

Alternate Occupancy |

Increasing Urban Density Through Reuse of Existing Garages

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ABSTRACT

The stand-alone parking garage exemplifies the twentieth century paradigm of the American city's reliance on car-centric infrastructure and encouragement of suburban sprawl. Over the past 100 years, streets have transitioned from the realm of the pedestrian to the domain of the automobile. The overabundance of cars in urban centers is a primary cause of congestion, pollution and diminished pedestrian safety in our cities. The car is a systemic problem in our culture; solutions must come from a variety of disciplines. Inexpensive and easy access to parking garages perpetuates the status quo.

Car-centric twentieth century city planning is counter to twenty-first century trends in urbanization, energy policy and sustainability. A reduction in parking spaces will reduce car numbers, encourage better mass transit and greater density in urban centers, and help move society towards a healthier, safer, more environmentally responsible way of life.

The stand-alone parking garage, whose sole function is the storage of cars, is an ideal place to begin to challenge the existing paradigm. Removal of parking capacity will simultaneously decrease the number of cars entering city centers and allow this space to instead be allotted to high-density mixed-use development. Instead of contributing to the building industry's growing waste stream, garages can be adaptively reused. Converting parking garages makes use of the energy embodied in the existing structures and saves time and money associated with demolition and new construction. Despite some challenges, reuse will reinforce a new, more enlightened way of thinking about the built environment.

This thesis argues that many existing parking garages can viably and effectively be converted to fulfill new functions in urban centers. This thesis explores the feasibility of adaptively reusing the existing parking garage on the west side of 1st Avenue at Columbia Street, in downtown Seattle. A combination of 140 units of housing and 25,000 square feet of commercial space inserted into the existing structure will convert the block-long parking garage into a mixed-use development. This will beneficially increase density while decreasing the accommodation of cars in Seattle, reducing the negative environmental impacts of car-centric infrastructure on the built environment.



INTRODUCTION

Over the past century, cities have slowly changed from dense places of pedestrian inhabitation to gridlocked networks for automobiles. The percentage of people living in cities has increased from 13%, in 1900, to 49%, in 2005, and is expected to be 60% by 2030 (United Nations 2005). With more people come more cars and the problem will only continue to worsen. People driving from outlying neighborhoods, suburbs, and exurbs to and from city centers contribute to global warming, the growing obesity epidemic, traffic related accidents, and generally make the whole of these cities less inviting places for pedestrians (Jacobs 1961; Jackson 2003; Jackson 2003; Gehl 2009). As the populations of our urban centers continue to swell, reducing the number of cars within them is vital because increases to the area of our roadways cannot keep pace (Shoup 2005). Reducing the amount of parking in city centers will reduce the overall number of cars in the city's downtown cores (Shoup 2005).

Once a building type of important utility, stand-alone parking garages are no longer the 'highest and best use' of space in urban centers. The space that cars currently inhabit will be essential to fulfill the rising demands for space associated with a greater density of living within the city. This thesis will examine the validity and architectural possibilities of reusing existing parking garages for new purposes, determine characteristics under which reuse is optimal, and propose the reuse of a specific parking garage in downtown Seattle. The following chapters explore how to understand and examine the design potential and inherent challenges of garage reuse.



Figure 1.1: Afternoon congestion on 6th Avenue in Seattle, WA

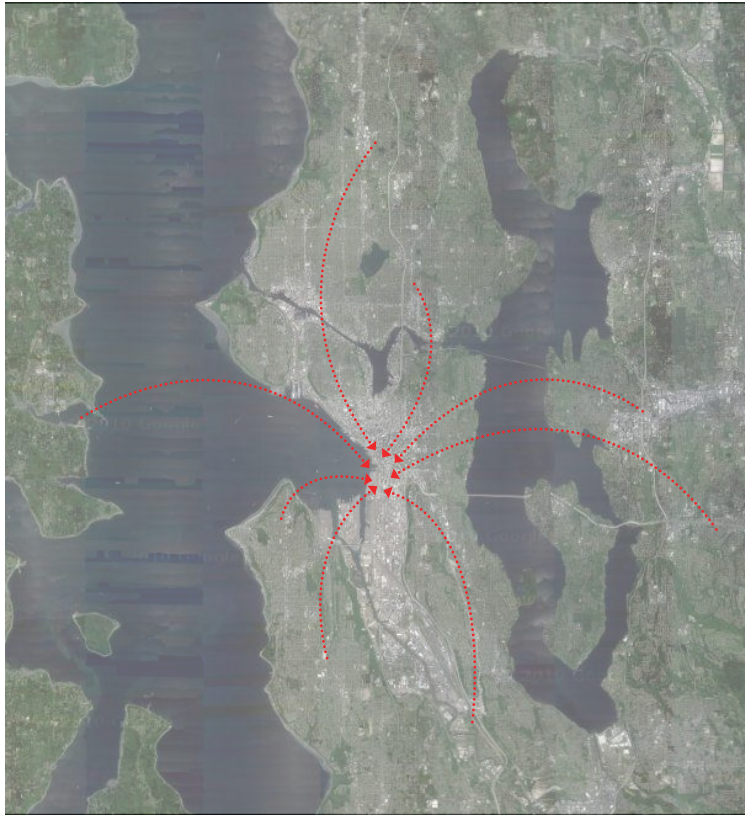


Figure 1.2: Commuting trends in the greater Seattle metro area

Chapter I looks closer at the problem of the current twentieth century paradigm of the car. Chapter II investigates the parking garage as a building type, documents existing conditions of 10 Seattle garages and considers potential issues with parking garage reuse. Parking structures represent a significant amount of embodied energy and material. Removal of a parking garage represents a large cost and the production of a huge amount of waste. Chapter III examines the general case for adaptive reuse of existing parking structures. Chapter IV takes stock of examples of actual parking structure reuse projects. In Chapter V, a specific garage in downtown Seattle is selected and the existing conditions, site considerations and reuse program are explored. Finally, Chapter VI describes the proposed reuse design.

CHAPTER I: THE PROBLEM

Vast amounts of infrastructure and space within and around our cities have been devoted to the car. Massive freeway systems link city to city. Bridges span wide expanses of water allowing drivers the most direct path from point A to point B. In urban spaces in the US, the car consumes close to half the total land area (Shoup 2005). In downtown Seattle, 28% of total land area is devoted to street right-of-ways. In many places in the central business district (CBD), less than 20% of the average street right-of-way is allocated to pedestrians, the rest being given over to the realm of the car¹. The city's urban fabric is frequently interrupted by buildings whose sole purpose is the storing of cars (see Figure 1.3 and Figure 1.4). Garages offer full city blocks of lifeless facades (see Figure 1.5). Curb cuts in the sidewalk interrupt continuity of pedestrian flow, create safety issues, and decrease the liveliness of public space (Gehl 2009).

Current automobile and parking trends in urban areas are not sustainable from an environmental perspective, or from the perspective of space in our cities. The United States has the second highest rate of vehicles per capita in the world at 828 cars per 1000 people (DOE 2011). Existing traffic infrastructure does not have the physical space for the continued expansion required to keep pace with increasing population trends and the on-going shift of populations from rural areas to urban centers.

Cities will be more vibrant and inhabitable places when the needs of people are placed above those of automobiles. Currently, there are approximately 70,000 off-street (including parking around the stadiums) and 5000 on-street parking

¹ Based on measurements of average block size, street widths and comparison of side walk and street spaces in downtown Seattle



Figure 1.3: Map of downtown parking garages from Gehl Architects 2009 report to the city of Seattle



Figure 1.4: 360 degree view from a single corner with numerous invitations to park



Figure 1.5: Existing street wall condition on 1st Avenue between Columbia Street and Cherry Street

spaces in downtown Seattle (Koch 2004). While many of the off-street parking spaces are incorporated (above and below grade) into portions of residential and commercial buildings, eighteen stand alone parking garages exist in the Central Business District (CBD) alone, representing 15% of the non-stadium off-street parking².

Cheap and abundant parking reinforces driving in cities. Systematically reducing parking spaces in the city will reduce the number of cars that enter the city (Shoup 2005). This thesis will proceed from the stance that the number of parking spaces should be reduced in urban centers in general, and from Seattle's CBD specifically. This systematic reduction should begin with stand-alone parking garages. In the Site Repair Pattern, from *A Pattern Language*, Christopher Alexander suggests that we should build on the worst part of a site, thus having the greatest benefit to the site overall (Alexander, 1977). Stand-alone parking garages are among the worst parts of many cities.

Better mass transit use and carpooling habits can only go so far. Decreasing car use in the city will also require increasing the density of people living in Seattle's downtown core. The CBD has ample employment and retail opportunities, but offers little in the way of opportunities for living. Currently, Seattle's CBD has over 100,000 jobs while only housing 4300 people (Gehl 2009). Increasing population in this part of the city will require greater density of things people need to live: housing, schools, childcare, grocers, healthcare and other services that extend the use of the district outside of the work day.

² Calculated from 2004 King County parking survey data



Figure 1.6: Sea of cars

Knocking down existing garages to make way for new development will only perpetuate the cycle of waste which parking garages have come to exemplify. Instead of being demolished, these structures should be reused. The structures that are now a constant reminder of the car will become new symbols of a healthier, more sustainable and more humane way of inhabiting cities.

CHAPTER II: GARAGE TYPE STUDY

In *The Architecture of Parking*, Simon Henley describes early parking garages as buildings that were “very simple, plain in plan, clever in section, graphic in elevation and non-referential. Instead, they were made to respond dimensionally and anatomically to the module and trajectories of a moving car” (Henley 2007). This response to the dimensional module of the car, coupled with the desire to maximize financial return per square foot and the limited amount of time that garages are intended to be occupied, leads to a number of consistent design characteristics. These common characteristics require careful attention and understanding prior to the adaptive reuse of existing parking garages. The following chapter explores the parking garage as a building type and documents existing conditions in ten parking garages in Seattle’s CBD, demonstrating common challenges for reuse and potential solutions

The designs of most parking structures are perfect evidence of Louis Sullivan’s now famous remark that in buildings, “form ever follows function”. As a building type, parking garage design strives to maximize the total number of parking stalls in a given building envelope and allow for efficient vertical and horizontal movement of cars. Remove the function, and we are left with a building type whose form seems challenging and unfit for a different function. Aldo Rossi takes a different stance on building form. He argues that building form endures, and new function can adapt to and be driven by that form (Rossi, 1982) In his discussion of *Propelling versus Pathological* form, Rossi makes a distinction between ‘propelling’ design elements that allow for or even encourage new function and ‘pathological’ design elements that inhibit new and alternate

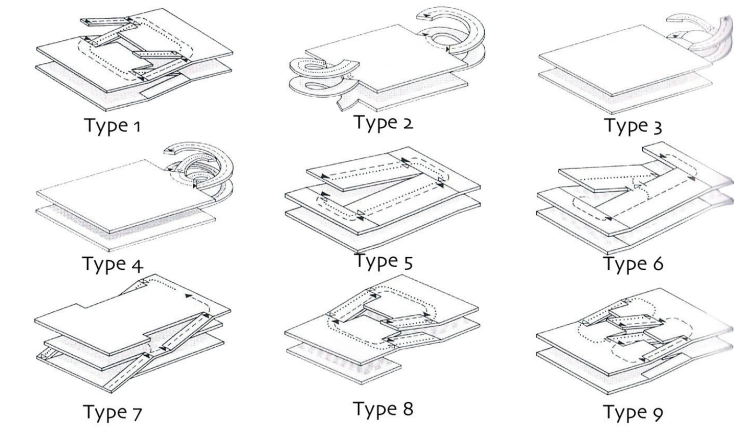


Figure 2.1: This image, from Deitrich Klose’s book *Multistorey Car Parks and Garages*, diagrams typical vertical circulation patterns found in many parking garages

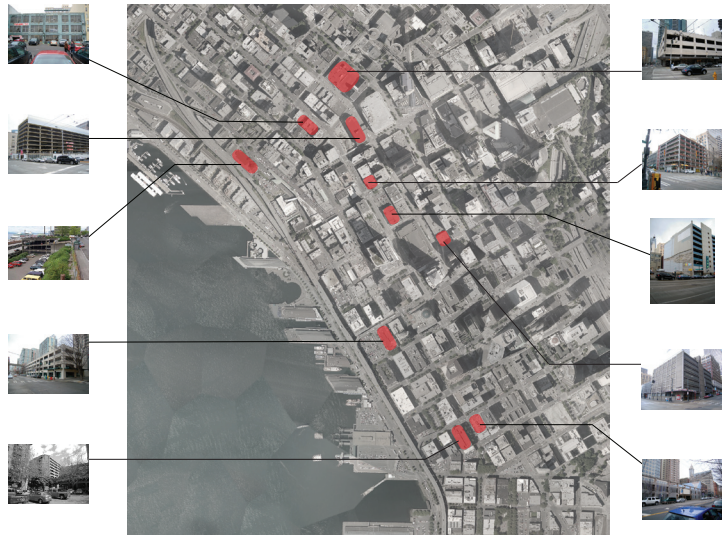


Figure 2.2: Map of Seattle's central business district with 10 study garages highlighted

function (Rossi 1982). Many design elements in a parking garage can be seen through this lens, but perhaps the most obvious is the means of vertical circulation. Figure 2.1 depicts nine different possibilities for vertical circulation in garages. Several types, most notably Types 3,4 and 7, have minimal floor area taken up by ramps. Vertical circulation that takes this form will be easy to work around or incorporate into a reuse design and could be considered to be *propelling*. Continuously sloping slabs, as in Types 5 and 6, or ramps that take up a large percentage of floor area, as in Type 9, will make assigning new function to the existing form much more challenging and could be considered to be *pathological*. Similarly, post-tensioned slab construction is a *pathological* characteristic.

Existing form of a given garage will play a crucial role in its potential for reuse. Some *pathological* conditions may exclude particular garages as reasonable candidates for reuse, while other aspects of a garage's existing form will provide powerful guidance for garage selection. Function and programming will inform many design decisions once a garage is selected for reuse.

Analysis of Existing Garage Stock in Downtown Seattle:

The analysis of parking structures as a building type began with exploring, measuring and diagramming ten garages in Seattle's CBD. Parking garages are relatively simple buildings, composed of a structural system - typically columns and beams - with some shear walls, slabs, vertical circulation ramps, and sometimes screening facade elements. While several garages in Seattle share similar elements, each one

has distinguishing characteristics, and a few are quite unique. Figure 2.2 is a map depicting the location of the ten garages that were selected for the study. These ten garages were selected for several reasons, most importantly to examine a variety of garage and circulation types (see Table 1) and to examine garages of various sizes and sampled evenly from throughout the downtown core.

Table 1 presents all of the gathered data for the ten selected study garages. Included categories for the study were chosen based on patterns that arose in my initial diagramming and data that seemed relevant and necessary for proceeding with reuse designs. The Vertical Circulation Condition column references Figure 2.1. This will be explained in more depth following the Challenges of Reuse section. The data presented should not be considered absolutely precise, but instead approximations¹.

Challenges of Reuse:

Floor to Structure Clearance and size of structural members:

When considering a garage for reuse, the distance from the floor to the underside of the structure for the slab above is a key dimension. This dimension is often minimized to increase the total number of floors achievable within a given zoning envelope. In downtown Seattle, the majority of garages analyzed had floor to beam dimensions between 7'3" and 8' (see Table 1 and Figure 2.3). While a ceiling could be placed at this level and meet the minimum height requirements according to the Seattle City Code (1208.2), environmental psychology suggests that this is an uncomfortable uniform ceiling height. Low ceiling heights also have negative day lighting implications that will be discussed below.

¹ Data was not collected from existing drawings, but rather on site at each garage by a single observer. While beam depth, floor to ceiling height and column spacing could all be measured with a relative degree of accuracy, plan dimensions, ramp % of floor area and number of parking spaces are all rough estimates



Figure 2.3: Concrete beams in two study garages with very low clearance to the underside of the structure



Figure 2.4: Double spiral ramp in the Bon Marche garage



Figure 2.5: The Triangle parking garage in Seattle's Pioneer Square has four sloped levels that act as both circulation and car storage

Depth of the spanning structural members is also an important dimension to consider. There was larger variation in beam depth documented in the study garages, with a range between 24 and 42 inches. Coupling the floor to beam dimension with the spacing of the structural grid provides a base unit that will likely be a critical factor when considering reuse possibilities. Partitioning space to align with the existing spanning structure is a basic design solution to overcoming issues of undesirably low ceiling height. Achieving large open spaces (greater than 14' to 20' in both directions) will be difficult. Removal of portions of the existing slab has the potential to create double height space and allow for designing beyond the base unit of the structural grid.

Ramped Circulation: A primary characteristic for differentiating between buildings of the type is the organization of the vertical circulation for cars. There are a variety of potential solutions (see Figure 2.1), but most fall broadly under one of two categories: continuously sloped floors or discrete ramps. When considering potential reuse, the simpler of the two systems to deal with is ramps. Downtown Seattle parking garages include examples of straight, curved and spiraling ramps. These ramps take up between 10 and 20% of the total floor area of a garage. Solutions for reuse may include incorporating the ramps into the vertical circulation for people or creating small pockets of double height spaces. Depending on the ramp configuration, if removed, the space could serve for atria or as a cavity for mechanical or passive heating and cooling functions.

Continuously Sloped Floors: Garages that employ continuously sloped floors as a means of vertical car circulation present a more complex set of issues when considering potential reuse. Sloped surfaces do not make for readily inhabitable spaces (see Figure 2.5) A variety of possible solutions exist for overcoming this difficulty. Removal of large portions, or all, of the slab may be possible in some existing garages, leaving behind a structural frame to infill. The environmental consequences of this possibility will be addressed in the life cycle assessment (LCA) portion of this paper. A program that can fit within and benefit from the sloped condition is another possibility (such as the office of Liberation, a Paris based newspaper, a case study discussed in Chapter IV). Adding a series of broad steps to the slope may also be a possible solution (see Figure 2.6). This option may allow for the integration of passive or active building systems within the interstitial space formed between new and existing structure.

Daylighting Challenges: The combination of deep floor plates required for double-load drive aisle efficiency and the low floor to ceiling heights make for challenging daylighting conditions when considering reuse of existing parking structures (see Figure 2.3 above). Typical new construction faces similar issues of floor plate depth (presuming a desire to maximize leasable square footage and therefore profit), but benefits from the ability to increase the surface area of windows. This can be accomplished by increasing floor to ceiling heights, increasing the perimeter wall area with atria or by diverging from perfect rectangular form. Assuming adequate daylight can be achieved to a depth that is twice the height of periphery glazing (see Figure 2.7) (Brown and DeKay 2001), on average the maximum daylight penetration into an existing garage will be



Figure 2.6: Existing parking ramp with insertion of new stepped platforms to create usable space on the sloped surface. Office of Liberation Newspaper, Paris, France. Photo from Architectural Record

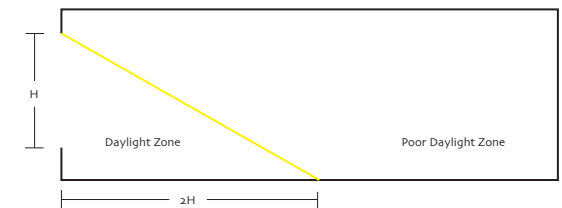
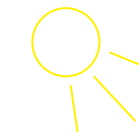


Figure 2.7: Diagram of daylight penetration correspondence with window height



Figure 2.8: The face of the existing column sits at the property line of many garages, such as this one.



Figure 2.9: Concrete panels with inlaid brick are attached outside the line of structure. Removing them would provide some space between the existing structure and the property line.

around 20 feet from all sides. This leaves over 60 percent of the interior of the building with poor daylighting. This fact may help direct potential reuse program options towards a use that requires space with complete lighting control. Depending on the existing structure of the garage, removal of portions of the slab may be possible. This could allow opportunities for internal atrium space or double height spaces that would allow light to penetrate deeper into the building.

Public Right-of-Way Encroachments: Most parking garages in the downtown core maximize the buildable square footage of their lot. In many cases, this places the buildings' structural systems (columns and beams) at the edge of the property line (see Figure 2.8). Complying with Chapter 32 of the Seattle City Code, dealing with encroachments into the public right-of-way (SBC 3202.2 & 3202.3) may limit design possibilities in the reuse of parking garages. Some kind of skin and insulation systems will be necessary exterior to the structural system to provide adequate energy performance in reuse designs. In cases where existing garages incorporate a screen system of some kind (as is the case with half of the ten study garages in Table 1), some space may exist between the structure and the property line (see Figure 2.9). In these cases, removal of the screen system may provide space with which to work, but likely not enough. Another possible solution would be for the city to grant right-of-way dispensations in the case of reuse projects of this type. With fewer cars in the downtown core, rights-of-way could be adjusted to allow more space for pedestrians, bikes and transit, and less space for cars. Amending air space allowances for buildings contributing to the decrease in downtown car traffic would make the conversion of parking garages to other purposes more feasible.

Removal of Portions of Floor Slab: As discussed above, removing portions of the slab from existing parking garages is desirable for many reasons including increased access to daylight, spatial variety within the building and allows for atrium and double height spaces. The ability to remove portions of the slab is dependent on a variety of factors specific to individual garages. Any system in which the slab and spanning structure are integrated will make the removal of portions of the slab more difficult and likely require complicated and costly structural renovations. Slab systems employing either precast pieces or steel decking will likely be easier to accommodate partial removal. Lifecycle assessment could also be employed to help determine the percentage of the total embodied energy of the building that is represented by the slab. At some point, one must question what percentage of the existing building can be removed before the exercise of reuse is no longer worthwhile.

Loads: While parking garages may generally seem to be massive, monolithic buildings with large structural capacity in order to support the weight of one ton steel cars, in reality, their structural live-load capacities are quite similar to that found in typical residential construction (45 lbs/sf). Many cars weigh in excess of 2000 pounds, but this weight is distributed over the large area of the car's footprint. For example, the structural capacity of a typical garage could not be converted to a library or archive which have live-load requirements of over 100 lbs/sf. Seismic load is another concern when considering reuse proposals. The majority of Seattle's downtown stand-alone garage stock was built between 1950 and 1975, prior to the Nisqually earthquake and the new, stricter seismic load requirements (see Figure 2.10). Seismic capacity and



Figure 2.10: This garage at 1st Avenue and Pike Street has been seismically updated. Most existing garages in the CBD have not.



Figure 2.11: Capped steel tension cables at the exposed edge of a post-tensioned slab system under construction on the University of Washington's south campus

requirements for upgrades must be understood on a case-by-case basis and will require the guidance of a structural engineer.

Post-tensioned Construction: Contemporary garages are now commonly constructed with a structural system of concrete columns and post-tensioned concrete slabs (see Figure 2.11). Long spans can be accomplished using post-tensioned systems and reducing the number of needed columns. This in turn increases the number of parking spaces and reduces obstructions to circulation throughout the garage. Additional material associated with depth of the structural beam system becomes unnecessary. Post-tensioned slabs involve a complex network of steel cable woven non-uniformly throughout each slab. When finished, the entire slab acts as a single unit. Because of this, selectively removing portions of the slab for purposes of day lighting, mechanical systems or to create larger volume spaces would be challenging at best. The difficulty of manipulating the post-tensioned slabs makes them poor candidates for reuse and they will not be considered further within the scope of this project.

Ease of Reuse:

Following the analysis of the data in Table 1 and an examination of the challenges to reuse presented by many common features of parking garages, a spectrum of reuse feasibility begins to emerge. Characteristics such as continuously sloped ramps and post-tensioned slabs are *pathological* and represent highly challenging garages for purposes of adaptive reuse. Characteristics such as high floor to ceiling heights, ramps that occupy a minimum

percentage of the total floor area, little need for seismic upgrade and slab construction that allows for portions to be easily removed are *propelling*, leading to potentially interesting and successful reuse. While none of the study garages have purely *pathological* or *propelling* characteristics, we can begin to exclude some of the garages from selection for the design portion of this thesis. Table 1 highlights those garages that will be considered in Chapter V for reuse.

Reuse Over Demolition:

This chapter lays out the potential challenges inherent with reusing existing garages, but also suggests that these challenges may be of benefit for reuse design. However, this alone may not justify difficulties involved with reuse rather than simply demolishing and rebuilding in the place of existing garages. The following chapter will make the argument that reuse is the appropriate option for many existing garages.

Garage	Plan Dimensions	Vertical Circulation Condition	Ramp as % of Floor Area	Number of Floors	Number of Parking Spaces	Column/Beam Construction (Shape)	Column Spacing	Height: Floor to Beam	Beam Depth	Slab Type	Facade Description
2nd & Stewart	107'x114'	Type 9	10%	5	350	concrete (R/R)	20' o.c.	11.5' (7')	2.5'	cast in place	brick and windows
3rd & University	115'x118'	Type 8	15%	9	600	concrete (R/I)	14' o.c.	7.5'	3'	cast in place	vert metal louvers: 6"
1st & Columbia (SE)	107'x176'	Type 8	10%	3	200	concrete (R/R)	20' o.c.	7.5'	2.5'	cast in place	structure at property line
1st & Columbia (SW)	107'x245'	Type 1	15%	10	800	concrete (R/I)	15' o.c.	7.25'	2.5'	cast in place	precast panels 8"
2nd & Pike	107'x114'	Type 5	100%	7	333	concrete (R/I)	18' o.c.	7.5'	3'	steel deck/conc	concrete/brick panels: 6"-t
3rd & Stewart (Bon)	111'x273'	Type 4	10%	9	900	concrete (42"D/ no beams)	30' o.c.	8'	1.5'	waffle slab	partial polycarbonate
Western & Spring	110'x243'	Type 1	10%	5	150	concrete (16" R/?)	20' o.c.	7'	2'	cast in place	precast panels 8"
Victor Steinbrueck Park	130'x300'	Type 7	5%	3	450	concrete (36"D/T)	30' o.c.	10'	3'	concrete Ts with	structure at property line
3rd & Virginia	230'x250'	Type 3	20%	3	125	concrete (24"D/ R)	22' o.c.	11.5'	1.5'	cast in place	structure at property line
2nd & Union	107'x178'	Type 5	100%	10	600	concrete		7'	2.5'	cast in place	structure at property line

Table 1 : Data collected from garage study. Key categories for garage selection are highlighted. Garages highlighted in the left column are considered appropriate for reuse

CHAPTER III: THE ARGUMENT FOR REUSE

Stand-alone parking garages are no longer the ‘best and highest use’ of space in our cities. Single purpose buildings are no longer a desirable building type in urban centers. If parking capacity is to be reduced, stand-alone garages are the most effective place to start. These garages currently have an average vacancy rate of 33% (Koch 2004). They are underutilized, unsafe and unattractive objects in our urban environment that promote unhealthy habits. Jane Jacobs stresses the importance of “eyes on the street” for a safe and vibrant urban environment (Jacobs 1961). Parking garages often inhabit the entire length of a block with nothing but dark, screened floors of parked cars. In his urban design studies for Philadelphia throughout the 1940’s-1960’s, Louis Kahn argued that there is a higher and better use for space within urban centers than parking (Reed 1989). The argument for removing the function of parking garages - storing cars - is clear, but should we remove the buildings themselves?

Waste Stream Diversion:

Minimizing the building industry’s waste stream by avoiding demolition is the most obvious argument for reuse. The EPA estimates that in 2003, 325 million tons of waste were generated from construction and demolition (Frey 2007). This is nearly 25% of the United States municipal waste stream (Merlino 2010). Sheer volume of waste is not the only consideration. Demolition and transportation costs are consequential. Calculations for demolition of one existing concrete parking structure in downtown Seattle show that it would cost nearly \$1,000,000 and require 1200 dump truck trips to the landfill before new construction on the site could



Figure 3.1: Concrete parking garages undergoing demolition.



Figure 3.2: Construction waste results in additional traffic congestion



Figure 3.3: Concrete construction waste

be considered¹. The resulting pile of concrete for this garage would be fifteen feet deep and cover an entire downtown Seattle block. Reuse will bring new life to an existing structure and greatly increase its useful life span.

Embodied Energy:

Members of the preservation community have written exhaustively about the need for, and benefits of, reuse of our existing building stock. In his article “The Greenest Building is One That is Already Built”, Carl Elefante argues for the environmental and social benefits of sustaining existing building stock. According to Elefante,

“We cannot build our way to sustainability. Even if, with the wave of a green wand, every building constructed from this day hence has a vegetative roof, is powered only with renewable energy sources, and is built entirely of environmentally appropriate materials, sustainability would still be far from fully realized. Seeking salvation through green building fails to account for the overwhelming vastness of the existing building stock.” (Elefante 2007)

Existing buildings represent substantial amounts of embodied energy. As the primary structural material in most Seattle parking garages, concrete is a particularly energy intensive building product. Patrice Frey defines embodied energy as, “the amount of energy associated with extracting, processing, manufacturing, transporting and assembling building materials” (Frey 2007). While embodied energy cannot be recovered, it is beneficial to consider the energy that buildings represent instead of simply assigning that expenditure to the past. Parking garages have outlived their designed function, but not the useful life span of their form and structure. The garage discussed above, for example, embodies roughly 6000 tons

¹ Calculated based on area take offs of the existing garage and data from Mewis, B. (2008). RSMMeans repair & remodeling cost data, 2009. Kingston, MA, RSMMeans. Mewis, B. (2008).

of carbon, or the equivalent of that generated by 1200 cars driving 12,000 miles (Figure 3.4).

Frey notes that in a typical building’s life span, its embodied energy accounts for just 16% of its life-long energy consumption while operations over the life of the building accounts for the other 74% (Frey 2007). Because of this fact, it is often argued that demolishing an existing building and replacing it with a new, energy efficient building is desirable from an energy use and environmental standpoint. However, as Mike Jackson, author of “Embodied Energy and Historic Preservation: A Needed Reassessment”, has calculated, if a building is demolished and replaced with a new energy efficient building, it will require 65 years of operation to recover the energy lost in demolition and reconstruction (Frey 2007). Considering that this is longer than the predicted life span of the average building constructed today², reuse of existing buildings is a desirable course to pursue. Parking garages typically have little in the way of existing mechanical and electrical systems, and often no façade systems. Because these systems tend to be the biggest energy saving components in new construction and will be required for any garage reuse project, the benefits of embodied energy of the structure and the operational benefits of new systems will be combined.

² The US Department of Energy assumes the average building life span in the US to be 60 years (DOE 2009)

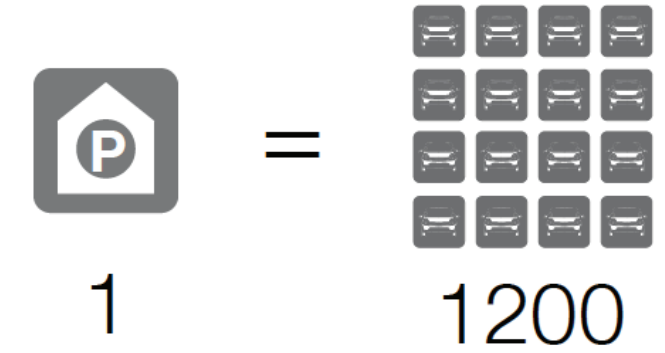


Figure 3.4: One garage embodies the same amount of carbon that 1200 cars produce driving over the course of a year.

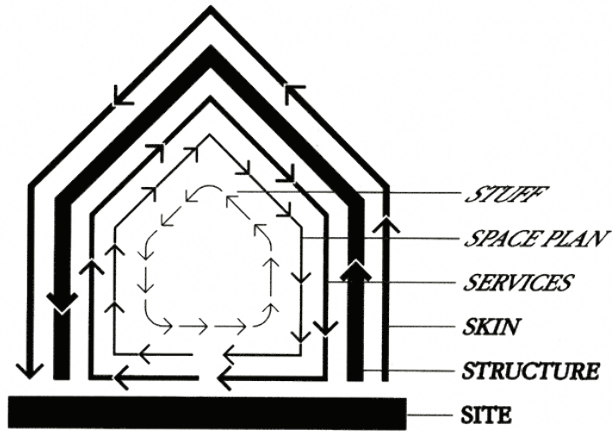


Figure 3.5: Structure is the most energy intensive component of most buildings as depicted in Stewart Brand's diagram from *How Buildings Learn*.

Structure Already Exists:

The raw structural infrastructure of most parking garages is worth considering further. In *How Buildings Learn*, Stewart Brand diagrams the components of a building (see Figure 3.5) to highlight the relationship of each part and their relative importance in the lifetime of the building (Brand, 1994). The structure and the skin are by far the largest (and most energy intensive) components of most buildings and therefore the key components to consider in reuse. Parking garages typically have little skin and are almost entirely structure. Their principle elements - foundation, columns, beams and floor slabs - are similar to the internal structure of most mid-sized buildings in urban areas. Both steel and concrete garages are essentially bare frames ready to be filled with new programs (see Figure 3.6).

Life Cycle Assessment:

To determine the actual energy and carbon saved through reuse instead of demolition and new construction, life cycle assessment (LCA) analysis must be employed. LCA analyses consider all of the inputs to a given building within a pre-defined scope. Typically this includes the energy used in the extraction, manufacturing, and transportation of materials; the construction of the building; and the demolition and transportation of waste to the landfill. These inputs are used to calculate the total energy consumed and carbon exhausted during the construction and demolition of a given building. LCA, as an analytical tool for promoting reuse is discussed in Appendix B.

An LCA analysis comparing conversion of the existing garage selected in Chapter V and hypothetical new construction is included in Appendix B. The key finding of that study compares the carbon generated in three scenarios: conversion or demolition and new construction of either steel or concrete frame buildings. The findings are illustrated in Figure 3.7. Constructing a new concrete frame building would generate nearly 5 times more carbon dioxide than reusing the existing structure. This is equivalent to one and a half times the carbon generated over the course of a year by the cars that currently park in that garage.

Stand-alone parking garages should no longer house cars in urban centers. Instead of being demolished and contributing to one of the problems that their decommissioning attempts to solve, garages should instead be reused to emphasize a new direction for the built environment. These buildings represent vast amounts of embodied energy and reusing their existing structure can save a major proportion of the energy needed to create a building with a new and more desirable purpose.



Figure 3.6: Comparison of the concrete structure of the existing Bon Marche garage (above) and the Colman Tower, a 16-story concrete frame building currently under construction (below), reveals constitutional similarity.

CHAPTER IV: CASE STUDIES

There are a limited number of case studies of converted parking garages. This chapter will examine four pertinent examples of reused parking garages, three from the 1980's and one recent project. The final two case studies are former industrial buildings converted to residential projects. These provide general strategies for buildings that once housed industry and now house people.

From Garage to Kindergarten, Berlin:

In 1974, a four-story garage was constructed in a predominately residential neighborhood in the southeastern quadrant of Berlin (see Figure 4.1). The garage was built to provide parking for a large commercial development that never materialized. No cars were ever parked in this garage. After six years of sitting vacant, it was determined that the structure could not be removed (1984). The building continued to take up space in the neighborhood as the residential fabric filled in around it; space that could not be used. The empty, concrete clad building in the middle of the residential neighborhood quickly became a blight.

A competition was held, and Berlin architects Dieter Frown and Gerhard Spangenberg were selected to convert the existing garage into a kindergarten. The neighborhood was in need of a school for young children, and the architects saw reusing the garage for this purpose as a way to bring an element of nature and fantasy to the building that would help to counteract the ecological waste embodied in the existing garage, and the waste of space that it had been in the neighborhood for the past six years (1989).

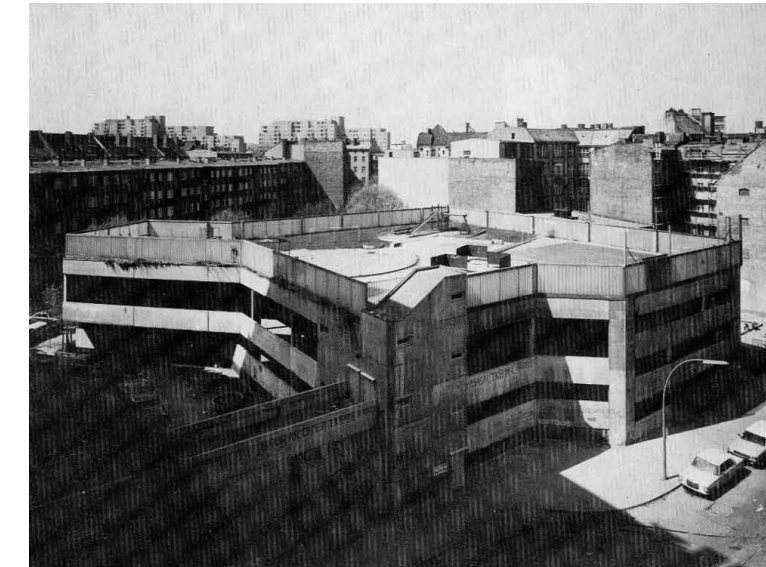


Figure 4.1: Existing garage prior to reuse. Image from Architektur + Wettbewerbe

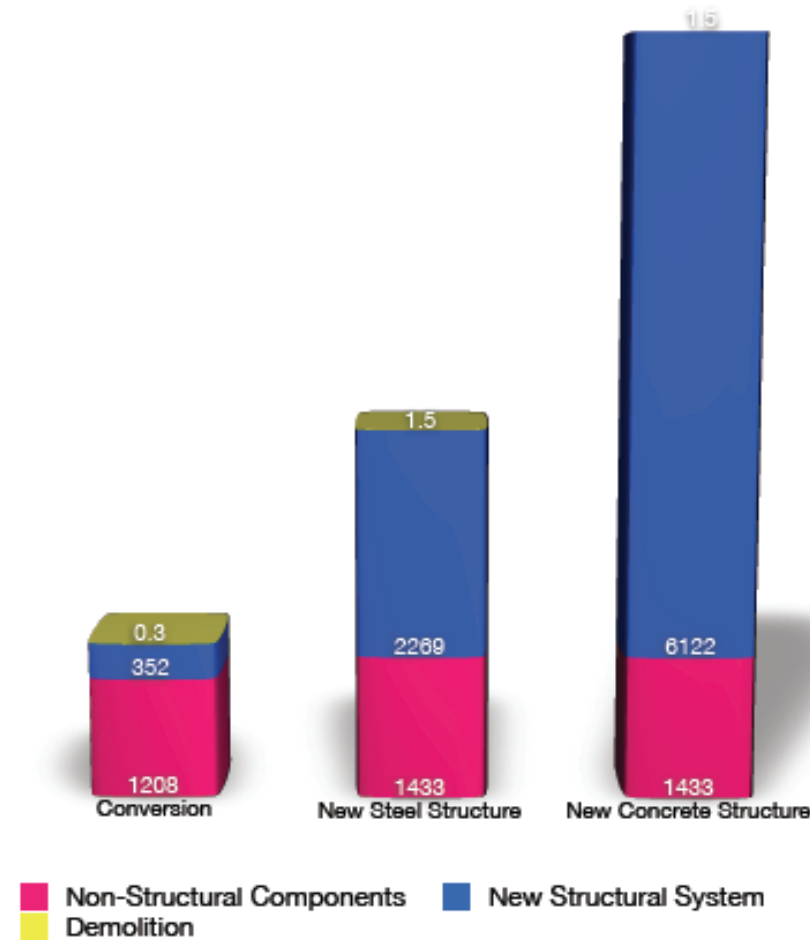


Figure 3.7: Projected Global Warming Potential (in tonnes of CO₂) of three scenarios. Comparison of the amount of carbon dioxide released by three scenarios: converting an existing garage to a residential building (Conversion), or demolishing the same garage and constructing a new comparably-sized residential building with steel (New Steel Structure) or concrete (New Concrete Structure) structural system.

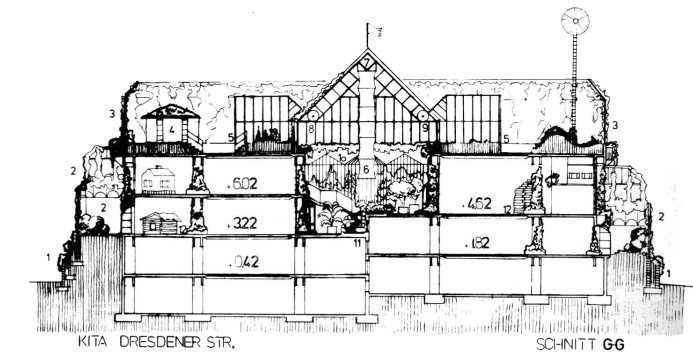


Figure 4.2: Conceptual section of the repurposed garage. Architektur + Wettbewerbe

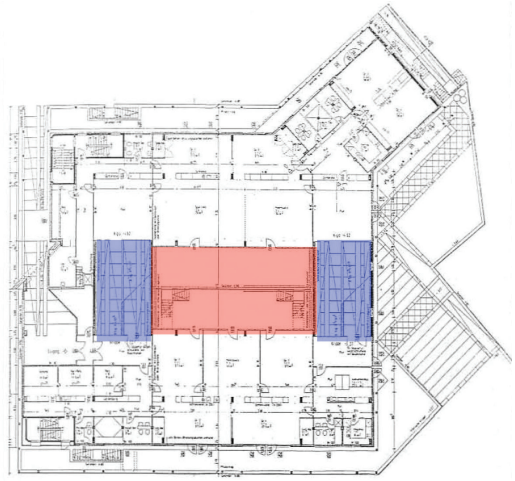


Figure 4.3: Floor plan of garage with existing ramps highlighted in blue and removed slab in red. Architektur + Wettbewerbe

The existing garage was approximately 40 feet tall, and contained 7 staggered half floors (see Figure 4.2). The staggered floors were likely to reduce the vertical distance that needed to be spanned by ramps between each level. There was likely a ramp at each end of the building connecting the floors (see Figure 4.3). The garage had a steel frame structure that was infilled, both floors and exterior cladding with precast concrete panels. The footprint of the building was approximately 125' by 115', giving it around 50,000 square feet of enclosed space.

The architects' primary design decisions for the building's reuse revolved around sustainability factors (although at the time of the building's conversion, the term's use was not as common as it is today). The most important intervention was the insertion of a greenhouse-like atrium space. A portion of the roof and the upper three floors were removed to create a large open light-filled space, covered by a greenhouse-like structure (see Figure 4.4). This atrium space dealt with several of the problems in converting parking structures discussed above. Not only did the atrium create double height space within the building, but it also helped deliver natural light to the central portion of the deep floor plates of the lower levels. The glass-roofed structure also acted as a solar heat collector in the cold months of the year, and could be opened to pull warm air out of the building during the summer, which created a stack ventilation effect throughout the building. It also became a place filled with plants, aiding the architects' vision of a natural oasis within the concrete city. The building's steel frame structure and infilled precast concrete system made this intervention manageable without the need of new structural interventions and is an excellent example of a desirable system when considering the reuse of an existing garage.



Figure 4.4: Rooftop green house and open space

To add to the sense of nature and fantasy, the architects wanted to add as many plants to the building as possible. A green roof, with both grassy space for the children's play and garden and compost area for their education was installed (see Figure 4.4). This relatively thin layer of soil likely exceeded the building's live load capacity and couldn't provide the necessary depth for larger plants. To accomplish the desired effect, the architects added a steel lattice screen system to the exterior of the building (see Figure 4.5), which acted as an armature for plants to grow to the full height of the building while bringing their root systems (and the soil they required) down to the ground where the building didn't have to support the added weight. The steel lattice as a screening system also recalls the facades of the typology from the kindergarten's past.

The original ramps were converted to vertical circulation that took the form of both stairs and a stepped ramp that lent the space a sense of playfulness and engaged the children while they moved up and down through the building (see Figure 4.6). The compact nature of the ramps was again ideal for reuse as they left the majority of each floor area level and reusable.

The architects were able to convert a building that had failed to fulfill its original purpose. It had become both an ecological waste and a blight on the surrounding neighborhood. Its conversion to an energy efficient (with 36% less energy use than buildings filling similar function in the city), vibrant, educational space for children provided a desirable and needed function in the community. This example, now 30 years old, highlights the vast potential for making sustainable, humane and desirable space by converting an existing garage.



Figure 4.5: Street view of reused garage highlighting steel lattice structure supporting vegetation.

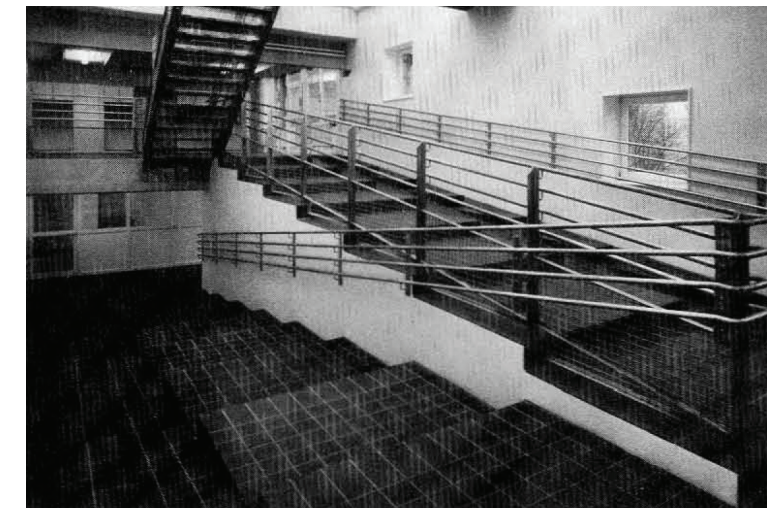


Figure 4.6: Existing ramps converted to broad steps to create places for children to play. Architektur + Wettbewerbe

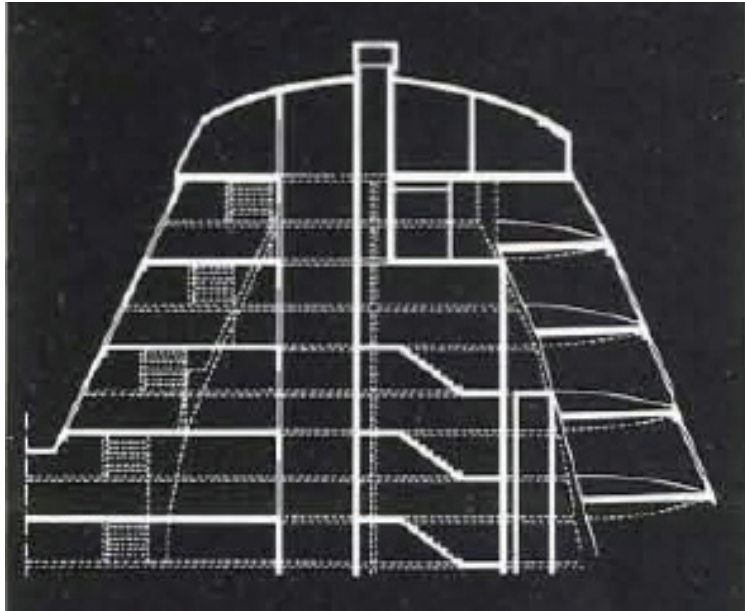


Figure 4.7: Section of existing parking garage prior to reuse. Image from Architectural Record

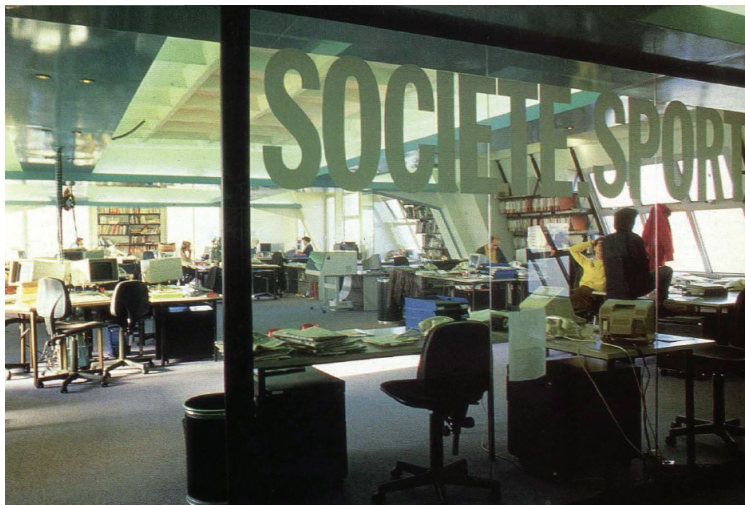


Figure 4.8: New work space with glass wall to facilitate connections throughout the office and maximize natural light. Photo from Architectural Record

Car Park to Newspaper Office, Paris:

In the early 1980's, a Parisian developer became interested in converting the top five floors of an existing, post war era parking garage into office space (Ellis, 1988). Patrick and Daniel Rubin, of the architecture firm Canal, had a vision for reuse that involved leaving the curving ramps connecting each level of the garage intact. This was not only important to the developer, as the removal of the ramps would constitute an insurmountable financial hurdle, but Canal argued that the ramps could benefit the building's future tenants as well. The French newspaper, Liberation, became the new tenant. Presented with minimal daylight, low floor to ceiling heights and preexisting ramps, Canal attempted to make the office space as open as possible (much less common in 1987 than today). The ramps connecting each half floor (see Figure 4.7) were left intact as a "physical and psychological link between departments" (see Figure 2.6 above). Wherever feasible, glass was used to partition space. This continued the sense of connection between departments and maximized the limited daylight available (see Figure 4.8). Ultimately, an underused garage with prime real estate at the center of Paris was put to a higher use and Canal provided Liberation with 58,000 SF of office space for a mere \$47/SF (1987; Ellis 1988).

Altes Parkhaus:

In 2010, Altes Parkhaus (old parking house) reopened as a major new amenity completing the final edge of the redeveloped Stubengasse Square in Munster, Germany. Fritzen + Muller-Giebler Architekten BDA re-envisioned the original 1964 parking garage (see Figure 4.9) which they described as

a "sober place" (2010) into a vibrant multi-use facility where art and people mix (CompetitionOnline 2010). The ground floor facing the square is comprised of large areas of glazing set directly into the existing concrete frame of the garage (see Figure 4.9). This floor and the 1st floor mezzanine are a combination of commercial retail and gallery space. The ground floor also houses an integrated bike station and storage area. The slab above the second floor was removed, but the concrete structure remains to make a "gritty" double height room for the office space component of the program (see Figure 4.10). Large areas of glazing have been added to create a daylighted space and help connect the second floor to the energetic life in the square below (see Figure 4.12). Two floors of residential lofts were added above the existing structure, using the concrete skeleton of the garage to carry the new loads. These floors house apartments situated around a large interior courtyard. The total project size after reuse is 65,000 SF. The project has been awarded the 2010 German Urban Architecture award and the 2011 Architecture Award for Concrete.



Figure 4.9: Before and after reuse of the garage on a central square in Muster. Photo credit to G. Erbring

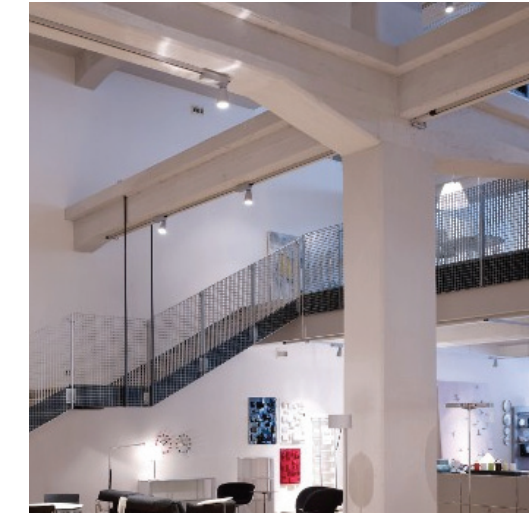


Figure 4.10: The slab of one floor of the parking garage was removed to create double height space. The structure was left intact to continue supporting the load above. Photo credit G. Erbring



Figure 4.11: The existing brick facade was deconstructed in places and curtain walls were added to bring in light. Photo credit G. Erbring



Park Place, Denver, CO:

In 1980, the architecture firm of Johnson, Hopson and Partners converted a 10 story parking garage, originally built in 1953, into a 100,000 square foot office building as an economical alternative to new construction. Because the existing garage had very limited access to day light (only a few small windows at street level), bringing additional light into the building was a key design concern. The brick on the street facade of the building was removed and replaced with a curtain wall of reflective, insulating glass (see Figure 4.12). The original garage utilized a 120' x 22' car lift instead of ramps in the central portion of the structure. The elevator was removed and half of the shaft was left as open atrium space to bring light into the center of the building. The rest of the shaft was used for vertical circulation and the delivery of HVAC systems throughout the building, which was important to overcome the low floor to ceiling heights. (Naim 1982)

Fuller Lofts:

The Fuller Lofts is an adaptive reuse and expansion of a 1920's concrete industrial building in East Los Angeles (Pugh 2008). The facade of the existing 103,500 square foot building was left intact and converted to market rate housing and 15,500 square feet of commercial space on the ground level. Capping the existing building is a vertical expansion comprised of two stories (30,000 square feet) of steel clad penthouse lofts (see Figure 4.13). An open air courtyard occupies the center of the building, allowing for greater access to daylight, increased capacity for passive ventilation, and contains the two main stairs for the complex, encouraging informal interaction between

Figure 4.12: Before and after photos of the Park Place garage conversion. Images from Architectural Record.

residents throughout the building. The proximity to light rail stop and the influx of people from a variety of socio-economic backgrounds has made this a successful project and helped to revitalize this once depressed neighborhood.

Torpedohallen, Copenhagen:

A 1950's motor boat factory was converted to 67 units of owner-occupied condos, totaling 92,000 square feet, in 2003 by Danish architecture firm Tungsten Vandkunsten. The existing building was stripped to its concrete frame of columns and beams, then infilled with steel, glass and wood. The center third of the building, which originally contained the slip to move completed boats into the adjacent canal, was maintained as an open air pedestrian corridor. It provides entrance access for all the units, fosters interaction and community, and allows residents a direct connection to the water (see Figures 4.14).



Figure 4.14: Torpedohallen as seen from the canal. Image from Copenhagen X.



Figure 4.13: Before and after images of the Fuller Lofts. Images from Pugh + Scarpa.

CHAPTER V: SITE AND PROGRAM ANALYSIS

Garage Selection:

Of the 10 downtown Seattle garages examined in Chapter II, the Central Parking System (CPS) garage at 701 1st Avenue was selected for closer analysis and used to test the validity and architectural desirability of garage reuse. The selected garage is the 10 story concrete structure on the southwest corner of 1st Avenue and Columbia Street, (see Figures 5.1 and 5.2). The garage, built in 1970, runs the entire 245-foot length of the block along 1st Avenue and has a depth of 105 feet. The garage is bounded by Post Avenue to the west. The garage has approximately 708 parking spaces within its 10 stories, making it the second largest garage in the CBD after the old Bon Marche garage, which has 900 parking spaces.

The structure utilizes a concrete frame of precast I-beams 15 feet on center with a depth of 30 inches (see Figure 5.3). The vertical structure along the 1st Avenue and Post Avenue facades are composed of 24 inch square, cast-in-place concrete columns 30 feet on center. Concrete girders span between the columns and pick up intermediate beams. The south façade is a continuous one-foot thick concrete shear wall and is a party wall to the adjacent building. The middle third of the Columbia Street façade is also a concrete shear wall, with openings to either side (see Figure 5.5). An 18-inch thick shear, at the mid-line of the building, is 90 feet long, beginning at the southern ramps. The interior vertical structure varies between the shear wall and a single row of columns, 15' on center. The slab to ceiling height is 9'6", with a clearance of only 7'3" below beams. The vertical circulation of cars results in a split level plan where the west half of the garage (split at

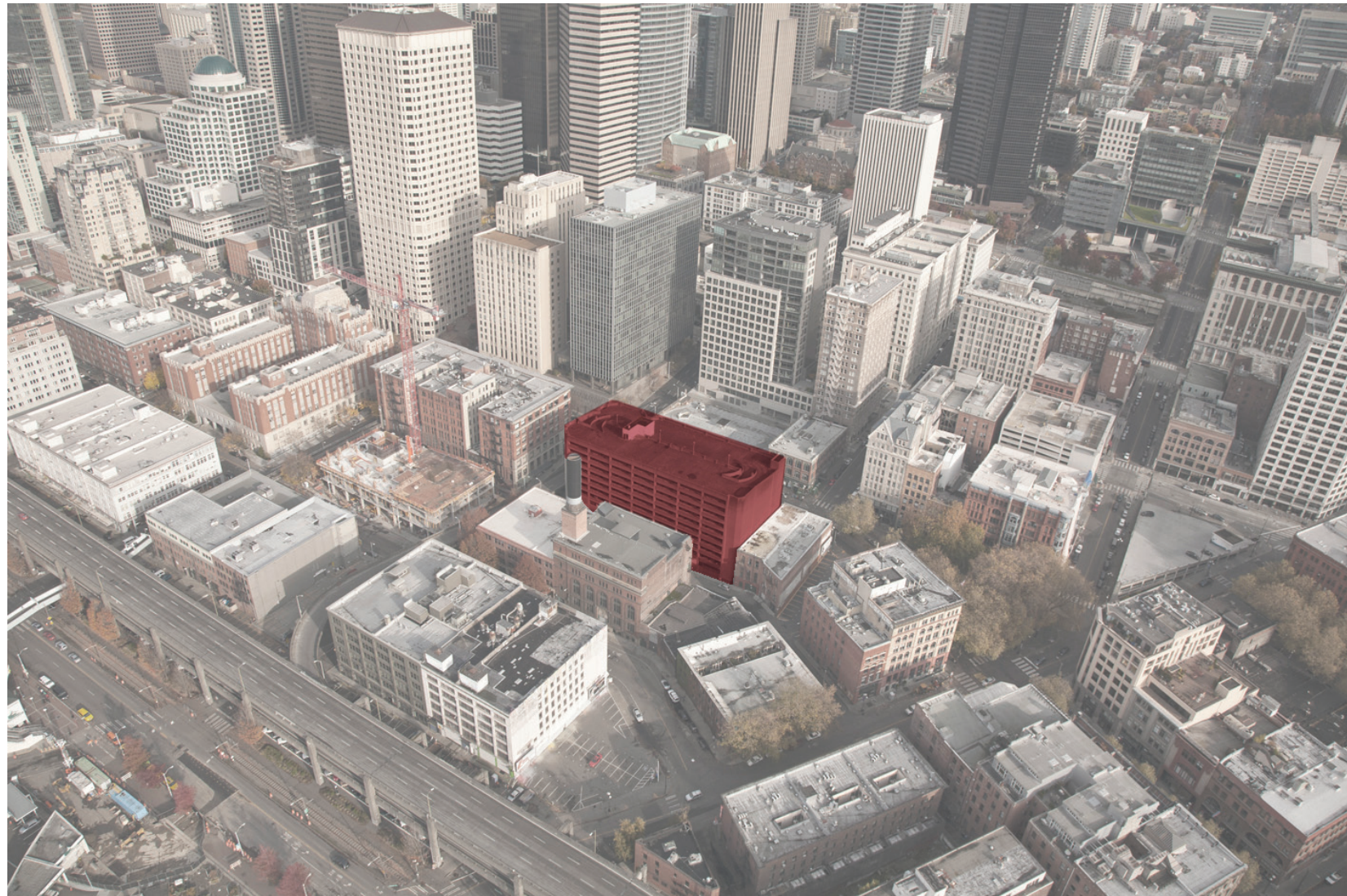


Figure 5.1: Aerial view of Seattle's Pioneer Square neighborhood with the garage at 701 1st Avenue highlighted. Photograph courtesy of Beau MacGregor.



Figure 5.2: Image of the existing garage. Above: view from the northwest. Below: view from the corner of 1st Avenue and Columbia Street.

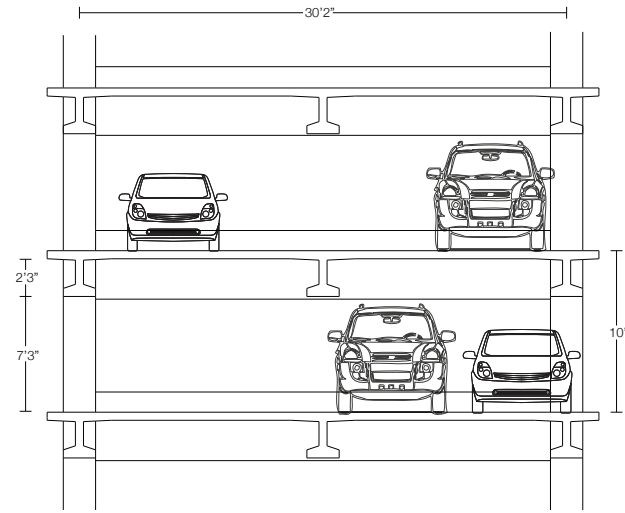


Figure 5.3: Section dimensioning one bay of the existing garage.

the central shear wall) is 5 feet higher than the east half (see Figure 5.5). The garage has two sets of split ramps at either end of the building, filling two 45 square foot voids in the slabs. Two existing elevators and an exit stair are located in the northern half of the building and act as an interior circulation core. A second exit stair is located at the southwest corner of the garage. Extensive images and drawings of the existing garage can be found in Appendix A and B, respectively.

An Example for the Type: The garage at 1st and Columbia is among the most challenging of the garages highlighted for potential reuse in Chapter II. Close beam spacing, low floor-to-ceiling heights and ramps that account for ~15% of the total floor area all put this garage on the more difficult side of the garages considered. The scope of this design thesis considers the reuse of a single garage. If a successful design can be accomplished in the most challenging circumstance, it can be inferred that garages with less challenging conditions could also be successfully reused.

Improving the Urban Environment: The block between Cherry Street and Columbia Street on 1st Avenue has no pedestrian interest because of the two parking garages that currently span the entire length of the block on both sides of the street (see figure 5.6). 1st Avenue is the primary north-south pedestrian corridor in downtown Seattle (Gehl 2009) and connects two vibrant areas of pedestrian activity - Pike's Place Market and Pioneer Square. With the exception of this block, 1st Avenue is a relatively pedestrian friendly thoroughfare, as noted in Gehl Architect's study of downtown Seattle as the most likely candidate for a pedestrian priority street (Gehl 2009). Columbia Street also marks the northern boarder



Figure 5.4: Structural system at the center-line of the garage

of Pioneer Square. Converting this particular garage and establishing storefronts along the ground floor will help to make this transition zone between downtown and Pioneer Square a more pedestrian friendly experience.

Fixing the Worst Part First: Chapter I of this thesis cites, Christopher Alexander's *Site Repair Pattern* as a rationale for focusing on stand-alone parking garages as the first place to remove parking capacity from the city (Alexander, 1977). The same rationale applies when choosing an initial garage as a test case. The worst one should be addressed first. Because of it's size, location across from another garage, and unscreened, unrelenting concrete facades, I believe that this particular garage represents the worst of the garages examined. Following Alexander's suggestion, the garage at 1st and Columbia is the most appropriate place to begin.

The Bigger They Are: The garage at 1st and Columbia is the second largest stand-alone parking garage in the downtown area. Removing more parking spaces will have a greater impact on driving in the city center. Also, LCA is based on material quantities. Larger structures require more material, and therefore have greater embodied energy. Reuse of this garage will preserve more embodied energy than most other garages in the city.

Site Analysis:

As mentioned above, the site is located at the junction of Seattle's Downtown and Pioneer Square neighborhoods, just inside the boundary of the Pioneer Square Historic District. The Historic District is zoned Pioneer Square Mixed (PSM),

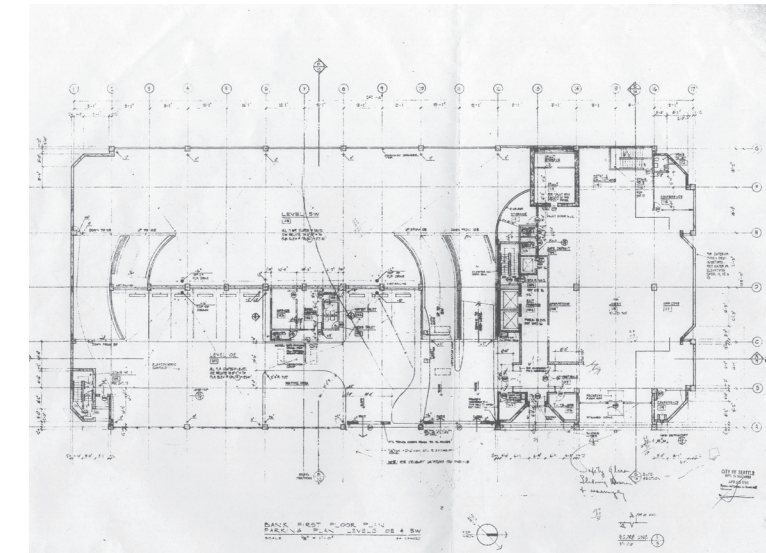


Figure 5.5: As built plan and sections of the existing garage at 701 1st Avenue



Figure 5.6: 1st Avenue between Columbia Street and Cherry Street. Parking garages currently form the street wall of the entire 250 foot long block.

which allows both commercial and residential development. The zoning height is restricted to 100 feet, with waivers allowing heights to reach 120 feet. While the building is located within the Historic District, it is only 40 years old and has no historic listings.

West of the garage, across Post Avenue, is the original Seattle Steam Plant building. Post Avenue has a 65 foot wide right of way that runs from Yesler Street, one block south of the garage, to Marion Street one block north of the garage. The Steam Plant building is on the historic registry, and will likely remain within its current envelope (with a maximum height of 80 feet at the southern end). For the reused garage, this will ensure continued access to south/southwest daylight and views overlooking Elliot Bay.

The east façade of the garage runs along 1st Avenue, a 90 foot wide right of way. This façade is of particular concern to the pedestrian experience as it currently lacks any human scale with its repetitive unscreened structure running the full 245-foot block (see Figure 5.7) With the historic buildings of the Pioneer Square district to the south rising to only 100 feet, the garage is not shadowed above the 5th floor for most of the day throughout the year.

North of the garage, the Columbia Street on-ramp to the Alaskan Way Viaduct creates a “concrete canyon” along the sidewalk. With the planned removal of the Viaduct in 2015, Columbia Street has the opportunity to become a desirable east-west pedestrian link from the city to the waterfront. A 105 foot by 95 foot solid concrete shear wall dominates the northern façade and will need to be addressed (refer to Figure

5.2 above) to improve the pedestrian environment along Columbia Street.

In 2010, the Pioneer Square Revitalization Committee (PSRC) released a report outlining a number of desires and strategies to improve the neighborhood over the next 5 years. Highlighted goals include “supporting economic growth” and “enhancing the built environment”. Specifically the committee aims to address blighted buildings, increase residential density, promote adaptive reuse, and grow commercial interests throughout the neighborhood (Pioneer Square Revitalization Committee Complete Report, 2010). All of these issues will be addressed in the program selection and adaptive reuse design of the 1st and Columbia garage.



Figure 5.7: 1st Avenue elevation of the garage at 701 1st Avenue.

Program:

The program for the garage reuse at 1st and Columbia is driven largely by the original argument of this thesis: parking should be reduced to encourage a reduction in the total number of cars and increased residential and commercial density in the city center. Reducing the number of cars making daily trips into Seattle can be addressed in two basic ways: the first, increasing alternative modes of transportation to and from the city center on a day-to-day basis and the second, increasing housing density in the city center to remove the need for daily car commuting. The former option is an issue of mass transit and planning and won't be addressed here. The latter is an architectural problem that can directly be addressed through the reuse of existing parking structures. Figure 5.8 suggests that people living in downtown Seattle are 60% less likely to drive to work than people living in Seattle neighborhoods (Gehl, 2009). Increasing the density of the downtown population requires increasing the things people need to live: housing, groceries, education, daycare and access to healthcare. Housing must come first. More people choosing to live downtown will drive the need for the other services. The garage at 1st and Columbia will be converted to a mixed-use building with residential units above elevated parking and street level commercial space. The potential for live/work units at the convergence of the residential and parking components will also be considered.

Increasing Density of Living: The lack of population density in Seattle's downtown is a function of a lack of housing options. In 2009, 232,290 individuals were employed in downtown Seattle. But residential units only exist to house, at most, a

third of that population (DSA 2011). Current housing numbers indicate that there are only 35,240 housing units available in the downtown core and surrounding neighborhoods including: Belltown, South Lake Union, and the west sides of Capitol Hill and First Hill (DSA 2011).

Vacancy Rates: People want to live downtown. Even with the higher price of housing in the downtown area and current difficult economic environment, residential vacancy rates are the lowest of any use sector. While the vacancy rate for commercial office space in Pioneer Square was 23% in the first quarter of 2011, the vacancy rate for housing was only 7%. The rental vacancy rate for the entire downtown core is lower still at only 3.6% (Dupre 2011). Conversely parking garages vacancy rates are higher. Throughout the downtown area, garages have an average daily vacancy rate of 33% (Koch, 2004). On average, one in three parking stalls is vacant. There is a clear demand for housing in the city's center that is currently unfilled. Looking closer at Pioneer Square, demand for more residential development is supported by the 16 story residential tower that is currently under construction one block northwest of the 1st and Columbia garage.

Economics: On average, a parking space in downtown Seattle generates \$262.70/month (Koch 2004). Monthly rates for the 1st and Columbia garage are \$195/month with a vacancy rate of 31% (Caballero 2010). With 708 available parking spots, the garage presumably generates \$81,500/month. In the fall of 2010, the average net revenue per square foot (NRSF) for all residential apartment unit types in the area was \$1.91/SF/month (Dupre 2011). At a vacancy rate of 3.6%, only 43,000 SF of converted residential would be capable of generating

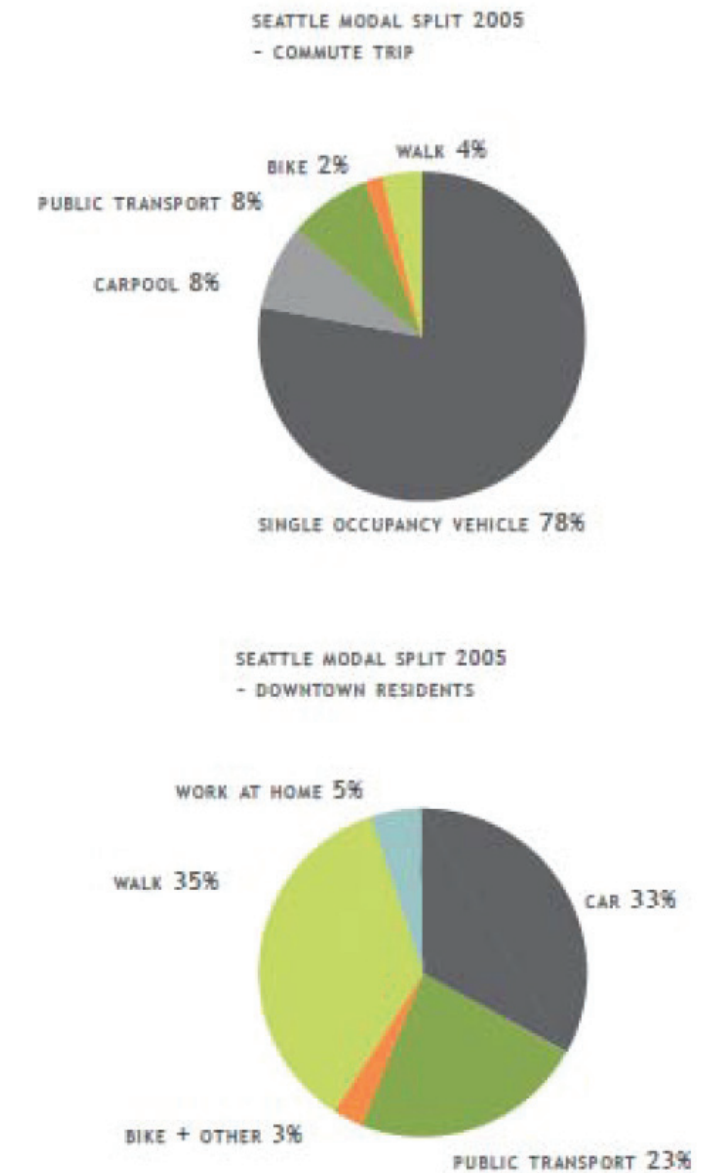
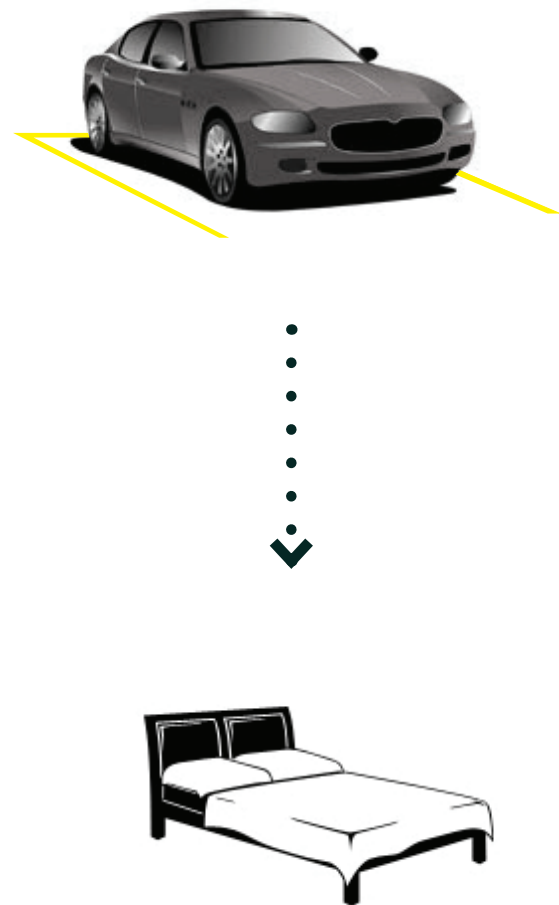


Figure 5.



the same monthly revenue. Preliminary design considerations suggest that it is feasible to create as much as 140,000 SF of residential space with the reuse of this garage. Without considering the commercial component of the project, the redesigned building is more economically desirable than the existing parking garage.

Ground floor retail and dining space will help meet the urban design goals outlined by the PSRC. A mixed-use program also allows for the inclusion of smaller units within the residential component as residents have desirable places to inhabit near by but outside of their living units. For similar reasons, shared social space throughout the residential portion of the building is desirable. Shared roof top space for residents will be prioritized on the west (higher) half of the buildings upper story, giving semi-public access to views of Elliot Bay.

Parking: Some parking will remain in the building's program. While seemingly counter to the central argument of this thesis, retaining some parking makes the project more compelling and consistent with present realities, rather than an idealized future of the city 20 or 30 years from now. Parking spaces will be limited to the residents of the building. There will not be one parking space per unit. Instead, they will be an added amenity rather than an automatic addition to units and potentially encourage shared vehicle programs. Even this small move will challenge existing Seattle Code, which currently require one parking space per residential unit. This incremental shift of parking regulations could then grow. In the future, parking could be phased out as fewer people own cars. Additional live/work units, storage space, or commercial/office space, could replace the existing parking. For the current design,

retaining two levels of parking has the added benefit of placing the residential units up higher, giving them better access to light and views. Live/work units that coincide with the lowest residential and highest parking levels will provide direct vehicular access to work spaces. Transitioning of materials and supplies and finished works can be facilitated.

Figure 5.8: Illustration of proposed parking stalls to beds conversion



Figure 6.1: Photographs depicting interior conditions of the existing garage.

CHAPTER VI: THE DESIGN

Design Derived From Form:

The existing structural conditions of the garage are the primary drivers of many design decisions. The first challenge is designing for the low floor to beam clearance. Above the second level, the vertical clearance is 7'3" beneath beams that are spaced 15' on center. Figure 6.1 shows interior photographs of the existing garage. The lower left image illustrates the intense horizontality of the space within the garage. Despite floor to slab heights of 9'6" between beams, the space is perceived as low and compressed. Figure 6.2 is a section depicting the existing conditions for a single bay of the garage and the proposed intervention of partitioning units based on the beam layout. The space between two beams defines the width of a cellular unit. Adjacent cells, either side-by-side or stacked, can then be combined to create a variety of possible spaces.

Mixed-Use Breakdown:

Figure 6.3 shows an existing section and two plans with proposed new program space overlaid. Residential units will occupy Levels 4 through 9.5, with 4 penthouse units occupying the east side of the existing roof. The existing elevator core and two exit stairs are retained as the means of vertical circulation throughout the building. The penthouses extend up to the 120' height limit, gaining views of Elliot Bay from their second floor terraces. The west side of the roof will become a shared outdoor landscape for all of the building's residents. Levels 1.5 through 3.5 will remain parking, maintaining the existing garage entrance and utilizing lower portions of the ramp sys-

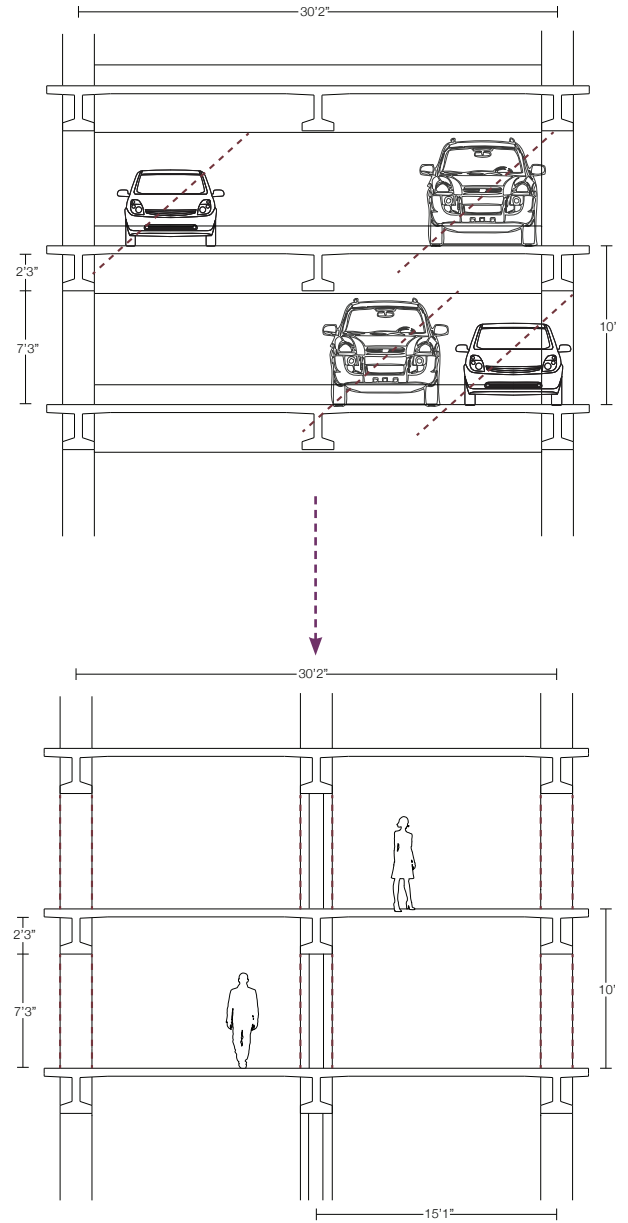


Figure 6.2: Existing structure informs the subdivision of space into 15' wide cells on the residential levels.

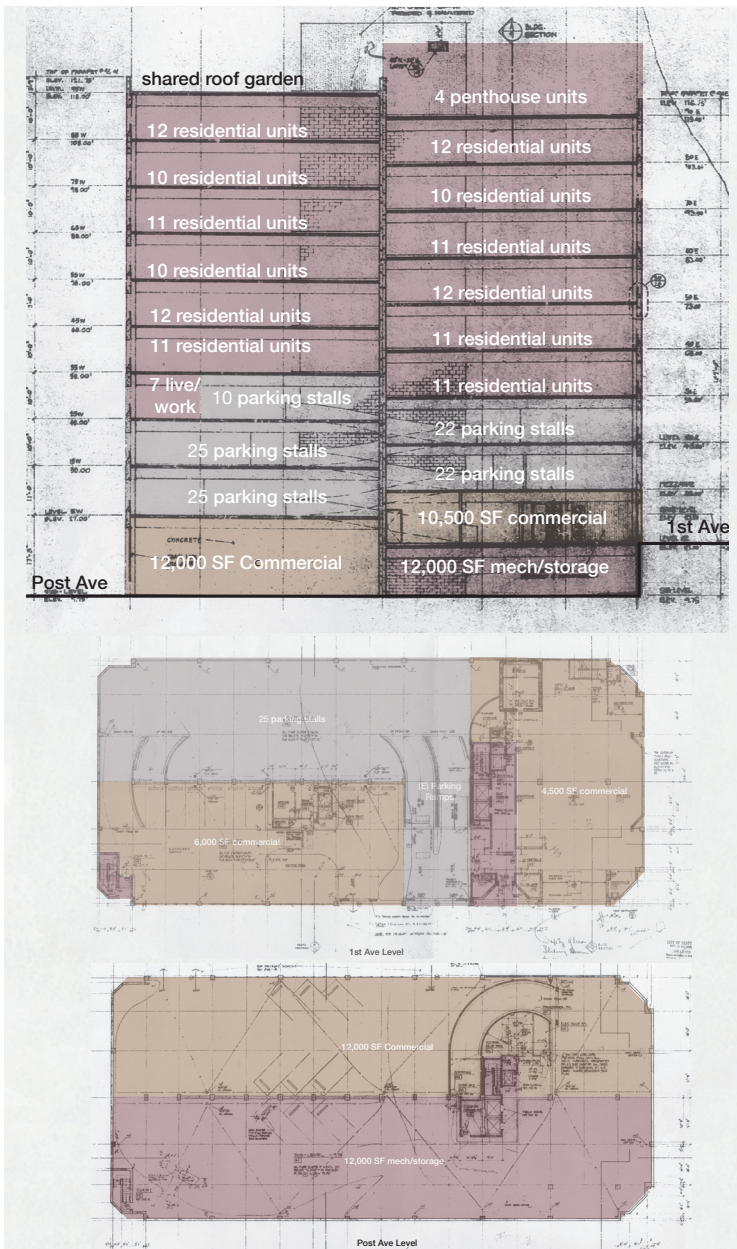


Figure 6.3: Mixed-use program diagrams overlaid on the garage's original plans and section.

tem for vehicular circulation. One hundred-four parking spaces will remain on the 5 half levels. The live/work units discussed in Chapter V, span levels 3.5 and 4.5. These will be discussed further below. The 1st and Post Avenue levels will become commercial/retail space as seen in Figure 6.3b.

While this thesis does not propose specific commercial uses, the structure of the existing building will inform the use of each commercial space. The floor to beam clearance on the 1st Avenue and Post Avenue levels are 9'3" and 14'9", respectively (with 11'9" and 17'3" floor to ceiling heights between beams). These higher clearances allow for larger open plan retail and commercial spaces to expand across to several bays without creating overly compressed spaces. The 6000 SF space south of the existing garage entrance has excellent pedestrian exposure on 1st Avenue. Due to the lowest ceiling heights of the three major commercial spaces it is best suited for subdivision into 2 or 3 retail spaces. The 4500 SF commercial space occupying the northern three bays of the building has an existing 30' floor to ceiling height. The prime location of this space on the corner of 1st Avenue and Columbia Street, coupled with the large volume, make it an ideal location for a restaurant, with room for a potential mezzanine covering some of the floor area. Because of the higher structure and ceilings, the 12,000 SF commercial space along Post Avenue could be better suited to a larger volume program, such as a larger retail store or grocery store.

Residential Arrangement Studies:

After determining the general program layout for the entire building, the majority of the design efforts for the interior of

the building were focused on the residential levels. Figure 6.4 shows four early-design plan layouts.

Minimal Intervention: The first proposes minimal intervention while maximizing the area of each unit (Figure 6.4a). The proposal has divisions at each beam, dividing each half-level into the maximum of 16 cellular units, all accessed from a central double-loaded corridor. With 12 half-levels of residential, a total of 192 units are possible. As a result of maximizing the net square feet per unit, each unit only receives light and views from a single wall. The 50' depth of each unit would essentially replicate the daylighting and glare issues of the existing garage (see Chapter 2: Challenges with Reuse). This iteration served as a baseline from which to proceed and represented a design for the greatest number of possible units.

Cut Ins: This option (Figure 6.4b) proposes removal of a portion of the floor slab from alternating bays. This would decrease the depth of alternating units while adding a second wall of glazing to the others. 16 units per half-level would still be possible, but with a combination of small units and large units, so some two cell units are proposed. This plan arrangement would work better with only 132 total units. Half of the units would be larger two cell units. Cutting the slab back also brings variety to the façade of the building and begins to give a sense of proportion and scale to the previously monolithic street wall.

Slot: To allow for access to daylight on two walls of every unit, this option proposes removing the innermost third of each half-level floor slab to create a central courtyard (Figure 6.4c). This option achieves 180 smaller units, with a depth of 33'

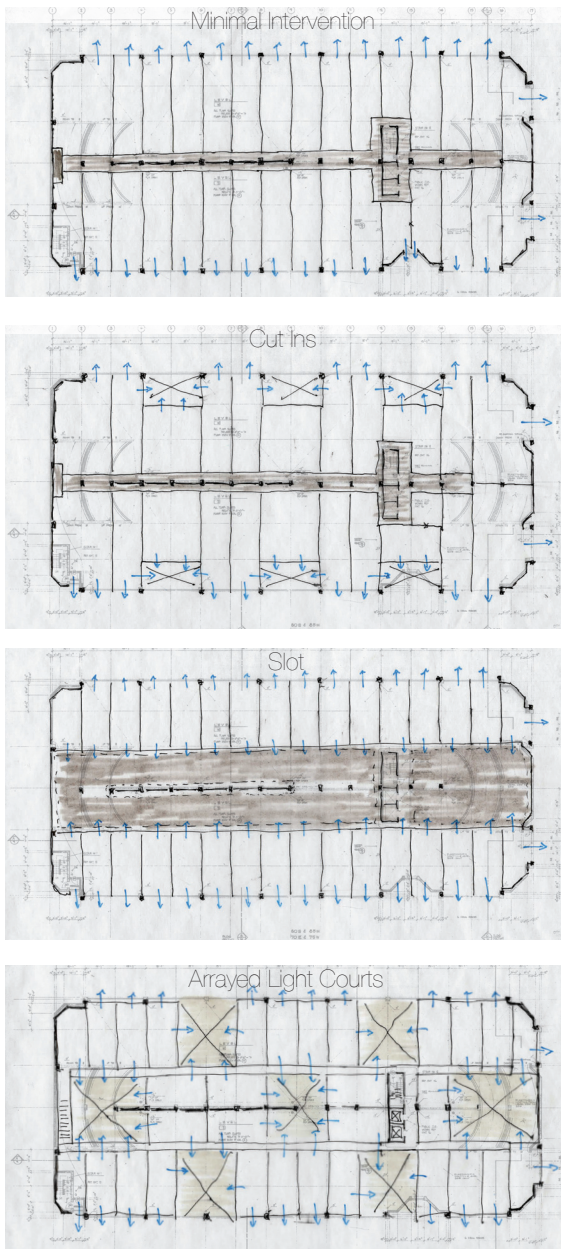


Figure 6.4: Early residential unit arrangement diagrams.

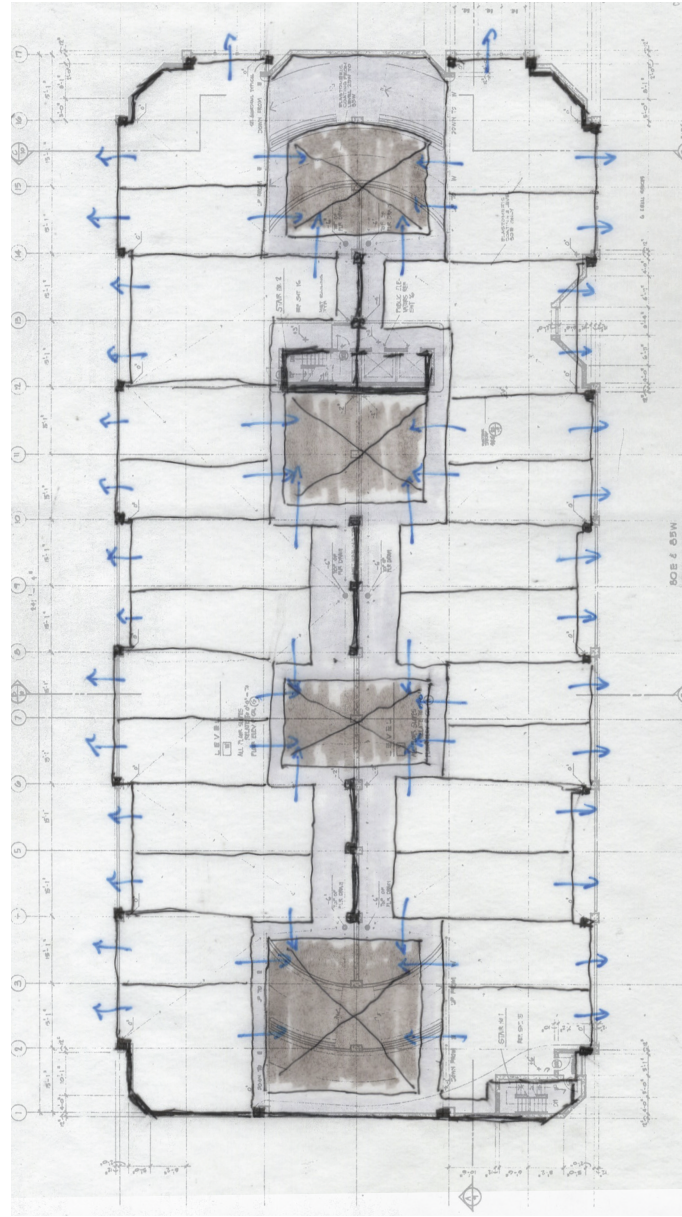


Figure 6.5: Hybrid Scheme - Combines advantages from earlier arrangement options.

and potential for glazing at each end of the space. This option requires the removal of nearly a third of the structure of the existing garage and major new structural interventions to deal with seismic loads after the north/south shear wall is decoupled from the diaphragm of the slabs. In addition to significant structural hurdles, this option also focuses the building inward, making little gesture to the street.

Arrayed Light Courts: Selectively removing 20% of the residential level evenly distributed throughout the plan produces interesting results (Figure 6.4d). The seven light wells have greater surface area than the single slot with the removal of substantially less structure (also from less essential locations). Every unit again has access to two window walls while adding an extra unit per floor. At 186 units, the total unit count is only slightly less than the minimal intervention approach. This option has the added benefit of removing the double-loaded corridor condition. While this option again modulates the depth of the façade, the 10 units per floor at the mid line of the building do not have direct access to the street and have reduced access to views and daylight.

Decision Factors:

The above design options developed from a variety of factors. The design for the first option focuses primarily on issues of economic feasibility such as: maximizing net rentable square feet, minimizing demolition costs and structural renovations. To varying degrees, the other three options balance economic viability with more architectural concerns, such as daylighting opportunities, quality of the spaces created, flexibility of unit plan, and a stronger urban gesture at street level. While the

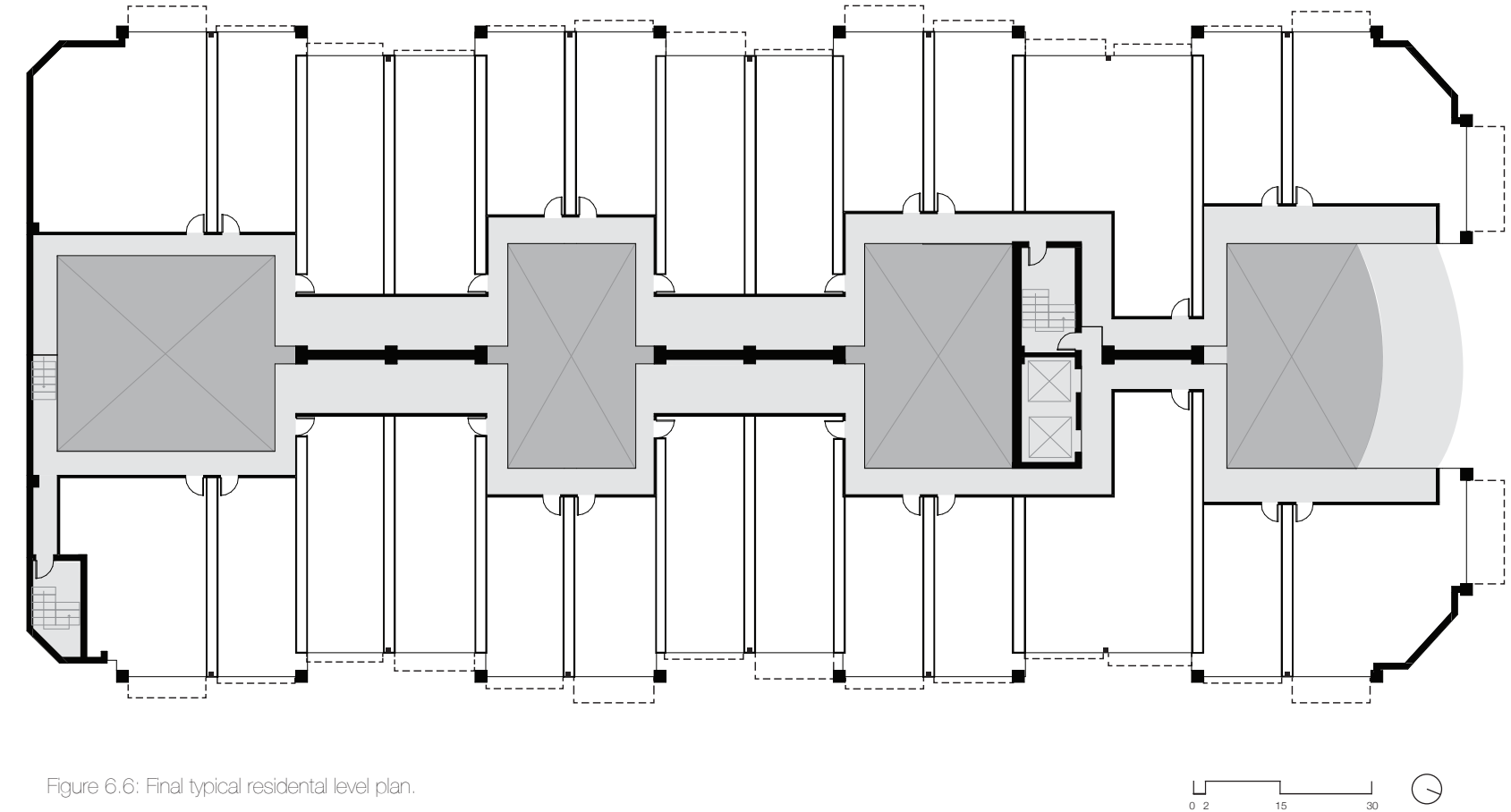


Figure 6.6: Final typical residential level plan.

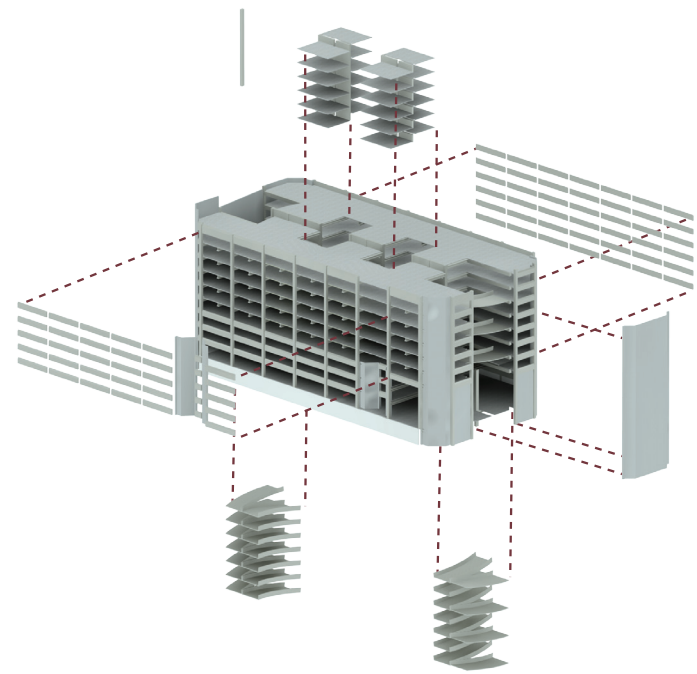


Figure 6.7: Selective demolition diagram.



Figure 6.8: Girder replacement strategy

final hybrid plan is an attempt to balance both sides of this equation, lacking a client or developer, the design decisions ultimately tended towards meeting the architectural concerns.

Hybrid: Figure 6.5 is a sketch of the final plan for the residential levels. The Hybrid removes the existing ramps and opens two new light wells along the central axis of the building above the 4th floor. Five different unit types are created, with a possible total of 156 units. Each unit has a window wall on the street side and at the rear of the unit. The circulation jogs in and out of the light courts, removing the double-loaded corridor condition. Every unit opens onto a light court instead of shear wall. The slab is cut back four feet from the column grid of alternating bays as an initial façade modulation. Figure 6.6 shows the final plan for a typical residential level.

Selective Demolition:

The final residential floor plan requires the removal of ~15% of the total structure of the existing garage. Figure 6.7 illustrates the major components of the existing structure that will be removed through the proposed design. Allowing for removal of some of the existing structure greatly improves the spatial character of the architecture. The benefits achieved as a result of some demolition outweigh the minimal increases in the total embodied energy lost from the project. Landfill diversion of the concrete waste can be achieved by coordinating demolition with nearby seawall reconstruction projects along the waterfront. The removed concrete can be broken up and used to stabilize the seawall and provide salmon habitat. A similar process was recently employed at the Olympic Sculpture Park with granite transported from the Cascade Mountains.

As discussed in the “Existing Conditions” section of the previous chapter, every other beam in the structural grid is supported by a 4’6” deep girder, that is in turn supported by two columns. These girders reduce the potential window area of the street façade by nearly half (see figure Figures 6.1 and 6.9). Because the slab is a one-way system, supported entirely by the beam system, the girders can be removed and replaced by columns at the end of each beam (see Figure 6.8). 10” square concrete columns, weighing 840 pounds will replace the 20,250 pound girders. The beam load will travel through the new columns to the 4th floor where the existing girder, reinforced from below, will carry the load back to the existing columns and through to the original foundations. Figure 6.9 shows views from a unit with and without the girder. The accompanying daylight simulations show that adequate daylight (a daylight factor of 2 or above) penetrates 8-10 feet deeper into the unit after the removal of the exterior girder. The added value of daylight and views justifies the removal of the girders.

Light Wells:

The exterior light wells have dimensions of 40’ by 45’. The inner two light wells are 40’ by 30’ (see Figure 6.10). These light wells are not large enough to bring significant daylight to units of the lower levels, however, they will provide ventilation flow through the units and allow residents direct access to open air by stepping out of their units. For reference, Figure 6.11 shows several buildings with light courts of similar dimensions along Central Park West in Manhattan. Despite the fact that New York buildings are significantly taller than the proposed building, the light courts add significant value to these properties. The bottom of each light well includes landscape

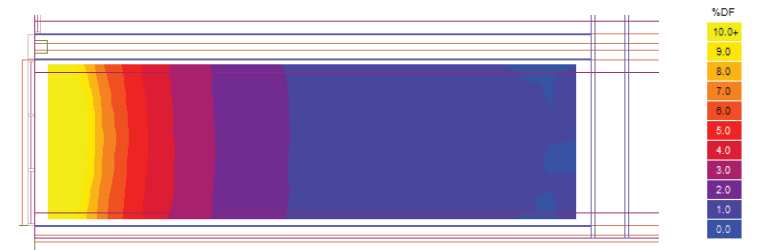


Figure 6.9a: With the girder in place, a daylight factor of 2 is achieved to a depth of 13’ from the window. The average daylight factor in the unit is 3.5.

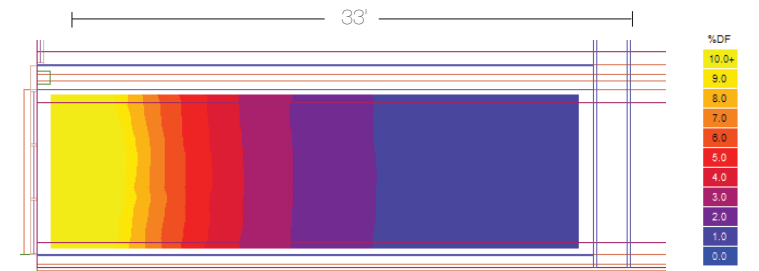
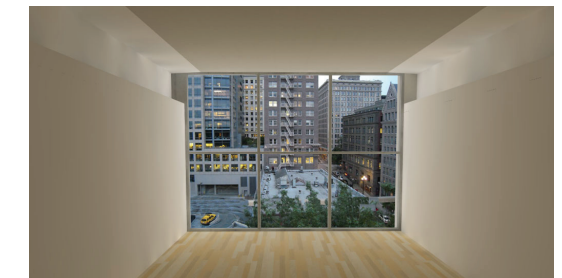


Figure 6.9b: By removing the girder, a daylight factor of 2 is achieved to a depth of 18’ from the window. The average daylight factor in the unit increases to 4.8.

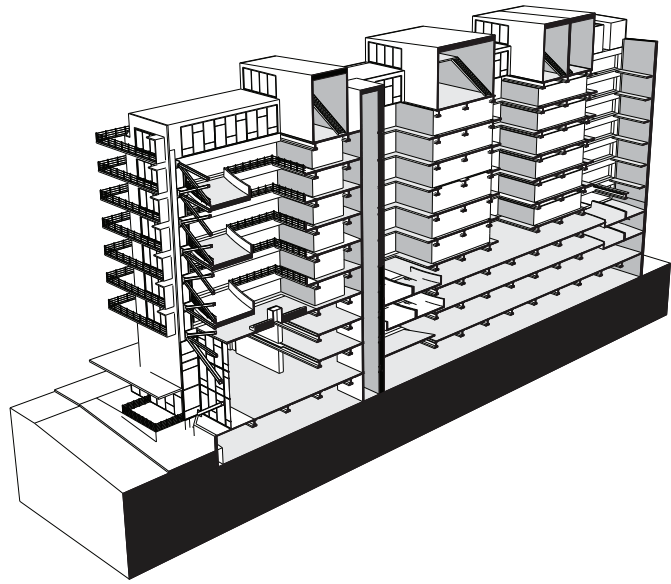


Figure 6.10: Isometric section depicting the four light courts along the central axis of the building.

features and will be accessible, shared space for all of the residents. As depicted in Figure 6.7, the northern shear wall will be removed, bringing more light into the northern court and giving the building and Columbia Street a more direct visual connection. Three existing ramps will be left intact in this court as well. These ramps will act as a reminder of the structure's former life as a parking garage and be a point of visual interest for the surrounding neighborhood. Figure 6.12 is a perspective view from the 5th level, looking across the northern light court to the city and water beyond.

Unit Layouts:

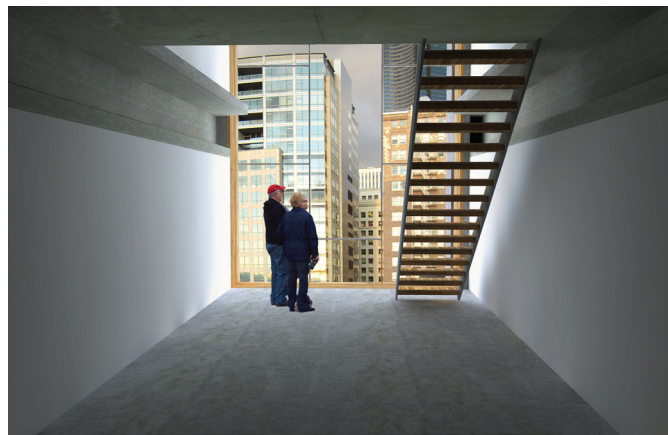
Throughout the design of residential floor arrangements, basic individual unit floor plans were tested to ensure that the spaces being created could become believable and livable residential units. However, designing specific unit layouts for the entire building is not the intention of this thesis. Rather, I envision the residential levels being partitioned and sold in single, double or even triple cell configurations to suit the needs of each resident. Single cells can become studio units. Two cells next to each other will create a larger one or two bedroom unit. Two stacked units can become a loft space with the removal of a portion of the floor slab of the upper cell. Combining two cells on the top parking level with a single cell on the fourth floor residential level will generate a live/work unit. A depth limit of 25' for the lower cells of the live work unit will maintain vehicular circulation for the parking level. Figure 6.15 depicts plausible arrangements for several potential cell configurations. Figure 6.13 images six various unit possibilities in their raw, unfinished form.



Figure 6.11: Aerial view of buildings with light courts along Central Park West.



Figure 6.12: Perspective view of the north light court looking out to downtown Seattle and Elliot Bay beyond.



The proposed single cell units vary between 375 SF and 500 SF. This is smaller than the typical single bedroom apartment or condo, which has hovered near 750 SF since the 1970's (Dupree, 2011). However, the possibility for some smaller units has potential benefits, especially during the current difficult economic climate. Unit price is based on net square feet, therefore smaller units could decrease a monthly rent or mortgage payment by as much as fifty percent. This is space that we no longer need. While the last 40 years have not been marked by a reduction in the amount of things people own, our things do take up significantly less space. (see Figure 6.14).



Figure 6.14: In the past 5 years, our things have become much smaller, requiring less space.

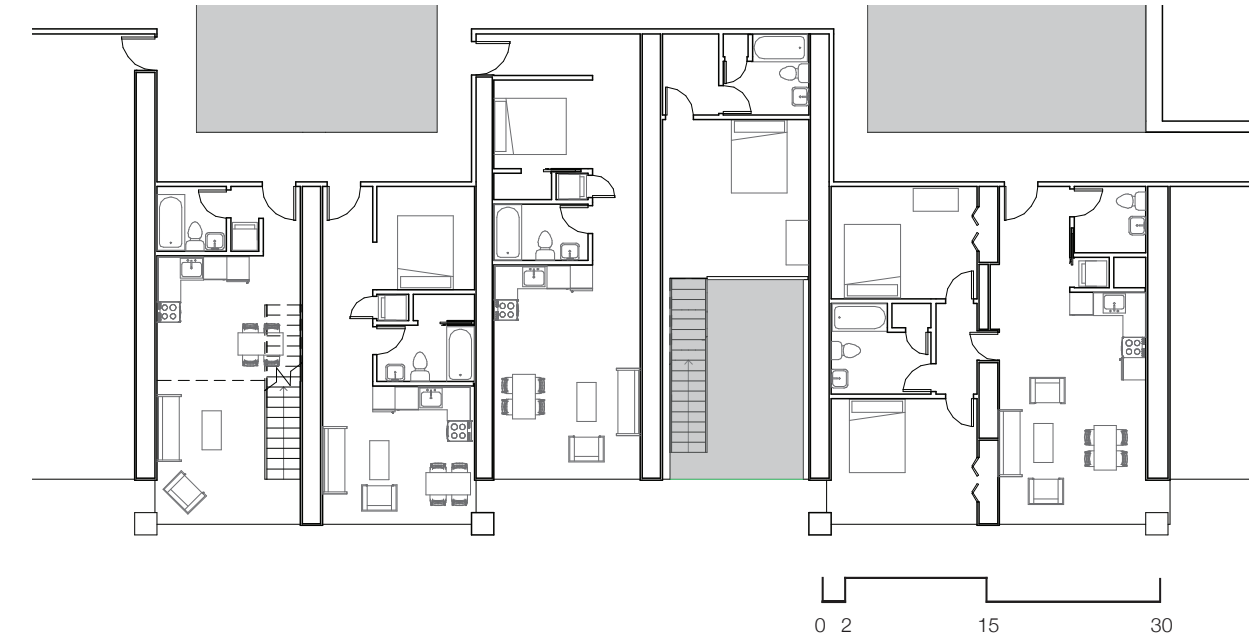


Figure 6.15: Feasible unit layouts.

Figure 6.13: Views of six units prior to habitation. The top row shows single cell units. The middle row shows units combining adjacent cells. The bottom row shows two and three cell lofted options.

Figure 6.16a: Enclosure in the plane of the columns will allow thermal bridging through the concrete structure and make heating the new building costly.



Figure 6.16b: Enclosure outboard of the column plane prevents thermal bridging.

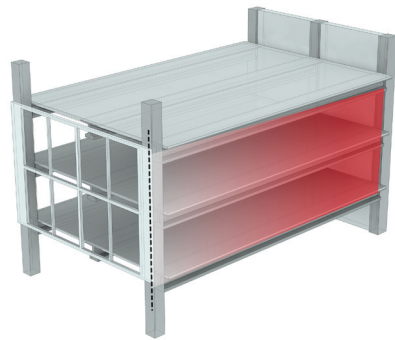
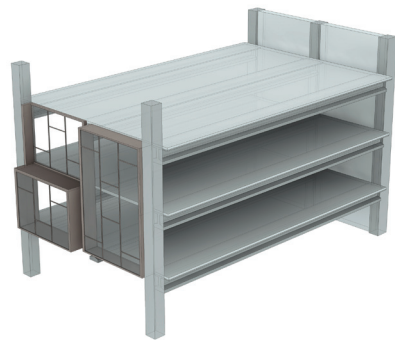


Figure 6.16c: Frame insertion bridges the gap between slab and column plane and achieves desirable modulation in facade system and suggests the cellular nature of the units that are enclosed.



Enclosure:

Inline: Figure 6.16 depicts three possible scenarios for enclosing the existing structure at the street façade. In the first, enclosure occurs in plane with the existing columns. The columns are then either left exposed, creating a thermal bridge to the entire concrete structure within, or must be wrapped, emphasizing the existing, monotonous base structure of the façade. Neither option is particularly appealing.

Outboard: The second option brings the enclosure to the street side of the column face. This breaks the thermal bridge, keeping heat in and cold out. While preferable to the first option, a continuous facade of enclosure does little to bring scale to the large elevation. This option also fails to address the gap between the slab and the column face that results from the removal of the girders.

Frames: The third option inserts a series of frames of three depths: 6 inches, 2 feet and 4 feet into the spaces between columns. These frames can be arranged in a variety of ways, some adding depth to the unit, others stacked to create small private balcony spaces. The frames span the gap between slab and column face and create a highly varied façade (see Figure 6.17). The frames, constructed with a steel frame, clad in metal and lined with wood, will be significantly lighter than the removed concrete girders and can be supported by the existing columns' structural capacity.

Above the street level, the remaining façade is clad in the same metal as the frames. Metal was chosen for the cladding system for the ease with which it can be modified to address the

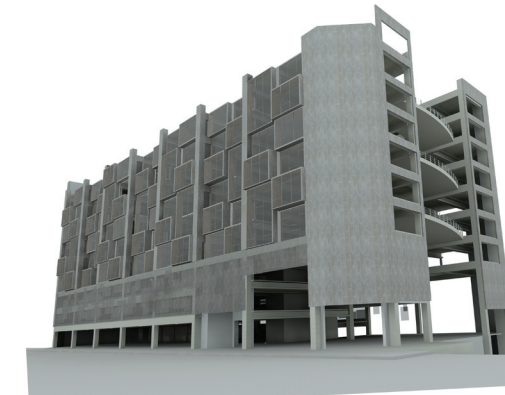
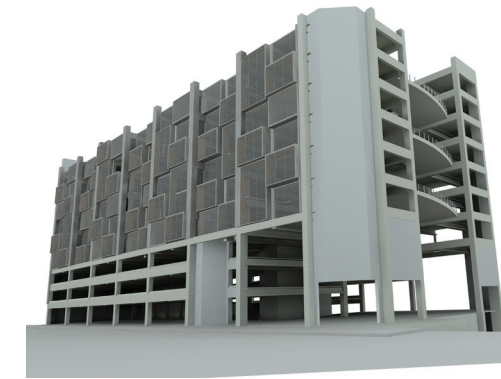
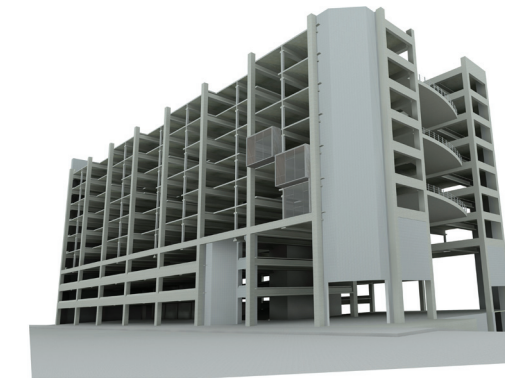
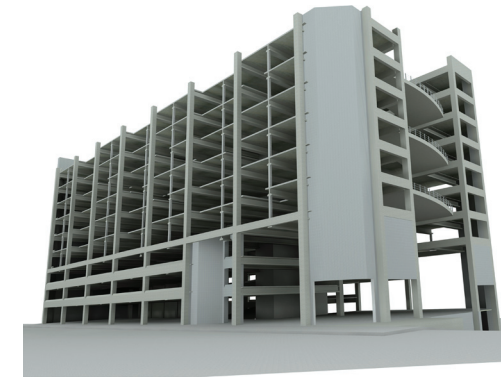


Figure 6.17: Progression of enclosure for the new building from the existing condition, through deconstruction and the application of the new cladding systems.

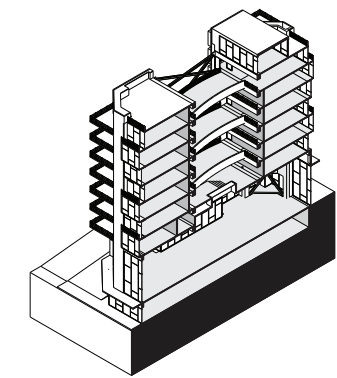
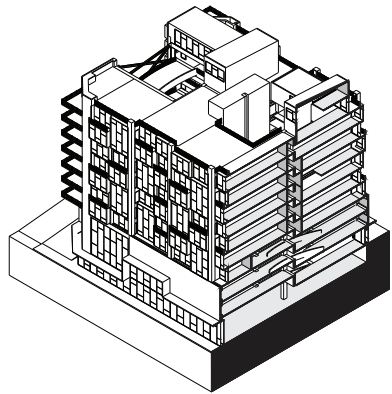
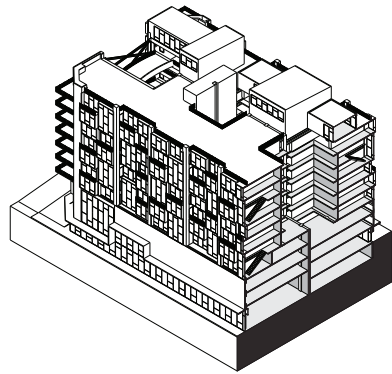


Figure 6.18: Transverse Isometric sections.

various façade components. At the north and south ends of the building, the existing concrete walls need to be insulated to prevent thermal bridging. Here the metal is used in a simple rain screen application to prevent weathering and damage to the insulation and vapor barrier below. Balconies for each unit on the north façade mitigate the large expanse of the building as it turns the corner from 1st Avenue to Columbia Street and from Columbia to Post Avenue (see Figure 6.19).

The façade of the remaining parking requires application of a screen that obscures views of the cars within, while allowing for some natural light and ventilation. Again, the same metal can be applied with a system of perforation. This aspect of the design was not fully realized in the course of this thesis.

The metal façade system terminates at a street level canopy. The underside of the canopy is wood lined, providing a warmer material where people interact with the building. The canopy opens up with a slated wood system over the parking entrance. The altered condition should make pedestrians more aware of potential interaction with entering and exiting cars. The street level is enclosed by a double skin glass façade. The line of columns resides between the two planes of glass, providing some thermal insulation. This space also doubles as display space at the street front for retail stores.

Figure 6.17 depicts the building in 9 stages from the existing condition, through removal of excess structure and the addition of the cladding system, to the final proposed design.



Figure 6.19: View from the corner of 1st Avenue and Columbia Street illustrating the new facade systems.



Street Improvement:

One of the rationales for the selection of this garage was the poor street condition created by the two parking garages lining both sides of the street the entire length of the block. Figure 6.20 depicts this condition before and after reuse of the 701 1st Avenue garage. The introduction of retail and commercial space coupled with the modulating canopy, make this stretch of 1st Avenue a more pleasant pedestrian experience.

Figure 6.21 depicts the before and after condition along Post Avenue. With the completion of this project and the new Colman Tower, one block north, Post Avenue has the potential to become a lively, pedestrian priority street. Cafes and retail spaces, hanging street lights and a new coarser grained street paving will help create a desirable environment in this currently underutilized space.



Figure 6.20: Improved street condition along 1st Avenue.



Figure 6.21: Before and after views of Post Avenue





Figure 6.22: View of the shared rooftop space on the west side of the building

CONCLUSION:

Connection to the Surrounding City: The final views of the project are from the rooftop, looking out across the Sodo skyline (Figure 6.22), and a bird's eye view of the garage in its surrounding context (Figure 6.23). The building occupies a unique space in the city: a space of transition. Pioneer Square meets Downtown. The predominately brick buildings step up from a consistent height to the glass and steel towers of the central business district. The orthogonal layout of the street grid shifts to match the shore of Elliot Bay.

The reuse of existing garages will begin a transition of a different nature. A transition away from twentieth century car-centric trends and towards cities that are more densely inhabited, where the needs of the pedestrian are placed above those of the automobile. This transition is imperative for our environment and our urban infrastructure. This thesis establishes that the transition is not only viable, it is architecturally compelling.



Figure 6.23: Bird's eye view of the building and surrounding context before and after reuse.



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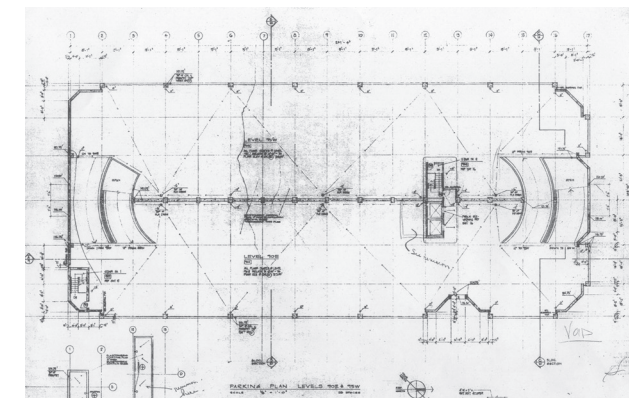
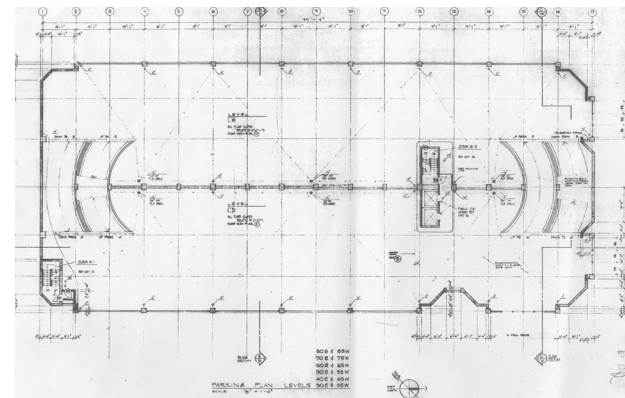
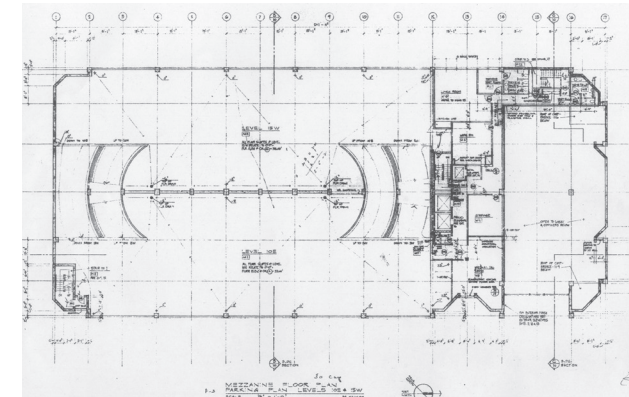
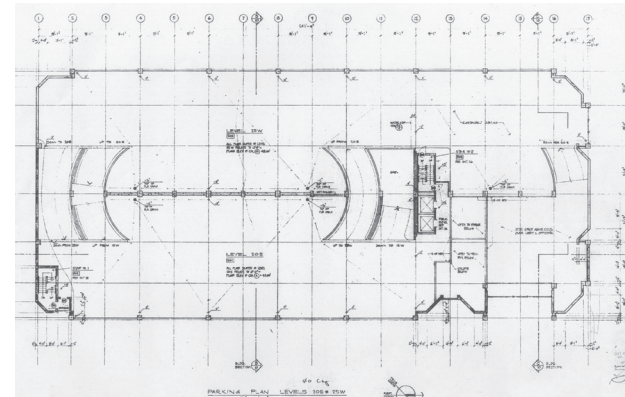
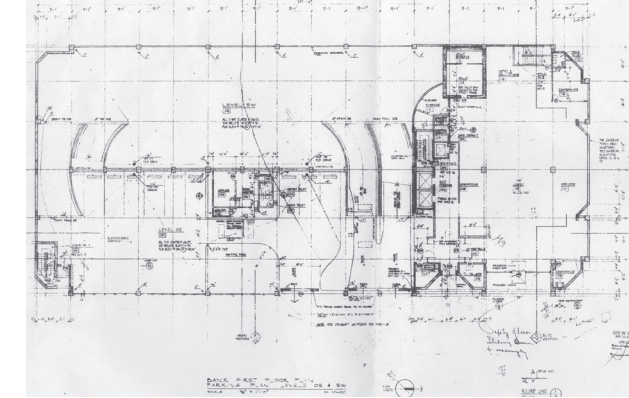
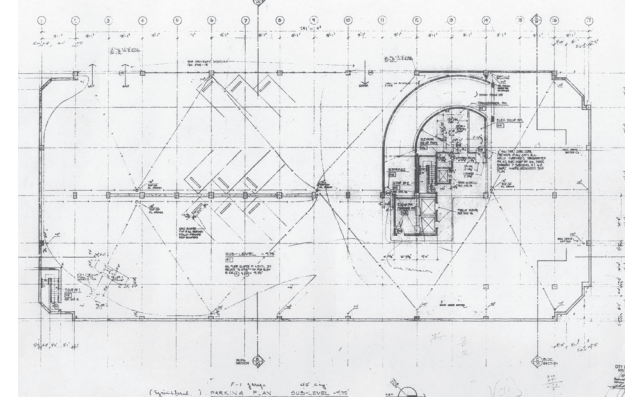
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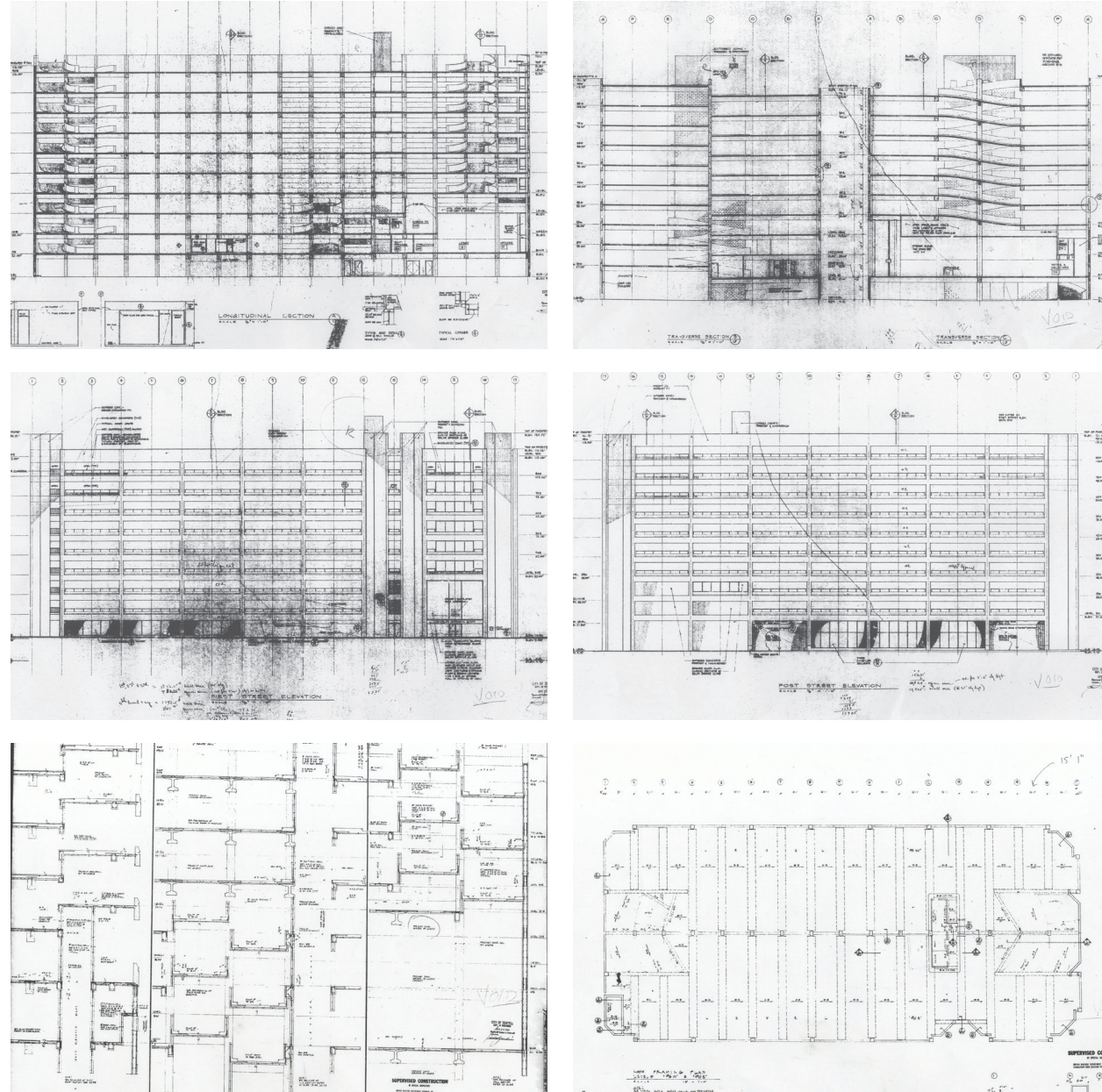
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APPENDIX A: EXISTING GARAGE DRAWINGS



Original Drawings for the garage at 701st Avenue from 1969. From top to bottom: Basement Plan, 1st Floor Plan, 2nd Floor Plan, Mezzanine Plan, 3rd-8th Floors Plan, 9th Floor Plan

Original Drawings for the garage at 701st Avenue from 1969. From top to bottom: Longitudinal Section, Transverse Sections, 1st Avenue Elevation, Post Avenue Elevation, Sections through parking ramps, typical Reflected Ceiling Plan.



APPENDIX B: LCA ANALYSIS

This investigation employs the Athena Institute's Ecocalculator to perform Life Cycle Assessment (LCA) analyses. The first step of this process is evaluating the existing energy, measured as Global Warming Potential (GWP), and resource use embodied in the existing garage. Analysis using the Athena Ecocalculator tool indicate that the existing garage represents an embodied GWP of 5956 tonnes of CO₂ and 41,000 tonnes of weighted resource use. This is the equivalent of the CO₂ emissions generated by nearly 1200 cars over the course of a year. While this emission of CO₂ cannot be undone by reusing the existing garage, the calculation provides an important baseline for comparison.

Conversion of the existing garage to a residential complex would involve the addition of many elements, most of which are outside the scope of this study. For the purposes of this study, the LCA analysis considers the addition of the following three systems for reuse: exterior cladding, interior partition walls and a roof. The exterior cladding was approximated as 30% glass, 40% spandrel panel and 30% metal cladding with ridged insulation. The interior partition walls were calculated to form 30' wide by 45' deep units and presumed to be constructed from steel studs covered in wall board and paint. This number was then increased by half to account for the addition of further walls within each unit. Though this is an estimate, an approximation is adequate as the contribution of the interior partitions to the total conversion calculation were less than 2%. The roof is modeled as a steel roofing system with R20 ridged insulation. The total calculated GWP for the conversion of the existing garage to residential units is 1560 tonnes of CO₂. As seen in Figure 3.7, the conversion represents only 25% of the GWP embodied in the existing garage.

Determining the LCA impacts of an equivalent new construction housing complex involves a more intricate design process than the conversion scenario. Therefore this process has been greatly simplified for the purposes of this study. The dimensions of the new construction project are assumed to be the same as those of the existing garage. Two structural systems for the new construction scenario were considered. The first structural system is a generic HSS Steel column and WF beam system. The floor system consists of steel open web joists with concrete topping. The second is a concrete frame and slab system. Foundation calculations are similar to those used for the existing garage. The exterior cladding, interior partitions and roof were assumed to be similar to the conversion scenario. This allows for a direct comparison of the additional GWP associated with the construction of a new construction option in place of using the structure of the existing garage. The GWP for the new construction structural systems are 2269 tonnes of CO₂ for the new steel system, and 6122 tones of CO₂ for the new concrete system. Table 2 shows a comparison of CO₂ per square foot for construction of the scenarios discussed above. Converting the existing garage to residential units contributes less than half as much GWP as the new steel frame construction option and only one-fifth that of the concrete frame option.

Conversion	6.2 kg/SF
New Steel Frame Construction	14.8 kg/SF
New Concrete Frame Construction	30.2 kg/SF

Table 2

For questions or comments, please contact Andy Brown at andybbrown@gmail.com