bicycle factory »
a *post*-post-Fordist urban intervention

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.

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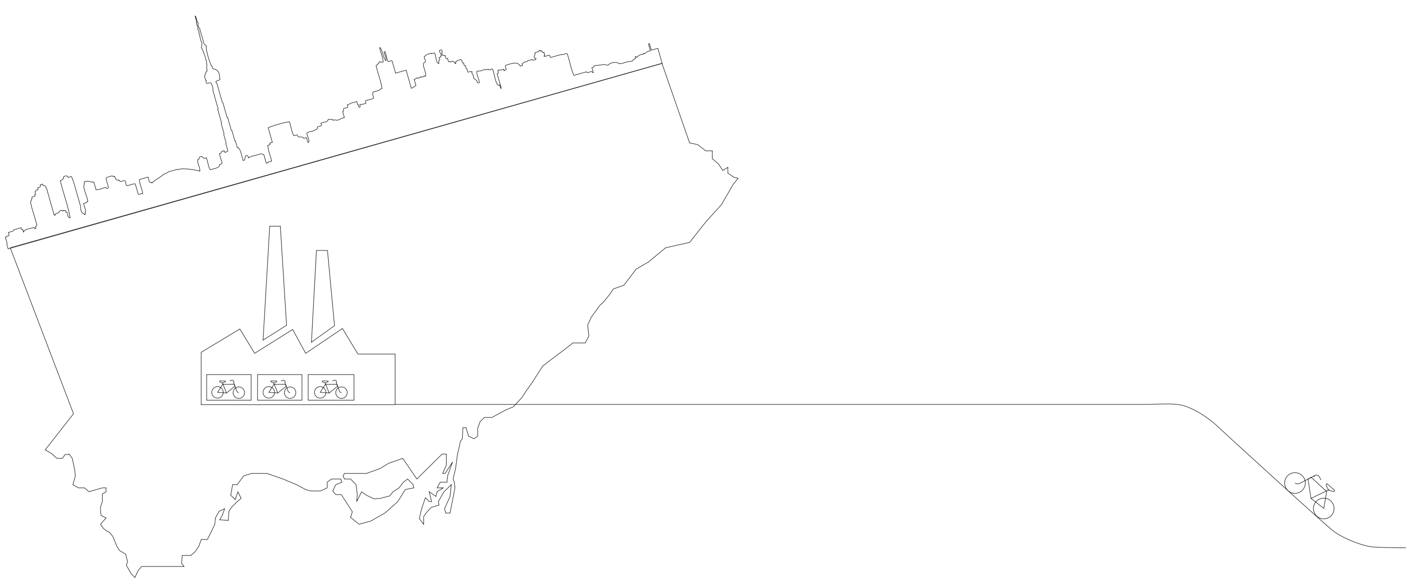

fig. 1 conceptual diagram/
bicycle factory as urban intervention in Toronto

abstract

Cities were once filled with bicycles and factories—urban typologies now regarded as anachronistic elements of the landscape, as their relationship to the built environment evolved throughout the Industrial Revolution, Fordism, and post-Fordism. The 20-century city was largely shaped by the automobile, which quickly displaced the human-powered mode of transportation. Meanwhile, spaces of production once spatially situated within their local markets were pushed further and further from the urban core, until offshored entirely to the developing world. These transformations have also left scars in the cities of advance economies, as 19th-century railways and other industrial remnants now impede on the human scale of urban life.

Today, after decades of aggressive industrialization, environmental sustainability has reached a point of global crisis. The bicycle and the factory, as artifacts that have endured the test of time, are summoned to help foster a sustainable, contemporary city. The thesis seeks to re-establish their relevance in the built environment, by reintegrating light manufacturing activity back into the urban fabric, and proliferating the bicycle as a self-mobility machine for everyday transportation.

An ideal 'post-post-Fordist' society is thus proposed, defined as, *[good] Fordism + [good] post-Fordism + counter-culture trends + novel ideas*. The post-post-Fordist city is envisioned as a dense, heterogeneous construct, while its post-post-Fordist urban intervention is presented as a bicycle factory in the city of Toronto. The architectural design acts as a catalyst to proliferate the bicycle and its infrastructure across the urban landscape, in the same way Ford's mass production of automobiles sculpted the modern city. It also spatially reconnects producers, workers, and consumers within a more cyclical, local economy.

As a microcosm of the post-post-Fordist metropolis, the building is a complex, interweaving, layered assembly, consisting of a hybrid typology of factory, pedestrian & cycling bridge, urban park, velodrome, and bike park. The bridges physically re-connect portions of Toronto's urban fabric torn apart by railways, while the architecture figuratively bridges between the project's urban scale (cycling masterplan), and its object scale (commuter bicycle commodity). The factory's transparent manufacturing process and democratic organization of labour are also composite systems, consisting of Fordist mass production and post-Fordist mass customization, while employing skilled and semi-skilled labour as a worker & consumer co-operative. The intervention embodies the bicycle's construction, movement, and social qualities in its tectonics, while enabling cycling infrastructure to permeate into the building. In this way, the proposal endeavours to lift us out of the industrial exploitation of the last century, while providing a relief from contemporary society's over-saturation of digital technology, to return the machine to its rightful place as an intuitive extension of our bodies.

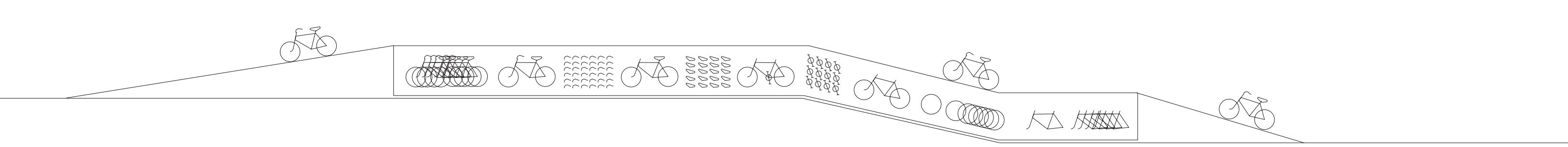

fig. 2 monkey on bicycle

acknowledgments

Like this thesis, its production has also been an intense, heterogenous assembly of ideas from actants to whom I owe immense gratitude for their idiosyncratic contributions:

to my supervisor **Adrian** — thank you for always pushing me to explore bigger and bolder ideas, your insightful and coherent direction, and incredible patience even when I strayed with 8-ft-long, 6-pt-font production process charts. But most of all, thank you for defending my thesis during my own moments of doubt, and your devotion and enthusiasm throughout.

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i. pre-face

Bicycles and factories—urban typologies that once populated cities but now relegated as anachronisms of the built landscape. Both artifacts experienced a period of morphological development during the Industrial Revolution, before rising to prominence in 19th-century society, as their relationship to towns evolved throughout the Fordist and post-Fordist eras of the 20th century. Cities largely displaced the human-powered mode of transportation with automobiles from Fordism onward, while the powerhouses of production were replaced with the intangible commodities of service and logistics throughout post-Fordism. Thus, as metropolises in advanced economies were being shaped by the motor vehicle, factories were simultaneously pushed further and further away from urban centres, eventually leaving domestic soil altogether to offshored facilities in developing nations overseas.

The thesis inserts itself within the larger conversation of global environmental sustainability through the lens of the city, by proposing a reindustrialization of the urban realm by mobilizing mobility. The crisis of the bicycle, and the crisis of the factory in the contemporary metropolis are investigated, and their amalgamation is proposed as a methodology toward a solution. The thesis asserts that because bicycles and factories are established elements of society that have persisted through the ages, they are are powerful typologies that offer immense potential for reinvigorating our constructed habitat. Bicycles, as an environmentally-friendly mode of transport, and factories, with their multiplying, trickle-down effect for the local economy, should be key players in creating healthy, thriving, sustainable cities of the present and future eras. By reasserting their agency in the 21st-century metropolis, the new energy-conscious paradigms of transportation and manufacturing can work together to activate urban space through localization and densification.

The goal therefore, is to change public perceptions about factories in the city, and the utility of the bicycle as a viable option for commuting and everyday transportation. Solutions that range from the urban scale to the object scale are presented, using architecture to literally and figuratively bridge between them. The thesis submits to instigate a 'post-post-Fordist' society, which in the context of this manifesto, is defined as: [good] Fordism + [good] post-Fordism + counter-culture trends + novel ideas. In other words, the new movement takes virtues from both the Fordist and post-Fordist eras, selectively magnifies currents outside mainstream trends, and proposes innovative ideas, as a way to mobilize new directions for the redefined city.

The ideal, sustainable, contemporary post-post-Fordist city, is thus conceptualized as a densely layered construct, whose multifaceted urban fabric facilitates all manner of interaction. More specifically, the relationship between manufacturing, transportation, and public space is reinterpreted, creating new points of interface in the community. The movement advocates for the re-localization, as opposed to the globalization, of factories, both to minimize the wastes of shipping long distances, and to spatially reconnect producers, workers, and consumers within a more cyclical, local economy. By reintegrating light manufacturing activity into the city, the thesis aims to remove the exploitation of labour from offshored post-Fordist factories, and ensure fair working conditions for the blue-collar class. Moreover, instead of continuing to cater to the city as a car-dominated platform, the post-post-Fordist urban core is envisioned as a predominantly cycling-based landscape.

Harnessing the collaborative potentials of the bicycle, the factory, and the city, the thesis proposes the insertion of a bicycle factory in the city Toronto as a post-post-Fordist urban intervention. The scarcity of large-scale bicycle manufacturers in North America, and lack of both cycling infrastructures and quality public spaces in Toronto, are factors that drive the project. The agent accordingly acts as a catalyst to stimulate the productive economy, transportation, and public realm. Essentially a microcosm of the heterogeneous post-post-Fordist city, the design consists of an interweaving, layered synthesis of various architectural program, manifesting as a hybrid typology of factory, pedestrian & cycling bridge, urban park, velodrome, and bike park. The bridges connect fragmented portions of the urban fabric and pass over, under, or through the building. This way, not only does the project directly inject cycling pathways into the transportation network, it reactivates the neighbourhood and city, by dissolving a blockage embedded in the landscape. Accordingly, the architecture also emulates the bicycle's construction, movement, and social qualities in its tectonics, and subsumes the transportation device and supporting infrastructures directly into its design.

The factory's manufacturing model is also a hybrid—merging Fordist mass production with post-Fordist mass customization, thereby taking advantage of the respective efficiencies and flexibilities supplied by each economic era. It appropriates the Fordist method of production to multiply, and distribute the bicycle across the city, allowing cycling infrastructure to penetrate the urban fabric, much in the same way the automobile paved the 20th-century cityscape. As a result, the composite system of fabrication contains segments of Fordism's mono-commodity assembly line, as well as post-Fordism's cell-based production strategy. The operation also implements a democratic labour organization model, by giving employees more agency over their working conditions. This is attained by retaining staff for skilled and semiskilled labour, applying teamwork strategies, and formalizing the business as a worker & consumer co-operative.

Lastly, the post-post-Fordist bicycle factory's single-design commodity, the commuter bike, is positioned as part of a 'decision fatigue' counter-culture trend—a reaction against the post-Fordist over-saturated market of endless varieties and options. As a utility vehicle, the design of the bicycle is optimized for urban riding, specifically catered to the snowfall-prone northern climate of a city like Toronto. It is intentionally designed to be an affordable, mid-range commuter bicycle, customizable in size and colour, with limited optional accessories, to be mass produced and disseminated across the city.

In this way, the intervention provides both the machine and infrastructure for cycling. It improves the connectivity of the city's transportation network, while offering various cycling amenities, and public space. The bicycle factory also creates opportunity for local blue-collar employment, which encourages more mixed-income neighbourhoods in the urban core. The marriage of bicycle, factory, and city thereby fosters bicycle culture, while promoting transparent, quality design and manufacturing in a post-post-Fordist society.

In many ways, the thesis is structured like its urban intervention, with various themes and typologies interwoven throughout. The narrative of the bicycle and the factory in relation to the city, is knit from the social tapestry of the Industrial Revolution, Fordism, and post-Fordism. Culminating in an architectural proposal, the urban intervention mirrors and recombines the ingredients into a richly variegated hybrid design. Fittingly bookended by the bicycle, the presence of the human-powered vehicle also permeates throughout the work—from the design of the physical commodity, to the shaping of architectural form; from the accommodation of the bicycle throughout the intervention, to its egalitarian condition driving the co-operative and collaborative nature of the operation.

The first chapter, *raw materials »* ACTANTS, is divided into two sections, **typology I — bicycle**, and **typology II — bicycle**, which trace the morphological evolution of the artifacts, and the story of their transforming relationship to the city, as delineated from the Industrial Revolution, through Fordism, to post-Fordism.

The second chapter, *factory »* ARCHITECTURAL URBAN INTERVENTION, is composed of four parts. The first, **pre-amble**, introduces the concept of post-post-Fordism, and how it would manifest at each of the urban, architectural, and object scales. The **economics** section outlines the funding mechanisms for the construction of the project, and the market outlook of the bicycle manufacturing sector. The next portion, **urban fabric**, zooms into the site chosen for the intervention, describing the area's history, transportation networks, current and future developments, topography, built morphology, and program. It also delves into the masterplan design for the immediate surrounding context, with emphasis on cycling infrastructure. The last **bicycle factory** segment, is an in-depth description, analysis, and illustration of the architectural manifestation of the intervention and its operation.

The third and final chapter, *product »* OBJECT, focuses on the device itself—the bicycle. **Bicycle commodity** positions the mono-product business strategy of the factory in relation to contemporary mainstream and counter-trend philosophies in manufacturing and marketing. Meanwhile, **bicycle design** details the mechanical components of the self-propelling vehicle, and the features that optimize its design as a city-oriented commuter bicycle.

p.p.s. The appendix, or ***post-post-script,*** *contains a comprehensive breakdown of the stages of production —* **production matrix** *exhibits the bicycle's entire manufacturing process, tracing the path of every component through the production line, whether fully fabricated from raw materials, purchased from suppliers and modified, or directly assembled into the complete bicycle. These include: specifications, dimensions, quantity and type of raw materials used, machinery, time required per operation, number of workers at each station, and number of hours of operation, shifts, workers, and products per day.*

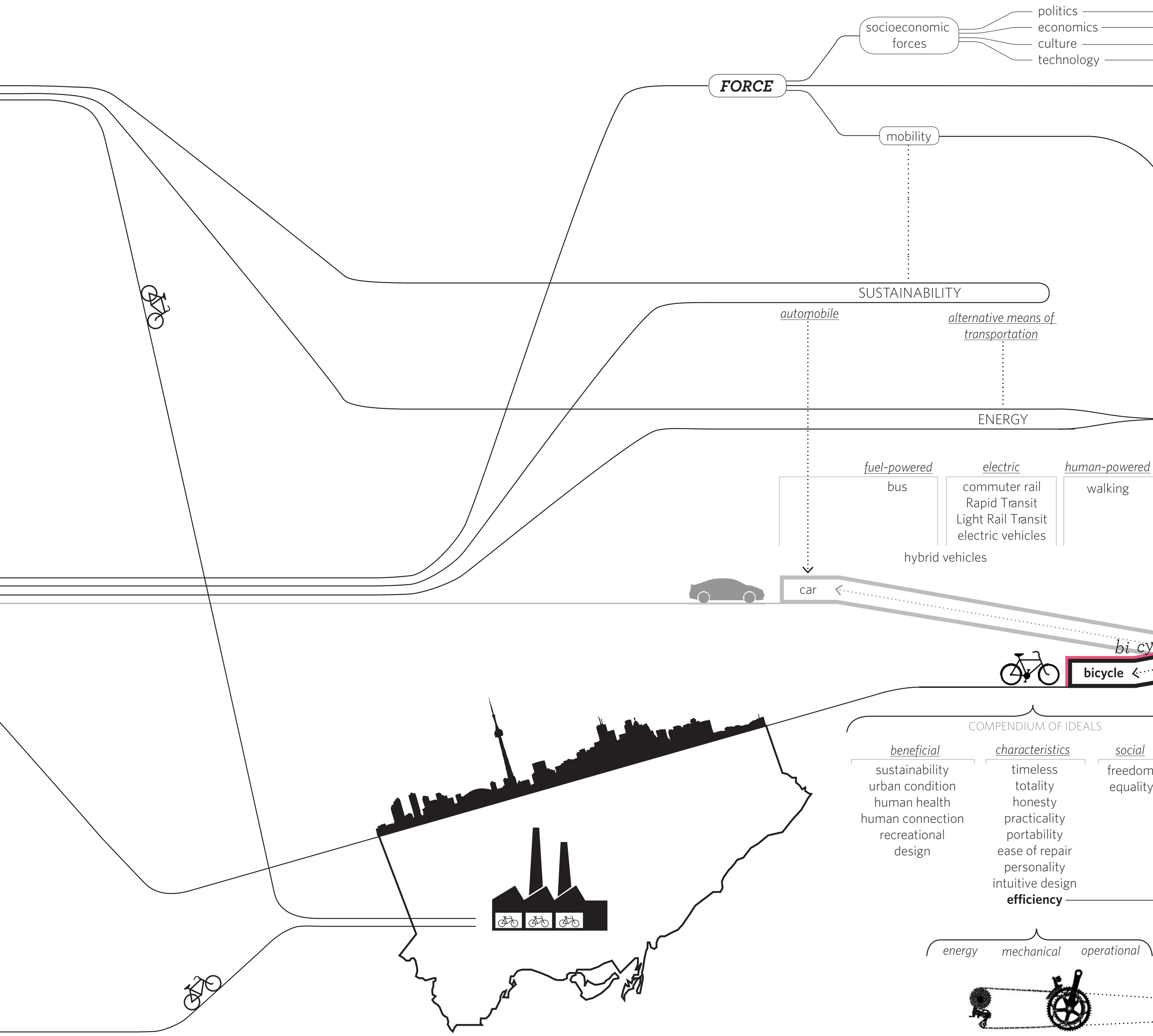
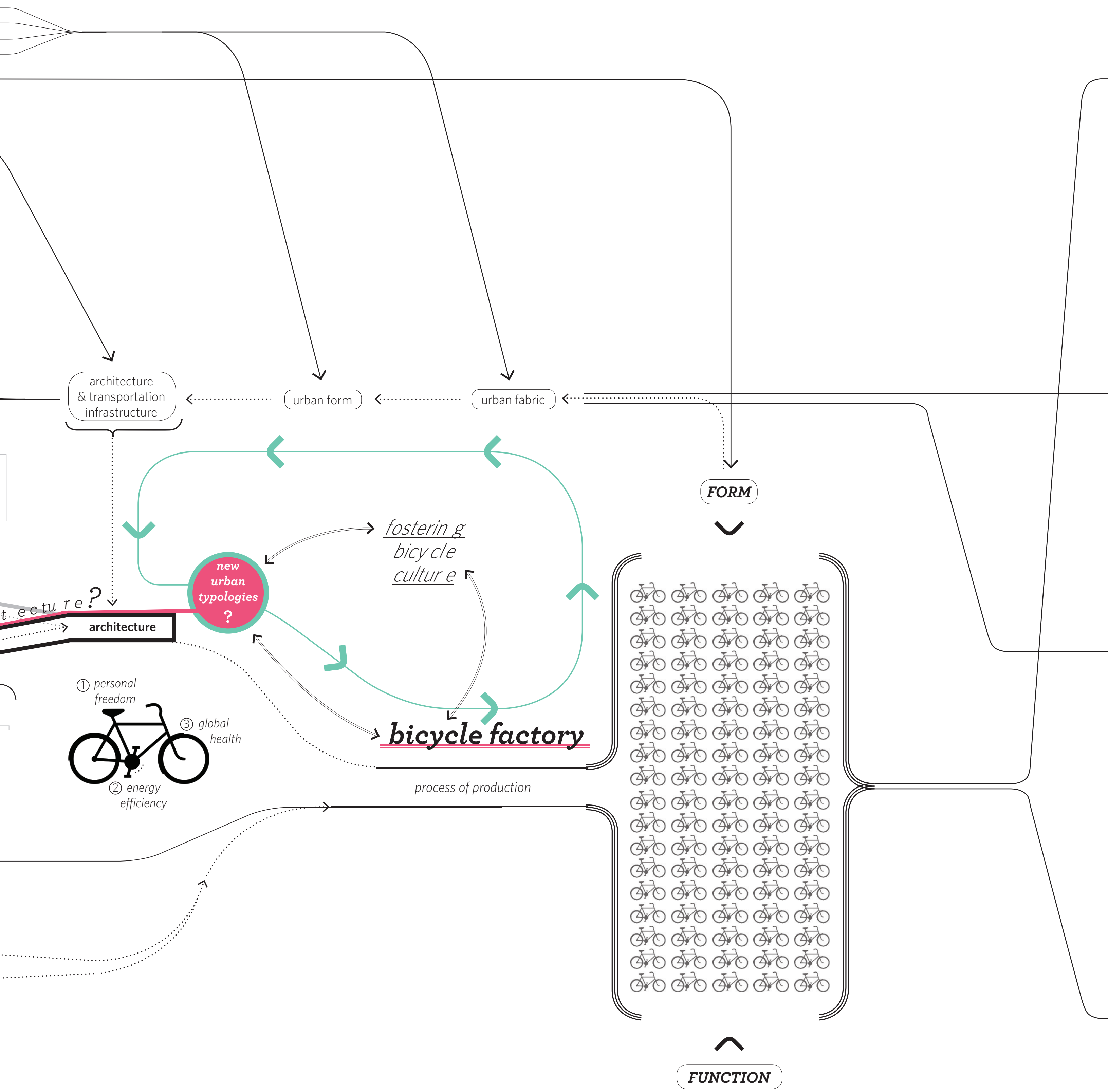


fig. 3 **conceptual diagram**/*thesis*



architecture & transportation infrastructure
urban form
urban fabric
FORM
fostering bicycle culture
new urban typologies ?
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architecture
bicycle factory
① personal freedom
③ global health
② energy efficiency
process of production
FUNCTION

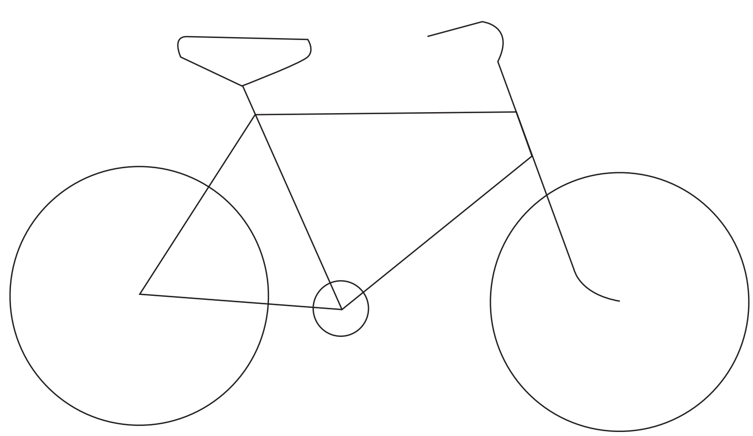


fig. 4 **bicycle typology**

1. *raw materials* » ACTANTS

1.1 typology I — bicycle

1.1.1 MORPHOLOGICAL EVOLUTION OF THE BICYCLE

1.1.1.1 WHAT IS A BICYCLE?

It is one of the most nearly perfect pieces of design known, due to the extreme amount of refinement it has undergone over the last century, and its purity of form.
— Sheldon Brown, *Sheldon Brown's Bicycle Glossary*

Today, the bicycle is a well-known typology. Despite the myriad of variations in utility, shape, size, weight, material, and colour, the standard form of the bicycle is easily identifiable—two matching wheels, held in-line by a simple tubular truss frame, driven with gears, chains, pedals, and equipped for riding with a saddle and handlebars. This image of the human-powered mode of transportation, which has been cemented into contemporary culture, is due to the remarkable fact that its basic design has not changed since the end of the 19th century.[1] In other words, the bicycle was, and remains, such a relevant and ingenious artifact, that it neither has seen significantly redevelopment, nor become obsolete or marginalized since its 'perfection'.

Even with the development of highly engineered or highly stylized contemporary varieties, which tend to be highly effective in one respect, but seriously lacking in another, the practicality of the bicycle's utilitarian typology has remained consistent.[2] The morphology of the conventional bicycle has maintained the optimal balance between form and function, engineering and aesthetics—truly making it "one of mankind's greatest inventions."[3]

1 Robert Penn, *It's All About the Bike: The Pursuit of Happiness on Two Wheels* (London: Penguin Books, 2011), 27.
2 Ibid., 29.
3 Ibid., 7.

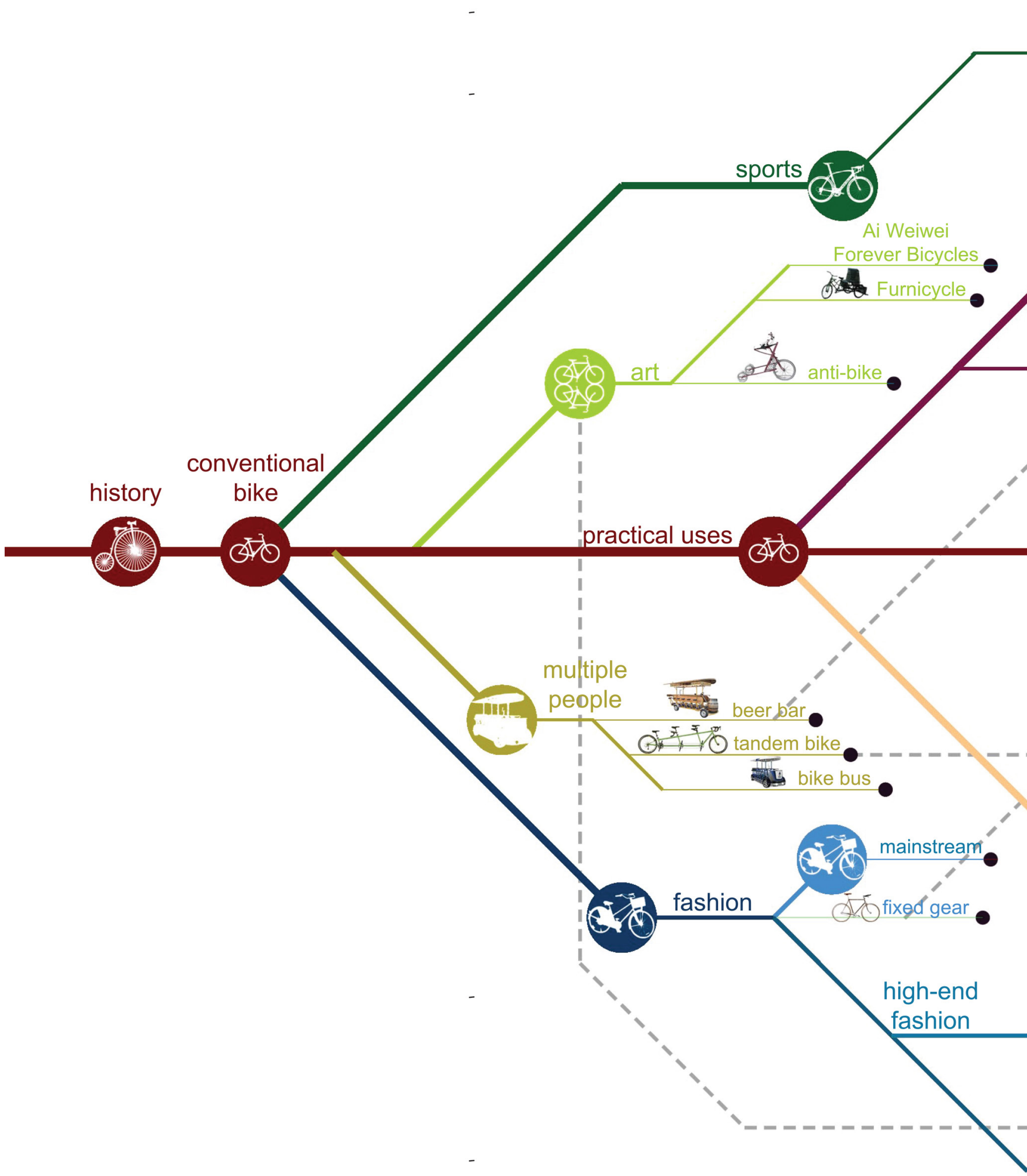
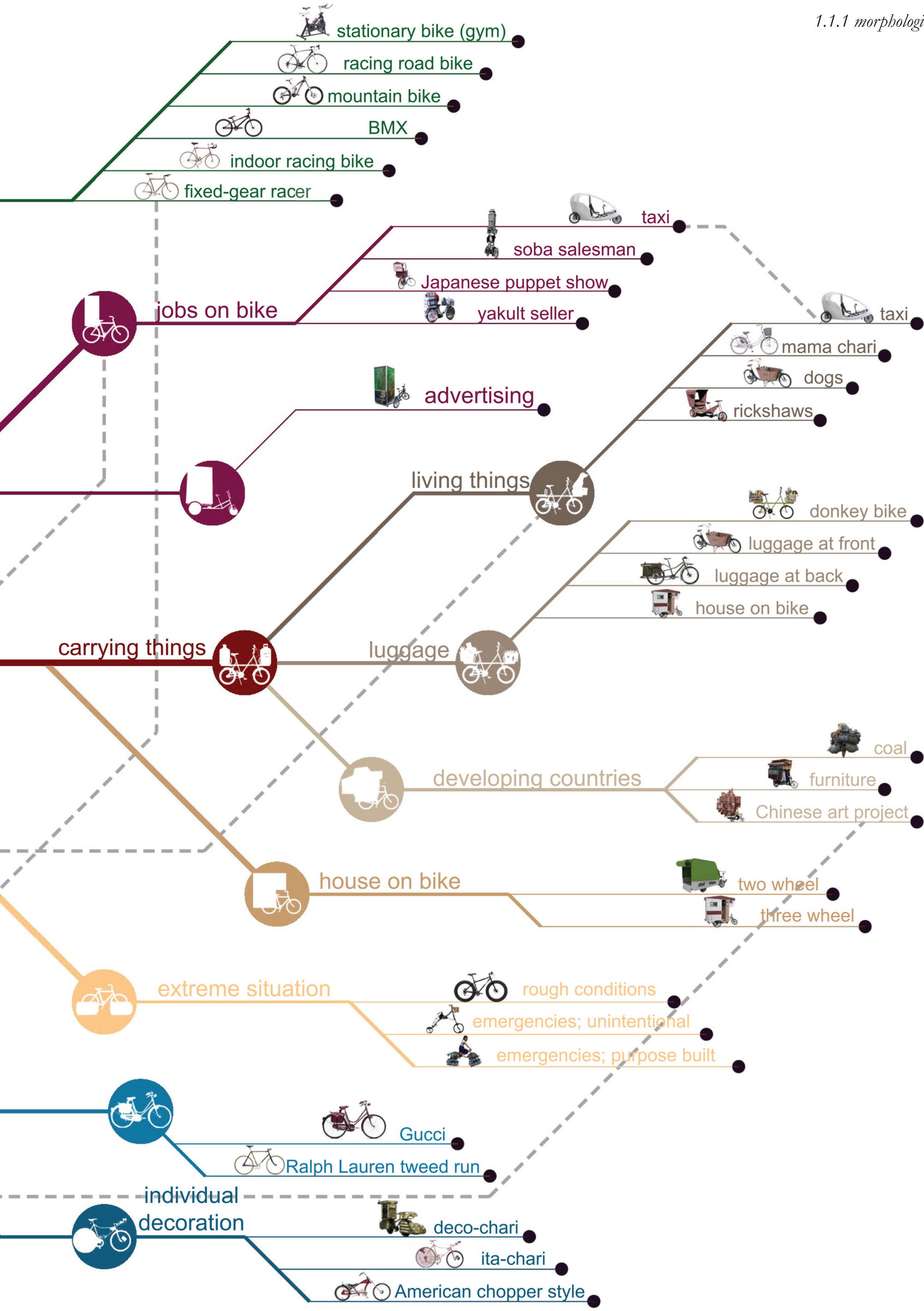


fig. 5 **bicycle evolution** / *branching development of bicycle diversification/ despite the wide variety of styles now available, the physics of the bicycle's utilitarian typology—its structural and mechanical configuration—has remained the same since its inception over a century ago*


stationary bike (gym)
racing road bike
mountain bike
BMX
indoor racing bike
fixed-gear racer
taxi
soba salesman
Japanese puppet show
yakult seller
jobs on bike
taxi
mama chari
dogs
rickshaws
advertising
living things
donkey bike
luggage at front
luggage at back
house on bike
carrying things
luggage
coal
furniture
developing countries
Chinese art project
house on bike
two wheel
three wheel
extreme situation
rough conditions
emergencies; unintentional
emergencies; purpose built
Gucci
Ralph Lauren tweed run
individual
decoration
deco-chari
ita-chari
American chopper style

1.1.1.2 TRANSFORMATION OF THE BICYCLE

fig. 6 **dandy horse**/*prelimary model of the velocipede/ forerunner of the modern bicycle*

The definitive origin of the bicycle is difficult to trace, as it appears that many iterations were developed in different places around the same time. The velocipede, the forerunner of the modern bicycle, experienced several major revisions, all with various people claiming to be its inventor as they built upon each other's innovations and failures, before settling into the form of the 'safety bicycle' we recognize today.

It is commonly accepted that the preliminary model of the velocipede was pioneered in Germany by Baron Karl von Drais. In 1815, a cataclysmic climate-changing volcano erupted, greatly impacting Europe's agricultural yield. Consequently, to avoid starvation, people were forced to eat their horses, the primary mode of transportation at the time. Karl von Drais proactively developed the 'dandy horse,' a saddle on wheels with no pedals, propelled by the user's own two legs as if in an act of walking or running. Subsequent improvements to von Drais' primitive version included the addition of pedals to the front wheel, first commercialized by Pierre Michaux in Paris during the 1860's. These were dubbed 'boneshakers' by the public due to their heavy cast iron and wood build, including iron ring tires. The 'high-wheeler's' lightweight steel construction, introduced by England's James Starley shortly thereafter, enabled and prompted the enlargement of the front wheel in order to maximize its fixed pedal-to-wheel propulsion.[4]

Finally, after various iterations of 'safety bicycles' flooded the market, the dangerously elevated high-wheelers, were successfully brought back down to earth by Starley's nephew, John Kemp Starley, in 1885. The introduction of a chain drive with sprockets that were capable of multiplying the revolution of the wheels, was critical in allowing them to return to an equal and smaller size.[5] The back-wheel-engaging chain drive meant that the rider's feet were kept safely away from the front wheel, and the lower stature meant stopping with one's feet on the ground, instead of tumbling headfirst

4 Michael Embacher, *Cyclepedia: A Century of Iconic Bicycle Design* (San Francisco: Chronicle Books, 2011), 10.
5 David V. Herlihy, *Bicycle: The History* (New Haven: Yale University Press, 2004), 235.

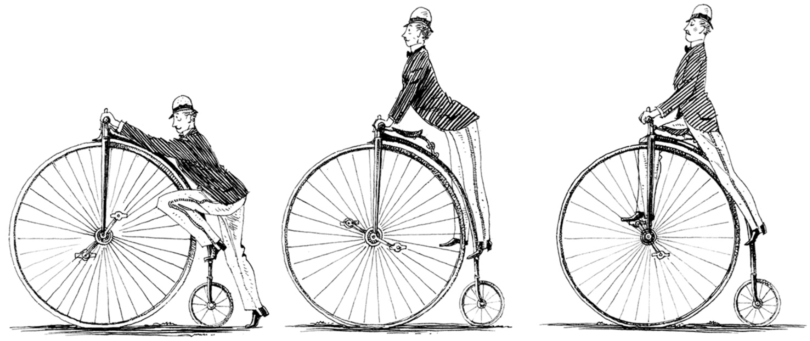


fig. 7 **high-wheeler**/*mounting instructions*

from a great height, was possible.[6] The replacement of the high wheeler's solid rubber tires with today's familiar pneumatic tires by John Boyd in 1888, further improved the bicycle's weight, and increased rider comfort.[7] The smaller wheels coupled with a rear chain drive meant the rider could now sit closer to the ground, and in the middle of the bike, effectively lowering and stabilizing their combined centre of gravity.[8] In 1895, the invention of the first derailleur in the United Kingdom, facilitated the changing of gears on a bike, thereby enabling travel at different speeds.[9] And thus, the safety bicycle with all its essential features evolved into the familiar form of the bicycle as we know it today.

Since then, aside from having been continually refined, and spawning eccentric albeit ultimately unsuccessful deviations, the bicycle has also branched out with functionally specialized varieties—from folding bikes at the end of the 19th century,[10] to city and touring bikes in the 1930's, racing bikes in the 1960's, and mountain bikes in the early 1970's[11]—all of which continue to be used and mass produced. Today, material and technological advancements have enabled carbon fibre frames and monocoques,[12] as well as 'smart' bicycles with built-in digital sensors and technology.[13] While the innovations are endless and will certainly continue to unfold as the human fascination with bicycles persists, the unwavering typology and steadfast relevance of the bicycle in all likelihood, will continue well into the future. Perhaps cycling expert and author Robert Penn encapsulates this best:

> *In both modes of transport, aeroplane and motor car, the vehicles have changed almost continuously. With the Rover Safety, however, the modern bicycle arrived virtually perfectly formed. Today in aeroplanes and automobiles and countless other mechanical devices there are numerous design variations and opportunities for improvement. With the bicycle, there is one absolute shape. Sir Isaac Newton said we make advances by standing on the shoulders of giants. No one has been able to climb upon Starley's back.*[14]

6 Ibid., 216.
7 Embacher, *Cyclepedia*, 10.
8 Penn, *It's All About the Bike,* 25.
9 Embacher, *Cyclepedia*, 11.
10 Ibid., 12.
11 René Kural and Yoshiharu Tsukamoto, *Bike Town Tokyo: Theory of Architectural Space and Planning: Workshop 2012* (Tokyo: Tokyo Institute of Technology, 2013), 15.
12 Embacher, *Cyclepedia*, 13.
13 Anna Winston, " 'Smart' bicycle by Vanhawks gives directions with flashing lights and vibrating safety alerts," *Dezeen*, May 6, 2014, http://www.dezeen.com/2014/05/06/vanhawks-valour-bicycle-connected-bluetooth-carbon-fibre-smart-bike/.
14 Penn, *It's All About the Bike,* 27-8.

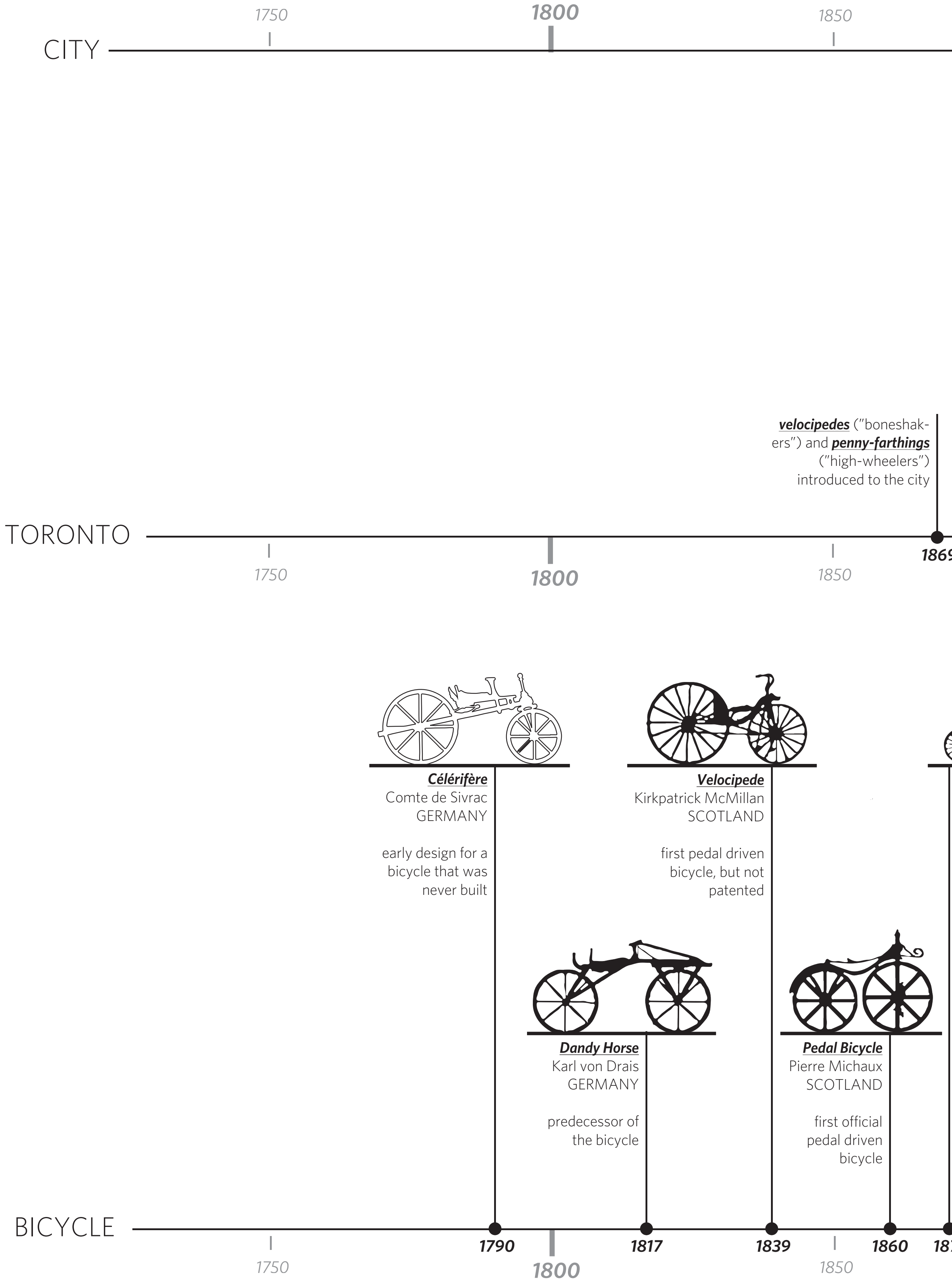
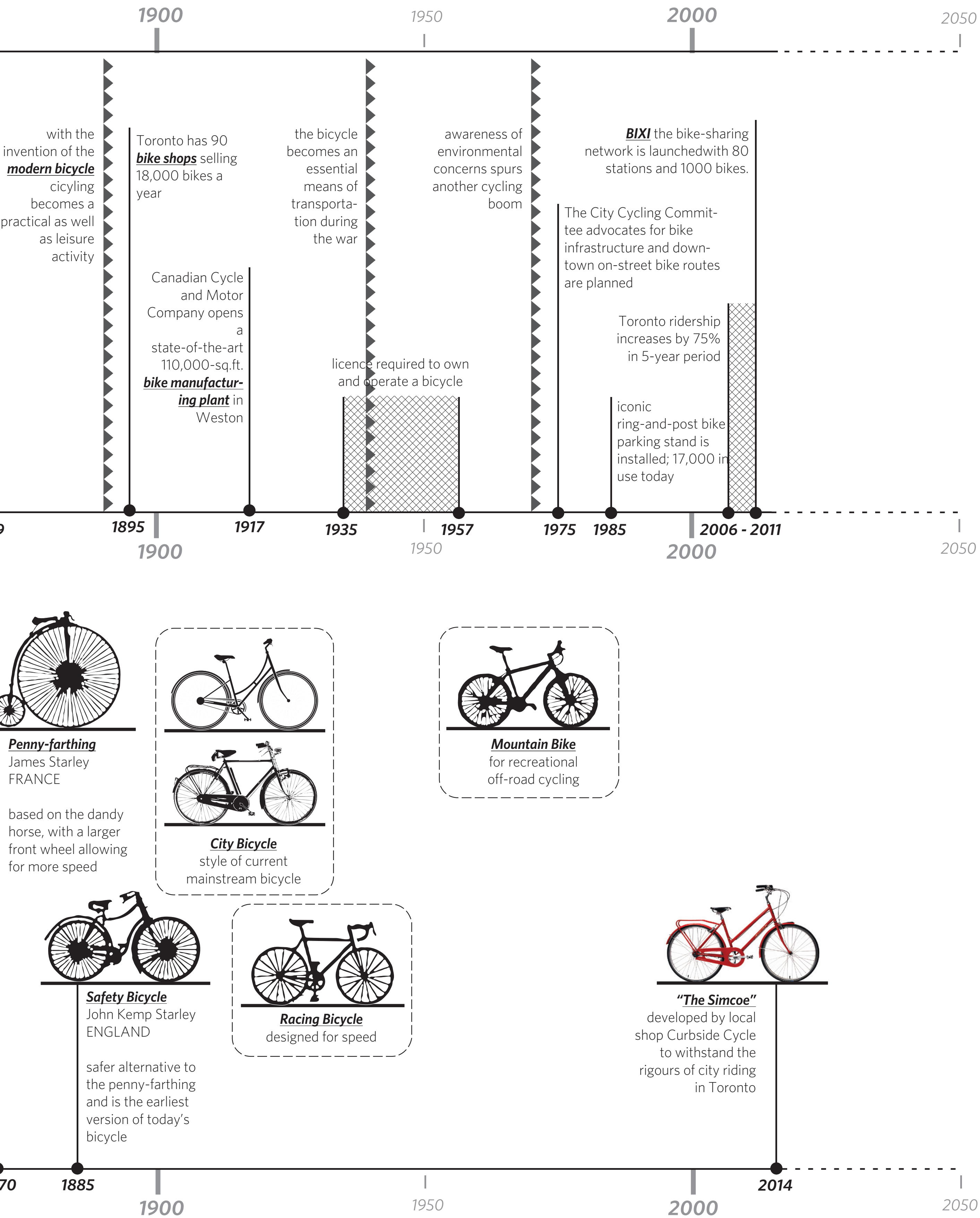


fig. 8 bicycle timeline/ *historical morphological, social, and urban evolution of the bicycle 1790 - present/ tracing the bicycle's formal development and social relationship to the city of Toronto*


1900
1950
2000
2050
with the invention of the **modern bicycle** cycling becomes a practical as well as leisure activity
Toronto has 90 **bike shops** selling 18,000 bikes a year
Canadian Cycle and Motor Company opens a state-of-the-art 110,000-sq.ft. **bike manufacturing plant** in Weston
the bicycle becomes an essential means of transportation during the war
licence required to own and operate a bicycle
awareness of environmental concerns spurs another cycling boom
The City Cycling Committee advocates for bike infrastructure and downtown on-street bike routes are planned
iconic ring-and-post bike parking stand is installed; 17,000 in use today
Toronto ridership increases by 75% in 5-year period
BIXI the bike-sharing network is launchedwith 80 stations and 1000 bikes.
1895
1917
1935
1957
1975
1985
2006 - 2011
Penny-farthing
James Starley
FRANCE
based on the dandy horse, with a larger front wheel allowing for more speed
City Bicycle
style of current mainstream bicycle
Mountain Bike
for recreational off-road cycling
Safety Bicycle
John Kemp Starley
ENGLAND
safer alternative to the penny-farthing and is the earliest version of today's bicycle
Racing Bicycle
designed for speed
"The Simcoe"
developed by local shop Curbside Cycle to withstand the rigours of city riding in Toronto
70
1885
2014

1.1.2 SOCIAL EVOLUTION OF THE BICYCLE

1.1.2.1 THE BICYCLE'S EFFECT ON SOCIETY

The bicycle and its predecessors brought lots of excitement to cities when they were first introduced in the late 19th century. They were personal machines that liberated man from the maintenance hassles of horses, as well as the constraints of railway lines, stations, and schedules. Operating such a device meant tremendous freedom in choosing one's desired path and speed, limited only by the rider's own capabilities. Rolling along city streets, or zipping through the countryside, it stitched an altogether new experience of space and time—truly transforming the idea of personal mobility.[15]

fig. 9 **safety bicyle**/ *advertisement for Starley's Rover Safety in* The Graphic, *March 1885*

But if the velocipede and its various boneshaking and injury-inducing prototypes achieved hardly more status than as playthings for the rich,[16] then it was the explosive commercial success of Starley's Rover Safety that brought the bicycle to the masses. Despite its initially high sales tag, it generated the bicycle boom of the 1890's,[17] as prices soon dropped to an affordable fraction of their original cost.[18] At the pinnacle of the boom in 1896, an astounding three hundred businesses produced over a million bicycles in the United States alone, making the industry one of the largest in the nation.[19] On a social level, the democratic nature of the bicycle played an instrumental role in liberating women and mobilizing the working class for the first time in history, and even helped to

15 Jessica Liefl, "Urban Pathways: Redesigning Toronto's Mobility" (Master's thesis, University of Waterloo, 2011), 38.
16 Herlihy, *Bicycle*, 7.
17 Ibid., 225.
18 Ibid., 7.
19 Ibid., 3-5.

fig. 10 **joy of cycling**/*Norman Rockwell painting for the* Saturday Evening Post*, April 1921*

widen the gene pool in rural areas.[20]

> *Above all, however, the bicycle was appealing as a personal vehicle. To youths it gave speed; to women, freedom and to many ordinary citizens it was simply a source of great pleasure and utility. To all, it offered exercise and adventure. […] The bicycle was, in effect, an antidote to the many tensions brought on by incessant innovation—even though, ironically, it was itself a product of that day's high technology.*[21]

Even more ironically, the new technology ushered in by the bicycle also had a hand in bringing its own mania to a halt in North America by 1897.[22] Much of the manufacturing equipment, factories, shops, and infrastructure established for the mechanical marvel paved the way for a new technological marvel—the automobile.[23] In Europe however, the bicycle's popularity largely persisted as a cheap means of transportation, exercise, and recreation.

Despite experiencing a brief resurrection during the 1930's Great Depression, it wasn't until World War II, when metal was scarce and automobile plant operations were suspended, that North Americans turned to the bicycle as an essential means of transportation. After the war, although the recreational appeal of cycling stuck, its utilitarian role was never able to achieve nearly the same status as the automobile, as the fuel-powered four-wheeler continued to dominate North American,[24] and even European roads.[25] Youth interest in wheelie bikes and lightweight sport racing and touring bicycles however, sparked a second bicycle boom in the late 1960's, generating the production of some forty-million bicycles worldwide between 1972 and 1974.[26] The energy crisis caused by the oil embargo of 1973 spurred this boom even more, as oil prices skyrocketed amidst growing environmental concerns for the planet.[27] In developing countries, the self-propelling machine mobilized countries like China, India, and Brazil by providing access to cheap and convenient transportation, while economically turning the once heavy importers of bicycles into some of the world's biggest exporters.

Today, activities such as bicycle touring, track and road racing, and both competitive and recreational mountain biking and BMX, have been growing with steady popularity worldwide.[28] However, in Canada, and much of North America, the bicycle never took off as a means of transportation to the same degree as it did in European cities. Much of it can be attributed to the the harsher climate, the greater distances between major towns in the vast landscape, and the early fervent adoption of the automobile,[29] which in turn also lead to car-sized roads, extended city blocks, and sprawling urban grain.[30]

20 Stefan Bendiks and Aglaée Degros, *Cycle Infrastructure* (Rotterdam: nai010 publishers, 2013), 8.
21 Herlihy, *Bicycle*, 264.
22 Ibid., 282.
23 Ibid., 5.
24 Ibid., 7-8.
25 Ibid., 336.
26 Ibid., 8-9.
27 Ibid., 365.
28 Ibid., 11.
29 Glen Norcliffe, *The Ride to Modernity: The Bicycle in Canada, 1869-1900* (Toronto: University of Toronto Press, 2001), 211-2.
30 Liefl, "Urban Pathways," 40.

1.1.2.2 THE BICYCLE'S EFFECT ON THE CITY

While the bicycle has been an established fixture for commuters in Europe for decades, particularly as cities in Denmark and the Netherlands started building extensive cycling networks by the late 1970's in response to the energy crisis,[31] urban cycling has only recently begun to resurface in North America. The continent's bicycle renaissance is lead by 'emerging cycling cities' such as New York City, Portland, and San Francisco, all recognizing the bicycle's indispensable role in creating sustainable, healthy, and liveable cities.[32] Analysts are also reporting a definitive trend over the past two decades toward a cycling revival in North America, as more and more Canadians and Americans are choosing the bicycle over the car for transport.

Nevertheless, the landscape still appears heavily mottled, as the vast majority of progress is being made in western North American provinces and states, and additionally, concentrated to gentrifying downtown and university areas in major cities, while suburbs remain car-dominated territories. Although 'emerging cycling cities' can boast some positive statistics, as a whole, the continent's modal share is still far below that of northern Europe.[33] Development of bike infrastructure in cities is also much slower than the Dutch transformation thirty years ago,[34] despite larger increases in funding to promote cycling over the past decade.[35]

Conversely, while developed countries around the world are attempting to reintroduce the bicycle on to its streets, major cities in developing countries like China, once teeming with bicycles in the 1970's and 80's, are becoming increasingly congested with automobiles.[36] Opting to swap the pedal-powered two-wheeler for a motorized four-wheeler, the growing affluent middle class[37] views the car as a status symbol,[38] as was once the case in North American society. Various levels of Chinese government are also attempting to revive cycling in the country as a means to alleviate gridlock, and reduce harmful car emissions for improved air quality.[39]

It is evident that we no longer view cities in the same way we once did at the dawn of the age of the automobile. Instead of creating corridors of congested pollutants,[40] urbanites are calling for cleaner and closer public spaces designed at the human scale. As alternative transportation expert Rodney Tolley observes:

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31 Steven Fleming, *Cycle Space: Architecture & Urban Design in the Age of the Bicycle* (Rotterdam: nai010 publishers, 2012), 7.
32 Bendiks and Degros, *Cycle Infrastructure*, 8.
33 John Pucher and Ralph Buehler and Mark Seinen, "Bicycling Renaissance in North America? An Update and Re-Appraisal of Cycling Trends and Policies," *Transportation Research Part A: Policy and Practice* 45, no. 6 (2011): 451-475.
34 Fleming, *Cycle Space*, 8.
35 Pucher and Buehler and Seinen, "Bicycling Renaissance in North America?" 451-475.
36 Liang Chen, "Automobile backlash may spark bicycle renaissance in China," *Global Times*, September 27, 2014, http://www.globaltimes.cn/content/883733.shtml.
37 Dominic Barton, Yougang Chen, and Amy Jin, "Mapping China's middle class," *McKinsey Quarterly*, June 2013, http://www.mckinsey.com/insights/consumer_and_retail/mapping_chinas_middle_class.
38 Jennifer Duggan, "Cycling in China: not for the faint-hearted," *The Guardian*, September 11, 2012, http://www.theguardian.com/environment/bike-blog/2012/sep/11/cycling-china-faint-hearted.
39 Chen, "Automobile backlash."
40 Bendiks and Degros, *Cycle Infrastructure*, 8.

> *If sustainable transport is defined as 'transport that meets the needs of the present without compromising the ability of the future generations to meet their own needs,' it is evident on many criteria that our current car-based travel patterns are unsustainable terms of present and future generations.*[41]

The massive transportation and societal benefits reaped from the successful implementation of cycling infrastructure in northern Europe have shown that the bicycle "is simply the most effective tool in our urban toolboxes for transforming the urban landscape."[42] With progress on the horizon in North America, exemplified by the conversion of car-dependent cities like Portland, there is ample proof that with enough intervention, it is possible to readopt the bicycle into the city as a healthy and practical part of the urban lifestyle.

fig. 11 **cycling culture in Amsterdam**

41 Rodney Tolley, *Sustainable Transport: Planning for Walking and Cycling in Urban Environments* (Cambridge: Woodhead Publishing Limited, 2003), 1.

42 Bendiks and Degros, *Cycle Infrastructure*, 8.

fig. 12 **Galerie des Machines (1889)**

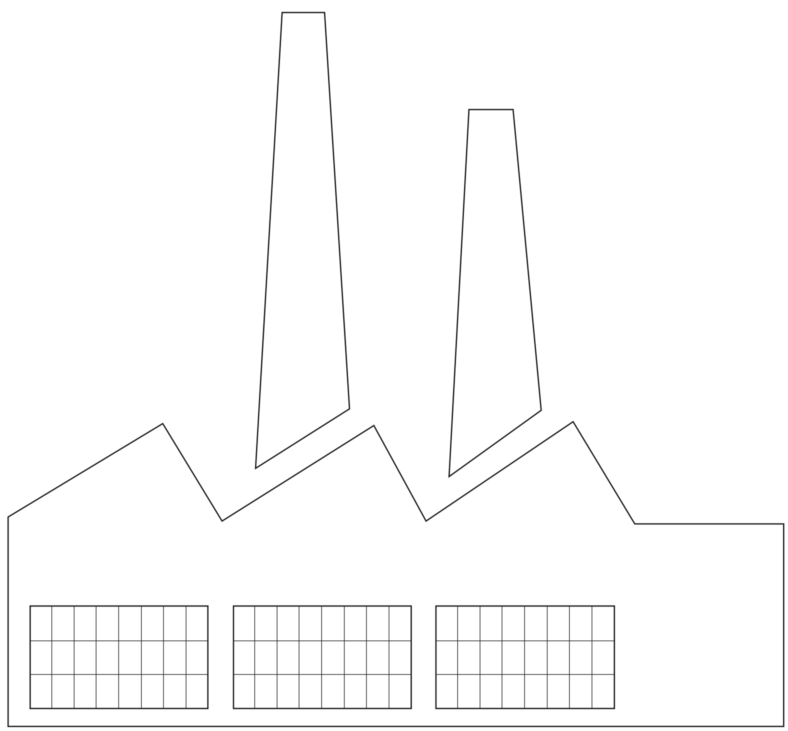


fig. 13 **factory typology**

1.2 typology II — factory

1.2.1 MORPHOLOGICAL EVOLUTION OF THE FACTORY

1.2.1.1 WHAT IS A FACTORY?

At first glance, factories appear to be one of the most elemental construction tasks. At the same time, they are also examples of the most extreme type of architecture which closely approaches the notion of a pure enclosed space. Combine frame and shell, floor plate and roof, add building services, windows and doors, and the factory is finished. Assembly halls and warehouses don't require complex spatial relationships or sophisticated view juxtapositions. A closer examination, however, reveals the complexity of these buildings. It is precisely this complete freedom of a simple closed space that makes these structures so interesting. Whereas "assembly line" factories offer bare functionality, architectural design often has to compete with industrial pre-fabricated buildings on a very small budget, being forced to create quality in detail using subtle means.

Of course, industrial architecture has much more to offer, answering not only to complex demands in terms of a smooth production process, but also anticipating future modifications and expansions. In addition, engineered services like heating and ventilation have to be joined with the often short-lived production equipment. When designing illumination, glare has to be minimized and the depth of the building calculated; air conditioning must not interfere with modern IT technology. Similarly to office buildings, factories also have to offer infrastructure for informal inter-departmental meetings and spontaneous "on the go" exchanges. The logistics of the production process and infrastructure (delivery and dispatch) must be adjustable to changing processes and fulfill the strictest demand on time and energy savings. This is where the custom-designed factory can greatly outperform a pre-fabricated hall by considering the operator's specific needs during the design process.

— Chris van Uffelen, *Factory Design*

The invention of the factory was an essential factor to the sweeping industrial revolution of the European 19th century, confirming the presence and consequence of architecture in modernism's great cultural revolution.

— Natasha Sandmeier, *The Factory: Manufacturing Identity*

1.2.1.2 TRANSFORMATION OF THE FACTORY

fig. 14 **cottage industry**/*pre-industrialization*

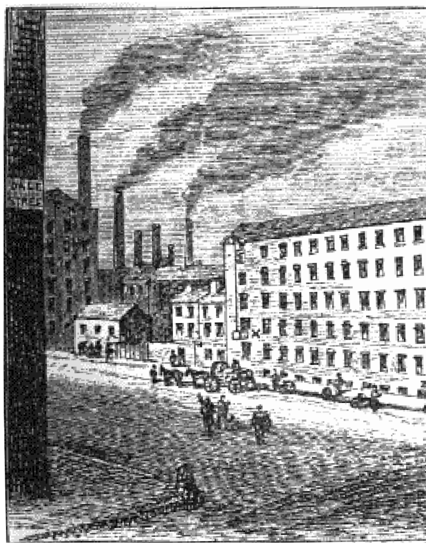


fig. 15 **multi-storey textile mill in Manchester**/ *early factory typology prevalent at the onset of the Industrial Revolution*

Factory Typology — Mercantile Era

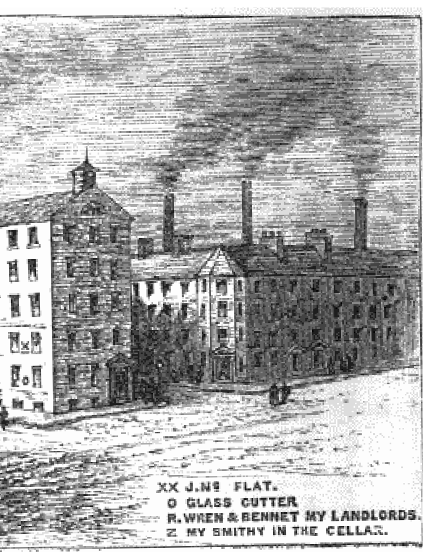
One could argue that factories have been around since the Middle Ages, when masons cut stones by hand for cathedral construction, and the introduction of covered sheds allowed work to continue into the winter.[1] Or the 12th-century Venetian Arsenal, with its army of shipbuilders mass-building ocean-bound vessels at incredible assembly-line like pace,[2] dubbed "one of the earliest large-scale industrial enterprises in history."[3]

But the typology of the factory building in contemporary society, did not emerge until the 18th and 19th century, as a direct byproduct of the Industrial Revolution.[4] Previously called a 'manufactory,' manufacturing largely involved 'manus facere', or 'manual production.'[5] Proto-factories consisted of local artisanal workshops and home-based cottage industries, in which handicraft was supplemented by hand tools or simple machinery.[6] Merchants distributed raw materials to rural families,[7] and collected finished products to sell on the marketplace.[8] Manufactories became necessary just prior to industrialization, when complex production processes required work to take place in one location, such as in the making of high-quality porcelain.[9] By the latter half of the 18th century, the introduction of steam power and more economical means of iron and steel production, enabled the proliferation of larger and more complex mechanically-powered machines. This rapid expansion thus also demanded an appropriate enclosure to house all the production—or, the factory.[10]

Facotory Typology — Industrial Revolution

The large spatial demands of consolidated production processes, often linked industrial buildings to innovative structural technologies, particularly ones serving longer spans. At the beginning of the Industrial Revolution, owing to the priority of functional performance over aesthetics, the form of factory buildings was largely dictated by engineers and industrialists; architects were more preoccupied with statelier affairs, such as the design of churches, estate houses, and civic buildings.[11] Early factories typically consisted of one building with a single power generator—often a water wheel or steam engine[12]—and 18th-century English textile mills were the first prevalent example of this emergent building type.[13] They used the height of their multi-storey construction to

1 Chris van Uffelen, *Factory Design* (Berlin: Braun, 2009), 8.
2 Robert C. Davis, *Shipbuilders of the Venetian Arsenal: Workers and Workplace in the Preindustrial City* (Baltimore: Johns Hopkins University Press, 1991), 201, back cover.
3 Rondo Cameron and Larry Neal, *A Concise Economic History of the World: From Paleolithic Times to the Present* (New York: Oxford University Press, 2003), 161.
4 "Industrial Revolution," *History.com*, 2009, http://www.history.com/topics/industrial-revolution.
5 van Uffelen, *Factory Design*, 7.
6 "Industrial Revolution."
7 who provided services in order to supplement their agricultural income
8 *Encyclopedia.com*, s.v. "Cottage Industries," 2007, http://www.encyclopedia.com/doc/1G2-1552100080.html.
9 van Uffelen, *Factory Design*, 8.
10 "Industrial Revolution."
11 David J. Whitehill, "Post-Industrial Production" (Master's thesis, University of Maryland, 2007), 39.
12 Mary Beggs-Humphreys and Hugh Gregor, *The Industrial Revolution* (London: Routledge, 2006), 24.
13 Whitehill, "Post-Industrial Production," 39.



harness the energy from water or steam powered machinery. In 1782, the first vertically integrated machine for milling flour, was designed by Oliver Evans, which accomplished the entire sequence of processes, from raw material to finished product, without additional human intervention.[14] The early mills were characterized by timber floors supported on timber posts and load-bearing masonry walls,[15] and later, with windows as large as the structure would allow, for maximum daylighting.[16]

By the end of the 18th century, iron had proved its strength, and industrial buildings were quick to adopt this new method of construction—replacing timber posts in textile mills with cast iron, and later, steel columns and girders.[17] Then as architects became more involved in the creation of spaces for manufacturing, factories started taking on greater design articulation and aesthetic expression. But as witnessed throughout history, when confronted with new building types with little to no precedent, architects are often challenged to find ways to unite the latest technology with established architectural styles. As a result, many of the first factory buildings "often borrowed decorative motifs from religious and civic architecture."[18] Jules Saulnier's Menier chocolate factory in early 19th-century France, consisted of iron-frame construction with Beaux Arts masonry and intricate ironwork.[19] Around the same time period, Karl Ludwig Althan's design for the Sayner Hütte foundry in Prussia was derivative of the basilican plan, with glass panels and clerestory windows set within a structural iron framework, as "[t]russes and connection details [came] together to create a structure of enormous Gothic expression."[20]

Around 1840, the development of heavier and louder machinery shifted factory construction toward predominantly single-storey structures, and in northern Europe, sawtooth skylights were employed as a cheap and effective way to bring light to the interior of increasingly deeper floor plates. In 1851, Joseph Paxton's seminal Crystal Palace of iron and glass at London's World Exhibition demonstrated a systematic, prefabricated method of construction that could conceivably be repeated indefinitely—thus appealing to notions of infinitely large factories.[21]

modernist factories

During this age of great transformation, industrial architecture had yet to develop an expression of its own,[22] as architects designed, built, and tested the factory building typology: Peter Behrens' AEG turbine factory building in Berlin could be read as a marriage between rationalized structure and architectural ornamentation. Built in 1909, it "stands at the turning point between nineteenth century historicism and the emergence of modern architecture."[23] Its long arcade hall created a large, open, linear plan, which

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14 Nina Rappaport, "Factory in Context: Timeline," *Vertical Urban Factory*, accessed January 7, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/timeline.php.
15 Whitehill, "Post-Industrial Production," 39.
16 Rappaport, "Factory in Context: Timeline."
17 Whitehill, "Post-Industrial Production," 39.
18 Ibid., 41.
19 van Uffelen, *Factory Design*, 8.
20 Whitehill, "Post-Industrial Production," 40.
21 van Uffelen, *Factory Design*, 8.
22 Whitehill, "Post-Industrial Production," 42.
23 Kurt Ackermann, *Building for Industry* (London: Watermark, 1991), 52.

innovatively utilized gantry cranes[24] instead of gravity, like its multi-storey predecessors. Described as a 'temple of power,' the functionality of this space was enclosed by neoclassical exterior walls[25]—massive and monumental, structure-concealing,[26] and complete with details celebrating the machine aesthetic.[27]

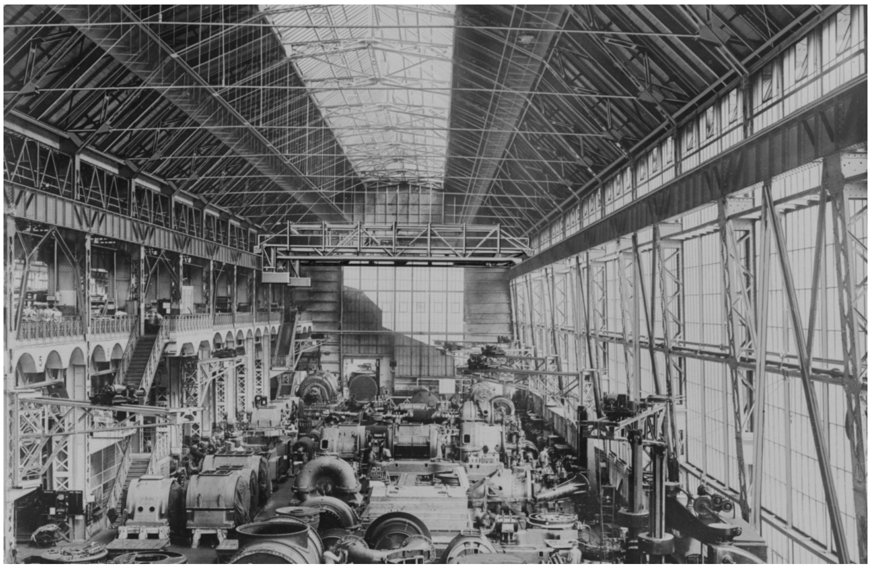


fig. 16 **AEG turbine factory (1909)**

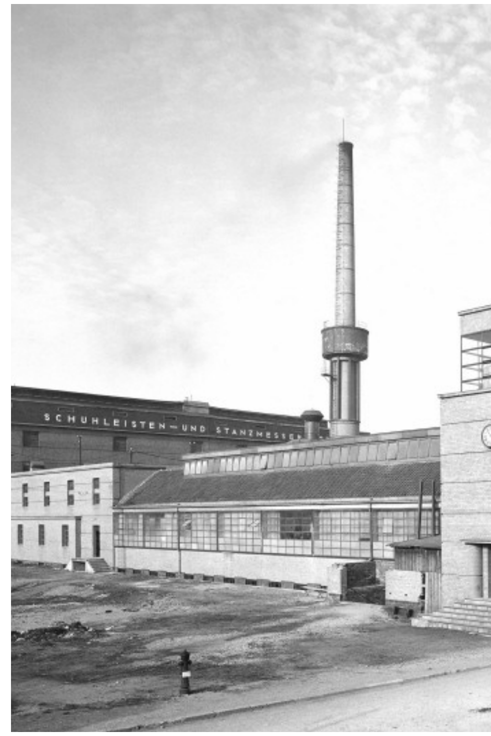


fig. 17 **Fagus-Werk (1913)**

Meanwhile, the shoe last factory, Fagus-Werk, built in Germany several years later by Walter Gropius, a student of Behrens, had already found its unique aesthetic foothold through modernism. Its clean lines were stripped of ornamentation, and proclaimed formal purity in the name of functionalism through the explicit expression of building volumes that were reflective of interior operations. The factory's expansive use of glass was also unprecedented, and later declared as the first curtain wall.[28]

By the 1920's and 1930's, architecture in the formative years of modernism had found a voice in the International Style.[29] The Van Nelle Factory in Rotterdam, completed in 1931,[30] more than a decade after Fagus-Werk, is often cited as a prime example of the International Style.[31] The spacious multi-storey facility of steel, glass, and concrete, providing generous amounts of natural light through its curtain wall, began as a processing plant for coffee, tea, and tobacco.[32] It too, boasted of a manufacturing process

fig. 18 **Van Nelle Factory (1931)**

24 Stanford Anderson, *Peter Behrens and a New Architecture for the Twentieth Century* (Cambridge, MA: The MIT Press, 2000), 136.
25 David Watkin, *The History of Western Architecture* (London: Laurence King Publishing, 1996), 508-9.
26 Whitehill, "Post-Industrial Production," 43.
27 Uygar Boztepe, "AEG & Peter Behrens: Symbolism in the First Corporate Identity Design" (Master's thesis, Izmir Institute of Technology, 2012), iv.
28 Whitehill, "Post-Industrial Production," 43.
29 *Encyclopaedia Britannica Online*, s.v. "International Style," last modified August 8, 2014, http://www.britannica.com/art/International-Style-architecture.
30 "Van Nelle Designfactory," *Architecture in Rotterdam*, accessed November 7, 2015, http://www.architectuurinrotterdam.nl/building.php?buildingid=15&lang=en&PHPSESSID=228f4fae13d7250ef550110c6208b879.
31 "Brinkman and the International Style in Architecture," *Artlark* (blog), March 22, 2015, http://artlark.org/2015/03/22/brinkman-and-the-international-style-in-architecture/.
32 "Van Nelle Designfactory."

that could be 'read' in the shape of its buildings.[33] As the reductive and functionalist philosophies of modernism took form, "[m]any classical modernist architects were interested in the factory as a contemporary place of production."[34]

Factory Typology — Fordism

While the modernists looked to production facilities for inspiration in aesthetic efficiency in early 20th-century Europe, Henry Ford's quest for efficiency in the act of manufacturing itself was being developed in America: the assembly line system of mass production would revolutionize the nature of manufacturing and factories around the world.[35]

In order to maximize sales, Ford set out to make cars that were affordable to the ordinary citizen, and employed a number of strategies to increase efficiency and lower operating costs.[36] Using Taylorism's Principles of Scientific Management, he strived to speed up, and thus expand production, through the meticulous engineering of worker movements into "a system of measurable operations."[37] The resulting assembly line, was a systematically designed organization of people and machinery in specific spatial sequence; they operated on a succession of identical items, which circulated along a fixed path through progressive stages of assembly.[38] Efficiency was derived from the mechanization of moving parts, and the repetitive motions of the stationary worker and machinery at each segment.[39]

Of course, the fast pace achieved on the assembly line could not have been realized without the advent of electricity. In fact, being among the first industrialists to see the potential of electricity in increasing production volume, Ford credits the realization of his accomplishments to the electrification of factories. The conversion from steam power to electricity allowed each tool to be equipped with its own electric motor, which allowed machinery to be arranged in sequence according to the flow of work.[40] Electricity enabled the assembly line. These prerequisites thus rendered "highly specialized manufacturing lines, within highly specialized factories […] it was the era of specialized spaces uniquely calibrated to increase […] mass production capabilities."[41]

These continuously-moving assembly lines naturally also required large, open workspaces—which were made possible by Albert Kahn's structural and architectural ingenuity. With the realization of the Packard Motor Company building in 1903, he became the first person to replace wood with the newly developed system of reinforced

33 van Uffelen, *Factory Design*, 10.
34 Ibid., 8.
35 Ian S. Huff, "Walmart 2.0" (Master's thesis, University of Waterloo, 2012), 37.
36 John Scott and Gordon Marshall, *A Dictionary of Sociology* (Oxford: Oxford University Press, 2009), 260.
37 Patrik Schumacher and Christian Rogner, "After Ford," ed. Georgia Daskalakis, Charles Waldheim, and Jason Young, *patrikschumacher.com*, 2001, http://www.patrikschumacher.com/Texts/AfterFord.htm.
38 *Oxford Dictionaries*, s.v. "assembly line," accessed October 24, 2015, http://www.oxforddictionaries.com/definition/english/assembly-line?q=assembly+line.
39 Dan Hoffman, "The Best the World Has to Offer," in *Stalking Detroit*, ed. Georgia Daskalakis, Charles Waldheim, and Jason Young (Barcelona: Actar Publishers, 2001), 44.
40 Jeremy Rifkin, *The Zero Marginal Cost Society: The Internet of Things, the Collaborative Commons, and the Eclipse of Capitalism* (New York: Palgrave Macmillan, 2014), 52.
41 Huff, "Walmart 2.0," 37.

concrete in industrial construction.[42] Kahn subsequently applied the technology on an even larger scale in 1909 for Ford's Highland Park automobile plant in Detroit.[43] The system's economical and efficient use of steel, inherent fireproofing qualities, and ability to span further distances,[44] provided the factory with large expanses of unobstructed space, making it suitable for virtually any type of manufacturing activity.[45]

At Highland Park, the world's first complex assembly line was split into four storeys of discrete stages of production, as materials flowed from top to bottom via gravity and mechanized conveyors, through chutes and floor openings.[46] The nature of the assembly line divided the manufacturing process into smaller tasks, thus spatially separating them into differentiated departments.[47] The verticality of the architecture reflected the vertical organization of the process, while the entire operation was accomplished seamlessly on site, from raw materials to distribution of the final product: the Ford Model T.[48] The factory's "externally expressed structure with infill glass walls became a basic unit of the industrial vocabulary,"[49] with "ordered façades [and] a civic air, its concrete frame rendered in the stately air of a one-half mile long brick and limestone façade. Order produced order. Straight lines produced more straight lines [...] Building itself was rendered as production."[50]

Facilitated by the expansive volume of its architecture, Highland Park soon became a precedent for factories around the world, as the pioneer of the assembly line and efficient large-scale production.[51] Its influence reached all the way to Italy, inspiring the construction of another iconic automobile plant: Fiat's Lingotto Factory. The gargantuan building—four storeys high and over half a kilometre long[52]—was the only physical manifestation of a short-lived Futurist movement obsessed with speed, machines, and technology. Built between 1915 and 1923 by engineer Giacomo Mattè-Trucco,[53] it attempted to model the rationality of the American factory, closely emulating Highland Park's multi-level reinforced concrete structure. Inside, rows upon rows of concrete columns created expansive orthogonal spaces for its all-encompassing assembly line.[54] It too, expressed the Fordist logic of its systematically organized interior, with a rational, ordered façade on the exterior. However, while displaying functionalist values in principle, the factory in fact represented a perversion of those ideals. This was particularly evident with the reversal of the top-to-bottom production process, undoubtedly to allow the placement of the test-track on the roof—the grand finale to a spectacle of production.[55] Although quickly proven to be no more practical than a 'symbolic flourish,' the building was nevertheless regarded by modernist architects, such as Le Corbusier, as the epitome of modernist aspirations.

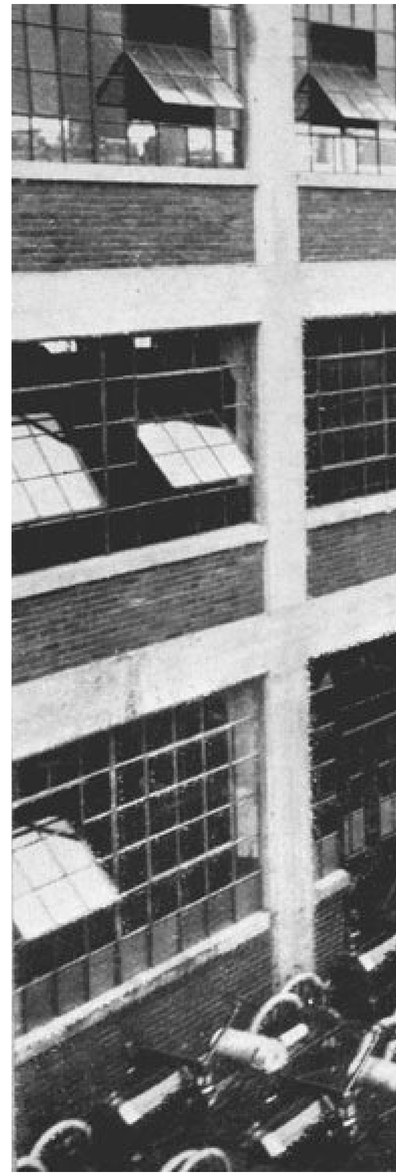
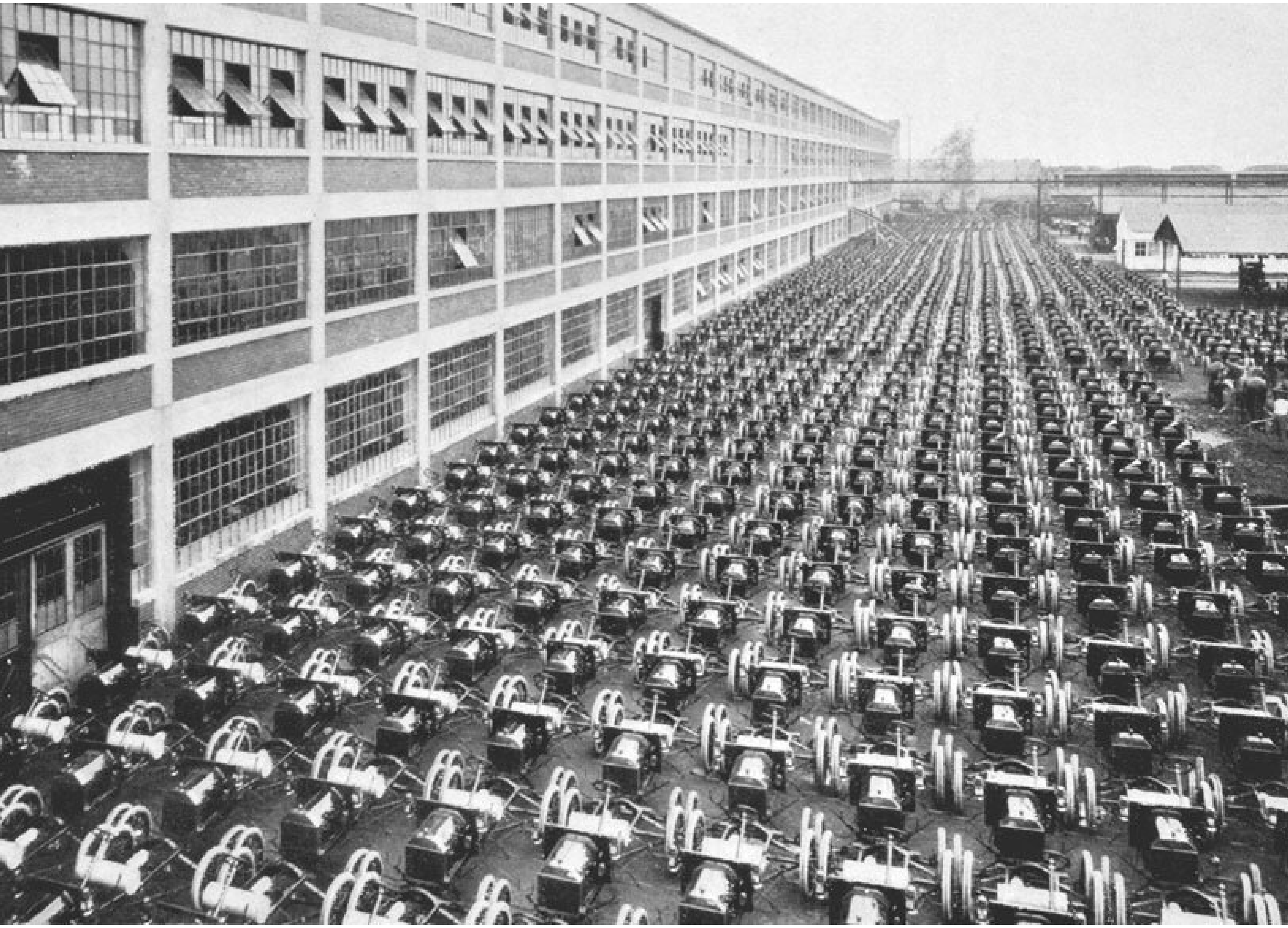


fig. 19 **Ford Highland Park plant (1909)**

42 Byron Olsen and Joseph Cabadas, *The American Auto Factory* (St. Paul, MN: MBI Publishing Company, 2002), 38.
43 Huff, "Walmart 2.0," 37.
44 Whitehill, "Post-Industrial Production," 42.
45 Schumacher and Rogner, "After Ford."
46 Nina Rappaport, "The Vertical Urban Factory," *Vertical Urban Factory*, accessed October 25, 2015, http://www.verticalurbanfactory.org/OVERVIEW.
47 J. Temple Black and Steve L. Hunter, *Lean Manufacturing Systems and Cell Design* (Dearborn, MI: Society of Manufacturing Engineers, 2003), 4.
48 Rappaport, "The Vertical Urban Factory."
49 Whitehill, "Post-Industrial Production," 42.
50 Hoffman, "The Best," 44-5.
51 Huff, "Walmart 2.0," 39.
52 Reyner Banham, "Fiat: The Phantom of Order," *Arts in Society* 72, no. 1164 (1985): 86-8.
53 van Uffelen, *Factory Design*, 10.
54 Banham, "Fiat," 86-8.
55 Rappaport, "The Vertical Urban Factory."



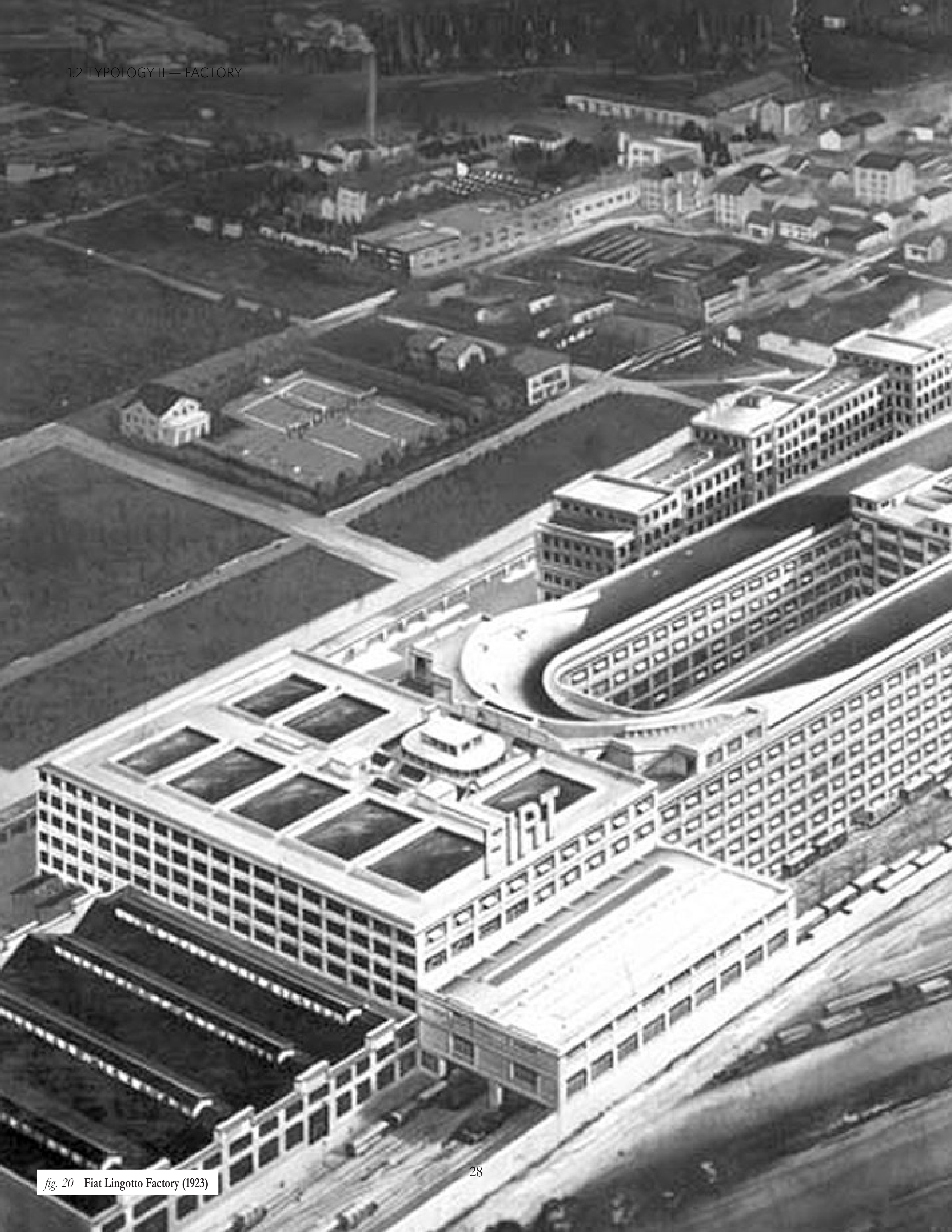


fig. 20 **Fiat Lingotto Factory (1923)**

Despite Fiat's forward-looking ambitions, by the time the Lingotto Factory was operational, it was already considered dated by American standards.[56] Ford had moved on from the single multi-storey building typology to the efficient arrangement of multiple single-storey buildings.[57] The vertical method of production had reached its limits: constrained by the size and number of holes the concrete floors allowed, the inflexibility exasperated the increasingly frequent changeovers of new product designs.[58] So while industrialists were busy modelling after Highland Park, Ford re-revolutionized his own production theories by applying the assembly line at the urban scale—that is, 'city as machine.'[59] Once again employing the services of Albert Kahn, his ideas materialized in the form of the Ford River Rouge complex, built between 1917 and 1928.[60] Previously, where distinct segments of the assembly line occupied different floors at Highland Park, they now filled entire low-rise buildings extruded to the required length.[61] Kahn's "integrated structural and saw-tooth skylight frame" construction, enabled the lateral expansion of space, to allow for flexibility within a rapidly-changing industry.[62] Buildings were connected together in sequence determined by the flow of parts and materials, which dictated the layout of the entire facility.[63] Fittingly, motor vehicles were used to transport parts between stations—effectively using the finished product itself as an extension of the assembly line.[64] The self-contained complex impressively accomplished the entire production process on site, from raw materials to completed product. And thus, the River Rouge complex paved the way for a paradigm shift in industrial enterprises from that of architectural verticality, to urban horizontality.[65]

fig. 21 **Ford River Rouge complex (1928) aerial**

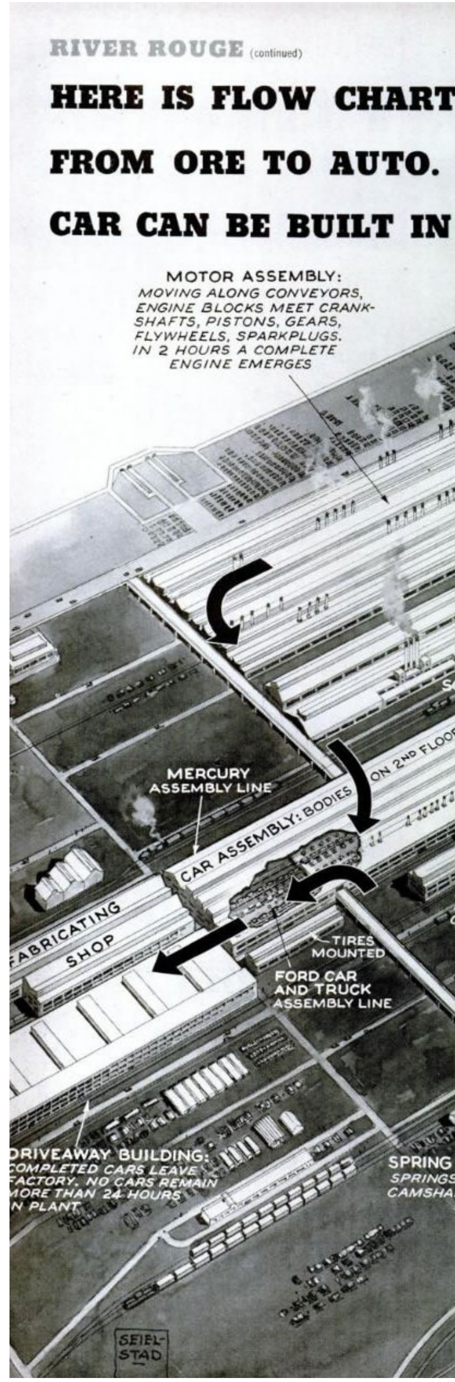
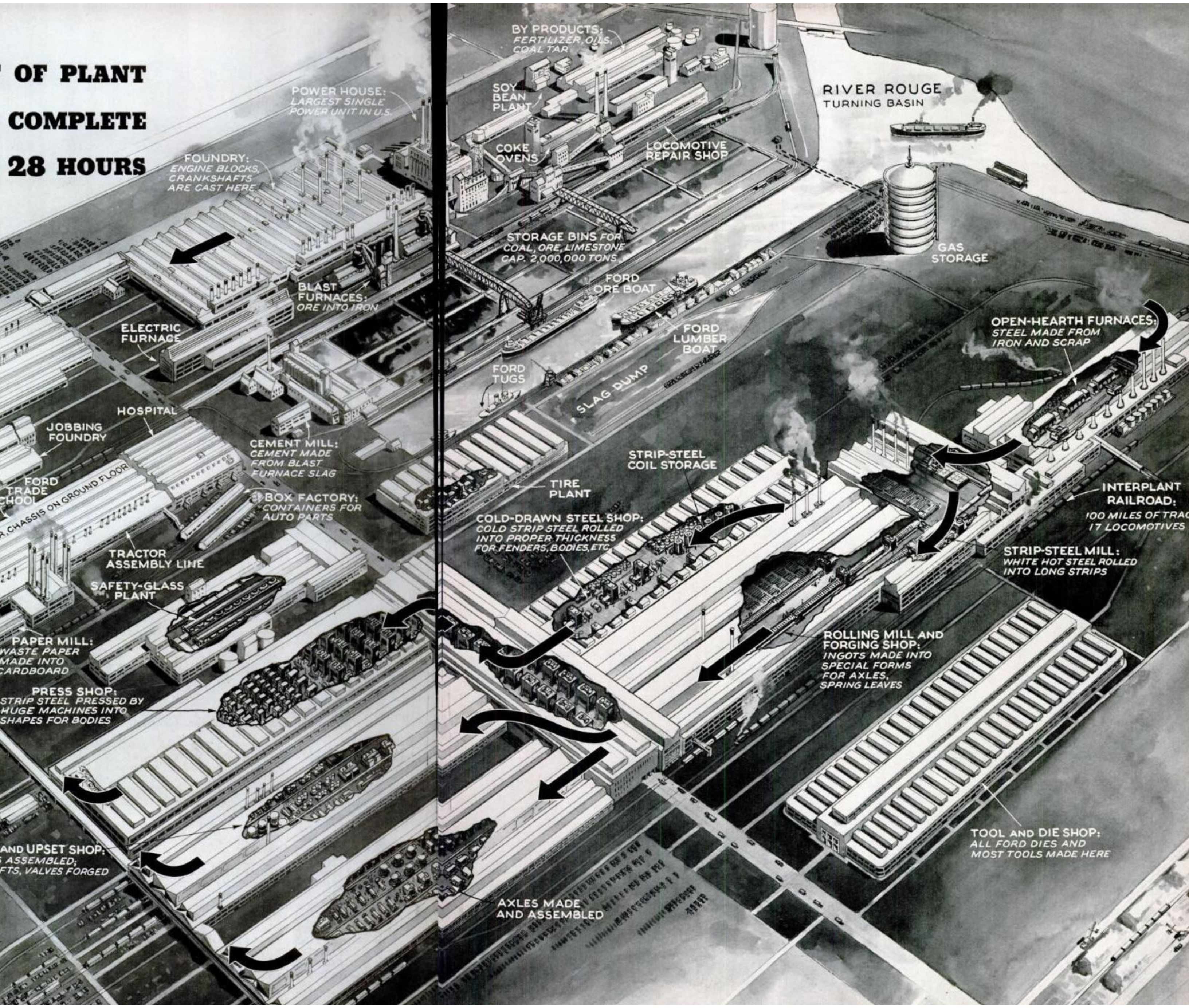


fig. 22 **Ford River Rouge complex (1928) production process**

56 Banham, "Fiat," 86-8.
57 Huff, "Walmart 2.0," 45.
58 Hoffman, "The Best," 45.
59 Schumacher and Rogner, "After Ford."
60 Huff, "Walmart 2.0," 45.
61 Schumacher and Rogner, "After Ford."
62 Hoffman, "The Best," 45.
63 Schumacher and Rogner, "After Ford."
64 Hoffman, "The Best," 45.
65 Huff, "Walmart 2.0," 45.


OF PLANT
COMPLETE
28 HOURS
BY PRODUCTS: FERTILIZER, OILS, COAL TAR
POWER HOUSE: LARGEST SINGLE POWER UNIT IN U.S.
SOY BEAN PLANT
RIVER ROUGE TURNING BASIN
COKE OVENS
LOCOMOTIVE REPAIR SHOP
FOUNDRY: ENGINE BLOCKS, CRANKSHAFTS ARE CAST HERE
STORAGE BINS FOR COAL, ORE, LIMESTONE CAP. 2,000,000 TONS
GAS STORAGE
BLAST FURNACES: ORE INTO IRON
FORD ORE BOAT
ELECTRIC FURNACE
FORD LUMBER BOAT
OPEN-HEARTH FURNACES: STEEL MADE FROM IRON AND SCRAP
FORD TUGS
SLAG DUMP
HOSPITAL
JOBBING FOUNDRY
CEMENT MILL: CEMENT MADE FROM BLAST FURNACE SLAG
STRIP-STEEL COIL STORAGE
FORD TRADE SCHOOL
BOX FACTORY: CONTAINERS FOR AUTO PARTS
TIRE PLANT
INTERPLANT RAILROAD: 100 MILES OF TRAC 17 LOCOMOTIVES
CHASSIS ON GROUND FLOOR
COLD-DRAWN STEEL SHOP: COLD STRIP STEEL ROLLED INTO PROPER THICKNESS FOR FENDERS, BODIES, ETC.
TRACTOR ASSEMBLY LINE
STRIP-STEEL MILL: WHITE HOT STEEL ROLLED INTO LONG STRIPS
SAFETY-GLASS PLANT
PAPER MILL: WASTE PAPER MADE INTO CARDBOARD
ROLLING MILL AND FORGING SHOP: INGOTS MADE INTO SPECIAL FORMS FOR AXLES, SPRING LEAVES
PRESS SHOP: STRIP STEEL PRESSED BY HUGE MACHINES INTO SHAPES FOR BODIES
TOOL AND DIE SHOP: ALL FORD DIES AND MOST TOOLS MADE HERE
AND UPSET SHOP: S ASSEMBLED; FTS, VALVES FORGED
AXLES MADE AND ASSEMBLED

Factory Typology — Post-Fordism

flexible models of production

The Fordist model of production dominated the industrial landscape for decades, before being superseded by Just-in-Time (JIT) manufacturing.[66] First developed in Japan after the Second World War, primarily within Toyota plants as the Toyota Production System (TPS), JIT did not percolate into Western industry until the 1980's, where it was widely adopted.[67] As its name suggests, JIT was a strategy in which materials or components were delivered right before they were needed in the production process, or 'just in time,' so as to save on inventory costs and minimize waste.[68]

> *[W]here Ford's economic model and industrial system grew from, and reacted to an era which attempted to achieve a planned economic and social stability, the TPS grew from era where this planned, stable, and predictable condition was in disarray following the Second World War, and no longer seen as an achievable reality. Thus, agility, flexibility, and an evolutionary capacity needed to be designed and integrated into their systems.*[69]

The Ford method of manufacturing attained efficiency through the mass production of identical parts moving along highly-specialized but fixed assembly lines. As a result, it demanded a great level of flexibility in its architecture, with large accommodating spaces, and expandable, modular construction. The entire factory was devoted to a single product. JIT logic inverted the Ford model by rendering the production process itself flexible. Instead of stockpiling sub-components or finished products and *pushing* the product to the consumer, Toyota's system was driven by market demand *pulling* the commodity through its production lines. It achieved this by making factory machines that were adaptable to different models of cars, and composing the manufacturing system out of linked cells adjacent to the assembly line, instead of moving along strictly designated paths. It varied production speeds, staffing needs, and retooled or shut down cells based on an instantaneous feedback loop of customer demand.[70]

The JIT approach also gave workers more agency in their roles, by allowing them additional control through the constant monitoring of the production process. On top of requiring more employee participation and expertise, it also fostered a teamwork environment between workers and managers. This was achieved through the use of architectural strategies such as the provision of shared common spaces, and the placement of R&D next to production lines.[71] All of these factors meant that Toyota and JIT factories were able to significantly reduce the architectural infrastructure required for warehousing, and differed greatly from Ford in its spatial, structural, and logistical organization.[72]

Japan wasn't the only country that discovered the benefits of a flexible, market-

66 Ibid., 53.
67 Mike Hanlon, "Learning from Dell - the faithful implementer of 'Just in Time,' " *Gizmag*, June 24, 2007, http://www.gizmag.com/go/7494/.
68 *Investopedia*, s.v. "Just In Time - JIT," accessed November 8, 2015, http://www.investopedia.com/terms/j/jit.asp.
69 Huff, "Walmart 2.0," 54.
70 Ibid., 54-6.
71 Nina Rappaport, "The Contemporary Factory," *Vertical Urban Factory*, accessed January 8, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/contemporary.php.
72 Huff, "Walmart 2.0," 54-6.

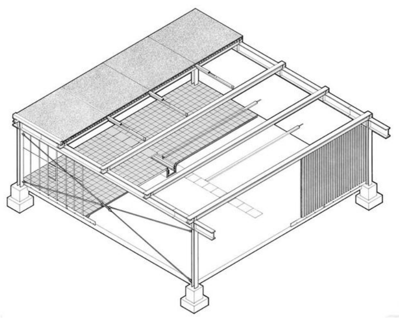


fig. 23 **Reliance Controls (1967) pre-fab assembly**

based production operation after WWII. Time switch manufacturer Reliance Controls' factory in the UK, built in 1967 by Team 4,[73] hit upon a similar idea. In this case, both the architecture and production system worked in concert to be optimally efficient and flexible to consumer demands.[74] In the post-war era, systems building was widespread in architecture, creating a landscape of "neutral, expandable buildings."[75] Structural expression reached its peak during the 'high tech' movement in England and France from the late 1960's onward.[76] In line with this trend, The Reliance Controls factory was constructed with prefabricated metal components, allowing it to be erected quickly and cheaply, and its architectural language further celebrated the structural steelwork. The factory consisted of a large open production floor with moveable interior partitions, that expanded and contracted based on the number of orders. Its innovation also involved moving the management office into the factory, and having a shared entrance between its blue-collar and white-collar employees, which was unprecedented before then.[77]

Volvo also attempted to tinker with the formula of Ford's assembly line in 1974, by introducing the 'team assembly system' at its new Kalmar assembly plant in Sweden. The whole operation was based around the use of car body carriers, so that workers could move easily around the cars, working on various tasks, instead of performing repetitive motions on the assembly line. Teams were assigned a set of tasks, and could organize their own schedule and work delegations, but had to meet production goals. The architecture was designed to facilitate and reflect this team dynamic—separate rooms for different teams, each with its own entrance, and large windows providing views to the outside. By attempting to create a pleasant working environment, Volvo hoped to increase product quality and efficiency by developing a more skilled and motivated work force. However, the experiment ultimately failed because costs increased exponentially due to time lost to team conflict resolution and stress management, and the architecture fell short of delivering the atmosphere originally envisioned. But the concept of teamwork assembly in manufacturing, at least in part, carried on to the U.S. and became successful and widely adopted.[78]

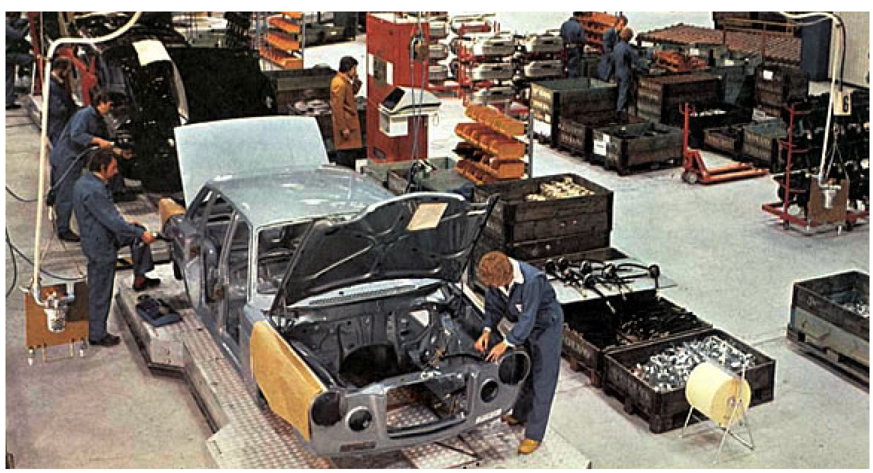


fig. 24 **team assembly system at the Volvo Kalmar plant (1974)**

73 Richard Rogers, Su Brumwell, Norman Foster, and Wendy Foster
74 "Reliance Controls," *Foster + Partners*, accessed November 8, 2015, http://www.fosterandpartners.com/projects/reliance-controls/.
75 van Uffelen, *Factory Design*, 10.
76 Whitehill, "Post-Industrial Production," 44.
77 "Reliance Controls."
78 Heinz Kohler, *Economic Systems and Human Welfare: A Global Survey* (Cincinnati, OH: South-Western, 1997), 278-279, 411-413.

offshored factories

By the 1970's and 1980's, the post-industrial era was being ushered in by the 1973 oil crisis and late 1960's recession following a post-World War II economic boom.[79] As factories were offshored from developed to developing countries for cheaper land and labour, new factory designs prioritized economy and expedience over innovation.[80] Steel production, which had soared since the Industrial Revolution and remained in high demand throughout both world wars, stagnated as the market became saturated with steel.[81] It caused a massive wiping out of factories in the Western world in the 1980's, in the same way cheaper steel production processes caused a proliferation of factories a hundred years earlier. Consequently, many abandoned factories in North America and Europe were and continue to be converted into loft apartments, offices, and museums.

fig. 25 **retrofitted Fiat Lingotto Factory (2003)**

contemporary factories

As factories continue to evolve with the fluctuating needs of society, "new modern factories for novel products and production processes are being built in the old industrial nations as well as in those still undergoing industrialization."[82] Just as modernist factories celebrated science and technological progress in its architecture and production, contemporary factories are adopting sustainable building practices and incorporating state-of-the-art manufacturing techniques, as well as providing more humane working conditions.[83] Production spaces, organization of workflow, and employee stations, have accordingly been reconfigured in these technologically and architecturally innovative factories.[84] "Contemporary factories […] address issues of environment and economy by building taller, using high-quality design, and cutting-edge technologies and allowing for visibility into the factory floor and engaging the urban environment."[85] Additionally, former turn-of-the-century factories, with their expansive, flexible spaces, are being readapted for use in light manufacturing.[86]

fig. 26 **Volkswagen Transparent Factory (2001)**

The Lingotto Factory, after being forced to close operations in 1982,[87] experienced a major renovation during the 20-year span between 1983 and 2003. The cultural retrofit, spearheaded by renowned Italian architect Renzo Piano, made use of the former manufacturing plant's large, flexible, rectilinear plan, creating an aggregation of public mixed-use and cultural venues.[88] After operations ceased in 1996, the former Van Nelle Factory was adapted into a complex for new media and design companies, and is now known as the Van Nelle Design Factory.[89] Some light manufacturing activities have also started to reoccupy vacated former factory buildings in cities, typically consisting of lofty

79 "Economy in 1973," *San Pedro High School Class of 1973*, accessed November 8, 2015, http://sphs73reunion.org/webpages/zremeconomy.html.
80 Rappaport, "The Contemporary Factory."
81 "Economy in 1973."
82 van Uffelen, *Factory Design*, 10.
83 Rappaport, "The Contemporary Factory."
84 Rappaport, "Factory in Context: Timeline."
85 "Vertical Urban Factory," *ARCHIZOOM*, accessed January 10, 2016, http://archizoom.epfl.ch/VerticalUrbanFactory.
86 Rappaport, "The Contemporary Factory."
87 triggered by the repercussions of the oil crisis
88 "Lingotto Factory Conversion," *Mimoa*, accessed November 8, 2015, http://www.mimoa.eu/projects/Italy/Turin/Lingotto%20Factory%20Conversion/.
89 "The Van Nelle Factory in Rotterdam is named as Holland's tenth UNESCO World Heritage Site," *NBTC Holland Marketing*, June 24, 2014, http://www.holland.com/uk/press/holland-news/general-news/van-nelle-factory-unesco-world-heritage.htm.

spaces easily adaptable to new machinery and fabrication processes. In Los Angeles, clothing manufacturer American Apparel reinhabits decommissioned factories for their integrated vertical assembly line, and immigrants in Johannesburg, South Africa utilize old office buildings as spaces of production.[90]

The increasing awareness for global sustainability also gave rise to more environmentally-conscious buildings and production processes, such the Herman Miller Factory in Holland, U.S. Built in 1995, it was innovative in its implementation of sustainable, passive architectural design in a factory structure.[91]

Volkswagen's iconic six-storey manufacturing facility,[92] built in Germany in 2001, appropriately dubbed the 'Transparent Factory,' poses itself as a museum of production. Virtually completely encased in glass,[93] the factory makes a spectacle out of the fabrication process to consumers in a display of "automated choreography."[94] The visual label is also a marketing strategy, symbolizing the car manufacturer's transparency in its production process, as well as representing the company's claim of openness and accountability.[95] The factory embodies the image of the corporation.

Today, the factory is not as revered as it once was during the modernist era,[96] as its iconic status during the first half of the 20th century was superseded by the skyscraper/office tower in the second half.[97] However, there is increasing international awareness and interest amongst manufacturing companies, architects, as well as the general public, for new ways of thinking about and approaching factory design.[98]

90 Rappaport, "The Contemporary Factory."
91 " 'Greenhouse' Factory & Offices," *William McDonough + Partners*, accessed November 8, 2015, http://www.mcdonoughpartners.com/projects/greenhouse-factory-offices/.
92 Rappaport, "The Vertical Urban Factory."
93 Justin Heinze, "The Top 25 Most Beautiful Factories in the World," *Better Buys*, March 5, 2015, https://www.betterbuys.com/cmms/the-worlds-25-most-beautiful-factories/.
94 Rappaport, "The Vertical Urban Factory."
95 Heinze, "The Top 25."
96 "Vertical Urban Factory."
97 Whitehill, "Post-Industrial Production," 41-2.
98 "Vertical Urban Factory."

1.2.2 SOCIAL EVOLUTION OF THE FACTORY

1.2.2.1 THE FACTORY'S EFFECT ON SOCIETY

Factory as Symbol

Much more than just the physical components of its architecture, the factory was a symbol of progress from the Industrial Revolution onward (until it was superseded by the 20th-century skyscraper):[99]

> *From the eighteenth century onward, factories have been markers: of revolution, technical and social, of innovation, in design and in process, of their moment, politically and economically. As such, factories are essentially short-lived, reflecting the exact circumstances of time and place with some precision. In the optimistic heyday of the Industrial Revolution the factory could be seen to stand for British mercantile strength and activity, or alternatively for the dark forces of wage-slavery […] The epitome of change, in itself both threatening and energizing, the factory has provided images as black or white as the argument required.*[100]

"[T]he economy at a given time and place sets the stage for certain cultural productions to be desirable, with architects acting out their design positions accordingly."[101] Thus, as a static artifact situated within a locus in the urban fabric, the factory became an embodiment of the intangible economic, political, and cultural flows of society, transcending far beyond its physical delimitations in space.

The factory was a technological icon—sacred spaces where the methodology around the fabrication of a single component propagated out to influence the design of entire cities. They housed the latest human fascination with machines, their assembly lines, and the allure of mass production and mass consumption. They were temples of innovation and production, of materials and systems, where practical solutions dwelled, both under their roofs, and within the very constitution of their walls.[102]

Hence it is hardly surprising, as industry developed, that businesses started using the factory and its associated image as a marketing strategy. By the beginning of the 20th century, American industrialists in Detroit were realizing that: "a company's building was its best form of advertising; it declared a place in the community through the fact of its physical presence."[103] The avant-garde Fagus-Werk factory, with its sleek modern aesthetic and use of new materials and construction techniques, was a well-crafted testament to the advanced manufacturing technologies and superior products found inside.[104]

Meanwhile, Fiat's Lingotto Factory, was a symbol of its host city; a metonym of Turin's industry: "Fiat is Turin, and Turin is Fiat. The company embodies and symbolizes the industrial power of the city." Although the factory was the physical manifestation of lofty albeit unpragmatic Futurist aspiration, it stood as a monument to industrial progress; a celebration of the spirit of the age: "Atop the building, the test track is like a king's crown, and just as a crown symbolizes some essential and dominating idea, so here

99 Whitehill, "Post-Industrial Production," 41-2.
100 Gillian Darley, *Factory* (London: Reaktion, 2003), 8-10.
101 Peggy Deamer, *Architecture and Capitalism: 1845 to the present* (London: Routledge, 2014), 1.
102 Darley, *Factory*, 8.
103 Hoffman, "The Best," 44.
104 van Uffelen, *Factory Design*, 8-9.

the car and its speed are celebrated in a form that presides over the work of the factory below…”[105]

In today’s image-obsessed society, factories continue to play a role in representing a company’s identity. Set up as a stage of production, Volkswagen’s Transparent Factory blends program and marketing into one.[106] “Structure works in service to concept.”[107]

Labour in Factories

factory worker exploitation in the industrialized era

But factories were not always such glamorous places. Their history has also been heavily tainted, set against a backdrop of class exploitation, wage-slavery, and poor working conditions—an account Karl Marx details and rallies against in his hugely influential *Capital*, written at the outset of sweeping industrialization.

Unshackled after the dissolution of guilds following the French Revolution, a free enterprise economy facilitated the establishment of amalgamated production centres employing unskilled workers.[108] Due to the large capital requirements of construction and acquisition of machinery, the rise of factories was enabled and accompanied by the growth of larger and larger manufacturing conglomerates in the 1880’s and 1890’s, who held an increasing amount of economic power.[109] This accumulation of wealth gave capitalists tremendous social leverage, which lead to the exploitation of the working class.[110]

Architecture, with its power of symbolism and spatial manipulation, played a considerable role in the control exerted by industrialists over their workforce.[111] Just as the rigorous rationality and order of fascist architecture was used as a tool to rule over the population and exhibit the power of the Regime in early 20th-century Italy,[112] the strict organizational structure of the factory system—from its ideas, to its operation, to its architecture—was used in a similar manner to exploit its labour:

> *Order was power. The order of vertical process shaped both the vertical office and the (then still vertical) assembly lines. This spatial and operational symmetry was not coincidental, nor was its extension into the organization of the city or the maintenance of social order. This socially legible and enforceable order was a necessary aspect of the massing of labour in sufficient quantities for industrial production.*[113]

Marx, borrowing from “Dr. Ure, the Pindar of the automatic factory” defined the

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105 Banham, “Fiat,” 86-8.
106 Heinze, “The Top 25.”
107 Whitehill, “Post-Industrial Production,” 44.
108 van Uffelen, *Factory Design*, 8.
109 David Karjanen, “The Wal-Mart Effect And The New Face Of Capitalism: Labor Market And Community Impacts Of The Mega-Retailer,” in *Wal-Mart: The Face Of Twenty-First Century Capitalism*, ed. Nelson Lichtenstein (New York, NY: The New Press, 2006), 145.
110 Gary Lapon, “What do we mean by exploitation?,” *SocialistWorker.org*, September 28, 2011, http://socialistworker.org/2011/09/28/what-do-we-mean-exploitation.
111 Hoffman, “The Best,” 45.
112 “The Fascinating World of Fascist Architecture,” *Casa Romana,* accessed November 9, 2015, http://www.myromeapartment.com/rome-city-guide/fascist-architecture/.
113 Hoffman, “The Best,” 45.

factory as " 'a vast automaton,[114] composed of various mechanical and intellectual organs, acting in uninterrupted concert for the production of a common object, all of them being subordinate to a self-regulated moving force,' " [115] where workers became 'living appendages' of the machine.

The resulting "wearisome routine of endless drudgery in which the same mechanical process is ever repeated, is like the torture of Sisyphus."[116] Poor ventilation and general low standards of hygiene lead to extreme squalid working conditions in 19th-century factories, which along with long working hours,[117] were made worse by the provision of wages barely adequate for subsistence.[118] When women and children were forced into the factory system out of necessity, they faced even more substandard working conditions, and were paid a fraction of what men earned.[119]

When industrial activity was transplanted from handicraft workshops and homes to aggregated production centres, craftsmen who were skilled in a particular trade were driven out of competition by these larger, more efficient, mechanized establishments. The consequent subdivision of labour into smaller and simpler tasks in these facilities required little to no skill from its workers.[120] In *Capital, Vol I*, Marx also identified the effects of the deskilling of the worker and the decline of trades: "Along with the tool, the skill of the worker in handling it passes over to the machine [...] there appears, in the automatic factory, a tendency to equalize and reduce to an identical level every kind of work that has to be done by the minders of the machine."[121] The worker was turned into a machine. But at the same time, the worker was also being replaced by the machine. In fact, as early as the beginning of the 19th century, a group of English workers called the Luddites, were so vehemently against manufacturing equipment displacing their jobs, that they broke into factories to destroy these labour-saving machines.[122]

Mr. Bucket was the only person in the family with a job. He worked in a toothpaste factory, where he sat all day long at a bench and screwed the little caps onto the tops of the tubes of toothpaste after the tubes had been filled. But a toothpaste cap-screwer is never paid very much money, and poor Mr. Bucket, however hard he worked, and however fast he screwed on the caps, was never able to make enough to buy one-half of the things that so large a family needed.
— Roald Dalh,
Charlie and the Chocolate Factory

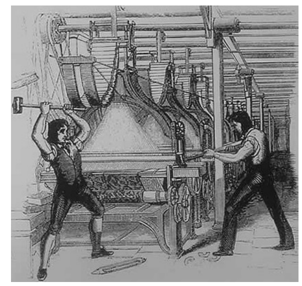


fig. 27 **Luddites destroying factory machines**

factory worker exploitation in the Fordist era

Meanwhile, in early 20th-century America, Fordism was taking over. In order to retain his workforce in exchange for the exhaustive toil, Ford's 'comprehensive industrialization' revolutionized social progress through high universal wages and regulated work hours long before they became legislated. This also gave workers the ability to literally afford the fruits of their labour. The assembly line enabled the mass production of identical, standardized products, which through economy of scale lead to cheaper commodities, and the affordability of luxury goods, such as the automobile. "The system could reproduce its own market in a self-fulfilling prophecy of economic expansion."[123] But on the other hand, the self-perpetuating process created complete

114 'a moving mechanical device made in imitation of a human being;' a self-operating machine
115 Karl Marx, *Capital: Volume 1: A Critique of Political Economy* (London: Penguin Books Limited, 1990), 544.
116 Ibid., 548.
117 Barbara Humphries, "Women and Capitalism," *In Defence of Capitalism*, April 10, 2002, http://www.marxist.com/women-and-capitalism.htm.
118 "Wages of Labour," *Marxists Internet Archive*, accessed November 10, 2015, https://www.marxists.org/archive/marx/works/1844/manuscripts/wages.htm.
119 Humphries, "Women and Capitalism."
120 Duncan Bythell, "Cottage Industry and the Factory System," *History Today* 33, no. 4 (1983): 17-23.
121 Marx, *Capital*, 545.
122 *Dictionary.com*, s.v. "Luddite," accessed November 11, 2015, http://dictionary.reference.com/browse/luddite.
123 Schumacher and Rogner, "After Ford."

worker dependency on the capitalist system:

> *Fordism understood as a socio-economic category, rather than a merely technological paradigm, presupposes the systematic integration of the reproduction of labour into a new and totalizing capitalist cycle. The advance of Fordism was a qualitative shift in the ability of industry to render workers' 'basic needs' (food, clothes, shelter, transport, etc.) as objects of comprehensive commodification.*[124]

Fordism became a social structure, that permeated into and was inseparable from all aspects of daily life. The subjectivity of the worker was diminished, while capitalist control was totalized.[125]

labour unions

The class struggle described by Marx between capitalist industrialists and factory workers found some relief in labour unions and state policy intervention. In the UK, although attempts were made for national general unions as early as the 1820's and 1830's,[126] their formation was not legalized until the late 1800's.[127] In the United States, unions grew in size before WWI, diminished in the 1920's, but developed again rapidly in the 1930's and 1940's, before peaking in the 1950's.[128] The Johnson-Forest Tendency, which was founded by radical-left Marxist theorists, published a number of pamphlets between 1947 and 1955 regarding the working class life and struggles within the Detroit automobile industry.[129] "Centralization reaches its physical limits, mass society, mass culture, and human being as a collective entity [...] The mass of urbanized workers demand more time. Time is money."[130] Legislation such as the Fair Labor Standards Act of 1938, introduced the forty-hour work week, set a national minimum wage, stipulated time-and-a-half overtime for certain jobs, and set regulations preventing child labour.[131] But as industrial processes computerized and factories became more and more automated by the 1960's, further labour issues unfolded, along with other political struggles which marginalized blue-collar workers during that time. In the United States, though wages and standards of living rose, working conditions deteriorated, leading to increasing numbers of worker strikes, as they battled not only exploitation by their capitalist employers, but also misrepresentation by their own unions.[132]

124 Ibid.
125 Ibid.
126 J. P. T. Bury, *The New Cambridge Modern History: Volume X: The Zenith of European Power, 1830-70* (Cambridge: Cambridge University Press, 1960), 346.
127 "History of Labour in Canada," *Canadian Labour Congress*, accessed November 11, 2015, http://canadianlabour.ca/why-unions/history-labour-canada.
128 "History of Labor Unions: Summary & Analysis," *Shmoop*, accessed November 11, 2015, http://www.shmoop.com/history-labor-unions/summary.html.
129 Asad Haider and Salar Mohandesi, "Workers' Inquiry: A Genealogy," *Viewpoint Magazine* (blog), September 27, 2013, https://viewpointmag.com/2013/09/27/workers-inquiry-a-genealogy/.
130 Hoffman, "The Best," 46.
131 CR, "Fair Labor Standards Act of 1938," *Pro President Obama Blog*, June 14, 2011, http://propresobama.org/2011/06/14/fair-labor-standards-act-of-1938/.
132 Sharon Smith, "The workers' rebellion of the 1960s," *SocialistWorker.org*, August 26, 2011, http://socialistworker.org/2011/08/26/workers-rebellion-of-the-1960s.

Industrial Society

The rise of industrial society, the era which Marx observes, describes, and theorizes on in his critique of political economy, *Capital*, was a period in which explosive and implosive forces, and notions of intensity versus extensity, were all encapsulated within one of the greatest phenomena of recent history—the machine. The introduction of the machine into the workforce, in many ways, was the birth of the Industrial Revolution,[133] which catapulted the paradigm shift from the practice of handicraft manufacturing to a vast system of machined machines.[134] The effects of this rapid transformation upon economic, social, and political relations, as well as that of the individual and collective psyche, were both extreme and extensive.

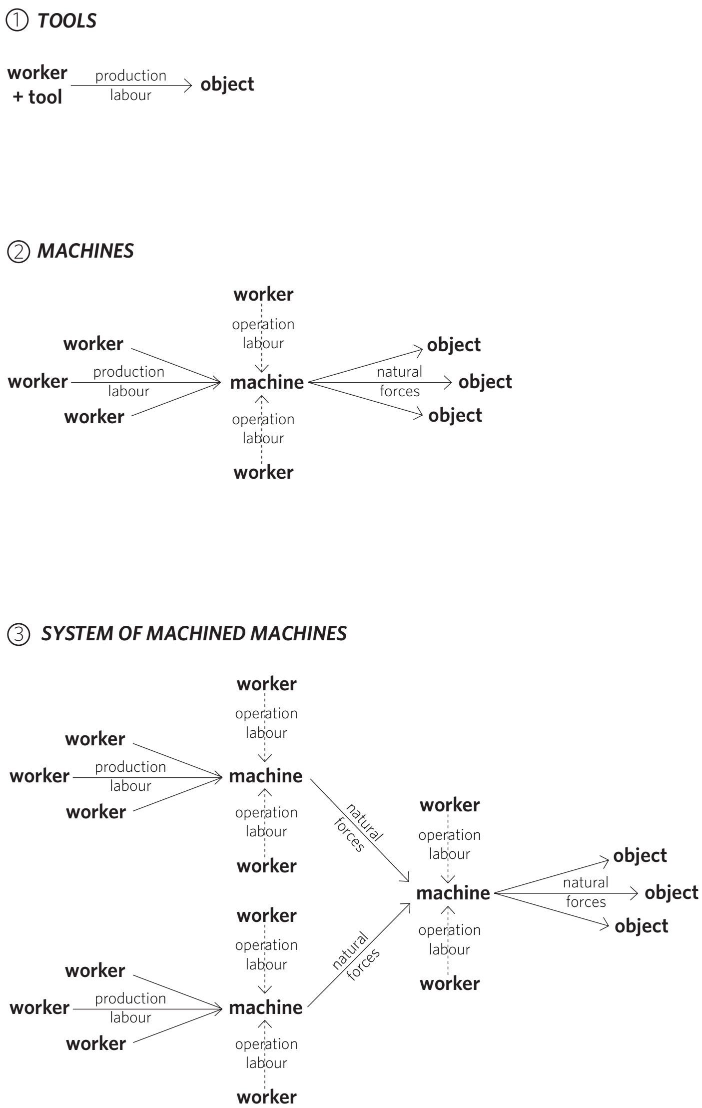


fig. 28 **development of machinery in the labour process according to Marx/** *worker under subjectivity of the machine*

133 Marx, *Capital*, 493.
134 Ibid., 506.

Modernism/Fordism

birth of modernism

The emerging modernist movement of the late 19th century, thus rose out of the necessity to reinvent all aspects of daily life owing to these societal reconstructions. Generally, it hinged upon a rejection of traditional principles, and the belief in continuous improvement and redefinition of the environment with the aid of scientific knowledge and technological advancements.[135] Like other historical periods, architecture and the built environment evolved as large-scale physical expressions of the spirit of the movement. In the modernist era, this largely meant the adoption of newly-available building materials and construction techniques, and the reduction of superfluous building elements to simple forms as derivatives of its function.[136]

> *Architecture, until that time, had been the very symbol of a static, spatial reference. It was called upon to lend balance to this newly unhinged world. The balance took the form of an explicit, spatial ordering, which served to prepare the population for the strict precision and hierarchy of the production system.*[137]

Indeed, "[t]he totalizing notion of fordism became instrumental to the underlying rationality of modern architecture and urbanism."[138] The successful class revolts in Europe after WWI not only supplied the necessary social and economic fodder for modern architecture, but also supplanted the classical architects of nobility, with self-made masters of the discipline, such as Behrens, Gropius, Le Corbusier, and Mies van der Rohe. The new design team, they themselves having risen out of 'the people,' and particularly following the destabilizing effects of the war, pursued the design of architecture for the masses. "The social democratic institutions of the welfare state became the mechanisms through which modern urbanism was advanced."[139] Taking inspiration from the stable rationality of factories, they sought to define the architecture of the modern era through the design of the mundane—mass housing, and mass produced domestic furnishings. And thus, the Ford factory entered the living room:

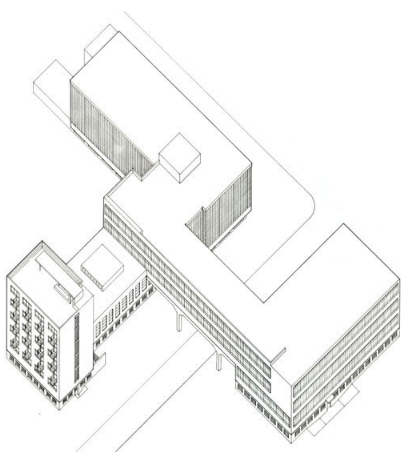


fig. 29 **Bauhaus School at Dessau (1926)**/*drawing showing discrete volumes of program*

> *The Fordist task posed was the development of optimally efficient standards and the taylorization of modern living […] The new paradigm of Functionalism implied an objectification and analysis of the design process and architectural composition was assimilated to the principles of fordist organization: decomposition, differentiation, repetition and integration.*[140]

The separation of program into discrete volumes, just like Ford's differentiation of tasks, can be seen in the Bauhaus School at Dessau, in Germany, where different functions are spatially optimized, and clearly discernible on the building's exterior. These Fordist-originated notions would soon extend into the urban realm as modernist proposals for the ideal city.[141] Thus it stands to reason, that "[t]he history of industrial

135 Art Berman, *Preface to Modernism* (Urbana, IL: University of Illinois Press, 1994), 16.
136 *The Free Dictionary*, s.v. "modern architecture," accessed November 11, 2015, http://encyclopedia2.thefreedictionary.com/Modernist+architecture.
137 Hoffman, "The Best," 44.
138 Schumacher and Rogner, "After Ford."
139 Ibid.
140 Ibid.
141 Ibid.

building is in many ways the history of modern architecture."[142] "Nor has any building type better supplied the always evanescent notions of modernity, its radical potential exaggerated far beyond the realizable."[143]

fig. 30 **mass production of the Ford Model T**

Fordist society

Meanwhile, Ford's production system and business model were so effective, that by 1916, three years after the implementation of the assembly line, there were 3.4 million cars on American roads, and a staggering 23 million by 1930. Indeed, "the automobile became the key 'engine' of economic growth,"[144] as it drove society toward an economy based on mass production and mass consumption.[145]

Ford's theories were not only pervasive within the manufacturing sector, or in its shaping of modernist architecture. They also found their way into the corporate structures of the service industry, with its comprehensive, tiered organization, and jobs characterized by mundane, repetitive tasks.[146] In fact, they were so influential that they permeated the entire socioeconomic strata of the first half of the 20th century.[147] During that time, the macroeconomic theories of John Maynard Keynes, first presented in 1936, swept across the United States. Its support for "direct market manipulation through state regulation to influence aggregate demand within a productive economy," built upon Ford's strategy of 'demand stimulation', or 'push' model of production.[148] Thus, the rigorously-controlled hierarchical organization of his production process served as a model for top-down state administration, in which totalizing economic control served to produce a 'welfare state.' The system was characterized by "universal mass production, corporate concentration, collective bargaining, and state-regulation," which resulted in a meticulously strategized, predictable, and inflexible structure, ill-equipped for evolution—just like his assembly lines.[149]

142 Whitehill, "Post-Industrial Production," 39.
143 Darley, *Factory*, 10.
144 Rifkin, *The Zero Marginal Cost Society*, 52.
145 Karjanen, "The Wal-Mart Effect," 145.
146 Schumacher and Rogner, "After Ford."
147 Scott and Marshall, *A Dictionary of Sociology*, 260.
148 Huff, "Walmart 2.0," 39.
149 Ibid.

Nevertheless, at the time, the successful economic implementation of Fordist logic in the United States spawned a flurry of international interest. The allure of complete production and consumption control, as well as predictable profit margins, imparted Fordism with adherents in Nazi-Germany and the Soviet Union of Stalin, where Albert Kahn executed hundreds of factories from 1929 to 1932.[150]

Postmodernism/Post-Fordism

Keynesianism > neoliberalism

By the 1970's and 80's, after the rapid economic growth experienced in the wake of the Second World War in postwar rebuilding, Fordism and Keynesian economics was superseded by neoliberalism.[151] This more liberated form of free-market capitalism was defined by "extensive economic liberalization and policies that extend the rights and abilities of the private sector over the public sector, specifically the shutting down of state and government power over the economy."[152] Thus, seen in contrast to the strict top-down regulations that defined Fordism, this transition was appropriately dubbed post-Fordism. The ongoing rapid development of telecommunications and transportation technology had enabled industry to tap into international markets at an increasing rate, thereby dissolving the national boundaries created by domestic economic policies, and aspirations for a welfare state. The accelerated flow of information and capital magnified the volatility of the economy, causing ever greater market fluctuations; the Fordist economy was seen as overly rigid and controlled, and unsuited to the emerging dynamic global marketplace.[153] A critical break in the Fordist system occurred with the worldwide economic recession of 1966/67 and subsequent oil embargo of 1973. Intensified by the 1968 protests against political oppression worldwide, the grave consequences that ensued called for a new social, political, and economic paradigm.

modernism/Fordism > postmodernism/post-Fordism

And thus, modernism and the material production of the Fordist era gave way to postmodernism and the immaterial production of the post-Fordist era, and the 'Death of Modern Architecture,' as declared by Charles Jencks in 1977. "Postmodern cultural production coincides with the historical crisis in the regime of mechanical mass-production, first developed by Ford in Detroit."[154] While the modernist era was marked by homogeneous repetition and systematic control—the signature of Ford's legacy—the postmodernist era was decidedly a rejection of those ideals, celebrating the diametrically opposite, heterogeneity and unpredictability. Patrik Schumacher and Christian Rogner describe a number of concurrent socioeconomic forces that contributed to the demise of modernism/Fordism and rise of postmodernism/post-Fordism in the 1970's and 1980's, namely: "shifting commodity markets, increasing electronic control of production, decreasing state regulation, increasingly global capital markets, and deteriorating labor relations."[155]

150 Schumacher and Rogner, "After Ford."
151 Huff, "Walmart 2.0," 51.
152 *Investopedia*, s.v. "Neoliberalism," accessed April 7, 2016, http://www.investopedia.com/terms/n/neoliberalism.asp.
153 Huff, "Walmart 2.0," 51-2.
154 Schumacher and Rogner, "After Ford."
155 Ibid.

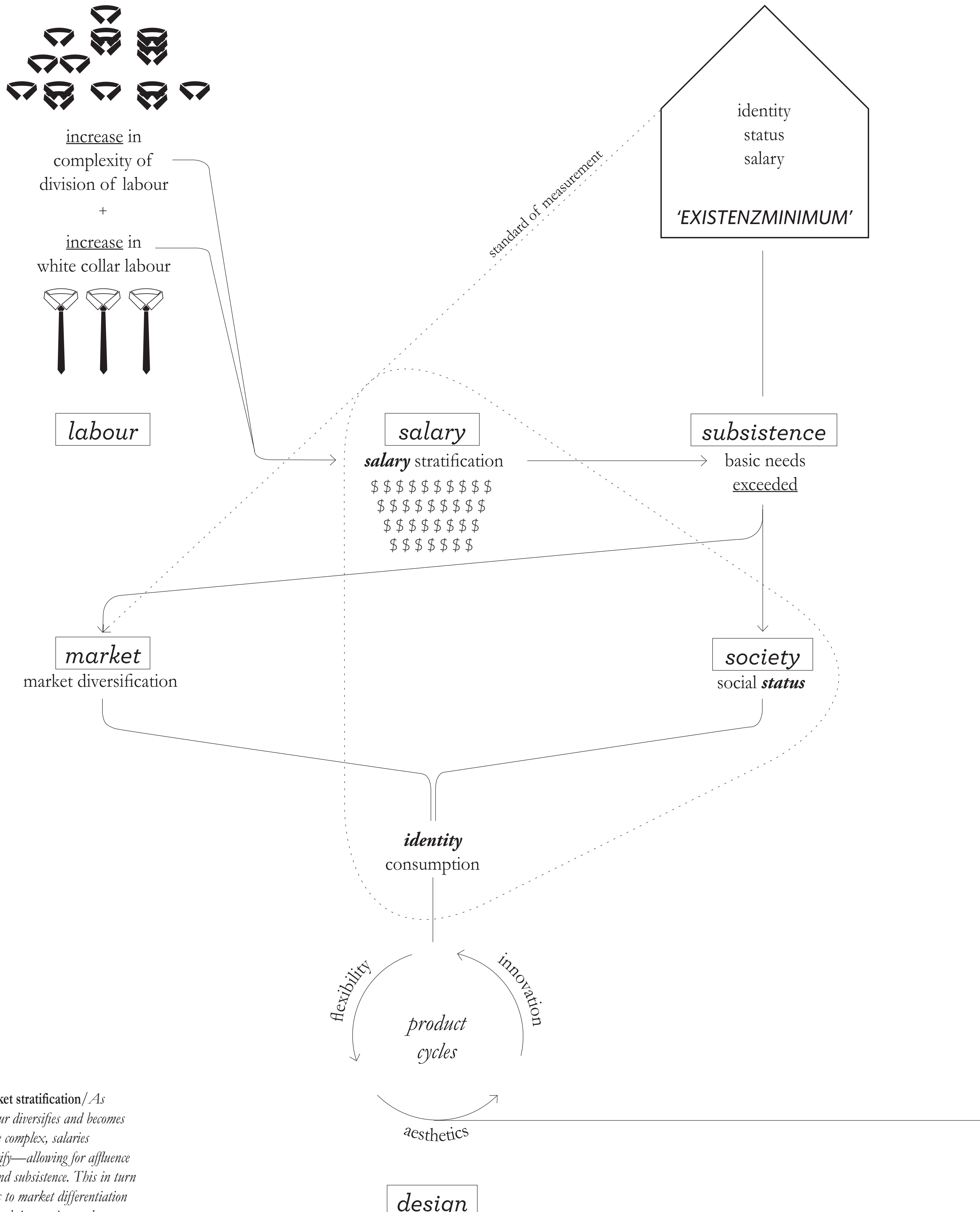


fig. 31 **market stratification**/*As labour diversifies and becomes more complex, salaries stratify—allowing for affluence beyond subsistence. This in turn leads to market differentiation through innovation and flexibility rather than simply cost reductions from mass production.*

fig. 32 **flexible production**/*The microelectronic revolution provides greater efficiency without economy of scale, through the use of computer-based technologies, and thus more flexible production demands.*

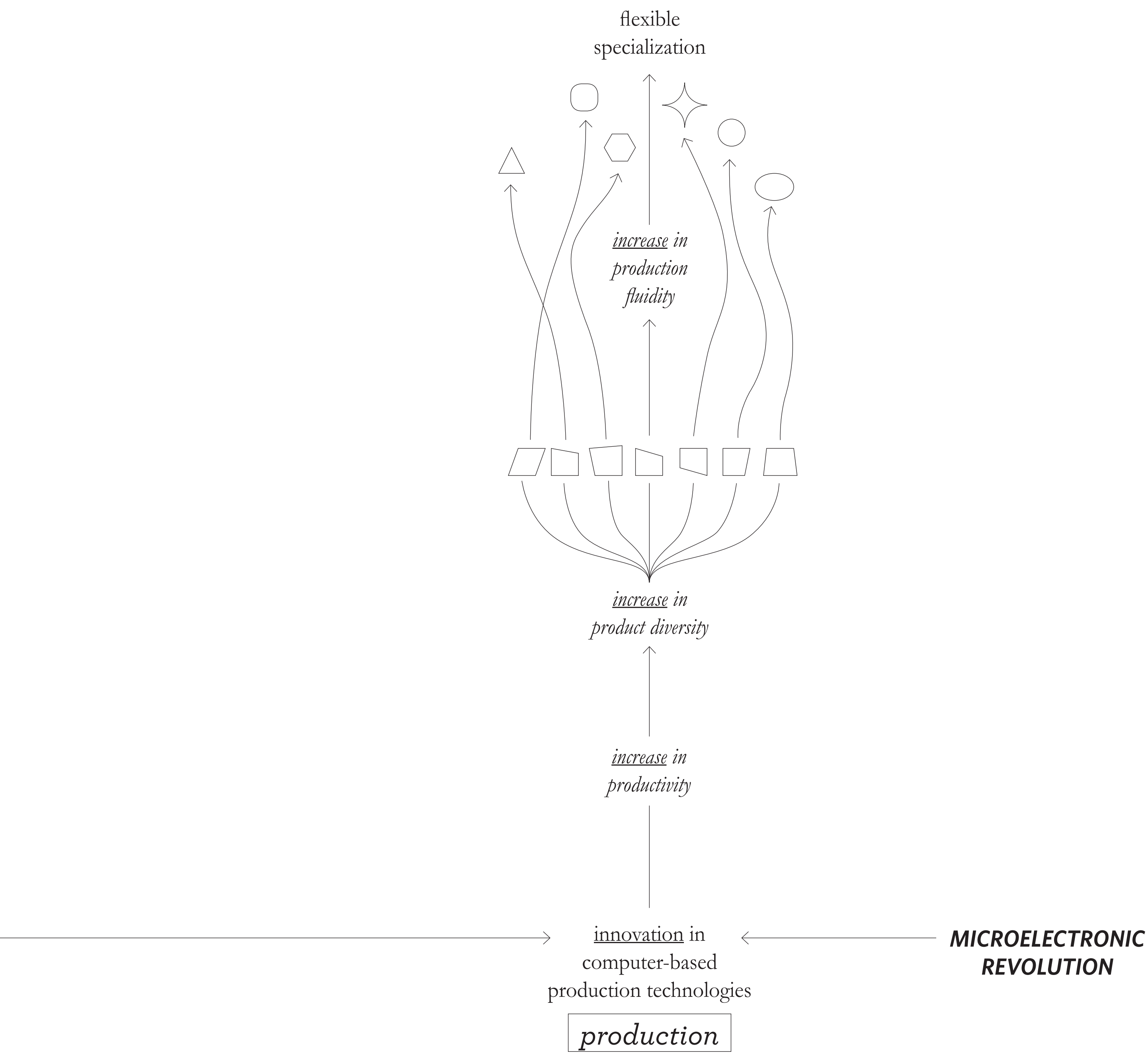
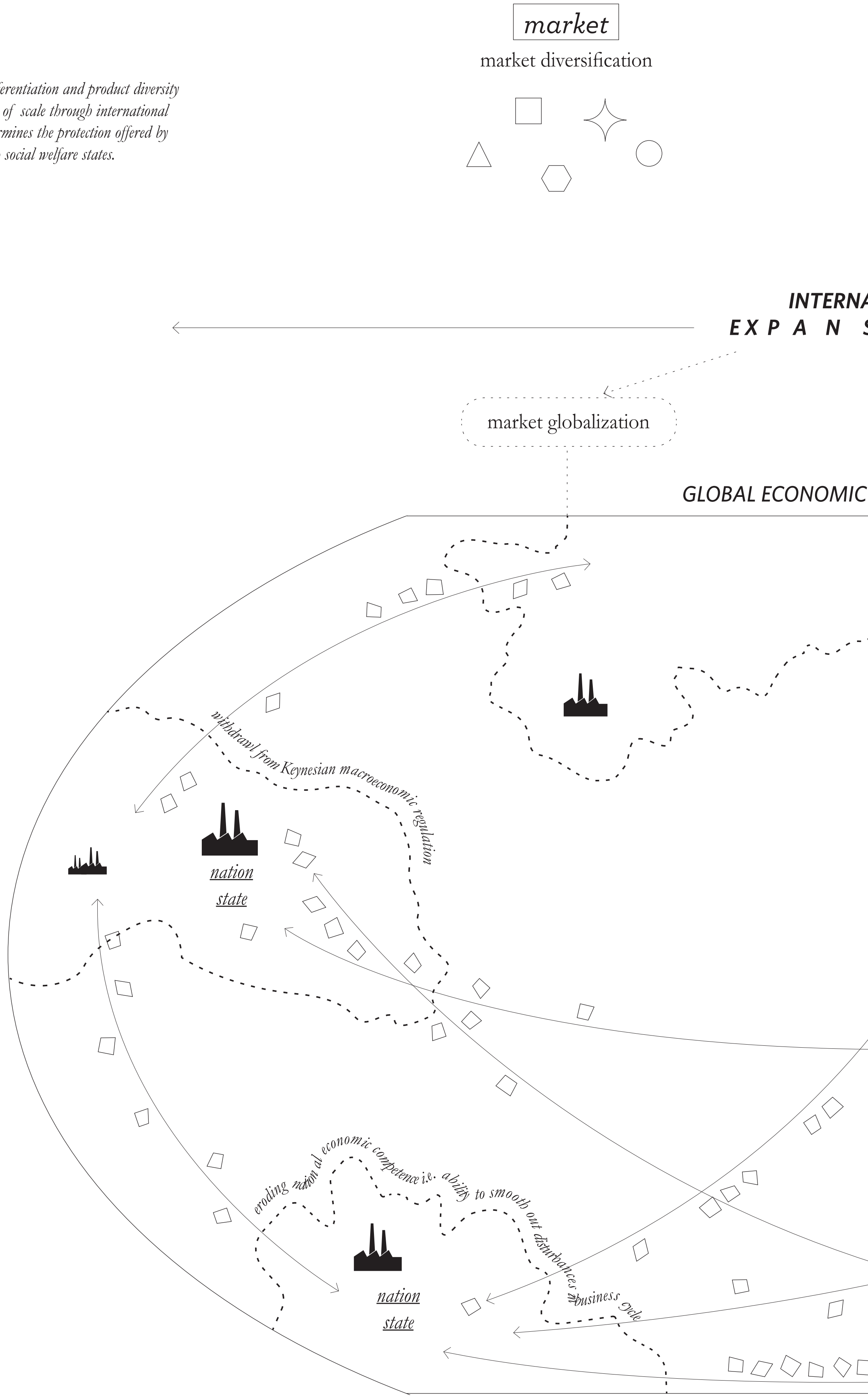
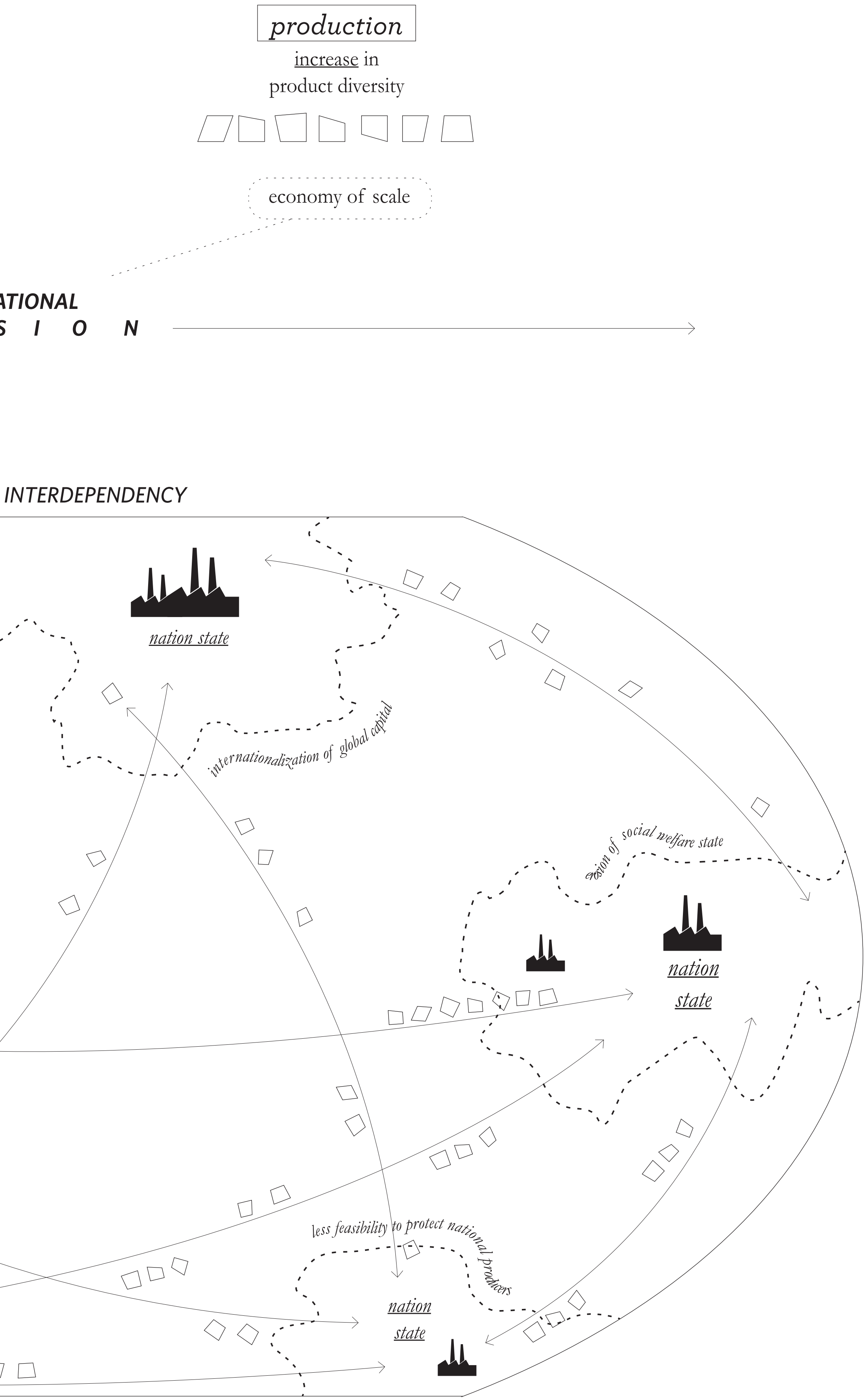


fig. 33 **vanishing state regulations**/*Market differentiation and product diversity recuperate loss of efficiency from economy of scale through international expansion. The global market thus undermines the protection offered by national economic policies, and breaks up social welfare states.*




production
increase in
product diversity
economy of scale
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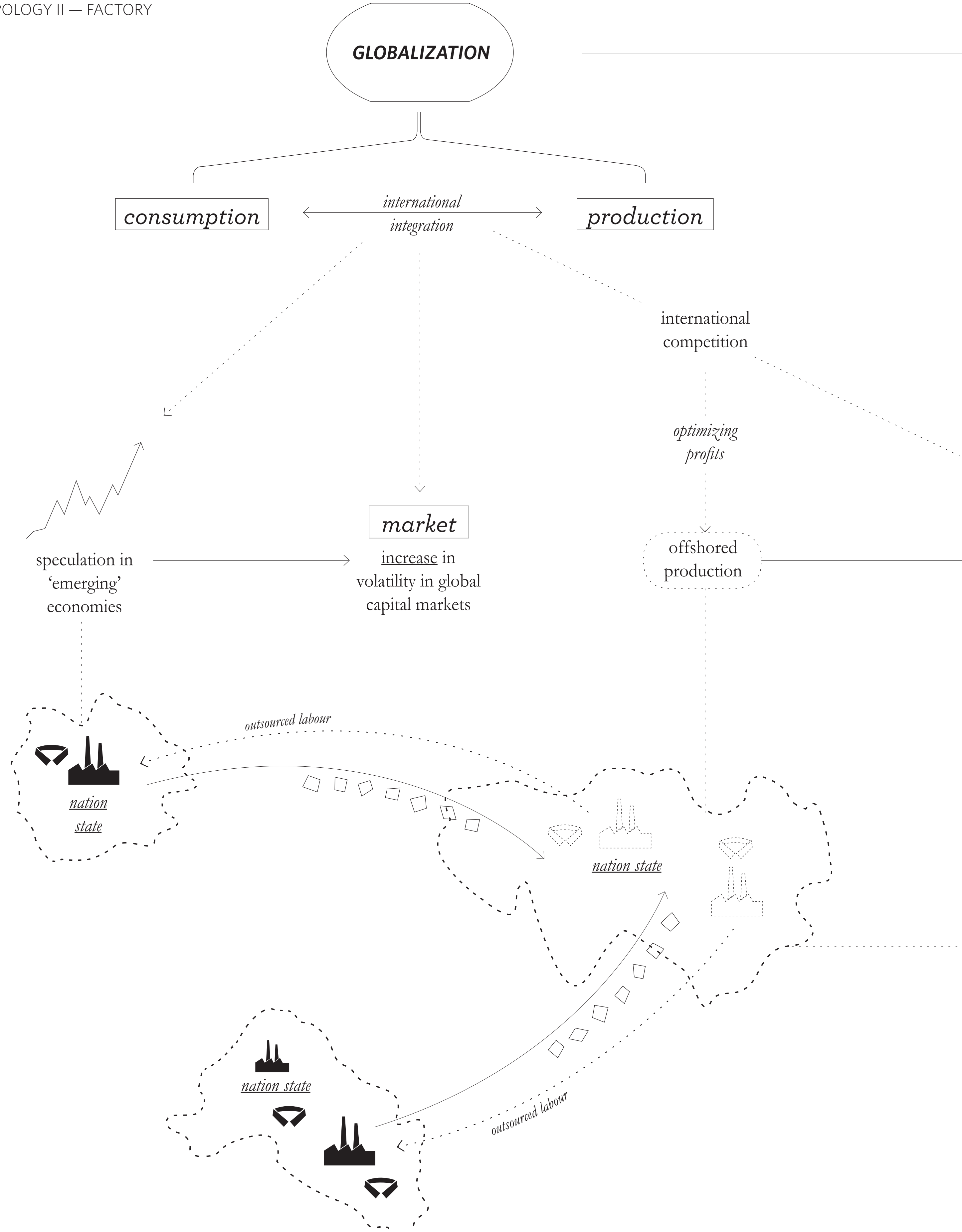
GLOBALIZATION
consumption
international
integration
production
international
competition
optimizing
profits
market
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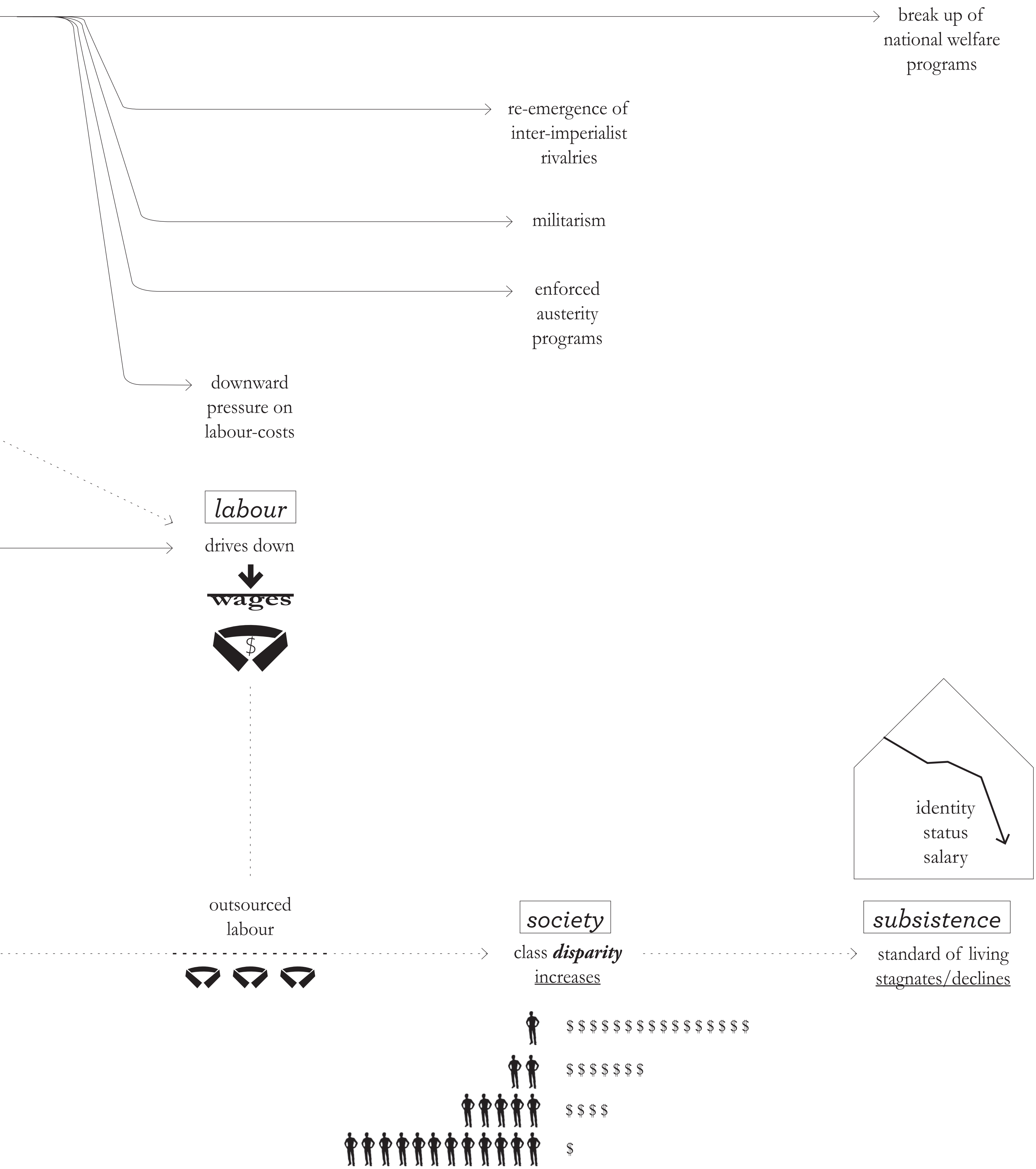
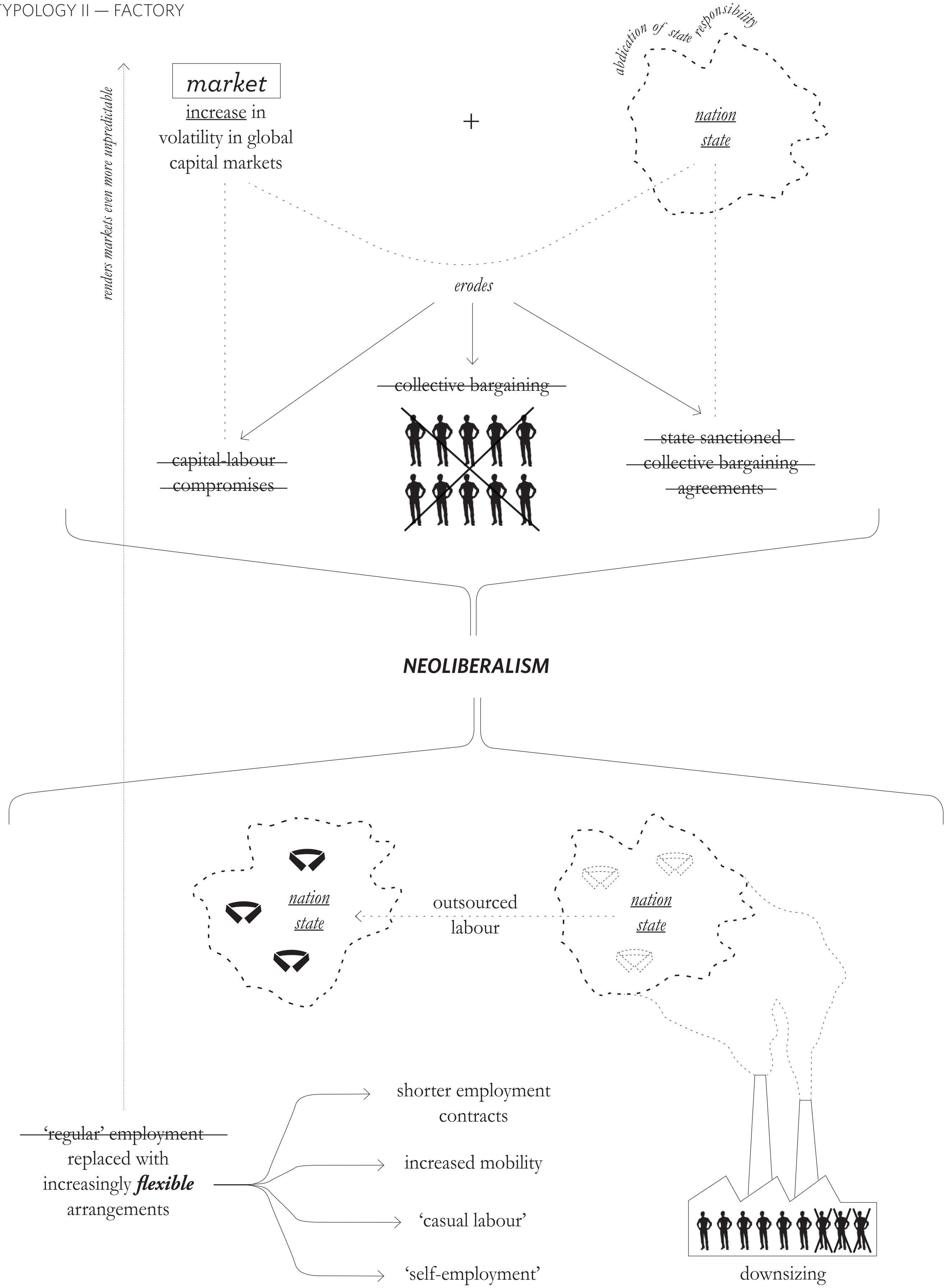


fig. 34 **globalization of capital markets**/*Globalization becomes the new paradigm of production and consumption cycles. International competition leads to offshore production practices and outsourcing of labour. The capital market becomes increasingly volatile, as standard of living declines and social stratification increases.*


renders markets even more unpredictable
market
increase in volatility in global capital markets
+
abdication of state responsibility
nation state
erodes
collective bargaining
capital-labour compromises
state sanctioned collective bargaining agreements
NEOLIBERALISM
nation state
outsourced labour
nation state
'regular' employment replaced with increasingly flexible arrangements
shorter employment contracts
increased mobility
'casual labour'
'self-employment'
downsizing

mass production > mass customization

The post-Fordist economy was volatile, flexible, and under constant modulation.[156] This increased freedom in production and variability of global markets, created a highly adaptable, albeit equally unpredictable, society.[157] Industry's gradual relinquishing of control of the market in exchange for a higher degree of flexibility in capital accumulation, precipitated the power shift away from producers toward consumers in the 1990's. This is often observed as the rise of 'consumer society,'[158] in which the emphasis lay not on the volume of mass manufactured goods pushed on to the buyer, but rather the agility with which producers could adapt to the ever-changing impulses of the market.[159] Marx outlines in his seminal *The Communist Manifesto*, that it is the competitive nature of capital accumulation that drives industrialists to continuously revolutionize the status quo of manufacturing, perpetually searching for a better, more efficient, means of production.[160] It was within this economic climate, from which the Just-In-Time system of production, successor of the Ford model, emerged and flourished, in order to better respond to the whims of a client-led marketplace.[161] Retailers and consumers now joined the feedback loop, leading to the era of mass customization.[162] "For the post-Fordist corporation, niche marketing and flexible production, once the purview of the hip boutique, replace mass marketing and mass production."[163]

national economy > international economy

As the manufacturing landscape gravitated toward increasing market differentiation and product diversity, the efficiencies once gained from economy of scale were thus recuperated through international expansion.[164] "The ease of truck transport, standardization of containerized shipping, and digital supply chains encouraged a new spatial organization that spread manufacturing globally."[165] It prompted prosperous nations to offshore and outsource their productive activities to cheaper lands in developing countries, with profits maximized via downward pressure on wages from international competition.[166] "No longer do advanced economies pursue the production of physical objects. On the contrary, developed countries specialize in services, information, and media while outsourcing industrial production to the developing world."[167] By 1980, creative forms of labour were quickly being reshaped in the image of capitalism, as the cultural industry, intellectual labour, and the service economy—what Michael Hardt and Antonio Negri call 'affective labour' or 'immaterial labour'—became the new paradigm in the developed world.[168]

fig. 35 **exploding labour relations/** *Volatility of global markets and erosion of state responsibility compromise collective bargaining power, and is replaced by neoliberalism. Stable employment is replaced by flexible employment norms, rendering markets even more unstable.*

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156 Kazys Varnelis, "Programming After Program: Archizoom's No-Stop City," *Praxis: Journal of Writing and Building* 8 (2006): 84.
157 Schumacher and Rogner, "After Ford."
158 Huff, "Walmart 2.0," 52.
159 Scott and Marshall, *A Dictionary of Sociology,* 257.
160 Karl Marx and Friedrich Engels, *The Communist Manifesto* (Minneapolis, MN: Filiquarian Publishing, 2007), 9-10.
161 Huff, "Walmart 2.0," 53.
162 Rappaport, "The Contemporary Factory."
163 Varnelis, "Programming," 84.
164 Schumacher and Rogner, "After Ford."
165 Rappaport, "The Contemporary Factory."
166 Schumacher and Rogner, "After Ford."
167 Varnelis, "Programming," 84.
168 Silvia Federici, "Precarious Labor: A Feminist Viewpoint" (lecture, This is Forever: From Inquiry to Refusal Discussion Series, Bluestockings Radical Bookstore, New York City, NY, October 28, 2006).

analogue technology > digital technology

Today, the increase in robotic automation and mass customization, enabled by digital technology, is dramatically transforming the nature of fabrication. "Now, with the advent of Computer Aided Design and Manufacturing (CAD/CAM), product design can flow from computer to production line, stimulating flexible networked manufacturing systems."[169] Digital manufacturing equipment such as CNC machines, 3D printers, and robotic arms, allow for flexible and efficient processes such as rapid prototyping and "networked collaborative product development." Technology is changing the modes of work as well as creating new forms of labour, trending toward less labour-intensive activities (i.e. digital manipulation and creativity), as systems become increasingly computerized.[170] In fact, between 1950 and 1968 in the United States, when factory operations first became automated, production output increased by 91%, while the number of manufacturing jobs only grew by 29%.[171] Interestingly, in contrast to when mechanization led to the division of labour which Marx was so critical of, today's increasing computer-controlled technological developments, have in many cases led to decreased job specialization; fewer people are able to execute an array of tasks, while still maintaining production efficiency.[172] With the proliferation of computerized production systems and consequent less need for unskilled labour, the contemporary factory has effectively transformed into a machine.[173]

1.2.2.2 THE FACTORY'S EFFECT ON THE CITY

Throughout time, transformations in the nature of capitalism, fundamentally linked to an era's dominant industrial model, have corresponded with equally distinct cultural and economic shifts. Combinations of these evolving economic, cultural, and industrial parameters have continually informed the program, grain, and shape of the city, carving into its landscape.

— Ian S. Huff, *Walmart 2.0*

Factory Urbanism — Mercantile Era

Manufactories in the 18th century started removing people from their dwellings and into centralized working environments, as the scattered typology of homes and local artisan shops clustered into larger nodes of mechanized production.[174] Early factories were predominantly textile mills powered by water wheels,[175] in which proximity to a natural source of running water was vital, both for power and transportation.[176] Thus, small worker settlements near rivers were common. Due to limited options in mobility,

169 Rappaport, "Factory in Context: Timeline."
170 Carl Benedikt Frey and Michael Osborne, "The Future of Employment: How susceptible are jobs to computerisation?" (Academic publication, University of Oxford, 2013), 12.
171 Smith, "The workers' rebellion."
172 *Encyclopedia.com*, s.v. "Division of Labor," 2003, http://www.encyclopedia.com/topic/Division_of_labor.aspx.
173 Rappaport, "Factory in Context: Timeline."
174 Huff, "Walmart 2.0," 37.
175 Whitehill, "Post-Industrial Production," 6.
176 Peter Mulenga, "Industrial Revolution," *Factory* (blog), August 6, 2014, http://factor09.blogspot.ca/2014/08/industrial-revolution.html.

factories were exclusively located in urban centres, which in turn, symbolized a new kind of city. Claude-Nicolas Ledoux's Royal Saltworks, built for Louis the XV in Arc-et-Senans, France in 1779, epitomized a type of industrial utopia, which "represented an idealized relationship between worker and manager, industry and landscape, and man and the universe."[177] Although more symbolic than functional,[178] it nevertheless romanticized an urban realm which facilitated harmonious relationships between the factory and its inhabitants.

fig. 36 **Royal Saltworks (1779)**/ *industrial utopia/harmony between worker & manager, industry & landscape, and man & the universe*

Factory Urbanism — Industrial Revolution

But by the latter half of the 19th century, in the throes of the Industrial Revolution, factories quickly grew to tremendous sizes[179]—as observed by Marx in *Capital*:

> *On the other hand, while extending the scale of production it renders possible a relative contraction of its arena. This simultaneous restriction of space and extension of effectiveness, which allows a large number of incidental expenses to be spared, results from the massing together of workers and of various labour processes, and from the concentration of the means of production.*[180]

This surge in production capability was largely afforded by the rapid development of coal and the steam engine.[181] As a result, factories also required increasing numbers of labourers,[182] which was supplied by a steady stream of rural dwellers migrating into towns looking for work. In this way, factories in part contributed to the rise of 'urban living,' as

177 Whitehill, "Post-Industrial Production," 6.
178 van Uffelen, *Factory Design*, 8.
179 Whitehill, "Post-Industrial Production," 6.
180 Marx, *Capital*, 446.
181 Whitehill, "Post-Industrial Production," 6.
182 *Everything Explained Today*, s.v. "Factory Explained," accessed December 18, 2015, http://everything.explained.today/Factory/.

they drew people into cities[183] and workers' housings developed around them.[184] In turn, the fertile marketplace attracted more and more businesses into the city. The increasing demand for expensive urban territory pushed factory building typologies upward, to accommodate vertical production processes or multiple floors of shared space between different producers.[185] Factories thus "fostered their own urbanization," often in the form of industrial slums, as manufacturers with similar and complementary processes (i.e. one factory's waste as another's raw materials) clustered together, and different neighbourhoods developed into areas for certain types of businesses.[186]

In addition, access to railroads—which supplied plants with coal and also ran on steam power—became the defining feature of factories in this era.[187] "[I]n contrast to manufactories, factories are extremely dependent of their environment and infrastructure" like the mills before them, which relied on a supply of kinetic energy from nature.[188] Consequently, as factory operations escalated and easily flooded local markets, access to transportation became critical for a wider distribution of goods.[189] In North America, dense multi-story factory buildings sprang up along the waterfronts and ports where many cities were established.[190] As such, these manufacturing nodes were often optimally sited in consideration of the proximity of the market, work force, raw materials, power source, and rail and water distribution infrastructures,[191] resulting in concentrated areas of industrial activity.

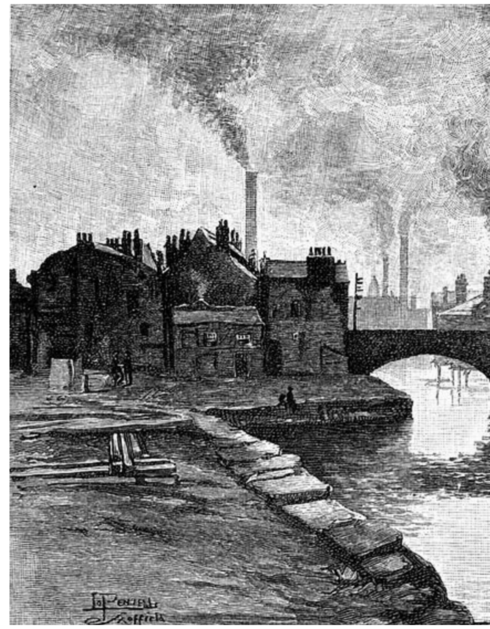


fig. 37 **Sheffield, England (1884)**/*industrial slums during the Industrial Revolution*

As factories continued to grow and spread, canals and railway systems expanded along with them.[192] Locomotive transport thus also enabled factories to move away from population-dense areas; they could be situated further away from localized markets and resources, which loosened industry's ties to water sites in downtown locations. At the same time, towns could no longer accommodate the increasingly bigger facilities, along with the growing realization that urban-situated factories presented a host of consequences. Namely, the dangerous and expansive rail yards interrupted the pedestrian-scale fabric of the city; and industrial pollutants, particularly concentrated along belts of intense industrial activity along waterfronts, imposed serious health risks to its inhabitants. While the working-class gathered around the factories where they were employed for convenient access, the more affluent moved 'uptown' into the hills to avoid the smoke.[193]

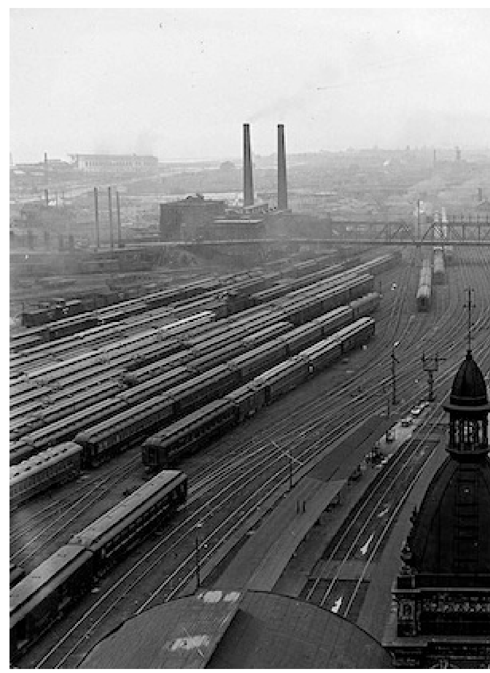
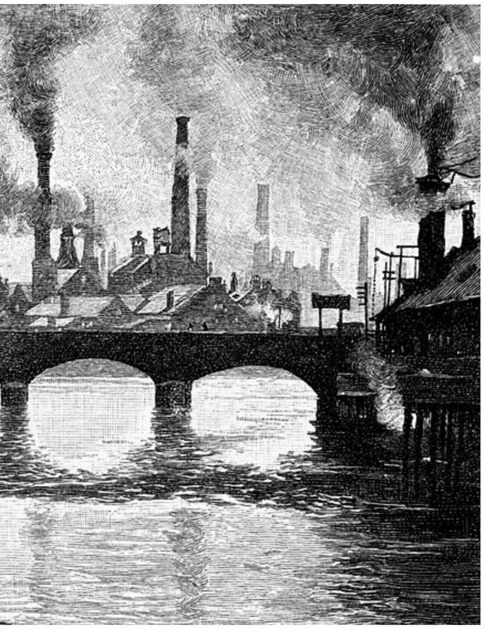


fig. 38 **Toronto railway lands (1926)**/*looking west from old Union Station tower*

modernist urban planning

As such, during this time, many ideas were put forth to solve the conundrum between living and working spaces, in response to a "profound crisis of urban

183 *World Public Library*, s.v. "Factory System," accessed December 18, 2015, http://www.worldlibrary.org/articles/factory_system.
184 Whitehill, "Post-Industrial Production," 6.
185 Nina Rappaport, "Installation Walkthrough," *Vertical Urban Factory*, accessed January 7, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/walkthrough_intro.php.
186 "Factory Explained."
187 Lee A. Miller, "Factory System," *Social Studies* (blog), July 22, 2015, http://socialstudies.school/2015/07/22/factory-system/.
188 van Uffelen, *Factory Design*, 8.
189 Miller, "Factory System."
190 Nina Rappaport, "New York Overview," *Vertical Urban Factory*, accessed January 9, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/new_york.php.
191 Black and Hunter, *Lean Manufacturing*, 1.
192 "Factory Explained."
193 Whitehill, "Post-Industrial Production," 6-7.



organization, impoverishment, and congestion" from which "a whole wing of modernist practice and thinking was directly shaped." The various modernist approaches all attempted to rationalize and spatially partition the programmatically overcrowded and unhygienic urban conditions brought on by industry.[194]

> *It also seems that modernism, after 1848, was very much an urban phenomenon, that it existed in a restless but intricate relationship with the experience of explosive urban growth […] strong rural-to-urban migration, industrialization, mechanization, massive reordering of built-environments, politically based urban movements […] The pressing need to confront the psychological, sociological, technical, organizational, and political problems of massive urbanization was one of the seed-beds in which modernist movements flourished. Modernism was an 'art of cities' and evidently found 'its natural habitat in cities'*[195]

One of the earliest solutions implemented to deal with the deteriorating quality of urban life, was Georges-Eugène Haussmann's renovation of Paris, directed by Napoléon III, and executed between 1853 and 1870.[196, 197] Wealthier families had begun to move to the west side of the city in part because there was more space, but also due to the fact that the prevailing winds blew smoke from the new factories toward the east.[198] The reconstruction sought to decongest the winding, narrow, disease-breeding streets of medieval Paris, by bringing in light and air via widened boulevards, parks, and public squares, as well as extended sewer and aqueduct systems. Haussmann's well-known apartment-block building typologies with unified heights and façades, served to knit the city fabric together into a cohesive whole.[199]

By the late 19th century, with the sharp increase in bicycle demand and production,[200] and availability of electric street cars, the advent of mass transportation meant that living within walking distance to work was no longer a necessity.[201] Furthermore, town planning policies for the first time in history, encouraged the separate zoning of industrial and residential areas, which workers would commute between.[202] In New York City for instance, 'Use' regulations distinguished 'residential,' 'commercial,' and 'unrestricted' zones, in which commercial zones prohibited heavy industry with offensive emissions, but allowed for light manufacturing activity. 'Height and Bulk' regulations controlled the setbacks of tall buildings from 1916 to 1961, in effect sculpting whole areas of rapidly growing urban form. Zoning laws were dictated by property values, which in turn was influenced by market demand—all to ensure the most optimal use of city land. Industrial activities usually found the cheapest plots, except certain 'vertical urban factories,' whose gross square footage to site area ratio allowed their businesses to remain competitive.[203] Due to these factors, the turn of the century saw many factories

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194 David Harvey, *The Condition of Postmodernity: An Enquiry Into the Origins of Cultural Change* (Cambridge, MA: Wiley-Blackwell, 1990), 25-6.

195 Tim Middleton, *Modernism: 1985-1991* (London: Routledge, 2003), 289-90.

196 Estevan Alvarado, "Baron Haussmann and the modernization of Paris," *Museum of the City* (blog), accessed December 22, 2015, http://www.museumofthecity.org/project/haussmann-and-revival-of-paris/.

197 although some work continued until 1927

198 Peter Miller, "The Haussmann building," *flickr* (blog), September 29, 2014, https://www.flickr.com/photos/64210496@N02/17304583786.

199 Alvarado, "Baron Haussmann."

200 David V. Herlihy, *Bicycle: The History* (New Haven: Yale University Press, 2004), 225.

201 "Factory System."

202 "Factory Explained."

203 Nina Rappaport, "Industrial History," *Vertical Urban Factory*, accessed January 10, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/industrial.php.

being segregated from other functions in the city, as they migrated further and further away from urban centres.[204] Some resettled at the edges of cities where cheap land and labour was abundant, while many others had already erected remote, self-contained model villages to house their workers, complete with community amenities and greenery.[205]

Evocative of model villages, 'Garden City,' was another prominent, albeit never fully realized urban manifesto, proposed at turn of the century in the United Kingdom by Ebenezer Howard. It described ideal, self-sufficient towns of 32,000 residents,[206] built outside the historic centres (i.e. London), where all the functional program of a city would be separated into rings or belts. The scheme depicted a rigorously planned urban model,[207] that had elements of both 'Town' and 'Country,' or 'Town-Country,' thereby providing the best of both worlds.[208] All the civic, cultural, and commercial programming would be placed at the centre of town, followed by rings of residential zones nestled within treed and vegetated estates. The 'nature' of these parks and gardens would serve as a barrier between houses and factories, which made up the outermost ring. This would be encircled by a rail line, which in turn would be surrounded by a swath of agricultural land.[209] Town-Countries would be separated from each other by greenbelt buffers, and connected via mass transit systems.[210] Indeed, Ebenezer's Garden City emerges as a direct precursor to the eventual totalizing effect of Fordist logic over American soil—the strict spatial separation of function in the factory, applied at the urban scale. In fact, many of Ebenezer's principles are still discernible in the urban code of the contemporary American city. Garden City in many ways, was conceived as a commodity to be mass produced and strictly managed.[211]

French architect Tony Garnier's proposal 'Une Cité Industrielle' presented several years later, described a similar utopian scenario: a town of 35,000 inhabitants located between a mountain and a river, situated to take advantage of hydroelectric energy. Vocational schools would be placed near their respective industries so that people would have better access to education. Interestingly, the proposal is reminiscent of an urban version of the early mills, which were sited near natural resources such as wind and water, to power plant operations.[212]

19th-century societies had undoubtedly begun to romanticize the natural environment and yearned for a return to 'untouched nature' as a relief from the various hazardous conditions wrought by modern industry. As such, they attempted to 'capture wilderness,' and intertwine it into everyday urban living—a notion that was made manifest in the hugely influential proposals put forth by the Congrès International d'Architecture Moderne (CIAM) during the early 20th century. The group was headed by Le Corbusier,[213] who had a deep fascination for the progressive technologies and rationality of Fordist industrialism, and sought to spread its functionalist ideologies

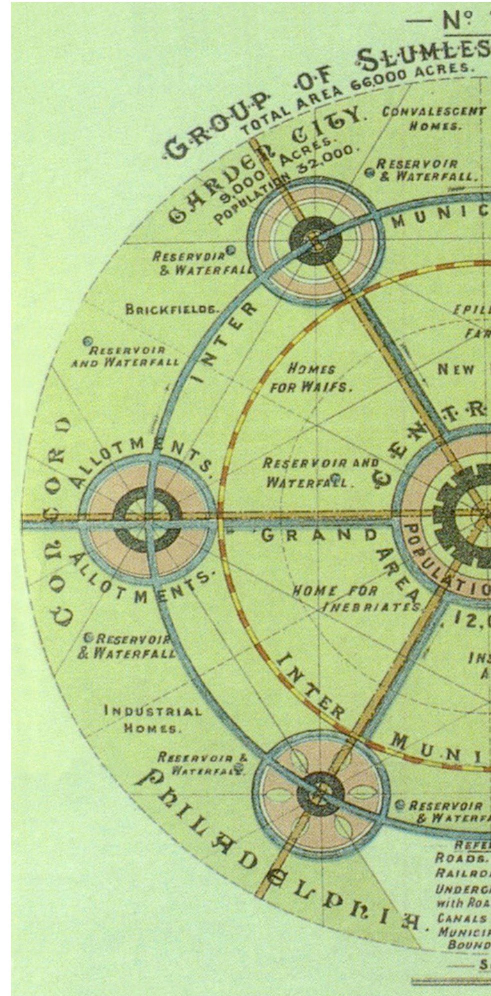


fig. 39 **Garden City (1898)**/*ideal 'Town-Country' urban model with ringed functional separation*

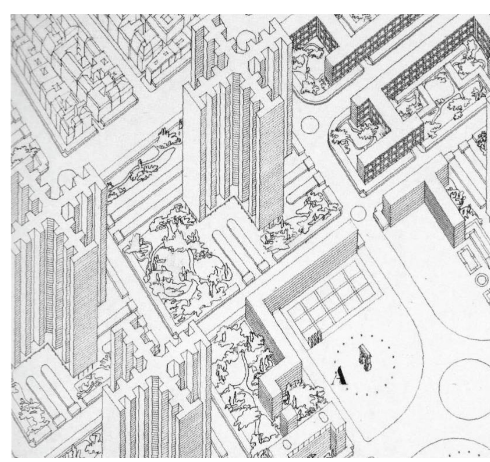
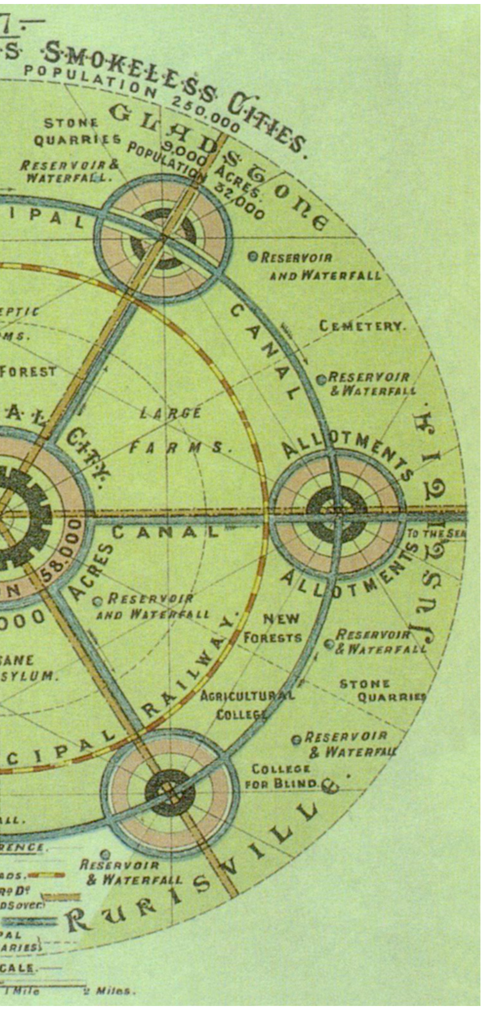
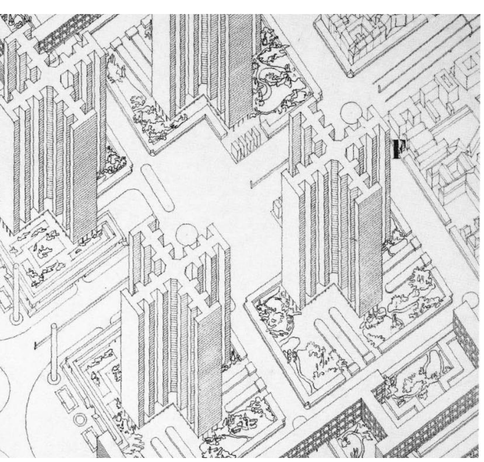


fig. 40 **Ville Radieuse (1933)**/*one of Le Corbusier's urban manifestos advocating functional separation, homogeneity, and hierarchy*

204 Whitehill, "Post-Industrial Production," 42.
205 van Uffelen, *Factory Design,* 8.
206 Whitehill, "Post-Industrial Production," 7.
207 Jane Jacobs, *The Death and Life of Great American Cities* (1961; reis., New York: Vintage Books, 1992), 17-8.
208 Whitehill, "Post-Industrial Production," 7.
209 Jacobs, *The Death and Life*, 17-8.
210 Whitehill, "Post-Industrial Production," 7.
211 Huff, "Walmart 2.0," 41.
212 Edu, "Top 10 Most influential urban-design books ever written," *otras Arquitecturas, otras Ciudades* (blog), October 29, 2014, http://otrarquitecturas.blogspot.ca/2014/10/top-10-most-influential-urban-design.html.
213 Whitehill, "Post-Industrial Production," 7-8.





across architecture, urbanism, and landscape. Formalized in 1928, the organization was composed of 24 architects from various European nations, who believed that a 'higher social existence' could be achieved through the design of architecture based upon current economic, political, and social climates. The separation of function within the city was of utmost importance, as they believed that the repetition of standardized parcels of urbanity based upon prescriptive formulas, was the only way to achieve a stable, harmonious relationship between the various forces in the urban ecosystem.[214] The 'Functional City,' proposed in 1933, advocated for the distinction of living, recreation, and employment areas[215] with the even distribution of population into tall apartment buildings[216]—while maintaining minimal distance between home and work. Its architecture called for the raising of buildings on pilotis, so that the 'natural' landscape could grow unencumbered underneath. "Rational architecture and urban design would be the means by which wild nature would be saved."[217]

Influenced by Ebenezer Howard's Garden City model of packaged modular urbanity, Le Corbusier had also developed a number of manifestos on his own, including: 'Plan For a City of Three Million Inhabitants' (1922), 'Plan Voisin' (1924),[218] and 'Ville Radieuse' (1933).[219] They all called for an eradication of existing urban environments, in favour of new infrastructure[220] that would encompass "differentiation (zoning and distinct functionalist articulation of each zone), repetition (homogeneity of each zone) and hierarchical integration (transport system)."[221] Like Howard, Le Corbusier envisioned urban form as a commodity that could be rationalized, standardized, and mass produced.[222] Fordist philosophies clearly had a profound effect on the modernist architectural and urban discourse of the period. "The modernist pattern of urbanization is the projection of this total social machine into space."[223]

<u>*Factory Urbanism — Fordism*</u>

early Fordism (centralization)

In fact, between 1890 and 1960, the American commercial landscape was dominated by 'Fordist cities'—entire towns devoted to the production of a single product, or metropolitan regions in the hands of a few large manufacturing firms. Some of the most prosperous cities in the nation at the time, notably, Detroit, Pittsburg, Bridgeport, were all involved in mono-industry economies. The ongoing consolidation of manufacturing facilities, or centralization of production, led to the rise of the mega corporation beginning at the end of the 19th century.[224] Although the progressive industrialization of civilization on the world stage was led by the United States (and in America, by Ford), Europe wasn't far behind. In Italy, Turin was the embodiment of the

214 Huff, "Walmart 2.0," 43.
215 Whitehill, "Post-Industrial Production," 8.
216 "Functionalist Architecture," *Archipaedia* (blog), November 26, 2009, https://archipaedia.wordpress.com/2009/11/26/functionalist-architecture/.
217 Whitehill, "Post-Industrial Production," 8.
218 Huff, "Walmart 2.0," 43.
219 Schumacher and Rogner, "After Ford."
220 Huff, "Walmart 2.0," 43.
221 Schumacher and Rogner, "After Ford."
222 Huff, "Walmart 2.0," 43.
223 Schumacher and Rogner, "After Ford."
224 Karjanen, "The Wal-Mart Effect," 145.

automobile mono-industry in its own right,[225] and its flagship, Fiat's Lingotto factory, emulated Ford's Highland Park plant in Detroit.[226] At the behest of Mussolini, mechanical engineer Ugo Gobbato, an expert in the rationalization of production, transplanted, organized, and consolidated all the smaller Fiat workshops scattered around Turin into the Lingotto Factory during its expansion between 1923 and 1928.[227] The increasing monopolization of Fiat in Turin through the concentration of the means of production, signified the centralization of capital of the automobile industry in Italy.

This overlap of city as industry and industry as city did afford certain opportunities vested in the mutual interests between society and economy. Cities benefitted from the commerce of all the industrial activity, and healthy communities provided a stable workforce for the factories. Consequently, businesses often funded local civic projects, such as schools, museums, charities—in effect setting up a 'social contract.' "Thus during the early twentieth century there was a clear spatial dimension to the economy of places: proximity between consumers, producers, and distributors was critical to an expanding regional economy and a well-integrated civic life."[228]

But by the early 20th century, Henry Ford was already expanding the assembly line beyond factory walls at the Ford River Rouge complex (1917-1928) in Dearborn, Michigan.[229] It was the mono-industry regional extension of Detroit; Detroit was the automobile, the automobile was Detroit, with "its singular devotion to the idea of industrial production, investing all of its resources into a technology and product that has transformed the face of every modern city."[230] The River Rouge facility effectively operated like a small town, dividing its program by employing separate buildings to fulfill different functional tasks.[231] It played an instrumental role in the shift of factory typology from single multi-storey buildings, to a horizontal multiplicity of low-rise buildings within a compound.[232]

late Fordism (decentralization)

After the completion of River Rouge, which was the world's biggest industrial facility at the time, Ford continued to deploy his principles at the regional and even national scales, by implementing a 'decentralizing anti-urbanism.' Working with Albert Kahn, Ford dispersed specialized factories across the country,[233] in which sub-processes once all under the same roof, were now optimally sited for each operation; i.e. the availability of the work force and raw materials and resources. A ubiquitous and expanding national highway system, extensive power grid, and other communications infrastructure, were constructed to connect the now severed manufacturing operations.

fig. 41 **Santa Monica Freeway, Los Angeles (1965)**/*highway network expanded with the Federal Highway Act of 1956*

225 Banham, "Fiat," 86-8.
226 Nina Rappaport, "Fiat Lingotto," *Vertical Urban Factory*, accessed January 13, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/fiat.php.
227 Victoria Grazia, *The Culture of Consent: Mass Organization of Leisure in Fascist Italy* (Cambridge: Cambridge University Press, 1981), 76.
228 Karjanen, "The Wal-Mart Effect," 145.
229 Huff, "Walmart 2.0," 45.
230 Hoffman, "The Best," 42.
231 Schumacher and Rogner, "After Ford."
232 Huff, "Walmart 2.0," 45.
233 Schumacher and Rogner, "After Ford."

fig. 42 **Levittown (1951)** / *archetypal post-war North American suburb*

Supplemented by access to affordable fuel, it rendered them completely free of the transportation and power source constraints of the early mills and industrialized factories,[234] thus continuing to push them further and further away from cities, and into the suburbs or industrial parks.[235] "This extension of fordist productive patterns fueled the rapid decompression of urban industrial cities and the decentralization of both mass production and mass consumption."[236]

The dispersal of industry was accompanied by a general trend in the decentralization of urban form during the second half of the 20th century.[237] After World War II, in order to meet the demand of returning veterans, the functionalist and modernist philosophies of Fordist industrialism had become status quo during the postwar housing boom. It was a necessary and pragmatic remedy for the shortage, in which the generation's view of 'good design' was conveniently supported by capitalistic mass production—translating into "the speedy and efficient production of a large number of dwellings." During this period of intense urbanization, housing became a standardized, mass produced commodity, as any other object manufactured on the assembly line.[238] This postwar scenario was far from the grand modernist visions of utopian metropolises during its early days.

The same networked highways, advancements in automobile technology, and affordable fuel that enabled the decentralization of factory operations, also facilitated the development of suburban form on vast plots of greenfield lands. Following the same trajectory as the morphological mutations of the factory, multiple-unit apartment complexes split into single-family homes, just as in the divorcing of various parts of the production process into separate buildings in the later phase of Fordism. Additionally, influenced by Howard's 'Garden City' and Le Corbusier's urban proposals, these developments consisted of "horizontal parcels of mono-programmatic residential fabric" of single-family houses. "The standardized single family dwelling built for the standard nuclear family became the new measure of the city; defining the grain of a horizontal, decentralized urbanism."[239]

> *Overall, the Fordist era left a distinctive mark on the American urban landscape: town and cities dominated by a stable set of well-capitalized industries, surrounded by lattices of class-stratified housing and smaller businesses, ringed by a set of suburbs that were truly 'bedroom' communities, i.e. dependent geographically and economically upon the vibrancy of the urban industrial core.*[240]

However, these physical manifestations of CIAM's modernist influence on postwar reconstruction in Europe, and particularly in North America, were far from ideal. It quickly became clear that engineering alone could not solve the urban predicament—by ignoring the social aspect of architectural and urban design, and dismissing the need for

234 Huff, "Walmart 2.0," 46.
235 van Uffelen, *Factory Design*, 10.
236 Schumacher and Rogner, "After Ford."
237 Charles Waldheim and Alan Berger, "Logistics Landscape," *Landscape Journal* 27, no. 2 (2008): 219.
238 Hilde Heynen, *Architecture and Modernity: A Critique* (Cambridge, MA: The MIT Press, 2000), 149.
239 Huff, "Walmart 2.0," 47-49.
240 Karjanen, "The Wal-Mart Effect," 146.

diversity in the city.[241]

Indeed, today, the paralyzing effects of modernist/Fordist urbanism have been made none more evident than in the city and surrounding region that started it all. "The historical closure of fordism as a model of socio-economic progress spelled the demise of Detroit, once the proud origin of modern industrial development. [...] Now Detroit stands devastated; overburdened by the infrastructural, architectural and human sediment of its fordist past." In fact, as early as 1961, Jane Jacobs anticipated the fate of the modernist-planned city at the peak of its prosperity:[242] "Virtually all of urban Detroit is as weak on vitality and diversity as the Bronx. It is ring superimposed upon ring of failed gray belts. Even Detroit's downtown itself cannot produce a respectable amount of diversity. It is dispirited and dull…"[243] Accordingly, "monotony, lack of diversity; these are the typical 'ills' or 'failures' of the modern city."[244]

fig. 43 **Detroit**/*industrial ghost town*

In Europe, the Fordist era was also coming to an end, as the automobile industry was among the hardest hit in the aftermath of the late 1960's economic downturn.[245] The oil crisis of 1973 eventually led to the closure of the Lingotto factory in 1982, which was part of a larger rapid reorganization of northern Italian industry's resources.[246] Reversing the centralization of workshops almost 60 years earlier, parts of the factory were dispersed to various facilities in an act of decentralization.[247]

241 Whitehill, "Post-Industrial Production," 8.
242 Schumacher and Rogner, "After Ford."
243 Jacobs, *The Death and Life*, 150.
244 Schumacher and Rogner, "After Ford."
245 *Everything Explained Today*, s.v. "1973 oil crisis explained," accessed January 15, 2016, http://everything.explained.today/1973_oil_crisis/.
246 Jeff Diamanti, "Postindustrialisation in the Present Tense," *Liverpool Biennial*, March 2014, http://www.biennial.com/journal/collaborations/postindustrialisation-in-the-present-tense.
247 "Lingotto," *Altrove The Torino DMC*, accessed January 13, 2016, http://www.altrovedmc.com/2013/01/l-like-lingotto/.

Factory Urbanism — Post-Fordism

international expansion of industry

But if the Fordist era took industry and atomized its processes across the nation, the post-Fordist era went a step further and disperse it around the world. This process was already underway by the 1970's, as globalization accelerated throughout the 1980's and 1990's.[248] National economic borders and their associated policies were eroded as technological advancements in the transmission of people, goods, and information, enabled industrial enterprises to continually broaden their market on the global stage.[249] With trends in manufacturing shifting toward market differentiation and product diversity, businesses were consequently able to offset the loss of efficiency from economy of scale through international expansion.[250] Furthermore, corporations in developed countries began to move their factories offshore,[251] taking advantage of the access to cheaper labour and more advantageous regulations abroad (i.e. tax-free zones).[252] This eventually led to the outsourcing, and contracting out of manufacturing activities to developing nations such as China and Mexico, almost entirely.[253] It allowed companies to be unencumbered by the financial liabilities of directly owning and operating factories. They could simply purchase the same products from facilities overseas at lower costs, while maintaining short-term contracts with them—all in the interest of economic flexibility.[254] Post-Fordism therefore, saw the removal of producers from the direct act of manufacturing, as they became more and more exclusively involved in the logistics and management of goods.[255]

urban extension of Just-In-Time factories

Fordism wasn't the only system that extended its production strategies out to the urban realm. The market-flexible manufacturing system, Just-In-Time (JIT), emerged in Japanese Toyota factories as the Toyota Production System (TPS) after WWII, and spread to the west in the 1980's.[256] It considered all secondary production facilities, transportation and communication infrastructure—from the inside of the factory to globally-scaled infrastructural networks—as a part its system of closely-linked individual cells running on a strict, calculated rhythm of production. The built environment therefore, was simply seen as an extension of the JIT factory. As a result, in order to optimize the efficiency of their production process, JIT producers were hugely influential lobbyists in the design and construction of urban systems, such as highways and local roads, that best facilitated their needs. They sought out prime sites located near infrastructure to create the best conditions to smooth their workflow. Zoning also played a part in keeping other program away from JIT industrial domain,[257] while simultaneously gradually regulating them out of downtown sites.[258] As such, these manufacturing facilities formed autonomous units

248 Saskia Sassen, "The Global City: Introducing a Concept and its History," in *Mutations*, ed. Rem Koolhaas and Hans-Ulrich Obrist (Barcelona: Actar Publishers, 2000), 104.
249 Huff, "Walmart 2.0," 51.
250 Schumacher and Rogner, "After Ford."
251 Huff, "Walmart 2.0," 52.
252 Sassen, "The Global City," 104.
253 Huff, "Walmart 2.0," 52.
254 Waldheim and Berger, "Logistics Landscape," 221.
255 Huff, "Walmart 2.0," 53.
256 Hanlon, "Learning from Dell."
257 Huff, "Walmart 2.0," 53
258 Rappaport, "Industrial History."

isolated from spaces of urban living by both scale and distance.

social alienation in productive society

In this manner, contemporary producers have become increasingly disconnected from both their labour force and consumer base[259]—a trend that initiated during the Industrial Revolution as factories were pushed further and further from cities,[260] and intensified over the course of the new wave of technological advancements of the Information Age.[261] As such, spaces of manufacturing have long been absent from the local setting of their market, promoting a society where consumers are progressively alienated from the processes of production, origins of goods, and the labourers that make them.[262] Conversely, factory workers have no relationship to the objects they make, as the JIT model of production ensures that they are promptly shipped off, often to end-users on a different continent.

Marx addresses both these forms of alienation in *Capital*:

i. **commodity fetishism** (consumer—commodity alienation): the dissociation of the commodity from the consumer by money and the process of exchange[263]

ii. **worker alienation** (worker—commodity alienation): the dissociation of labour-power and the commodity from the labourer[264]

Marx believed that the inanimate objects produced by human labour are automatically ascribed a 'fetishism,' such as value, which is then able to govern the social relationships between people:[265]

> *There the products of the human brain appear as autonomous figures endowed with a life of their own, which enter into relations both with each other and with the human race. So it is in the world of commodities with the products of men's hands. I call this the fetishism which attaches itself to the products of labour as soon as they are produced as commodities, and is therefore inseparable from the production of commodities.*[266]

However, in a capitalist society, due to the emphasis on the economic relation between things (i.e. relative monetary values of commodities), the social relations between people (i.e. who makes what, who works for whom, etc.) is obscured—thereby concealing the true nature of the human relationships in production.[267] In the post-Fordist world, this in turn has been exacerbated by the growing geographical elongation between the different players of productive society.

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259 Huff, "Walmart 2.0," 58.
260 van Uffelen, *Factory Design*, 8-10.
261 Mathias Humbert, "Technology and Workforce: Comparison between the Information Revolution and the Industrial Revolution" (Academic paper, University of California, 2007), 6.
262 Huff, "Walmart 2.0," v.
263 Isaak Illich Rubin, *Essays on Marx's Theory of Value* (Montreal: Black Rose Books, 1990), 5.
264 *Marxists Internet Archive Encyclopedia*, s.v. "Alienation," accessed January 7, 2016, https://www.marxists.org/glossary/terms/a/l.htm.
265 "Marxism & Alienation," *Marxists Internet Archive*, accessed January 7, 2016, https://www.marxists.org/subject/alienation/.
266 Marx, *Capital*, 165.
267 Ben Fine and Alfredo Saad-Filho, *Marx's Capital* (London: Pluto Press, 2004), 25-6.

urban spatial disconnection in productive society

In the past two to three decades, corporations have offshored and outsourced much of their productive activity, in favour of a service-centric economy of management and logistics, supported by information, media, and creative forms of labour.[268] "[The urban service economy is becoming increasingly independent from the industrial development of a region. There are indications that globalization, and the shift from an industrial to a knowledge-based economy, weaken the spatial ties between manufacturing production and services."[269] Although the flow of information and global travel is now faster and more convenient than ever before, the speed and ease of transfer has simultaneously facilitated the physical separation—by distance, scale, and time—of urban elements that were once tied together by necessity.

> *This has created a fundamental spatial disconnect between production, manufacturing, and consumption within the city; where local economies often have no relationship with the production or subsequent economic benefit of the goods they consume [...] Productive industrial entities and territory, once ingrained in the inhabited city fabric have gradually disappeared; leaving behind smooth, frictionless surfaces of retail, logistics, and service, lacking a social viscosity, and consideration for the public dimension of the city.*[270]

<u>*Factory Urbanism* — Post-*Post-Fordism?*</u>

urban spatial reconnection in productive society?

While many of the trends that unfolded at the onset of the post-Fordist era continue today, some counter-trends are also starting to emerge, as de-industrialized Western municipalities explore new ways of retaining manufacturing businesses and jobs in the city.[271] With the recent economic recessions and general financial instability, coupled with rising costs of fuel and foreign labour and uncertainty about their future availability, the validity of the global manufacturing model is being challenged on multiple fronts.[272] In fact, many European cities have begun to take action against the loss of local manufacturing—Paris initiated a program to bring studio workshops and other flexible spaces for fabrication back into the city, and Bologna took steps to ensure the sustainability of its small-scale makers. Multi-storey factory buildings have also returned from their obsolescence in the early Fordist era for light manufacturing in Asia, such as in the high-density fabric of Hong Kong, or China's most rapidly developing new city, Shenzhen.[273] Volkswagen's multi-storey 'Transparent Factory' in Dresden, Germany, is deeply embedded in the urban fabric—transporting automobile parts from a logistics centre by integrating one of the city's streetcar lines into the facility as part of its cargo

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268 Huff, "Walmart 2.0," 52-3.

269 Dieter Läpple, "The German System," in *The Endless City: The Urban Age Project by the London School of Economics and Deutsche Bank's Alfred Herrhausen Society*, ed. Ricky Burdett and Deyan Sudjic (London: Phaidon Press, 2007), 240.

270 Huff, "Walmart 2.0," v.

271 Nina Rappaport, "Vertical Urban Factory," *Vertical Urban Factory*, accessed January 11, 2016, http://skyscraper.org/EXHIBITIONS/VERTICAL_URBAN_FACTORY/vuf.htm.

272 Huff, "Walmart 2.0," 6-7.

273 Rappaport, "The Contemporary Factory."

distribution system.[274]

digital cottage industry

At the same time, the advent of digital manufacturing equipment has prompted the rise of small startup fabrication studios in North American cities, allowing them to be competitive again.[275] The 'cottage industry' is also experiencing a resurgence, with the rise of online platforms such as Etsy, eBay, etc. They enable people to act as craftsmen in their own homes, as new communication and transportation technology (instead of traditional merchants and horses), are equipping them with the means to sell and ship all over the world.[276]

vertical urban factory

Architectural critic, and director of think tank project 'Vertical Urban Factory,' Nina Rappaport, advocates for the reinsertion of multi-storey factories for light manufacturing back into the urban fabric:

> *While the global factory has become a place of cheap products and exploitative working conditions, a new turn to transparent local production with new technologies can produce numerous goods including food processing, high-tech products, fashion, and furniture. Smaller lighter and cleaner industries are revitalizing neighborhoods and industrial infrastructures in cities. If industrialists and urban planners reconsider the potential for building vertically and thus more densely in cities, as well as mixing uses of residential and industrial buildings this, in turn, would reinforce and reinvest in the cycles of making, consuming, and recycling as part of a natural feedback loop in a new sustainable urban spatial paradigm.*[277]

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274 Basem Wasef, "21 Cool Facts About the Transparent Volkswagen Factory," *Popular Mechanics*, December 7, 2011, http://www.popularmechanics.com/cars/g705/21-cool-facts-about-the-transparent-volkswagen-factory/?slide=15.

275 Huff, "Walmart 2.0," 7.

276 Chris Anderson, *Makers: The New Industrial Revolution* (New York: Crown Business, 2012), 50.

277 "Vertical Urban Factory."

2. factory » ARCHITECTURAL URBAN INTERVENTION

2.1 pre-amble

2.1.1 THE FACTORY AND THE CITY

Once a symbol of progress in the city during the Industrial Revolution, the factory inflated in size and was driven further and further away from urban centres throughout the Fordist period. As these trends continued, the post-Fordist era pushed factories completely off the domestic map as they were offshored from developed to developing countries, leaving behind a smooth, frictionless urban landscape of services and logistics. As detailed in the last chapter, this push and pull dynamic between factories and cities over the last few centuries, is what has spawned the specificities, particularities, and intricacies of the current, and ever-changing built urban environment.

As our cities continue to grow, the past several decades in Canada have been marked by a shift away from "continuous expansion of the urban periphery to the more complex layering of the urban centre."[1] We now know that the heterogeneous layers of the urban fabric and the richness they provide, cannot be undermined, as they directly inform the vibrancy and vitality of the city.[2] This is viewed in contrast to the mono-industrial regions of late Fordism, or the vacant and ghostly factory shell remnants of post-Fordism, which were supplanted by service, operation, and management—essentially replacing thesis tangible with the ethereal. We now know (what Jane Jacobs predicted as early as the 1960's), that balanced, thriving cities require high quality physical artifacts—factories, transportation infrastructure, pedestrian-scale public spaces—in order to generate the kind of friction needed in the city for social collision, interaction, and exchange.

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1 Valerie Wright, "Complexity & Community" (Master's thesis, University of Waterloo, 2016), iii.

2 Serge Salat, Loeiz Bourdic and Caroline Nowacki, "Assessing Urban Complexity," *International Journal of Sustainable Building Technology and Urban Development* 1, no. 2 (2010): 160-67.

2.1.2 POST-POST-FORDISM

Using Nina Rappaport's position on the reintegration of vertical factories into the city as a point of departure, this thesis submits the design for a bicycle factory in the city of Toronto as a 'post-post-Fordist' urban intervention. Humans have long fantasized about living in harmony with their surroundings, whether it's with nature, or industry, as exemplified by Ledoux's Royal Saltworks (1779), or Howard's proposal for 'Garden Cities' (1898). These utopian models reveal an innate desire for proximity between our living, working, and recreational spaces. Today, as the globalizing trends of the post-Fordist era reach a point of saturation, the new millennium is in fact witnessing the return of local economic ecosystems.

As defined by and within the scope of this thesis, the post-post-Fordist society is in part the counter-culture already starting to occur in reaction to post-Fordist practice, i.e. re-localization vs. globalization. It is an amalgamation of significant contemporary movements that deviate from broad definitions of post-Fordism, and the extension and intensification of those trends toward an anticipated near-future scenario. It weaves these notions and new assertions about the way the city should function, into envisioned ideal realities. Noted British political economy theorist Bob Jessop observes:

> *Without significant discontinuity, it would not be* post-*Fordism; without significant continuity, it would not be post-*Fordism. *This double condition is satisfied where: (a) post-Fordism has demonstrably emerged from tendencies originating within Fordism but still marks a decisive break with it; or (b) the ensemble of old and new elements in post-Fordism demonstrably displaces or resolves basic contradictions and crises in Fordism - even if it is also associated with its own contradictions and crisis tendencies in turn.*[3]

Operating along the same lines, the *post*-post-Fordist movement combines virtues from the philosophies and strategies of both the Fordist and post-Fordist eras, by continuing certain ideas, while discontinuing others. In the ideal contemporary city, the post-post-Fordist inwardly-aggregating urban environment is a rich, variegated tapestry of interweaving functional program, designed to increase and optimize points of interaction. It brings light manufacturing activity back into the urban realm, to spatially reconnect producers, workers, and consumers, while providing fair working conditions for the blue-collar class, as a way to eliminate the exploitation of cheap labour in offshored factories overseas. The sustainable city naturally also integrates extensive cycling networks into its urban fabric. Appealing to the counter-internationalization trends already taking place, the relationship between factory and city in a post-post-Fordist context is reimagined to generate novel interactions between manufacturing, transportation, and public space, thereby establishing a new kind of metropolis.

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3 Bob Jessop, "Post-Fordism and the State," in *Post-Fordism: A Reader*, ed. Ash Amin (Malden, MA: Blackwell Publishers, 2000), 257.

the post-post-Fordist SOCIETY
= *(good) Fordism + (good) post-Fordism + counter-culture trends + new ideas*
- » open/transparent/receptive
- » more collaboration between public and private sectors

the post-post-Fordist CITY
- » densification/intensification/re-centralization/inwardly-aggregating core
- » heterogeneous/multifaceted/interweaving and strategic layering of program
- » harmonious collision of urban life/increased points of interaction/friction
  - › redefined relationship and new interface between manufacturing, transportation, and public space
- » re-localization vs. globalization
  - › elimination of exploitation of cheap labour in offshored post-Fordist factories
    - : fair working conditions for blue-collar class
  - › spatial reconnection between producers, workers, and consumers
    - : reintegration of light manufacturing activity
- » sustainable
  - › cycling infrastructure propagated throughout

the post-post-Fordist BICYCLE FACTORY

- » symbol of Toronto as a cycling vanguard
- » catalyses reindustrialization, by mobilizing mobility
- » active participant in the pulse of urban life
- » hybrid architectural typology of factory, pedestrian & cycling bridge, urban park, velodrome and bike park
  - › heterogeneous amalgamation of architectonic objects
  - › expands urban cycling network into interior architectural environments
  - › brings public realm into factory via transparency in manufacturing process
- » hybrid post-post-Fordist 'Just-Right' model of production
  - › Fordist mass production efficiency + post-Fordist mass customization flexibility
    - : Fordist mono-commodity assembly line
      - · 'push' model of production through the large-scale manufacturing of a single, affordable vehicle, distributing it around the city, and watching the infrastructure grow
    - : post-Fordist adaptable cellular production line
      - · 'pull' model of production determined by market demand
      - · lean manufacturing elimination of waste and inefficiencies
      - · computer-automated machinery enables efficient product customization
- » democratic labour organization model of production
  - › employees have more agency over working conditions
    - : skilled and semiskilled labour
      - · spectrum of work from full automation to handicraft requires more worker expertise
      - · labour rotation demands broader range of worker skill, versatility, and flexibility
    - : teamwork
      - · fosters more collaborative relationship between workers and managers
      - · Volvo's flexible team assembly system applied to bicycle assembly
    - : worker & consumer co-operative
      - · collective democratic ownership where employment circumstances and product specifications are determined by members
      - · positive social feedback loop of consumption

the post-post-Fordist BICYCLE FACTORY BICYCLE

- » single product design
  - › counter-trend of enduring, classic, Fordist simplicity in design and selection vs. ephemerality of post-Fordist rapid product turnovers
  - › decision fatigue
    - : overwhelming choice in post-Fordist society leading to prioritization of quality and functionality over product variety
      - · commodity is personalized through our relationship with it
      - · less product turnover and regular maintenance produces less waste
  - › customizable mid-range commuter bicycle with a few optional accessories mass produced and disseminated across the city

2.1.3 THE POST-POST-FORDIST BICYCLE FACTORY

This thesis offers the insertion of a bicycle factory in the city of Toronto as an agent of change, acting as a catalyst to mobilize the economy, transportation, and public space. The design proposal consists of five main elements:

i. a **factory building** whose form is extruded from and raised off of the site
ii. **pedestrian & cycling bridges** that connect fragmented portions of the urban fabric and pass over, under, or through the factory building
iii. an **urban park** with pavilion buildings that sit atop the factory building at street level
iv. an open **velodrome** that floats above the urban park
v. an **outdoor bike park** for off-road cycling just below the elevated factory

Deeply embedded in the urban fabric, the project unfolds as a microcosm of the ideal post-post-Fordist city—as bicycle factory, cycling infrastructures, and public spaces interweave in, around, and through each other to create a complex, layered, architectural artifact. The combination of factory, pedestrian & cycling bridge, urban park, velodrome and bike park in a hybrid typology, create intertwining public and private spaces that participate as active components of urban life. As a result, the factory is also able to adopt a high degree of transparency in its manufacturing process, by bleeding the public realm right into its spaces of production, including integration of the urban cycling network within its facilities.

Unlike commodity-obsessed Fordist and post-Fordist eras, the post-post-Fordist intervention is designed to be an antidote, or 'a machine for de-commodification.' The factory's hybrid 'Just-Right' model of production combines the efficiency of Fordist mass production, with the flexibility of post-Fordist mass customization. On one hand, it employs Fordism's assembly line to mass produce a single, affordable bicycle. This 'push' model of production is utilized to disseminate the human-powered vehicle throughout Toronto to instigate the growth of cycling infrastructure, much in the same way Ford's automobiles and subsequent cars shaped the 20th-century city. On the other hand, the operation also takes advantage of the adaptability of post-Fordism's cellular production line and its market-dictated 'pull' system of manufacturing. The adoption of Just-In-Time, or lean manufacturing's elimination of waste and inefficiencies, is facilitated by computer-automated machinery, which in turn also enables efficient product customizations.

The post-post-Fordist bicycle factory redefines the status quo of employment in a productive setting through its democratic labour organization models, by giving its staff more agency over their working conditions. It achieves this in three main ways—by employing skilled and semiskilled labour, applying teamwork strategies, and establishing the business as a worker & consumer co-operative. The tasks involved in the stages of production span from full computer-automation to handicraft work, all of which require a certain degree of expertise beyond unskilled jobs. Its labour rotation policy further demands a broader range of worker skill, versatility, and flexibility. The operation also fosters a more collaborative relationship between workers and managers, and uses Volvo's team assembly system as a precedent for its own bicycle assembly. Lastly, the collective democratic ownership of the worker & consumer co-operative, where the circumstances of employment and product specifications are determined by its members, provides a positive social feedback loop of consumption in the city.

The intervention contributes to environmental sustainability by supplying both the vehicle and infrastructure for cycling, as a way to encourage the use of bicycles over automotive transport. It serves the city of Toronto by improving the connectivity of the cycling network and opening up a knot in the urban fabric; creating local employment; and providing didactic and engaging public spaces. The hub also fosters and celebrates bicycle culture in the city, while promoting quality design and manufacturing. In this way, the hybrid typology of the project aims to bring light manufacturing activity back into the city by recalibrating public perceptions about the factory. It endeavours to be a symbol for Toronto on the world stage as a leading metropolis in both cycling and manufacturing.

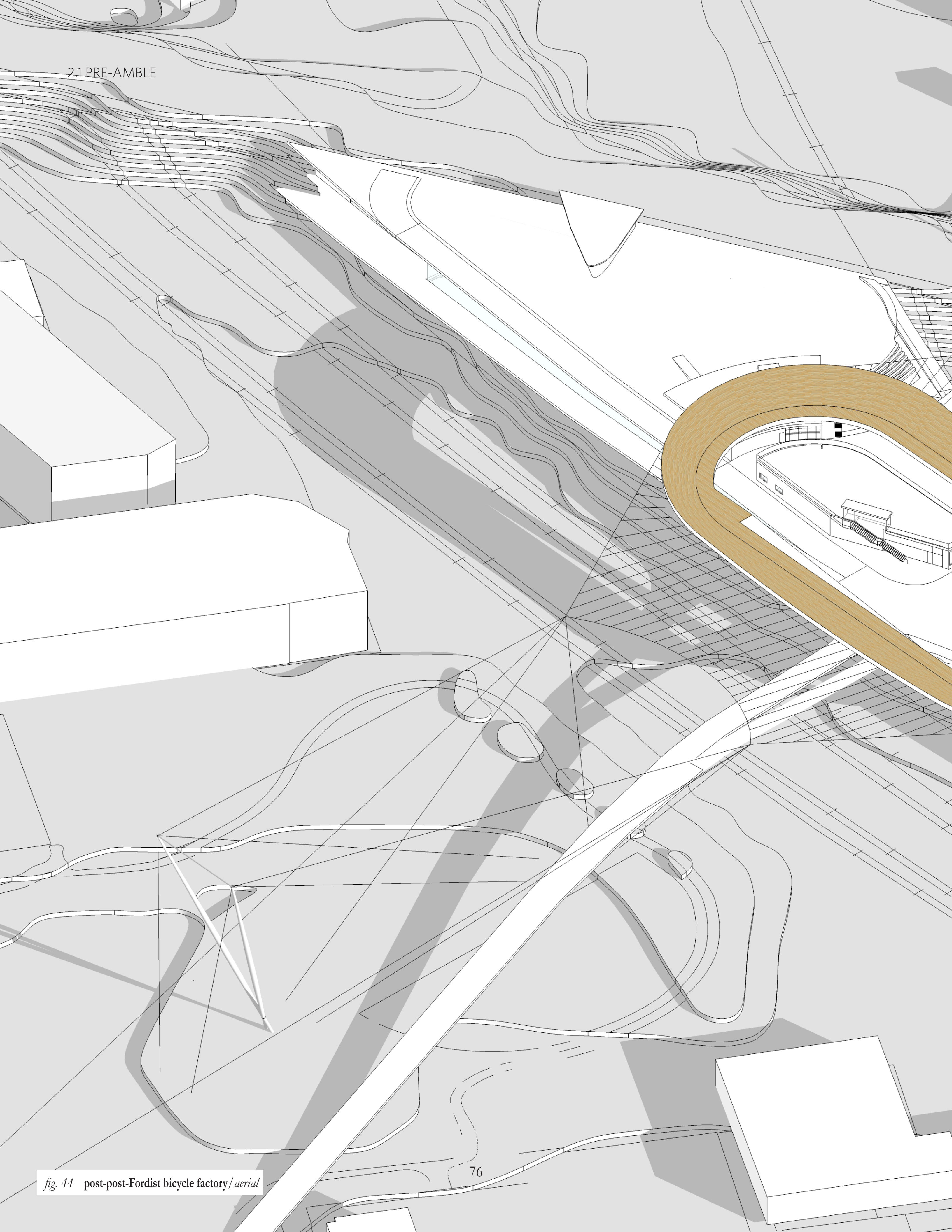
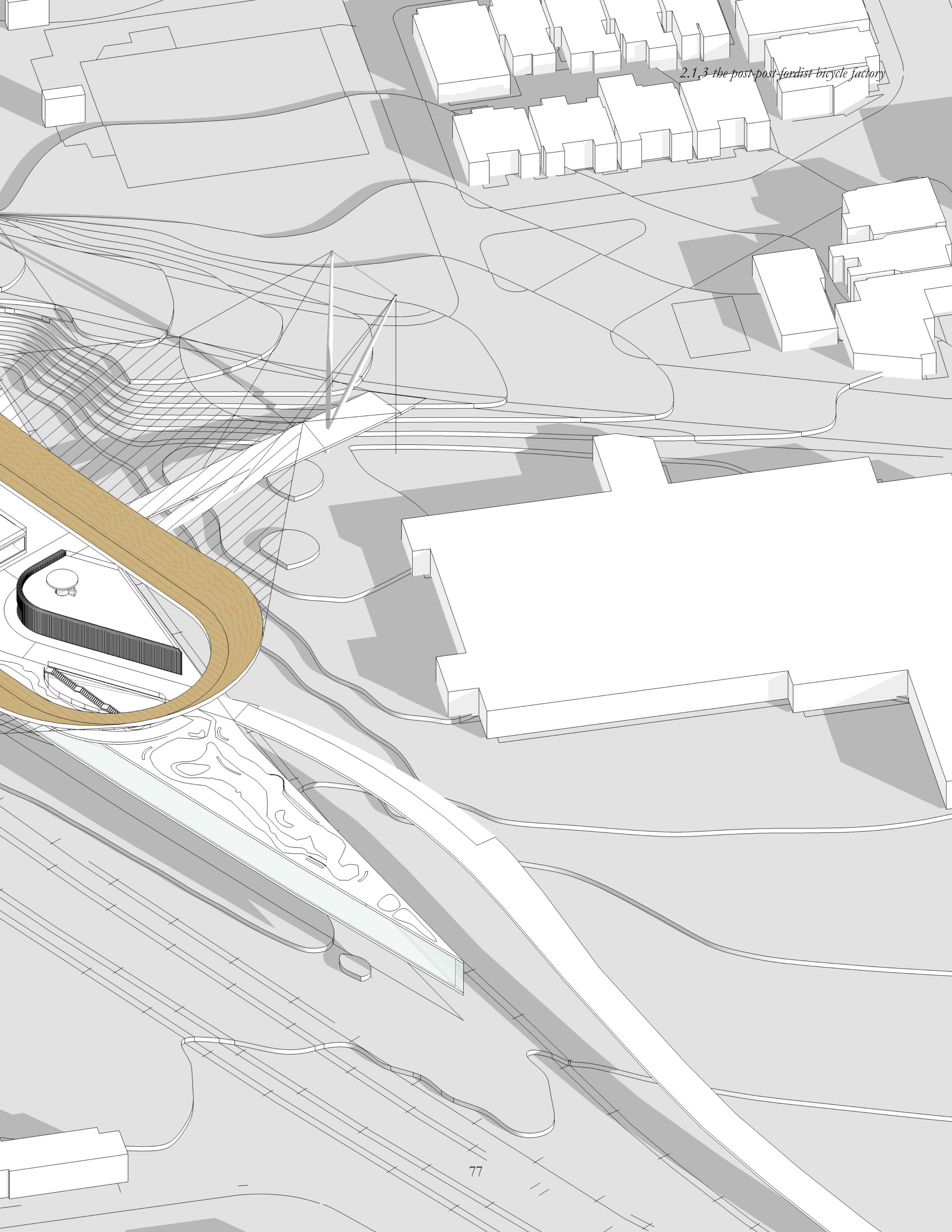


fig. 44 **post-post-Fordist bicycle factory/** *aerial*



2.2 economics

2.2.1 municipal public-private partnership

The post-post-Fordist bicycle factory is realized through a government collaboration due to the economic, transportation, and social benefits it would provide for the city of Toronto. Although public-private partnerships (P3's) for infrastructure projects typically place most or all of the initial risks and responsibility of construction and its associated costs on the private sector, the intervention's unique conflation of program justifiably calls for a shift in the balance of stakeholder roles. As a multifaceted factory which literally absorbs the city's transportation system into its design, as well as providing an urban park and recreational facilities, the intervention proposes an equal share of building expense between factory and municipality. Because of the direct, and rippling long-term benefits provided by each of its functional tiers for Canada's largest metropolitan city, the project thus would seek funding from all three levels of government.

After construction, maintenance of all public structures and amenities—bridges, urban park, velodrome, and bike park—would be shouldered by government entities, while the bicycle factory would be responsible for the upkeep of the industrial building. Authorities also expected to grant the fledging enterprise an incubation period to ensure its survival during the initial stages of operation, in the form of tax breaks, subsidies, and the like. This public-funded support would afford the company a chance to break into the market, while weathering the volatility of the economy. For the city, even if the bicycle factory were to no longer operate in the building in the future, the vast, highly-flexible space of its architecture would allow it to be easily occupied by another manufacturer, or converted into a variety of other uses.

The community initiative Friends of West Toronto Railpath would also be brought on as a non-stakeholder partner, but would be given the chance to provide input on the specifics of the design, particularly as it pertains to the West Toronto Railpath phase II bridge.

2.2.1.1 THE BICYCLE FACTORY'S P3 PARTNERS

proprietary business (private)
- » **BICYCLE FACTORY** —for profit
  - › **BIKE SHOP** —for profit
  - › **BICYCLE PRODUCTION GALLERY** —not for profit

leaseholder business (private)
- » **FRAME BUILDING WORKSHOP** —for profit
- » **FACTORY CAFE** —for profit
- » **MAKER SPACE** —non-profit
- » **COMMUNITY DIY WORKSHOP** —non-profit
  - › **COMMUNITY DIY WORKSHOP CAFE** (sublease) —for profit

government (public)

: FEDERAL
- » *Infrastructure Canada*

: PROVINCIAL
- » *Infrastructure Ontario*

: MUNICIPAL
- » *Toronto & East York Community Council*
- » *Planning and Growth Management Committee*
- » *Economic Development Committee*
- » *Public Works and Infrastructure Committee*
  - › **PEDESTRIAN & CYCLING BRIDGES**
- » Community Development and Recreation Committee
  - › **URBAN PARK**
  - › **VELODROME**
  - › **BIKE PARK**

member collectives (community)
- » *The Ontario Co-operative Association*
- » *Friends of West Toronto Railpath*
  - › **WEST TORONTO RAILPATH PHASE II BRIDGE**

2.2.2 FEDERAL FUNDING FOR INFRASTRUCTURE

"We will invest now in the projects our country needs and the people who can build them. Interest rates are at historic lows, our current infrastructure is aging rapidly, and our economy is stuck in neutral. Now is the time to invest."[1] reads the party platform of the newly-elected Liberal federal government of Canada.

> *And it's critical to Prime Minister Justin Trudeau's intention to transform Canada's economy into one built on sustainable development and less dependant on fossil fuels. […] And there are suggestions that Finance Minister Bill Morneau will add an extra incentive when he brings down his first budget on Tuesday by increasing the federal government's normal contribution of one-third of the total cost of these [infrastructure] kinds of projects to as much as half, a recognition that cities don't all have the money to start such work this fall. […] The long-term depends far more on building new rapid-transit systems and roads. And on investing in new technology and innovation, including projects that will help reduce greenhouse gas emissions. Those things will create jobs, too, just not as many and not as quickly. So the prime minister is trying to find that delicate political balance with his government's first budget. On one hand, acting now to create jobs, on the other signaling that the government is laying the groundwork for those long-term projects that won't be of obvious benefit to voters until well after the next election.*[2]

The key mandates of the 2016 Canadian federal budget—infrastructure, job creation, and environmentally-friendly initiatives—are precisely what the bicycle factory urban intervention delivers, making it a perfect candidate for government support.

2.2.3 NORTH AMERICAN MANUFACTURING & EMPLOYMENT

With Canada's recent downturn, and rising unemployment rates, political authorities are desperately trying to find ways to stimulate the country's economy. Nevertheless, while both the price of crude oil and the Canadian dollar reached 13-year lows at the beginning of 2016, the slide has given the manufacturing sector a boost, as cheaper energy and increased exports to the U.S. have strengthened sales. Mid-2015, Canadian Business reports:

> *Jamie Feehely, managing director of Canadian Structured Finance at credit rating agency DBRS, foresees the economy shifting away from oil and gas—which constituted a significant percentage of Canadian GDP in the last five years—and back to manufacturing. "With the oil and dollar decline, Canada may now be considered more competitive for manufacturers to build plants in the country."*[3]

Manufacturing is truly the engine of a nation's economic prosperity, providing 17% of global GDP. Siemens reports, that "1 US dollar in gross value-added in industry generates 1.4 US dollars in gross value-added in other branches of economy," and "each

1 "Investing Now," *Liberal Party of Canada*, accessed March 21, 2016, https://www.liberal.ca/realchange/investing-now/.

2 Chris Hall, "Trudeau tracker: Can budget 2016 deliver on Liberals' infrastructure promises?," *CBC News*, March 21, 2016, http://www.cbc.ca/news/politics/trudeau-tracker-infrastructure-chris-hall-1.3498839.

3 Sissi Wang, "The oil industry's loss is the manufacturing sector's gain," *Canadian Business*, July 7, 2015, http://www.cbc.ca/news/politics/trudeau-tracker-infrastructure-chris-hall-1.3498839.

job in manufacturing creates 2.2 jobs in other sectors." Moreover, "industry enables more well-paid employment than the service industry [and] each job in industry is typically linked with several jobs at suppliers and associated service providers."[4] The multiplication effect associated with industrial jobs and value-added of goods carries immense potential for jumpstarting the economy.

In fact, Canada and the United States are now experiencing a 'manufacturing renaissance,' after outsourcing their productive activities to Asia throughout the post-Fordist period. At the same time, while China is hailed as 'the world's factory,' particularly as a source of cheap commodities, the developing country's accelerating growth since the 1980's has slowed, as labour conditions improve and wages rise, and higher quality products are being created. Under this scenario, the cost of imported goods would face increasing competition against locally manufactured products. Thus, the uncertainty about the future availability of cheap labour and low-cost merchandise, could shift the balance toward the more lucrative alternative of domestic production.

2.2.4 GLOBAL BICYCLE MANUFACTURING

fig. 45 **bicycle factory in China/** *workers assemble children's bicycle wheels*

Bicycle manufacturing, like the rest of industry's migration across the Pacific Ocean, has been dominated by Asian producers since the onset of post-Fordism. Japan had the largest share of the market from the 1970's until the 1980's,[5] when it was overtaken by Taiwan. When China entered the game making low-end bikes in the 1990's, Taiwan redirected its energy toward mid and high-end models, and today, still holds significant market share in those arenas. Currently, China makes about 67% of the world's bikes, although most of them are of inferior quality that cost less than $100. But with the rise of the middle class in the world's most populous country demanding higher quality products, including bicycles,[6] China has recently started producing more expensive bikes.[7] American bicycle expert Sheldon Brown chronicled the phenomenon of the global bicycle manufacturing landscape on his website:

4 "The Future of Manufacturing," *Siemens*, accessed March 21, 2016, http://w3.siemens.com/topics/global/en/industry/future-of-manufacturing/Documents/feature-infografik/all/en/index.html#/introduction/15.
5 Sheldon Brown, "Shimano 3-speed Hubs," *sheldonbrown.com*, 2013, http://www.sheldonbrown.com/shimano333.html.
6 ironically, Chinese consumers seeking higher end bikes constitute a large portion of Taiwan's sales
7 Jens Gould, "Taiwan: The Bicycle Kingdom," *The Financialist*, August 21, 2014, https://www.thefinancialist.com/taiwan-the-bicycle-kingdom/.

Background: The International Bicycle Cycle

Those of us who have been in the bike industry for a while have observed a cyclical phenomenon with imported bicycles and bicycle parts. It was first noticeable in Japan in the years following WW2. Here's how it goes:

Stage 1: *Underdeveloped country of* [insert name here] *uses cheap labor to make cheap, low-end products. Reputation for making cheap, inferior copies.*

Stage 2: *Developing country of* [insert name here] *decides to move into higher-quality, higher-value production. Quality control and design improve, often benefiting from the advice of partners in more developed countries.*

Stage 3: [insert name here]*'s improved product quality is noticed, [insert name here]'s reputation rises.*

Stage 4: [insert name here]*'s high wages and shifting exchange rates begin to erode the competitive pricing advantage formerly enjoyed.*

Stage 5: *Increasing quality and pricing make* [insert name here]*'s products un-competitive with lower-wage developing* [Other Developing Country]*'s output. [Insert name here] establishes partnerships in* [Other Developing Country]*, builds factories, teaches them how to improve their quality.*

Stage 6: [Insert name here] *can no longer manufacture bicycle parts at a competitive price, more and more manufacturing for export is shifted to* [Other Developing Country]. *Some high-end production for the domestic market may continue.*

By this time, [Other Developing Country] *has hit stage 2 and will go through the same sequence over a period of years.*

Japan was the prototype for this sequence. Reached stage 2 in the late 1970s, stage 3 in the early 1980s, stage 4 in the mid 1980s, Stage 5 in the late 1980s and stage 6 by the early 1990s. Japanese bicycles have not been imported to the U.S. in significant number since then, though high-end, high-value Japanese-made parts are still somewhat available.

The next country in this sequence was Taiwan, which hit stage 3 in the mid-late 1990s and is currently in stage 5.

Following behind Taiwan is mainland China, currently (2006) in stage 3.

Singapore is also in the game, for parts but not for complete bikes. Singapore has no important independent bicycle parts manufacturers, but Japanese parent companies, especially Shimano, own extensive production facilities there.

Major bicycle producing countries still stuck in stage 1 include India and South Korea. Whenever India gets ready to move up, it is expected to be a very important player.

Major Western European countries hit stage 6 in the late '70s, just as Japan was moving into stage 3.[8]

8 Brown, "Shimano 3-speed Hubs."

In North America however, although many companies design and/or assemble imported parts (which are manufactured in Asia), the large-scale production of bicycle frames is virtually nonexistent. In Canada, Quebec-based Cycles Devinci, who specializes in aluminum frames, is the last mass bike manufacturer in the country.[9] Across the border, Detroit Bikes, founded only in 2011, takes pride in being one of the only mass-producers of bicycles in the United States. Presently, a staggering 99.5% of bicycles sold in the country originate from Asia.[10]

In short, these sets of economic conditions have already laid the groundwork for the proposed bicycle factory in Toronto. The thesis anticipates that bicycle frames (at least decent quality ones) would no longer be imported en mass to rival the cost of local manufacturing in the near future, thus justifying in-house frame-building. It therefore proposes, that the bicycle factory and infrastructure would be constructed and operational within the next 10 years, or by 2025.

9 Tom Babin, "How Devinci, the last Canadian bike manufacturer, is competing in a globalized world," *Calgary Herald*, September 16, 2014, http://calgaryherald.com/news/local-news/how-devinci-the-last-canadian-bike-manufacturer-is-thriving-in-a-globalized-world.

10 "FAQ," *Detroit Bikes*, accessed March 24, 2016, http://detroitbikes.com/faq/.

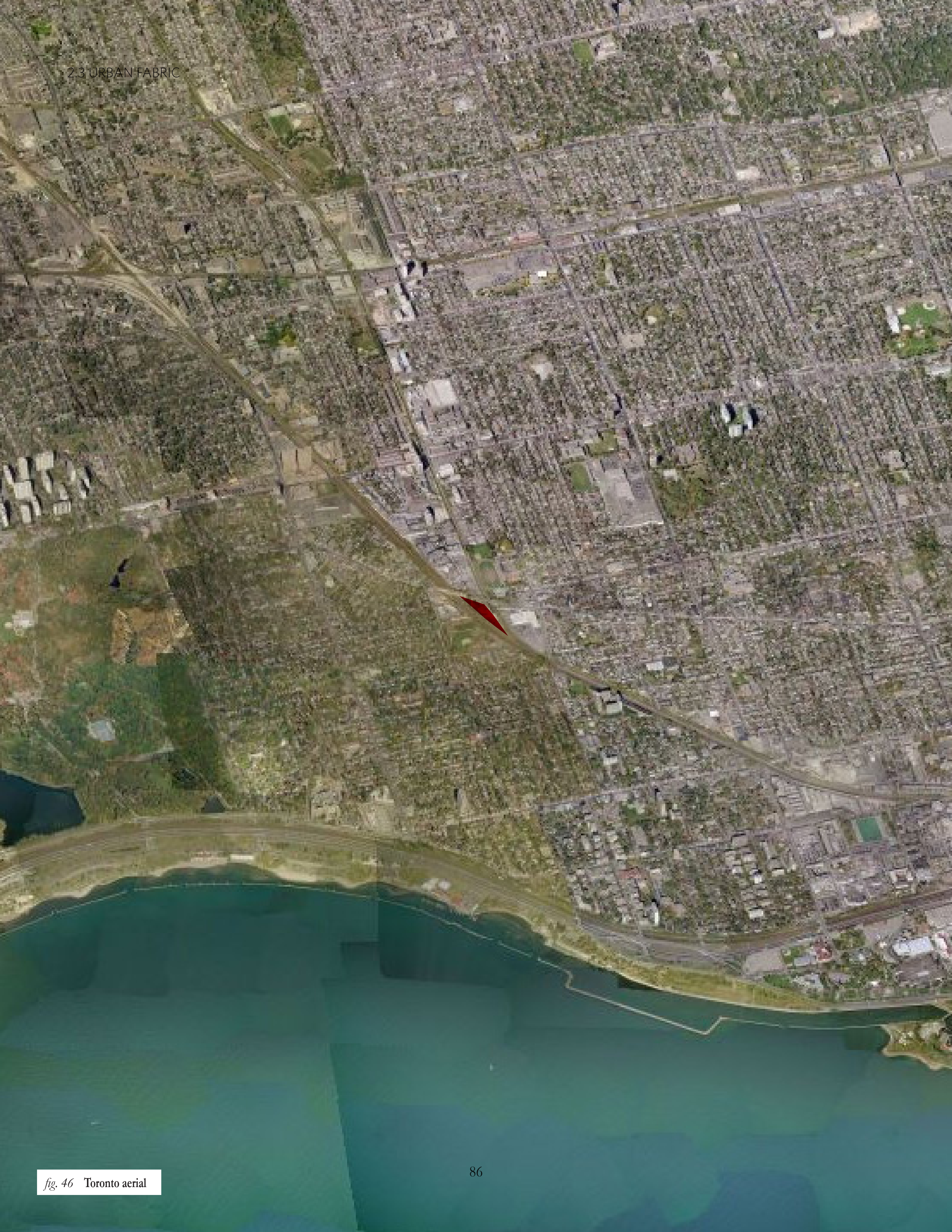


fig. 46 **Toronto aerial**

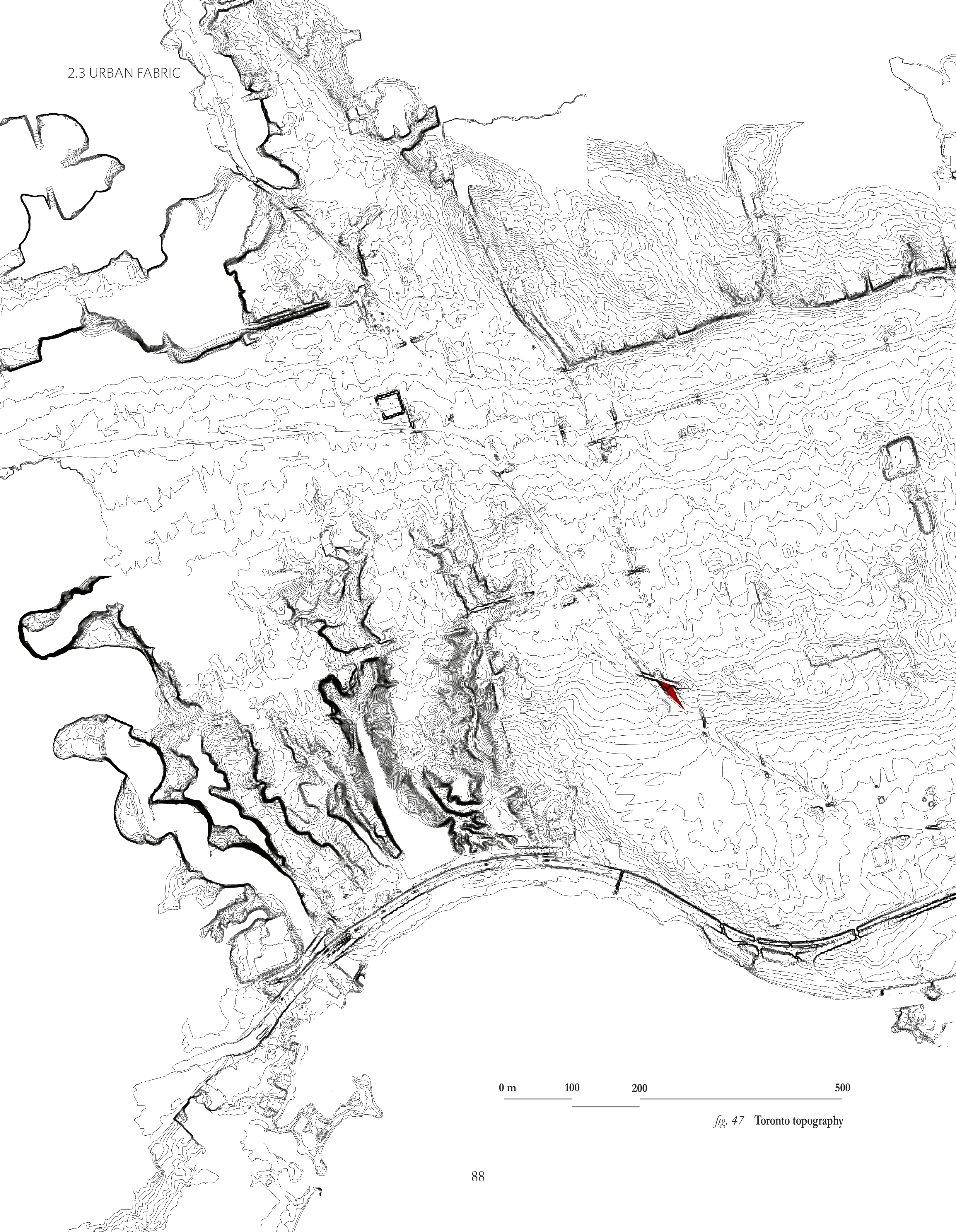
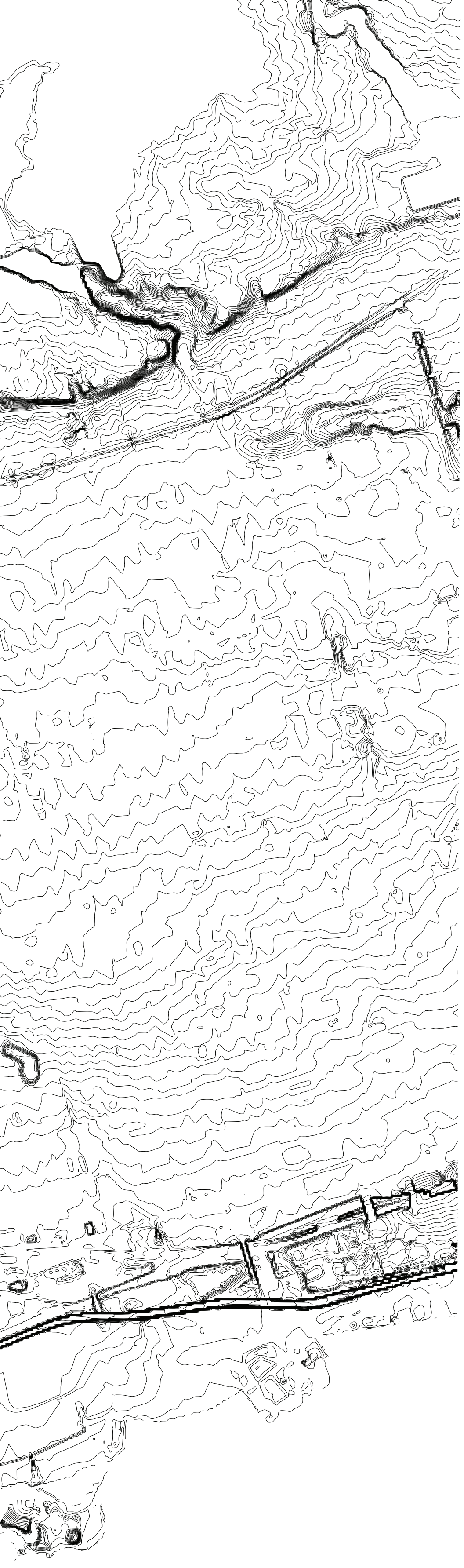


fig. 47 Toronto topography



2.3 urban fabric

2.3.1 SITE

2.3.1.1 HISTORICAL CONTEXT

The site chosen for the bicycle factory is a hallmark remnant of Toronto's Fordist industrial past. Typical of most major North American cities, manufacturing plants settled along the waterfront, or gravitated toward the outskirts of town. But as the city grew, these operations migrated along with the expanding perimeter, leaving behind growth rings of abandoned or repurposed factory buildings. Usually developed along major shipment routes such as railroads, these industrial regions and their supporting transport systems were eventually engulfed into the urban fabric. As railway lines were the dominant means for conveying goods between key metropolitan areas in North America for much of the 19th and 20th centuries, they cut through the landscape unyieldingly—much in the same way late and post-Fordist regional highways traverse national territories today. Their inter-regional scale, and precedence over the land in order to maximize time and distance efficiency, gave little consideration to future development. Consequently, they directly informed urban settlement patterns, such as the placement of factories along its length, as other functions of the city became secondary or tertiary to its path. Over the decades, as trucks, roads, and expressways replaced much of freight train traffic in land transportation, city planning developed more rationalized urban forms and systems around rail corridors. Hence today, these historic industrial monuments and their irregularly shaped sites—made more pronounced by the regularity of the surrounding street grid—stand as physical testimonies of amendments in city planning, economic policies, and social values.

This is the context from which the proposal site was borne—the result of interstitial space between branching railway corridors forming a narrow, triangular strip of property. Located at the southernmost tip of the Junction Triangle neighbourhood in Toronto's west end, it is flanked along its three edges by the fork of two GO Transit commuter rail lines and arterial road Dundas St W, which bridges over them. The north-west/south-east running mainline was laid down in 1873, and currently accommodates the GO Transit Milton and Kitchener lines, as well as the airport-bound Union Pearson Express (UP Express) line.[1] The north/south running rail line was constructed two decades earlier, in 1855, and services the GO Transit Barrie line. This segment of Dundas St W[2] which borders the northern edge of the site, was built during the War of 1812, with subsequent modifications for the overpass that came with the construction of the railways. It too, existed prior to the surrounding orthogonal streets, as it cuts through the urban fabric at disorderly diagonal angles on the west side of the city.

The historic roadway not only formed irregularly shaped parcels of land along its oblique path, but created another anomaly in the city, in which three arterial roads converge just east of the site—east-west College St; north-south Lansdowne Ave; and north-west/south-east Dundas St W. The last segment of College St angles southwestward to terminate at Dundas St W, before being impeded by the railway lines on the other side. The junction of these three major thoroughfares forms a large triangular island just east of the proposed site, around which traffic often flows in a haphazard, confusing, and dangerous manner.

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1 operates on a portion of the Kitchener route
2 from the Humber River to Ossington St

fig. 48 *(right)* GO Transit Barrie rail line flanking northeast edge of site/*view looking southeast from Dundas St W bridge/site visible on right side of photo*

fig. 49 *(far right)* GO Transit Milton and Kitchener and UP Express rail lines flanking southwest edge of site/*view looking southeast from Dundas St W bridge*

fig. 50 *(right)* factories along former freight rail lands/*view looking southeast from West Toronto Railpath*

fig. 51 *(far right)* abandoned or readapted factories along railway lines/*view looking southwest from West Toronto Railpath*

fig. 52 *(above)* **large triangular traffic island at intersection of College St, Lansdowne Ave, and Dundas St W**/*view looking east from Dundas St W*

fig. 53 *(right)* **Dundas St W bridge over GO Transit Barrie rail line**/*view looking northwest from No-Frills parking lot/ site visible on left side of photo*


express
DIESEL

fig. 54 site urban context


Lansdowne Ave
College St
West Toronto Railpath
Sterling Rd
Dundas St W
Sorauren Ave
SORAUREN
PARK

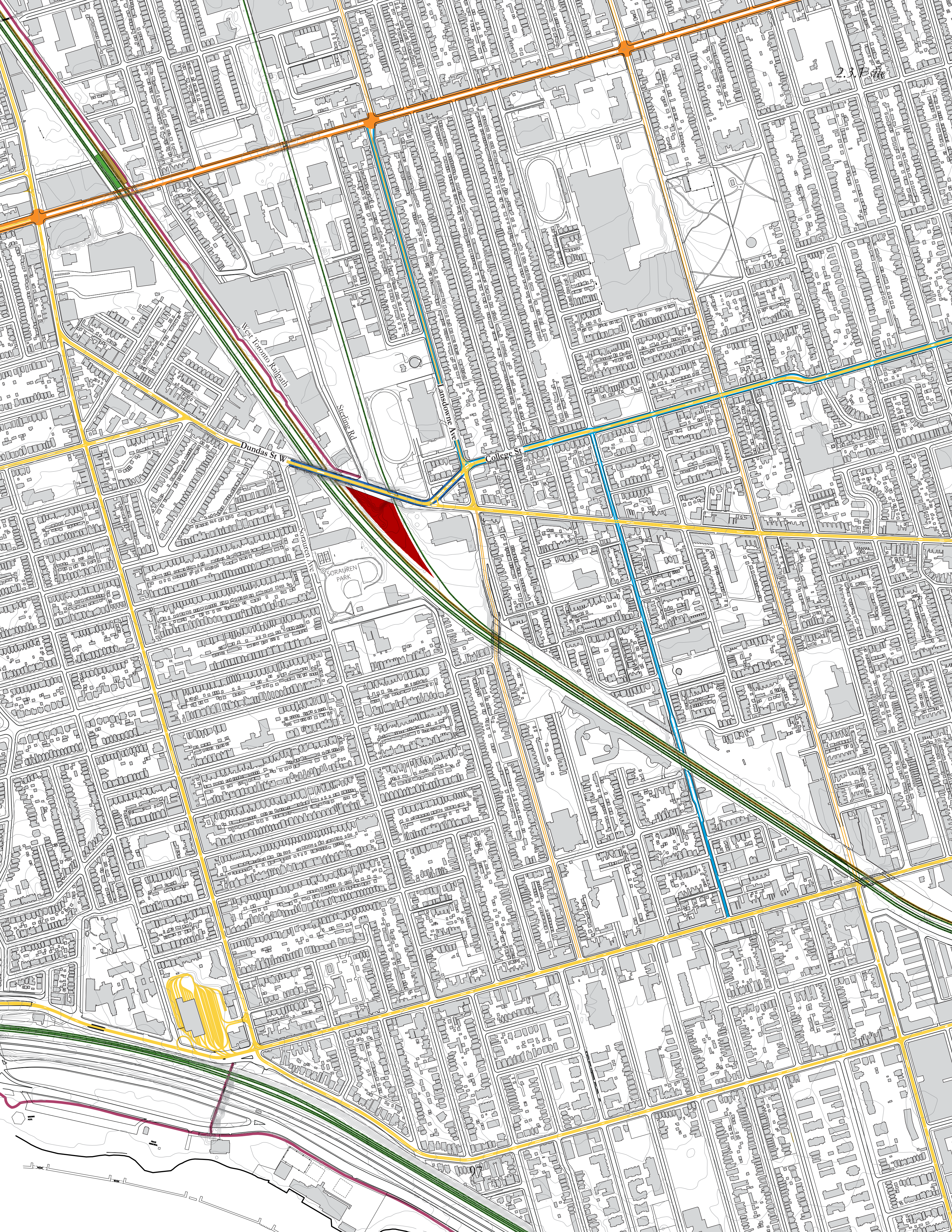
2.3.1.2 TRANSPORTATION NETWORKS

Sitting at the point where several Toronto neighbourhoods meet—Junction Triangle to the north, Parkdale to the south, Roncesvalles Village to the west, and Brockton Village to the east—the property is located within a confluence of transportation arteries. Walking, cycling,[3] TTC streetcar,[4] and TTC buses, are among the network of different modes of local travel. Additionally, the GO Transit & UP Express commuter rail lines run along the edges of the property, with its Bloor Station situated less than a kilometre north of the site. Here, the UP Express provides service to Toronto Pearson International Airport, as well as Union Station downtown, and is conveniently located adjacent to Dundas West Station of the TTC's east-west running Bloor subway line. Unfortunately, despite the availability of mass transit in the area, the rail corridors with their oblique vectors, large scales, and harsh conditions, essentially create a wall in the city, by failing to blend into the urban fabric. They cut through and bifurcate the entire west end of the city, effectively impeding passage on either side of their trajectories. They hamper access to and from central downtown Toronto, and its Roncesvalles Village and Parkdale residential neighbourhoods, High Park, and beyond.

fig. 55 *(left)* **Dundas St W bridge**/ *view looking west/ modes of transportation shown include railway, streetcar, car, bicycle*

fig. 56 *(right)* **site transportation networks**/ *i.e. GO Transit, UP Express, TTC streetcar, cycling routes*

3 West Toronto Railpath, Dundas St W, College St
4 Dundas St W, College St, Lansdowne Ave


West Toronto Railpath
Sterling Rd
Lansdowne Ave
Dundas St W
College St
Sorauren Ave
SORAUREN PARK

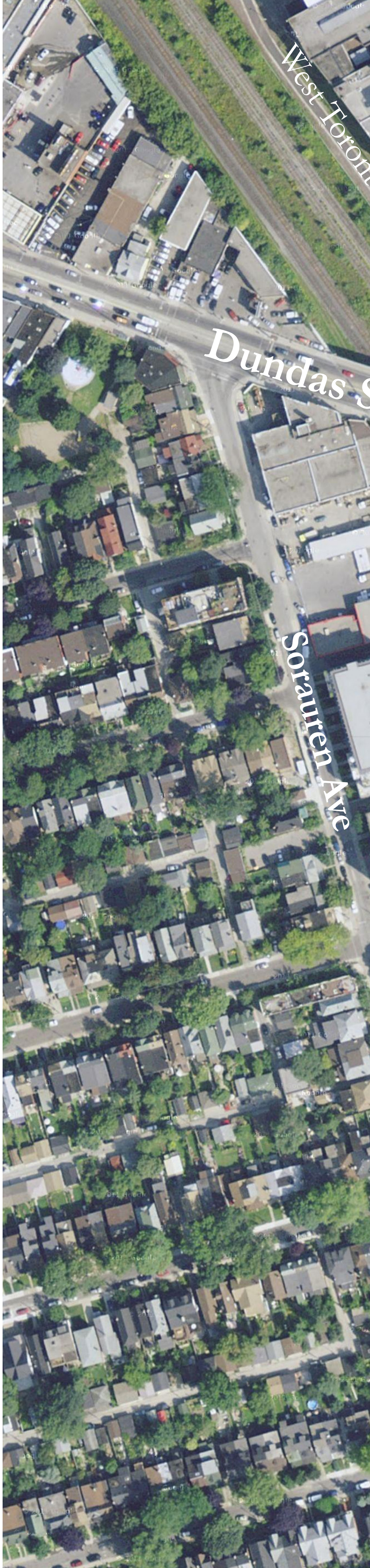


fig. 57 site context

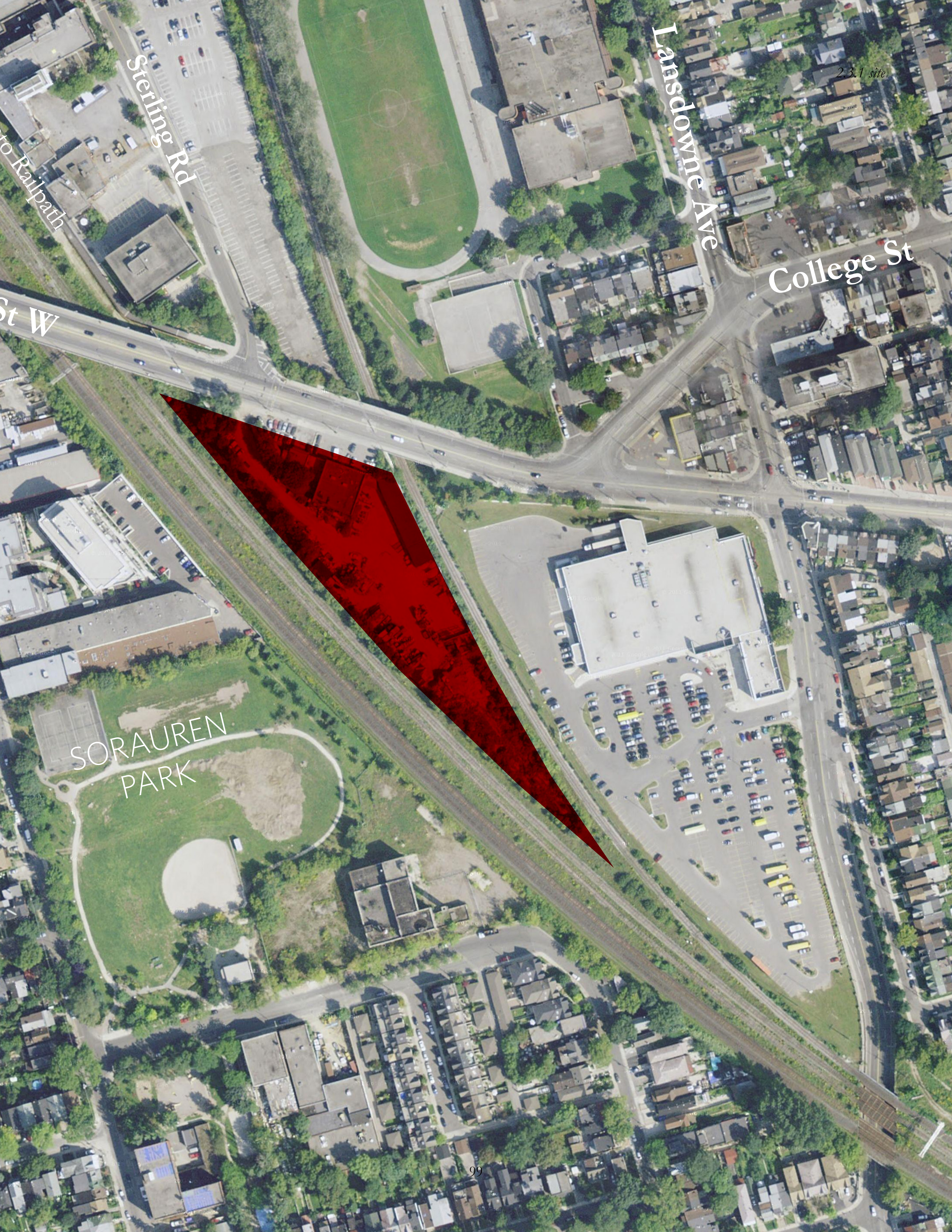

2.3.1 site
Sterling Rd
Lansdowne Ave
College St
to Railpath
St W
SORAUREN
PARK

fig. 58 **cyclists at Dundas St W and Lansdowne Ave intersection**/*view looking east from Dundas St W*

fig. 59 **GO Transit commuter train and West Toronto Railpath/**
view looking northwest from West Toronto Railpath

<u>*Cycling Infrastructure*</u>

West End Bikeways

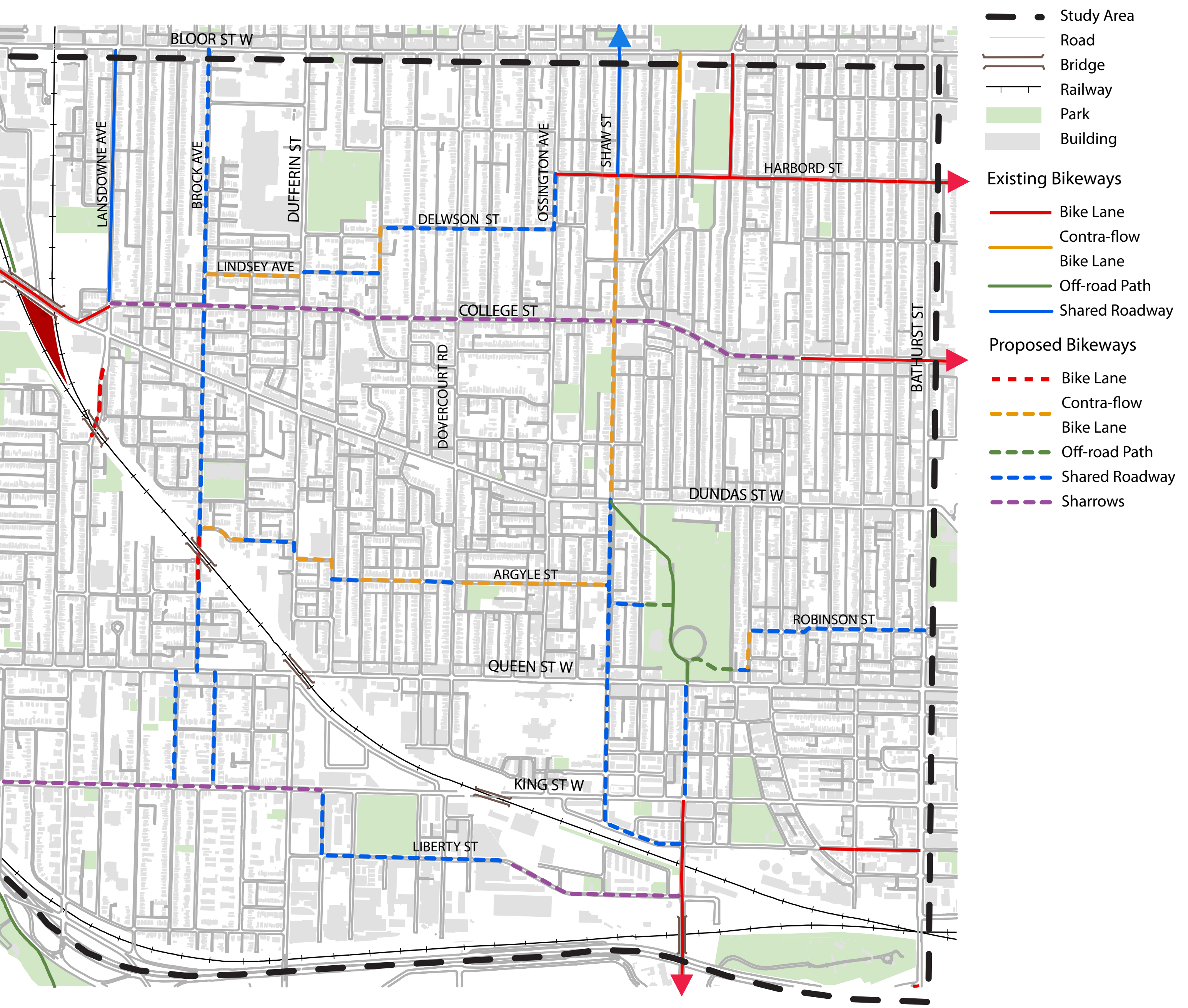
The cycling network is particularly compromised by this blockage in the urban fabric, with its low priority in the city's mobility hierarchy. Although municipal effort has been made in the past few years to increase the number of bike lanes, it is evident that the quantity and quality of existing cycling infrastructure in the vicinity of the site (and the city as a whole) is still lacking. This is in part, naturally, due to the difficulty of traversing the rail corridors. A joint initiative by the Toronto Transportation and the Toronto Cyclists Union in 2009, conducted a study "to address gaps in the Bikeway Network and improve cycling conditions in the area south of Bloor Street West to the Gardiner Expressway, and from Parkside Drive to Bathurst Street […] and the goal is to work with the public to identify cycling infrastructure projects in the study area that can be completed in 2009 and 2010."[5] The 'West End Bikeways' document identified the challenges of creating a 2-km grid of bike routes throughout the city[6] by:

i. discontinuous and disjointed streets
ii. the CN rail line
iii. street-car tracks on east-west arteries (i.e. College St and Dundas St W)

Before implementation of the project, less than a half-kilometre portion of Dundas St W just north of the site from Sorauren Ave to College St had bike lanes, and a short segment of Lansdowne Ave between College St and Bloor St W was designated as 'shared roadway.' For north-south connections, the proposal recommended a shared roadway on Sorauren Ave, bike lanes on a small section of Lansdowne Ave as it dips below the train tracks, and a shared roadway on Brock Ave. To date, the latter two have been implemented, with no apparent plans on the horizon for the former. A more vexing issue for the city however, is creating the east-west flow of bicycle traffic impeded by the railway infrastructure. The only quasi-solution put forth in the 'West End Bikeways' report was a strategy to link fragments of the existing cycling network for access to and from central Toronto to High Park, with multiple unfavourable jogs along its course. The scheme called for adding 'rush-hour sharrows' on College St, which would connect to the existing bike lanes on Dundas St W, before turning onto the proposed shared roadway on Sorauren Ave. It would subsequently turn again onto a new contra-flow bike lane on Fermanagh Ave for direct access to High Park via a proposed shared roadway on High Park Blvd. So far, actual progress appears even more patchwork than the plan, as only the rush-hour sharrows[7] along College St and contra-flow bike lane on Fermanagh Ave have been realized.

fig. 60 **proposed West End bikeways**

5 City of Toronto, Transportation Services, *West End Bikeways: Project Summary* (Toronto, 2009), https://www1.toronto.ca/city_of_toronto/transportation_services/cycling/files/pdf/west-end-bikeways-031009.pdf.
6 first recommended by the Toronto Bike Plan report in 2001
7 with arguable effectiveness


BLOOR ST W
LANSDOWNE AVE
BROCK AVE
DUFFERIN ST
OSSINGTON AVE
SHAW ST
HARBORD ST
DELWSON ST
LINDSEY AVE
COLLEGE ST
DOVERCOURT RD
BATHURST ST
DUNDAS ST W
ARGYLE ST
ROBINSON ST
QUEEN ST W
KING ST W
LIBERTY ST
Study Area
Road
Bridge
Railway
Park
Building
Existing Bikeways
Bike Lane
Contra-flow
Bike Lane
Off-road Path
Shared Roadway
Proposed Bikeways
Bike Lane
Contra-flow
Bike Lane
Off-road Path
Shared Roadway
Sharrows

West Toronto Railpath

On the other hand, the West Toronto Railpath, a collaborative project between the City of Toronto and community initiative Friends of the West Toronto Railpath, has been hailed as a highly successful urban intervention. Completed in 2009, phase I of the multi-modal pathway converted unused portions of the historic railway property into a paved trail for non-motorized transit. It starts at Cariboo Ave, just north of Dupont St, and follows the southeastward GO Transit Kitchener/Milton railway track for approximately 2 km. The railpath currently terminates on the north side of Dundas St W and Sterling Rd, just across the street from the site. Plans for phase II are underway, which would extend where phase I left off, running along the southwestern edge of the site, and continue as a pedestrian & cycling path along the corridor toward the centre of downtown Toronto.

fig. 61 *(far left)* West Toronto Railpath/*view looking southeast*

fig. 62 *(left)* West Toronto Railpath/*view looking southeast*

fig. 63 *(right)* entrance to termination of phase I of West Toronto Railpath at Dundas St W and Sterling Rd/*view looking northwest*

2.3.1.3 URBAN DEVELOPMENT

The distorted nature of the urban fabric in this part of Toronto is palpable when one travels along Dundas St W, as it effectively creates a blind spot in the city. The major thoroughfare is typically bustling with cafes, bars, restaurants, boutique shops, or residences—until one reaches the Dundas St W overpass environs. Not only do the tangle of streets and railways place the flow of traffic in hazardous disarray,[8] the 10-metre-high berm of the bridge infrastructure creates a visual disconnect, both of which fail to foster favourable conditions for vibrant city life. Indeed, the street frontage conveys the sense of being stuck in an automobile-centric, industrial past—with its lumber yards, car dealerships, gas/car wash station, parking lots, and the like—all in all creating an urban environment unsuitable for human-scale occupation.

fig. 64 **northwest foot of Dundas St W bridge**/*view looking northeast*

fig. 65 **berming up toward southeast foot of Dundas St W bridge**/*view looking northwest from Dundas St W*

fig. 66 **Dundas St W bridge**/*view looking northwest from Dundas St W*

fig. 67 **'edge of the world' intersection at Dundas St W and College St**/*view looking southwest from College St*

8 as around the Dundas-College-Lansdowne triangle

Sterling Rd

Most of the manufacturing buildings once optimally sited along the freight train corridors have gone out of commission, and now either sit empty, or have been readapted for other uses. Like the rest of the world's economic powers in the 1980's, this mass exodus of domestic operations in Canada was largely trigged by the the 1960's recession, 1973 oil crisis, and subsequent offshoring of factories to developing nations for cheaper land and labour. But some industrial activity does remain in the area, such as Nestlé Canada's chocolate factory just northwest of the site, with access off of Sterling Rd. It was established over a century ago in a region once teeming with factories, although is now an anomaly. Once a little-known industrial urban pocket in the city not long ago, the Sterling Rd group of properties has rapidly been developing into one of Toronto's most popular artist live-work neighbourhoods, complete with circus school, axe-throwing club, paintball venue, artist studios, galleries, and a plethora of other creative businesses.

> *[Philip] Beesley, an architect and professor at the University of Waterloo [...] moved his studio here about a year and a half ago, to an abandoned transformer factory that had been freshly repurposed for just his kind of work. [...] "It's on jet fuel right now," says Beesley. "And it's going to change. It's in an intermediate state right now and that's got its own fragility. At a minimum, we can see just the same pattern of gentrification. Toronto's a laboratory for that." Beesley, however, sees other forces at play on Sterling Rd. Between two railway lines, Sterling is an island of otherness that's left it impervious to the gentrifying forces flowing around and past it in recent years. "Maybe the disorientation of the city grid is helpful here, maybe it's something else. But it seems like there's some pushback—things that have their own place in the culture, that can't just be rolled over."*[9]

fig. 68 **Sterling Rd with mostly vacant or repurposed former factory buildings**/*view looking northwest*

9 Murray Whyte, "Sterling Rd: Artistic hotbed, but with development plans looming, for how long?," *Toronto Star*, August 12, 2012, http://www.thestar.com/entertainment/visualarts/2012/08/12/sterling_rd_artistic_hotbed_but_with_development_plans_looming_for_how_long.html.

fig. 69 one of many artist live-work arrangements in the Sterling Rd neighbourhood

Employment Lands

A large portion of the former factory sites along the railway tracks in the Junction Triangle neighbourhood, including the swath of area around Sterling Rd, and the proposed site, are designated Employment Lands in the zoning bylaws of Toronto's Official Plan. The Provincial Policy Statement, the Ontario government's document for land use planning policies, also has strict measures to preserve Employment Lands, for the obvious reason that they provide space for jobs the city. Consequently, these zones are highly resistant to any type of non-industrial development, being protected by multiple tiers of government, even as rezoning requests are continually being made and largely rejected. In spite of this, developmental pressures in the past two decades have already triggered the conversion of several former factory buildings just west of the site, into loft apartments, with more in the works, as well as the construction of new condominiums. Indeed, consistent with Toronto's current property development climate, "the odd lots, factories and manufacturing buildings have begun to succumb to the pressures of a city that is continually under pressure to absorb more people."[10]

Opposition to the rezoning of the Employment Lands, is well summarized by Councillor Paula Fletcher: "There's nothing wrong with condos [...] but not in this location [...] It's set aside for stable employment."[11] The Nestlé Canada factory also lobbied heavily against proposed Sterling Rd mixed-use developments[12] out of fear pressure from increasing residential growth would force its operations out of the area.

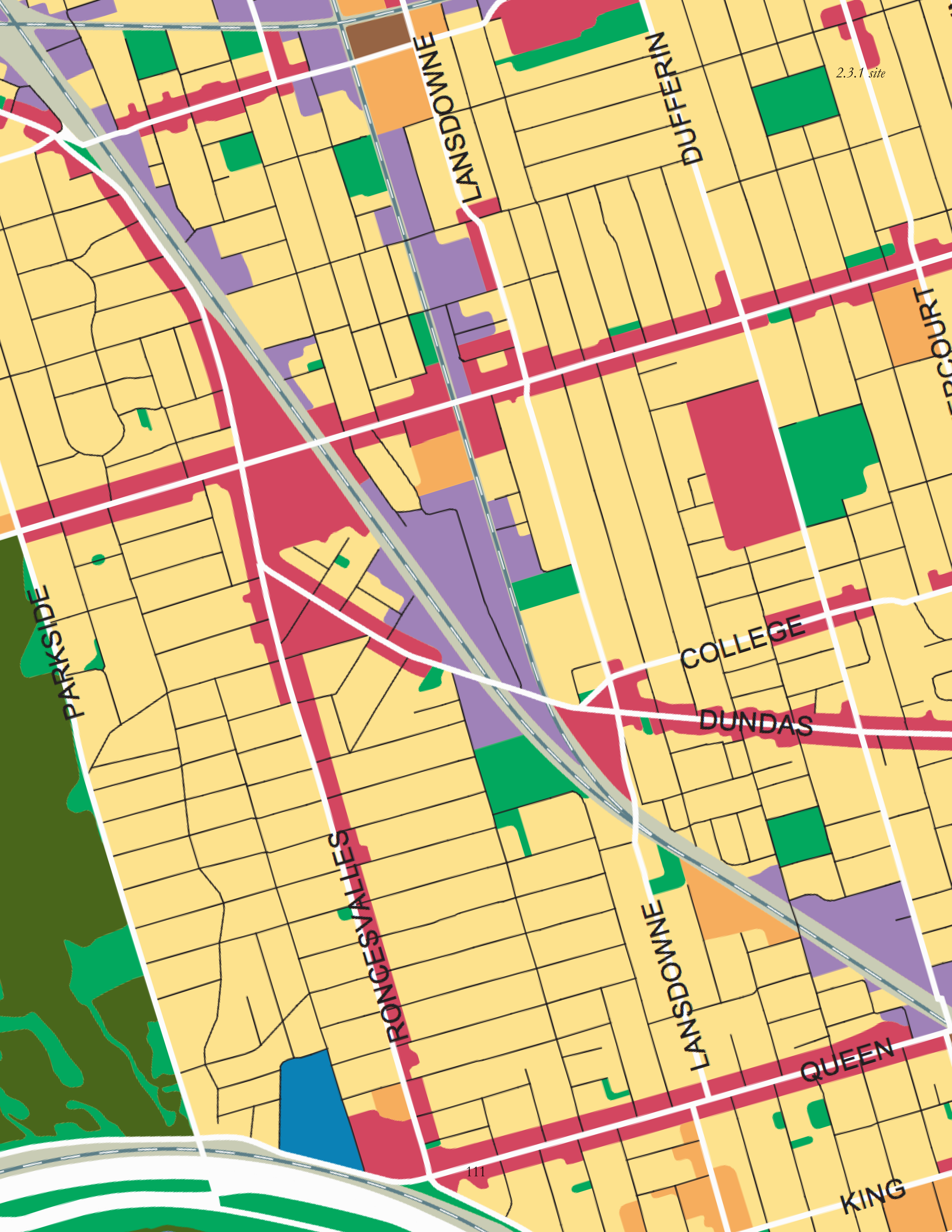
fig. 70 *(left)* new residential development on Employment Lands just east of the site/*view looking southwest from Dundas St W bridge*

fig. 71 *(right)* partial Land Use Plan from Toronto's Official Plan

10 Drew Sinclair and Annabel Vaughn, "FACTORYtown" (Third Year Option Studio, University of Waterloo, 2014).

11 Tim Alamenciak, "Toronto planning committee rejects proposed Sterling Rd. condo project opposed by Nestlé," *Toronto Star*, November 8, 2012, http://www.thestar.com/news/gta/2012/11/08/toronto_planning_committee_rejects_proposed_sterling_rd_condo_project_opposed_by_nestl.html.

12 a battle it eventually lost in 2014



2.3.1 site
LANSDOWNE
DUFFERIN
STERCOURT
PARKSIDE
COLLEGE
DUNDAS
RONCESVALLES
LANSDOWNE
QUEEN
KING

fig. 72 **site topography**

2.3.1.4 URBAN MORPHOLOGY & PROGRAM

Residential high-rises would most certainly dominate the skyline in an area where the tallest building in the neighbourhood is the 10-storey heritage Tower Automotive building on Sterling Rd. Sitting within an enclave surrounded predominantly by residential fabric, the built morphology of the site's surrounding context is primarily composed of two-to-three-storey homes on quiet tree-lined streets, or neighbourhood shops along arterial roads, with public amenities, such as schools, churches, and parks, sprinkled throughout. In the site's immediate context along Dundas St W to the north, is public French-language high school École Secondaire Toronto Ouest, as well as the Nestlé Canada factory and Sterling Rd neighbourhood. South of Dundas St W, big-box grocery chain No-Frills and its expansive parking lot occupies the property just east of the site and GO Transit Barrie railway tracks. Sorauren Park,[13] residential neighbourhood Roncesvalles Village's public green space on the west side of the site and tracks. Several factory-converted loft apartments, and residential buildings under construction are situated just north of the park.

Site Morphology & Program

The geometry of the site itself is irregular in both plan and section. Its 8,700 m^2 (93,646 ft^2) area also boasts a 10-m change in topography due to its unique situation, with the northern end sitting on the flank of the elevated railway overpass, and its southern tip sloping steeply down to the railway beds. It currently houses a number of low-rise car dealership buildings with parking lots facing the sidewalk. The extensive 'backyard' appears to be an industrial yard, with truck and vehicle access provided just off of Dundas St W across from Sterling Rd.

2.3.1.5 SITE POTENTIAL

The site was chosen for its irregular shape and dramatic topography, the layering of continuous semi-private corridors with road networks, and its situation in a rich and complex urban context. It possesses the potential to generate design parameters and constraints that provide fertile fodder for the production of compelling architecture, urban infrastructure, and public space.

13 It is important to note, that because of its position relative to the railway tracks, Sorauren Park lies in a particularly difficult location to access from the east, without taking necessarily roundabout routes via Sorauren Ave, or Lansdowne Ave

fig. 73 **typical residential fabric of site context**/*predominantly two-to-three-storey homes on quiet tree-lined streets/view looking west from Sorauren Ave*

fig. 74 **typical residential fabric of site context**/*increasing numbers of former factory buildings are being converted into loft apartments/view looking northwest from Sorauren Ave*

fig. 75 **Sorauren Park**/*view looking southeast*

fig. 76 *(top right)* **Nestlé chocolate factory**/ *view looking north from Sterling Rd*

fig. 77 *(right)* **No-Frills grocery store**/*view looking north*

fig. 78 **industrial yard of existing site**/*view looking south from Dundas St W*

fig. 79 **industrial yard of existing site**/*view looking southwest from Dundas St W*

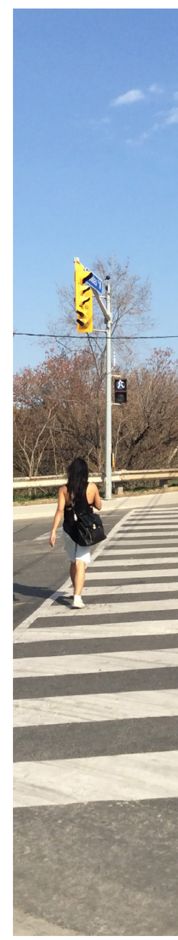


fig. 80 *(far left)* **street frontage of existing site**/*view looking southeast from Dundas St W*

fig. 81 *(far left)* **street frontage of existing site**/*view looking west from Dundas St W*

fig. 82 *(left)* **intersection of Dundas St W and Sterling Rd**/*view looking southeast*

2.3 URBAN FABRIC

fig. 83 **existing site context/** *1:2500*


2.3.1 site
LANSDOWNE AVE
COLLEGE ST

fig. 84 **masterplan**/*post-post-Fordist city & urban intervention/ 1:2500*

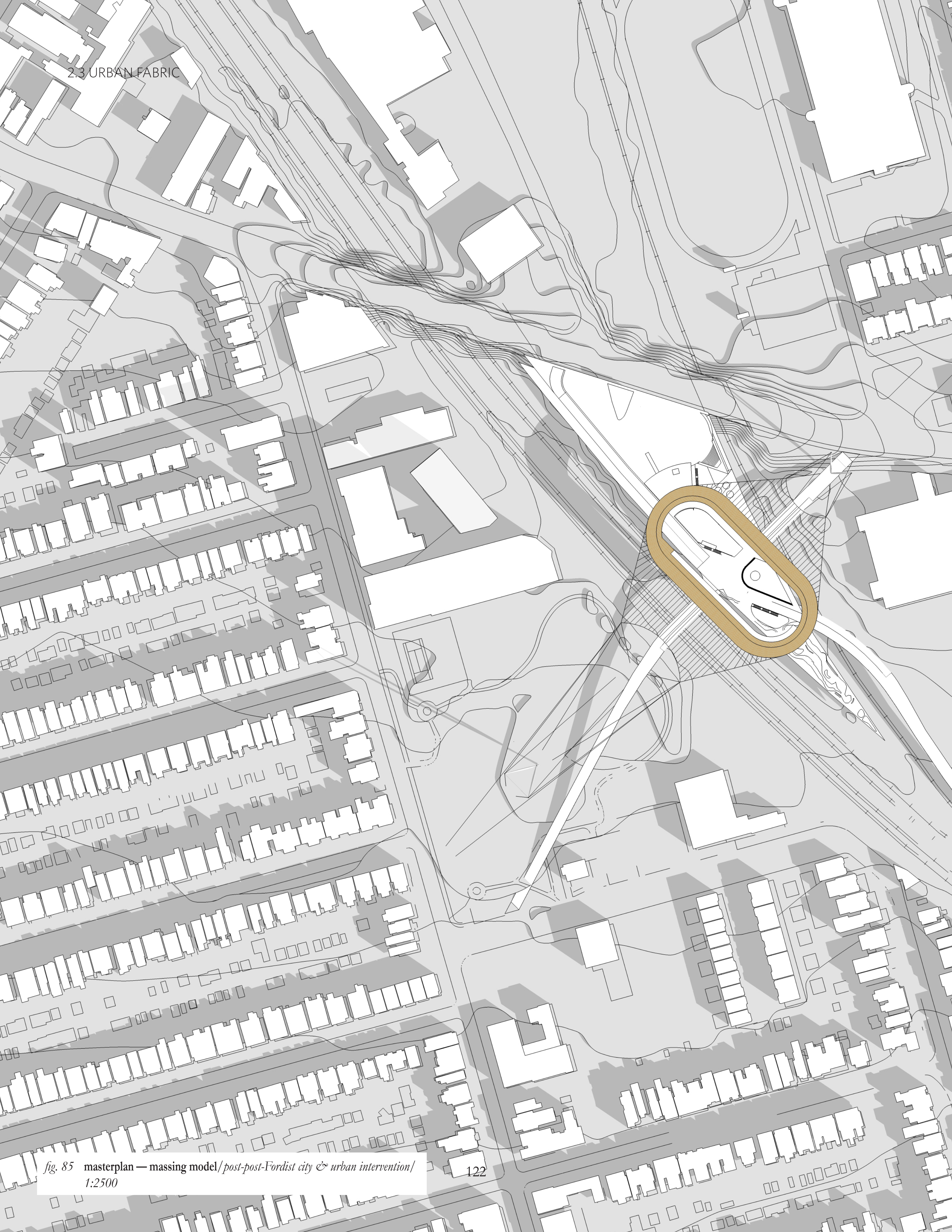


fig. 85 **masterplan — massing model**/*post-post-Fordist city & urban intervention*/ *1:2500*

2.3.2 MASTERPLAN

2.3.2.1 SITE + FACTORY + BICYCLE

So why site + factory + bicycle? Why is this a potent mix? The common thread is that they are all seemingly anachronistic elements—but together, hold the potential to unlock the city in a powerful way. It re-inaugurates anachronistic typologies and technologies to reinvigorate an anachronistic remnant of the urban fabric. The intervention presents an opportunity to return to first principles by bringing together established, historical artifacts, and alchemizing them into a powerful agent in the city. It knits together three pillars of the contemporary metropolis: land (site), transportation (bicycle), and economy (factory), and reinterprets them for the current and future eras. The post-post-Fordist bicycle factory in the city catalyses reindustrialization, by mobilizing mobility.

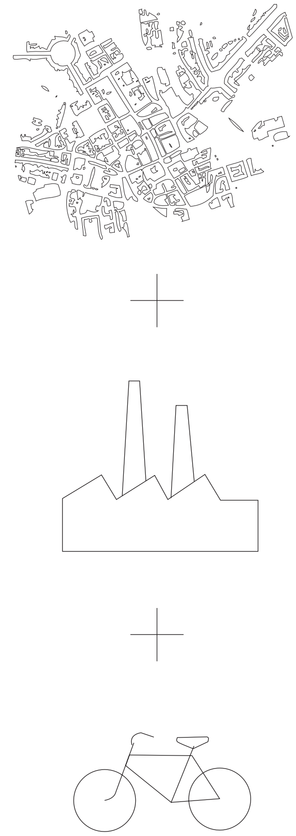


fig. 86 **conceptual diagram**/*city + factory + bicycle*

2.3.2.2 SITE SELECTION

Through its choice of site, the intervention advocates for the use of less rectilinear, and more irregularly-shaped residual plots of land in the city. This is in direct contrast to the urban sprawl effects of greenfield development, characteristic of late Fordism. It also adheres to current North American efforts toward metropolitan densification, as opposed to peripheral expansion. Within urban territory, certain properties are more resistant to regeneration, as they often require some 'design acrobatics.' For instance, the requirement for a 30-m setback from railway infrastructure for residential buildings, coupled with constrained lot boundaries and topographical challenges, create unfavourable conditions for developers to erect condominiums on the chosen site. However, with Toronto land values skyrocketing and developmental pressures mounting, previously dismissed sites are in fact starting to become more lucrative. From an environmental standpoint, concentration in the city is key to minimizing our energy footprint and land consumption. In this way, it also charges architects to partake in issues of urban sustainability by utilizing inefficiently occupied real estate to densify the built environment.

2.3.2.3 SITE INTERVENTION

[Anti-Industrial-Revolution, Anti-Fordist, Anti-Post-Fordist] Post-Post-Fordist Urban Planning

The project doesn't create density in the traditional sense of the concept by maximizing building storeys and floor area. Instead, it efficiently stacks layers of program on the site—industry/employment, public space/recreation, infrastructure/transportation—while maintaining congruity with the area's built height. This programmatic and formal strategy directly challenges patterns of urban development throughout the Industrial Revolution, Fordist, and post-Fordist eras.

The site intervention in fact reconnects portions of the city indiscriminately torn apart by the large-scale rail infrastructures built to service 19th-century factories, which at the time were growing in both number and size. It is effectively a contemporary factory that heals a wound in the urban fabric inflicted by its historical predecessors. During the late 19th and early 20th centuries, a number of proposals for better allocation of living and working spaces were presented to solve this very predicament caused by the immense size of plants and their transport systems, which fragmented, congested, and polluted the city. These ideas, such as Howard's 'Garden City' (1898), and other modernist town planning strategies, like zoning policies that pushed factories away from city centres, were heavily based upon Fordist philosophy. They not only failed to resolve the urban organization crisis, but the rationalization, functional separation, and total homogenization of city and society, actually resulted in sprawling, sterile, and inhumane spaces to live.

Post-Fordist Just-in-Time (JIT) producers also lobbied for zoning policies specifically to form large enclaves of industrial activity that cloistered them away from the city and its inhabitants. Eventually, globalization lured factories out of prosperous nations, to the more lucrative territories of cheap land and cheap labour. This created a huge vacuum in late-20th-century cities, leaving them with the immaterial labour of service and logistics, which created a glossy, streamlined, automobile-centric landscape lacking any consideration for the pedestrian-scaled public domain.

In reaction to these preceding eras, a post-post-Fordist society advocates for the harmonious collision of all aspects of urban life. The avant-garde bicycle factory is deeply embedded in Toronto's urban fabric. It preserves the site's Employment Lands designation to sustain and generate jobs in proximity to its workforce in the city, and integrates the public realm in innovative ways. While the belts of Employment Lands in the city may have at one point been at the edge of town, over time they have been incorporated into the urban fabric, and should thus be embraced.

Our cities are smarter now—we no longer heedlessly erect pollution-emitting heavy industries in the middle of city centres or residential areas. Technological innovations, and an awareness for conservation of the planet, have also contributed to less toxic or wasteful production processes, and will continue to be even smaller, cleaner and 'greener'. Moreover, city planning policy today is more tactful in the way zoning designates adjacency or separation of program, avoiding the rookie mistakes of the Industrial Revolution, or the wrongheaded approach of Fordism-influenced modernist urban planning. But the stigma of factories still exists from over a century ago, and it is time we set aside the post-Fordist tendencies of shunning these building blocks of the economy to extra-urban territories, or foreign soils. The mandate of the post-post-Fordist city is clear: sustainability, intensification, heterogeneity, strategic layering of program—and inserting light manufacturing activity back into the city as a proud, and visible part of the urban landscape.

Bottom-Up Strategies

In contrast to Fordism's totalizing, top-down control over society, the site intervention employs *distribution* and *proliferation* as a bottom-up approach to urban transformation, by:

i. a using the **multiplication effect of manufacturing** to strengthen the local and domestic economy
ii. using a key transportation intersection to **propagate cycling infrastructure** across the built environment
iii. using the design of the commuter bicycle to entice people to use cycling as a form of transportation in the city, while **empowering and mobilizing the masses**, regardless of social status

2.3.2.4 LOCAL MANUFACTURING FOR THE LOCAL ECONOMY

*i. a using the **multiplication effect of manufacturing** to strengthen the local and domestic economy*

As detailed in a previous section, the advantages of manufacturing for social prosperity are manifold. It creates a trickle-down effect, triggering a myriad of jobs in other sectors, as well as contributing to a more balanced economy. During the Industrial Revolution, manufacturing operations were located in urban centres for proximity to labour markets, consumer markets, transportation, energy, and resources. But as Ford deployed his production methodologies from the scale of the factory (Highland Park), to the scale of the city block (River Rouge), and subsequently to the regional and national scales, extensive highway systems, power grids, and communication infrastructure had to be constructed to connect the dispersed processes. As a result, industry was decentralized, producers were further away from their labour pool and customer base, and both workers and consumers became increasingly alienated from the act of manufacturing. Post-Fordist off-shoring practices further dissociated people from the origins of purchased goods, and factory workers from the fate of the fruits of their labour. Karl Marx identified this very issue of commodity fetishism and worker alienation as early as the mid-19th century, when the craftsman was detached from his craft, and social human relationships in manufacturing were obscured. Factories have now long been removed from the local setting of their markets and resources, creating a fundamental spatial disconnect between its actants. But just as they were once situated in the city for practical reasons, we can still harness those same potentials today. The post-post-Fordist movement calls for a spatial reconnection, via re-centralization and re-localization, to bring light manufacturing back into its rightful place in the city.

The advantages of fostering local economies in which local manufacturing primarily supplies local demand, can be identified on many levels. First, it reconnects producers, consumers, and commodities in a cyclical, intelligible, and meaningful way, restoring direct maker to end-user relationships in an act of 'de-alienation.' It also puts less emphasis on sprawling infrastructural systems and significantly reduces transportation time and distances. Moreover, factories insert diversity and tangible friction into the smooth, service-oriented post-Fordist urban landscape. They bring with them blue-collar employment, which acts to de-gentrify areas by encouraging mixed-income neighbourhoods in the city. Lastly, local manufacturing helps to create more self-sufficient and sustainable cities that are less prone to the volatilities of the global market.

2.3.2.5 CYCLING INFRASTRUCTURE

ii. using a key transportation intersection to ***propagate cycling infrastructure*** *across the built environment*

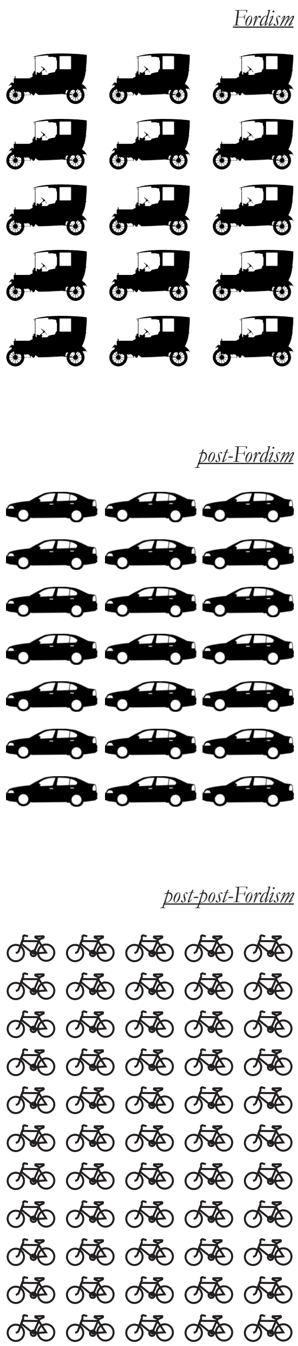


fig. 87 **conceptual diagram**/*Fordist, post-Fordist, and post-post-Fordist proliferation of modes of transportation across the city*

The vast majority of inhabited North American territory (and many other countries around the world) has been defined by the singular legacy of Henry Ford's strategy for mass producing the automobile, which infiltrated into society to shape entire urban landscapes. In the post-Fordist era, JIT factories unofficially dictate the design and construction of transportation infrastructure to lubricate the flow of production, as they extend their sphere of operation outside facility walls for maximum control. The post-post-Fordist bicycle factory parallels the Fordist approach of taking a single vehicle, multiplying it, distributing it around the city, and watching it grow. It also puts a spin on the post-Fordist notion of infrastructural intervention. While the building does instigate and integrate the city's mobility network into its structure, it is not a part of its shipping route, and therefore does not directly provide value to its operation. It does however, indirectly benefit the business by increasing cycling facilities, and thereby encouraging bike sales.

As a mobility node, the intervention operates as a catalyst from which cycling infrastructure would branch out and propagate through the urban fabric. Once implemented, it could conceivably become one of the most significant bicycle route intersections in Toronto.[14] One can imagine a scenario in the the near future where the bicycle nucleus, currently 'off-grid', becomes a significant part of the main network of streets as the bicycle gains more precedence in local transport. At minimum, the current design has the capability to immediately impact pedestrian & cycling networks, by providing passage and opening up a blockage in the city. Surrounded by an array of transportation options, the locale also offers the potential for bicycles to interface with the train, subway, streetcar, and bus. It would thereby equip commuters with the power and convenience of combining different modes of mobility to best suit their needs.

With a sizeable portion of the population living in the High Park neighbourhood west of the tracks, and many more moving just north of Bloor St W on Toronto's west end, providing direct, convenient access into the core is crucial. Studies show that the modal share for bicycles in Toronto is increasing, as densification makes a downtown already plagued with car traffic even more congested. While the city has been considering cycling in its urban design and planning frameworks, improvements are still falling short of immediate, impactful change as compared to other North American cities like New York, San Francisco, Montreal, and Vancouver. Proposed for the near future, i.e. 2025, and riding on the coattails of the global bicycling renaissance, the thesis anticipates that the modal share in the central core will have increased to about 10%, from the current 3.1% average, which will continue to encourage the construction of more bicycle-related infrastructure. The cycling mode share of the proposal site's surrounding neighbourhoods is presently already higher than the rest of the core (5.0%), and significantly higher than

14 grounds to situate a variety of public amenities at the hub

the rest of the city (1.3%).[15]

With new residential developments on the horizon for the Junction Triangle environs, the bicycle factory & hub would provide service to a growing neighbourhood population. New projects include a 10-storey condominium at Sorauren Ave and Dundas St W, just west of the site, slated to complete construction by the summer of 2016; and the Perth Sterling Revitalization is a recently Ontario-Municipal-Board-approved Sterling Rd mixed-use residential, office, and artist live-work loft regeneration scheme. Amidst the wave of new building projects, speculations can be made that other 'soft sites'—developments having "potential intensification opportunities"[16]—such as the low-density No-Frills property with its expansive car parking lot, will be converted into large residential and multi-use complexes. In these settings, the bicycle factory's cycling infrastructure and public urban park amenities would provide service to an increasing number of community urban dwellers.

Pedestrian & Cycling Bridges

The two main spines of the pedestrian & cycling infrastructures are:

i. the **College-Sorauren bridge**, which completes the east-west connection across the railway tracks
ii. the modified **extension of phase II of the West Toronto Railpath**, which bridges over the rail lines toward city centre

The two paths converge at an intersection in the middle of the urban park, but also branch off to provide more direct express lanes through the factory building. This configuration essentially creates a rotated off-grid intersection, in which the southwest trajectory of the College-Sorauren bridge works well to compensate for the northwest trajectory of Dundas St W on the west end. This creates better access to and from a part of the city with no east-west arterial road, thereby providing a less circuitous route between the High Park area and downtown Toronto.

The generous 6-m widths of the bridges provide enough space for two cycling lanes and a pedestrian walkway, as well as a row of trees in between. A critical design constraint of the site is the minimum 9 m clearance requirement over the railways in order to allow room for the proposed electrification of the GO Transit rail system. This means that the points at which the structures traverse the railway corridors, must be at least 9 m above the surface of the track. By having multiple areas of interface with both the architecture and urban fabric, these bridges not only connect moments of fragmentation in the street matrix, they also negotiate the various scales of building and city, which serves to stitch together a rider's spatial experience along their lengths.

15 Toronto Cycling Think & Do Tank, *A Snapshot of Urban Cycling in Toronto* (Toronto, 2012), http://www.torontocycling.org/uploads/1/3/1/3/13138411/a_snapshot_of_urban_cycling_in_toronto_23_june_tl.pdf.

16 City of Toronto, City Planning, *Planning Justification Report — 3636 Bathurst Street*, by Bousfields Inc. on behalf of 3636 Bathurst Street Limited (Toronto, 2011), https://www1.toronto.ca/city_of_toronto/city_planning/community_planning/files/pdf/3636bathurst_planning-report.pdf.

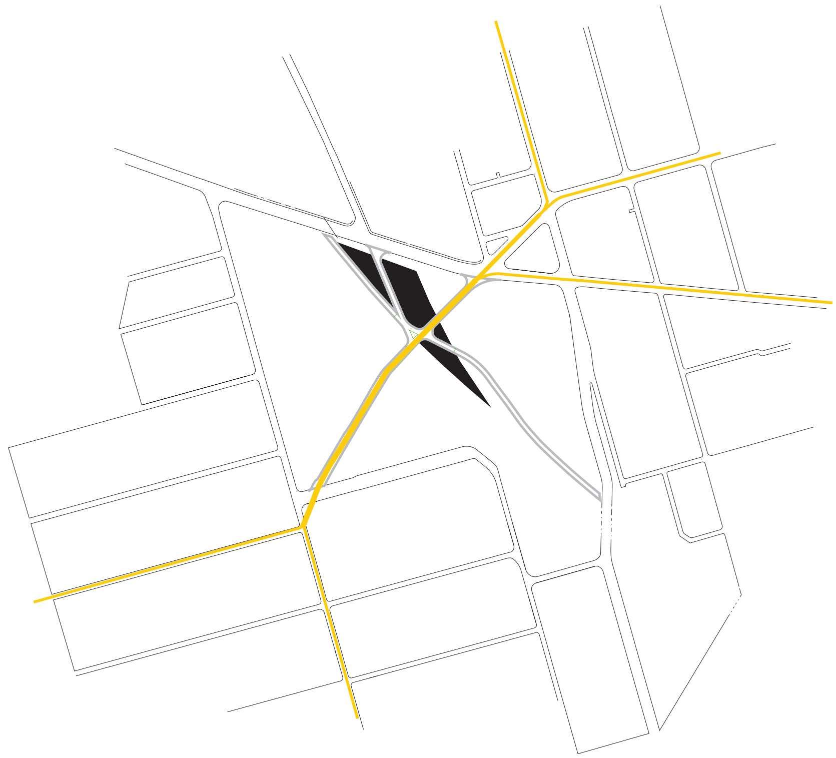


fig. 88 College-Sorauren bridge urban connections

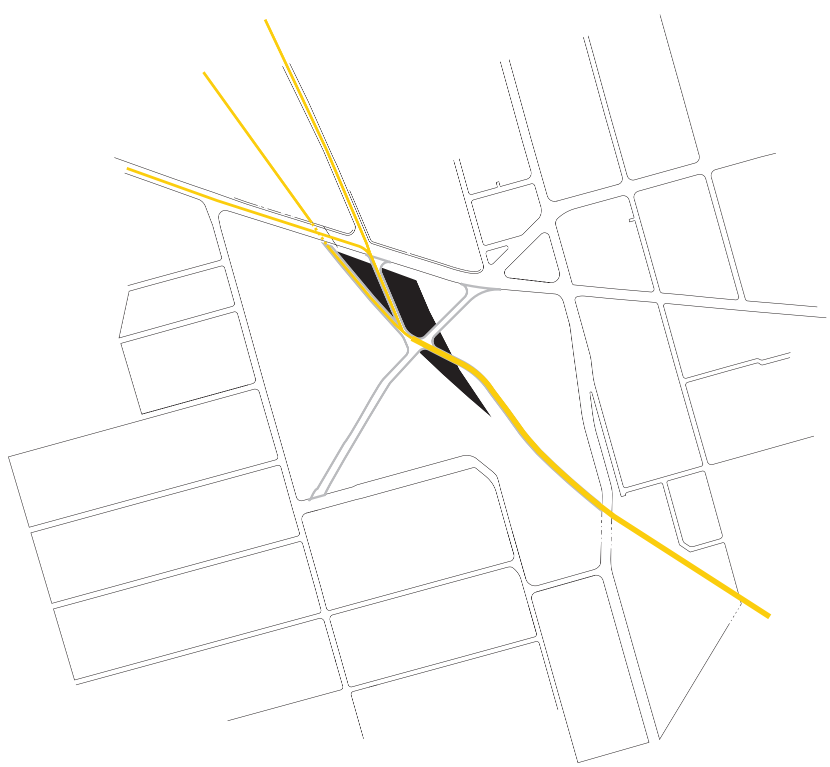


fig. 89 extension of phase II of the West Toronto Railpath urban connections

College-Sorauren Bridge

College-Dundas-Lansdowne Intersection

The College-Sorauren bridge's two landing points in the streetscape are of particular importance, as unlike the West Toronto Railpath bridge, which is a designated trail off of the main grid, they feed directly into the city's flow of traffic, so seamless integration with the urban fabric is of utmost importance. As previously described, the convergence of three major roads in this part of town—College St, Dundas St W, and Lansdowne Ave—has manifested in a small triangular city block/large traffic island[17] just east of the site. Although most likely constructed to avoid the collision of a three-arterial-road junction, the flow of traffic around the resultant island and its three separate intersections is hardly streamlined and safe. This condition is particularly hazardous at the junction where College St merges into Dundas St W, where adjoining collector road St Helens Ave also enters and exits. Moreover, the approximately 45 degree angle at which the two main roads meet has created an elongated intersection, further exacerbated by its steepness as it rises to meet the Dundas St W railway overpasses. But most importantly, unlike the adjacent intersections, there are no traffic lights or crossing signals of any kind here,[18] presumably to mitigate the proximity of traffic signals along this stretch of Dundas St W.

As the College-Sorauren bridge is designed to extend the last segment of the College St trajectory toward Sorauren Ave, its northeastern end meets the ground at the College St/Dundas St W/St Helens Ave intersection, further complicating the junction. The addition of traffic lights here, with a bicycle signal, is therefore deemed critical, in order to allow cyclists to merge in and out of the bicycle path safely and expediently via the College St bike lanes. Due to the oblique angle of the streetcar rails relative to the direction of bicycle crossings, they are specifically designed to pass over the tracks at greater than 45 degree angles for safety reasons. The entire intersection is also paved, with solid-painted bicycle crossings, to visually increase driver awareness and moderate vehicle speeds at a complex traffic node.

To further facilitate the flow of urban life within the immediate context of the site, the thesis proposes the small but effective urban improvement strategy of transforming the traffic island into a 'gyratory.' A gyratory is a large traffic roundabout with buildings on the central island, which is a common feature in the winding historic streets of the United Kingdom. It would be equipped with three completely synchronized sets of traffic lights at each of its corners to prevent congestion, and the possibility of vehicles stopping at every red light between the short distances. Shared lane markings, or chevrons, are also added to the gyratory's Lansdowne Ave segment, linking the street's strangely unconnected bike lanes just south of Dundas St W and shared bike lanes just north of College St. Moreover, streetscaping elements, such as sidewalk paving, trees, and benches, would not only improve the harsh conditions of the neighbourhood, but also serve to display and emphasize the function of the gyratory. Improving the streetscape where the bridge stitches into the urban fabric, as the gates from which the urban park and bicycle factory connect into the city, is a significant aspect of the intervention.

17 complete with gas station, shops, and residences

18 The author can personally attest that attempting to cross the intersection on a bicycle with unyielding cars and streetcars is a highly dangerous affair.

fig. 90 **College-Dundas-Lansdowne intersection/**
1:100

2.3.2 masterplan


SORAUREN PARK
SORAUREN AVE
WABASH AVE
"SORAUREN PLAYGROUND"
FERMANAGH AVE

Sorauren-Wabash-Fermanagh Intersection

On the other, southwestern end, of the College-Sorauren bridge, an entirely different setting is presented. After spanning like a canopy over Sorauren Park, the bridge terminates at the southern edge of the park and merges with Wabash Ave in the residential neighbourhood of Roncesvalles Village. Here, a small incision is made in the urban fabric at the northwest corner of Charles G. Williams Park, as a means to extend the bridge's trajectory directly to the corner of Sorauren Ave and Fermanagh Ave. This operation completes the east-west link desired by the city, by feeding the pedestrian & cycling path straight into High Park via the recently implemented contra-flow bike lane on Fermanagh Ave. The thesis also proposes transforming Sorauren Ave into a shared bikeway, another bicycle route considered by the municipality, but never realized. This would provide a bicycle-friendly connection between the College-Sorauren bridge and arterial road Queen St W.

As the extension of the bike path from the foot of the bridge severs a portion of the Charles G. Williams Park's playground,[19] a small island is created on the other side, which becomes a cyclist's repose, complete with DIY bike fix stations. Like the intersection at the other end of the bridge, the entire Sorauren Ave/Fermanagh Ave/Wabash Ave intersection is paved, as well as slightly raised, to call attention to the unique urban condition at this junction. It slow vehicular traffic, as well as discourages motorists from using it as a thoroughfare, fostering instead, a more pedestrian, bicycle, and neighbourhood friendly plaza. The protected intersection also creates a safer zone for children and their families to travel across between the playground and Sorauren Park. Furthermore, the foot of the bridge is situated right next to the planned Wabash Community Centre on the southern portion of Sorauren Park. Parts of it, such as the Town Square and Field House are already completed and in operation, with the community centre set to open in 2018. All in all, the College-Sorauren bridge fulfills the Parkdale-High Park community's desire for a connection between the West End Railpath, and Sorauren Park & Wabash Community Centre.

West Toronto Railpath Phase II Bridge

The proposed phase II extension of the West Toronto Railpath is absorbed into the design of the intervention as the second spine of the pedestrian & cycling infrastructure. It begins where phase I left off, just below the Dundas St W overpass, slopes up to the urban park where it meets the College-Sorauren route, before crossing over the GO Transit Barrie rail line, and sloping down to terminate at the railway bridge over Lansdowne Ave. From there, phase II of the railpath would continue along the tracks toward the centre of downtown Toronto.

fig. 91 **Sorauren-Wabash-Fermanagh intersection/** *1:100*

19 colloquially known as Sorauren playground

2.3.2.6 DISSEMINATION OF THE COMMUTER BICYCLE IN THE CITY

iii. using the design of the commuter bicycle to entice people to use cycling as a form of transportation in the city, while ***empowering and mobilizing the masses****, regardless of social status*

Over a century after the bicycle and streetcar were first employed on a mass scale, they continue to mobilize inhabitants in the city, allowing people to live further than walking distance from work. The scale, speed, and travel time of a bicycle make it the optimal form of local transport, and if more widely implemented, over time would inform the grain of the urban landscape. If mobility were restricted exclusively to walking, cities would not be able to grow—but rather begin to resemble medieval villages more than contemporary metropolises. Moreover, concentrated industrial ghettos and workers' housing would spring up around factories, just as they did during the Industrial Revolution before the advent of mass transportation. Homogenous densification is not condoned in the post-post-Fordist city. Conversely, a Fordist/post-Fordist automobile-centric society (our current reality), creates vast, wasteful, distances between living and working spaces—suburban melting-pots and bedroom communities, big box stores with enormous parking lots, and extensive highway infrastructure networks. Cars inflict cities with buildings and city blocks unsuited to pedestrians (and cyclists), and spawn large, monolithic swaths of homogenous development.

Unlike cars with their high initial price tags as well as subsequent maintenance costs, bicycles are affordable to a much larger range of the demographic, making it a more democratic way to commute. Ever since the introduction of the safety bicycle in the 1890's, cycling expert and author Robert Penn notes: "Perhaps the greatest impact of the bicycle was in breaking down hitherto rigid class and gender barriers. There was a democracy to the bicycle that society was powerless to resist."[20] In this way, the bicycle has the ability to mobilize the masses, thus empowering people and neighbourhoods across all levels of social strata.

The collective, distributive, and decentralized nature of the bicycle makes it the perfect antidote to the car-dominated cityscape. Its ability to create social, cultural, political, and infrastructural networks, renders it a powerful agent of change in the city. The self-propelling machine is a self-organizing entity that can in and of itself create infrastructure though its dispersion as well as critical mass. The bicycle also produces infrastucture. More specifically, the act of riding a bicycle, creates infrastructure—the more bicycles there are out on the road, the more pressure there is on the city to implement cycling routes and facilities.

The design of the bicycle factory's flagship commuter bicycle takes into account the specific functional, comfort, and aesthetic requirements of riding in a northern climate city. It forms the last piece of the puzzle in the thesis proposal, which presents interventions ranging from the urban scale, to the scale of the artifact, while focusing on the architectural scale of the bicycle factory.

20 Robert Penn, *It's All About the Bike: The Pursuit of Happiness on Two Wheels* (London: Penguin Books, 2011), 5.

fig. 92 **post-post-Fordist bicycle factory**/ *axonometric view*

<u>2.4 bicycle factory</u>
2.4.1 ARCHITECTURE

2.4.1.1 CULTURAL SYMBOL

Throughout civilization, architecture has always served as a powerful symbol expressive of its epoch. Accordingly, the factory of the Industrial Revolution represented progress, innovation, and technology. While the image of the typology—both its public perception and architecture—has undoubtedly transformed through the years, it has always embodied the political, cultural, social, and economic currents of its time.

The bicycle factory is thus proposed to be such a symbol in the city, by channelling a forward-looking post-post-Fordist zeitgeist—the renaissance of manufacturing and expansion of cycling networks in the dense, layered, and multifaceted metropolis. Just as Fiat's Lingotto factory came to represent Turin and its automobile industry, the bicycle factory strives to be a symbol of Toronto as a cycling vanguard. And just like the Lingotto factory's automobile-glorifying test track 'crown,' the bicycle too, is celebrated in the same manner with a 'floating' velodrome .

The architecture of the Fagus-Werk factory employed progressive materials and construction technology as a way to advertise its cutting-edge production equipment and quality products. In the contemporary era, Volkswagen's Transparent Factory takes this marketing strategy even further. Its facility is enveloped in a sleek, transparent glass skin, in order to showcase the even sleeker high-tech production line found inside, simultaneously broadcasting the company's commitment to openness and honesty. Likewise, the bicycle factory of the post-post-Fordist era declares its identity and philosophy through architecture. The tectonics emulate the bicycle's structure and are expressive of its movement and social qualities. As a prominent figure on the horizon, the intervention acts as both a visual and symbolic icon in Toronto's urban landscape.

2.4.1.2 ARCHITECTONICS

<u>Production of Infrastructure</u>

When taken at face value, the bicycle factory manufactures bicycles, but the intervention in fact 'produces' much more—infrastructure, public space, skilled and semiskilled labour, knowledge (education, technical skill, experience), social awareness, and cycling culture. It utilizes infrastructure to negotiate the spatial conditions between the city's communal territory and privatized Employment Lands. In this context, the building is infrastructure, produces infrastructure, and is constrained by infrastructure.

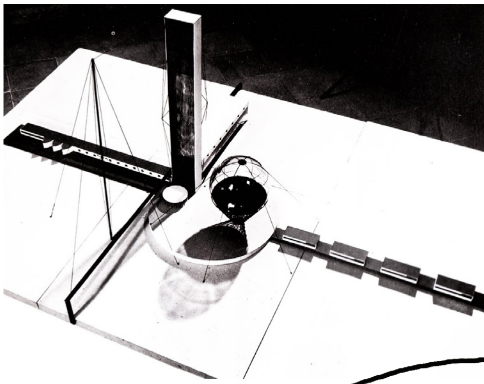
<u>Hybrid Typology</u>

During late 18th-century Europe, architects of the early factories had just begun experimenting with structure, form, and ornamentation, in search for a distinctive language for the new typology. Likewise, the hybrid typology of the bicycle factory employs various architectural strategies to express its unique identity. It also rejects and endeavours to reverse the post-Fordist propensity for building cheap, expressionless sheds to house its offshore factories. The originality of the intervention's composite design situates it in the ethos of the post-post-Fordist era, by (re)defining the relationship between transportation, manufacturing, and public space in the city. It comprises of five main typologies:

i. **factory typology** — large, open, single-storey space supported by a semi-regular column grid and deep waffle slab roof, with abundant natural light provided by large windows, skylights, and courtyards
ii. **pedestrian & cycling bridge typology** — bridges that split and reconnect along their paths to traverse over, or through the factory building
iii. **urban park typology** — large outdoor space with pavilions housing various public amenities, cycling paths, greenery, and an assortment of landscape furniture and objects
iv. **velodrome typology** — full-size outdoor velodrome track suspended on cables and masts over the urban park
v. **bike park typology** — outdoor bike park with dirt mounds below the elevated factory building

Constructivist Style

Not only is the form of the building sculpted by a series of constraints (i.e. context, site, program), a number of architectural strategies are deployed to articulate morphology, expression, and style. Derivative of constructivist design, in which "assorted mechanical objects are combined into abstract mobile structural forms,"[1] the intervention is similarly composed of an assemblage of disparate parts. During its heyday in the 1920's and 1930's, the constructivist style represented science and technological advancement. This reinterpretation of the anachronistic style, is befitting for an intervention revitalizing an anachronistic program based on technology, galvanizing the production of an anachronistic object, and reinvigorating an anachronistic portion of the urban fabric. These established, historical elements provide a nostalgic stability—serving as analogue counterparts to much of today's high-tech digital technology.

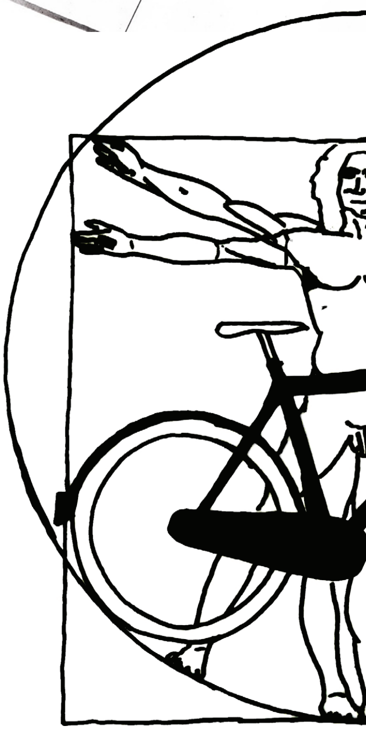


Parti & Tectonics

The product of this heterogeneous amalgamation of architectonic objects, results in discernible functional forms, clearly legible in the architecture. But unlike purist modernist volumes, such as the Fagus-Werk factory, which also claimed to express interior operations on its exterior, the morphology of the bicycle factory is a complex synthesis of contextual restraints, functional efficiencies, and expressive intentions.

The large, flexible spatial requirements of the factory is articulated as a mass—a form directly extruded from the boundaries of the site for maximum floor area. The volume is then lifted on pilotis, so that the top of its roof slab (the surface of the urban park) is level with the street. As a result, the building is half-buried into the steep terrain of the property's northern end, so that its southern tip cantilevers over the bottom portion of the site. The effect of these set of moves emphasizes the unique shape of the site, thereby calling attention to the irregularity of the urban fabric in this area.

To break up the monumentality of the mass, it is excavated, sliced, and cut into, while shapes are extruded from its top plane. Functionally, this translates into courtyards,



1 Amy E. Arntson, *Graphic Design Basics* (Boston, MA: Wadsworth Publishing, 2011), 214.

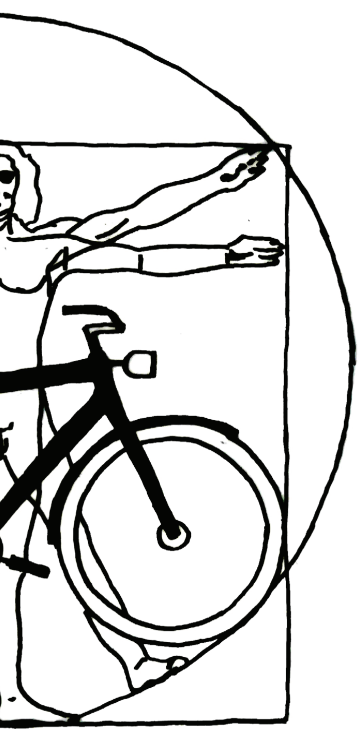
pavilion buildings, skylights, and sculptural landscape elements. In the open urban park, the protrusions (pavilions) organize and frame the space, while the landscape forms texturize its surface. In the enclosed factory, the depressions (courtyards) organize and frame the space, while the landscape forms above are transmitted through its thickened roof structure, creating a highly textured ceiling.

The trajectories of the bridge infrastructure also puncture through the factory at different levels, which can be read as open linear planes, or lines, passing through a volume. These layered paths of motion enable and articulate the flow of bicycle traffic throughout the site. Although not strictly a transportation structure, the velodrome is another facilitator of bicycle movement—an open, elongated ring-shaped object that hovers above the urban park and its pavilions. Hung by cable from two masts on either end, the track is nested within a network of taut lines, as its shape informs the contours of the pavilions below, and acts as a roof over the urban park. The bike park, a space for a different kind of leisure riding, is allotted the area below the raised factory building. A landscape made entirely out of dirt, this outdoor space is composed of groups of earthen mounds arranged in strategic succession.

fig. 93 (left) **Lenin Institute proposal (1927) by Ivan Leonidov**/*constructivist style inspiration*

The overall effect produced can be understood as a series of stacked, floating layers. The factory draws on juxtaposition strategies of solid vs. void, and volume vs. line, to articulate the formal composition of its architecture. The urban park's outdoor 'room', is delimited on its ground plane by the shape of the building[2] it sits on, framed by the pavilion buildings in its space, and 'roofed' over by the velodrome. The form of the cycling infrastructure is dictated by the motion of a body on the bicycle. In *Skateboarding, Space and the City: Architecture and the Body,* urban and architectural commentator Iain Borden, writes about the similar act of skateboarding, as the " 'production' and 'reproduction' of space through the 'body-centred' practice."[3]

fig. 94 (below) **the bicycle as an extension of the human body**



<u>*Emulating the Bicycle*</u>

The bicycle is a machine—an assemblage of parts working in concert to transform human power into kinetic energy, which translate as forward-moving trajectories. Emulative of a bicycle's construction and movement, the intervention brings together a bricolage of architectural ingredients to mobilize society along specific paths, whether it's cycling paths, or paths toward a post-post-Fordist society. Its architecture can be regarded as a three-dimensional tectonic tracing of the bicycle's gestures in space, whose composition further takes inspiration from the device's structure and mechanics. The various programmatic layers of the design all interweave and interlock with each other—working in unison like a well-oiled machine.

Together with the human body, the bicycle becomes a self-propelling engine that converts energy from one form (potential energy of food) into another (kinetic energy of movement), thereby amplifying force and speed. In similar fashion, the factory operates as a large-scale machine—taking raw materials and adding time, energy, and intent, to fabricate an object of greater value and meaning. This significance attached to the product of human labour, which in turn originates from the human brain, is what Marx defines as

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2 and site, by extension

3 Douglas Cunningham Spencer, "Skateboarding, Space and the City: Architecture and the Body (2001) by Iain Borden," *Culture Machine*, accessed March 27, 2016, http://www.culturemachine.net/index.php/cm/article/view/203/184.

a commodity's 'fetishism.' According to Marx, this attribute drives the social relationships between people in productive society. Thus in the same way a bicycle augments the input of human exertion, the proposal takes a simple machine, and magnifies its impact across the community, city, and beyond. Like a bicycle, the intervention also serves functional and practical purposes, by stimulating the economy through manufacturing, and providing the physical infrastructure for mass transportation.

the bicycle is adaptable

The bicycle has a remarkably adaptable framework. Its components can easily be exchanged for new or upgraded parts, thus preventing the entire device from being discarded should a single element fail. The combinations are almost endless, yet its functionalities are highly focused. Similarly, despite the bicycle factory's specialized configurations structured for specific programmatic activities, its shell is designed to be versatile, customizable, and anticipatory of future use. The factory is a large, open space with a semi-regular column grid which can be converted into almost any kind of manufacturing facility, or accommodate a variety of other program. The same holds true for the open plane of the urban park and its pavilion buildings.

Retrofits of buildings are not uncommon, and it is realistic to expect societal currents to shift. Therefore, it is most prudent to design flexible spaces that can be re-appropriated for prospective occupation, so as to minimize waste. For example, the Lingotto Factory (Fordist era), although not intended for this purpose, was transformed by renowned Italian architect Renzo Piano into a large mixed-use cultural venue (post-Fordist era), due to the flexibility offered by its enormous open plan and regularly-spaced structure.

the bicycle is open

Unlike a car, which is effectively a capsule, the bicycle has an open configuration, which leaves its rider exposed to the elements. This 'openness' of the bicycle is translated into an 'openness' in the proposal's architecture, manufacturing process, and business philosophy. Structurally, this quality is expressed through the design's eclectic collection and juxtaposition of tectonic elements, in contrast to the large, enclosed, rectilinear volumes characteristic of modernist buildings. In fact, the factory is the only part of the project that is completely covered; all other program—urban park, bike park, velodrome, bridges—are open to the outdoors, with varying degrees of partial shelter.

Symbolically, this open vocabulary alludes to the openness, transparency, and receptiveness of a post-post-Fordist society. Unlike the hermetically-sealed, monolithic Fordist factory, with a rationalized structure and façade exerting power over its workforce, the post-post-Fordist building is open, polylithic, and consists of asymmetrical configurations and non-modular skins. The mechanisms of Fordism's capitalist control however, extended far beyond exploitation of its factory workers. The monotonously expansive walls of the Fordist plant not only contained and kept its employees in check, but also created a solid barrier between its secretive production processes, and the rest of the city. Today, changing attitudes about the participation and contribution of factories to society are impacting the way manufacturing businesses are investing in their public image. For instance, like Volkswagen's Transparent Factory, not only are they allowing and facilitating visibility of the production floor, guided tours of the manufacturing process are often also available, functioning as a marketing strategy, and in many cases, as an additional source of revenue.

Antithesis to Fordist notions of seclusion and concealment, the post-post-Fordist bicycle factory fully adopts a philosophy of openness and transparency, by inviting the public inside its walls. An exhibition space in a pavilion building that fronts onto Dundas St W, provides a comprehensive walkthrough of the manufacturing process, complete with parts and prototypes. From here, visitors can walk down to a cafe on the factory floor, where the day-to-day activities of the operation can be observed from afar. Guided tours through the production floor are are also available for more immersive explorations. For a more passive experience, offshoots of the main bridges, which provide express lanes for cyclists through the factory, act as dynamic observatories with various elevations and vantage points, for panoramic views out over the bustle.

Emulative of the bicycle's inherent anti-capsular nature, the project's open architectural language appropriately generates open-air cycling facilities, as a result. It also broadcasts the bicycle factory's belief in complete transparency of the production process, in fact employing numerous architectural strategies to draw visitors inside. Like Volkswagen's Transparent Factory, the post-post-Fordist bicycle factory sets a precedent for how future production facilities could be integrated into the urban fabric by providing visibility and access to its operation, as an active participant in the pulse of urban life.

the bicycle is connective

By virtue of its ability to change position in space, the bicycle is an apparatus used for making connections. Likewise, the design intervention creates new relationships on multiple levels. It stitches together fragmented portions of the urban fabric while merging seamlessly into the surrounding context. The project also enables the continuous flow of bicycle traffic, and facilitates its connection to other forms of transportation. Finally, by replanting the factory back into the city, the proposal reconnects workers and consumers with each other, the manufacturing process, and the final product.

the bicycle is egalitarian

As elaborated in previous sections, the democratic nature of the bicycle is what bestowed the human-powered vehicle with its egalitarian status all throughout history, whether it's liberating women, or mobilizing the less affluent. By means of a number of architectural strategies based around 'the circle',[4] the bicycle factory endeavours to mirror this attribute by providing spaces that promote and reflect equality. In the sphere of the project, the utility of the shape (and its derivatives), as well as the significance of its iconography, are used to explore various notions of equality, community, collaboration, and openness throughout.

The velodrome is the largest and most pronounced element in the design that incorporates the circle. Effectively an elongated circle, its flared half-circular ends are a precise delineation of the necessary inclined turning radii of bicycles travelling at top speeds. The nature of equality is inherent in the symmetry of its geometry, as racers ride laps around the track, governed by the set of rules that enforce fairness in the

4 the word 'cycle' has its origins in the Greek 'kuklos', or 'circle'

competitive sport.

Doubling as a floating roof over the urban park, the velodrome's profile is consequently projected onto the landscape below, informing the shape of its pavilion buildings. The two buildings located on the 'infield' of the velodrome (the bike kitchen and bike shop) are additionally sculpted by the intersection of the pedestrian & cycling bridges, resulting in curvaceous, open, and welcoming façades. These design translations are further propagated inside each building to the spiral stair, cylindrical glass elevator, and various built-in furnitures.

On the factory level, scattered throughout the production floor, amorphous circle-derived figures define communal spaces such as meeting rooms, workshops, and lounge spaces. Meanwhile, a circular configuration, which inhibits hierarchical layouts, enables the team workflow of the bicycle assembly hubs.

the bicycle is delightful

Well building hath three conditions: firmness, commodity, and delight.
— Vitruvius, *The Ten Books on Architecture*

In the same way a bicycle can serve utilitarian or recreational purposes, the bicycle factory is as delightful as it is practical. Its whimsical structure houses a plethora of various bicycle-focused amenities—pedestrian & cycling bridges, velodrome, bike park, cycling paths, snake run, bike kitchen, bike shop, frame building workshop—all with varying degrees of use and leisure, or a combination thereof. The urban intervention is thus designed to be a delight to look upon, a delight to use, and a delight to play in.

Integrating the Bicycle

On a more practical level, beyond emulating all the qualities of this marvellous machine, the architecture integrates the bicycle into its design in multiple ways. Conceived as a fully 'bicycle-permeable' project, the intervention gives cyclists significantly more access to buildings than standard human-body-centric models. By inverting this archetype, the thesis explores how a bicycle-focused design differs from traditional typologies, and what the potentials of this bicycle-architecture interface could be. This in fact expands the post-post-Fordist mandate to permeate cycling infrastructure throughout the city, right into the interior environment of buildings. Extending this sphere of access would further facilitate the use of bicycles in everyday urban life.

The Danes are no strangers to this concept, as citizens of one of the top cycling nations in the world. Denmark native Bjarke Ingels, a progressive and influential architect on the international stage, is a firm believer in bicycle-accessible buildings. His design studio BIG's Danish Pavilion at the Shanghai World Expo in 2010 "placed the bicycle at the centre of the scheme," and was "designed around a double loop that takes cyclists in and out of the building, enabling them to experience the various exhibits directly from the bicycle saddle."[5]

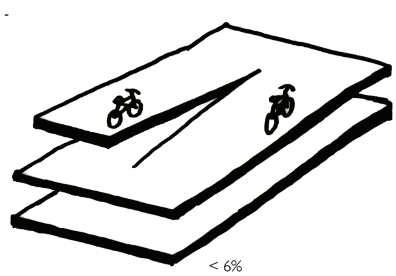
5 Gavin Blyth, *Velo-City: Architecture for Bikes* (Munich: Prestel, 2014), 130-1.

fig. 95 **Danish Pavilion (2010)**

fig. 96 **8 House (2010)**

In the same year, BIG's 8 House project was completed in Copenhagen—a mixed-use 10-storey residential block building with continuous cycling paths throughout. It allowed residents to ride all the way from their front door to the street (or vice versa). 8 House stacks all ingredients of a lively urban neighborhood into horizontal layers of typologies connected by a continuous promenade and cycling path up to the 10th floor creating a three-dimensional urban neighborhood where suburban life merges with the energy of a city, where business and housing co-exist.

Likewise, the proposal forefronts the bicycle in the architectural design by optimizing its use throughout the site, and interfacing the mobility device with various building elements. The elliptical shape of the velodrome and sculpted landscape of the bike park are the most obvious facilities designed explicitly for the bicycle, or more specifically, for recreational cycling, whether it's competitive racing, or performing tricks on dirt mounds. Beyond that, cycling routes are provided on the bridges and throughout the urban park, with comfortable slopes and turning radii for different cycling speeds. Larger bicycle-accommodating passenger elevators, and stairs with bike channels are also provided throughout the intervention. Additionally, outdoor bicycle furniture, such as lock stands, and benches with slots for bikes are scattered throughout the urban park. In fact, the entire thickened façade of the bike shop with its vertical fins, is designed to double as bicycle parking racks.



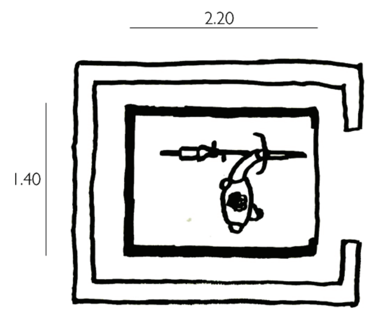


fig. 97 *(far left)* **bicycle ramp slope requirements**

fig. 98 *(left)* **bicycle elevator dimensions**

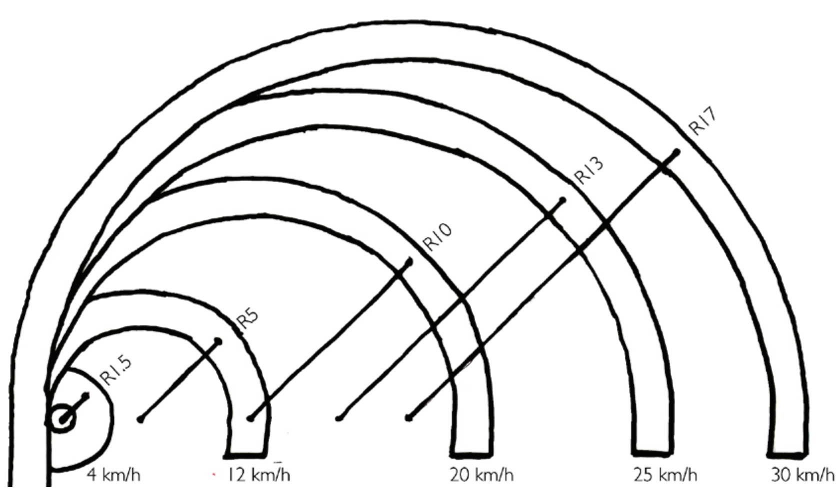


fig. 99 **bicycle turning radii at various speeds**

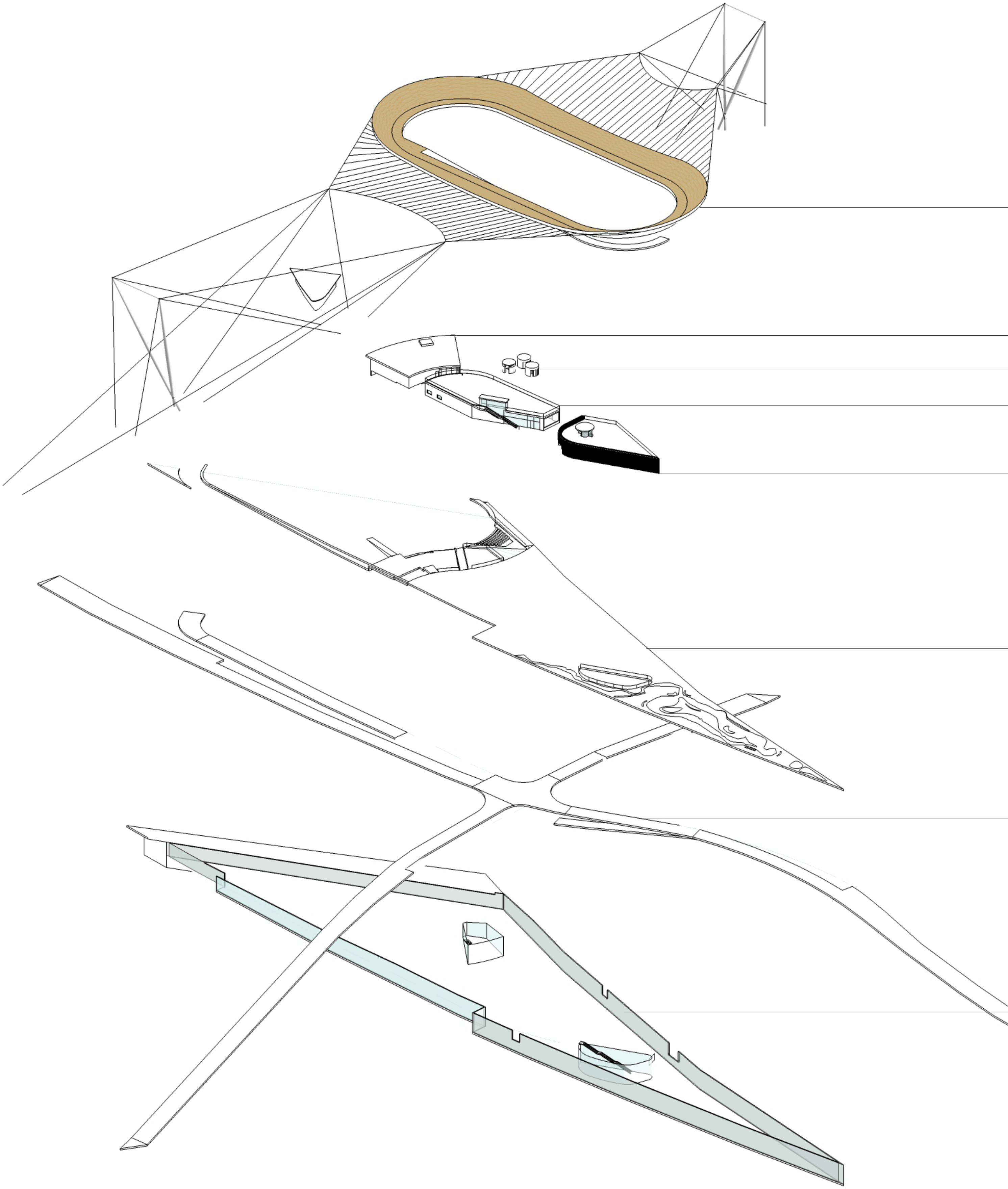


fig. 100 **exploded axomometric diagram**

2.4.1.3 PARTI, SPATIAL LOGICS, & CONSTRUCTION

<u>*Factory*</u>

i. ***factory typology*** — *large, open, single-storey space supported by a semi-regular column grid and deep waffle slab roof, with abundant natural light provided by large windows, skylights, and courtyards*

Just as the typology of the bicycle—its basic structure and mechanics—has retained the same fundamental design for over a hundred years, the architecture of the bicycle factory is also rooted in 19th-century industrial typologies. While multi-storey mills were the dominant type during and prior to the first half of the 1800's, single-storey factories with sawtooth skylights prevailed from the 1840's onward. This shift occurred before the electrification of industrial buildings, in order to accommodate the introduction of heavier machinery in increasingly larger complexes with less access to perimeter sunlight. The iconic AEG Turbine Factory (1909) was innovative in its simple, linear plan housed in a single-storey space, with floor-to-ceiling windows spanning between regularly-spaced vertical supports. The facility made use of large gantry cranes to transport parts freely throughout its interior volume, instead of the gravity mechanisms of earlier mills—essentially appearing and operating like a giant machine. The bicycle factory, likewise, is a single-storey building with floor-to-ceiling heights ranging from 3.4 to 5.4 m, using a combination of large windows and curtain wall to maximize daylighting. Unlike the turbine plant's long arcade form,[6] the bicycle factory has an asymmetric triangular shape, with a semi-regular column grid, so it further employs skylights and courtyards to bring sunlight deeper into the floor plate. It too, makes use of overhead gantry structures to convey materials and components along segments of its production line, in orchestrated, automated, fashion.

The typology of the post-post-Fordist factory in fact has little in common with most factories of the early Fordist period, as they had reverted to vertically integrated, gravity-assisted systems within multi-level rationalized structures and façades, as seen in Highland Park (1909), Fagus Werk (1913), Lingotto Factory (1923), and Van Nelle (1931). The bicycle factory does however, employ some modernist strategies for daylighting, like the Fagus Werk and Van Nelle factories, and of course, adopts a version of the Lingotto Factory's rooftop test track for bicycles.

factory structure

While many contemporary factories predominantly use steel, such as steel columns and open web steel joists for longer spans, the proposal's hybrid typology necessarily calls for a hybrid strategy. First, taking the urban park's unique situation atop the bicycle factory into consideration, a concrete roof is chosen—for the robustness of its dense, solid, building material, and ability to withstand the wear and tear of an outdoor public surface. The application of reinforced concrete for industrial buildings hails back to the early Fordist period, when Albert Kahn first used it for the Packard Motor Company Building in 1903, and subsequently for Ford's Highland Park plant in 1909. The then-innovative system provided large expanses of free space to accommodate bigger machines and various configurations of the assembly line. The bicycle factory employs a deep, reinforced-concrete waffle slab for its roof construction, which imparts the

6 or classical detailing and thick massive walls with a rationalized façade

underside of the structure with a coffered ceiling. Waffle slabs are two-way systems that offer more structural, weight, material, and cost efficiencies than its one-way, or flat slab counterparts. The strategic placement of material allows for a deeper section, thereby affording longer spans.

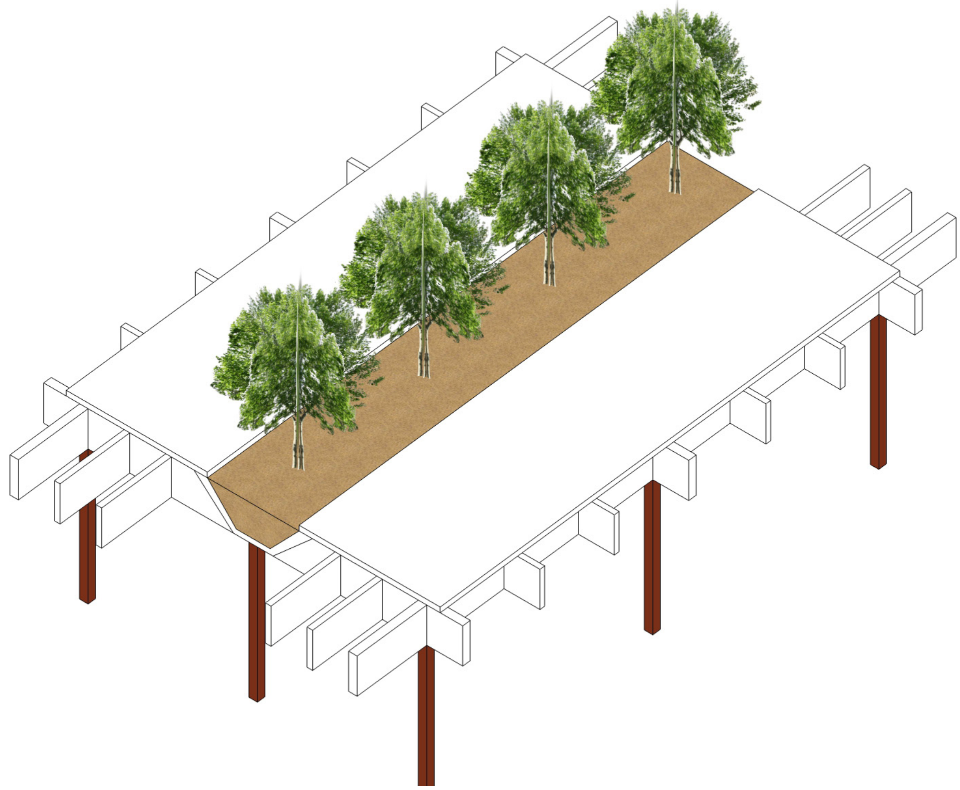
The factory's concrete roof is then supported on square HSS steel columns arranged in a 6 x 9 m grid, with slight deviations in the placement of supports along the 6-m spacing grid lines as required, to accommodate interior production configurations, or pavilion structures above. Steel provides a greater strength-to-weight ratio than concrete, making it the optimal choice for columns, as the smaller profile minimizes its footprint on the factory floor, which enables more flexible open space, and optimizes visibility in the production space. Although not technically a waffle slab, the composite system of square HSS steel columns supporting an open, gridded concrete roof in David Chipperfield's St. Louis Art Museum, serves as a key precedent. Using similar 'waffle' dimensions, a modular bicycle factory roof 'unit' consists of a 4 x 3 grid of coffers with four supporting steel posts at each corner.

fig. 101 (left) **St Louis Art Museum (2012) coffered ceiling**/*roof precedent structure*

The bicycle factory's waffle structure consists of a 200-mm top slab, and 1400-mm-deep ribs, resulting in a total assembly thickness of of 1600 mm. This necessary depth accommodates the planter trenches for trees placed throughout the urban park, which interrupt the pattern of the roof structure wherever they are situated. The size of the trenches, which are trapezoidal in cross-section, is calculated based on the volume of soil required per 7-m-tall tree with an approximate canopy of 4.5 m. Based on the guidelines given by urban landscape product designers DeepRoot Green Infrastructure, 8.5 cubic metres of soil is required for a tree of the specified size. With a 5-m linear tree distribution, the depth of soil needed is determined to be 1200 mm deep, which in turn informs the thickness of the roof structure. Additional columns which are not part of the column grid system, are placed directly under the planters. The tree trenches, which effectively act as massive beams, are thus evenly supported along their paths.

In this way, the regularity of the coffered ceiling emphasizes the vastness of the factory space, while providing a point of reference from which scale and distance can be gauged throughout the volume. The surface is further articulated by the urban park's changes in grade, and the concrete corridors of the tree trenches that punctuate the roof. These nuanced forms are translated through the thickened structure, and can be 'read' on the underside of the waffle slab, creating a highly textured, and formally dynamic ceiling.

fig. 102 (right) **bicycle factory waffle ceiling & roof structure axonometric diagrams**



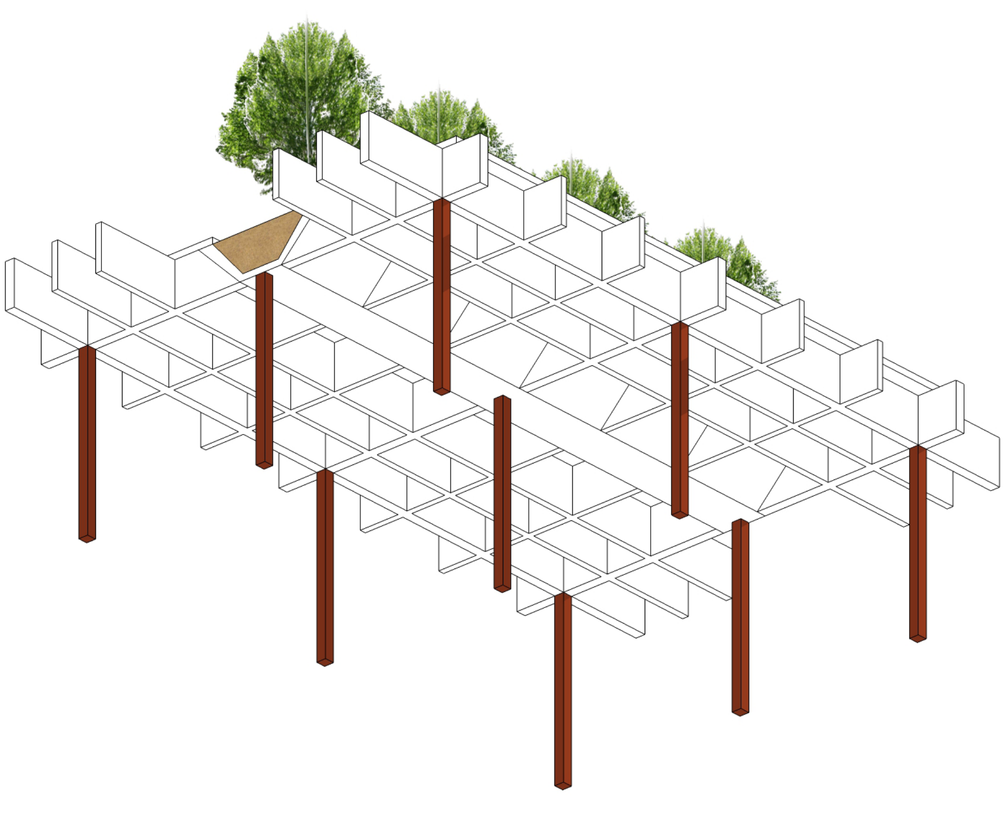
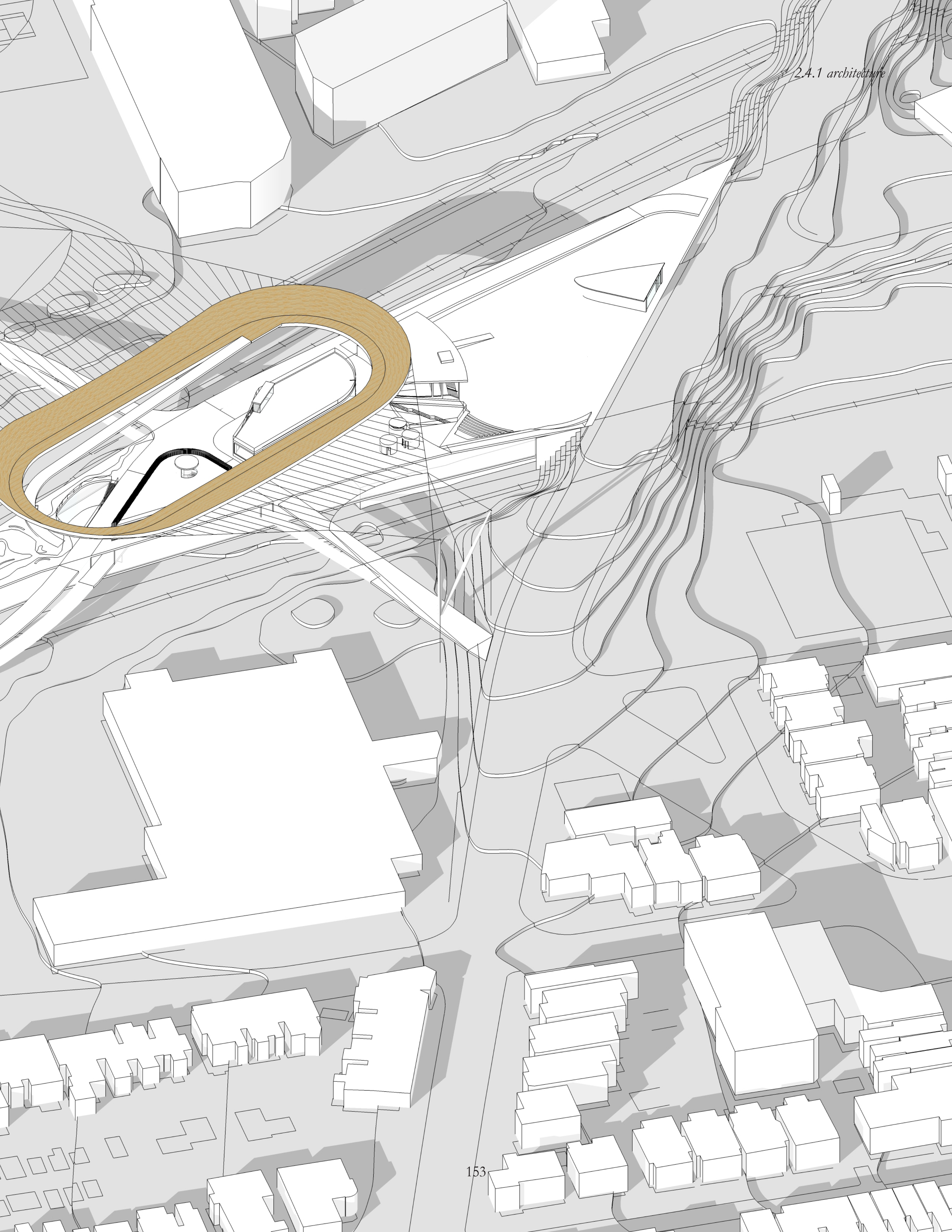


fig. 103 **post-post-Fordist bicycle factory**/ *axonometric view*



Bridges

ii. **pedestrian & cycling bridge typology** — bridges that split and reconnect along their paths to traverse over, or through the factory building

The pedestrian & cycling infrastructures not only bridge the physical spaces they connect, but also effectively mediate the threshold between urban and architectural dimensions, as they flow effortlessly from city street, to building, and back, along unbroken trajectories. Although not commonplace, the strategy of passing bridges through buildings is not an entirely novel idea. In fact, the defining feature of Le Corbusier's Carpenter Center for the Visual Arts (1963), is "an architectural promenade that runs through the center of the building that connects the interior studios, galleries, and screening rooms to the public spaces within the building, as well as to the campus."[7] Those spaces were also designed to be passively observed from the bridge through expansive windows, so as not to interfere with the activities inside. More recently, Volkswagen's Transparent Factory (2006) incorporated the city's tramline infrastructure into its design, using its own freight car to supply components to the plant.

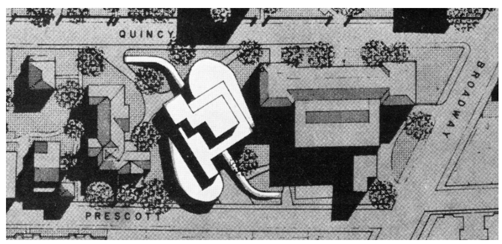


fig. 104 *(far left)* **Carpenter Center for the Visual Arts (1963)**/ *bridge through building precedent*

fig. 105 *(left)* **Carpenter Center for the Visual Arts (1963) site plan**/ *bridge through building precedent*

Similarly, the intervention's pedestrian & cycling bridges also serve to ground and embed the bicycle factory into the surrounding urban fabric. The bridges offer multiple vantage points for observation of production activity, as their trajectories weave in and out of the facility, passing over, and through the building at various levels. With trees running along their entire exterior lengths, planter trenches are incorporated in similar fashion to the trees in the urban park over the factory.

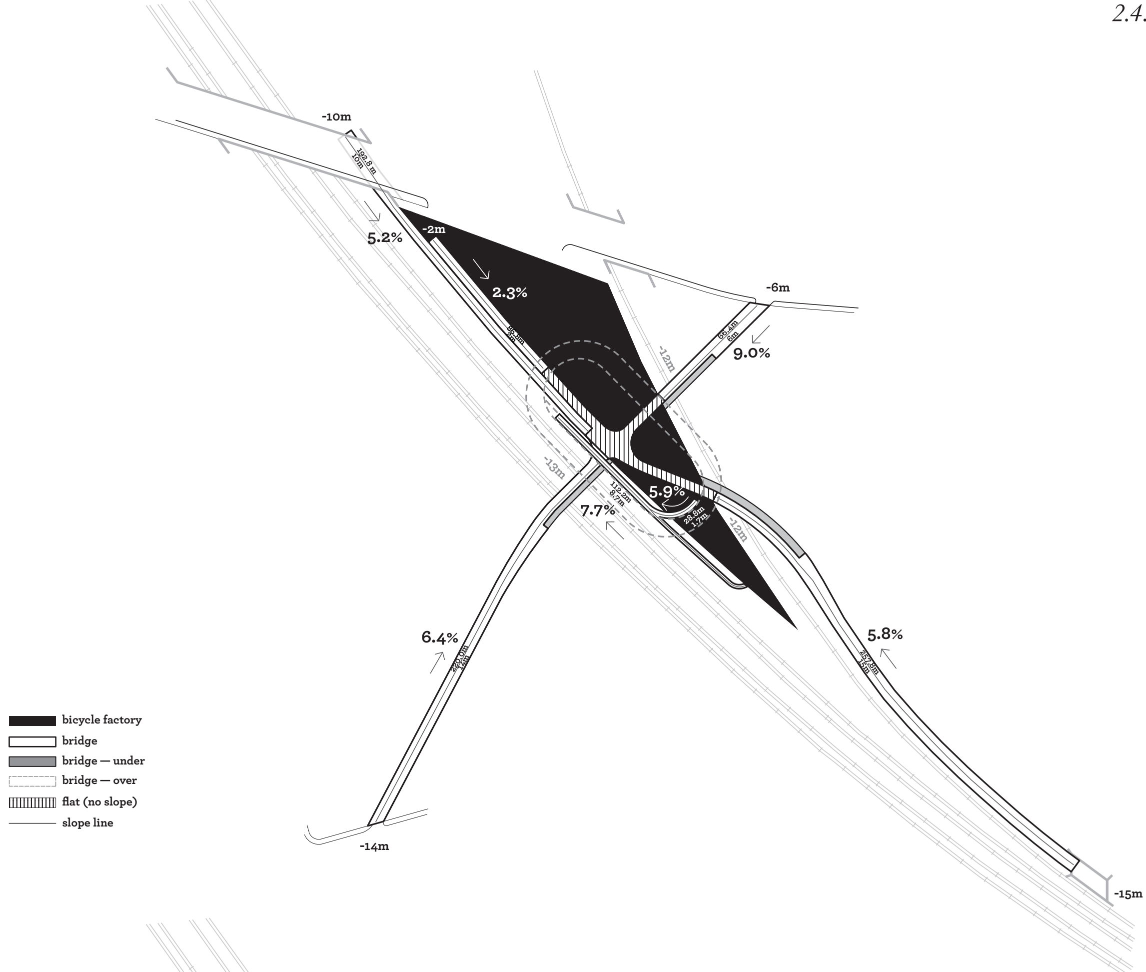
pedestrian & cycling bridge slopes

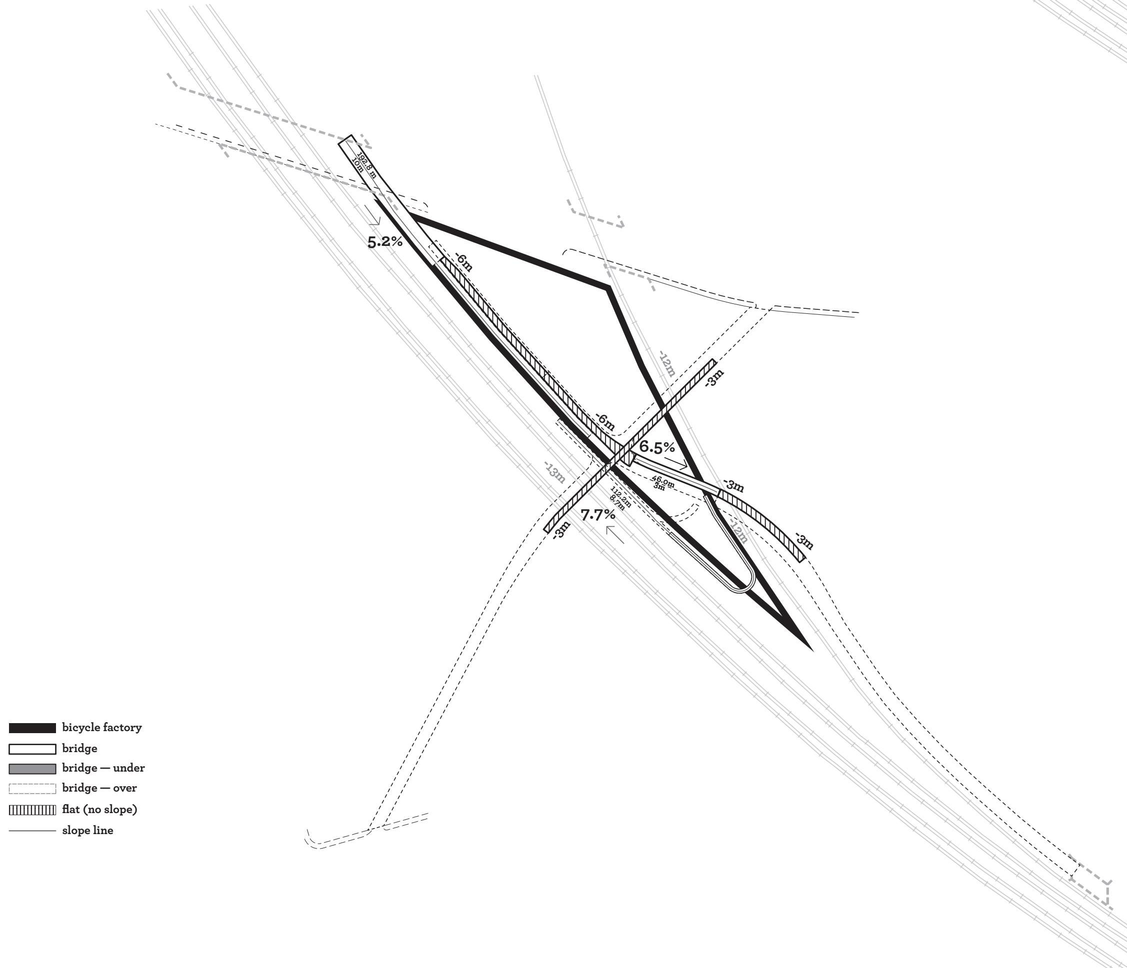
For riding ease and safety, the bridges are inclined just enough to provide the optimal balance between comfort and travel efficiency. The Bicycle Network, one of the largest cycling membership organizations in the world, provides the following recommendations for cycling ramps, which were used to determine the lengths and slopes of the pedestrian & cycling bridges:

5-6% — *for up to* 240 m
7% — *for up to* 120 m
8% — *for up to* 90 m
9% — *for up to* 60 m
10% — *for up to* 30 m
11+% — *for up to* 15 m

fig. 106 **bicycle factory pedestrian & cycling bridge slopes**

7 Andrew Kroll, "AD Classics: Carpenter Center for the Visual Arts / Le Corbusier," *ArchDaily*, March 13, 2011, http://www.archdaily.com/119384/ad-classics-carpenter-center-for-the-visual-arts-le-corbusier.


-10m
5.2%
-2m
2.3%
-6m
9.0%
-12m
-13m
5.9%
7.7%
-12m
6.4%
5.8%
-14m
-15m
bicycle factory
bridge
bridge — under
bridge — over
flat (no slope)
slope line


5.2%
-6m
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-3m
-6m
6.5%
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-13m
7.7%
-3m
-3m
bicycle factory
bridge
bridge — under
bridge — over
flat (no slope)
slope line

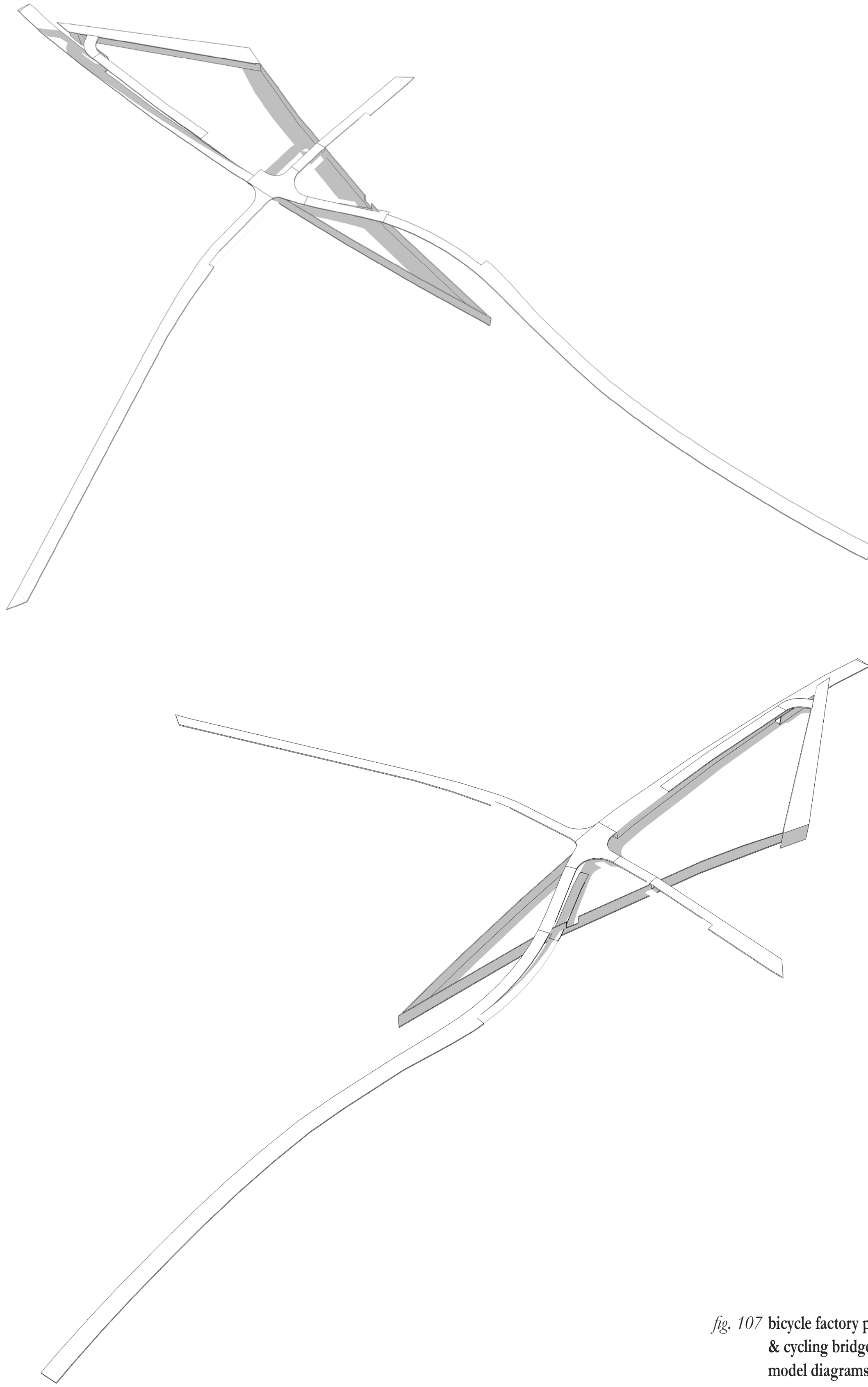


fig. 107 **bicycle factory pedestrian & cycling bridge massing model diagrams**

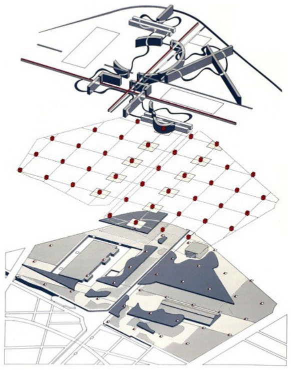


fig. 108 **Parc de la Villette (1983) conceptual parti diagram**/ *layering of "points, lines, and surfaces"*

fig. 109 **Aldo van Eyk playground**/ *landscapes with abstract objects and textures*

Urban Park

iii. **urban park typology** — large outdoor space with pavilions housing various public amenities, cycling paths, greenery, and an assortment of landscape furniture and objects

The urban park is conceived as a textured surface upon which objects are placed, or sculpted from the landscape. The complex, stratified nature of the park is reminiscent of Bernard Tschumi's Parc de la Villette (1983), with its layering of "points, lines, and surfaces."[8] Just like the Parisian park's contemporaneity and forward-looking spirit, the bicycle factory's urban park design similarly does not allude to any historical models. In fact, it is quite self-referential—the direct extrusion of the floor plate from the site; the velodrome-derived pavilion shapes; the spatial requirements of truck, car, and bicycle paths and turning radii.

Like the Parc de la Villette, the intervention's public surface is also framed by a number of pavilions,[9] which organize and serve as points of reference within the larger outdoor space. Not only are relevant events staged around the pavilions, but interior activities also spill out, creating a high level of permeability between inside and outside. The buildings and outdoor spaces are further negotiated with pedestrian & cycling paths throughout, or what Tschumi designates in the Parc de la Villette, as 'lines' that act as the main demarcation of movement across the arena.

The surface of the park is further articulated by the 2-m change in elevation between the northern section of the park at street level, and the rest of the park at a higher grade. This move was necessary to allow enough distance[10] between the underside of the pedestrian & cycling bridges and the railway tracks they cross over, while enabling the surface of the park to meet them at the same level. This condition naturally creates different zones in the park, while offering a more dynamic surface of ramps, raked seating, and sloping lawns.

The eschewing of traditional park typologies thus results in a contemporary urban park deeply informed by its setting and function. Aesthetic inspiration is also taken from Isamu Noguchi's sculptural landscapes, as well as Aldo van Eyk's playgrounds, both of which consist of formally abstract objects and textures that don't bear resemblance to typical landscape features, or playground elements. As a result, the landscape becomes a democratic surface—just as the bicycle is an egalitarian device—that enables people of all age groups to partake and explore its dimensions.

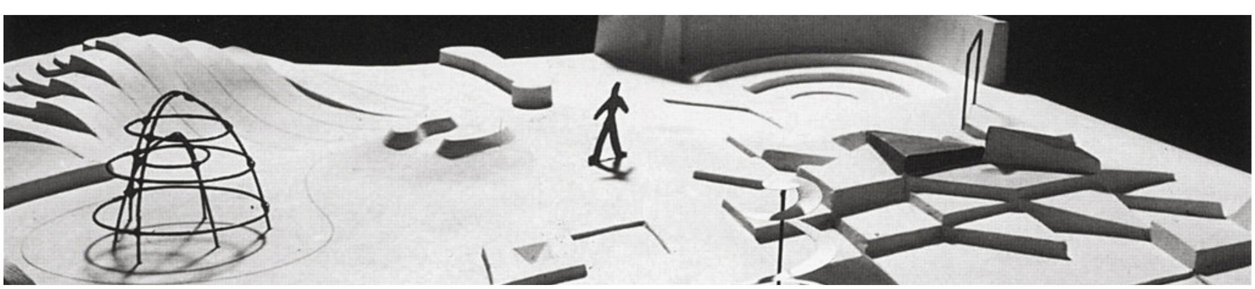


fig. 110 **model for United Nations Playground (1952) by Isamu Noguchi**/*landscapes with abstract objects and textures*

8 Eduardo Souza, "AD Classics: Parc de la Villette / Bernard Tschumi," *ArchDaily*, January 9, 2011, http://www.archdaily.com/92321/ad-classics-parc-de-la-villette-bernard-tschumi.
9 albeit with far less regularity and uniformity of size, and less 'folly-like'
10 9-m minimum to allow for future electrification of the GO Transit rail system

<u>*Velodrome*</u>

iv. **velodrome typology** — full-size outdoor velodrome track suspended on cables and masts over the urban park

While the full-size, floating, open-air velodrome certainly deviates from the standard typology of competitive cycling infrastructure, the concept is derived from an amalgamation of a number of progressive designs. As mentioned previously, the Lingotto Factory's rooftop test track serves as a key inspiration—both for the grandeur of its Futurist vision, and the parallel it provides between the automobile's test track, and the bicycle's racetrack. Due to the tight turning radius of the loop at either end, Fiat's rooftop installation in fact resulted in a less-than-practical function as a method of product quality control. Nevertheless, it arguably served the more important role of acting as a 'king's crown,' by glorifying the automobile and the speed it delivered, right above its production below.

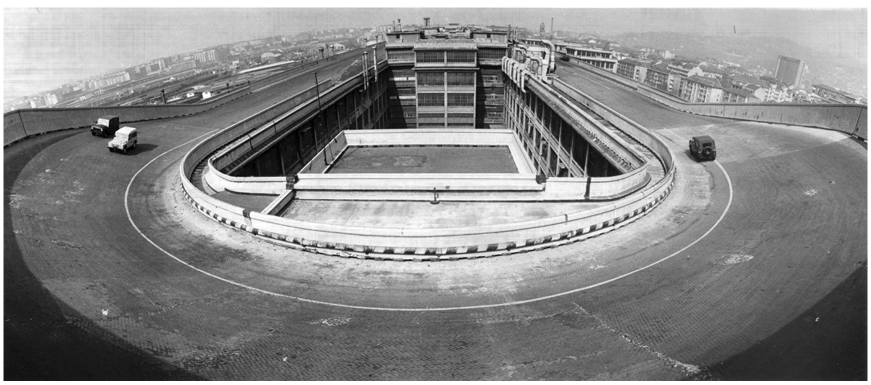


fig. 111 (left) **Fiat Lingotto Factory (1923) rooftop test track**

fig. 112 (right) **Hovenring bridge (2012)/** *suspended ring hung by cables*

fig. 113 (far right) **Hovenring bridge (2012)/** *pedestrian & cycling crossing*

fig. 114 (right) **Snowdon Aviary (1964) structure configuration drawing**

The bicycle factory's velodrome does not deny its partial status as a folly, nor does it take itself too seriously. In fact, it embraces its nature as a 'symbolic flourish,' and its statement as a celebration of the bicycle in the post-post-Fordist era. It too, functions as a testing track for both the factory's R&D department, and the individual frame builders in the building's maker space. In fact, a ramp that starts from inside the building provides direct access to the velodrome, merging halfway with another ramp from the urban park for public access. In addition to formalized competitions, the velodrome can also be used recreationally on a day-to-day basis. An inner lane is provided to allow the track to function as a flat cycling course, or as a stepping stone for the hesitant beginner velodrome user.

As the velodrome directly informs the shape of the bike kitchen and bike shop pavilions below, the roofs of the buildings effectively create a fragmented 'infield.' Both buildings provide access to their respective roofs, so that spectators are able to watch races (or quotidian leisure riding) from the velodrome's inner field, in a complete reversal of the typical spatial relationship between a racetrack and its audience. The elevated status of the velodrome is also situated to look over the activities of the urban park, factory operations, and the city beyond. The underside of its structure is 6.5 m above the surface of the park, creating a sheltered, but lofty space beneath.

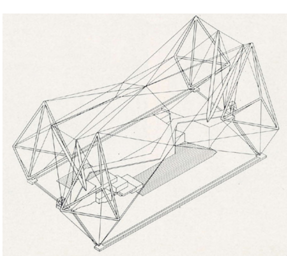
During its glory days, the Lingotto Factory symbolized Turin and its booming automobile industry. Thus as the highlight of the operation, the rooftop test track arguably served as a representation of the Fiat plant itself, and Turin by extension. In the

fig. 115 **Bicycle Club (2012) proposal** */mini rooftop velodrome*

same way, the velodrome, as the design intervention's most visually striking feature with its dramatic structural configuration, intends to represent Toronto and its forward-looking aspirations for the bicycle in the post-post-Fordist era.

Albeit much smaller in size, NL Architects' proposed Bicycle Club design "combines bike hire and sales facilities with a mini rooftop velodrome […] designed primarily for those wanting to test-ride bicycles from the shop below rather than out-and-out racers."[11] It too, uses the velodrome as the building's centrepiece, while doubling as a roof over the indoor and outdoor spaces below.

The velodrome's structure takes inspiration from another bicycle intervention—the Hovenring bridge. Completed in 2012, the suspended, cable-stayed, circular pedestrian & cycling crossing, bridges over a particularly busy road intersection in the Netherlands. It is essentially a floating disk 72 m in diameter, largely supported by a single 70-m high mast at its centre via a circular array of cables originating from the top of the post. "The architects' desire to create as much transparency and openness as possible has resulted in an incredibly economical structure."[12]



For the design proposal, the structural strategy of the Hovenring bridge's single-mast-and-cables supporting a concrete ring, is combined with a simplified version of Cedric Price's Snowdon Aviary structure, in which splaying double masts on either end prop up the entire framework. The bicycle factory's velodrome is thus supported along its cross-axis by two 40-m high diverging masts on either end, via a series of steel cables uniformly attached to the outside perimeter of the track. The resultant effect, is an elongated ring floating over the urban park, nested within a network of wires stretching toward tall V-shaped supports on either end.

11 Blyth, *Velo-City,* 129.
12 Ibid, 46.

Bike Park

v. **bike park typology** — outdoor bike park with dirt mounds below the elevated factory building

While the typology of the outdoor bike park itself follows a fairly standard design for off-road cycling, its location beneath an elevated building—taking advantage of the remnant space on a sloping site—is a unique feature. The specific riding features of the park are closely modeled after Toronto's recently constructed Sunnyside Bike Park (2012) just south of High Park. The city hired Jay Hoots, which they dub "the most experienced bike park designer in North America," for the commission. It was initiated to "address the lack of off-road cycling venues in the west end of the city," in hopes that "it will reduce or eliminate informal parks being created in ecologically sensitive areas in the High Park neighbourhood."[13] Clearly, there is a community demand for these types of cycling amenities, particularly on Toronto's west end, and a municipal desire to keep them within contained, officially designated areas. The proposal's bike park fits the bill perfectly, as an additional dirt biking facility positioned in a more central and accessible location in the city. Similar to Sunnyside, the proposed bike park includes a skills trail, pumptracks, jump lines, and a wall ride which doubles as a retaining wall along the northern perimeter of the park. It can be accessed from the phase II extension of the West Toronto Railpath.

fig. 116 **Sunnyside Bike Park (2012) in Toronto**

13 "Sunnyside Bike Park," *City of Toronto*, accessed April 4, 2016, http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=1571dada600f0410VgnVCM10000071d60f89RCRD&vgnextchannel=5c98dada600f0410VgnVCM10000071d60f89RCRD

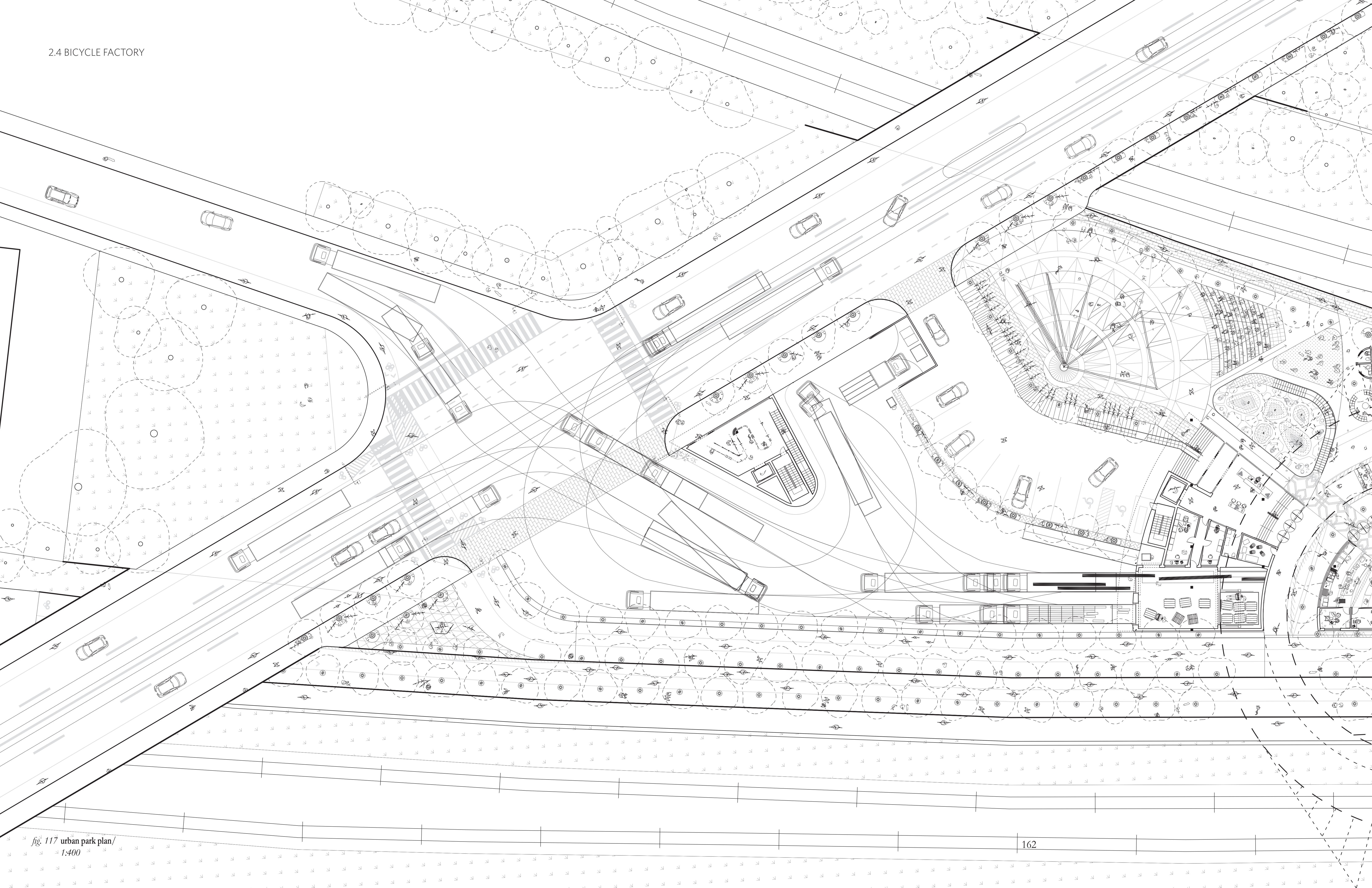
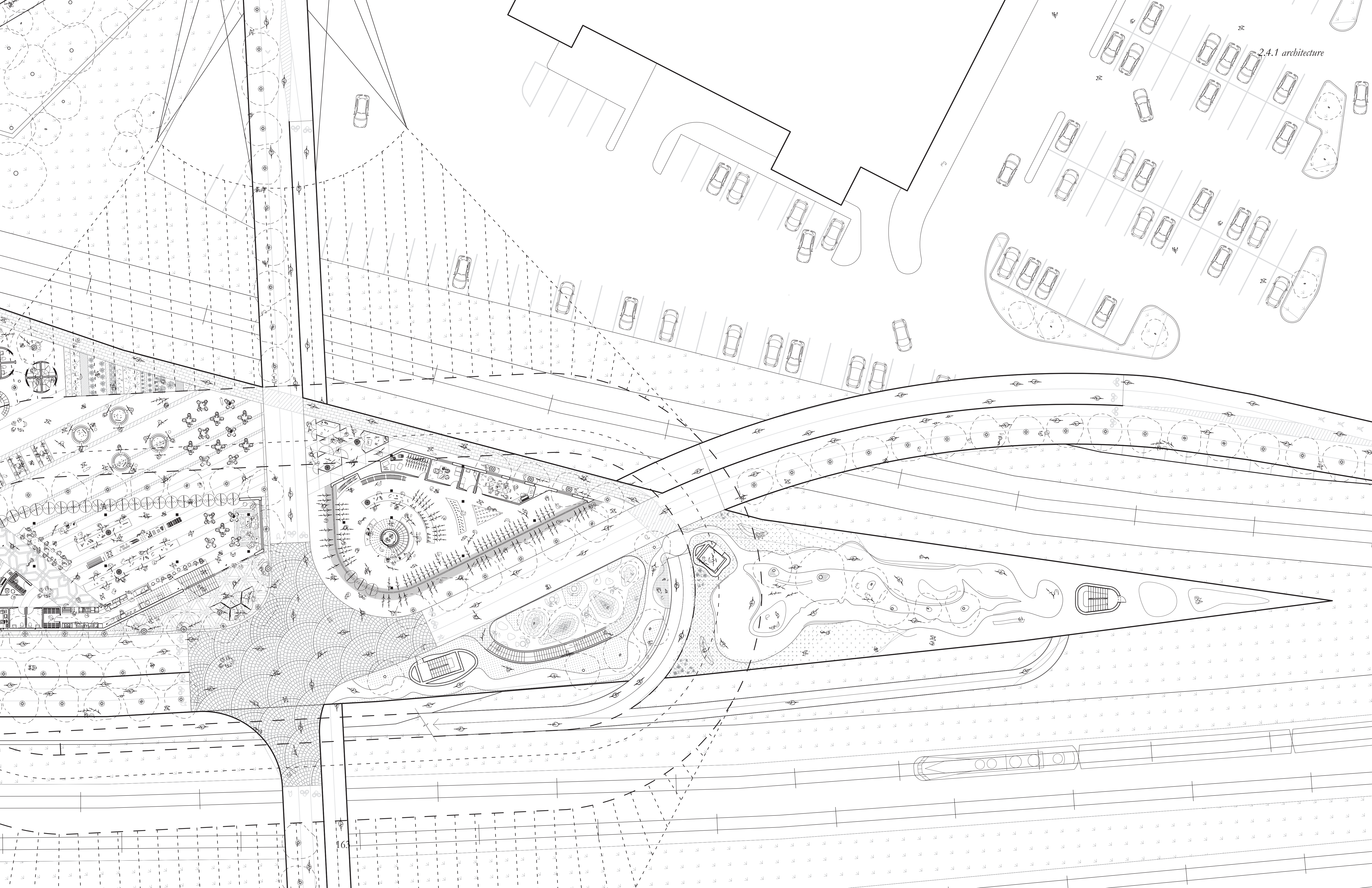


fig. 117 urban park plan/
1:400



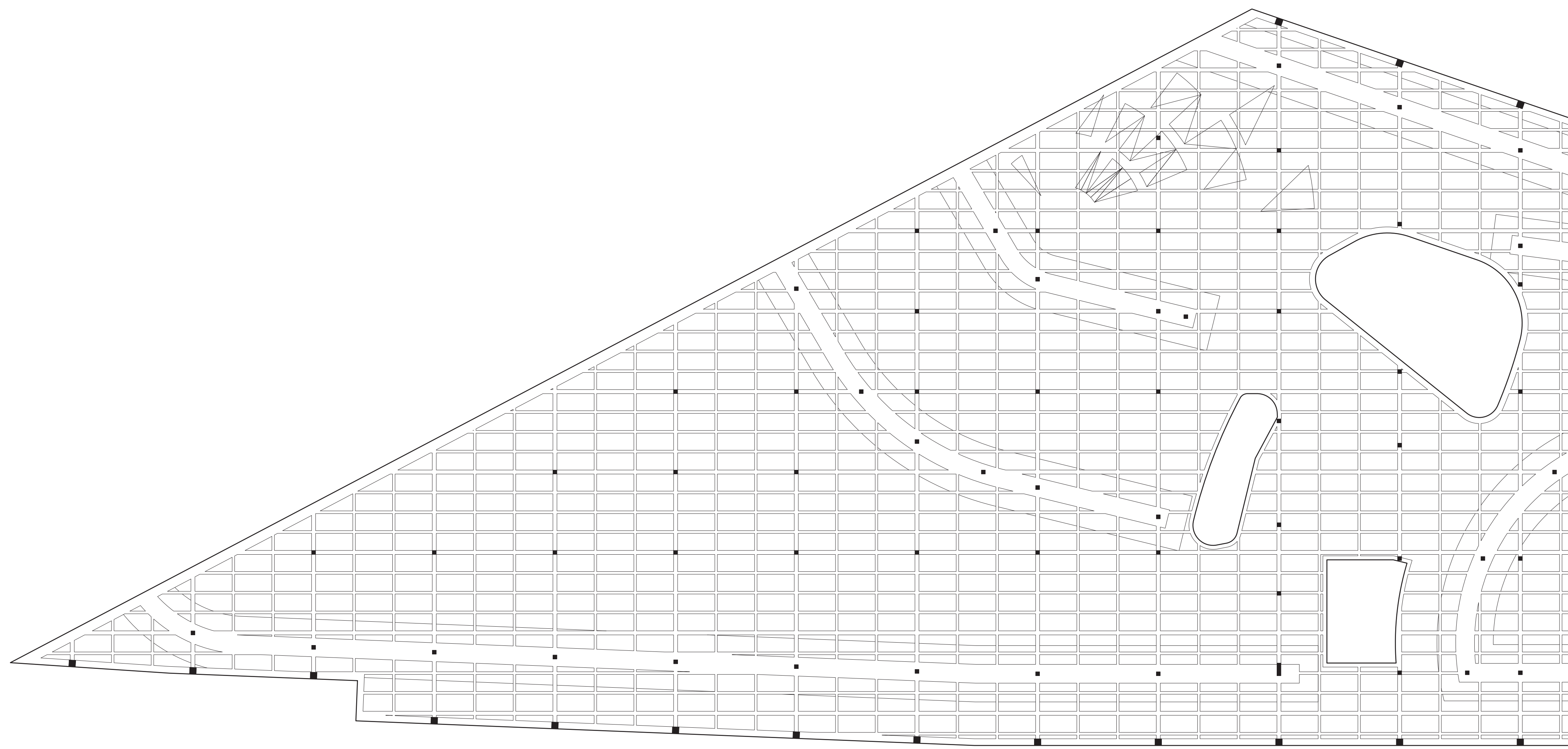
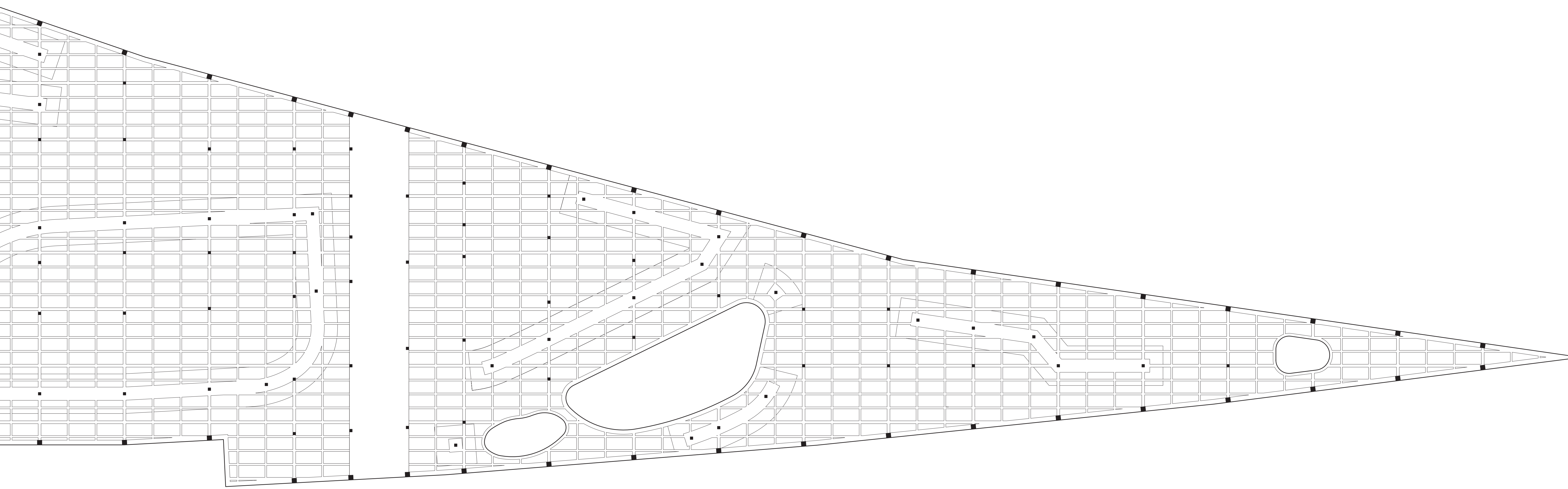


fig. 118 reflected ceiling plan/
1:400



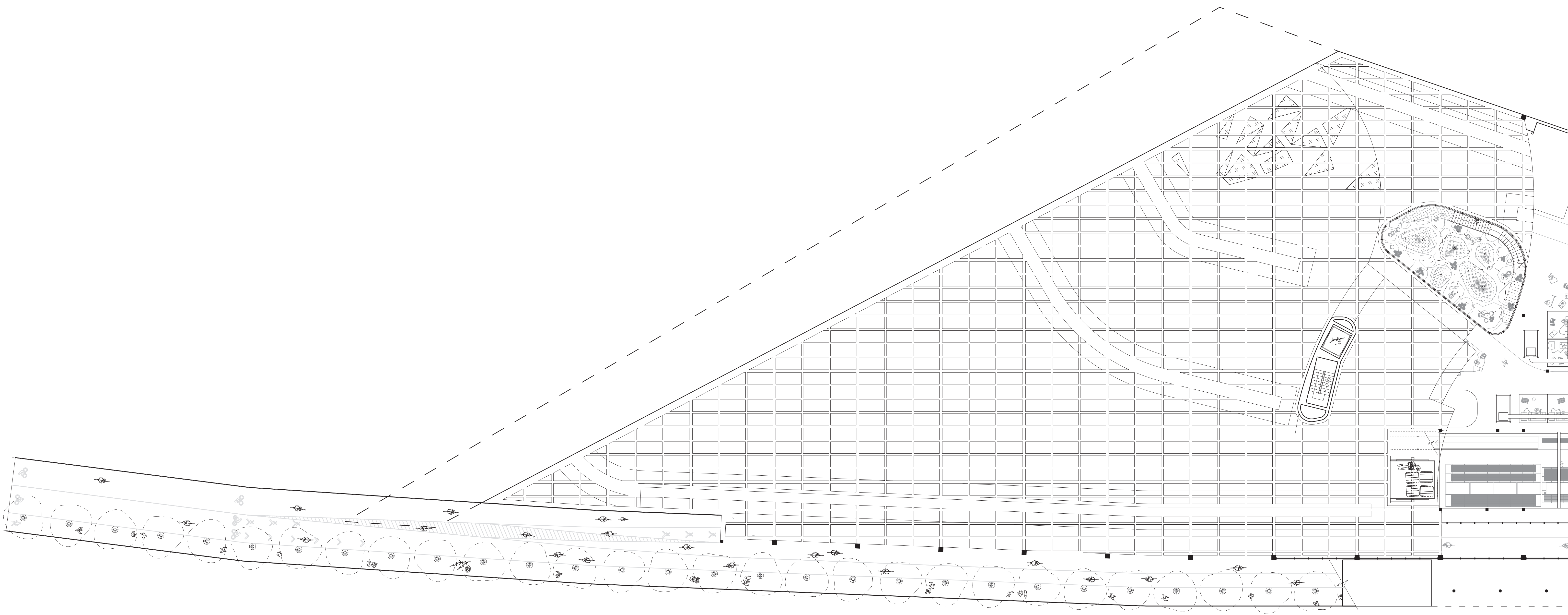


fig. 119 factory bridge 'mezzanine' level plan/ *1:400*

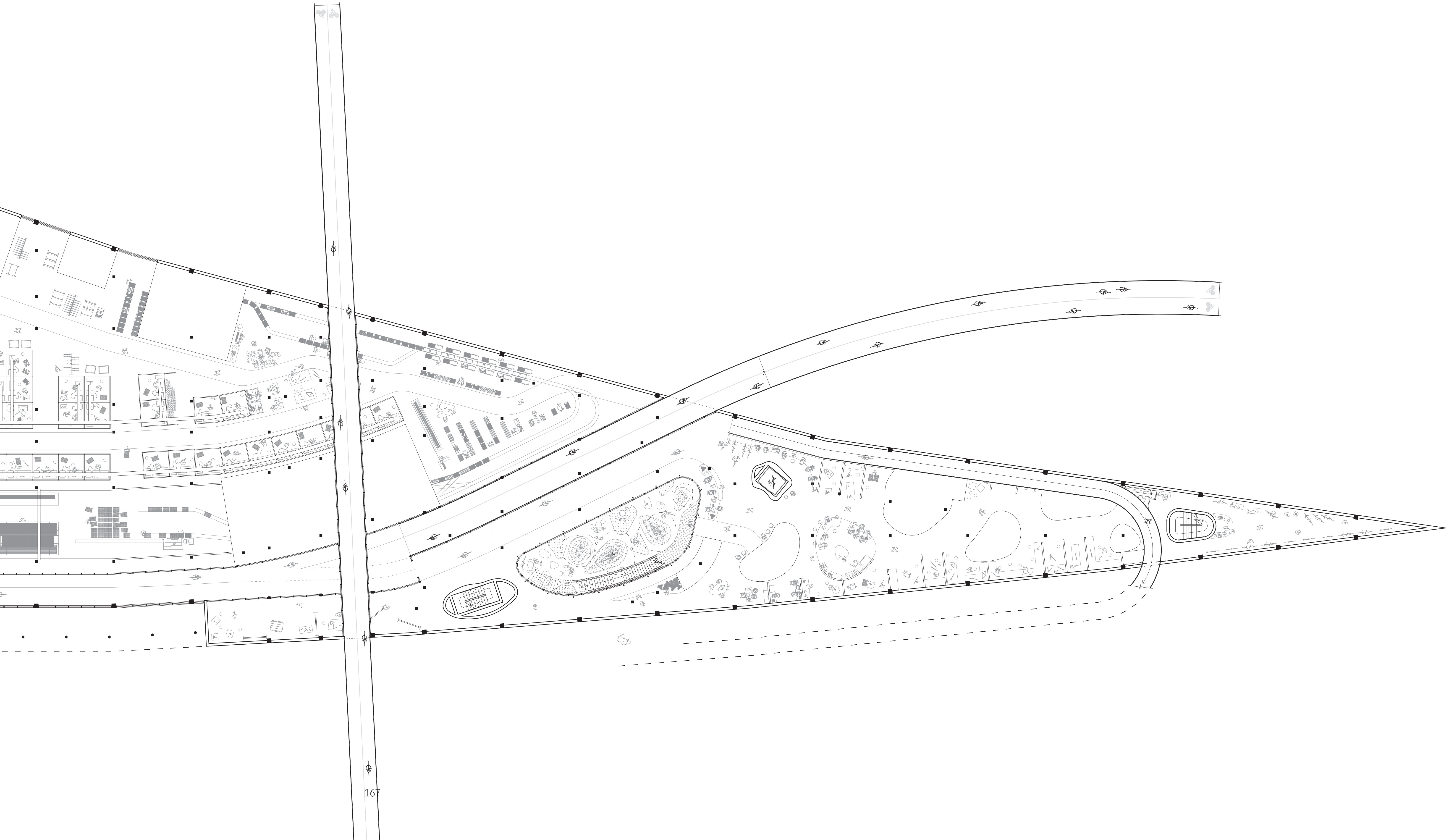
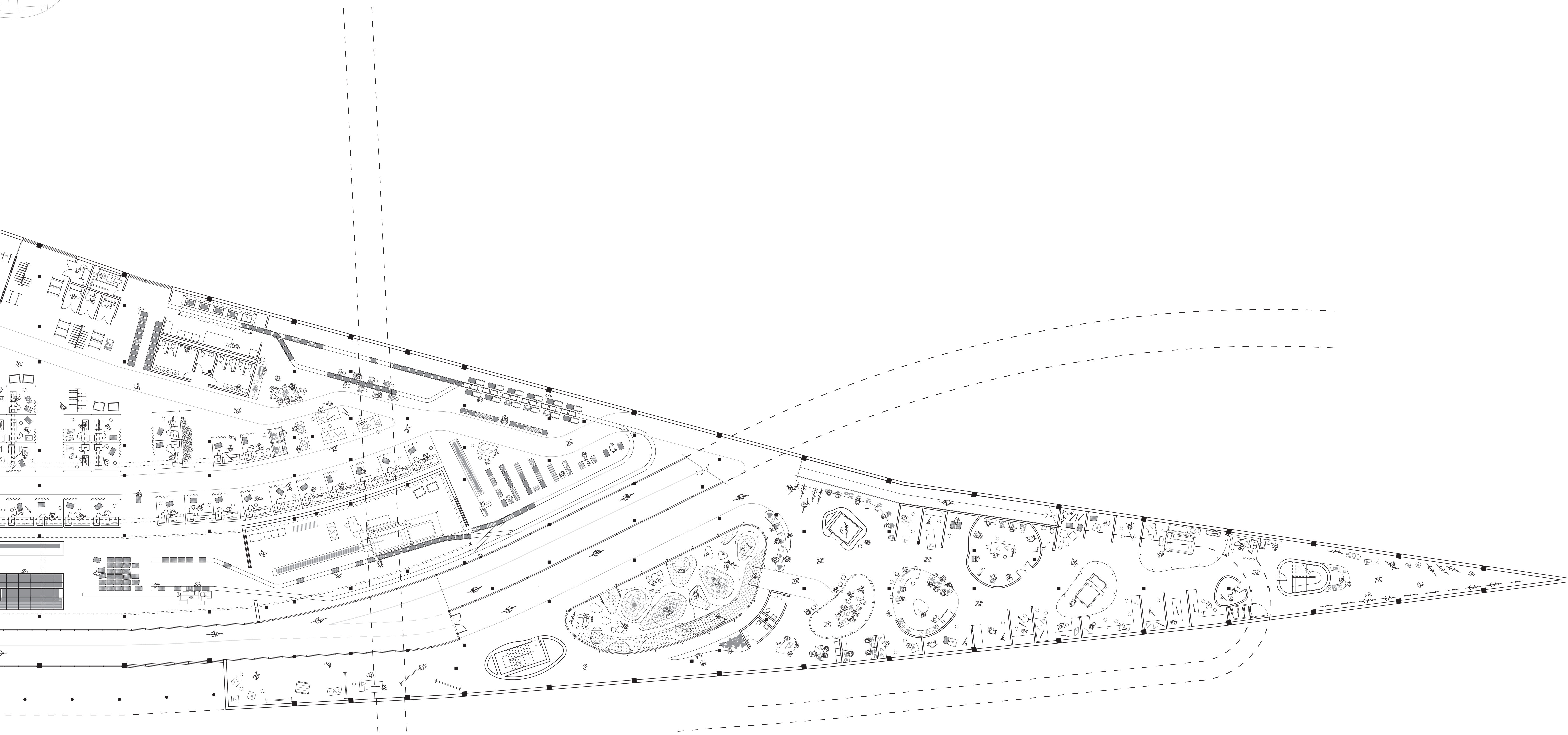


fig. 120 **factory plan/**
1:400



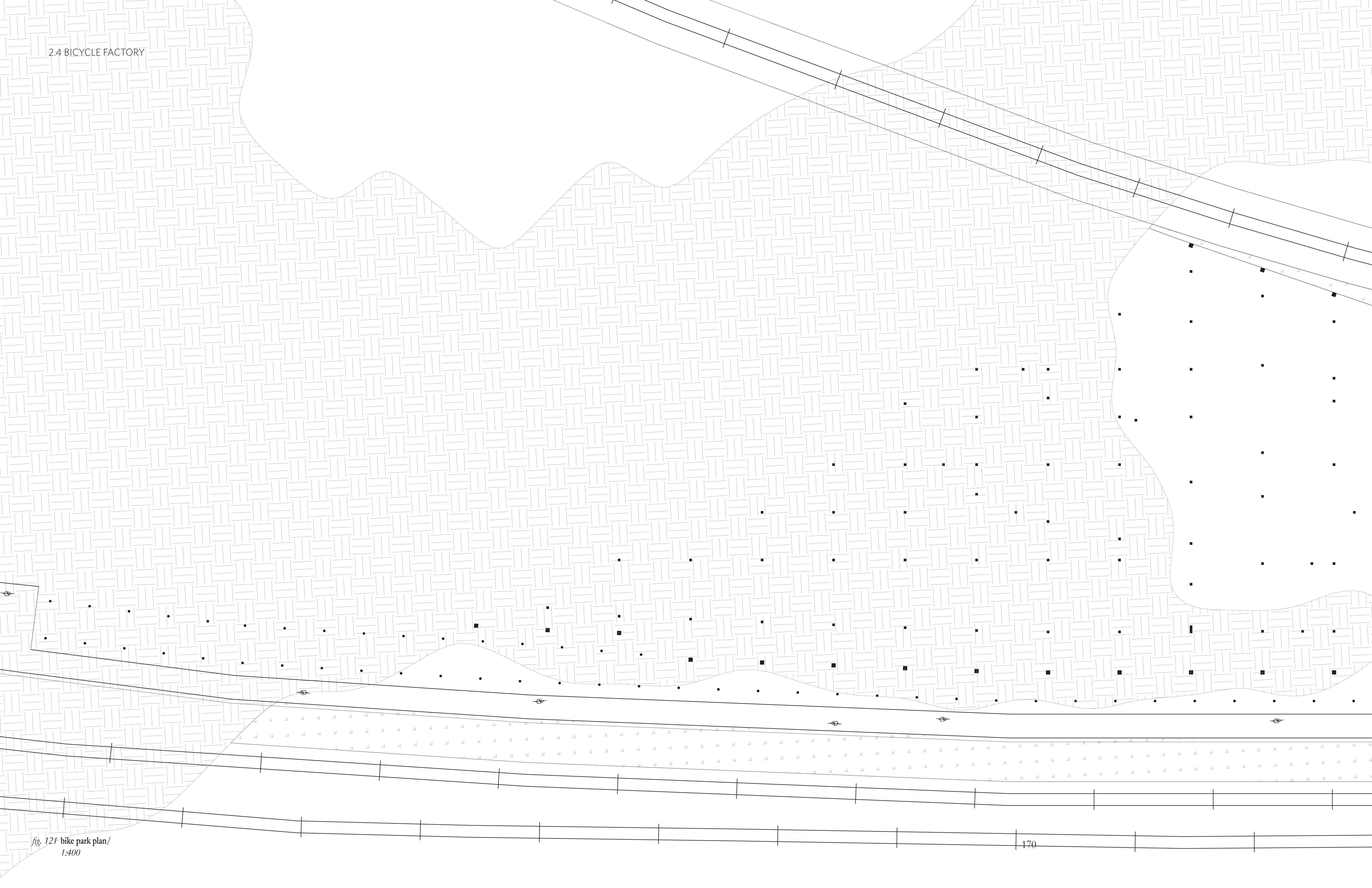
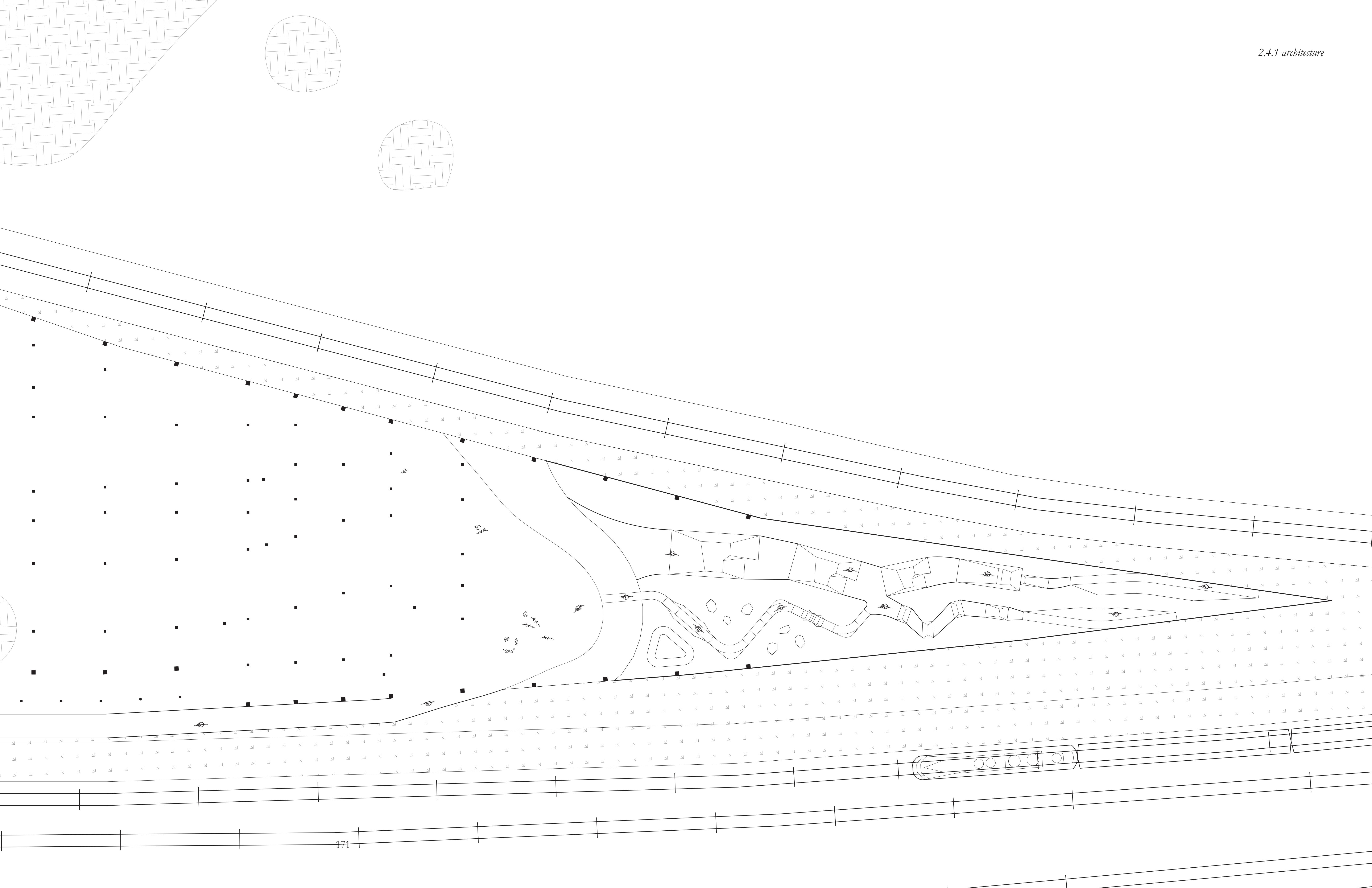


fig. 121 bike park plan/
1:400



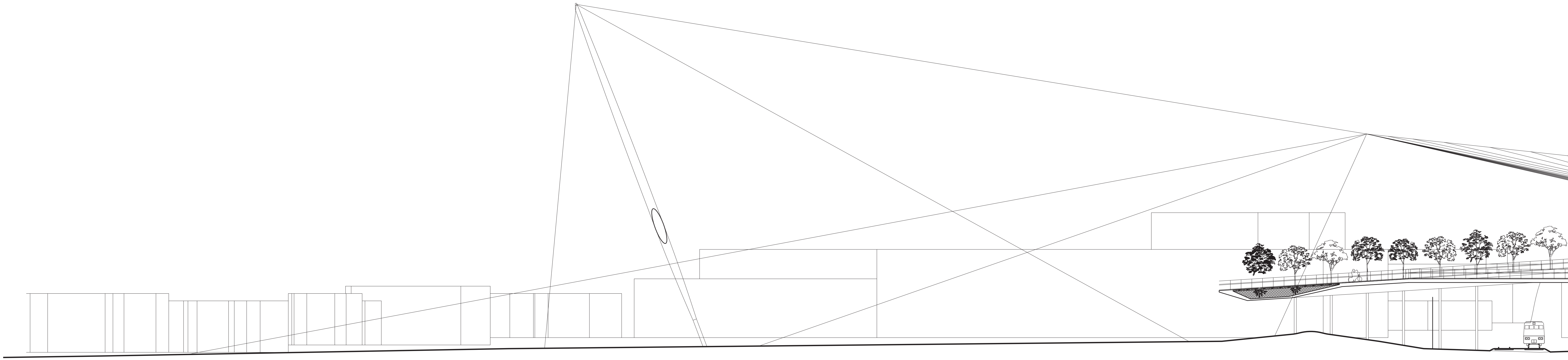


fig. 122 cross section/
1:500

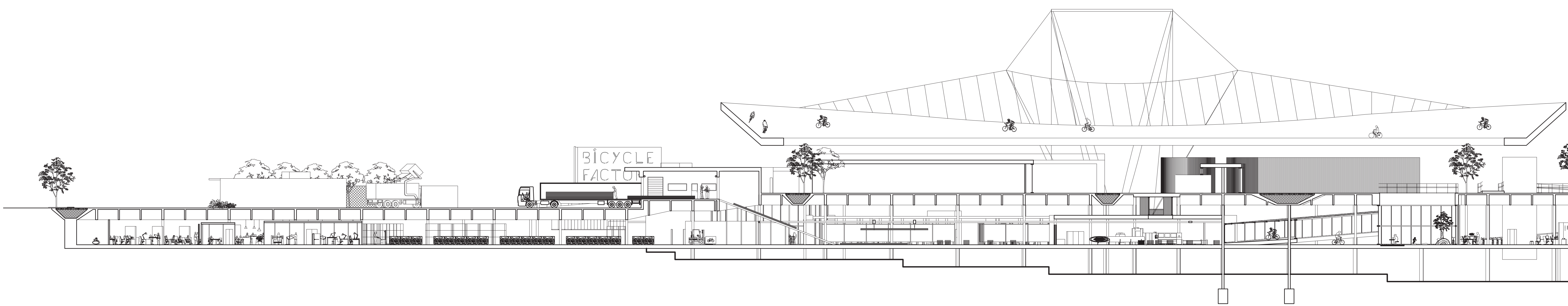
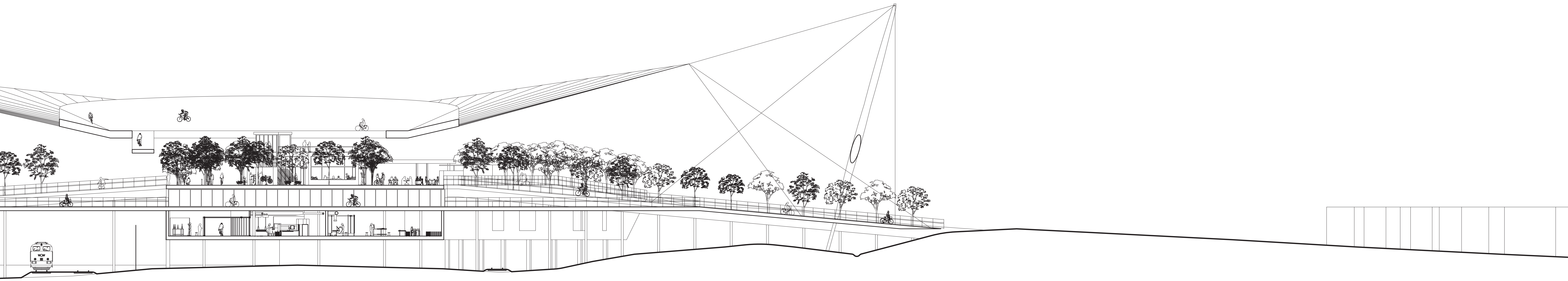
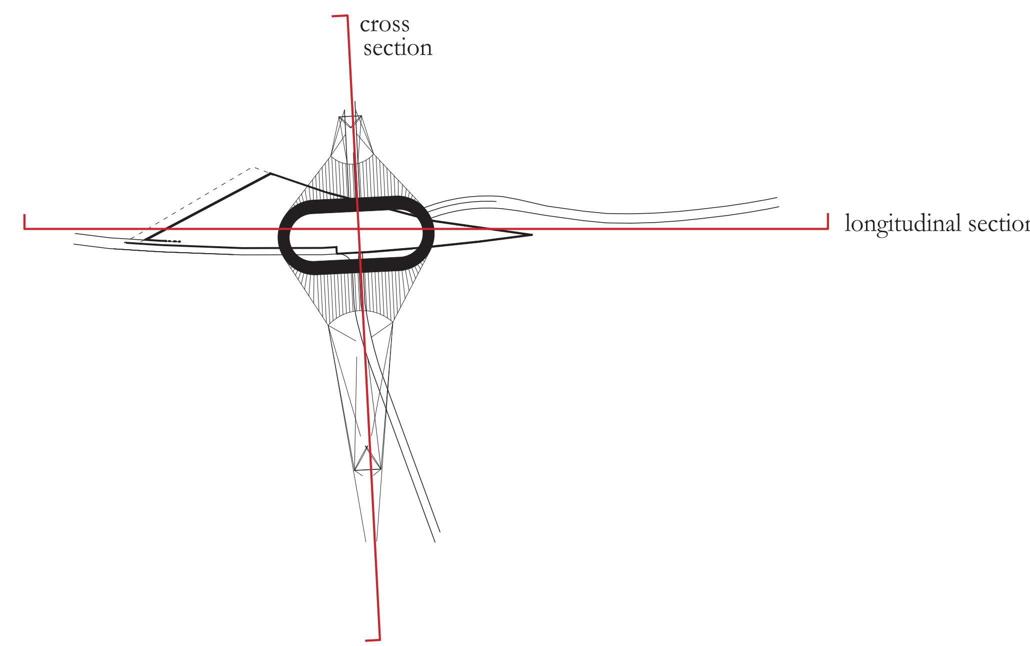


fig. 123 longitudinal section/
1:500




cross
section
longitudinal section

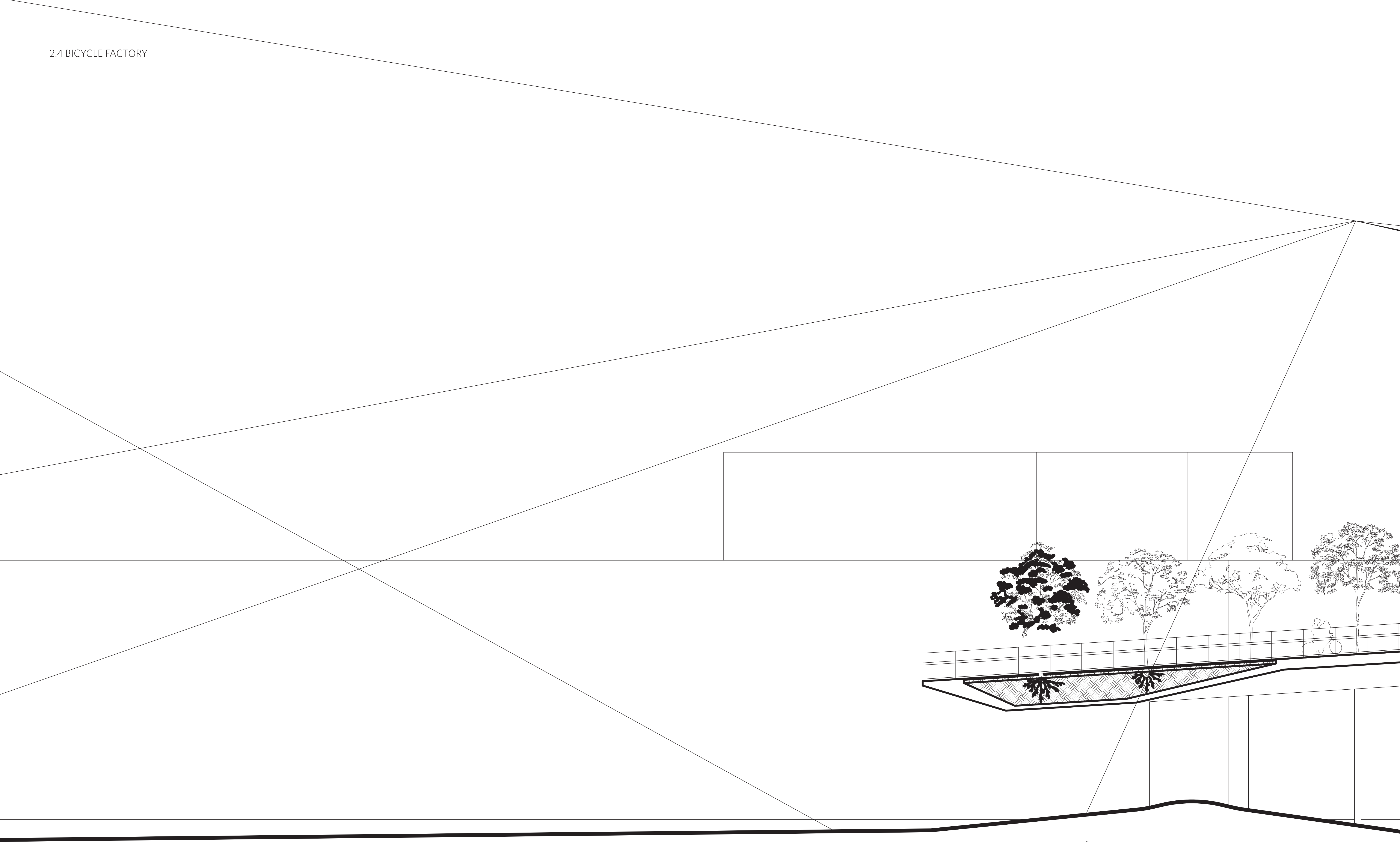
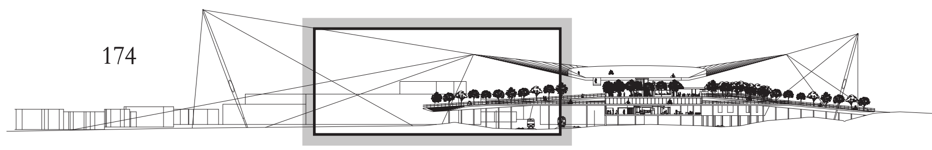
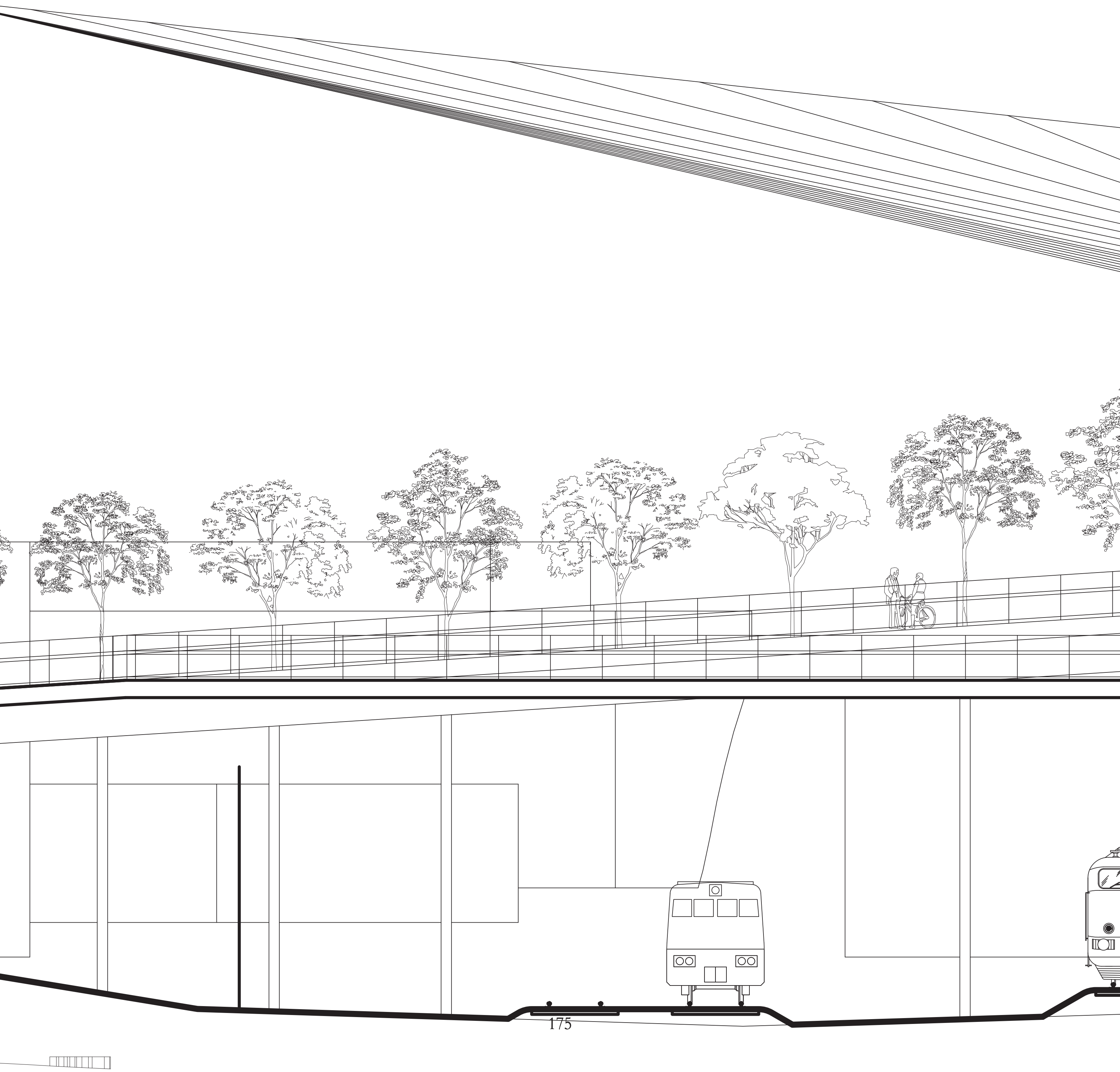


fig. 124 **cross section**/*enlarged series — pt.1*
1:250





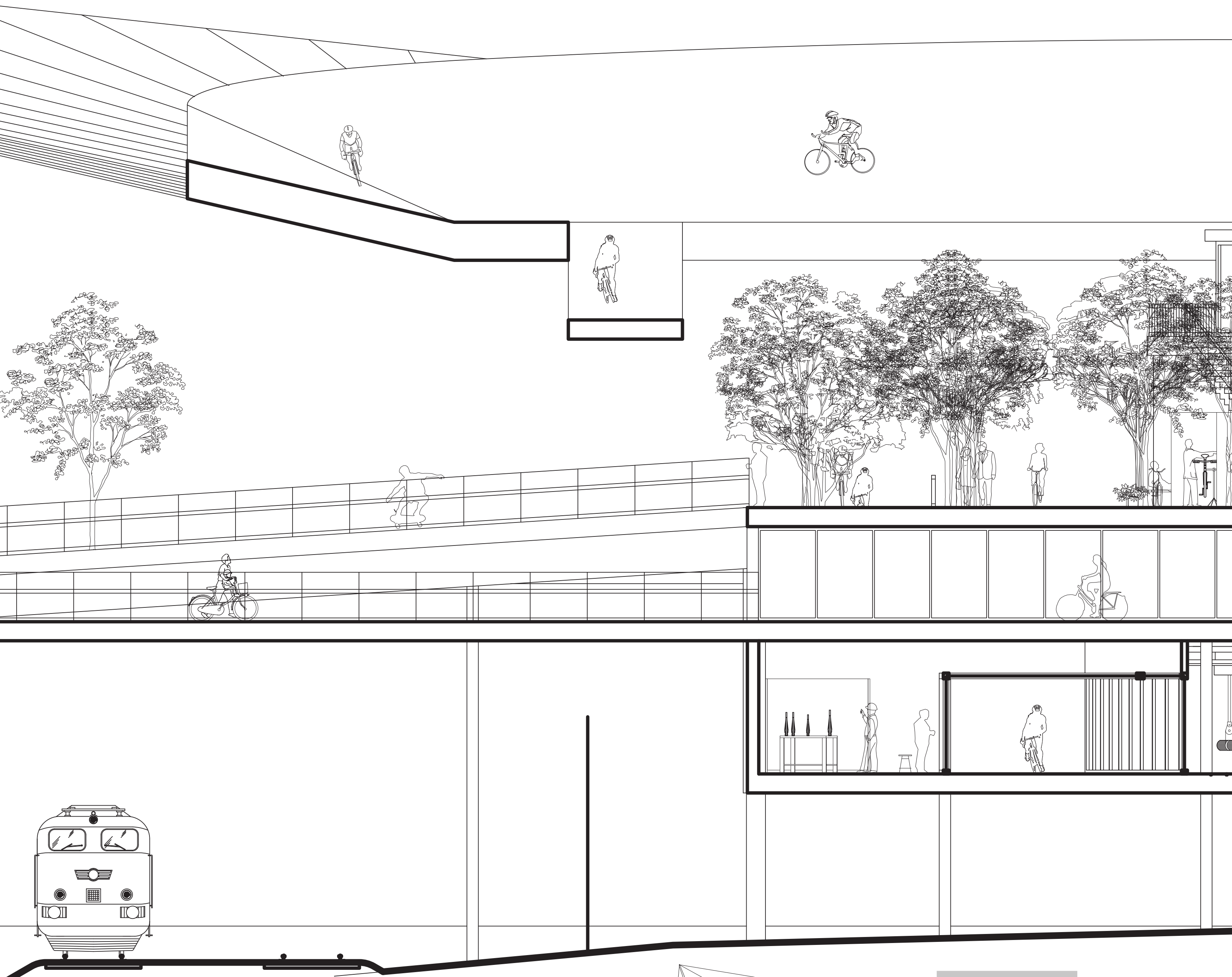
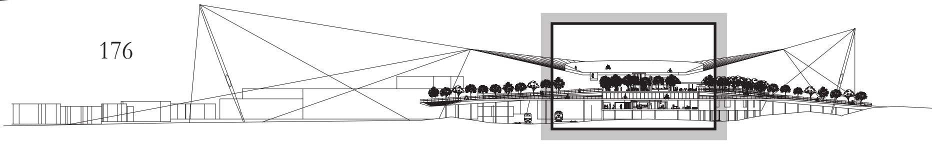
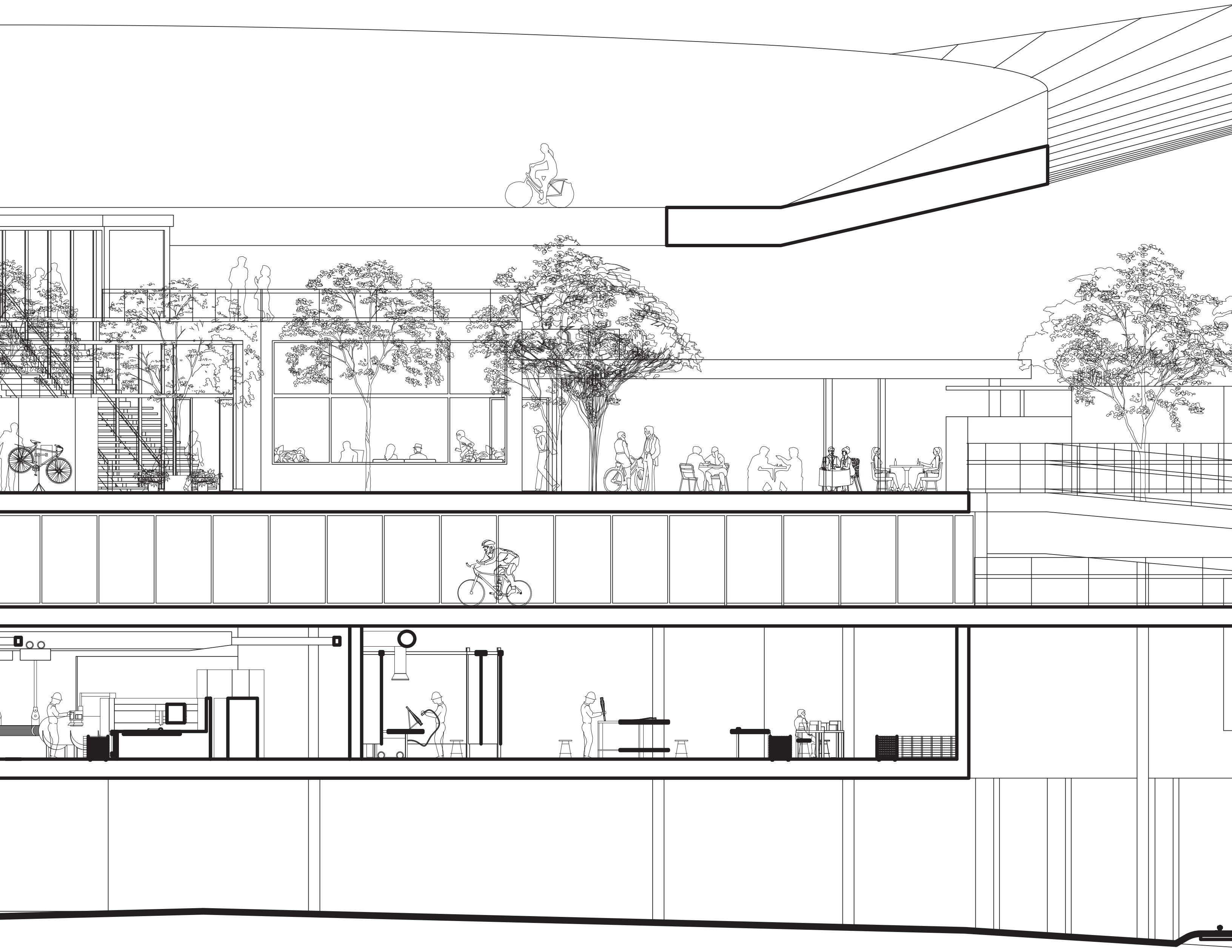


fig. 125 **cross section**/*enlarged series — pt.2*
1:250





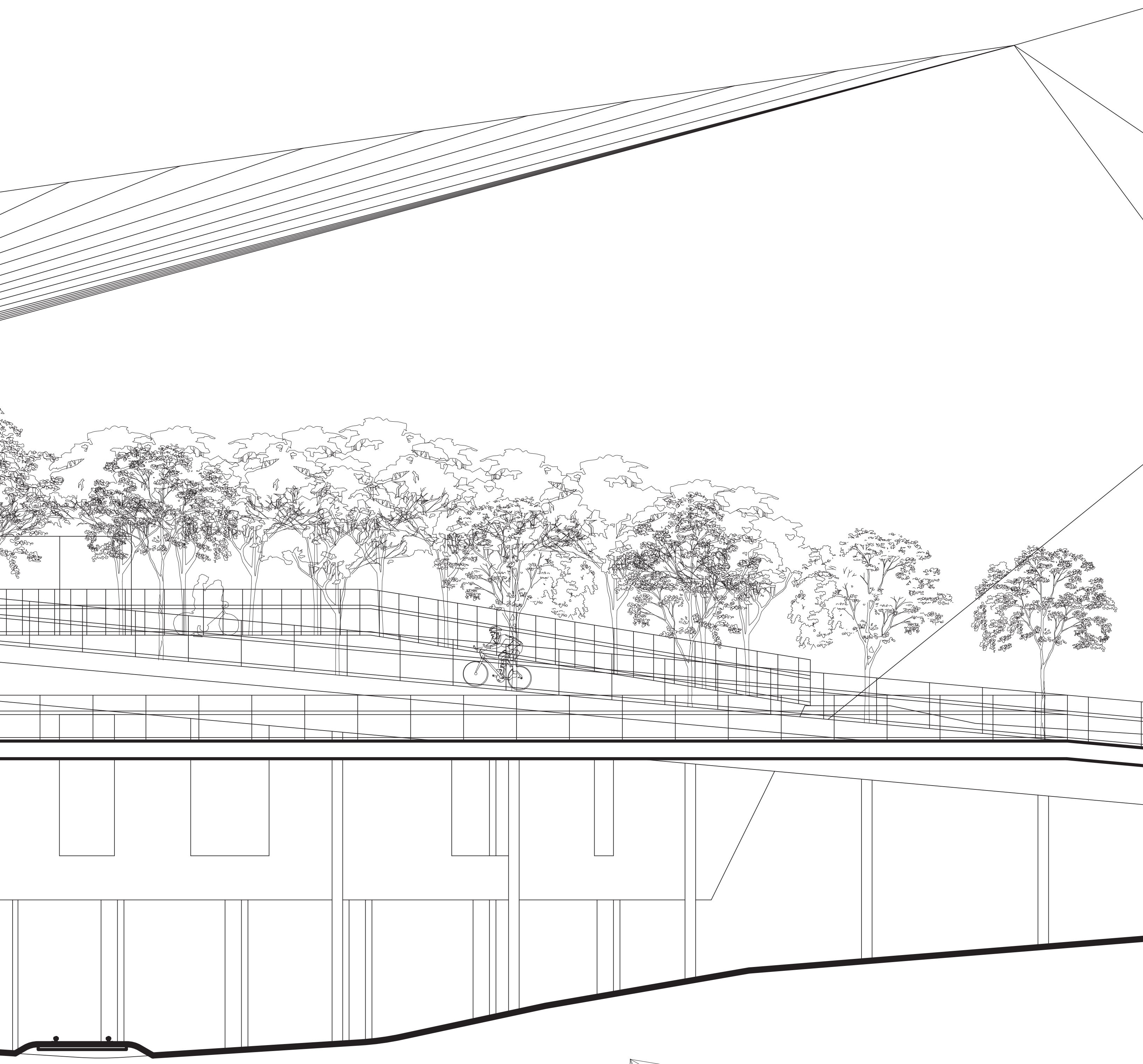
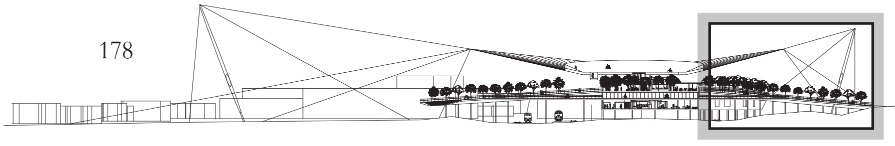
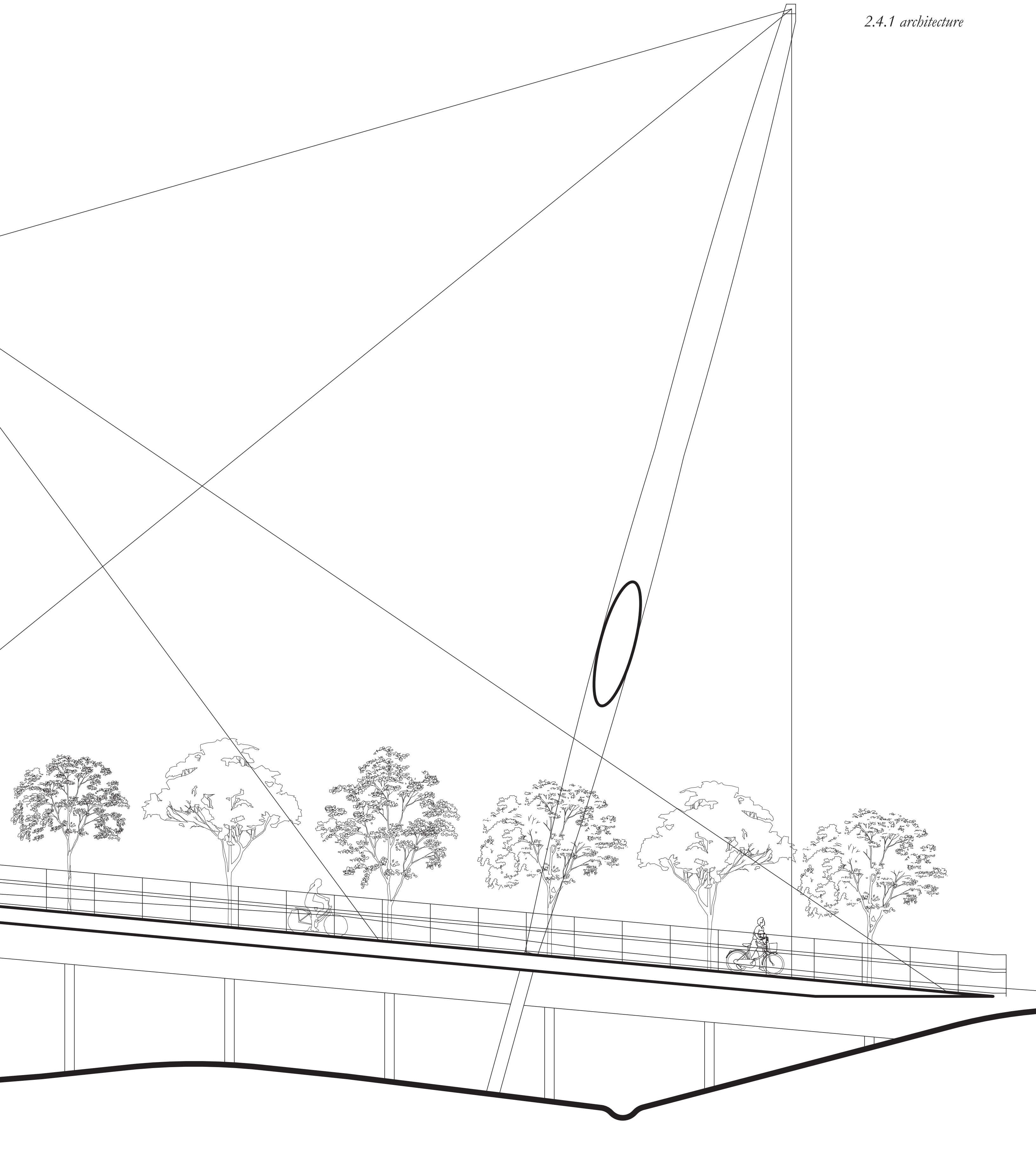


fig. 126 **cross section**/*enlarged series — pt.3*
1:250





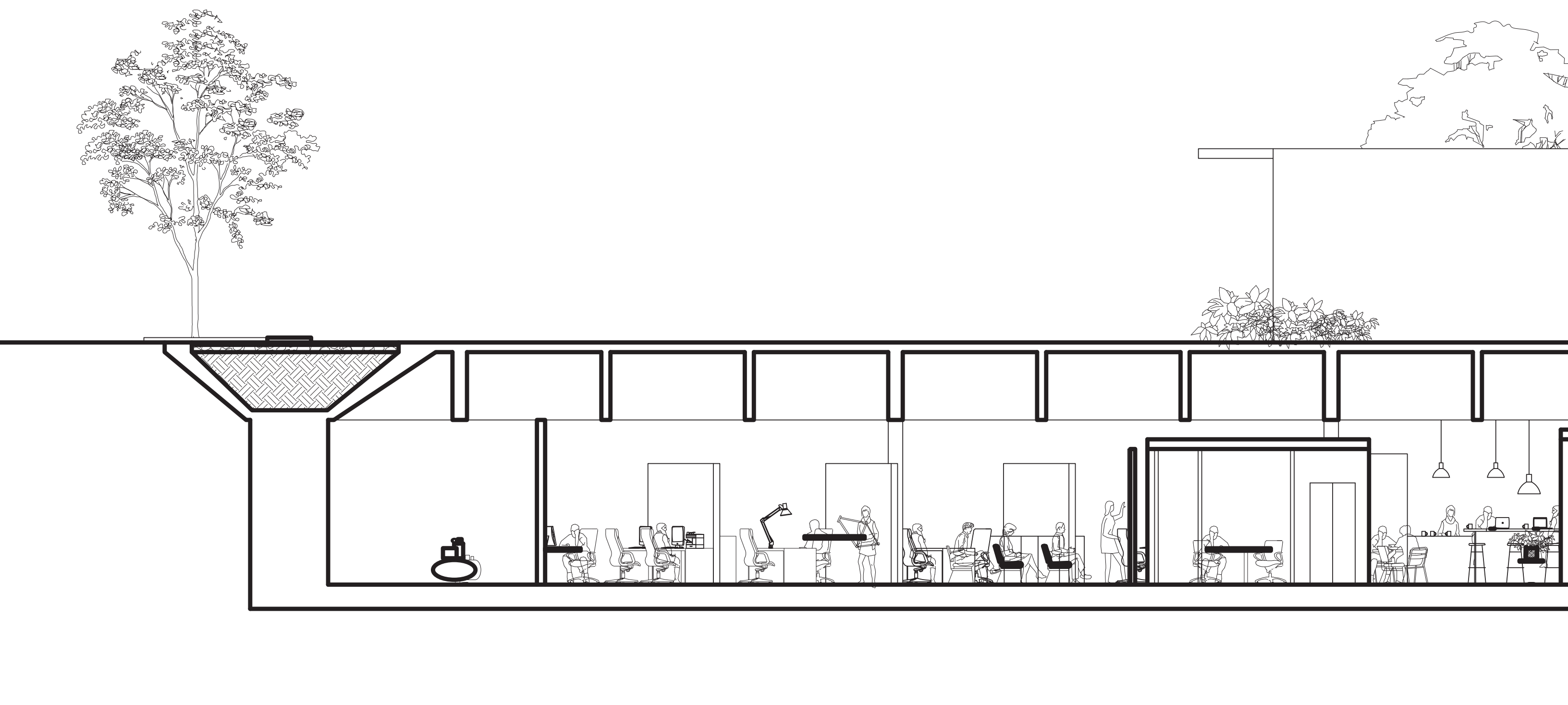
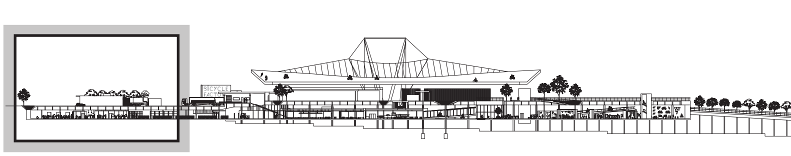
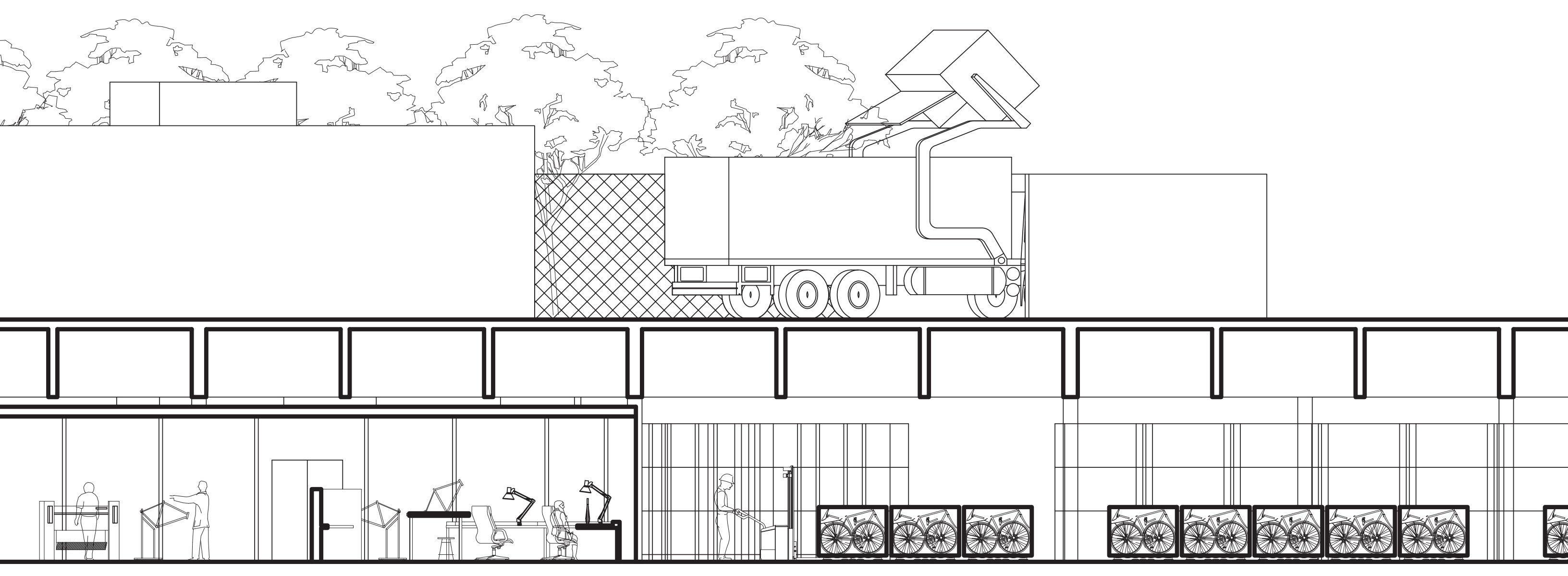


fig. 127 **longitudinal section**/*enlarged series — pt.1*
1:250





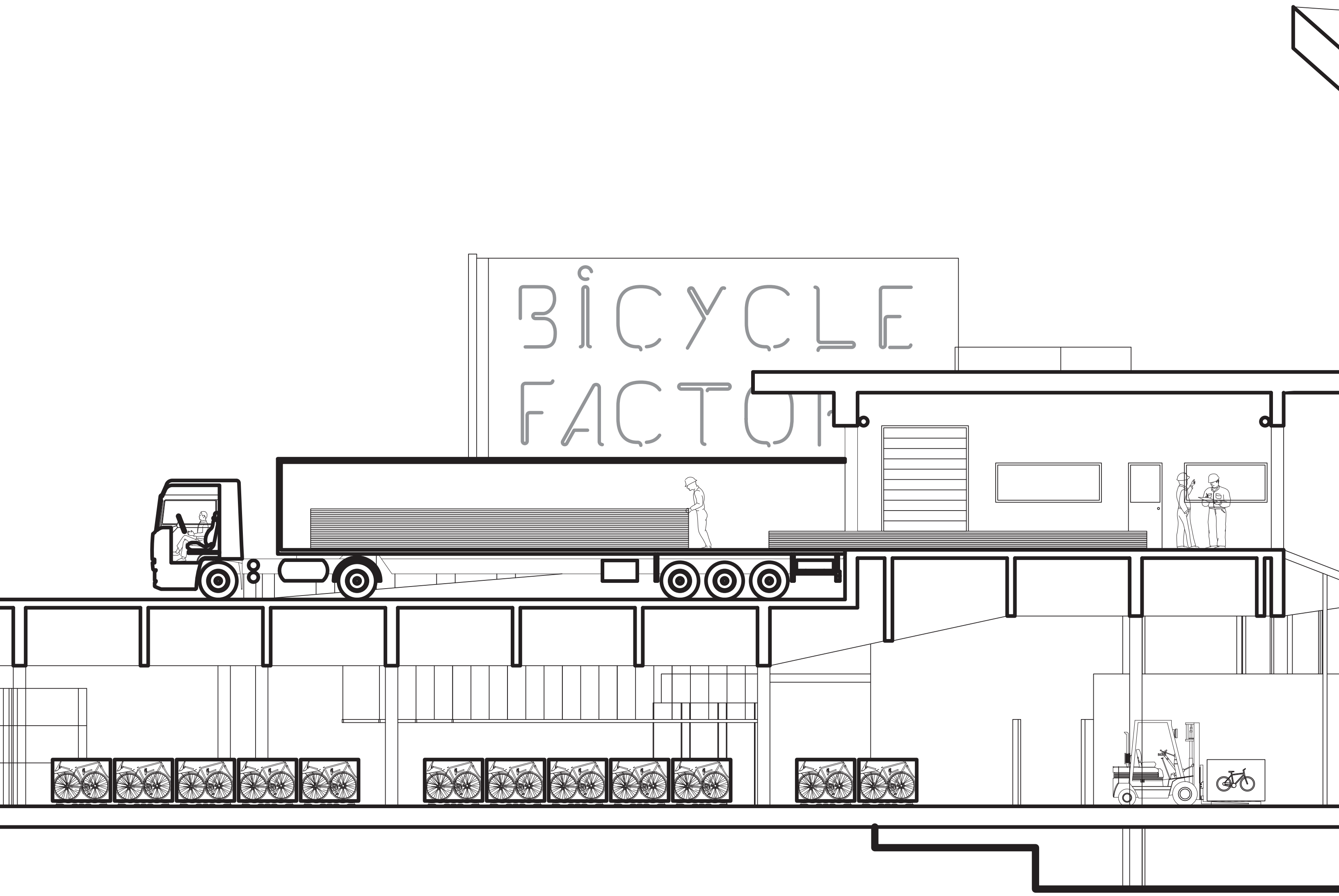
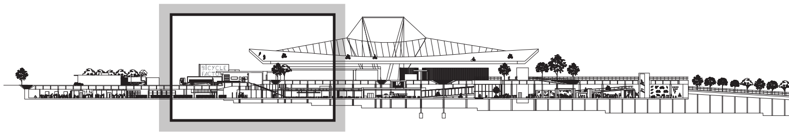
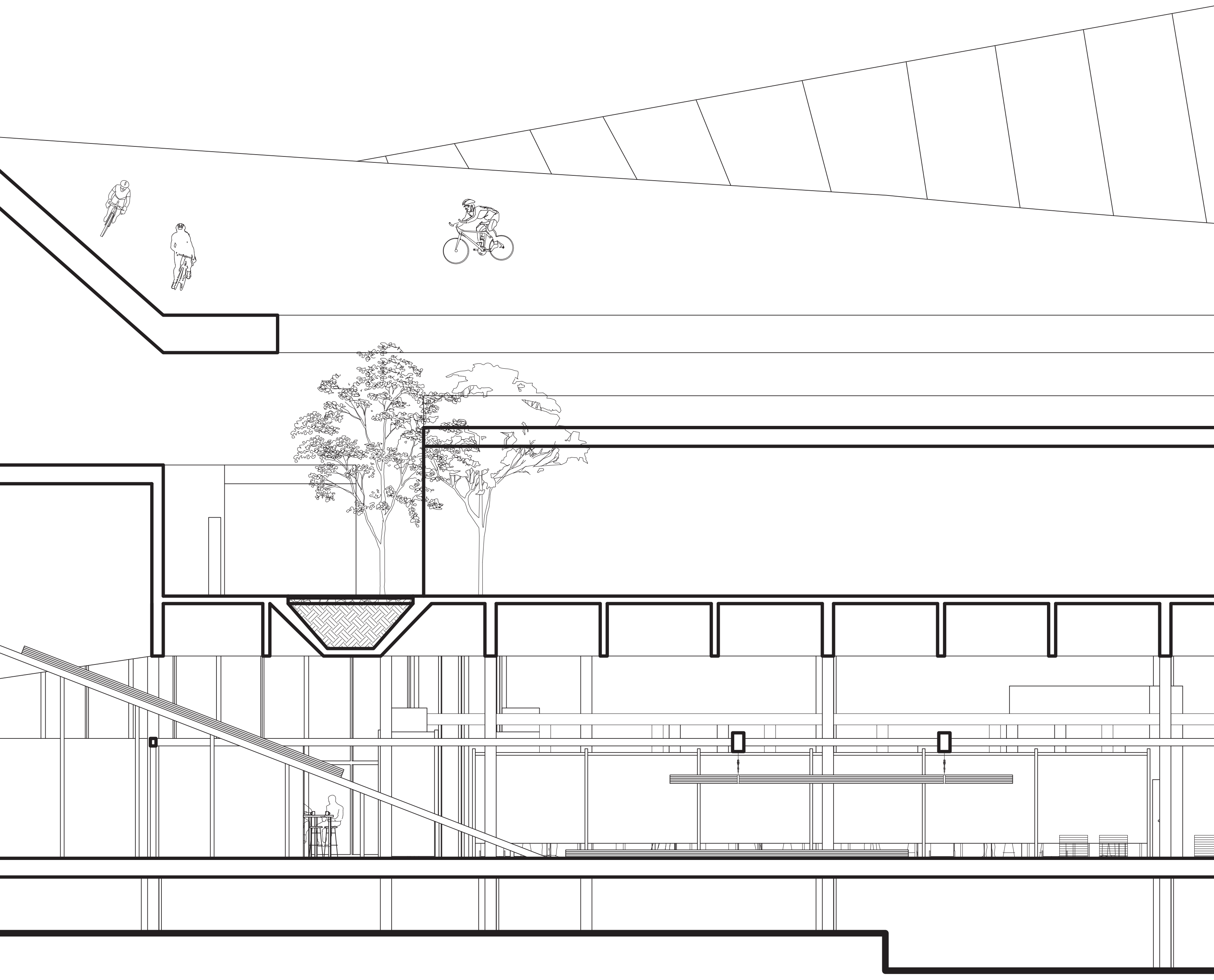


fig. 128 **longitudinal section**/*enlarged series — pt.2*
1:250





2.4 BICYCLE FACTORY

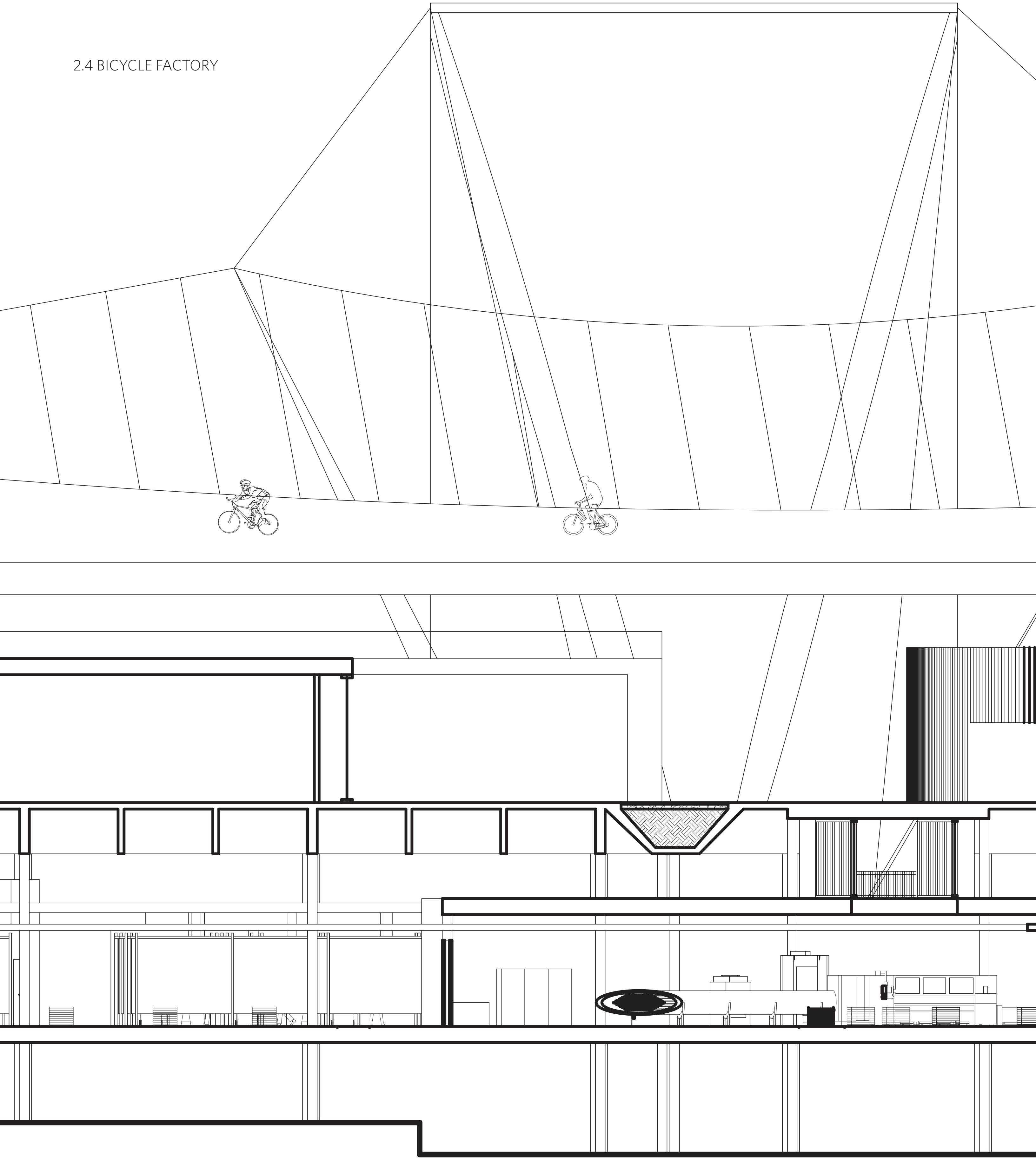
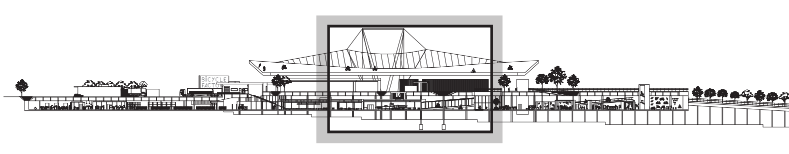
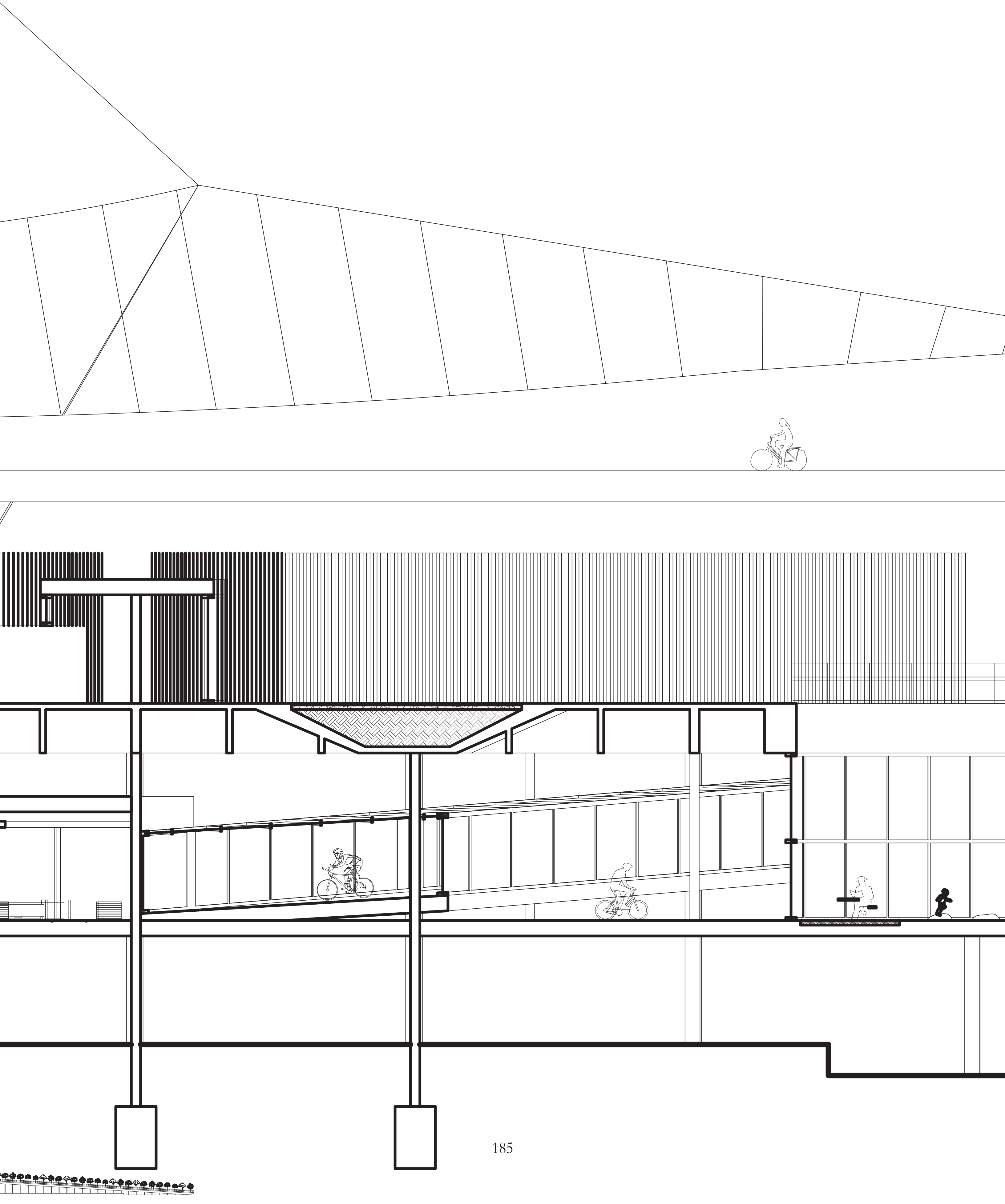


fig. 129 **longitudinal section**/*enlarged series — pt.3*
1:250





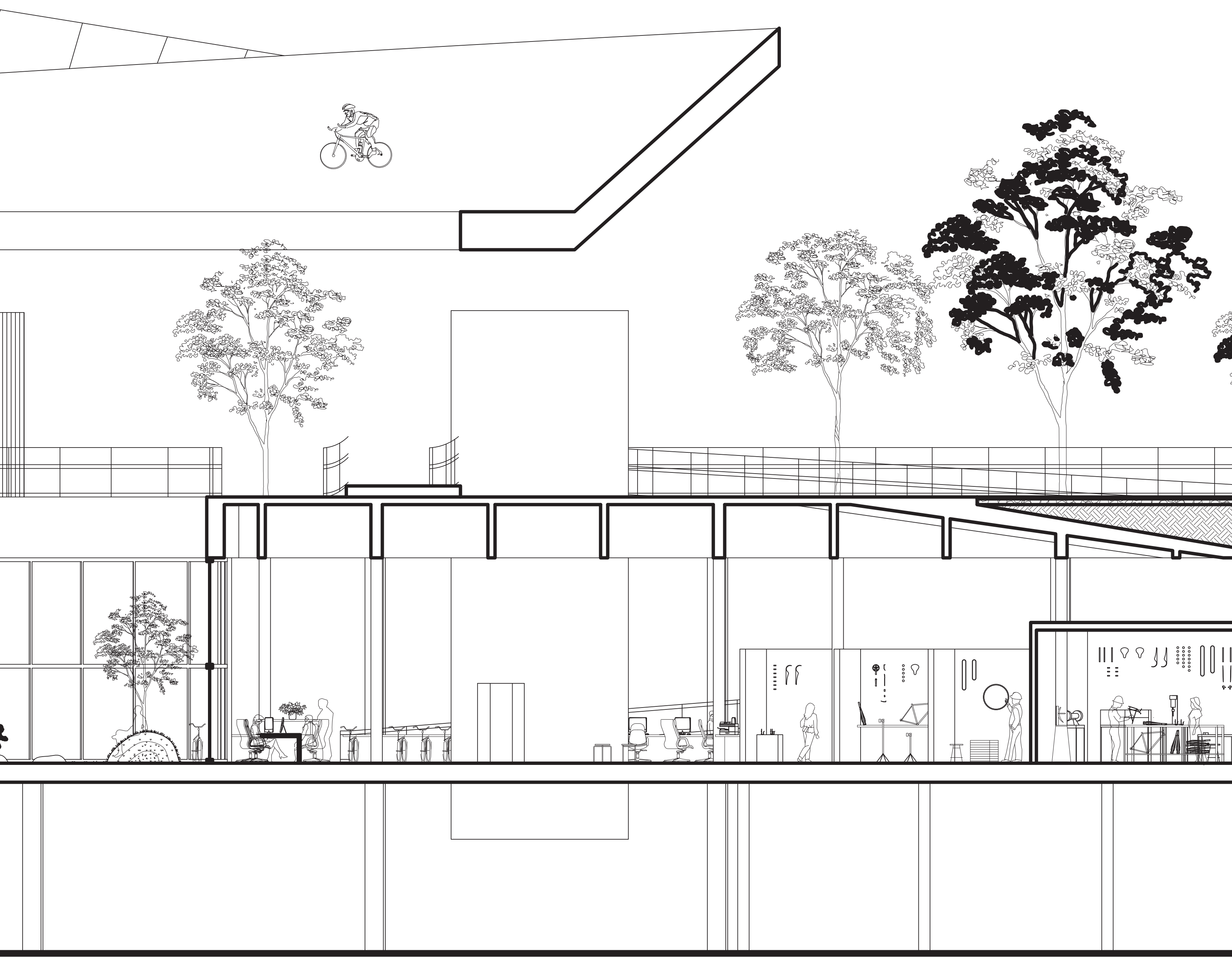
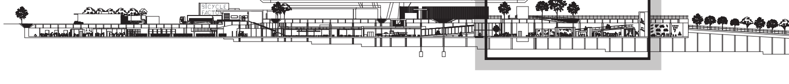
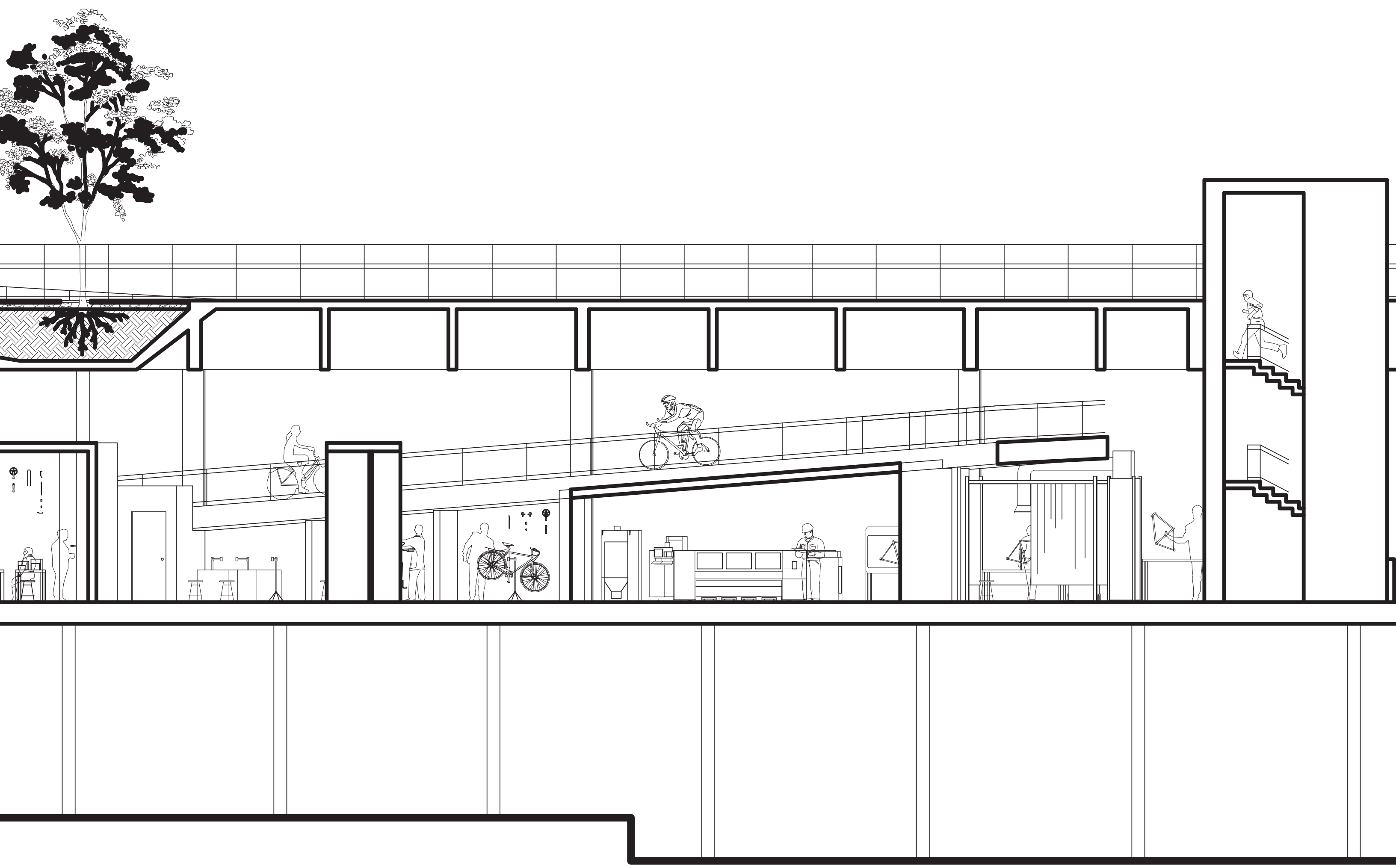


fig. 130 **longitudinal section**/*enlarged series — pt.4*
1:250





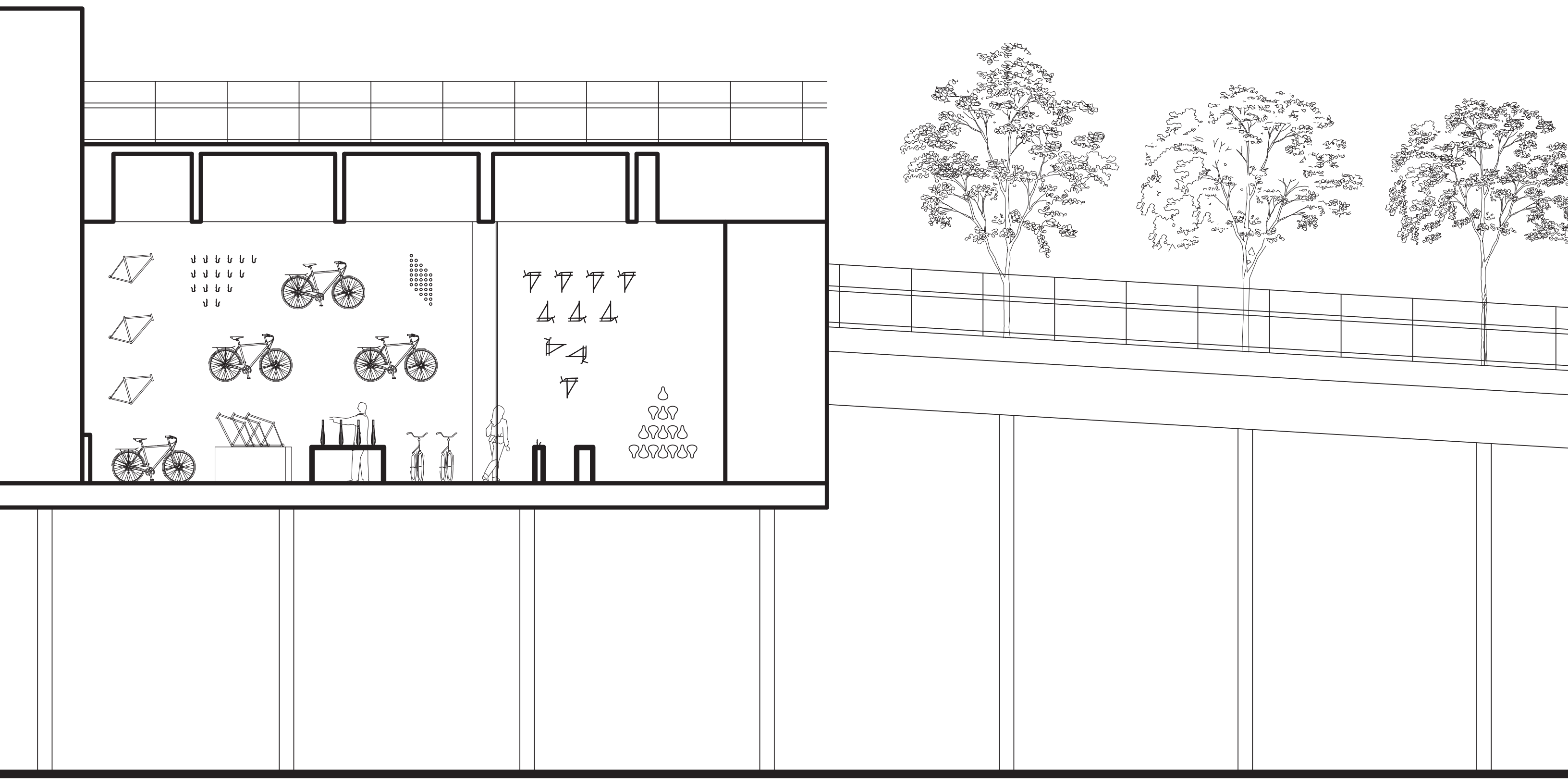
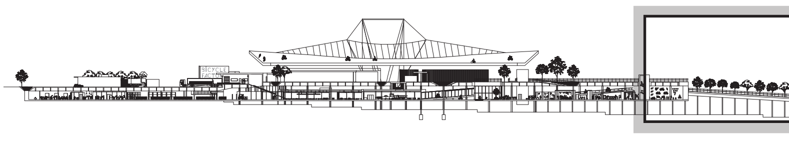
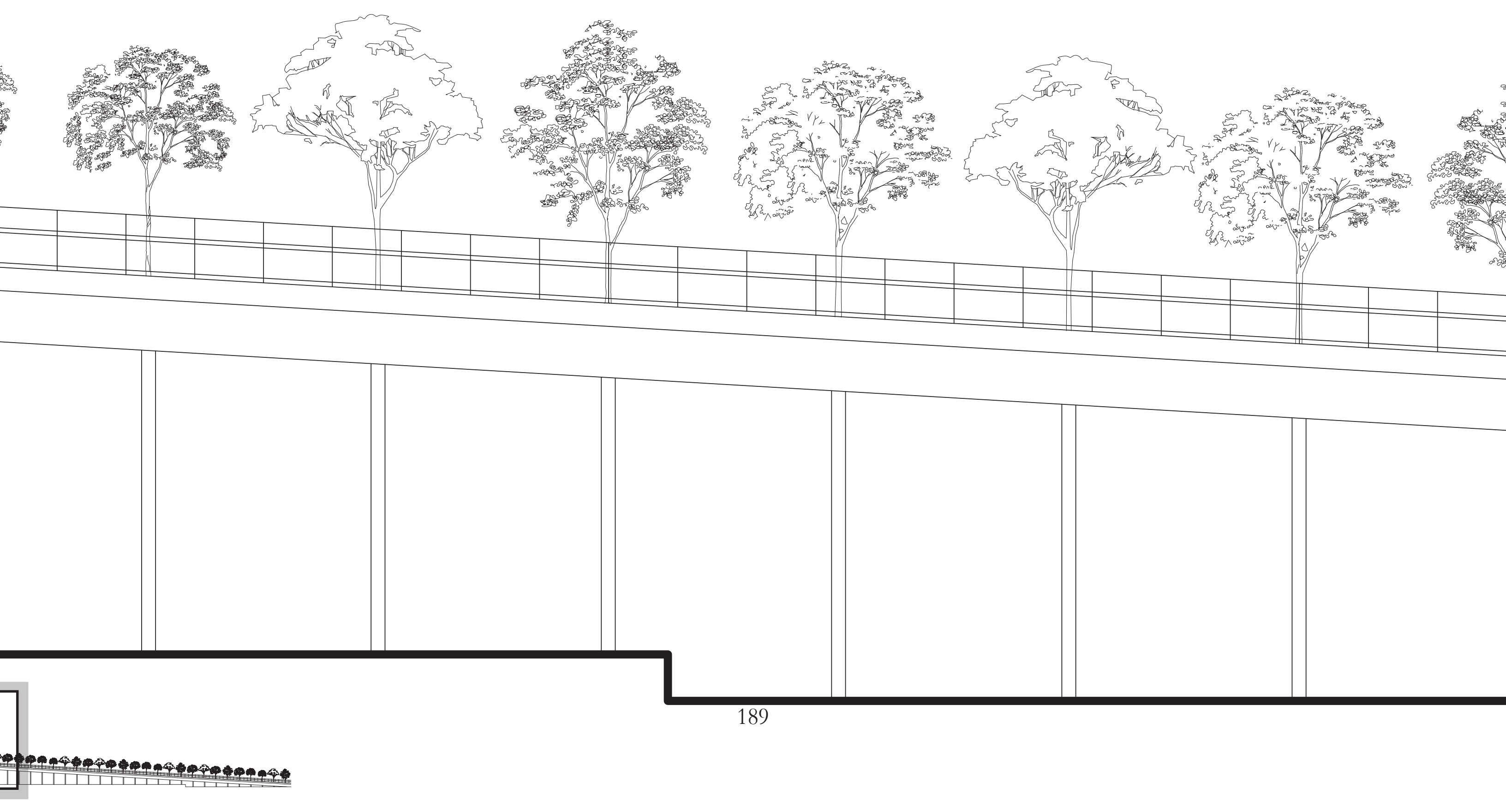


fig. 131 **longitudinal section**/*enlarged series — pt.5*
1:250





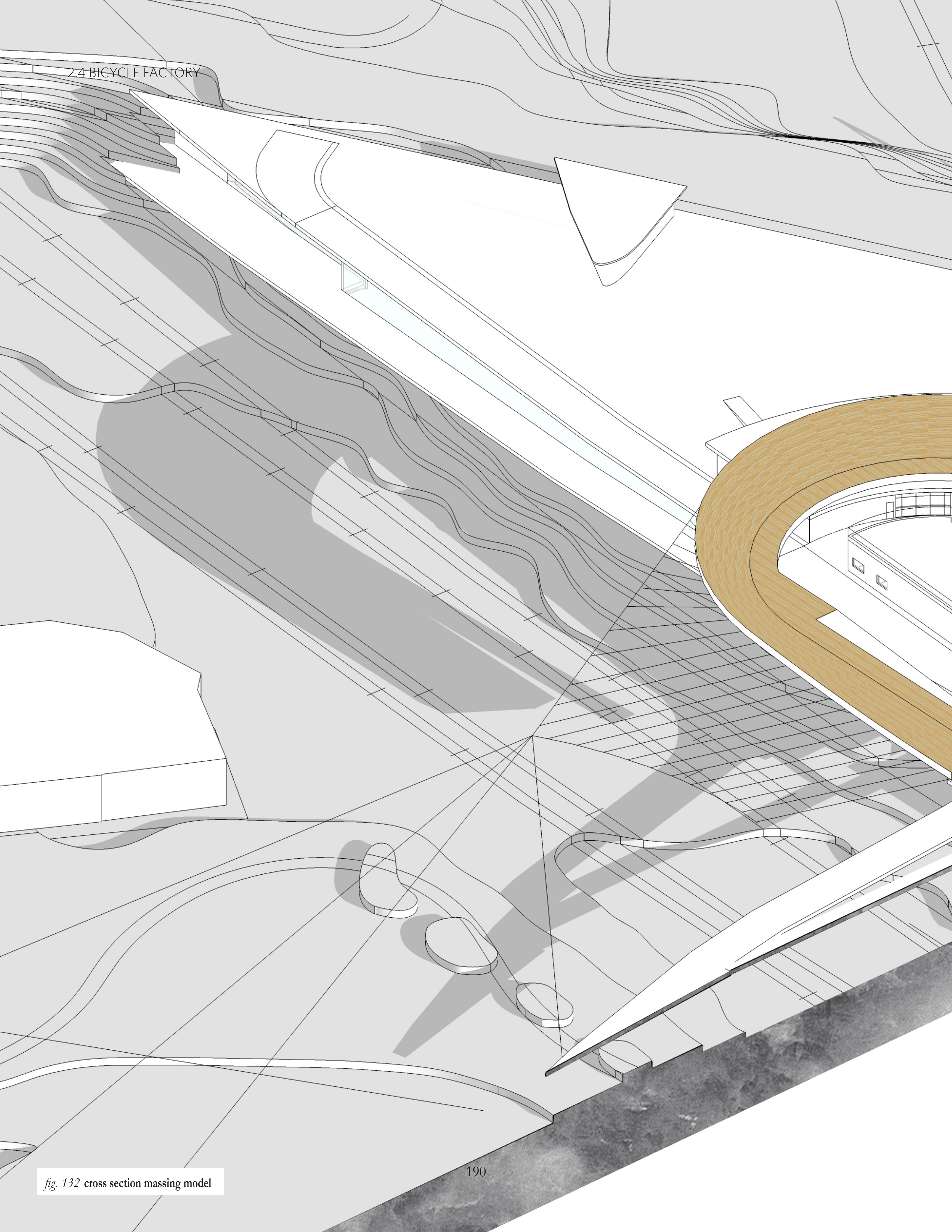
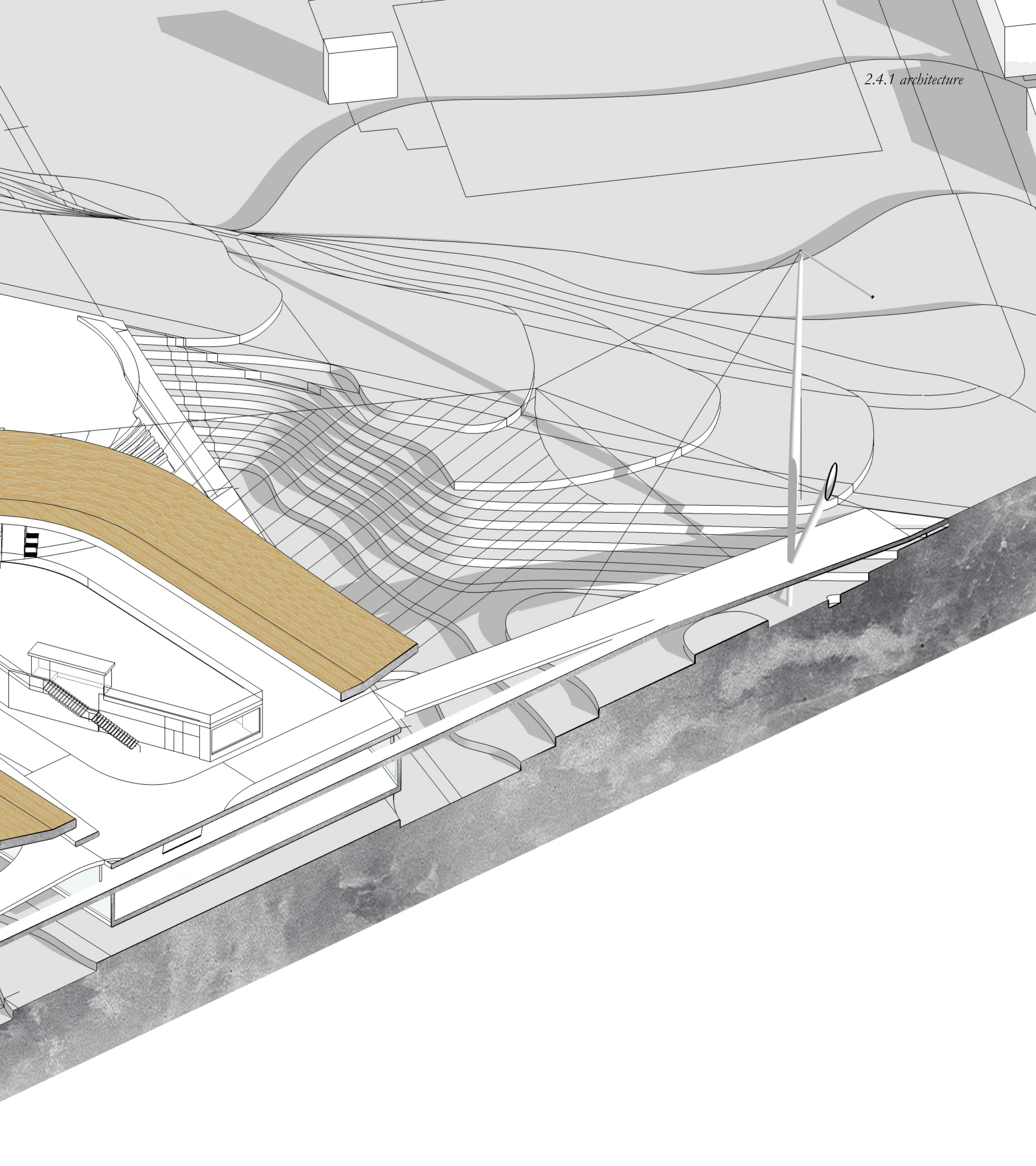


fig. 132 cross section massing model



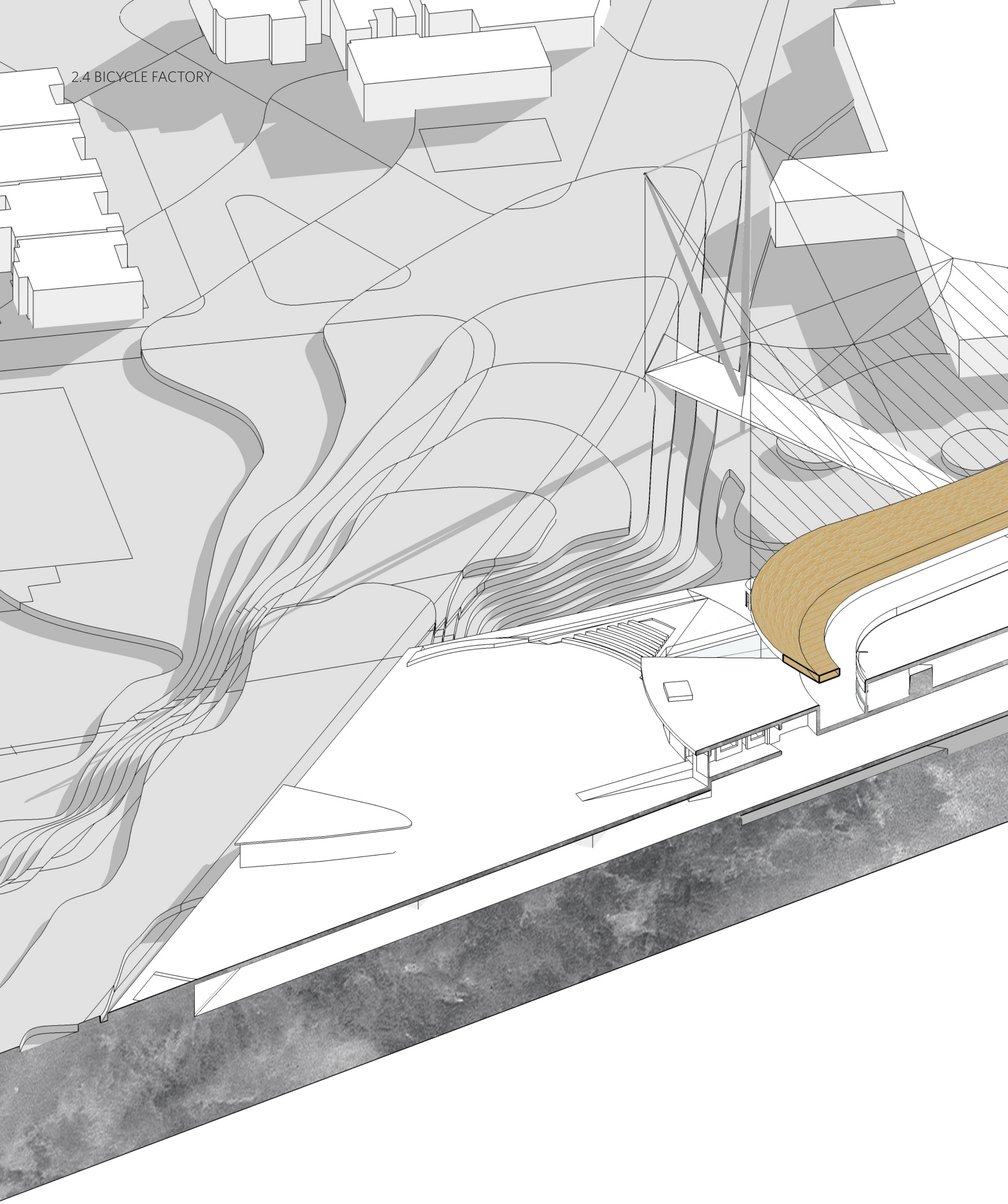
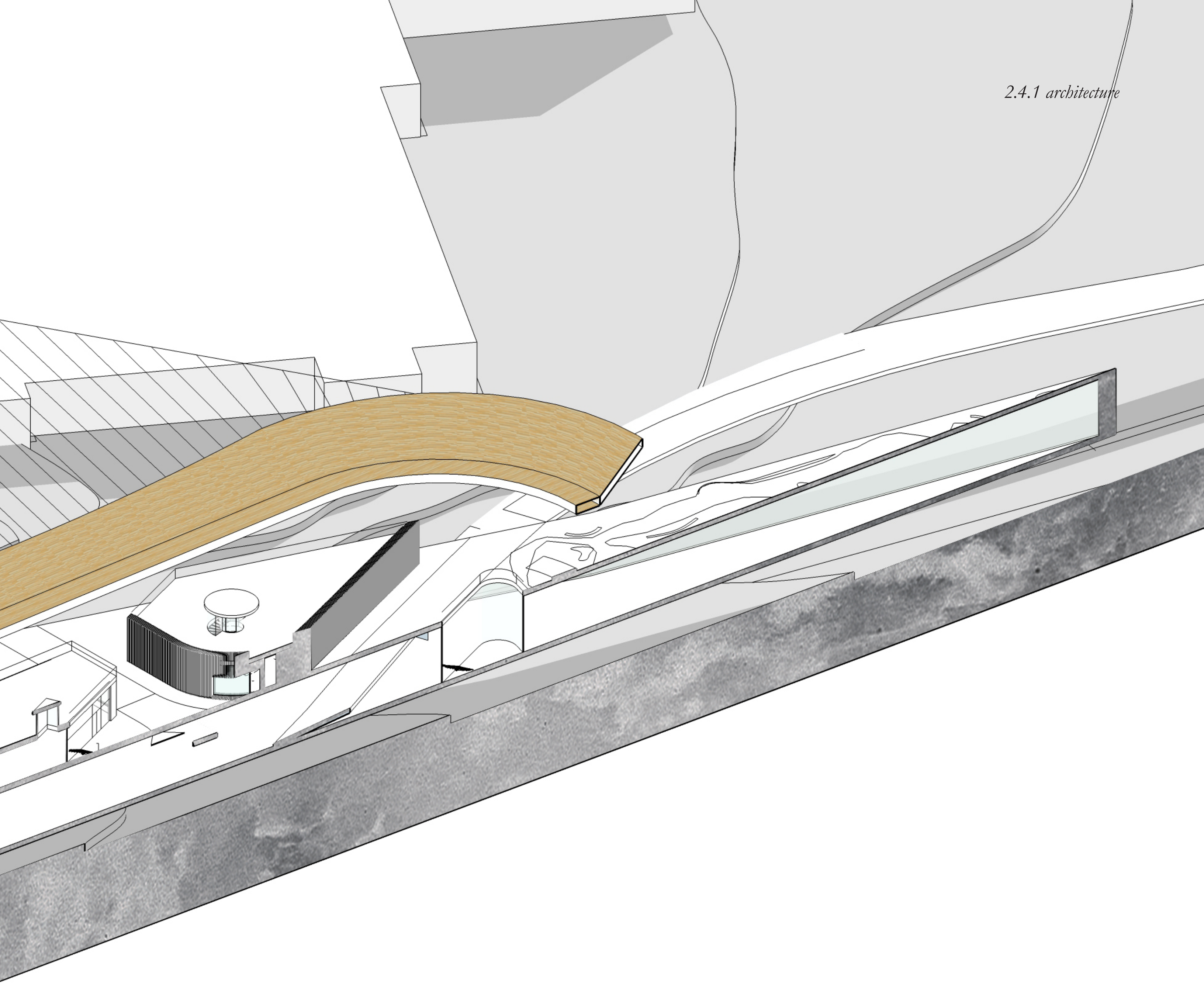


fig. 133 longitudinal section massing model



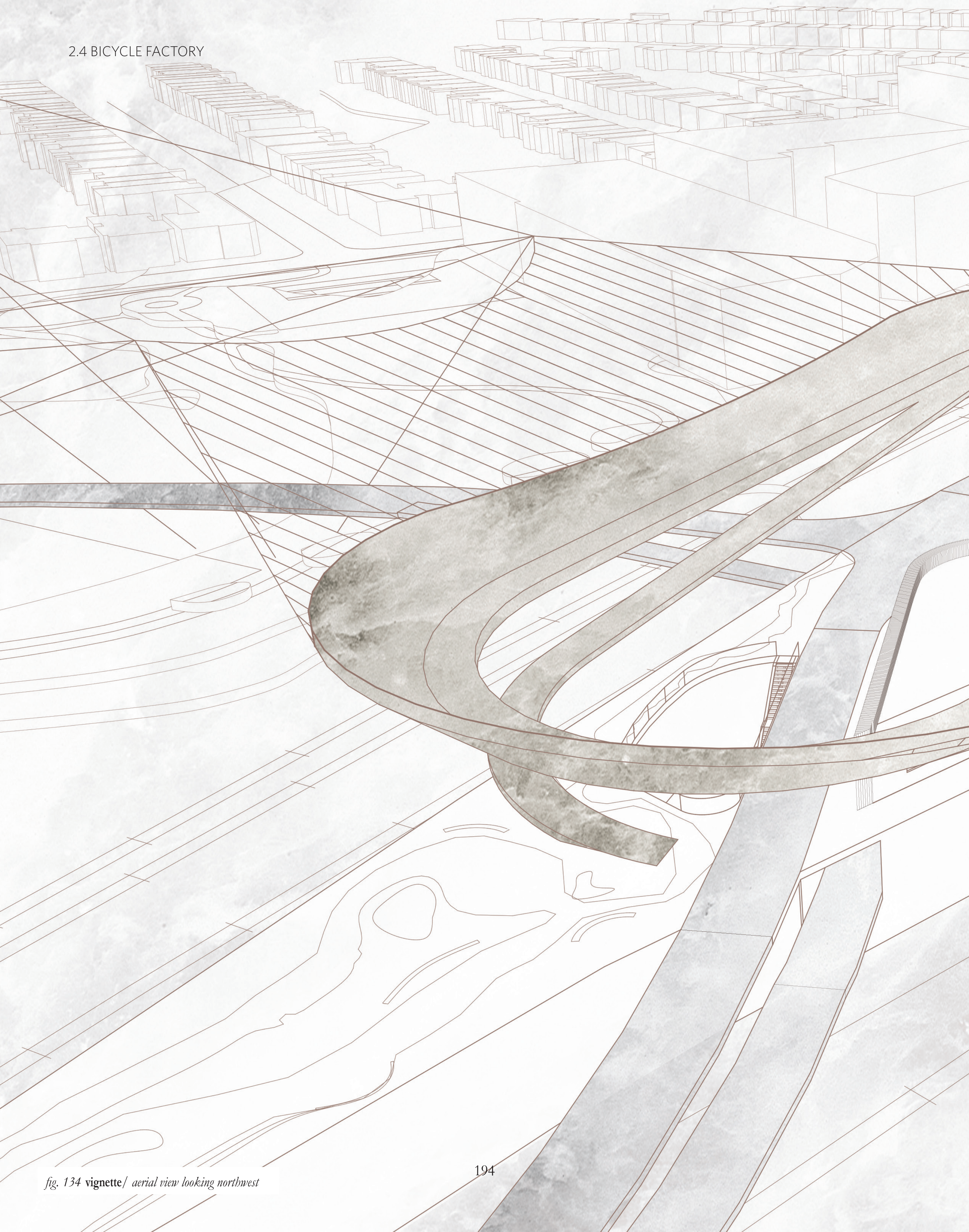
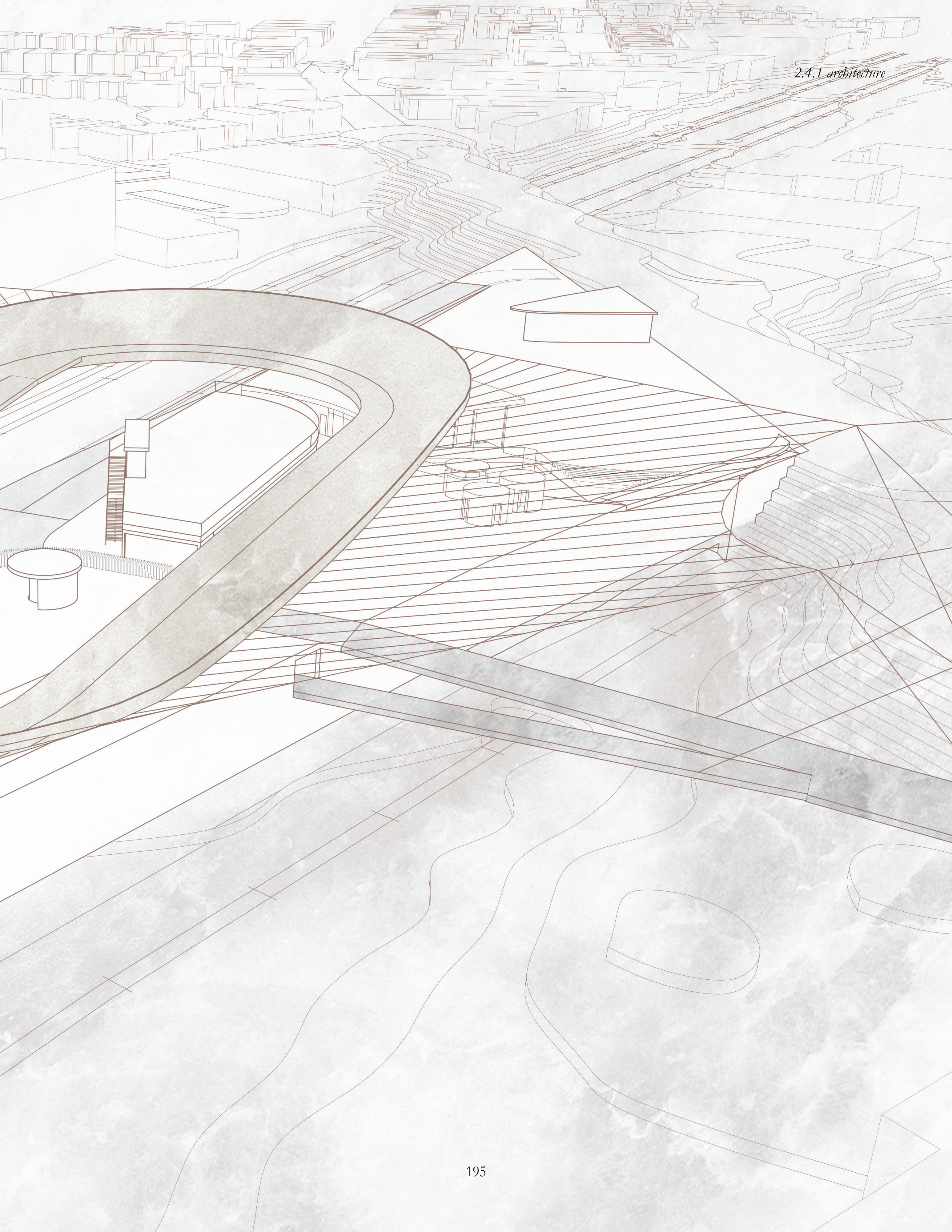


fig. 134 **vignette**/ *aerial view looking northwest*



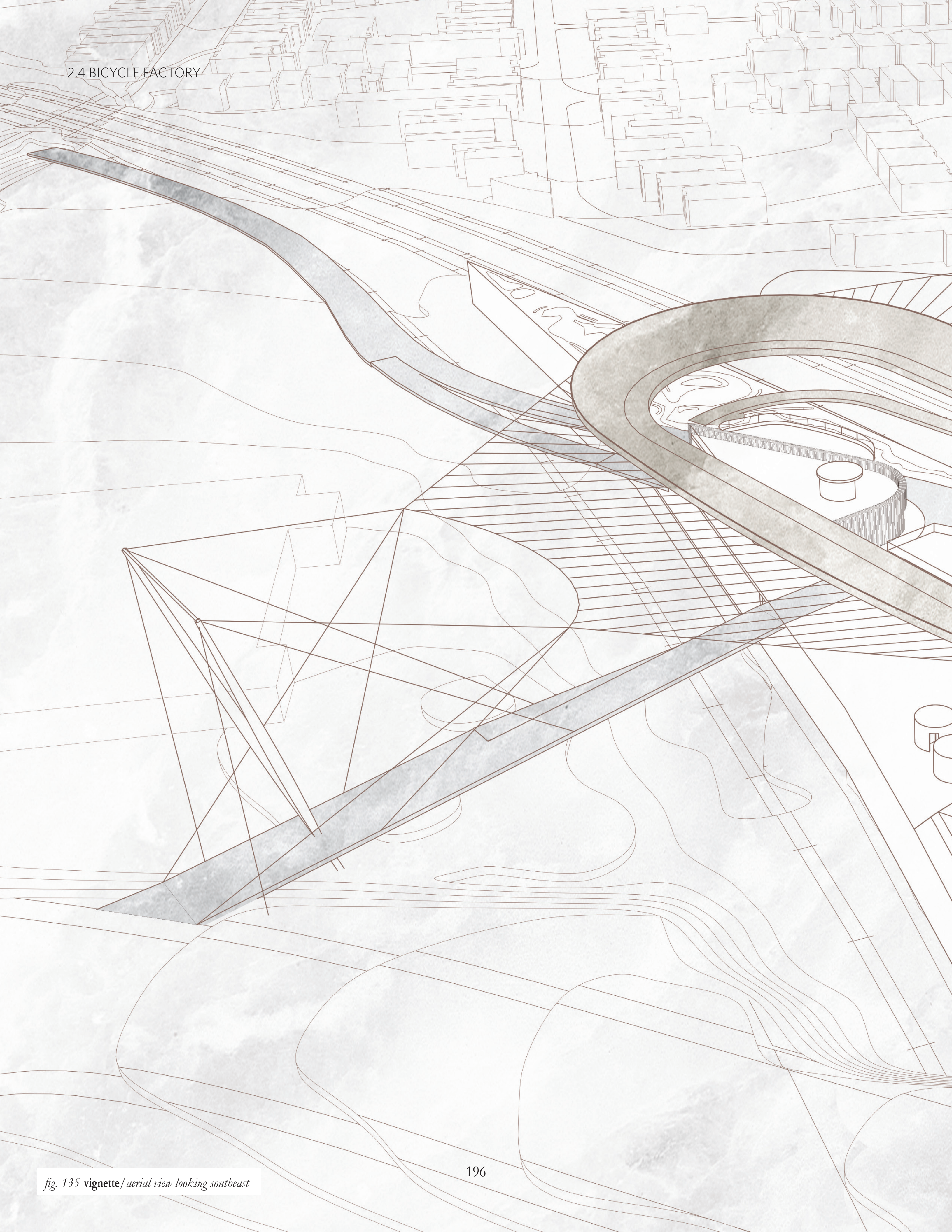


fig. 135 **vignette**/*aerial view looking southeast*

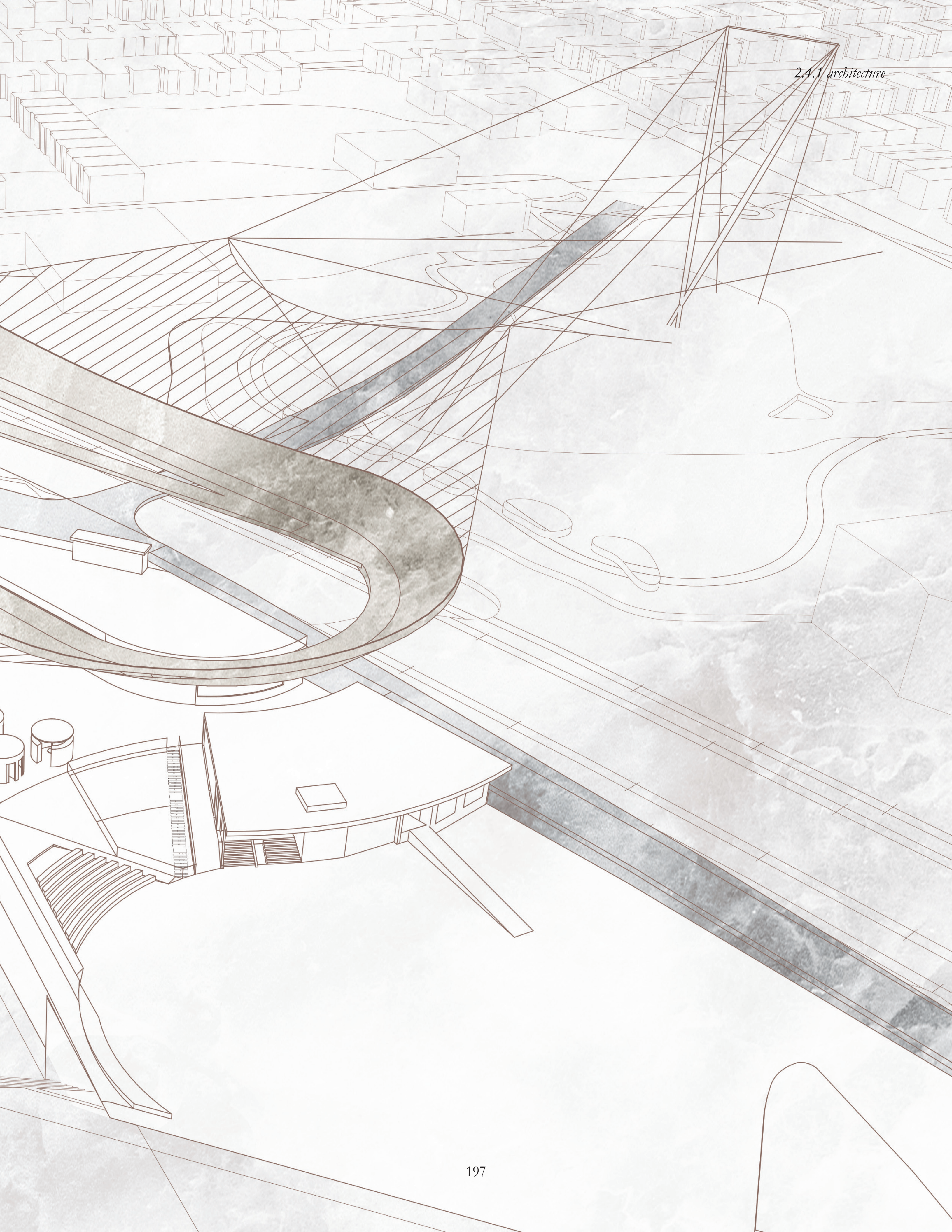


fig. 136 **vignette** / *view looking east from Dundas St W bridge*

fig. 137 **vignette** / *view looking southwest from Dundas St W and College St intersection*

fig. 138 **vignette**/*view looking northwest from snake run in urban park*

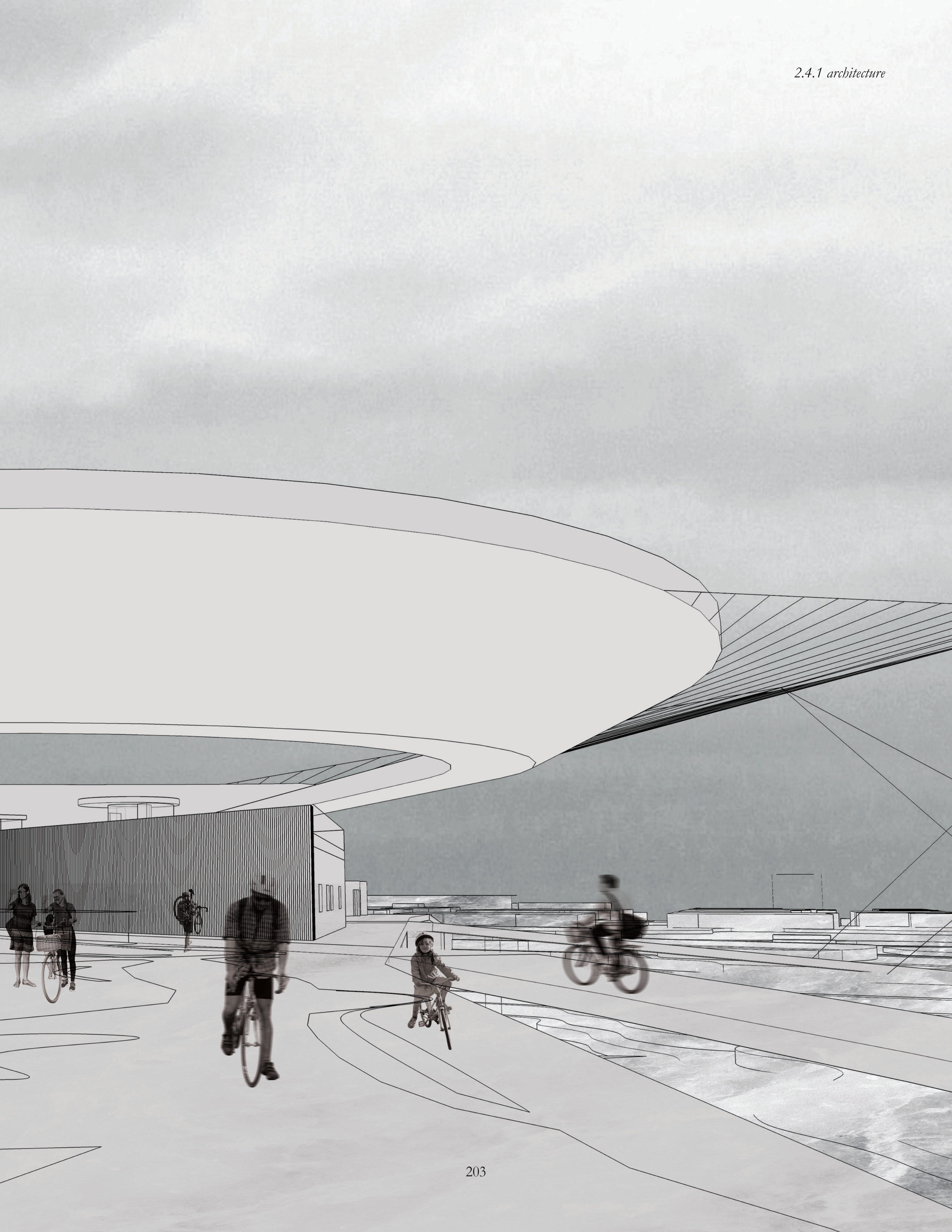


fig. 139 **vignette** / *view looking southwest from College-Sorauren bridge*

fig. 140 **vignette** / *view looking south from urban park*

2.4.2 PRODUCTION MODEL

2.4.2.1 PRODUCTIVITY

> *It has been 100 years since Henry Ford introduced the modern assembly line and forever changed the course of manufacturing. The combination of interchangeable parts and time-efficient processes created a system that eventually sold 15 million Model T Fords and made the automobile one of the centerpieces of American culture.*
>
> *One hundred years later, the modern assembly line is still the main arm of the global manufacturing industry. Ford's model has withstood the test of time and is still proving to be an efficient process. But it's not done evolving yet.*
>
> *Today, there are still many challenges facing manufacturing executives as they work to optimize the assembly line. The majority of these problems center on the speed and accuracy of production. Manufacturing facilities need to create quality products, and they need to do so in a time efficient manner. In order to keep the manufacturing process strong, executives must constantly innovate to reduce waste, speed up automated processes and ensure that enterprise quality management remains unhindered.*
>
> *One of the most crucial methods of ensuring enterprise quality management is the ability to receive instant feedback on automated processes. Manufacturing executives cannot wait until a product is packaged and sent out to vendors in order to realize that the quality does not conform to expected standards. Now, using statistical process control software, assembly lines can be shut down in a timely fashion as soon as variation is detected on an assembly line.*
>
> — Ed van Rens, *The Modern Assembly Line: 100 Years Later*

The primary goal of any large-scale production model is efficiency—time, space, energy, material, labour, cost—factors all highly attuned to each other and working in concert to generate the largest yield for the least amount of resources. But as with any complex system, slight shifts in priority can generate vast differences in the balance of its various influences, and therefore, outcome.

Fordist or 'Just-In-Case' (JIC) Model of Production

Ford's objective was to maximize sales, and thus profit, by manufacturing a vehicle affordable to the ordinary citizen. Through economy of scale, the Ford model of production was able to attain the efficiency it needed to increase product availability to the masses in both bulk and price. Large quantities of identical objects were manufactured through the scientifically systematized, rhythmic movements of workers and machines along sequentially streamlined assembly lines. This formula raised productivity considerably by decreasing operating expenses, and thus cost of final goods, which were then pushed on to the consumer.

efficiency gain — time, energy, labour

The Fordist method maximized on its use of time and energy, by having a continuously running production line operating at full capacity, with no interruptions for quality control either during fabrication, or at the end. The division of labour into a series of simple, routine tasks also cut down on operational resources, by allowing factory employees to work more efficiently. This requirement for unskilled labour, with its repetitive motions, and no responsibility for ensuring product standards, meant that workers could be hired for very low wages. All in all, savings in time, energy, and labour translated into savings in cost, and thus more profit for the capitalist.

efficiency loss — space, material

But this push model of production also had its inefficiencies. The highly-specialized, rigid, assembly lines not only demanded large, accommodating spaces, but the inflexible, nonstop nature of its manufacturing process also meant that ample room had to be provided for stockpiling materials and components, as well as finished merchandise. In fact, it is sometimes referred to as the Just-In-Case (JIC) manufacturing system as distinguished from the Just-In-Time (JIT) model of production—'just in case' supplies dwindled low enough to halt production processes, which would have been catastrophic to its flow. But this also presented the risk of inventory over-accumulation, occupying storage space, if sales plunged or new upgraded models were introduced. The omission of product quality checks also significantly increased the chances of fabricating finished nonfunctional products. All of the increased output further came at the expense of a lack of product variety, and the exploitation of labour on top of inhumane factory working conditions.

Post-Fordist or 'Just-In-Time' (JIT) Model of Production

On the other (post-Fordist) hand, the Toyota Production System (TPS), or JIT model of production, maximized revenue by eliminating inefficiencies. Where Fordism lacked in efficiency, the post-Fordist model thrived, and vice versa. Thus in many ways the exact inverse of Fordist logic, JIT used labour, space, and material strategically (just as meticulously as Ford applied Taylorism to his methodology), by allowing customer demand to pull the commodity through its production lines. In contrast to the assembly line's fixed trajectory, TPS was structured around a versatile network of linked cells, each with its own set of tasks that ran alongside the main path of production.

Facilitated by advancements in communication and technology, JIT processes relied on a system of instantaneous feedback loops. This way, parts and materials arrived just before they were needed on the production floor, which greatly reduced the need for storage infrastructure. Rigorous quality control was also carried out throughout, in order to ensure defective partial assemblies were discovered and fixed, before moving on. Thus, the entire operation was under constant surveillance, so that production speeds and staffing needs could easily be adjusted based on the market. Every unit consisted of multiple cells equipped to perform the same range of function, so that various pods could be shut down or retooled as necessary. Demand was ensured by providing consumers with a range of merchandise, which was made feasible through the flexible cell structures and machinery that could adapt to different models of goods.

TPS expert Shigeo Shingo, writes about 'seven wastes' of the manufacturing process: overproduction, over-processing, faulty products, inventory storage, waiting between steps, motion of people and equipment, and transportation. These elements are cornerstone to the JIT method, which today, is also appropriately dubbed 'lean manufacturing.'

efficiency gain — space, labour, material

In terms of efficient use of space, Toyota's production system greatly surpassed that of its predecessor, Ford. Its versatile technology did not require the expansive facilities of Fordist plants, nor its large warehouses to store materials and goods. Whereas traditional industrial models saved on labour by treating the worker like a machine, JIT systems used people to oversee automated machines, and optimized its allocation of work based on market demand. While Fordism streamlined its assembly process to reduce time, energy, and labour costs, Toyotist philosophy prescribed exercising obsessive control of space, labour, and material to trim redundancies. The flexible JIT system, with its persistent monitoring, could thus avoid the wastes of overstock, overproduction, and substandard merchandise.

efficiency loss — time, energy, labour

This flexibility naturally also resulted in the loss of efficiency in other areas. On the JIT production line, the start-and-stop nature of its operation, the multiple product changes in quantity and variety, as well as the frequent steps taken for quality measures, meant more time and energy was expended compared to the steady continuity of its Fordist counterpart. It also meant that more labour was required to carry out these logistical tasks and inspections. In fact, today's evolved lean manufacturing system adds an additional 'eighth waste': workforce, by asking—are workers being used effectively? Although automation allowed less people to be used for the same productive output, the semiskilled to skilled labour required to operate more complex machinery was correspondingly more costly. For workers, this also meant a certain degree of unpredictability due to the allocation of shift work (and job security) based on the fluctuations of market demand.

Post-post-Fordist or 'Just-Right' Model of Production

While Fordist and post-Fordist models of production differ in approach, their common goal is to maximize profit, through whatever means the capitalist can concoct. This singular devotion is the driving force behind each methodology's strict, and explicit logic. The post-post-Fordist intervention on the other hand, has a more complex manifesto to mobilize:

◊ to (re)shape Toronto as a 'cycling city' by using the proliferation and distribution of the bicycle across the built landscape to generate cycling infrastructure, networks, and other accommodations, as a way to infiltrate into its urban fabric, local society, and culture

Thus, the goal of the factory is to mass produce an affordable (albeit not 'cheap'[14]) commodity, while still making a profit. Like its architectural enclosure, the post-post-Fordist bicycle manufacturer takes a hybrid approach, thereby relying on both push and pull strategies to deliver its goods to the public. As the bicycle is pushed to consumers at one end, its pull through fabrication is simultaneously moderated by markets on the other. By taking strategies from Ford's assembly line, and borrowing elements from Toyota's adaptable cells, the composite 'Just-Right' production model thus takes advantage of the efficiencies and benefits afforded by both methods.

efficiency gain — time, energy [Fordist mass production of a single product]

The greatest strength of Ford's technique, is the productivity gained from the large-scale manufacture of a single design. The brand's Model T, as the first affordable automobile, arguably represents the creation of all subsequent motor vehicles available to the masses, insofar that the sheer quantity of cars on roads during the 20th-century literally paved the constructed urban landscape. Aligning with this powerful notion, the bicycle factory thereby appropriates the mass production, and consequent mass availability, of a single, well-designed vehicle—utilizing its efficiency and simplicity, to achieve the desired cycling cityscape.

In true Fordist style, this efficiency in time and energy is optimized by powering a continuously running operation. Segments of the bicycle's production line function in logical, assembly line fashion, but these repetitive motions are largely performed by computer-automated machines. In areas where more human intervention is required, employees are not assigned a mono-task; rather, a rotational strategy between various stations is implemented. This ensures that workers are well-versed in multiple zones of the production process, which not only provides the factory with more staffing and scheduling flexibility, but more importantly, establishes a nature of semiskilled to skilled labour that is far from the monotonous drudgery of sweatshops.

efficiency gain — labour, material [post-Fordist lean manufacturing for market demand]

The bicycle factory also applies lean manufacturing's centrepiece 'fat-trimming' logic to its processes. Rigorous quality control measures are implemented throughout the operation to minimize waste from defective products, so that problems can be solved before they become irreparable further down the assembly line. Digitally-controlled machines maintain production standards in the automated sections of the factory, while workers verify, and perform regular quality inspections throughout. Although not as complicated as automobile assembly, a range of skillsets and types of labour are involved in building a bicycle frame—from CNC laser cutter technicians and operators who monitor the cutting of steel tubes to length, to tradespeople who manually weld the tubes together into a complete frame. This condition creates an optimal ratio between the use of workers and machines, which means that labour is applied most effectively where it is needed. While attempts are made to keep the flow of production, and thus availability of work, consistent, labour can also be altered by adjusting staffing needs in the event of acute market fluctuations.

14 by 'cheap,' the author is referring to mass-produced, imported, $100 Walmart bicycles made in sweatshop factories in China that are cheap in both price, and quality

Thus, recognizing the consumer society it operates within, the bicycle factory is also attuned to the demands of the market. With the aid of present-day information technology, the business is able to instantaneously and systematically gauge consumer patterns to forecast future needs in order to make informed decisions about levels of output. Accordingly, portions of the production line also mimic a JIT manufacturing system, with 'pods' or various repeating stations that form flexible, connected, organizational structures. Individual cells can be paused when deemed necessary if markets fall below a certain threshold. But unlike a JIT production line, reconfiguring instruments and working arrangements to adapt to different models of products would not be necessary.

efficiency loss — time, labour

Compromises in efficiency of time and labour, when benchmarked to the Ford model of production, are comparable to similar losses experienced by the JIT method. While quality control does require extra time and work, it is deemed a crucial, and therefore worthwhile part of the process. It maintains a certain caliber of production output, as well as minimizes the likelihood of wasting material resources. Although tool changeovers for different models are not necessary, customized frame size orders do require unique corresponding parts to be kept together, thus resulting in slightly increased logistics. Furthermore, because of the semiskilled to skilled labour employed, worker compensation is naturally higher than the wages of the unskilled workforce of Fordist plants, or of offshored post-Fordist factories in developing countries.

efficiency equilibrium — space

While the bicycle factory isn't designed for stockpiling large quantities of raw materials and components like traditional plants, nor for the stripped-down, instantaneous turnaround of lean manufacturing, it does provide an optimal amount of space for inventory. For instance, the floor space allotted to completed and boxed bicycles fills exactly one semitrailer truck, and is also the yield of a full day's operation. Similar to the JIT method, raw materials and components are delivered on a regular basis, with quantities liable to change based on levels of consumption. At full productive capacity, the bicycle factory works around the clock, but can shorten its hours of operation if demand falls below a certain threshold. This way, the hybrid model neither blindly charges ahead with production at top speed only to let bicycles sit in storage, but neither does it allow the markets to affect its daily operations as directly as with the JIT method. Like Fordist factories, an expansive volume with a semi-regular column grid is provided, which accommodates specialized segments of the production line that require more space. But more importantly, the building is designed to be available for future occupation, so as to reduce architectural waste, while optimizing its use-efficiency.

Fordist mono-product mass production + post-Fordist mass customization

Despite the Ford-esque lack of variety of the business model's mono-product, it nevertheless aligns with the post-Fordist shift toward mass customization. Bespoke frames made to fit unique body dimensions can easily be accomplished at the bicycle factory without much slowdown to processing. In fact, the only parameter that deviates from the standard, is the lengths of the various tubes in the frame. Since this function is performed by the CNC laser cutter, they can be cut to any specified length as is digitally programmed, without any reduction in speed. The parts would then flow through the ensuing stages of production in the same way as the standardized pieces. Nevertheless, some delay is still expected to occur for the extra tagging and identifying of corresponding pieces.

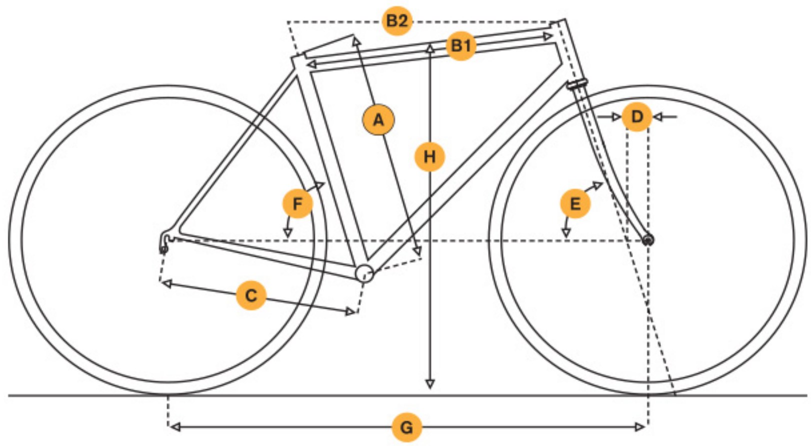


fig. 141 **bicycle size customization**

Fordist economic stability vs. post-Fordist market volatility

In this way, by not partaking in the extreme measures taken by the preceding eras, a safety cushion is provided at either end. Some of the volatility of the market is tempered, by providing a degree of continuity and predictability in the operation, while optimizing efficient use of resources. A composite system is chosen in light of the fact that the contemporary era is neither facing a Fordist need for planned economic and social stability, nor the aftermath of those rigid economic structure falling apart after WWII. Today, while the Just-In-Time method has been applied extensively across the industrial landscape, there are concerns about the efficacy of this model in dealing with crises, such as large-scale disaster or terrorist attacks. Often, in these cases, entire systems become paralyzed, leaving companies with no alternative routes or 'just-in-case' back-up plans to deploy. In the neoliberal economy, the markets are volatile, but relatively predictable, thus supplying room for both methods to be executed simultaneously, and with the aid of technology, adjusted accordingly.

2.4.2.2 LABOUR

Exploitation of Labour During the Industrial Revolution, Fordist, and Post-Fordist Eras

Throughout the Industrial Revolution, artisanal workshops and manufactories gradually reorganized into larger, and more efficient, mechanized factories. Consequently, craftsmen who once used simple tools as extensions of their limbs, instead themselves became implements enslaved to these 'mechanical giants'. In Capital, Marx likened this arrangement to "a vast automaton," with workers as "living appendages"[15] of the machine. The resulting repetitive motions of the cheap, unskilled labour is one of the ways in which class exploitation was carried out by capitalist industrialists to drive profits. Trades declined, and craftsmen were dissociated from their craft, as the division of labour not only turned the worker into a machine, but displaced their jobs as well. This oppression was made worse by the long working hours for less-than-subsistence wages in harsh, unventilated, and unsanitary environments, where women and children were further discriminated against.

During the early 20th century, factories were beginning to adopt Ford's revolutionary high-efficiency, mechanized and electrified assembly line, whereby monopolizing corporations with ever-increasing power, continued exploiting the blue-collar class. In Ford's plants, in order to keep the turnover rate of his workers under control, so as to minimize costs associated with hiring and training new people (which becomes a highly inefficient affair), Henry Ford implemented the famous five-dollars-a-day contract with his employees:

> *At the time, workers could count on about $2.25 per day, for which they worked nine-hour shifts. It was pretty good money in those days, but the toll was too much for many to bear. Ford's turnover rate was very high. In 1913, Ford hired more than 52,000 men to keep a workforce of only 14,000. New workers required a costly break-in period, making matters worse for the company. Also, some men simply walked away from the line to quit and look for a job elsewhere. Then the line stopped and production of cars halted. The increased cost and delayed production kept Ford from selling his cars at the low price he wanted. Drastic measures were necessary if he was to keep up this production.*[16]

Despite the progressive pay and regulated work hours, labourers were still subject to the drudgery of the assembly line and its inhumane working conditions. Ford's employees were thus manipulated into thinking that they were not being treated unfairly with the offer of comparatively higher wages. But at the same time, they were inadvertently wrapped up in a fabricated Fordist lifestyle, where basic needs were commodified, and they could afford luxuries such as the very device they spent their days labouring on. This created a system where the working class was simultaneously exploited by, and dependent upon, the capitalist establishment.

Labour unions in North America became prominent by late-Fordism (1930's to 1950's), but automation in factories and misrepresentation by unions caused more worker strife in the 1960's. Although post-Fordist JIT factories gave workers more agency in their roles by employing semiskilled to skilled labour for their computerized production systems, it also meant that less jobs were available as automation increased productivity levels and replaced the need for human intervention. This market-determined job instability in the post-Fordist era was further tipped by globalization sending factories overseas. Labour was exported to developing countries, so that the same exploitation simply took place in foreign territory, and the pattern repeated itself.

Indeed, when one begins to imagine the interior of a post-Fordist factory, perhaps

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15 Karl Marx, *Capital: Volume 1: A Critique of Political Economy* (London: Penguin Books Limited, 1990), 544.

16 Tim Worstall, "The Story of Henry Ford's $5 a Day Wages: It's Not What You Think," *Forbes*, March 4, 2012, http://www.forbes.com/sites/timworstall/2012/03/04/the-story-of-henry-fords-5-a-day-wages-its-not-what-you-think/#51b3d9db1c96.

Edward Burtynsky photographs come to mind—impossibly vast expanses of space filled with rows upon rows of identically uniformed factory employees; a sea of workers. "Patterns, uniformity, the sharing of an identical task, carried out on a massive scale, the sameness of industrial forms and entertainment forms."[17] But this is in fact a very Fordist scene—the homogeneity, the repetitive task, the mass production—because what we in advanced economies see as post-Fordism, is simply the manifestation of Fordism in developing countries.

commodity alienation

Since the post-mercantile days of cottage industries with their artisan workshops, craftsmen, and tradespeople, the singular goal of capitalist society has been to maximize profit by raising efficiency in all manner of ways. With an economy increasingly focused on the movement of money (an abstract value attached to objects), the social relations within manufacturing ecology are concealed. This is what Marx identifies as alienation—both consumer-commodity and worker-commodity alienation. These dissociations began at the onset of industrialization, when craftsmen were severed from their craft (both to be handed over to the machine), to factories moving further and further away from their workforce and consumer base, all the way to contemporary globalized culture, where this condition has been stretched across entire oceans.

De-exploitation of Labour in the Post-post-Fordist Era

The post-post-Fordist movement thus commits to eliminating the exploitation of cheap labour in offshored post-Fordist factories overseas, which can be achieved by bringing manufacturing activity back into developed nations, and fostering instead, a more local relationship between producers, workers, and consumers. It also lobbies to ensure fair working conditions for the blue-collar class, by giving employees more agency over their working conditions, which is realized in the bicycle factory by:

i. employing **skilled and semiskilled labour**
ii. applying **teamwork** labour organization models
iii. establishing the business as a **worker & consumer co-operative**

Skilled & Semiskilled Labour

Due to the size and scope of the operation and methods of production used, the bicycle factory employs a range of labour that require various sets of skills, as they each incorporate different levels of interaction with machinery. Roles span from the digital programming and overseeing of computer-controlled automation processes, to activities that rely solely on worker intervention, with myriad versions of human-machine collaboration in between. These allocations are determined by the cost of available technology compared against the cost of labour needed to complete the same set of tasks. But the efficacy and efficiency of the respective outputs are prioritized over the difference in expenditure. This way, both labour and technology are optimally placed in ratios where each excels the most, while balancing cost and quality. The different kinds of

17 Alison Hulme, "The aesthetics of post-Fordism…?," *Commodity Tactics* (blog), March 9, 2014, https://commoditytactics.wordpress.com/2014/03/09/the-aesthetics-of-post-fordism/.

labour involved in the daily operations of the bicycle factory are as follows:

i. **skilled labour** — CNC lathe technicians & operators, CNC laser cutter technicians & operators, welders, defective product problem solvers
ii. **semiskilled labour** — bicycle assemblers, wheel-makers and builders, machine shop operators, sandblasters, powder coaters, forklift operators, washing tank operators
iii. **unskilled labour** — packagers, shipment loaders/unloaders

The segments of the production line which are completely automated, are stages of processing that require extreme precision, such as laser cutting or threading steel tubing for the frame. Partially automated systems involve procedures in which work is carried out by machines, but whose movement is largely controlled by staff. For example, gantry cranes are used for transporting oversized material too heavy to be handled by people—namely, the 30-foot long tubes of chromoly steel that are fed into the CNC laser cutter. Partial-automation is also used for conveying assembly components during sensitive parts of the process, such as overhead tracks that move hanging bicycle frames from the powder-coating booths into the paint-setting ovens for baking. Then, there is work that requires the scrupulous eye and judgement of the craftsman, such as the welding of chromoly tubes together into a perfectly aligned frame, or the final assembly of a functional bicycle from its various components. The requirement for these human-oriented tasks are characterized by the need for constant adjustments and readjustments in order to achieve the complex set of parameters for the desired result.

Although computers can accurately gauge the precision of machined parts, the technology is only effective to a certain extent, and final worker inspection is always required to check, and resolve any imperfections that arise. For example, the wheel building machine consists of a fully-automated unit in which the trueness of the wheel is tested and adjusted accordingly. The wheel is then either released into a 'good' or 'bad' pile, the latter for instances where the machine is not able to perfectly align the component due to a number of possible reasons (i.e. a defective spoke). A worker must then take over to find, and resolve the issue (i.e. switch out the offending spoke). The rigorous implementation of quality control across the production line thus entails the full verification, expertise, and engagement of human labourers.

In fact, instead of the deskilling that occurred in manufacturing plants throughout industrialization and Fordism, the bicycle factory enables and encourages the reskilling of the worker. This is achieved not only with the more handicraft aspects of the operation, but also by enlisting contemporary technical specialists such as CNC machine operators. Although a certain amount of unskilled labour is necessary, such as for packaging, and the loading and unloading of shipments, many duties operate on a rotational basis. This way, even though a certain degree of labour division is unavoidable for the business in order to attain efficiency and remain competitive, individual workers are not performing the same mono-task day after day. Rather, employees receive training in, and become versatile in multiple stages of the production process.

Thus, as an antithesis to Marx's description of the 19th-century factory, this thesis posits a reversal of the drudgery of repetitive toil that demoted the labourer to a mere cog in a machine. By requiring semiskilled to skilled workers, the nature of manufacturing a frame from scratch and its fabrication into a complete bicycle in the post-post-Fordist factory inherently inhibits the use of cheap labour. Harking back to proto-industrialization days, it endeavours to reverse the antiquated notion by reinstating machines and technologies as intuitive extensions of the human body.

Teamwork Labour Organization Models

Influenced by the rise of worker unions, post-Fordist innovations in labour organization models directly responded to the high levels of exploitation that occurred during preceding economic eras. Several attempts were made in factories to negotiate relations between its different tiers of staff, as well as between workers, in order to adopt a more egalitarian and collaborative working environment.

post-Fordist communal workspaces

The JIT production model, by giving people a higher degree of control in their jobs, thus also encouraged more cooperation between workers and managers. It achieved this architecturally by designating communal spaces, and placing research and development next to plant operations. The Reliance Controls factory was also a pioneer in this issue in the late 1960's, by locating its management office in the same space as the production floor, as well as designing an entrance for both blue and white collar staff. Likewise, the bicycle factory fosters a teamwork dynamic between its workers and managers by providing collective spaces for all employees,[18] and situating administration offices and R&D on the factory floor close to production lines.

Volvo's team assembly system

But during the early post-Fordist period, Volvo was the only manufacturer who made any serious attempts at reforming working relationships in the factory. From the 1970's to 1990's, it researched, developed, and finessed the 'team assembly system' at two of its plants in Sweden. The car maker first ran a comprehensive testing of this innovative production and labour organization model at its Kalmar assembly plant in 1974. Then, after experiencing tremendous success there, the teamwork concept was pushed even further at its Uddevalla facility in 1988. According to an article in the New York Times in 1987:

> *The Kalmar plant, which opened in 1974, was largely an industrial response to Swedish social attitudes in the late 1960's and early 1970's. The antagonism toward business throughout the West in that period hit particularly hard in Sweden, with its full employment, restricted immigration, generous welfare programs and liberal political tradition. In the auto industry, absenteeism rose, quality and efficiency declined, and companies had trouble recruiting young people.*[19]

It was clear to the company that increasing pay, like Ford's early 20th-century fix, was no longer an effective strategy to combat worker apathy—more had to be offered.

18 as well as the general public!

19 Steve Lohr, "Making Cars the Volvo Way," *The New York Times*, June 23, 1987, http://www.nytimes.com/1987/06/23/business/making-cars-the-volvo-way.html?pagewanted=all.

"The something extra was a different working environment, more varied jobs, greater responsibility for quality and an active role in decision-making."[20] Eschewing Ford's principles of systematized repetition and JIT efficiency-elimination strategies, Volvo hoped to maximize both production efficiency and product quality by creating a gratifying working environment for its employees through teamwork. The logic was that by doing so, its workforce would be more proficient (higher quality product) and more stimulated (higher efficiency production) to perform.

The sequential assembly line was renounced in favour of automated car body carriers that travelled around to various teams of about 15-25 people, each having been assigned a set of broadly defined tasks, such as installing electric wiring, or upholstery. Working groups essentially formed their own microcosm on the production floor, where the high-tech, computer-controlled carriers enabled members to maneuver around a vehicle with ease. The nature of the batch-work method allowed each worker to complete, and be well-versed in a range of tasks. Not only was the arrangement a radical departure from the tedium of assembly-line work, but its flexibility enabled crew members to easily fill in for each other for sick days or time off. Each squad was given the freedom to organize its own schedule and work delegations, but had to achieve production goals. This created an environment in which people had much greater agency in their jobs, but were accountable to those who worked right next to them, as opposed to the foremen of more traditional models. Workers also routinely performed quality control, which was additionally monitored by a central computer, so that any issues could swiftly be traced back to teams or individuals.

Indeed, the democratic teamwork philosophy in the Swedish factory was truly progressive, as, "[e]qually unusual is where Volvo found Kalmar's managers. Virtually all of the plant's 104 white-collar employees came off the shop floor. Moreover, all major decisions at the plant, whose work force totals 920, must be approved by a joint committee representing both labor and management."[21]

Kalmar employees were much happier under the new structure, and as a result, quality and productivity improved substantially, which in turn increased profits. At the Uddevalla plant, the next-step ambition of this working methodology was for each squad to assemble an entire car on its own. Unfortunately, the system also came with its inefficiencies, as team conflict resolution and stress management had started to hinder productivity, and both plants were shut down by the mid-1990's.

> *This "experiment" was not only a bold step in creating humane work, but a success in a wide range of performance measures. Rapidly improving productivity and quality was combined with superior flexibility, low cost tooling, unparalleled customer orientation and a unique responsiveness to market demands.*[22]

Even though the team assembly model was only successful for a short period of time at Volvo, the concept of a more lateral approach to business management was adopted by Japan, and then the United States. In fact, appropriating this philosophy,

20 Ibid.
21 Ibid.
22 Ibid.

Toyota had doubled GM's efficiency by the late 1980's. "Before long, everyone was talking of 'reengineering' the firm, of creating 'the horizontal corporation' that is guided by an inspirational leader who holds together a web of self-managed worker teams. By the early 1990s, almost 20 percent of U.S. firms were operating under some version of the new system."[23]

teamwork in the bicycle factory

In the bicycle factory, a version of Volvo's teamwork model is applied to the assembly portion of the production line—namely, the carousels where various components are installed onto the frame to form a complete bicycle. But unlike Volvo's car body carriers, the bicycle carousels remain stationary, clustered in an array on the factory floor, each too, forming its own microcosm within the operation. Equipped with three bicycle stands, the carousels pivot the stations between its three team members as partial assemblies are passed on from worker to worker, with enough room in between for assemblers to move around a bicycle with ease. This way, every worker is able to have his or her own fixed, personalized station set up as they wish. But they also have the option of relocating to the different stands on the carousel instead of rotating the device—all subject to the collective decisions of the group.

Similar to Volvo's Uddevalla plant, each team is responsible for the assembly of a full, finished product. Thus, in contrast to the subset of duties laid out at the Kalmar plant, every group performs the same set of tasks to bring a bicycle to completion. But within the teams, individual workers can assemble entire bicycles on their own, or the work can be split into stages based on the the group's preferences for allocations, scheduling, and other decisions, as determined by its unique teamwork dynamics. This in turn, could be influenced by different skill levels, personal working styles, etc. Squads can thus reorganize their work as often as they wish from day to day, or even throughout the day. In fact, the working groups themselves are not fixed; assemblers periodically rotate around to different squads, so that a larger collaborative network is established throughout the factory. But at the very least, every team member must have the ability to assemble an entire bicycle on their own from start to finish.

Employees are free to schedule their time and take as many breaks as needed, but must be accountable to their fellow staff in order to collectively meet production quota. By having multiple people working on the completion of one bicycle, a mutual system of quality control is inherently established, resulting in higher product consistencies. Moreover, as the bicycle is much smaller and less complex to assemble than a car, the risk of team conflict is arguably greatly reduced.

Other parts of the production line, although not as structured as the team assembly system, also loosely apply some of its philosophies, such as the rotation of duties, so that workers are accustomed to carrying out a variety of jobs. It equips staff with more skills, allows their tasks to be more varied and interesting, and keeps them more engaged and integrated in the production process. This creates a greater sense of shared responsibility, with more workers able to collectively resolve issues should complications arise. It also provides the factory with more agility in scheduling without compromising efficiency, as people are able to take over some of each other's roles in

23 "Application 22.3 Team Work in Sweden," *Cengage Learning*, accessed April 17, 2016, http://www.swlearning.com/quant/kohler/stat/resources/applications/app22_3.doc.

cases of illnesses or vacation.

By adopting this teamwork philosophy for its operation, the bicycle factory endeavours to create a versatile and immersive environment that fosters interaction and camaraderie between its workers. They are accountable to each other, but also learn from each other, thus also greatly facilitating training processes. In this setting, people have more stake in their jobs, take a more active stance in decision-making, and overall have more responsibly to ensure production quality and efficiency.

Worker & Consumer Co-operative

In a hierarchical capitalist society, co-operatives have emerged as an alternative, egalitarian business model. The democratic architecture of the factory intervention, manufacturing and accommodating the democratic bicycle, thus also necessitates a democratic system of operation. Following the hybrid typology of the design, the governance structure is also a hybrid—a multi-stake co-operative, or in this case, a composite worker & consumer co-operative. In the context of the post-post-Fordist society, worker co-operatives offer a (re)structuring of the city through labour relations, and a consumer co-op deviates from the traditional business model by directly involving end-users in the conversation. Moreover, the lateral teamwork approach of co-operatives reflects the collective, dispersed, and decentralized nature of bicycles.

The basic premise of a co-operative is defined by its collective democratic ownership, and a one-vote-per member policy, no matter how much one contributes to, or uses the company's services. The Ontario Co-operative Association, On Co-op, defines the following "Seven Co-operative Principles:"

1. voluntary and open membership
2. democratic member control
3. member economic participation
4. autonomy and independence
5. education, training, and information
6. co-operation among co-operatives
7. concern for community[24]

worker co-op

According to On Co-op, "the primary reason for the [worker] co-op to exist is to create employment for its members. The members are both employees and owners of the company. They operate their business together and make decisions about important issues including wages, production methods and finances."[25] This setup is therefore ideal for new business with the ambition to thrive, by marketing a product its worker-members are invested in. By shifting the power away from the capitalist, and on to the collective,

24 "What is a Co-operative?," *Ontario Co-operative Association*, July 2013, http://ontario.coop/cms/documents/2/STR01_What_is_a_Co-op_FINAL.pdf.
25 Ibid.

worker participation and expertise are programmed into the system. Worker-members have a stake in the product, and working conditions of employees are self-driven and self-realized. Although job rotation is already implemented in the production model, workers-members have the option of furthering their training, should they desire to develop and round out even more of their skills in the factory.

On top of the general coop principles, the worker co-op principles as defined by CICOPA (International Organisation of Industrial, Artisanal and Service Producers' Co-operatives) are:

1. They have the objective of **creating and maintaining sustainable jobs and generating wealth, to improve the quality of life of the worker-members, dignify human work, allow workers' democratic self-management and promote community and local development.**
2. The **free and voluntary membership of their members**, in order to contribute with their personal work and economic resources, is conditioned by the existence of workplaces.
3. As a general rule, **work shall be carried out by the members**. This implies that the majority of the workers in a given worker cooperative enterprise are members and vice versa.
4. The worker-members' relation with their cooperative shall be considered as different from that of conventional wage-based labour and to that of autonomous individual work.
5. Their **internal regulation is formally defined by regimes that are democratically agreed upon and accepted by the worker-members.**
6. They shall be autonomous and independent, before the State and third parties, in their labour relations and management, and in the usage and management of the means of production.

Although Volvo was not a co-operative, its socialist philosophies at Kalmar and Uddevalla displayed some key co-operative principles. This is exemplified by its decision to almost exclusively hire white-collar staff who previously worked as blue-collar employees on the factory floor, as well as implementing a joint worker-manager committee for collectively making major company decisions.

Mondragón Cooperative Operation, is a worker co-operative federation that runs Orbea, the largest bicycle manufacturer in Spain. While there are the challenges of operating in a capitalist market economy, many people often point to Mondragón as one of the biggest and most thriving examples of co-operatives. More locally, Urbane Cyclist Worker Co-op Bicycle Store in Toronto is a precedent for a successful worker co-operative that assembles and sells bicycles.

consumer co-op

As defined by The Ontario Co-operative Association, members of a consumer co-op "make decisions about what to sell, provide, where products come from or other key issues," in which "[t]he members own the co-op store or must be a member to use the services."[26] In the bicycle factory, one becomes a member of the co-op when they purchase a bicycle, thus allowing consumers to continue to participate in its productive cycling culture. This is in complete contrast to traditional commerce models where the customer has no relation to the merchant once the sale is complete. Here, a lifetime guarantee is provided on the frame, and cyclists are expected to return to the shop for new or upgraded parts, install accessories, get a paint job for the frame, tune-ups, and so forth. As a consumer-member, they also make decisions about product-related issues, such as the specifications of parts, and choice of suppliers for any changes in design, or new models in the future. Thus, instead of an economic post-Fordist feedback loop, the consumer co-op creates a positive post-post-Fordist social feedback loop. It fosters local manufacturing and cycling through the direct community involvement and engagement of its members.

Therefore, as a hybrid worker & consumer co-operative, the members of the bicycle factory consist of workers as well as consumers. Worker-members have agency over the particulars of their employment and working conditions, and collectively own the factory, while consumer-members have influence over the specificities of the commodity produced. As a collective, they all make decisions about the future directions of the business based on its operating philosophy, whether it's designing new products, updating technology, or collaborating with other associations.

Thus, the cyclical model of manufacturing comes full circle with the worker & consumer co-operative. The production, labour, and business philosophies truly reflect the intention of the enterprise—to reconnect producers, consumers, and commodities in a local, sustainable, virtuous feedback loop, by restoring worker-commodity, and consumer-commodity relationships, in a an act of 'de-alienation.'

2.4.2.3 PRODUCTION PROCESS

Production Line

The post-post-Fordist bicycle factory's hybrid 'Just-Right' model of production combines the efficiency of Fordist mono-commodity based assembly line manufacturing, with the lean and flexible operational methods of post-Fordism, to achieve high levels of quality and productivity. Accordingly, it also takes advantage of the mass production and mass customization practices of the respective eras.

Fordist mass production

Taking an early-Fordist approach, the bicycle factory uses a fully integrated process of manufacturing, much like Ford's Highland Park plant, in which all stages of production occur within the same facility, from raw material to finished product. Here,

26 Ibid.

the entire fabrication of the frame, and assembly of the bicycle is completed in sequence on-site. The factory's configuration also alludes to the River Rouge plant, the next step in Ford's evolution of the industrial complex during the early-Fordist period, in which the finished product was effectively used as an extension of its own assembly line. Although not strictly a functional part of the operation, the bicycle and its cycling paths permeate throughout the intervention, in essence acting as an external continuation of the path of production.

The proposal's specialized manufacturing line devoted to a single object, occupying an expansive space with a regular column grid, is also a hallmark of Fordist industrial typologies. But unlike the primitive mechanizations of early 20th-century fixed systems of production, the accommodating flexibility of current digital technology, plus more advanced mechanical assemblies, allow tools to be effortlessly calibrated for different models of bicycles.[27] This is further facilitated by the hybrid nature of the production line, which incorporates segments of sequential procedures, as well as JIT-style mutable processing units. Moreover, unlike the complexity of the automobile, bicycle production employs much less elaborate, and thus more easily adaptable manufacturing equipment.

post-Fordist mass customization

A significant marker in the transition from Fordism to post-Fordism, was the shift away from mass production toward mass customization, largely afforded by new technologies which were unavailable at the turn of the century. The post-post-Fordist factory thereby takes advantage of present-day capabilities to carry out mass customization in the midst of a mass production operation. Its sole, flagship product can just as quickly and precisely be tailored to a user's body dimensions as the replication of standard-sized frames. This is enabled by the computer-controlled laser cutter, truncating and coping the chromoly steel tubes in the frame to any dimension desired without any loss in efficiency. Colour can also be infinitely customized by mixing different combinations of base powder coat paints, although this step would require extra preparatory time and tool changes. The bike shop, as the factory's retail face, offers this service to the public by taking physical body measurements for custom orders. In fact, as this personalized data would be transferred to the factory's computer control centre instantaneously, the turnaround period for a bespoke frame could be as short as a few hours—the amount of time it takes for a bicycle to complete its journey from raw material to finished assembly.

For extra personalization, optional accessories are also provided at the bike shop, made by the factory to accommodate different riders' specific utilitarian needs. For example, the front basket is a practical fixture for shopping aficionados; the leather portage strap facilitates comfortable handling for commuters regularly frequenting destinations with stairs, or for easy device maneuverability during weekend trail rides; the water bottle cage for longer commutes; and the bell for safe riding in the city. Thus, by modifying parameters for frame dimensions, colour, and choice of accessories, each commuter bicycle becomes a highly personalized commodity, despite their basis in the same design.

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27 provided that the bicycle technology is not drastically altered i.e. steel frame instead of carbon fibre or aluminum

stages of production

1. SHIPPING & RECEIVING

- *i.* ***loading dock***
  - » two semi-trailer docking bays provide platform for unloading *materials* and component parts, and loading boxed bicycle
- *ii.* ***vertical reciprocating conveyor***
  - » industrial open elevator shuttles component parts and boxed bicycles between loading dock level and factory level
- *iii.* ***incline conveyor***
  - » moving belted ramp transfers *materials* from loading dock down to factory
- *iv.* ***incline conveyor landing pad***
  - » padded area at bottom of ramp provides space for receiving *materials* to be placed in storage

2. MATERIALS & PARTS STORAGE

- *i.* ***materials storage pull-out racks***
  - » storage structure for *materials*
- *ii.* ***component parts shelves***
  - » storage compartments for component parts

3. CNC MACHINES

- *i.* ***CNC lathe***
  - » cuts, threads, and reduces profile of *metal tubing* for frame parts and component parts
- *ii.* ***CNC laser cutter***
  - » cuts and copes *metal tubing* and sheet metal for frame parts and component parts

4. MACHINE SHOP

- *i.* ***bar cutter***
  - » cuts *metal bar* for component parts
- *ii.* ***bar bender***
  - » bends *metal bar* for component parts
- *iii.* ***break***
  - » bends *sheet metal* for component parts
- *iv.* ***fender roller***
  - » rolls *sheet metal* for component parts (fenders)
- *v.* ***bead roller***
  - » rolls *sheet metal* for component parts (chainguards)
- *vi.* ***tube bender***
  - » bends *metal tubing* for component parts (handlebars)
- *vii.* ***grinder***
  - » grinds cut ends of *metal tubing* and *metal bar* for component parts
- *viii.* ***vibratory deburring machines*** x12
  - » smoothes cut edges of *metal tubing* and *sheet metal* for frame parts and component parts

5. PURPOSE-BUILT TOOLS
   1. ***drills*** x2
      - punches holes in *metal tubing* for frame parts
   2. ***circular saw***
      - cuts slits in *metal tubing* for frame parts (seat tubes)
   3. ***crimping machines*** x3
      - crimps *metal tubing* for frame parts
   4. ***breaks*** x2
      - bends *sheet metal* for frame parts

6. WASHING TANKS
   1. ***cleaner & degreaser tank***
      - cheated tank filled with industrial cleaner & degreaser agitates contents to remove dirt and grime from *metal tubing* and *sheet metal* for frame parts and component parts
   2. ***washing tank***
      - tank filled with soap & water agitates contents to clean *metal tubing* and *sheet metal* for frame parts and component parts
   3. ***rinsing tank***
      - tank filled with water agitates contents to rinse *metal tubing* and *sheet metal* for frame parts and component parts
   4. ***rust inhibiting tank***
      - tank filled with rust inhibitor solution agitates contents to protect *metal tubing* and *sheet metal* for frame parts and component parts from oxidation
   5. ***drying tank***
      - heated tank dries *metal tubing* and *sheet metal* for frame parts and component parts

7. WELDING BOOTHS
   1. ***frame tack welding booths*** x4
      - cubicles for tack welding *metal tubing* together into frames
   2. ***frame welding booths*** x18
      - cubicles for complete welding of frames
   3. ***parts welding booths*** x7
      - cubicles for welding *sheet metal* and *metal bar* into components

8. FRAME ADJUSTMENT AREA
   1. ***frame reamers*** x2
      - widens seat tube opening to restore original dimensions before deformities caused by welding
   2. ***frame alignment tables*** x2
      - worktables with preset specialized tools for adjusting and aligning welded frames
   3. ***defective frame management tables*** x3
      - worktables for fixing defective frames and components

9. SANDBLASTING
   1. ***sandblasting booths*** x4
      - small enclosed rooms for sandblasting frames

10. PAINTING

- *I.* ***PRIMER COAT***
  - *i.* ***primer powder coating booths*** x2
    - » enclosed rooms for spraying primer powder paint onto frames and component parts
  - *ii.* ***primer coat ovens*** x4
    - » ovens for baking frames and component parts to set primer powder paint
  - *iii.* ***primer coat cooling areas*** x4
    - » areas for baked primer powder painted frames and component parts to cool
- *II.* ***FINISH COAT***
  - *i.* ***finish powder coating booths*** x2
    - » enclosed rooms for spraying finish powder paint onto frames and component parts
  - *ii.* ***finish coat ovens*** x4
    - » ovens for baking frames and component parts to set finish powder paint
  - *iii.* ***finish coat cooling areas*** x4

11. WHEEL BUILDING

- *i.* ***wheel threading area***
  - » area for threading spokes into wheel hubs
- *ii.* ***wheel lacing machines*** x2
  - » clamps spokes to nipples after spokes are fed through hole in wheel rims
- *iii.* ***wheel truing machine***
  - » loosens and tightens nipples on opposite sides of rims to true wheels
- *iv.* ***wheel assembly area***
  - » table for spoked rims to be fitted with rim strips, inner tubes, and tires

12. ASSEMBLY

- *i.* ***parts pre-assembly hubs*** x4
  - » tables for assembly of component parts
- *ii.* ***bike assembly hubs*** x3 @ 3 stands/hub
  - » carousels with bicycle stands for assembly of bicycle

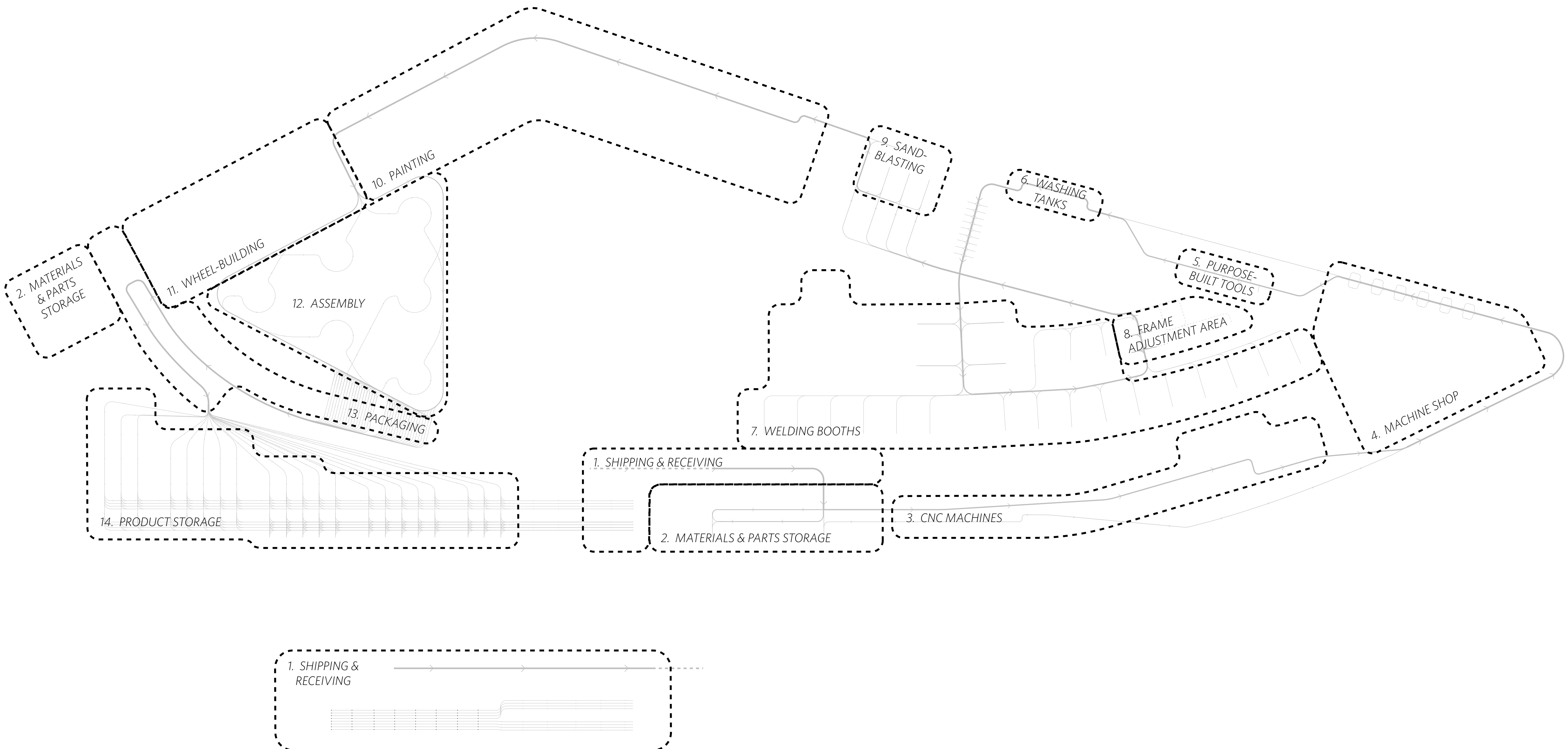
13. PACKAGING

- *i.* ***boxing station***
  - » area for packaging partially assembled bicycles, components, and manuals into boxes

14. PRODUCT STORAGE

- *i.* ***boxed product storage area***
  - » area for storing a full day's production in boxes on pallets ready for daily shipping

fig. 142 **factory production zones/** *1:400*



9. SAND-BLASTING
6. WASHING TANKS
5. PURPOSE-BUILT TOOLS
10. PAINTING
2. MATERIALS & PARTS STORAGE
11. WHEEL-BUILDING
12. ASSEMBLY
8. FRAME ADJUSTMENT AREA
13. PACKAGING
7. WELDING BOOTHS
4. MACHINE SHOP
1. SHIPPING & RECEIVING
14. PRODUCT STORAGE
3. CNC MACHINES
2. MATERIALS & PARTS STORAGE
1. SHIPPING & RECEIVING

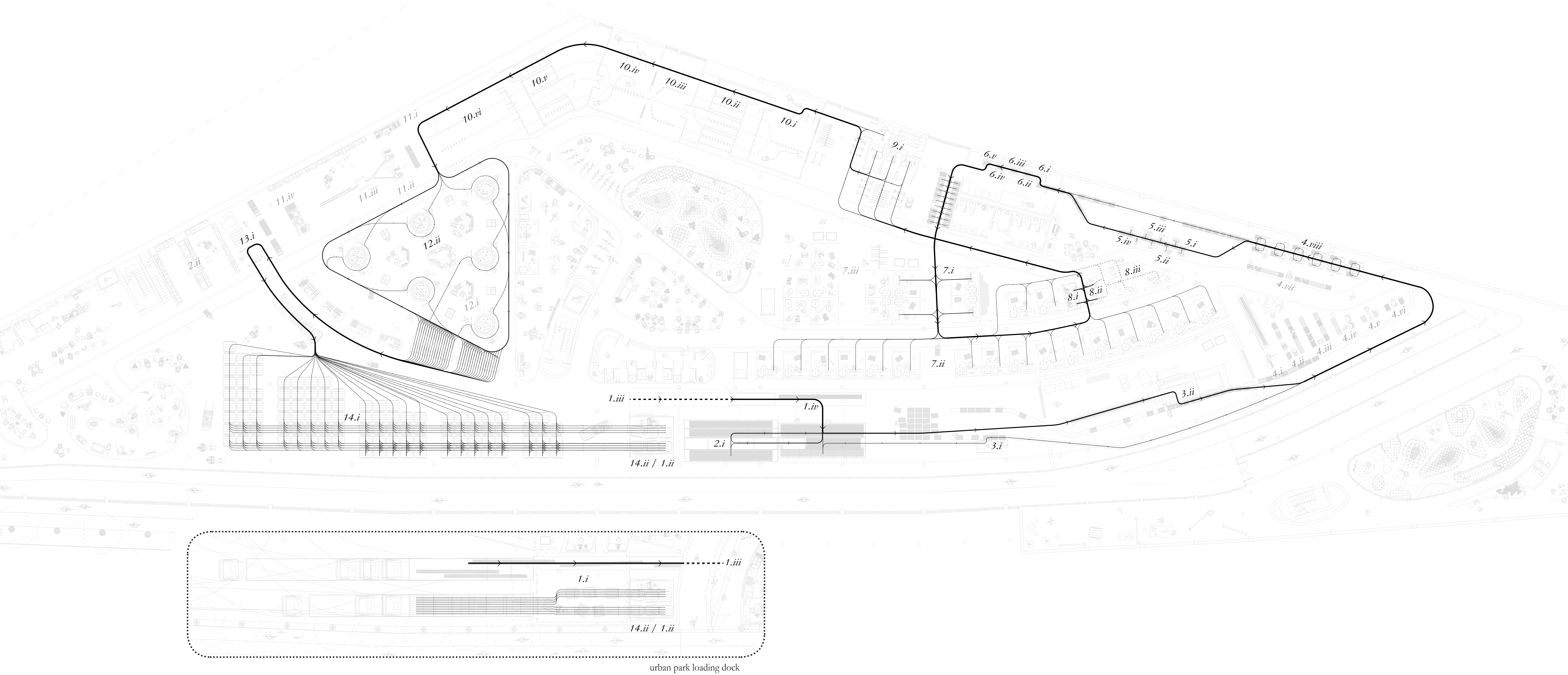


fig. 143 bicycle frame production process/
1:400

					PROPERTIES				
					specifications	dimensions			
						per part			
system	**#**	**component parts**	**sub-component parts**	**# per bicycle**		**diameter**	**length**	**width**	**area**
FRAME — tubing	1	**bottom bracket shell**		1		∅ 45 mm	68 mm	-	-
	2	**head tube**		1		∅ 30 mm	137 mm	-	-
	3	**down tube**		1		∅ 28.6 mm	652 mm	-	-
	4	**seat tube**		1		∅ 28.6 mm	537 mm	-	-
	5	**top tube**		1		∅ 25.4 mm	537 mm	-	-
	6	**chainstay (right)**		1	*diamond frame — 4130* ***True Temper*** *chrome molybdenum (chromoly steel) tubing w/ rear fender & rack mounts and eyelets, holes for kickstand mount, holes for water bottle cage mount, chainguard eyelet and mount holes, cable guides*	∅ 22.2 mm	374 mm	-	-
	7	**chainstay (left)**		1		∅ 22.2 mm	374 mm	-	-
	8	**seat stay (right)**		1		∅ 14 mm	428 mm	-	-
	9	**seat stay (left)**		1		∅ 14 mm	428 mm	-	-
FRAME — sheet metal	10	**dropouts**		2		-	-	-	3,000 mm^2
	11		**rear fender mount**	1		-	-	-	2,200 mm^2
	12		**rear fender & rack mount**	1		-	-	-	2,200 mm^2
	13		**cable guides**	7		-	-	-	140 mm^2
STEERING	1	**fork**		1	*4130* ***True Temper*** *chrome molybdenum (chromoly steel) w/ disc brake mount, front fender & rack eyelets*	-	-	-	-
	2	**headset**		1	*1 $^1/_8$” ∅ (29 mm) threaded black alloy*	∅ 29 mm	-	-	-
	3	**stem**		1	*1” ∅ (24 mm) aluminum alloy*	∅ 24 mm	-	-	-
	4	**handlebar**		1	*flat bar — $^7/_8$” ∅ (23 mm) aluminum alloy*	∅ 23 mm	-	480 mm	-
	5	**grips**		2	*leather wraps*	∅ 27 mm	100 mm	-	-
CONTROL	1	**brake levers**		2	*standard pull —* ***Velo Orange*** *Grand Cru Brake Levers Regular Pull*	-	-	-	-
	2	**brake cable**	**brake cable housing**	2	***Shimano*** *Road Brake Cable Set*	-	-	-	-
	3	**shifter**		1	*grip shifter —* ***Shimano*** *Nexus 3-speed Shifter*	-	-	-	-
	4	**shift cable**	**shift cable housing**	1	***Shimano*** *Road Shift Cable Set*	-	-	-	-
	5	**brakes**		2	*mechanical disc brake —* ***Shimano*** *mechanical disc brake w/ 160 mm rotors*	∅ 160 mm	-	-	-
DRIVETRAIN	1	**bottom bracket**		1	*cartridge —* ***Shimano***	-	-	-	-
	2	**crankset**	**crankarm (left)**	1	*single chainring —* ***Velo Orange*** *Grand Cru Fluted Single Crankset 44T forged aluminum alloy w/ 170 mm-long crankarms*	∅ 181 mm	170 mm	-	-
	3	**pedals**		2	*toe-clip compatible pedal — aluminum alloy*	-	82 mm	66 mm	-
	4	**chain**		1	*$^1/_2$” x $^3/_{32}$” rustproof chain —* ***Shimano***	-	-	-	-
	5	**cog**		1	***Shimano*** *Nexus Sprocket 18T*	77 mm	-	-	-
WHEELS	1	**front hub**		1	*bolt-on —* ***Shimano*** *Deore Front Hub w/ centre lock 32-hole*	-	-	-	-
	2	**rear hub**		1	*internal-gear hub —* ***Shimano*** *Nexus 3-speed Internal Hub*	-	-	-	-
	3	**spokes**	**spoke nipples**	64	***DT Swiss*** *Champion 14-gauge stainless steel*	2 mm	300 mm	-	-
	4	**rim**		2	*double wall —* ***Velo Orange*** *PBP Rim 700 x 32C 32-hole aluminum alloy*	622 mm	-	19 mm	-
	5	**rim tape**		2	*700 x 32C*	-	-	-	-
	6	**tire**		2	*commuter tire —* ***Kenda*** *Kwick Tendril 700 x 32C*	622 mm	-	32 mm	-
	7	**inner tube**		2	*presta valve*	-	-	-	-
SEATING	1	**saddle**		1	*touring saddle —* ***Brooks*** *Cambium C17 die-cast aluminum, steel, vulcanized natural rubber, cotton*	-	283 mm	162 mm	-
	2	**seatpost**		2	*built-in clamp — 1” ∅ (25 mm) aluminum alloy*	∅ 24 mm	350 mm	-	-
ACCESSORIES — included	1	**chainguard**		1	*18-ga chromoly steel sheet metal*	-	-	-	28,300 mm^2
	1a		**chainguard mounts**	2	*18-ga chromoly steel sheet metal*	-	-	-	826 mm^2
	2	**front fender**		1	*23-ga aluminum alloy*	-	-	42 mm	53,700 mm^2
	2a		**front fender stay**	1	*3 mm stainless steel round bar*	5 mm	772 mm	-	-
	2b		**front fender mount**	1	*17-ga aluminum alloy*	-	-	-	826 mm^2
	3	**rear fender**		1	*23-ga aluminum alloy*	-	-	42 mm	73,800 mm^2
	3a		**rear fender stay**	1	*3 mm stainless steel round bar*	5 mm	734 mm	-	-
	4	**rear rack**		1	*6 mm stainless steel round bar*	-	474 mm	130 mm	-
	4a		**rear rack mount**	1	*17-ga aluminum alloy*	-	-	-	3,420 mm^2
	5	**kickstand**	**kickstand mount**	1	*aluminum alloy*	-	300 mm	-	-
	6	**head badge**		1	*custom order — embossed bronze plate*	-	50 mm	28 mm	-
	7	**number tag**		1	*stamped thin aluminum sheet*	-	50 mm	28 mm	-
ACCESSORIES — optional extra	8	**front rack**		1	*6 mm stainless steel round bar*	-	360 mm	352 mm	-
	8a		**front rack mount**	1	*17-ga aluminum alloy*	-	-	-	3,492 mm^2
	9	**water bottle cage**		1	*6 mm stainless steel round bar*	-	150 mm	77 mm	-
	9a		**water bottle cage mount**	1	*17-ga aluminum alloy*	-	-	-	1,119 mm^2
	10	**bell**	**bell mount**	1	***Shinola Detroit*** *Copper Bike Bell*	-	-	-	-
	11	**portage strap**		1	***Walnut*** *Portage Strap*	-	-	-	-

fig. 144 bicycle component specifications

MATERIAL														FABRICATION			
4130 True Temper chrome molybdenum (chromoly steel) tubing						aluminum alloy tubing	stainless steel round bar		chromoly steel sheet metal			aluminum alloy sheet metal					
9.14 m (30') long						*9.14 m (30') long*	*6 m long*		*1.22 x 2.44 m (4x8') = 2.9768 m^2*			*1.22 x 2.44 m (4x8') = 2.9768 m^2*					
#1	#2	#3	#4	#5	#6	#1	#1 — 1/4" ∅	#2 — 1/8" ∅	#1 — *3 ga*	#2 — *18 ga*	#3 — *20 ga*	#1 — *17 ga*	#2 — *23 ga*				
∅ 45 mm	*∅ 30 mm*	*∅ 28.6 mm*	*∅ 25.4 mm*	*∅ 22.2 mm*	*∅ 14 mm*	*∅ 23 mm*	*∅ 6 mm*	*∅ 3 mm*	*6.1-mm thick*	*1.2-mm thick*	*0.9-mm thick*	*1.2-mm thick*	*0.6-mm thick*	manufacture	modify	assemble	purchase
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**please refer to post-post-script for full sequence of production table*

3. product » OBJECT

3.1 bicycle

3.1.1 BICYCLE COMMODITY

Any customer can have a car painted any colour that he wants so long as it is black.

— Henry Ford, *My Life and Work*

While the post-post-Fordist bicycle factory's one-product approach is part of its mass production strategy to maximize output and efficiency, the premise is also consciously positioned within an emerging contemporary counter-trend. Namely, in the increasingly diversifying post-Fordist market, it stands as a reaction to the era's dizzying proliferation of unlimited options. Recognizing that at any given time, there are numerous schools of thought and social momenta occurring alongside mainstream modes of operation, this thesis aligns with a less wasteful, and more streamlined approach to the commodity market—an awareness that is subsumed into the larger post-post-Fordist movement. Accordingly, it advocates for a more enduring, classic, Fordist simplicity in design and selection, versus the ephemerality of the rapid product turnovers of post-Fordism. In this way, the intervention, by appropriating two well-established typologies—the factory and the bicycle—acts as a post-post-Fordist grounding of fleeting post-Fordist tendencies.

3.1.1.1 DECISION FATIGUE

While the flexibility and heterogeneity of post-Fordism was a rejection of the rigidity and homogeneity of Fordism, 'decision fatigue' has also been brought on by the current era's fixation on increasing product variety and infinite customizations. In the post-Fordist world, people have been conditioned to think that more choices are always better, but studies have found that options, and ergo decision-making, depletes our mental energy. Thus in many situations, the more selection there is, the more overwhelmed we feel, so the less happy we are. Companies like Trader Joe's, a successful grocery chain, has been using this phenomenon to its advantage. Whereas most supermarkets try to outcompete each other by offering more variety, Trader Joe's thrives on providing its customers with a much smaller range of good quality products. Research shows that shoppers are more satisfied with purchases if their choices are limited because there is less likelihood of having made the 'wrong' selection.

Apple is another prominent example of a business that has adopted this philosophy, with its limited, but high-quality product line, not to mention its belief in the simplification of user experience, which permeates through all of its designs. In fact, the rise of 'iPhonization'—the phenomenon where the exact same device is shared by hundreds of millions of people around the world—makes a direct case against the notion that consumers always want more variety. Rather, it seems to point to the fact that people prioritize the quality and functionality of a commodity over the novelty of owning something different from their neighbour. The physical configuration of the products may be identical, but our relationship to the one we possess and the way we use it, becomes a very personal affair. With the iPhone, there is a high degree of control over the customization of the user interface i.e. wallpaper, apps, music collection, etc. and the same holds true for the bicycle. Even though the outward appearance, and mechanical operating system is the same, our connection and emotional attachment to the device is what is special i.e. where we choose to ride it day to day, the extra (or minimal) accessories we attach to it to suit our specific needs, how we fix and maintain it, etc. Moreover, having the option of tailoring a bicycle to conform perfectly to each of our unique physical dimensions, makes it an even more personalized object.

Minimizing Waste

Not only does product 'de-diversification' eliminate the stress of decision fatigue, but it also generates less waste, by cultivating a market with more exchangeable components, as opposed to fabricating more parts to deal with incompatibility between different models. Older versions of products in perfect working order, are often discarded by owners seeking out the latest, shiniest, design. While progress is always a positive force in society, the contemporary obsession with the perpetual hunt for 'the next best thing,' creates a culture of rapidly upgradeable and replaceable objects, which is materially wasteful and environmentally unsustainable. Instead, the focus should be on developing solid designs with quality construction. By paying more attention to the maintenance of a device, less waste from careless turnover would be generated, while enabling us to be more in tune with our personal objects. Bicycle frames can often last a lifetime, but due to lack of care and faster deterioration of other components, entire devices are often discarded. Therefore, educating the public and equipping them with the skills to service and repair their bikes is crucial, which is a key component of the intervention's program. In a way, this notion of minimizing product waste can be appended as an additional area of waste elimination in lean manufacturing.

3.1.1.2 COMMUTER BICYCLE

Secondly, the mono-product scenario merely paints a snapshot of the first stage of the bicycle factory's journey. It is inevitable for businesses to continuously evolve over time, as they adjust to feedback both from their level of success and changing market demands. The chief priority of the proposal at its inception, is the dissemination of the commuter bicycle, through the cultivation of the virtuous cycle between the bicycle and its infrastructure in the city. Because its goal is to promote cycling as a form of transportation, and as the largest market in this sector, the focus is on manufacturing a customizable mid-range commuter bicycle with a few optional accessories, by taking advantage of the cost efficiency offered by mass production. Detroit Bikes, one of the only large-scale producers of bicycles in North America, is used as a real-life precedent. Established in 2011 with a single design, the factory now offers two, and has plans to develop more in the future, which is a conceivable path of evolution for the post-post-Fordist bicycle factory.

Customization

The fundamental technology of the bicycle has remained the same for over a hundred years, despite fluctuating aesthetic trends throughout history. As a commuter bicycle, its utility is more important than its appearance, and thus the option of fitting the bicycle to one's unique body dimensions is arguably more practical than providing multiple design variations. As previously described, colour and accessories can also be customized to offer cyclists the option of personalizing the bicycle's look and function.

3.1.2 BICYCLE DESIGN

The bicycle factory's flagship product is a classic utility bicycle designed to be versatile for longer urban commutes, shorter errand runs, as well as occasional recreational excursions. Arguably, neither of the most popular types of bikes used in the city right now are satisfactory for the range of urban activities that take place in Toronto. Moreover, even if residents own more than one bicycle, it is uncommon for people to make equally good use of all of them, with one—most likely a commuter bike—that is used far more frequently than the rest.

Cruiser-style 'city bikes' are comfortable for short rides, and are often accessorized with various fittings to further enhance the user experience, but are much too cumbersome for longer trips—the hassle in fact discouraging people from using their bikes more often.

» pro: upright sitting position, wide tires, and sturdy build makes for a comfortable ride
» pro: baskets and racks can be used for transporting things easily; particularly useful for running errands
» con: heavier build and wide tires (causing greater rolling resistance) means more energy must be expended for propulsion
» con: bulkier form makes for inconvenient handling; not ideal for frequent stops

While mountain bikes make for a more comfortable ride for short distances on bumpy city roads, their stockier build means the rider has to exert more energy, thus, making it impractical for longer commutes or leisure rides.

» pro: wide tires with deep treads, shock-absorbing and sturdy frame make for a comfortable ride
» con: heavy, stocky build, and wide tires with deep treads creates more grip (friction) and rolling resistance, meaning that more energy must be expended for propulsion

Road bikes (i.e. fixed-gear bicycles) provide the lightweight convenience for handling and the energy efficiency for longer rides, but are not particularly comfortable on any surface but perfectly smooth paving, and are highly impractical for carrying things.

» pro: lightweight build, narrow tires with shallow treads make it easier to cycle longer distances by reducing overall mass, friction, and rolling resistance

- » pro: lightweight, unadorned frame makes it easy and convenient to handle and maneuver
- » con: stiff frames and narrow tires with shallow treads make for uncomfortable rides by transmitting all imperfections on the surface of the road to the rider
- » con: forward-leaning (rather than more upright) sitting position can be tiresome for non-professional casual users
- » con: stripped down simplicity of design lacks the various utilitarian functions practical for city roaming, such as baskets for transporting goods, bells, and in some cases, brakes for stopping

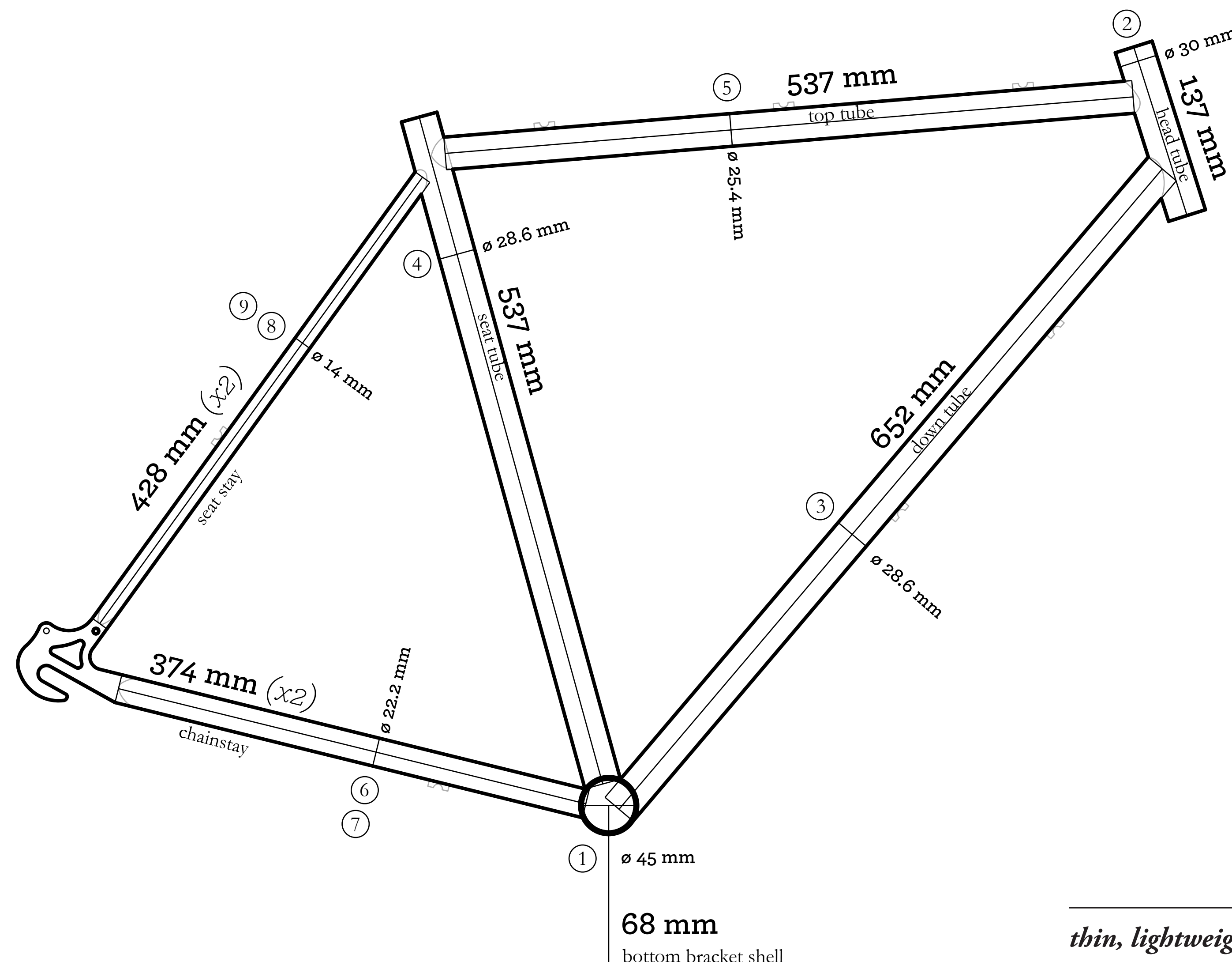
The design of the bicycle factory's commuter bike, is based on the fact that a well-designed and well-made device can, and should, fulfill all of the functional and comfort requirements of urban cycling, thus performing well on all fronts:

i. **nimble** enough to weave through traffic with ease
ii. **sturdy** enough to take on city roads with comfort
iii. equipped with the **essential gear** for urban survival

The bicycle is conceived as a well-priced, high-end midrange product employing high quality design, and craft. It features components from trusted, reliable, and top of the line manufacturers such as Brooks, Shimano, Velo Orange, and Kendra. The device is intended to achieve the optimal affordability for the majority of the population, without being so cheap that it becomes a disposable commodity. Even though the priority is to promote cycling culture, there also exists the need to foster an appreciation for higher quality bicycles (and other commodity). This encourages owners to maintain and take care of them regularly, so as to reduce unnecessary waste from discarded bikes.

classic DIAMOND FRAME *for simplicity and mass-appeal*

◊ well-known tried, tested, and true typology that does not attempt to be ostentatious or experiment with unusual forms



thin, lightweight, and strong CHROMOLY STEEL FRAME *with some flex*

◊ slight flex provides some relief from bumpy roads, without resulting in too much wasted energy
◊ thin profile and lightweight structure allow for long comfortable rides, and ease of handling
◊ durability & longevity: "High-quality steel has a very high yield strength or elastic range"[1] and unlike carbon, is not prone to sudden failure[2]
◊ steel is easily repairable and readily available, making it the most popular frame material around the globe[3]

1 Robert Penn, *It's All About the Bike: The Pursuit of Happiness on Two Wheels* (London: Penguin Books, 2011), 33.
2 Ibid., 34.
3 Ibid.

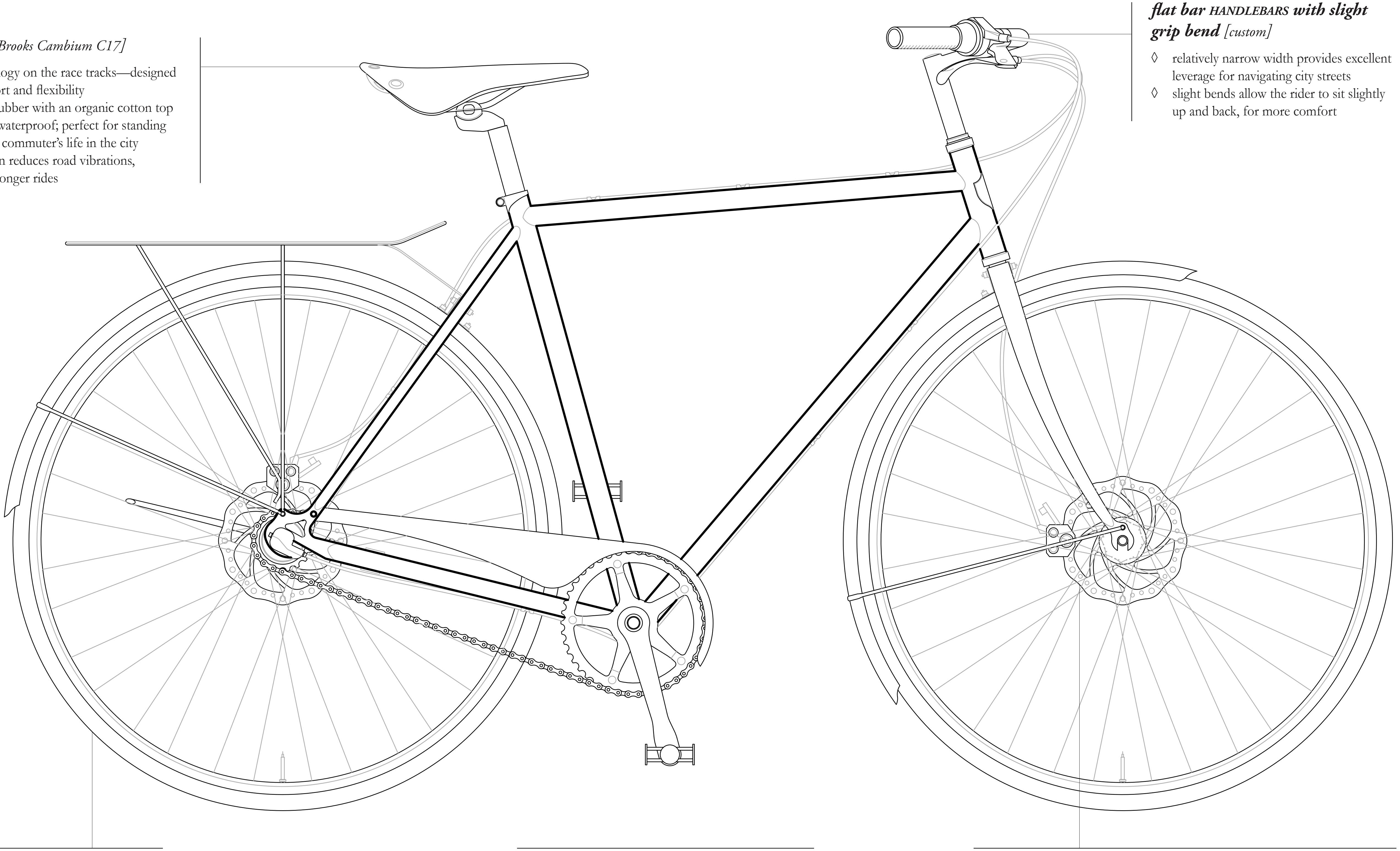
fig. 145 bicycle frame

ultra comfortable **SADDLE** *[Brooks Cambium C17]*

◊ taken from professional technology on the race tracks—designed for optimal performance comfort and flexibility
◊ made from vulcanized natural rubber with an organic cotton top
◊ flexible, maintenance-free, and waterproof; perfect for standing up to the daily wear and tear of commuter's life in the city
◊ Brooks' 'hammock' construction reduces road vibrations, providing optimal comfort for longer rides

flat bar **HANDLEBARS** ***with slight grip bend*** *[custom]*

◊ relatively narrow width provides excellent leverage for navigating city streets
◊ slight bends allow the rider to sit slightly up and back, for more comfort



commuter bike **TIRES** *[Kendra Kwick Tendtil 700 x 32C]*

◊ wider than road bike tires but thinner than mountain bike or cruiser-style 'city bike' tires with medium treads for optimal balance between comfort and efficiency
◊ centre of the tire has a continuous ridge to allow it to roll effortlessly (less friction and rolling resistance)
◊ edges of the tire incorporate just enough tread to grip onto city streets, bike paths, dirt roads, etc.

only equipped with most essential fittings

◊ provides the most practical functions for urban cycling
◊ remains relatively lightweight for maneuverability and riding ease

mechanical **DISC BRAKES** *[Shimano mechanical disc w/160 mm rotors]*

◊ responsive and powerful braking system for optimal safety on city streets, particularly in the rain
◊ don't get clogged with mud and snow (perfect for winter riding in Toronto)
◊ rotors are easily replaced

fig. 146 bicycle design

additional fittings available

- ◊ allows people to customize their bicycle according to the desired level of utility
- ◊ provides option for a more personalized product
- ◊ accommodates a range of affordability

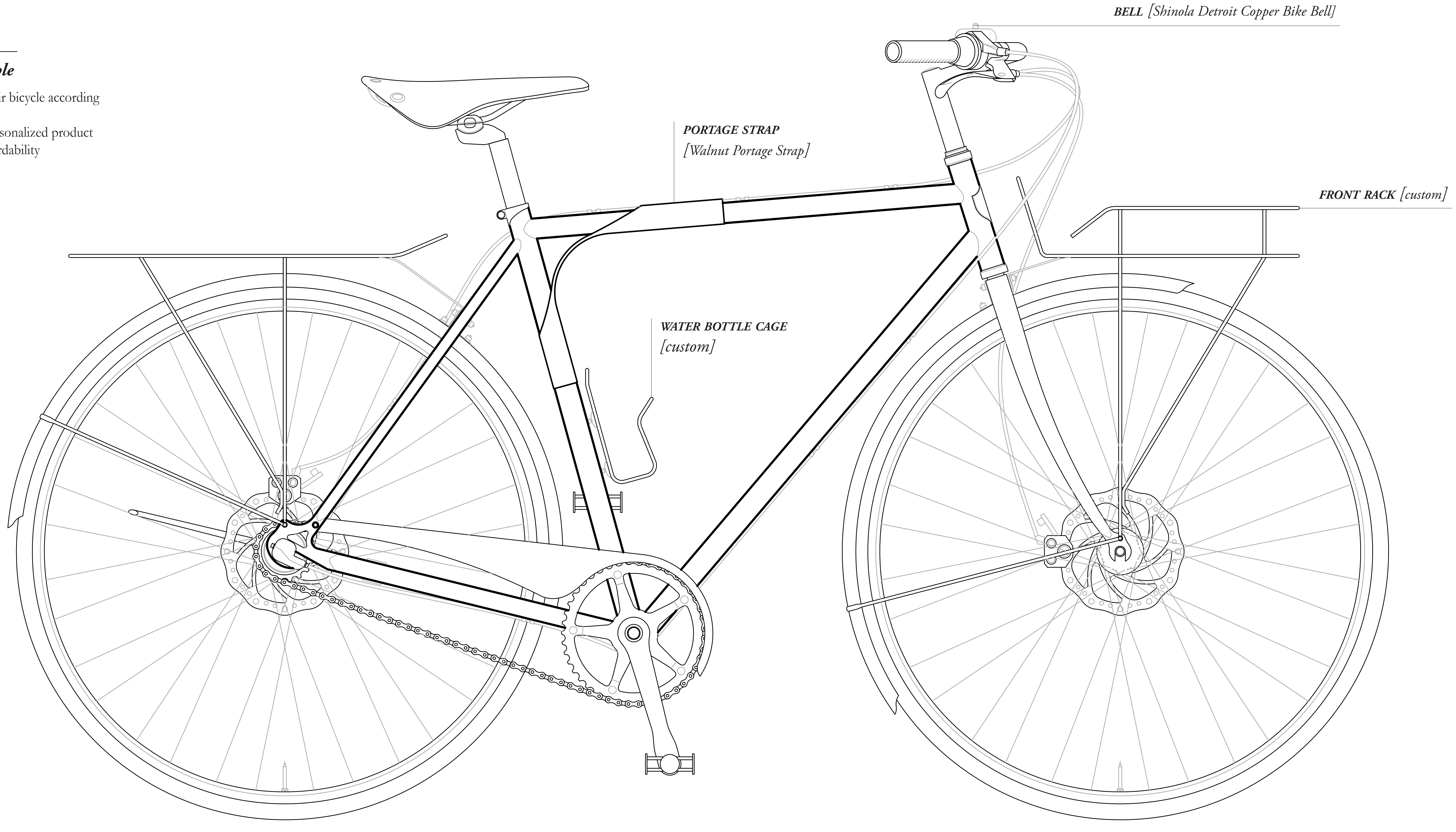


fig. 147 bicycle design with optional accessories

fr (frame)	*1*	bottom bracket shell
	2	head tube
	3	down tube
	4	seat tube
	5	top tube
	6	chainstay (right)
	7	chainstay (left)
	8	seat stay (right)
	9	seat stay (left)
	10	dropouts
st (steering)	*1*	fork
	2	headset
	3	stem
	4	handlebar
	5	grips
co (control)	*1*	brake levers
	2	brake cable
	3	shifter
	4	shift cable
	5	brakes
dt (drivetrain)	*1*	bottom bracket
	2	crankset
	3	pedals
	4	chain
	5	cog
wh (wheels)	*1*	front hub
	2	rear hub
	3	spokes
	4	rim
	5	rim tape
	6	tire
	7	inner tube
se (seat)	*1*	saddle
	2	seatpost
ac (accessories)	*1*	chainguard
	2	front fender
	3	rear fender
	4	rear rack
	5	kickstand
	6	head badge
	7	number tag
	8	front rack
	9	water bottle cage
	10	bell
	11	portage strap

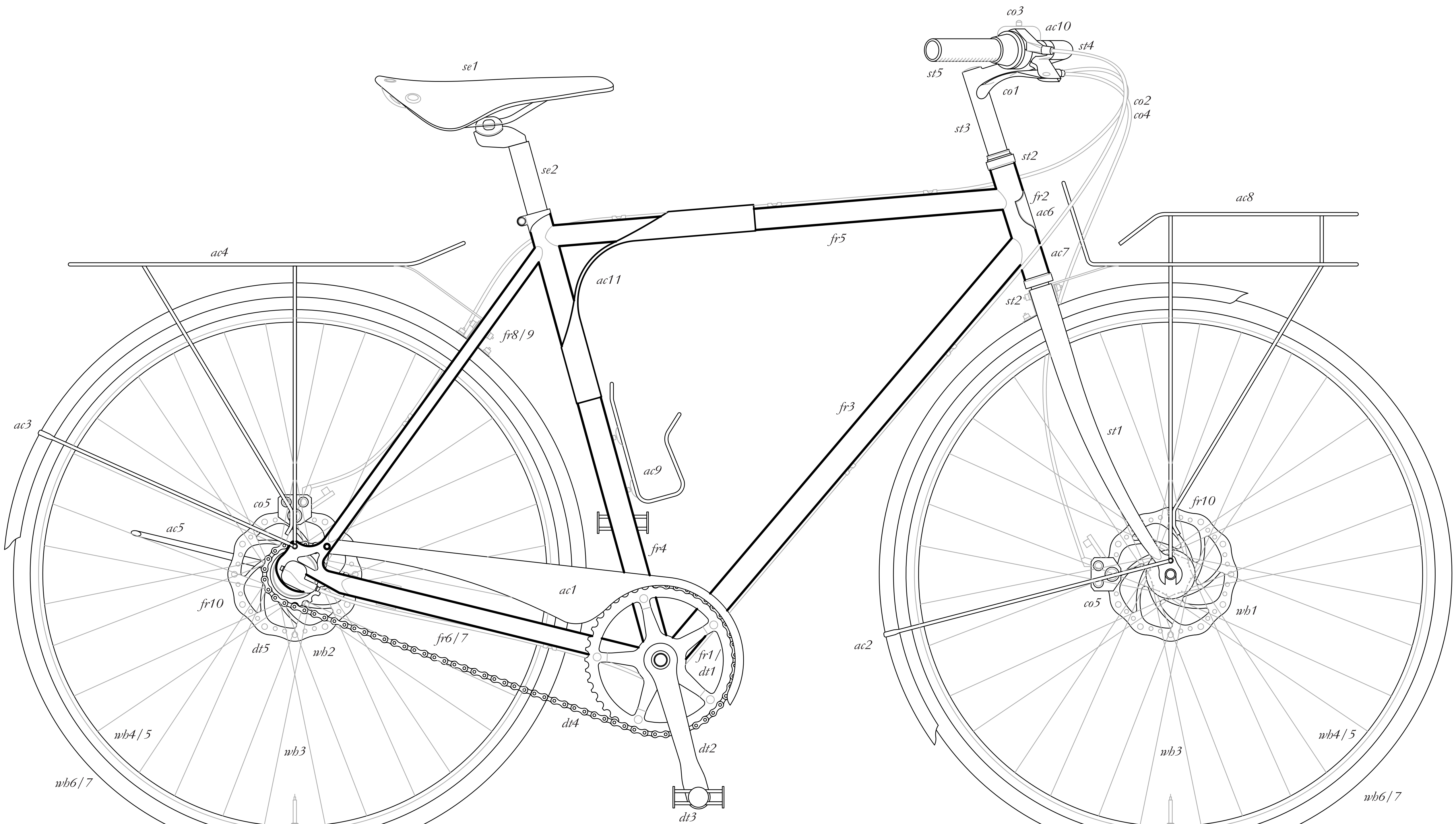


fig. 148 bicycle anatomy

x. post-script

Cities are constantly evolving, with their changing economic models, social attitudes, and cultural currents, but the built environment is rarely able to progresses at the same pace. This delay has consequently created entire swaths of territory devastated by these transformations, as in the case of Detroit. Certain urban features in cities like Toronto also allude to an industrial past, but whose irrelevant presence in the fabric now impede on its neighbourhoods' ability to thrive. Thus, as these societal agents continue to inform the morphology of the constructed landscape, it is important for architects to not only understand them and their contextual environs on a surface level, but to also engage in the origins of the influences at stake. This entails understanding historical patterns, why and how they evolved the way they have, their advantages and disadvantages, and the implications of modifying their parameters.

This kind of investigation not only enables architects to design era-appropriate buildings, but further equips them with the means to use architecture as an implement to direct and curate these forces effectively toward an envisioned, ideal future. Buildings can thus exert a positive influence in the shaping of our cities, avoiding the repercussions of ill-conceived constructs which have little regard for historical and urban contexts, or the human scale. Thus, by weaving a proposal from established, seemingly anachronistic elements of society, the thesis advocates for classic, timeless artifacts, and the importance of their role in the contemporary city. The environmentally-friendly bicycle and local urban factory, are used in contrast to the fast-paced, wasteful, and unsustainable reality of the post-Fordist economy.

For this reason, an in-depth analysis of the historical evolution and role of the two actants in urban society, is conducted. It traces the ways in which they have both sculpted, and been influenced by the city through the Industrial Revolution, Fordism, and post-Fordism. This working methodology is consequently clearly reflected in the design of the post-post-Fordist urban intervention. For example, one of the lessons that can be gleaned from the way radical modernist city planning models spawned functional segregation in the city and sprawling suburbs, is that the solutions were too far removed and extreme to have influenced society in a positive way. It resulted in proposals that were not only not fully considered, but impossible to test on such a massive scale.

The thesis proposal's strategy therefore, takes ingredients directly from past and present real-life scenarios, and applies them to suit current conditions accordingly. This is the very reason the envisioned post-post-Fordist movement combines the advantages and familiar characteristics of Fordism, with the successful aspects of post-Fordism, and the new currents rising against mainstream trajectories, to create a solid foundation for the urban intervention. While recognizing that 'originality' is an important part of civilization, the thesis takes a more pastiche approach toward innovative design. It is arguably a more effective way to operate, as incremental steps are more readily acceptable and thus more easily absorbed into society, instead of risking being outright rejected, or causing mayhem.

Although the proposal consists of a single project with specific programs and ambitions, the post-post-Fordist bicycle factory is also intended to be a precedent, as a means toward achieving the imagined ideal future of post-post-Fordist urban society. While the bicycle and the factory are the two artifacts chosen for the proposal, this hybrid strategy can be deployed to activate any latent urban potential, by understanding its historical underpinnings, transplanting it from conventional context, and discovering new relationships with which to redefine the city. The working methodology thereby operates as a framework for future developments in post-post-Fordist society. It also warns of the risk of designing with an architectural 'tunnel vision,' and that rather, relevant scales, whether it's urban, regional, national, global, object, or even molecular, should be considered. The strategy thus extends the scale of research, understanding, and influence of the architect, enabling designers to make more informed decisions about the built environment.

The strength of the project lies not only in its diversity, but in the way typically discrete elements interact in new, exiting, and powerful ways, as a microcosm of the heterogeneous post-post-Fordist city. The intervention achieves this on multiple levels, with its hybrid typology, interweaving structural construct, layered programs, and composite production model. It challenges the status quo by creating a unique urban condition based on an unconventional economic foundation. This manifests as an architectural artifact and community infrastructure which also challenges traditional models of construction, as it sits within the urban interstices of the city. The architectural scope is further extended to include the masterplan, the production and labour model, as well as the design of the commodity.

Even though the proposal is a speculative architecture, the project is firmly grounded in the realities of present-day society as if it were to be constructed. This is not only achieved thorough the rigorous analysis of historical trends and the placement of the proposal along those trajectories, but through the comprehensive methodology of the design investigation, which considers many facets of the building's realization. This includes the project's situation on an existing site, partnerships, funding, economics, markets, business models, production systems, labour organization, etc.—thus allowing it to be as conceivable as it is provocative.

On that account, the design has the ability to catalyze and mobilize Toronto's urban manufacturing and cycling landscapes in significant ways, particularly with the lack of bicycle manufacturers in North America. Moreover, by creating a flexible architecture with large accommodating spaces, the thesis responds to the fact that societal currents are always in flux, and buildings consequently need to be adaptable enough to respond to those inevitable changes, lest its obsolesce in the future creates waste, or worse, impedes urban development.

While the project is explored from multiple angles, and various layers are unpacked, there are still many questions that can be asked of this speculative post-post-Fordist architecture, city, and movement. Even though a snapshot of the beginning of the factory's journey is unfolded, how does the operation evolve? How do its products change over time? What does a postpostmodernist society look in tandem to post-post-Fordism? How does post-post-Fordism influence postpostmodernism, as Fordism and post-Fordism respectively influenced modernism and postmodernism? How does this new economic and social paradigm affect the city and how does it continue to transform the urban fabric? But no matter how society, the city, or the economy evolve through time, architecture has the power to transform and channel these social wills by bringing together a variety of ideas and disciplines in novel ways, stimulating our imagination as it continually sculpts and re-sculpts our urban habitat.

xx. post-post-script

production matrix

					PROPERTIES					MATERIAL											
					specifications	dimensions				4130 True Temper chrome molybdenum (chromoly steel) tubing						aluminum alloy tubing	stainless steel round bar		chromoly steel sheet metal		
										9.14 m (30') long						*9.14 m (30') long*	*6 m long*		*1.22 x 2.44 m (4x8') = 2.9768 m² = 2,976,800 mm²*		
						per part				#1	#2	#3	#4	#5	#6	#1	#1 — 1/4" ⌀	#2 — 1/8" ⌀	#1 — 3 ga	#2 — 18 ga	#3 — 20 ga
system	#	component parts	sub-component parts	# per bicycle		diameter	length	width	area	*⌀ 45 mm*	*⌀ 30 mm*	*⌀ 28.6 mm*	*⌀ 25.4 mm*	*⌀ 22.2 mm*	*⌀ 14 mm*	*⌀ 23 mm*	*⌀ 6 mm*	*⌀ 3 mm*	*6.1-mm thick*	*1.2-mm thick*	*0.9-mm thick*
FRAME — tubing	1	bottom bracket shell		1	*diamond frame — 4130* ***True Temper*** *chrome molybdenum (chromoly steel) tubing w/ rear fender & rack mounts and eyelets, holes for kickstand mount, holes for water bottle cage mount, chainguard eyelet and mount holes, cable guides*	⌀ 45 mm	68 mm	-	-	✖	-	-	-	-	-	-	-	-	-	-	-
	2	head tube		1		⌀ 30 mm	137 mm	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
	3	down tube		1		⌀ 28.6 mm	652 mm	-	-	-	-	✖	-	-	-	-	-	-	-	-	-
	4	seat tube		1		⌀ 28.6 mm	537 mm	-	-	-	-	✖	-	-	-	-	-	-	-	-	-
	5	top tube		1		⌀ 25.4 mm	537 mm	-	-	-	-	-	✖	-	-	-	-	-	-	-	-
	6	chainstay (right)		1		⌀ 22.2 mm	374 mm	-	-	-	-	-	-	✖	-	-	-	-	-	-	-
	7	chainstay (left)		1		⌀ 22.2 mm	374 mm	-	-	-	-	-	-	✖	-	-	-	-	-	-	-
	8	seat stay (right)		1		⌀ 14 mm	428 mm	-	-	-	-	-	-	-	✖	-	-	-	-	-	-
	9	seat stay (left)		1		⌀ 14 mm	428 mm	-	-	-	-	-	-	-	✖	-	-	-	-	-	-
	9 chromoly steel tubes/bike					-				*6 diameters of chromoly steel tubing*						-	-	-	-		
FRAME — sheet metal	10	dropouts		2	-	-	-	-	3,000 mm²	-	-	-	-	-	-	-	-	-	✖	-	-
	11		rear fender mount	1		-	-	-	2,200 mm²	-	-	-	-	-	-	-	-	-	-	✖	-
	12		rear fender & rack mount	1		-	-	-	2,200 mm²	-	-	-	-	-	-	-	-	-	-	✖	-
	13		cable guides	7		-	-	-	140 mm²	-	-	-	-	-	-	-	-	-	-	-	✖
	11 chromoly steel sheet metal parts/bike					-				-						-	-	-	*3 gauges of chromoly steel sheet metal*		
TOTAL — frame	*13 unique parts OR 20 parts/bike*					-				*6 diameters of chromoly steel tubing*						-	-	-	*3 gauges of chromoly steel sheet metal*		
STEERING	1	fork		1	*4130* ***True Temper*** *chrome molybdenum (chromoly steel) w/ disc brake mount, front fender & rack eyelets*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	headset		1	*1 1/8" ⌀ (29 mm) threaded black alloy*	⌀ 29 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	stem		1	*1" ⌀ (24 mm) aluminum alloy*	⌀ 24 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	handlebar		1	*flat bar — 7/8" ⌀ (23 mm) aluminum alloy*	⌀ 23 mm	-	480 mm	-	-	-	-	-	-	-	✖	-	-	-	-	-
	5	grips		2	*leather wraps*	⌀ 27 mm	100 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CONTROL	1	brake levers		2	*standard pull —* ***Velo Orange*** *Grand Cru Brake Levers Regular Pull*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	brake cable	brake cable housing	2	***Shimano*** *Road Brake Cable Set*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	1	shifter		1	*grip shifter —* ***Shimano*** *Nexus 3-speed Shifter*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	shift cable	shift cable housing	1	***Shimano*** *Road Shift Cable Set*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	brakes		2	*mechanical disc brake —* ***Shimano*** *mechanical disc brake w/ 160 mm rotors*	⌀ 160 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DRIVETRAIN	1	bottom bracket		1	*cartridge —* ***Shimano***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	crankset	crankarm (left)	1	*single chainring —* ***Velo Orange*** *Grand Cru Fluted Single Crankset 44T forged aluminum alloy w/ 170 mm-long crankarms*	⌀ 181 mm	170 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	pedals		2	*toe-clip compatible pedal — aluminum alloy*	-	82 mm	66 mm	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	chain		1	*1/2" x 3/32" rustproof chain —* ***Shimano***	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	cog		1	***Shimano*** *Nexus Sprocket 18T*	77 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
WHEELS	1	front hub		1	*bolt-on —* ***Shimano*** *Deore Front Hub w/ centre lock 32-hole*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	rear hub		1	*internal-gear hub —* ***Shimano*** *Nexus 3-speed Internal Hub*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	3	spokes	spoke nipples	64	***DT Swiss*** *Champion 14-gauge stainless steel*	2 mm	300 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	4	rim		2	*double wall —* ***Velo Orange*** *PBP Rim 700 x 32C 32-hole aluminum alloy*	622 mm	-	19 mm	-	-	-	-	-	-	-	-	-	-	-	-	-
	5	rim tape		2	*700 x 32C*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	tire		2	*commuter tire —* ***Kenda*** *Kwick Tendril 700 x 32C*	622 mm	-	32 mm	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	inner tube		2	*presta valve*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
SEATING	1	saddle		1	*touring saddle — Brooks Cambium C17 die-cast aluminum, steel, vulcanized natural rubber, cotton*	-	283 mm	162 mm	-	-	-	-	-	-	-	-	-	-	-	-	-
	2	seatpost		2	*built-in clamp — 1" ⌀ (25 mm) aluminum alloy*	⌀ 24 mm	350 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
ACCESSORIES — included	1	chainguard		1	*18-ga chromoly steel sheet metal*	-	-	-	28,300 mm²	-	-	-	-	-	-	-	-	-	-	✖	-
	1a		chainguard mounts	2	*18-ga chromoly steel sheet metal*	-	-	-	826 mm²	-	-	-	-	-	-	-	-	-	-	✖	-
	2	front fender		1	*23-ga aluminum alloy*	-	-	42 mm	53,700 mm²	-	-	-	-	-	-	-	-	-	-	-	-
	2a		front fender stay	1	*3 mm stainless steel round bar*	5 mm	772 mm	-	-	-	-	-	-	-	-	-	-	✖	-	-	-
	2b		front fender mount	1	*17-ga aluminum alloy*	-	-	-	826 mm²	-	-	-	-	-	-	-	-	-	-	-	-
	3	rear fender		1	*23-ga aluminum alloy*	-	-	42 mm	73,800 mm²	-	-	-	-	-	-	-	-	-	-	-	-
	3a		rear fender stay	1	*3 mm stainless steel round bar*	5 mm	734 mm	-	-	-	-	-	-	-	-	-	-	✖	-	-	-
	4	rear rack		1	*6 mm stainless steel round bar*	-	474 mm	130 mm	-	-	-	-	-	-	-	-	✖	-	-	-	-
	4a		rear rack mount	1	*17-ga aluminum alloy*	-	-	-	3,420 mm²	-	-	-	-	-	-	-	-	-	-	-	-
	5	kickstand	kickstand mount	1	*aluminum alloy*	-	300 mm	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6	head badge		1	*custom order — embossed bronze plate*	-	50 mm	28 mm	-	-	-	-	-	-	-	-	-	-	-	-	-
	7	number tag		1	*stamped thin aluminum sheet*	-	50 mm	28 mm	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL — components	*40 unique parts/bike OR 108 parts/bike*				-	-				-						*1 diameter of alloy tubing*	*2 diameters of stainless steel round bar*		*1 gauge of chromoly steel sheet metal*		
TOTAL — complete bike	*53 unique parts/bike OR 128 parts/bike*				-	-				*6 diameters of chromoly steel tubing*						*1 diameter of alloy tubing*	*2 diameters of stainless steel round bar*		*3 gauges of chromoly steel sheet metal*		
ACCESSORIES — optional extra	8	front rack		1	*6 mm stainless steel round bar*	-	360 mm	352 mm	-	-	-	-	-	-	-	-	✖	-	-	-	-
	8a		front rack mount	1	*17-ga aluminum alloy*	-	-	-	3,492 mm²	-	-	-	-	-	-	-	-	-	-	-	-
	9	water bottle cage		1	*6 mm stainless steel round bar*	-	150 mm	77 mm	-	-	-	-	-	-	-	-	✖	-	-	-	-
	9a		water bottle cage mount	1	*17-ga aluminum alloy*	-	-	-	1,119 mm²	-	-	-	-	-	-	-	-	-	-	-	-
	10	bell	bell mount	1	***Shinola Detroit*** *Copper Bike Bell*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	11	portage strap		1	***Walnut*** *Copper Bike Bell*	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
TOTAL — optional accessories	*4 unique parts/bike OR 4 parts/bike*				-	-				-						-	*1 diameter of stainless steel round bar*		-		
TOTAL — complete bike + optional accessories	*57 unique parts/bike OR 132 parts/bike*				-	-				*6 diameters of chromoly steel tubing*						*1 diameter of alloy tubing*	*2 diameters of stainless steel round bar*		*3 gauges of chromoly steel sheet metal*		

fig. 149 production matrix

		USE OF MATERIAL					FABRICATION													
aluminum alloy sheet metal											CNC lathe					CNC laser cutter			bar cutter	
1.22 x 2.44 m (4x8') = 2.9768 m^2 = 2,976,800 mm^2																				
#1 — 17 ga	*#2 — 23 ga*	*per bike*			*per day*						*per bike*				*per day*	*per bike*		*per day*	*per bike*	*per day*
1.2-mm thick	*0.6-mm thick*	length or area of material used	# parts per tube, bar, or sheet	% tube, bar, or sheet used/bike	# tubes, bars, or sheets used/432 bikes		manufacture	modify	assemble	purchase	cut	thread	reduce profile	operation time/bike	operation time/432 bikes	cope	cut	operation time/432 bikes	cut	operation time/432 bikes
-	-	68 mm	134	*0.74%*	3.20	**3.20** *[#1 Ø 45 mm chromoly steel tubes]*	✖	-	-	-	10 sec	60 sec	-	70 sec	8 hr 24 min	-	-	-	-	-
-	-	137 mm	66	*1.52%*	6.57	**6.57** *[#2 Ø 30 mm chromoly steel tubes]*	✖	-	-	-	10 sec	-	20 sec	30 sec	3 hr 36 min	-	-	-	-	-
-	-	652 mm	14	*7.14%*	30.84	**56.24** *[#3 Ø 28.6 mm chromoly steel tubes]*	✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	537 mm	17	*5.88%*	25.40		✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	537 mm	17	*5.88%*	25.40	**25.40** *[#4 Ø 25.4 mm chromoly steel tubes]*	✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	374 mm	24	*4.17%*	18.00	**36.00** *[#5 Ø 22.2 mm chromoly steel tubes]*	✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	374 mm	24	*4.17%*	18.00		✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	428 mm	21	*4.76%*	20.56	**41.12** *[#6 Ø 14 mm chromoly steel tubes]*	✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	428 mm	21	*4.76%*	20.56		✖	-	-	-	-	-	-	-	-	8 sec	-	57 min 36 sec	-	-
-	-	***3,535 mm*** *or* ***0.39*** *chromoly steel tubes used/bike*			***168.53*** *chromoly steel tubes used/432 bikes/day*		*9*	-	-	-				***100 sec****/bike*	***12 hr****/432 bikes/day*	***56 sec****/bike*		***6 hr 43 min 12 sec****/432 bikes/day*	-	-
-	-	5,200 mm^2 *x 2*	572	0.35%	1.51	**1.51** *[#1 – 6.5 mm chromoly steel sheet metal]*	✖	-	-	-	-	-	-	-	-	-	25 sec *x 2*	6 hr	-	-
-	-	2,700 mm^2	1,102	0.09%	0.39	**0.78** *[#2 – 1.2 mm chromoly steel sheet metal]*	✖	-	-	-	-	-	-	-	-	-	4 sec	28 min 48 sec	-	-
-	-	2,700 mm^2	1,102	0.09%	0.39		✖	-	-	-	-	-	-	-	-	-	4 sec	28 min 48 sec	-	-
-	-	180 mm^2 *x 7*	16,537	0.04%	0.17	**0.17** *[#3 – 0.9 mm chromoly steel sheet metal]*	✖	-	-	-	-	-	-	-	-	-	3 sec *x 7*	2 hr 31 min 12 sec	-	-
-	-	***17,060 mm^2*** *or* ***0.0057*** *chromoly steel sheet metal used/bike*			***2.46*** *chromoly steel sheet metal used/432 bikes/day*		*4*	-	-	-	-				-	***79 sec****/bike*		***9 hr 28 min 48 sec****/432 bikes/day*	-	-
-	-	***3,535 mm*** *or* ***0.39*** *chromoly steel tubes used/bike*			***168.53*** *chromoly steel tubes used/432 bikes/day*		***13*** *unique frame parts OR*							***100 sec****/bike*	***12 hr****/432 bikes/day*	***135 sec****/bike*		***16 hr 12 min****/432 bikes/day*	-	-
		17,060 mm^2 *or* ***0.0057*** *chromoly steel sheet metal used/bike*			***2.46*** *chromoly steel sheet metal used/432 bikes/day*		***20*** *frame parts manufactured/bike*													
-	-	-	-	-	-	-	-	✖	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	700 mm	13	7.66%	33.07	**33.07** *[#1 Ø 23 mm aluminum alloy tubes]*	✖	-	-	-	8 sec	-	-	8 sec	57 min 36 sec	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-		✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-		✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-		✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	✖	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-		✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-		✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-		✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	40,700 mm^2	73	*1.37%*	5.92	**5.92** *[#2 – 18-ga – 1.2-mm thick chromoly steel sheet metal]*	✖	-	-	-	-	-	-	-	-	-	20 sec	2 hr 24 min	-	-
-	-	964 mm^2 *x 2*	3,087	*0.06%*	0.28	**0.28** *[#2 – 18-ga – 1.2-mm thick chromoly steel sheet metal]*	✖	-	-	-	-	-	-	-	-	-	4 sec *x 2*	57 min 36 sec	-	-
-	✖	57,700 mm^2	51	*1.96%*	8.47	**8.47** *[#2 – 23-ga – 0.6-mm thick aluminum alloy sheet metal]*	✖	-	-	-	-	-	-	-	-	-	10 sec	1 hr 12 min	-	-
-	-	772 mm	7	*14.20%*	61.71	**61.71** *[#1 Ø 5 mm stainless steel round bar]*	✖	-	-	-	-	-	-	-	-	-	-	-	2 sec	14 min 24 sec
✖	-	964 mm^2	3,087	*0.03%*	0.14	**0.14** *[#1 – 17-ga – 1.2-mm thick aluminum alloy sheet metal]*	✖	-	-	-	-	-	-	-	-	-	4 sec	28 min 48 sec	-	-
-	✖	77,800 mm^2	38	*2.63%*	11.37	**11.37** *[#2 – 23-ga – 0.6-mm thick aluminum alloy sheet metal]*	✖	-	-	-	-	-	-	-	-	-	15 sec	1 hr 48 min	-	-
-	-	734 mm	8	*12.50%*	54.00	**54.00** *[#1 Ø 5 mm stainless steel round bar]*	✖	-	-	-	-	-	-	-	-	-	-	-	2 sec	14 min 24 sec
-	-	3,000 mm	2	*50.00%*	216.00	**216.00** *[#1 Ø 5 mm stainless steel round bar]*	✖	-	-	-	-	-	-	-	-	-	-	-	8 sec	57 min 36 sec
✖	-	3,600 mm^2	826	*0.12%*	0.52	**0.52** *[#1 – 17-ga – 1.2-mm thick aluminum alloy sheet metal]*	✖	-	-	-	-	-	-	-	-	-	4 sec	28 min 48 sec	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
2 *gauges of aluminum alloy sheet metal*		***700 mm*** *or* ***0.077*** *aluminum alloy tubes used/bike*			***33.07*** *aluminum alloy tubes used/432 bikes/day*		*10*	*1*	*1*	*26*				***8 sec****/bike*	***57 min 36 sec****/432 bikes/day*	***61 sec****/bike*		***7 hr 19 min 12 sec****/432 bikes/day*	***12 sec****/bike*	***1 hr 26 min 24 sec****/432 bikes/day*
		4,506 mm *or* ***0.751*** *stainless steel round bar used/bike*			***324.43*** *stainless steel round bars used/432 bikes/day*															
		59,688 mm^2 *or* ***0.0201*** *chromoly steel sheet metal used/bike*			***8.66*** *chromoly steel sheet metal used/432 bikes/day*															
		140,064 mm^2 *or* ***0.0471*** *aluminum alloy sheet metal used/bike*			***20.32*** *aluminum alloy sheet metal used/432 bikes/day*															
2 *gauges of aluminum alloy sheet metal*		***3,535 mm*** *or* ***0.39*** *chromoly steel tubes used/bike*			***168.53*** *chromoly steel tubes used/432 bikes/day*		***23*** *unique parts OR* ***31*** *parts manufactured/bike*							***108 sec****/bike*	***12 hr 57 min 36 sec****/432 bikes/day*	***196 sec****/bike*		***23 hr 31 min 12 sec****/432 bikes/day*	***12 sec****/bike*	***1 hr 26 min 24 sec****/432 bikes/day*
		700 mm *or* ***0.077*** *aluminum alloy tubes used/bike*			***33.07*** *aluminum alloy tubes used/432 bikes/day*		***1*** *part modified/bike*				***33.3 bikes****/hr @* ***54%*** *operation/day*					***18.4 bikes****/hr @* ***98%*** *operation/day*			***300 bikes****/hr @* ***6%*** *operation/day*	
		4,506 mm *or* ***0.751*** *stainless steel round bar used/bike*			***324.43*** *stainless steel round bars used/432 bikes/day*		***1*** *unique part OR* ***2*** *parts assembled/bike*				***1 worker****/6.5-hr shift x 2 shifts/day =* ***2 workers****/day*					***4 workers****/8-hr shift x 3 shifts/day =* ***12 workers****/day*			***1 worker****/1.5-hr shift x 1 shift/day =* ***1 worker****/day*	
		59,688 mm^2 *or* ***0.0201*** *chromoly steel sheet metal used/bike*			***8.66*** *chromoly steel sheet metal used/432 bikes/day*		***26*** *unique parts OR* ***99*** *parts purchased/bike*													
		140,064 mm^2 *or* ***0.0471*** *aluminum alloy sheet metal used/bike*			***20.32*** *aluminum alloy sheet metal used/432 bikes/day*															
-	-	5,437 mm	1	*100.00%*	108.00	**108.00** *[#1 Ø 5 mm stainless steel round bar]*	✖	-	-	-	-	-	-	-	-	-	-	-	20 sec	2 hr 24 min
✖	-	3,672 mm^2	810	*0.12%*	0.13	**0.13** *[#1 – 17-ga – 1.2-mm thick aluminum alloy sheet metal]*	✖	-	-	-	-	-	-	-	-	-	4 sec	7 min 12 sec	-	-
-	-	720 mm	8	*12.50%*	13.5	**13.5** *[#1 Ø 5 mm stainless steel round bar]*	✖	-	-	-	-	-	-	-	-	-	-	-	2 sec	14 min 24 sec
✖	-	1,602 mm^2	1,858	*0.05%*	0.06	**0.06** *[#1 – 17-ga – 1.2-mm thick aluminum alloy sheet metal]*	✖	-	-	-	-	-	-	-	-	-	4 sec	7 min 12 sec	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	✖	-	-	-	-	-	-	-	-	-	-
1 *gauge of aluminum alloy sheet metal*		***6,157 mm*** *or* ***1.0262*** *stainless steel round bar used/bike*			***121.5*** *stainless steel round bars used/108 bikes/day*		*4*	-	-	*1*	-				-	-		-	***22 sec****/bike*	***2 hr 38 min 24 sec****/432 bikes/day*
		5,274 mm^2 *or* ***0.0018*** *aluminum alloy sheet metal used/bike*			***0.19*** *aluminum alloy sheet metal used/108 bikes/day*															
2 *gauges of aluminum alloy sheet metal*		***3,535 mm*** *or* ***0.39*** *chromoly steel tubes used/bike*			***168.53*** *chromoly steel tubes used/432 bikes/day*		***27*** *unique parts OR* ***35*** *parts manufactured/bike*							***108 sec****/bike*	***12 hr 57 min 36 sec****/432 bikes/day*	***198 sec****/bike*		***23 hr 45 min 36 sec****/108 bikes/day*	***34 sec****/bike*	***4 hr 4 min 48 sec****/432 bikes/day*
		700 mm *or* ***0.077*** *aluminum alloy tubes used/bike*			***33.07*** *aluminum alloy tubes used/432 bikes/day*		***1*** *part modified/bike*				***33.3 bikes****/hr @* ***54%*** *operation/day*					***18.2 bikes****/hr @* ***99%*** *operation/day*			***105.9 bikes****/hr @* ***17%*** *operation/day*	
		10,663 mm *or* ***1.7772*** *stainless steel round bar used/bike*			***445.93*** *stainless steel round bars used/432 bikes/day*		***1*** *unique part OR* ***2*** *parts assembled/bike*				***1 worker****/6.5-hr shift x 2 shifts/day =* ***2 workers****/day*					***4 workers****/8-hr shift x 3 shifts/day =* ***12 workers****/day*			***1 worker****/4.5-hr shift x 1 shift/day =* ***1 worker****/day*	
		59,688 mm^2 *or* ***0.0201*** *chromoly steel sheet metal used/bike*			***8.66*** *chromoly steel sheet metal used/432 bikes/day*		***27*** *unique parts OR* ***100*** *parts purchased/bike*													
		145,338 mm^2 *or* ***0.0488*** *aluminum alloy sheet metal used/bike*			***20.51*** *aluminum alloy sheet metal used/432 bikes/day*															

bar cutter		bar bender		brake		fender roller		bead roller		tube bender		grinder		vibratory deburring machine *x 12*			
														machine operation @ *1 batch/hr*			
per bike	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per batch*		*per day*	
cut	operation time/432 bikes	bend	operation time/432 bikes	bend	operation time/432 bikes	roll	operation time/432 bikes	roll	operation time/432 bikes	bend	operation time/432 bikes	grind	operation time/432 bikes	max # per batch	max # bikes/ batch	# batches/ day	operation time/432 bikes
-	-	-	-	-	-	-	-	-	-	-	-	-	-	172	172	3	3 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	90	90	5	5 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	18	18	24	24 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	22	20	20 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	22	22	20	20 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	32	14	14 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	32	32	14	14 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	28	16	16 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	28	28	16	16 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	**132 batches**/*432 bikes/day*			**132 hr**/*432 bikes/day*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	118	59	7	7 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	196	196	3	3 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	196	196	3	3 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	1176	168	3	3 hr
-	-	-	-	-	-	-	-	-	-	-	-	-	-	**16 batches**/*432 bikes/day*			**16 hr**/*432 bikes/day*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	**148 batches**/*432 bikes/day*			**148 hr**/*432 bikes/day*
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	60 sec	7 hr 12 min	60 sec	7 hr 12 min	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	-	-	25 sec	3 hr	-	-	40 sec	4 hr 48 min	-	-	-	-	18	18	24	24 hr
-	-	-	-	5 sec *x 2*	1 hr 12 min	-	-	-	-	-	-	-	-	196	98	5	5 hr
-	-	-	-	45 sec	5 hr 24 min	50 sec	6 hr	-	-	-	-	-	-	15	15	29	29 hr
2 sec	14 min 24 sec	15 sec	1 hr 48 min	-	-	-	-	-	-	-	-	10 sec	1 hr 12 min	-	-	-	-
-	-	-	-	5 sec	36 min	-	-	-	-	-	-	-	-	196	196	3	3 hr
-	-	-	-	45 sec	5 hr 24 min	70 sec	8 hr 24 min	-	-	-	-	-	-	10	10	44	44 hr
2 sec	14 min 24 sec	15 sec	1 hr 48 min	-	-	-	-	-	-	-	-	10 sec	1 hr 12 min	-	-	-	-
8 sec	57 min 36 sec	90 sec	10 hr 48 min	-	-	-	-	-	-	-	-	40 sec	4 hr 48 min	-	-	-	-
-	-	-	-	5 sec	36 min	-	-	-	-	-	-	-	-	196	196	3	3 hr
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12 sec/*bike*	**1 hr 26 min 24 sec**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**135 sec**/*bike*	**16 hr 12 min**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**40 sec**/*bike*	**4 hr 48 min**/*432 bikes/day*	**60 sec**/*bike*	**7 hr 12 min**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**108 batches**/*432 bikes/day*			**108 hr**/*432 bikes/day*
12 sec/*bike*	**1 hr 26 min 24 sec**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**135 sec**/*bike*	**16 hr 12 min**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**40 sec**/*bike*	**4 hr 48 min**/*432 bikes/day*	**60 sec**/*bike*	**7 hr 12 min**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**256 batches**/*432 bikes/day*			**256 hr**/*432 bikes/day*
300 bikes/*hr @* **6%** *operation/day*		**30 bikes**/*hr @* **60%** *operation/day*		**26.7 bikes**/*hr @* **68%** *operation/day*		**30 bikes**/*hr @* **60%** *operation/day*		**90 bikes**/*hr @* **20%** *operation/day*		**60 bikes**/*hr @* **30%** *operation/day*		**30 bikes**/*hr @* **60%** *operation/day*		**20.25 bikes**/*hr @* **89%** *operation/day*			
1 worker/*1.5-hr shift x 1 shift/day =* **1 worker**/*day*		**1 worker**/*7.5-hr shift x 2 shifts/day =* **2 workers**/*day*		**1 worker**/*5.4-hr shift x 3 shifts/day =* **3 workers**/*day*		**1 worker**/*7.5-hr shift x 2 shifts/day =* **2 workers**/*day*		**1 worker**/*5-hr shift x 1 shift/day =* **1 worker**/*day*		**1 worker**/*7.5-hr shift x 1 shift/day =* **1 worker**/*day*		**1 worker**/*7.5-hr shift x 2 shifts/day =* **2 workers**/*day*		**2 workers/12 machines**/*7.5-hr shift x 3 shifts/day =* **6 workers**/*day*			
20 sec	2 hr 24 min	100 sec	3 hr	-	-	-	-	-	-	-	-	60 sec	7 hr 12 min	-	-	-	-
-	-	-	-	5 sec	36 min	-	-	-	-	-	-	-	-	196	196	3	3 hr
2 sec	14 min 24 sec	100 sec	3 hr	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	-	-	-	5 sec	36 min	-	-	-	-	-	-	-	-	196	196	3	3 hr
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22 sec/*bike*	**2 hr 38 min 24 sec**/*432 bikes/day*	**200 sec**/*bike*	**6 hr**/*108 bikes/day*	**10 sec**/*bike*	**1 hr 12 min**/*432 bikes/day*	-	-	-	-	-	-	**60 sec**/*bike*	**7 hr 12 min**/*432 bikes/day*	**6 batches**/*432 bikes/day*			**6 hr**/*432 bikes/day*
34 sec/*bike*	**4 hr 4 min 48 sec**/*432 bikes/day*	**320 sec**/*bike*	**20 hr 24 min**/*432 bikes/day*	**145 sec**/*bike*	**17 hr 24 min**/*432 bikes/day*	**120 sec**/*bike*	**14 hr 24 min**/*432 bikes/day*	**40 sec**/*bike*	**4 hr 48 min**/*432 bikes/day*	**60 sec**/*bike*	**7 hr 12 min**/*432 bikes/day*	**200 sec**/*bike*	**21 hr 36 min**/*432 bikes/day*	**262 batches**/*432 bikes/day*			**262 hr**/*432 bikes/day*
105.9 bikes/*hr @* **17%** *operation/day*		**21.2 bikes**/*hr @* **85%** *operation/day*		**24.8 bikes**/*hr @* **73%** *operation/day*		**30 bikes**/*hr @* **60%** *operation/day*		**90 bikes**/*hr @* **20%** *operation/day*		**60 bikes**/*hr @* **30%** *operation/day*		**18 bikes**/*hr @* **90%** *operation/day*		**19.8 bikes**/*hr @* **91%** *operation/day*			
1 worker/*4.5-hr shift x 1 shift/day =* **1 worker**/*day*		**1 worker**/*7-hr shift x 3 shifts/day =* **3 workers**/*day*		**1 worker**/*6-hr shift x 3 shifts/day =* **3 workers**/*day*		**1 worker**/*7.5-hr shift x 2 shift/day =* **2 workers**/*day*		**1 worker**/*5-hr shift x 1 shift/day =* **1 worker**/*day*		**1 worker**/*7.5-hr shift x 1 shift/day =* **1 worker**/*day*		**1 worker**/*7.5-hr shift x 3 shifts/day =* **3 workers**/*day*		**2 worker/12 machines**/*7.5-hr shift x 3 shift/day =* **6 workers**/*day*			

MANUFACTURING PROCESS

purpose-built tools												washing & drying tanks		pre-weld area		frame tack welding booths x 4		frame welding booths x 18		parts welding booths x 5 (x 7)		frame reamer x 2	
drill — hole punch					circular saw — cut	crimping machine — crimp			brake — bend			machine operation @ 20 min/batch											
#1			#2		#1	#1	#2	#3	#1	#2	per day	per tray	per day			per bike	per day	per bike	per day	per bike	per day	per bike	per day
chainguard mount screw hole	water bottle cage mount screw hole	kickstand mount screw hole	drain hole	seat post hole	seat post slit	chainstay mid-tube crimp	chainstay end-tube crimp	seat stay end-tube crimp	mounts	cable guides	operation time/432 bikes	max # per tray	# trays/432 bikes	frame	other components	TIG welding	operation time/432 bikes	TIG welding	operation time/432 bikes	TIG welding	operation time/432 bikes	ream	operation time/432 bikes
-	-	-	-	-	-	-	-	-	-	-	-	72	6	x	-								
-	-	-	-	-	-	-	-	-	-	-	-	51	9	x	-								
15 sec	-	-	-	-	-	-	-	-	-	-	1 hr 48 min	10	44	x	-								
15 sec	15 sec x 2	-	15 sec	15 sec	15 sec	-	-	-	-	-	10 hr 48 min	10	44	x	-								
-	-	-	-	-	-	-	-	-	-	-	-	12	36	x	-								
-	-	-	15 sec	-	-	15 sec	15 sec	-	-	-	5 hr 24 min	24	18	x	-								
-	-	15 sec x 2	15 sec	-	-	15 sec	15 sec	-	-	-	9 hr	24	18	x	-								
-	-	-	15 sec	-	-	-	-	15 sec	-	-	3 hr 36 min	31	14	x	-	12 min	86 hr 24 min	60 min	432 hr	-	-	6 min	43 hr 12 min
-	-	-	15 sec	-	-	-	-	15 sec	-	-	3 hr 36 min	31	14	x	-								
4 min 45 sec/bike/day											34 hr 12 min/432 bikes/day	203 trays/432 bikes/day		9	-								
-	-	-	-	-	-	-	-	-	-	-	-	54	16	x	-								
-	-	-	-	-	-	-	-	-	10 sec	-	1 hr 12 min	198	3	x	-								
-	-	-	-	-	-	-	-	-	10 sec	-	1 hr 12 min	198	3	x	-								
-	-	-	-	-	-	-	-	-	-	10 sec x 7	8 hr 24 min	3040	1	x	-								
1 min 30 sec/bike/day											10 hr 48 min/432 bikes/day	23 trays/432 bikes/day		4	-								
6 min 15 sec /bike/day											45 hr/432 bikes/day	226 trays/432 bikes/day		13 frame part tray stacks for welding		12 min/bike	86 hr 24 min/432 bikes/day	1 hr/bike	432 hr/432 bikes/day	-	-	6 min/bike	43 hr 12 min/432 bikes/day
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6 min 15 sec/bike											45 hr/432 bikes/day	408 trays/432 bikes/day		-	3 other components tray stacks for welding	-	-	-	-	16 min/bike	115 hr 12 min/432 bikes/day	-	-
6 min 15 sec/bike											45 hr/432 bikes/day	634 trays @ 9 trays/batch = 71 batches @ 20 min/batch = 23 hr 40 min/432 bikes/day		16 tray stacks for welding		12 min/bike	86 hr 24 min/432 bikes/day	1 hr/bike	432 hr/432 bikes/day	16 min/bike	115 hr 12 min/432 bikes/day	6 min/bike	43 hr 12 min/432 bikes/day
19.2 bikes/hr @ 89% operation/day												18.3 bikes/hr @ 99% operation/day				20 bikes/hr @ 90% operation/day		18 bikes/hr @ 100% operation/day		18.8 bikes/hr @ 96% operation/day (5 booths)		20 bikes/hr @ 90% operation/day	
2 workers/7.5-hr shift x 3 shifts/day = 6 workers/day												1 worker/8-hr shift x 3 shifts/day = 3 workers/day				4 tack welders/4 frame tack welding booth/7.5-hr shift x 3 shifts/day = 12 tack welders/day		18 welders/18 frame welding booths/8-hr shift x 3 shifts/day = 54 welders/day		5 welders/5 frame welding booths/8-hr shift x 3 shifts/day = 15 welders/day (5 booths)		1 worker/7.5-hr shift x 3 shifts/day = 3 workers/day	
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	25 min	180 hr	-	-
-	-	-	-	-	-	-	-	-	-	-	-	72	6	-	-	-	-	-	-	-	-	-	-
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	x	-	-	-	-	4 min	28 hr 48 min	-	-
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-											-	9 trays/432 bikes/day		-	2 other components tray stacks for welding	-	-	-	-	29 min/bike	52 hr 12 min/108 bikes/day	-	-
6 min 15 sec/bike/day											45 hr/432 bikes/day	643 trays @ 9 trays/batch = 72 batches @ 20 min/batch = 24 hr/432 bikes/day		18 tray stacks for welding		12 min/bike	86 hr 24 min/432 bikes/day	1 hr/bike	432 hr/432 bikes/day	45 min/bike	167 hr 24 min/432 bikes/day	6 min/bike	43 hr 12 min/432 bikes/day
19.2 bikes/hr @ 89% operation/day												18 bikes/hr @ 100% operation/day				20 bikes/hr @ 90% operation/day		18 bikes/hr @ 100% operation/day		18.1 bikes/hr @ 100% operation/day (7 booths)		20 bikes/hr @ 90% operation/day	
2 workers/7.5-hr shift x 3 shift/day = 6 workers/day												1 worker/6-hr shift x 3 shifts/day = 3 workers/day				4 tack welders/4 frame tack welding booth/7.5-hr shift x 3 shifts/day = 12 tack welders/day		18 welders/18 frame welding booths/8-hr shift x 3 shifts/day = 54 welders/day		14 welders/14 frame welding booths/8-hr shift x 3 shifts/day = 42 welders/day (7 booths)		1 worker/7.5-hr shift x 3 shifts/day = 3 workers/day	

frame alignment table *x 2*		sandblasting booth *x 4*					primer powder coating booth *x 2*					oven *x 4*			cooling area *x 4*			finish powder coating booth *x 2*				
												machine operation @ *20 min/batch*			*10 min/batch*							
per bike	*per day*	*per bike*	*per batch*		*per day*		*per bike*	*per batch*		*per day*		*per batch*	*per day*		*per batch*	*per day*		*per bike*	*per batch*		*per day*	
align	operation time/432 bikes	sandblast	max # bikes/ batch	per batch	# batches/ day	operation time/432 bikes	powder coat	max # bikes/ batch	operation time/ batch	# batches/ day	operation time/432 bikes	max # bikes/ batch	# batches/ day	operation time/432 bikes	max # bikes/ batch	# batches/ day	operation time/432 bikes	powder coat	max # bikes/ batch	operation time/ batch	# batches /day	operation time/432 bikes
5 min	36 hr	8 min	1	8 min	432	57 hr 36 min	4 min	5	20 min	87	28 hr 48 min	5	87	29 hr	5	87	14 hr 30 min	4 min	5	20 min	87	28 hr 48 min
***5 min**/bike*	***36 hr**/432 bikes/day*	***8 min**/bike*	***57 hr 36 min**/432 batches/432 bikes/day*				***4 min**/bike*	***28 hr 48 min**/87 batches/432 bikes/day*				***29 hr**/87 batches/432 bikes/day*			***14 hr 30 min**/87 batches/432 bikes/day*			***4 min**/bike*	***28 hr 48 min**/87 batches/432 bikes/day*			
-	-	75 sec	4	5 min	108	9 hr	60 sec	10	10 min	44	7 hr 12 min	10	44	14 hr 40 min	10	44	7 hr 20 min	60 sec	10	10 min	44	7 hr 12 min
-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
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-	-	45 sec	4	3 min	108	5 hr 24 min	30 sec	10	5 min	44	3 hr 36 min	10	44	14 hr 40 min	10	44	7 hr 20 min	30 sec	10	5 min	44	3 hr 36 min
-	-	60 sec	4	4 min	108	7 hr 12 min	30 sec	10	5 min	44	3 hr 36 min	10	44	14 hr 40 min	10	44	7 hr 20 min	30 sec	10	5 min	44	3 hr 36 min
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-	-	70 sec	4	4 min 40 sec	108	8 hr 24 min	30 sec	10	5 min	44	3 hr 36 min	10	44	14 hr 40 min	10	44	7 hr 20 min	30 sec	10	5 min	44	3 hr 36 min
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-	-	***4 min 10 sec**/bike*	***30 hr**/108 batches/432 bikes/day*				***2 min 30 sec**/bike*	***18 hr**/176 batches/432 bikes/day*				***58 hr 40 min**/176 batches/432 bikes/day*			***29 hr 20 min**/176 batches/432 bikes/day*			***2 min 30 sec**/bike*	***18 hr**/176 batches/432 bikes/day*			
***5 min**/bike*	***36 hr**/432 bikes/day*	***12 min 10 sec**/bike*	***87 hr 36 min**/540 batches/432 bikes/day*				***6 min 30 sec**/bike*	***46 hr 48 min**/94 batches/432 bikes/day*				***87 hr 40 min**/263 batches/432 bikes/day*			***43 hr 50 min**/263 batches/432 bikes/day*			***6 min 30 sec**/bike*	***46 hr 48 min**/94 batches/432 bikes/day*			
***24 bikes**/hr @ **75%** operation/day*		***19.7 bikes**/hr @ **91%** operation/day*					***19.2 bikes**/hr @ **98%** operation/day*					***19.7 bikes**/hr @ **91%** operation/day*			***39.4 bikes**/hr @ **46%** operation/day*			***19.2 bikes**/hr @ **98%** operation/day*				
***1 worker**/6-hr shift x 3 shifts/day = **3 workers**/day*		***4 workers/4 sandblasting booths**/7.5-hr shift x 3 shifts/day = **12 workers**/day*					***2 workers/2 powder coating booths**/7.5-hr shift x 3 shifts/day = **6 workers**/day*					***1 worker/4 machines**/7.5-hr shift x 3 shifts/day = **3 workers**/day*						***2 workers/2 powder coating booths**/7.5-hr shift x 3 shifts/day = **6 workers**/day*				
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***5 min**/bike*	***36 hr**/432 bikes/day*	***12 min 10 sec**/bike*	***87 hr 36 min**/540 batches/432 bikes/day*				***6 min 30 sec**/bike*	***46 hr 48 min**/94 batches/432 bikes/day*				***87 hr 40 min**/263 batches/432 bikes/day*			***43 hr 50 min**/263 batches/432 bikes/day*			***6 min 30 sec**/bike*	***46 hr 48 min**/94 batches/432 bikes/day*			
***24 bikes**/hr @ **75%** operation/day*		***19.7 bikes**/hr @ **91%** operation/day*					***19.2 bikes**/hr @ **98%** operation/day*					***19.7 bikes**/hr @ **91%** operation/day*			***39.4 bikes**/hr @ **46%** operation/day*			***19.2 bikes**/hr @ **98%** operation/day*				
***1 worker**/6-hr shift x 3 shifts/day = **3 workers**/day*		***4 workers/4 sandblasting booths**/7.5-hr shift x 3 shifts/day = **12 workers**/day*					***2 workers/2 powder coating booths**/7.5-hr shift x 3 shifts/day = **6 workers**/day*					***1 worker/4 machines**/7.5-hr shift x 3 shifts/day = **3 workers**/day*						***2 workers/2 powder coating booths**/7.5-hr shift x 3 shifts/day = **6 workers**/day*				

oven *x 4*			cooling area			wheel-threading area		wheel-lacing machine *x 2*		wheel-truing machine		wheel assembly area		parts pre-assembly hub *x 4*		bike assembly hub *x 6 @ 3 stands/hub*				boxing station *x 3*	
machine operation @ *20 min/batch*			*10 min/batch*													*1 hr/bike*					
per batch	*per day*		*per batch*	*per day*		*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*per bike*	*per day*	*20 min/bike*	*20 min/bike*	*20 min/bike*	*per day*	*per bike*	*per day*
max # bikes/ batch	# batches/ day	operation time/432 bikes	max # bikes/ batch	# batches/ day	operation time/432 bikes	thread	operation time/ 432 bikes	lace	operation time/432 bikes	true	operation time/432 bikes	assembly	operation time/432 bikes	assembly	operation time/432 bikes	stand #1	stand #2	stand #3	operation time/ 432 bikes	box	operation time/432 bikes
5	87	29 hr	20	22	3 hr 40 min	-	-	-	-	-	-	-	-	-	-	✖			-		
29 hr*/87 batches/432 bikes/day*			***3 hr 40 min****/22 batches/432 bikes/day*			-	-	-	-	-	-	-	-	-	-						
10	44	14 hr 40 min	40	11	1 hr 50 min	-	-	-	-	-	-	-	-	-	-	-	✖				
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10	44	14 hr 40 min	40	11	1 hr 50 min	-	-	-	-	-	-	-	-	-	-	-	-	✖	-		
10	44	14 hr 40 min	40	11	1 hr 50 min	-	-	-	-	-	-	-	-								
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10	44	14 hr 40 min	40	11	1 hr 50 min	-	-	-	-	-	-	-	-	60 sec	7 hr 12 min	-	✖				
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58 hr 40 min*/176 batches/432 bikes/day*			***7 hr 20 min****/44 batches/432 bikes/day*			***1 min****/bike*	***7 hr 12 min****/432 bikes/day*	***4 min****/bike*	***28 hr 48 min****/432 bikes/day*	***3 min****/bike*	***21 hr 36 min****/432 bikes/day*	***3 min****/bike*	***21 hr 36 min****/432 bikes/day*	***13 min****/bike*	***93 hr 36 min****/432 bikes/day*	*5*	*4*	*7*	*16*		
87 hr 40 min*/263 batches/432 bikes/day*			***11 hr****/66 batches/432 bikes/day*			***1 min****/bike*	***7 hr 12 min****/432 bikes/day*	***4 min****/bike*	***28 hr 48 min****/432 bikes/day*	***3 min****/bike*	***21 hr 36 min****/432 bikes/day*	***3 min****/bike*	***21 hr 36 min****/432 bikes/day*	***13 min****/bike*	***93 hr 36 min****/432 bikes/day*	***1 hr****/bike*			***432 hr****/432 bikes/day*	***10 min****/bike*	***72 hr****/432 bikes/day*
19.7 bikes*/hr @* ***91%*** *operation/day*			***39.3 bikes****/hr*			***60 bikes****/hr*		***30 bikes****/hr @* ***60%*** *operation/day*		***20 bikes****/hr @* ***90%*** *operation/day*		***20 bikes****/hr*		***18.5 bikes****/hr*		***18 bikes****/hr*				***18 bikes****/hr*	
1 worker/4 machines*/7.5-hr shift x 3 shifts/day =* ***3 workers****/day* -						***1 worker****/7.5-hr shift x 1 shift/day =* ***1 worker****/day*		***2 workers/2 machines****/7.5-hr shift x 2 shifts/day =* ***4 workers****/day*		-		***1 worker****/7.5-hr shift x 3 shifts/day =* ***3 workers****/day*		***4 workers/4 hubs****/8-hr shift x 3 shifts/day =* ***12 workers****/day*		***18 workers/6 hubs****/8-hr shift x 3 shifts/day =* ***54 workers****/day*				***3 workers/station****/8-hr shift x 3 shifts/day =* ***27 workers****/day*	
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-		-	-		-	-	-	-	-	-	-	-	-	***30 sec****/bike*	***54 min****/108 bikes/day*	-	-	-	-	-	
87 hr 40 min*/263 batches/432 bikes/day*			***11 hr****/66 batches/432 bikes/day*			***1 min****/bike*	***7 hr 12 min****/432 bikes/day*	***4 min****/bike*	***28 hr 48 min****/432 bikes/day*	***3 min****/bike*	***21 hr 36 min****/432 bikes/day*	***3 min****/bike*	***21 hr 36 min****/432 bikes/day*	***13 min 30 sec****/bike*	***94 hr 30 min****/432 bikes/day*	***1 hr****/bike*			***432 hr****/432 bikes/day*	***10 min****/bike*	***72 hr****/432 bikes/day*
19.7 bikes*/hr @* ***91%*** *operation/day*			***39.3 bikes****/hr @* ***46%*** *operation/day*			***60 bikes****/hr*		***30 bikes****/hr @* ***60%*** *operation/day*		***20 bikes****/hr @* ***90%*** *operation/day*		***20 bikes****/hr*		***18.3 bikes****/hr*		***18 bikes****/hr*				***18 bikes****/hr*	
1 worker/4 machines*/7.5-hr shift x 3 shifts/day =* ***3 workers****/day*						***1 worker****/7.5-hr shift x 1 shift/day =* ***1 worker****/day*		***2 workers/2 machines****/7.5-hr shift x 2 shifts/day =* ***4 workers****/day*		-		***1 worker****/7.5-hr shift x 3 shifts/day =* ***3 workers****/day*		***4 workers/4 hubs****/8-hr shift x 3 shifts/day =* ***12 workers****/day*		***18 workers/6 hubs****/8-hr shift x 3 shifts/day =* ***54 workers****/day*				***9 workers/station****/8-hr shift x 3 shifts/day =* ***27 workers****/day*	

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