel → what's the ~~[illegible]~~ that pay the test?
→ what's the cost of getting it tested?
→ warranting reuse in (structural?
↓
Yes, both the hospital / new fire station / government owned buildings!

↳ REAL DECONSTRUCTION
↳ residential / commercial
↳ most projects involved contractors + parks joining as sub-contractors
↳ provide TAX deduction
↳ "Commercial Cut Brilla"
↳ "Full House"
↳ $ 61557 ft
↳ 765 labor hours → flexurated
↳ doors, cabinetry, bathrooms, etc...
↳ asbestos removal → working w another contractor for that
↳ angle grinder → ~~[illegible]~~ instead of sawzalling(?)
↳ bricks sold through FB Marketplace
↳ premanufactured trusses → dismantled by whole pieces → sold @ FB
↳ lumber is much easier to re-use when properly trimmed, processed
↳ forklift used from Clarkes → warehouse, etc.
↳ tipping fees increased
↳ grants → value
↳ grant $ → venting out warehouse
↳ City of ...

↳ Online Shop
↳ adding value of material
↳ who are the main customers?



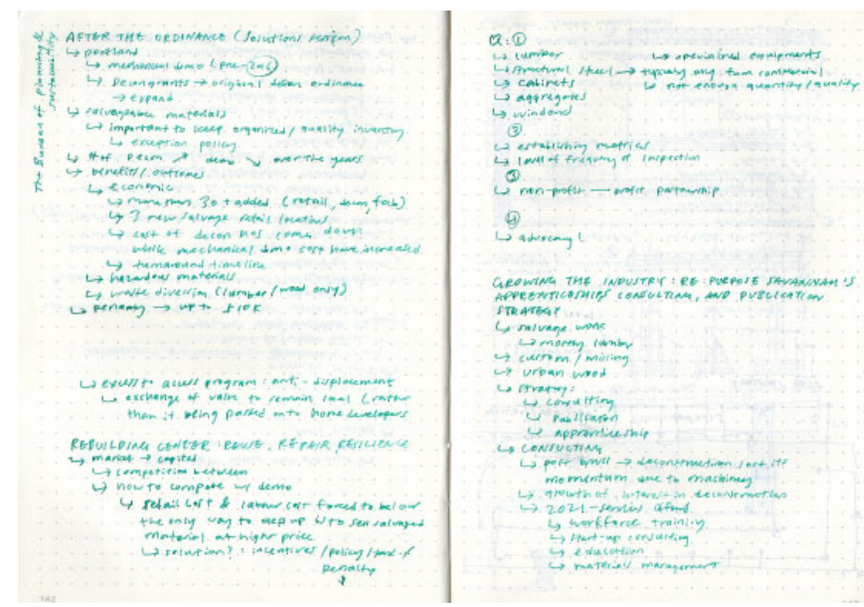
↳ BLADE HAUS : local decommissioned wind blades converted to public furniture
↳ Playground (?)
↳ MAREI MAN : housing complex

↳ development Pro:
↳ goal: "best use of the land"
↳ establishing streams of materials
↳ resultant value established by
↳ reliability
↳ "Tax incentives"

↳ Q:
↳ difference between Europe & N. America?
A ↳ level of legislation & sector
↳ second-hand materials (eg: structural steel)
↳ cost: end / reusing materials vs new
A ↳ materials are free / low
↳ (above) ; marie
↳ external hires? other participants?
↳
↳ operational Q →
↳ online batch.
↳ material scent / cost (fees) / storage
↳

BOULDER UNVEILED: TRIUMPHS IN RECONSTRUCTING RESIDENTIAL AND COMMERCIAL BUILDINGS & Boulder + Parks Reconstruction)

↳ "gone is gone"
↳ cost of children work to qualifying demolition
↳ demolition is the norm / standard
↳ limits materials to have a second life
↳ Circular Boulder (goals)
↳ 2023 : emissions 30%
↳ 2035 : network
↳ 2040 : carbon - positive
↳ net energy of built environment, new
↳ City of Boulder ordinance 8366
↳ Energy Hearts : 85% diversion
↳ residential project focused
↳ deposit payments:
↳ reduce C&D material sent to landfill
↳ compliance
↳ transparency
↳ deconstruction report NEW study
demo ↳ city costs (monitoring) — $ 219 / permit
↳ city cost reach cost — $ 0.09 / SF
↳ environmental costs — $ 0.74 / SF
↳ cost to comply — $ 5.30 / SF
→ using policy as a tool to have everyone (contractor, etc) to be on board and be compliant
↳ Boulder Train Tax
↳ resource Central
↳ 1.5 FTE : reconstruction staff
↳ Boulder's pecan partners
↳ Resource Central : donation based drop facility
↳ western disposal



The Student of Planning & Sustainability

AFTER THE ORDINANCE (Solutions Forum)
↳ problems
↳ mechanical demo (pre-2015)
↳ Deconstructs → original design ordinance → expand
↳ salvageable materials
↳ important to keep organized / quality inventory
↳ exception policy
↳ ~~[illegible]~~ Recon ↗ demo ↘ over the years
↳ benefits / outcomes
↳ economic
↳ manufacturing 30 + added (retail, design, tech)
↳ 3 new / salvage retail locations
↳ cost of deconstruction has come down; while mechanical demo costs have increased
↳ turnaround timeline
↳ hazardous materials
↳ waste diversion (lumber / wood only)
↳ Recycling → up to $10K

↳ EXWHY + alumni program : anti-displacement
↳ exchange of value to remain local (rather than it being passed onto home developers

REBUILDING CENTER : REUSE, REPAIR, RESILIENCE
↳ market → capital
↳ competition between
↳ how to compete w/ demo
↳ retail cost & labour cost forced to be low the only way to keep up w/ to sell salvaged material at higher price
↳ solution? : incentives / policy / tax / penalty

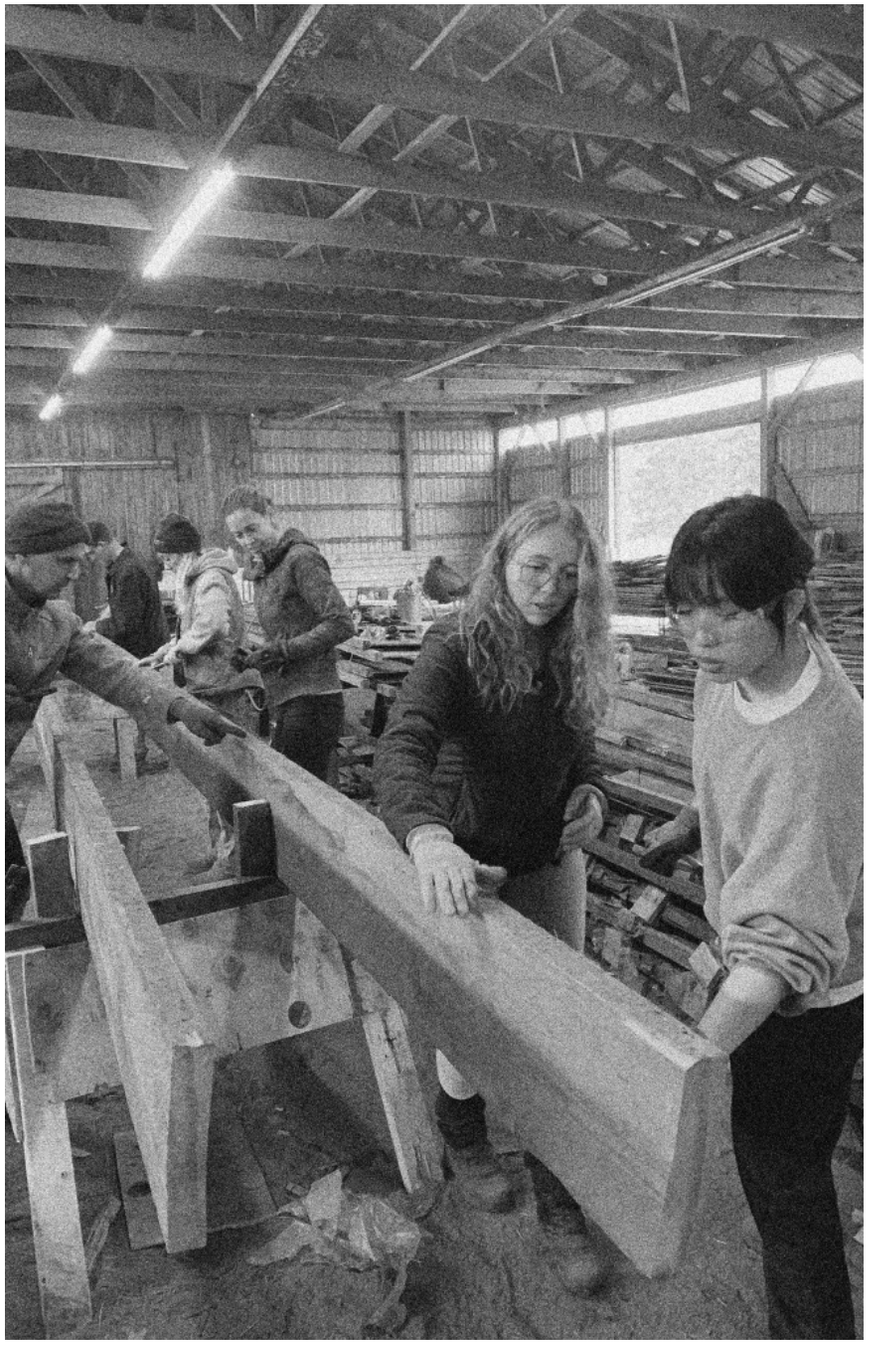
Q: ①
↳ lumber — ↳ specialized components
↳ structural steel ↳ typically only from commercial
↳ cabinets — ↳ not enough quantity / quality
↳ aggregates
↳ windows
②
↳ establishing metrics
↳ level of frequency of inspection
③
↳ non-profit — profit partnership
④
↳ advocacy

GROWING THE INDUSTRY : RE-PURPOSE SAVANNAH'S APPRENTICESHIP CONSULTANT, AND PUBLICATION STRATEGY
↳ salvage work
↳ mostly lumber
↳ custom / milling
↳ urban wood
↳ strategy:
↳ consulting
↳ publication
↳ apprenticeship
↳ construction
↳ post WWII → deconstruction / anti-tiff momentum due to machining
↳ growth of interest in deconstruction
↳ 2021 - series, attend
↳ workforce training
↳ start-up consulting
↳ education
↳ material management

E. Deconstruction Experience

I had the opportunity to engage in hands-on deconstruction work with Ouroboros Deconstruction under the supervision of Juliette Cook, co-founder of Ha/f Climate Design and lecturer at the University of Waterloo. As part of a small group of University of Waterloo students, I participated in a site visit to the organization's warehouse, where we conducted de-nailing of salvaged lumber, gaining direct experience with material reclamation processes.

This visit, which took place in 2023 at the beginning of my master's studies, served as my initial exposure to deconstruction practices and significantly informed the development of my thesis.



F. Final Presentation

Thank you Jane Mah Hutton, Rick Haldenby, Maya Przybylski, and Meredith Moore for joining the conversation as panelists for my thesis defence. I'm immensely grateful to have had my father there, who made the trip from Niagara to Cambridge, and for all of my peers I've been fortunate to call my friends and fellow students. Thank you Monica Gutierrez and Anita Hu for helping me curate the final presentation. It was a pleasure to share my thesis, *MATERIAL WORKS: Optimizing Material Circularity through Reversing Architecture,* with the University of Waterloo School of Architecture as the concluding presentation of my Master of Architecture degree.

GLOSSARY

CIRCULAR ECONOMY: refers to a closed-loop model of an economy where waste is eliminated and product are sold, consumed, collected and then reused, remade into new products, returned as nutrients to the environment or incorporated into global energy flows

DECONSTRUCTION: describes a process of selective disassembly of a building at the end of its life to recover materials and components or systems for potential reuse or recycling. It is an approach to building removal that can extract resources so they can be used for high value future uses

DESIGN FOR DECONSTRUCTION (OR DISASSEMBLY): describes how a building is designed to be readily taken apart at the end of its useful life so that the components can have a second use. To facilitate this, a design team needs to consider how the major systems can be deconstructed during renovations and end-of-life

DIVERSION (WASTE DIVERSION, LANDFILL DIVERSION): is the process of diverting waste from landfills or incinerators through various means such as reuse, recycling, composting or gas production through anaerobic digestion. Waste diversion is a key component of effective and sustainable waste management and a major policy objective of many governments

EMBODIED ENERGY/CARBON: is the energy (and resultant carbon emission) used in all the processes necessary to produce a material or component

LIFE CYCLE ANALYSIS (LCA): is a comprehensive method for assessing a range of environmental impacts across the full life cycle of a product system, from materials acquisition to manufacturing, use and final disposition. The ISO standard ISO 14040 defines the processes for carrying out LCA calculations

RECLAIM: is to cover something of value from a waste stream

PREPARING FOR RE-USE: checking, cleaning or repairing recovery operations, by which products or components of products that have become waste are prepared so that they can be re-used without any other pre-processing

RE-USE: any operation by which products or components that are not waste are used again for the same purpose for which they were conceived

WASTE: any substance or object which the holder discards or intends or is required to discard

SALVAGE: is typically something extracted from the waste stream as valuable or useful