Crossfit Design: Maximizing Building Potential Across Broad Time and Modal Domains

CROSSFIT DESIGN:
MAXIMIZING BUILDING POTENTIAL
ACROSS BROAD TIME AND MODAL DOMAINS

A Thesis Presented

by

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DEDICATION

This thesis project is dedicated to my father, Douglas T. Goodale II, who taught me how to build, how to think, and always encouraged me to pursue the life of a Renaissance Man.

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This thesis project would not have been possible without the support and endless patience of my wife, Leni Brongers, and my two daughters, Willamina and Viola. Thank you for standing by me for the countless hours during which I was chained to my desk and unavailable as a husband and father.

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ABSTRACT

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MAY 2009

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Crossfit is a unique method of physical exercise founded on a specific set of underlying scientific principles. The ultimate goal of Crossfit is to maximize work potential across broad time and modal domains.

This project attempts to apply the concepts and principles of Crossfit to architecture to maximize living potential of built environments across broad time and modal domain by means of an architecture that is kinetic, interactive, responsive, and continually reconfigurable.

The focus of the project is the design of an approximately 35,000 sf building titled The Motus Center for Kinetic Art Science. The building serves both as an actively used gymnasium and movement studio as well as an interactive museum and gallery of kinetic arts and sciences. The building site is located on Cross Street in Boston, Massachusetts between Hanover Street and Salem Street, in an area known as the Artery Strip.

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CHAPTER 1

INTENT (PURPOSE) OF PROJECT

The study and understanding of the human body and its relation to the built environment has a long and involved history in architectural practice. This project seeks to further the exploration of the meaning of the body and systems of physical movement in architecture and spatial studies.

The thesis of the project is centered around the study and research of a particular system of movement and fitness training known as Crossfit.

Crossfit is a unique method of physical exercise developed by Greg and Lauren Glassman of Santa Cruz, CA in the late 1990's. The Glassmans are a husband-and-wife team of fitness trainers with a background in gymnastics and strength training practices. Starting in 2001, the Glassmans began posting their distinctive workouts free on the internet in order to share their collective knowledge with their clients and friends. What began as a simple experiment in an open-source approach to learning about fitness quickly became a major trend in fitness training worldwide.

Crossfit is loosely defined as a broad and inclusive general fitness. It incorporates elements of gymnastics, Olympic weightlifting, powerlifting, sprint training, endurance sports, calisthenics, and martial arts, as well as wide variety of lesser known movement systems such as kettlebell swinging, buildering, and parkour. It is defined more specifically as constantly-varied functional exercise performed at high intensity.

Crossfit has developed a unique approach to fitness and exercise physiology that challenges much of the prevailing wisdom of contemporary fitness method as practiced in most gyms. The scientific method of collection, observation, and interpretation is central to

the philosophy of Crossfit. The study of Crossfit has yielded a central hypothesis that has become the goal or motto for the practice of the system which is that by performing constantly varied functional exercise at high-intesity, the trainee can *maximize work capacity across broad time and modal domains.* Work capacity is defined as power output (P), which is in turn defined as work divided (W/T). Thus the goal is to improve an athlete's power output across broad time and modal domains, that is in exercises of varying duration (time domains) and of varying types, or modes, of movement (modal domains).

This project attempts to apply the concepts and principles of Crossfit to architecture to maximize *living potential* of built environments across broad time and modal domain by means of an architecture that is kinetic, interactive, responsive, and continually reconfigurable. For this purposes of this project we shall define living potential as a building's or environment's ability to meet the required ongoing programmatic demands of its users.

In furtherance of this goal, the following design goals were established:

Develop flexibility and responsiveness to:

Solar:

- daylighting
- gain for heating vs. shading for cooling

Wind:

- structural resistance
- natural ventilation

Temperature:

- inside vs. outside differential

Seasonal variation

Occupancy

- accommodate change in number of occupants

Use:

-short and long term changes in program and use

- reprogrammable shape

Wear & tear/decay:

-flexible structure to accommodate revision

Assess flexibility-usability tradeoff

CHAPTER 2

RESEARCH ESSAY

Designing for Change: a Study of Adaptable Architecture

In How Buildings Learn, author Stewart Brand identifies a dysfunction of contemporary architecture and construction:

> Between the world and our idea of the world is a fascinating kink. Architecture, we imagine, is permanent. And so our buildings thwart us. Because they discount time, they misuse time…Almost no buildings adapt well. They're designed not to adapt: also budgeted and financed not to, constructed not to, administered not to, maintained not, regulated and taxed not to, even remodeled not to. But all buildings (except monuments) adapt anyway, however poorly, because the usages in and around them are constantly changing… New usages retire or reshape buildings…from the first drawings to the final demolition, buildings are shaped and reshaped by changing cultural currents, changing real-estate value, and changing usage.[1]

The inflexible, static nature of buildings leads to enormous waste of resources, both financial and material, as buildings are continually remodeled and demolished in response to changing use and various social pressures in a manner that is usually extremely inefficient. Brand advocates for adaptable, flexible architecture that is designed and built to accommodate change.

How can we as architects achieve this adaptable architecture?

What ingrained concepts in architectural practice and education lead to the design and construction of static architecture? What social and cultural factors reinforce static architecture?

What is flexible architecture? What can it be? What does it look like in practice?

What recent technological developments are fueling growth in flexible, adaptable, and kinetic architecture?

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[1] Brand, Stewart. *How Buildings Learn : What Happens After They're Built*. (New York, NY: Viking 1994), 11

The problem of static architecture is first and foremost an issue of how we conceive of architecture and the common image of what an architect is and does. Central to this issue is the definition of architecture as permanent and enduring: "The whole idea of architecture is permanence…in wider use, the term 'architecture' always means 'unchanging deep structure.' It is an illusion."[2]

Traditionally, the study of architecture has focused primarily on works of lasting duration and has eschewed vernacular building and transient construction as not being worthy of being considered architecture. This has created a bias in architecture towards conceiving of architecture as being permanent and static which is continually reinforced through the study of architectural history:

> Architecture has often been called *frozen music.* Others have referred to it as the permanent expression of an age—the freezing of an era; the petrification of an idea; the recording in stone of an isolated fragment of history.
> Architecture has traditionally been perceived as enduring, permanent structures. For centuries the architect has aspired to permanence. He has continually searched for materials and structural systems that would increase the length of time a building might stand. Even today, with but a few exceptions, there is little consideration given by the architect or the client to the life of any building other than to assume that it will always stand…Revered and praised …are the timeless monuments of ancient Egypt, the temples of the classical world, and the medieval cathedrals of Europe…These timeless monuments of the ancient, classical, and medieval world are lauded as great cultural achievements. There is little doubt that these noble structures represent and exemplify the era in which they were built or that they provide national symbols of excellence. Unfortunately, the result has been that most current buildings were also designed to be monuments. It has not been considered that any building might at some future time be altered, expanded, contracted, moved, or terminated. Such changes are only conceivable at great additional expense. It is apparent that the monument syndrome of static, permanent architecture has persisted throughout history into these dynamic times. We continue to educate the would-be architect to be a monument builder.[3]

A change in architectural education is necessary to effect a transformation of the field to flexible design and thinking. We must imbue our study of architecture with an understanding of the nature of dynamic change from the very beginning:

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[2] Ibid, 11

[3] Zuk, William, and Roger H. Clark. *Kinetic Architecture*.(New York: Van Nostrand Reinhold 1970). 4 This book, written by two professors of architecture at the University of Virginia in 1970, was ahead of its time. It remains one of the most comprehensive and relevant texts on the subject.

Important, too, to the exploration of kinetic architecture is recognition by the schools of architecture of the kinetic evolution which is taking place. The emphasis of education will have to change to anticipate the growth that is taking place in this field. There are many new areas to be explored and researched. There are many developments in other fields which must be considered. There are many new parameters to be considered. There is a new vocabulary to be formulated and a new aesthetic to be expressed. Kinetic architecture is now at the beginning stage—we stand at an architectural frontier.
Ours is an age of change, of dynamicism, of unrest, of revolution. This is an age of rapid transportation, of instant communication, of high-speed computers, and of an explosion in knowledge. With a society that is mobile and dynamic, with technological developments occurring at an unprecedented rate, with an increasing inability to accurately predict the future, with changes of great magnitude taking place within short periods of time, with other disciplines and interests working themselves into architecture, and with an obvious move toward an open-endedness in all aspects of life, we must move toward kinetic architecture, an architecture which can adapt to a changing set of pressures which mould form. What happens to fixed structures that are built to last for about one hundred years when they have outlived their usefulness within five or ten years, or very often before they are even completed?"

Further compounding the problem is the consumer-driven culture of "starchitecture". Architecture is as susceptible to the pitfalls of consumerism as any industry. The comiditization of building as a profit-driving marketing image has made celebrities of an elite cast of architects. The rock-star status afforded some architects has a tendency to inflate egos and encourages an unrealistic image of the architect as an auteur solely responsible for the vision and success of a project, similar to the popular image of a movie director. But, much like film, almost all projects of any significant scope are collaborative works carried out by a broad network of people. The "starchitect" culture worships the supremacy of artistic vision.[4]

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[4] Sibel, John. "Letter to the Editor." *New York Times*. 20 December, 2007, in response to the article: "Critic's Notebook: Review of 'Let the 'Starchitects' Work All the Angles'", *New York Times* 16 December, 2007:

In "Architecture of the Absurd," I distinguish between celebrity architects who, with rare exceptions, meet the needs of their clients and those who do not.
On the one hand, there are many star architects who nonetheless think of themselves primarily as practical artists. Designers such as Antonio Gaudí, I. M. Pei, Eero Saarinen, Richard Neutra, Mies van der Rohe and Moshe Safdie have produced exciting and innovative designs while being attentive to their clients' needs and limitations.
On the other hand, there are star architects who think of themselves primarily as fine artists. Architects such as Josep Lluís Sert, Le Corbusier, Frank Gehry, Daniel Libeskind and Steven Holl have designed huge sculptures that, as buildings, are absurdly dysfunctional and wasteful.
In my book, I applaud the fanciful (even extravagant) designs of the former group of starchitects.
"Architecture of the Absurd" condemns only those architects who, by considering themselves sculptors first,

Stewart Brand dubs this trend in contemporary architecture "Magazine Architecture" for its focus on creating visually appealing graphic presentation of the design for awards competitions and architecture magazines. The constant focus on image yields stagnant design that does not adequately address important needs or fulfill its functional requirements and is incapable of adaptability.[5]

This highlights a conflict between art and science in the practice of architecture. The "starchitecture" and "magazine architecture" syndromes are largely a result of wide-scale preference for architecture as a fine art, essentially large, expensive, functional sculpture, all at the expense of architecture as craft that equally values science and art and considers building performance to be central to the success of a design.[6]

A renewed focus on architecture as craft may help to alleviate some of the industry's failure to provide practical yet adaptable designs while still creating captivating

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create buildings that fail to meet the budgets of the clients and the functional needs of those who have to live and work within them.

[5] Brand, 55-56: A major culprit is architectural photography…Clare Cooper Marcus said it most clearly: "You get work through getting awards, and the award system is based on photographs. Not use. Not context. Just purely visual photographs taken before people start using the building." Tales were told of ambitious architects specifically designing their buildings to photograph well at the expense of performing well…"Awards never reflect functionality. I remember serving on a jury one time and suggesting, 'Okay, we've winnowed this down to ten projects that we really like. Let's call the clients and see how they feel about the buildings. Because I don't want to give an award to a building that doesn't work. I was hooted down by my fellow architects."
In London, architect Frank Duffy fumed to me about "the curse of architectural photography, which is all about the wonderfully composed shot, the absolutely lifeless picture that takes time out of architecture— the photograph taken the day before move-in. That's what you get awards for, that's what you make a career based on. All those lovely but empty stills of uninhabited and uninhabitable spaces have squeezed more life out of architecture than perhaps any other single factor."
[6] Brand 56: The problem with architects…is they think they are artists, and they're not very competent." …the history of architecture as a profession…was always around distinctions of "art" that architects distinguished themselves from mere "builders"—starting in the mid-19th century, when the profession emerged, and continuing to the present clay. "Art-and-Architecture" are always clumped together. The problems of "art" as architectural aspiration come down to these: Art is proudly non-functional and impractical. Art reveres the new and despises the conventional. Architectural art sells at a distance.

spaces. Art is inherently impractical due to its experimental nature. Craft is inherently functional, but includes an element of artfulness.[7]

The impracticality of the art-focused design has, in a way, pushed architects to the fringes of the design community. Most buildings are not designed by architects.[8] Of the small percentage of buildings that are designed by architects, the role of the architect has also become diminished as a result of the division that has developed between architects, developers, and builders. The complexity of the design and construction industries has necessitated a fragmentation of specialization which has unfortunately reduced the ultimate power and influence that the architect can maintain through a project. Architects have become subordinate to the developer. Instead of playing the role of master builder or planner firmly in control of a project, architects are often being utilized primarily for their artistic input.[9]

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[7] Brand, 54. Architect Peter Calthorpe maintains that many of the follies of his profession would vanish if architects simply decided that what they do is craft instead of art. The distinction is fundamental…
"If a pleasure-giving function predominates, the artifact is called art: if a practical function predominates, it is called craft." Craft is something useful made with artfulness, with close attention to detail. So should buildings be,
Art must be inherently radical, but buildings are inherently conservative. Airt must experiment to do its job. Most experiments fail. Art costs extra, how much extra are you willing to pay to live in a failed experiment? Art flouts convention. Convention became conventional because it works. Aspiring to art means aspiring to a building that almost certainly cannot work, because the old good solutions are thrown away, The roof has a dramatic new look, and it leaks dramatically"

[8] Rybczynski, Witold. *Looking Around* (New York, Viking Press, 1997), 63: Fewer than 5% of buildings are designed by an architect.

[9] Brand, 62. The architect is being marginalized by the pathological fragmentation of the building professions and trades. Is the architect a generalist, a maker of buildings, or a specialist, a mere artist? That question haunts the profession, because students are attracted to architecture as a wondrous calling for great souls guiding huge projects with all-embracing talent and skill. After graduation they encounter a tawdry reality—architect as deskilled and disempowered minor player who is increasingly left out entirely.
A standard commercial building project is set in motion by a speculator (who may not plan to be the landlord) contracting with an architectural office for a building design. The design goes through a gauntlet of permits and emerges distorted, if at all. At this point the work is handed over to a battery of engineers— structural, service, "value," etc.—who have been trained to a completely different discipline than the architect and who are scrupulously shielded from any skill or interest in aesthetic design. Then responsibility shifts to a general contractor, with the architect now reduced to an observational rather than supervisory role. The contractor passes 80 percent of the work to subcontractors.

This fragmentation of roles and specialization further reinforces the trend towards architectural practice that is focus too much on art and not enough on craft.

Another aggravating factor is the financial aspect of buildings as property investments. Buildings are inexorably linked to land, ownership, and investment. Buildings are perceived as usable resources, but are actually investments, used to increase land value. For investments to grow, they need to be stable. This encourages development with predictable outcomes.

Many buildings are built as speculative investments without a known end user. Design for speculative projects where the user has not been defined could be impetus to create flexible designs able to adapt to a wide range of users in. Instead this results in a one-size fits all approach to design the developer determines the use in terms of maximizing investment[10]

The contractual nature of building projects similarly leads to static thinking by architects. Because nearly all projects require detailed plans and specifications to establish an exact scope of work, which serves largely to prevent disagreements and lawsuits, many architects come to conceive of the project as being exactly what is drawn and specified. Many builders and construction managers know that the process is more fluid and conceive of the project in terms of process and sequence. Unfortunately, the standard procedures of

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They are often the ones with the cutting—edge technical skills, but they are too far downstream to affect design. Once the building is finished, it is turned over to facilities managers who will actually run the building. They of course have had no hand in its design. The speculator sells to a landlord, who rents to tenants, whose sole design function is to pay retroactively for the whole mess.
The process has evolved in par to disperse responsibility and foil lawsuits. It fails in that respect too. Lawsuits increase yearly. Sc far, two partial solutions to the fragmentation problem have emerged, one characteristically Japanese, one pragmatically American.

[10] Kronenburg, 17 Instead of being open to being used by whoever has the most need (social or commercial), the type of user is determined by investment potential - typically office, luxury apartment or retail, Programmatic design in speculative development is therefore strictly defined, The design and manufacture of buildings is, of course, associated with needs, aspirations and predictions, but the principal underlying driver is economics; what will prove to be the best financial investment over time.

contractual drawings and construction schedules encourage a process that does not easily accommodate change along the way.[11]

In order to begin a reformation of architecture towards flexible design, we must first recognize the extent to which concepts of permanence and stasis pervade our thinking. Perhaps the crucial notion which will have to be closely scrutinized is that for a building to be good it must be absolutely stable or static. Historically, a building's success has been, at least in part, measured by how well and how long it remained standing under all possible ravages from time and nature. This criterion is erroneous.[12]

The problems that exist in architecture necessitate a change in conception of design as a continual process that is never ending: [13] [14]What is needed is a conversion from an

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[11] Brand, 64. The time to correct mistakes is not available, shout the architects, the contractors, the bankers. and the clients. Right, groans Alexander, and that's why most buildings are crappy. 'There is real misunderstanding about whether buildings are something dynamic or something static. The architect has such a narrow niche. Anything different from the idea that you make a set of drawings and someone else builds the thing is incredibly threatening. People get just absolutely freaked out. I think it's because it raises specters about contracts. Matisse Enzer, a contractor who has worked with Alexander, agrees: Architects think of a building as a complete thing, while builders think of it and know it as a sequence—hole, then foundation, framing, roof, etc. The separation of design from making has resulted in a built environment that has no 'flow' to it—you simply cannot design an improvisation or an adaptation. It's dead.'

[12] Zuk, 10 Basically, a building's success must be judged on how well the form satisfies the set of pressures acting upon it. A form should be stable in relation to the set of pressures—meaning the form should react to the set of pressures establishing an equilibrium; it should not be stable with reference to time. This is not intended to suggest that some structures should not rightfully be static —emotionally it may be necessary to provide some degree of fixity and historical continuity — but it is to suggest that the architectural form must be free to adapt to changes that take place within the set of pressures acting upon it and the technology that provides the tool for interpretation and implementation of these pressures

[13] Frank Duffy hectors his profession: "The reason 1 hate these architectural fleshpots so much is because they represent an aesthetic of timelessness, which is sterile. If you think about what a building actually does, how it is used through time—how it matures, how it takes the knocks, how it develops, and you realize that beauty resides in that process—then you have a different kind of architecture. …The conversion will be difficult because it is fundamental. The transition from image architecture to process' ircIite'tire is a leap from the certainties of controllable things in space to the self- organizing complexities of an endlessly raveling and unraveling skein of relationships over time. Buildings have lives of their own.

[14] Zuk, 9 Undoubtedly, the acceptance of kinetic architecture would force many changes on the traditional practice of architecture and on the way we look at architecture. Design will have to be recognized as a continuous process; it will not stop when the building is erected. It will be necessary to continually monitor the original set of pressures. Only through this process will kinetic architecture be meaningful. Continual change is implicit to the concept of development which suggests that a time-oriented developmental principle of useful life will have to be considered for each generating system within the set. We must be concerned

architecture based on image and static thinking to a more fluid architecture based on a collaborative process that is continually, dynamic, and open-ended. It should include an awareness and receptivity to user input, and recognize that an architect can't, and should not try to, control the user or subsequent use or modification.[15]

Darwin's theory of evolution posits that the survival of an organism or species depends on the ability to adapt to changing environments. The concepts of evolution and adaptability are being adopted by architects and designers to enable an understanding of systems and dynamic functions:

> We know that all living systems exhibit adaptive behavior. That is, they possess an ability to react to their environments in such a way that is favorable, in some sense, to the continued operation of the system. A self-organizing system maintains its existence through a continual interaction with its environment. Changes within the system or in the larger world invoke an automatic response aimed at restoring a favorable balance, or. homeostasis, between internal and external conditions. In a living system, this point of equilibrium will change as the organization of the system evolves.[16]

As with all species, adaptability has been a integral part of human evolution and development.[17]

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about and work toward processes that will permit a better understanding of the set of pressures, and must find techniques that will permit continued evaluation of the pressures and the changes that take place within them. As technology improves, our ability to understand the pressures should also improve. Architectural decisions will have to be based upon increasing quantities of useful information, necessitating systematic studies. "

[15] Brand, 71. Some architects see it coming. Herman Hertzberger, in Holland, writes, "The point, is to arrive at an architecture that, when the users decide to put it to different uses than those originally envisaged by the architect, does not get upset and consequently lose its identity.... Architecture should offer an incentive to its users to influence it wherever possible, not merely to reinforce its identity, but more especially to enhance and affirm the identity of its users."
Sir Richard Rogers affirms, "One of the things which we are searching for is a form of architecture which, unlike classical architecture, is not perfect and finite upon completion.... We are looking for an architecture rather like some music andi poetry which can actually be changed by the users, an architecture of improvisation

[16] Abel, Chris "Evolutionary Planning" *Architectural Design*, December (1998). 563—4.

[17] Kronenburg, 10. Human beings are flexible creatures. We move about at will, manipulate objects and operate in a wide range of environments. There was a time, not too long ago in evolutionary terms, when our existence was based on our capacity for movement and adaptability; indeed it is to this that we owe our survival as a species. Most cultures now lead a more or loss sedentary life, but it could be that flexibility is once again becoming a priority in human development and that technological, social and economic changes are forcing, or at least encouraging, a new form of nomadic existence based on global markets, the world wide web and cheap, fast transportation.

Flexibility is not just about "desire and possibility, but also from economy and necessity."[18] For most of history, human life has been mobile and flexible and so too our buildings. Flexible building are nothing new; in fact, most buildings through time have been highly flexible and adaptable. From simple portable structures like the tipi, yurt, or tent, to mud wall to timber framing, our buildings have adapted with us.[19]

Many examples of flexibility exist in both traditional and modern buildings. Early European tithe barns were simple utilitarian buildings but also served social functions and events. Many Japanese houses still have tatami rooms that serve as highly reconfigurable multifunctional spaces. The 20th century brought the development of a wide spectrum of flexible and portable structures, from the quonset hut to aircraft hangers to mobile homes.[20]

Most modern buildings have at least some basic elements of flexibility. Operable components like windows and doors are by nature reconfigurable.[21]

Portable, mobile, and flexible structures have always existed alongside of architecture-with-a-capital-"A", but have commonly been disregarded as non-architecture:

> Workable flexible architecture can be found in every sphere of human activity — commerce, industry, education, medicine. military and entertainment - but the vast majority of western architecture is static, of single purpose and with standardized furniture and fittings. So why is this? The reason is circumstantial and, it would seem, has more to do with recent economic cultural history than with the character of human personality or the responsive requirements that we can now identify in contemporary architecture. Though building development takes place around an infrastructure that appears to consist of unmoving objects — roads, bridges, and site boundaries — the perception that this is an apparently continuous and unchanging backdrop is untrue.
> Change constantly takes place as economic, social and cultural pressures impact on both building development and infrastructural needs. Society is never static; human civilization has an integral tendency towards change — usually towards progress and improvements in the condition of human existence. Consequently, the impact of this on the built environment is manifest; roads are extended and re-routed; services repaired, improved and reinstated; buildings demolished and rebuilt. The first outward indication of an emerging nation's changing economic status is the erection of buildings, often of some identifiable significant status. Thomas Walter's 1863 Capitol building in

[18] Ibid.
[19] Ibid, 13.
[20] Ibid.
[21] Zuk, 10.

nineteenth-century Washington, USA can be compared to Cesar Pelli's late twentieth-century Petronas Towers (1998) in Kuala Lumpur, Malaysia in this way.[22]

Despite the criticisms of the architecture industry levied herein, numerous architects have been designing adaptable, flexible, and kinetic architecture for decades.

The range of responses and approaches to designing for change is varied and wide. Stewart Brand argues for simple, practical, utilitarian design.[23] Brand stresses the importance of scenario-based planning and post-occupancy evaluation. Robert Kronenburg's series of books, including Portable Architecture and Flexible: Architecture that responds to change, have studied and advocate for mobile, flexible, and reconfigurable designs. In Kinetic Architecture, Zuk and Clark espouse specifically kinetic buildings that physically move and change shape. Recent works, such as iA: Interactive Architecture, a

[22] Kronenburg, 16.

[23] Brand, 186. Most design in the real world is guided by rules of thumb. What might be the rules of thumb for strategic building designers? Some can be borrowed directly from chess players: "Favor moves that increase options: shy from moves that end well but require cutting off choices; work from strong positions that have many adjoining strong positions.'" More specific to buildings: overbuild structure so that heavier floor loads or extra stories can be handled later; provide excess services capacity: go for oversize ("loose fit") rather than undersize. Separate high- and low-volatility areas and design them differently. Work with shapes and materials that can grow easily, both interior and exterior. "Use materials from near at hand," advises Massachusetts builder John Abrarns. "They'll be easier to match or replace." A spatially diverse building is easier to make use adjustments in than a spatially monotonous one—people can just move around. Medium-small rooms accommodate the widest range of uses. When in doubt, add storage. Add nearby storage—closets, cabinets, shelving; and deep storage—attics, basements, unfinished rooms without windows. What begins as storage can always become something else, and if it doesn't, there's never enough storage anyway. Shun designing tightly around anticipated technology. As energy analyst John Holgren says to all futurists, "We overestimate technology in the short run and underestimate it in the long run." So design loose and generic around high tech. You will be wrong about what is coming, and whatever does come will soon change anyway.

It wouldn't take much adjustment to unleash the full ingenuity of architects on the juicy problems of designing for time. They could supplement the dutiful process of programming with the enjoyable practice of scenario planning. They could do more post-occupancy evaluation, particularly of their own buildings, but also of existing buildings that relate to new projects. They could seek the stability of ongoing relationships with clients instead of the all-at-once, do-or-die, design-crisis approach now employed. They could seek new ways to employ time as a tool in building design and use. "Time," wrote Francis Bacon in 1625, "is the greatest innovator."

bookzine edited by Kas Oosterhuis[24], take kinetic architecture to another level by exploring responsive and interactive architecture.

Many modernist architects promoted flexibility. LeCobusier's Une Petite Maison (1923-4, Lake Geneva, Switzerland), Eileen Gray's E-1027 (1926-9 Roquebrun-Cap Martin, France), and Jan Brinkman's and Cornelius van der Vlugt's Van der Leeuw House (1928-9, Rotterdam)all incorporated elements of flexibility and adaptability. [25]

The Une Petit Maison used gridded, folding and sliding screens to create a temporary guest area, and an extending dining room table to accommodate extra diners.[26]

E-1027 featured a variety of built-in but flexible components that blurred the line between building and furniture. Desks, tables, chairs, and cabinets were designed to slide out from walls and various surfaces, and to fold and retract when not in use. The center area of the house was a large open floor plan multi-function space with a series a smaller accessory rooms immediately adjacent, in what is now referred to as a cave-and-commons approach.[27]

The Van der Leeuw House had large glass wall sections that rolled up and out of the way and a retractable glass solarium roof. This house was one of the earliest designs to feature active electrically controlled components such as fans, sink faucets, light fixtures, and remote-controlled curtains.[28]

The Rietveld Schroder House stands-out as an example of flexible design in early modernist architecture. Designed in 1924 by Dutch architect Gerrit Rietveld for Truus Schröder-Schräder, a progressive artist and mother of three, the house featured an open-

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[24] Oosterhuis, Kas iA Interactive Architecture vol 1. (Rotterdam, Episode Publishers, 2007)
[25] Kronenburg, 25.
[26] Ibid, 26.
[27] Ibid.
[28] Ibid.

floor plan that could serve a variety of functions. Rietveld designed the house with large open spaces that could be divided by means of sliding and revolving partition panels. [29]

The use of movable partitions for creating flexible space has now become commonplace, particularly in commercial office spaces; a host of manufacturers now market products specifically for this purpose.

The decades following World War II saw an increase in interest in flexible and reconfigurable architecture.

Cedric Price was one of the primary developers of more actively reconfigurable and highly flexible architecture Although he built very little, his approach to architecture and to time-based urban interventions was majorly influential to later work by Archigram, Rem Koolhaas, and Rachel Whiteread, as well as Renzo Piano &Richard Roger's Pompidou Center in Paris. One of Price's most well-known projects was the Fun Palace. Produced in collaboration with Joan Littlewood, a London theater director, the idea was to build a 'laboratory of fun' with facilities for dancing, music, drama and fireworks. Central to Price's project was the belief that through the use of new technology the public could have unprecedented control over their environment, resulting in a building which could be responsive to the user's needs.[30]

Using an unenclosed steel structure serviced by travelling gantry cranes, the building was comprised of a kit of parts: pre-fabricated walls, platforms, floors, stairs, and ceiling modules that could be moved and assembled by the cranes. Virtually every part of the structure was variable. "Its form and structure, resembling a large shipyard in which

[29] Ibid, 27
[30] Ibid, 60.

enclosures such as theatres, cinemas, restaurants, workshops, rally areas, can be assembled, moved, re-arranged and scrapped continuously".[31]

Archigram continued the exploration of many of Price's concept in their projects, particularly the Plug-In City. The Plug-in city theorized a sprawling network of structural tubes or "silos" to which were attached numerous modular components or "capsules." The capsules could travel along the silos and be relocated at will by means of a series of cog rails, elevators , and large gantry cranes. The silos also housed flexible mechanical connections that could be detached and reattached as needed.[32]

As with most of Archigram's work, the project was hypothetical and was intended to promote a re-visioning of urban environments:

> On a human scale, the Plug-In city represents possibilities and a return of civilized culture to a nomadic population, with the abilities and desires to move in short periods of time. It will turn into a mobile and well-connected culture, a population accustomed to following jobs and other resources as they move. The obstacles of relocation will be significantly reduced, and jobs, houses, and lives will become semi-permanent and more worldly.
>
> This society built upon temporary elements would ironically become more permanent. The adaptability of the small details to a gradually changing civilization would keep society alive, revisable, and workable, reducing the need for mass reconstruction. The ever-moving and ever-changing elements of the design would create a large-scale level of solidity and stability that the world has not yet experienced.
>
> These semi-nomadic people, with their travelling shops and homes, would be part of a megastructure of resources, just as earlier civilizations built around their resources. This is just an expansion upward and outward of the resources. This level of connectivity via resources is a permanent house for impermanent objects.
>
> This megastructure is meant to infiltrate the city as already built, using paths made by roads for cranes and expanding on infrastructure that already exists. this megastructure could penetrate city boundaries and connect entire countries. Might we see entire countries covered in a mega-grid of power, water, and transportation (both the transportation of capsules and of people)?

> The Plug-In City would serve as a physical representation of mobility and adaptability while also promoting a unity and connection that modern society has yet to see. We are exchanging information faster and further than ever before, and the Plug-In City would help to turn this virtual exchange into something tangible - the efficient and easy exchange of physical objects and space, and the direct sharing of physical resources over the vastest expanses.[33]

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[31] Ibid.
[32] Cook, Peter *Archigram* (Boston, Basel, Switzerland, 1972,1990), 10
[33] Ibid, 12.

Cedric Price and Archigram are just two examples from a group of architects from their era whose work became known the Megastructure style. While many of the designs by the Megastructuralists showed great promise for their use of flexible and adaptable elements, the effectiveness of the approach suffered in part due to the grandiose, utopian visions that they presented. Many of the advantages of re-configurability and adaptability were lost on the wider public because of the enormous scale and the fantastic, sci-fi nature of the projects. Very few of the well-known Megastructuralist projects were ever built, mainly because most were highly theoretical and not feasible to construct.

A similar style that was contemporary to the Megastructure movement was the Metabolist movement. Driven primarily by the work of several Japanese architects including Kenzo Tange, Kisho Kurokawa, and Kiyonori Kikutake, the Metabolists explored design that used an approach similar to that of the Megastructuralists: large scale urban revision by means of sprawling infrastructure to support flexible and reconfigurable modular components. While many of the Metabolist's designs were just as fantastical as the Megastructuralists, due to Japan's rampant economic growth during the 1960's and '70's, several of the Metabolist designs were actually constructed. One notable example is the Nakagin Capsule Tower, designed by Kisho Kurokawa (1972,Tokyo). The building utilized the "plug-in" concept promoted by Archigram, with a series of individual capsules that fit into a larger underlying structural framework.[34]

By the early 1980's, flexibility, adaptability, and kinetic architecture had fallen out of vogue. While many of the practitioners of the Megastructure and Metabolist approaches continued to explore their ideas, their technologically driven, futurist visions no longer

[34] Kronengurg, 42.

grabbed center stage in architecture media. But many of the concepts of flexibility, adaptability, re-configurability, and kinetic and interactive architecture have gained renewed interest in the past ten to fifteen years.

The Suitcase House Hotel (2002, Beijing), designed by Gary Chang of EDGE Design in Hong Kong, utilizes a simple, basic flexibility similar to that of the Rietveld Schroder house and E-1027. The Suitcase House features one main open floor plan that serves as a multi-function living area. The specific program areas such as kitchen, bedrooms, and bathroom are housed in compartments below the main floor level. The accessories are hidden away until needed, at which time they can be accessed by trap doors in the floor. As the trap door folds up, it becomes a wall partition thus creating a privacy barrier.[35]

Many of the innovations in the realm of kinetic architecture have been developed by the entertainment and sport industry.

The sports stadium has been a building form that has pushed the boundaries of large-scale kinetic re-configurability. Hybrid indoor-outdoor stadiums are among the largest and most expensive buildings projects in history.

In addition to serving multiple sports functions, most stadiums also host concerts and conventions. The sports functions are best served by open-air environments and natural turf playing surfaces, but benefit from protection from the elements in the even of unfavorable weather. Most concerts also benefit from the option of being outdoor or indoor depending on the weather, while conventions are generally only indoor events.[36]

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[35] www.edge.hk.com
[36] Kronenburg, 80.

Many of these modern stadiums have featured retractable roofs. The Toronto SkyDome (1989, Toronto), designed by a team of architects and engineers led by architect Rod Robbie and engineer Mike Allan, was one of the first examples of a large scale operable roof systems. The roof consists of three segments than slide and rotate into a stack at one of the building. The roof spans 673 feet at the widest point, and reaches a height of 284 feet at the zenith and takes 20 minutes to change positions. When fully retracted, 90 percent of the seats, and 7.9 acres of space are open to the sky.[37]

The Allianz-Ganz Arena designed by Herzong and De Meuron (2005, Munich) incorporates a responsive aspect of a very different nature. The face of the building is composed of flexible plastic membrane panels fit into a clamping grid of rubber tubes that allow the plastic membrane to continually expand and flex as environmental conditions change. Additionally, each panel is fitted with a series of colored LED lights that are computer controlled. The panels can be made to change color. The original intent was to color the panels depending on which of the two local soccer clubs was playing. Given the nature of the LED lightings system, the façade can be programmed to display an infinite variety of patterns or messages.[38]

Technological advances in the areas of computer-aided design, computer actuated manufacturing, computer controlled components, and robotics are helping to drive further advances in kinetic and interactive architecture.

The Dutch architect Kas Oosterhuis has been at the forefront of interactive architecture. Oosterhuis has published numerous articles on the books on the subject of interactive architecture and designed several projects that pushed the boundaries of

[37] Ibid, 81.
[38] Ibid, 162.

possibility of interactive space. While many of his design projects have been purely hypothetical, Oosterhuis has actually built several groundbreaking prototypes of interactive and kinetic systems. The Muscle Body project is an architectural body that consists of a continuous flexible skin that responds to various inputs including the number of occupants and their location and movement in the space. The structure responds by changing shape, transparency, and by emitting various sounds. The Muscle Body is constructed with a skin made out of lycra, a stretchable fabric commonly used in sporting equipment. The skin is attached to a series of 26 spiralling tubes made out of flexible pex piping, a product normally used for water piping. The tubing, activated by computer controlled components, acts as a muscle to move and stretch the skin in reaction to the various inputs.[39]

Another prominent architect in the area of interactive architecture in Usman Haque, a Malaysian-British architect and professor of architecture at the Bartlet School of Architecture, London. Haque has created numerous art installations and building projects that explore responsive and interactive design principles. Haque's Reconfigurable House project was an installation at the Intercommunication Center in Tokyo that explored interactivity with "smart" buildings components. The Reconfigurable House was constructed from thousands of low tech electronic components that can be continually reconfigured by the user by means of sensors and actuators that can be controlled via a computer interface. The project sought to challenge commonplace conceptions of smart buildings: "Smart homes actually aren't very smart simply because they are pre-wired according to algorithms and decisions made by designers of the systems, rather than the people who occupy the houses."[40] In contrast to typical smart homes which are incapable of

[39] Oosterhuis, 16
[40] www.haque.co.uk

structural change overtime, the Reconfigurable House can continually adapt both shape and function according to the users needs.[41]

Beyond the many flexible buildings that are now being generated, the area with perhaps the greatest potential lies in developing a flexible and adaptable means of practice. Continual developments in virtual reality, holography, and rapid prototyping are allowing architects, designers, and engineers to practice in an increasingly real-time method. Photogrammetry and 3d scanning technologies allow designers to quickly generate highly accurate 3d models of existing physical environments. Three-dimensional modeling software is becoming increasingly sophisticated while also becoming more user-friendly; programs such as Rhino and Google Sketchup allow people to quickly create 3-d models with incredible speed, accuracy, and photorealistic detail. Other software products such as Autodesk 3ds Max, Viz, and Maya harness animation functions originally intended for video game production to study kinematic actions and time based response of designs. Virtual reality environments and holographic projection are allowing designers and users to experience and test products and buildings before physically producing them. Laser cutters and three-dimensional printers now allow designers to quickly and accurately create physical prototypes of even the most irregular forms. The capabilities inherent to CAD/CAM technology and the interface with computer numerically controlled (CNC) manufacturing equipment allow architects and builders to achieve new efficiency in producing customized, irregular forms and building components that would previously have been impossible or too costly to produce. With further integration of these existing technology there is potential for developing highly flexible and interactive methods of design. This can potentially include the user to a much greater extent in both the design

[41] www.interactivearchitecture.org

phase and later in post-production reconfiguration of products and space by better enabling the user to visually and experience design options.

The field of architecture is broad and extremely diverse. While much of the industry is hampered by the dysfunction outlined in the first portion of this paper, there are many architects, engineers, and designers who are exploring the areas of adaptability, flexibility, responsiveness, and interactivity. The important lesson to be learned is that we need architects and designers to think and conceive of architecture and construction not as static object based design produced by the vision of a singular omniscient designer, but instead as a continually dynamic, process-oriented, collaboration between a group of people including both designers and users.

CHAPTER 3

SITE SELECTION AND ANALYSIS

The project site was selected from several sites along the Artery Strip in Boston that were initially suggested by the studio professor during the fall semester. The selected site is located on Cross Street in Boston, MA between Hanover Street and Salem Street.

The Artery Strip is an area of Boston that simultaneously presents great challenges and potentials. The area had until recently been dominated by the elevated portion of Interstate 93 which has now been rebuilt underground in the massive infrastructure project known as the Big Dig. The removal of the above ground portion of the highway in this area has left a vast expanse of open land in the heart of the extremely densely built downtown Boston. The highway had previously created a significant physical separation between the Financial District to the south which is replete with modern 20th C high rise office buildings, and the North End which consists primarily of 3 to 5 story masonry buildings of 19th and early 20th C era construction. The drastic dichotomy between the two districts is glaringly apparent from all points along the Artery strip.

Despite the fact that the majority of the vehicular traffic in this area is now below ground on Rt. 93, Cross Street is still a highly trafficked thoroughfare, with an average of several thousand cars per hour during most of the daylight hours. Given the proximity to highly frequented landmarks such as the Haymarket, City Hall Plaza, Fanueil Hall, and countless mercantile establishments in the North End, the site also receives steady pedestrian traffic for most of the day.

The majority of the area of the site is currently used as short term parking that is easily accessible from Cross Street. If at all possible, the project should incorporate or maintain on-site parking as this is a scarce resource in the congested downtown area.

Though many high rise buildings are located nearby to the south of the site, the breadth of the open space left by the removal of the elevated highway combined with the southwest orientation of the primary edge of the site gives the building site excellent solar exposure; solar gain should be considered a major factor here for energy production via photovoltaic panels, passive soar heating, and daylighting, as well as an issue of excessive heat gain during summer months which will need to addressed with appropriate shading and cooling elements. The open nature of the of the site and the relative proximity to the waterfront and ocean winds make the site highly wind swept. While the wind has the potential to be harnessed for energy, the proximity of the high-rise buildings can create severe turbulence, which can be challenging for effective turbine design. Additionally, the dense urban environment make the noise production factor of most wind turbines not acceptable. This site would require specific low-sound emitting turbine if wind power is to be incorporated in the design.

CHAPTER 4

PRECEDENT STUDIES

The precedent studies undertaken for in this studio, and for this project, differed slightly from the normal analysis of existing buildings types that has been typical of past master's thesis projects. Instead, the precedent research focused on exploring new methods of design and planning, specifically information based, data-driven, and parametric design processes.

The following excerpts represent the bulk of the precedent concepts studied for this project.

Data driven forms: data-driven forms are the result of deriving forms from fields of found data. As spatial models, the forms explore two concepts: the delamination of passage from one data set to another and arbitrary cross-fade (between data sets). An algorithmic function extracts from linked Web pages as two sets of points in the three dimensional matrix. Using spline-based interpolation, two sets of curves are generated. From further functions, the two sets of intertwined surfaces, or "lamina", are formed. A series of crossing links (cross-fades) are then framed between the conjoined surface-forms, producing a rich enmeshing of distorted frames and surface modulations[42]

Cartographies: 'To represent a reality is to begin to transform it.' Jose Antonio Sosa, paraphrasing Deleuze, suggested that "each system of representation should be assigned a different capacity for organizing the world."[43]

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[42] Gausa, Manuel, et al *The Metapolis Dictionary of Architecture*, (Barcelona, Ingoprint, 2003) 149

[43] Ibid 102

Machinic phylum: Gilles Deleuze and Felix Guattari have suggested that [the] abstract reservoir of machinelike solutions common to physical systems as clouds, flames, rivers, and even phylogenic lineages of living creatures to be called the "machinic phylum"—a term that would indicate how nonlinear flows of matter and energy spontaneously generate machinelike assemblages when internal or external pressures reach a critical level, which only a few abstract mechanisms can account for. In short, there is a single machinic phylum for all the different living and nonliving phylogenetic lineages.

The "machinic phylum" of Deleuze and Guattari describes the same non-nested hierarchy as the continuum theorized by the engineer s Robert Le Ricolais. Le Ricolais suggests that matter, material, constructional systems, structural configurations, space, and place comprise a continuous spectrum rather than isolated domains. Such an understanding provides a model for organizing forces and their effects that is communicative, reverberating across scales and regimes?

Le Ricolais's studies of column failure are a specific instance of this model in operation. Transcending the purely geometric nature of a structure, Le Ricolais is interested in the new geometries that arise as a consequence of the column's deformation on the way to failure. Thus, material behavior takes an active role in the genes new structural forms. Moreover, the forces that act on the component. model behave diagrammatically, in that they can be rescaled to that of an entire tower.

Like the relationship between intensive and extensive logics, or the relationship between matter force logics and codification systems, architects are inevitably implicated in

the tension between the generative and limiting poles of both. The potentials that flow off of this tension inevitably find their expression within multiple levels, from the non-human stuff of construction to the character of a building's occupation.[44]

For image, refer to Atlas of Novel Tectonics,
by Reiser and Umemoto, pg 111

Figure 1 - Le Ricolai's automorphic tubes

[44] Reiser, Umemoto. *The Atlas of Novel Tectonics*(New York, Princeton Architectural Press, 2006) 111-113

Coilings: braids, contortionisms, bends and (un)bendings, strategy, geometry, fold, fold (unfold-refold), topological and trajectory.[45]

Interdisciplinary exchange: Science is not always the source of trans-disciplinary exchanges, sometimes there is a flip. Henri Bergson's work in philosophy, for instance, prefigures Bernhard Riemann's work in mathematics. Theoretical physicist Lee Smolin gives the example that solving the structure of amorphic geodesic pool covers led him to tensor calculus, and then into the physics of gravity. Tensegrity structures are now serving as the model for cell membranes themselves. Our modes of thought in architecture might indeed influence the way of understanding the universal.

This opens a tremendous opportunity for growth within the discipline of architecture. Architecture will always be a defective representation of other disciplines, hence the exhaustion of architecture that based itself, for example, on cinema and literature. But there are models that exist that are as useful to the film director in the discipline of film-making as to the architect in the discipline of architecture.

This suggests that the same conceptual models can migrate bet disciplines, where they are instantiated within the conditions and limits inherent in those disciplines.[46]

Poise in an allied discipline: The desire for a pure structural skin, an optimal condition for aircraft, becomes a limiting factor for architecture. Where the contradictions of structure and skin are resolved too smoothly they lose architectural potential. In aviation

[45] Gausa 114
[46] Reiser 126

technology; geodetics geometrically and structurally registers the transition from a skeleton model, derived from the technology of boat-building, to a pure structural skin model While the ultimate resolution of this technologically is monocoque construction, we find that the geodetic moment displays greater capacity for structural variation and adaptability. The monocoque shell skin, in contrast, optimizes toward a single function—structural economy.[47]

New possibilities for spatial structures: the case of geodesics/geodetics: The current discussion regarding the tactics of achieving forms and programmatic heterogeneity in the realm of architecture and planning has occasioned a reassessment of spatial models and technologies heretofore relegated to the scrapheap of utopian modernism. Such modernist systems have come to be associated with the structures of a totalizing spatial ideology and an attempt to produce homogeneous and unified architectural languages.

With the advent of new models for organization, changed conceptions of geometry and geometry's relation to matter, and new conceptions of universal space, a thoroughgoing reevaluation of the modernist models for structuring space and the execution and delivery of such systems is possible. Non-repetitive tiling, fractal geometries, branching systems, and unstructured grids are among the new geometries available for use.

The geometric and structural system known as geodetics is one such direction we have explored. Popularized by R. Buckminster Fuller and his followers as an architectural and urbanistic panacea, it is presently encountered in the occasional fairground structure or military installation, usually in the form of a dome. Fuller's geodetics have become detached from their utopian projections, but this history has unfortunately obscured a prior

[47] Ibid 98

and, ironically, more open set of possibilities in the field of descriptive morphology an aeronautics.[48]

Adaptation: the flexible capacity of fitting and/or moulding a conceptual, abstract, strategy to specific, concrete, conditions[49]

Activity: a dynamic architecture is vitalizing: it generates not only aesthetics – or shape – but also (above all) activity (not merely functional action), but as active materialization of simultaneous actions and uses – as operative movements, generators of interchange operations between programmes, shapes, assiduous spaces, and events.

It is an architecture capable of favouring spaces that are more "unsettled", precisely by virtues of being active and activated: produced with a reactive (reactivating), flexible, plural and relational will, catalysts of possible (inter)actions between space(s), culture(s), information(s), and behaviours.[50]

Evolutionary: systems, actions, or processes capable of evolving are evolutionary. that is to say, the evolutionary is capable of growing and developing, mutating and transforming, altering, varying, deforming, and/or being influenced through codes or generic internal basic rules, precise and flexible, at once determinate and indeterminate, and through bits of specific external information, fortuitous and contingent, at once foreseen and unforeseen.[51]

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[48] Ibid 132
[49] Gausa 32
[50] Ibid
[51] Ibid 206

Body-space as dynamic continuum: Having once begun to architect their surroundings, human beings never stop. A person turns a desert or a forest into an architectural surround by how she moves through it. Advancing and cutting paths, fending for herself and defending herself, she uses her limbs to erect enclosures or break them. That which has been architected blocks, guides, facilitates, comforts, contains, or suggests containing.

An architecturally imbued person will architect every manner of surroundings. An architecturally imbued person will architect every manner of surroundings, even a vast open plain. Any architectural surround she once experienced can become a four-dimensional point of reference for a person standing on an open plain.

Organisms that person need to construct their hypotheses and enter them, surrounding themselves with ordered presentations of their suppositions. Our claim: architecture can help a person figure herself out.

Environment-organism-person is all that is the case. Isolating persons from their architectural surrounds leads to a dualism no less pernicious than that of mind and body.[52]

In addition to these text based precedents, visual methods were studied, specifically visualization of proteins, vascular networks, and various biological systems. The following images are excerpted from these visual studies:

[52] Gins, Madeline Architectural body (Tuscaloosa, AL, University of Alabama Press, 2002) 42

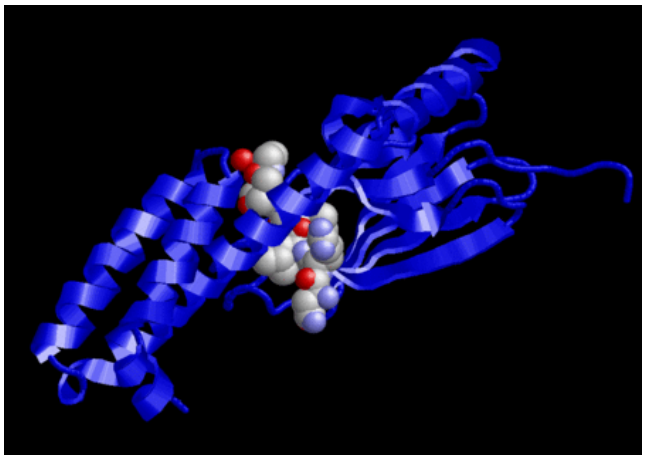
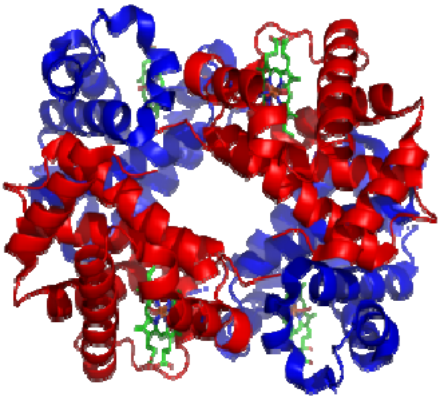


Figure 2 – Visualization of Coiling Protein Structures



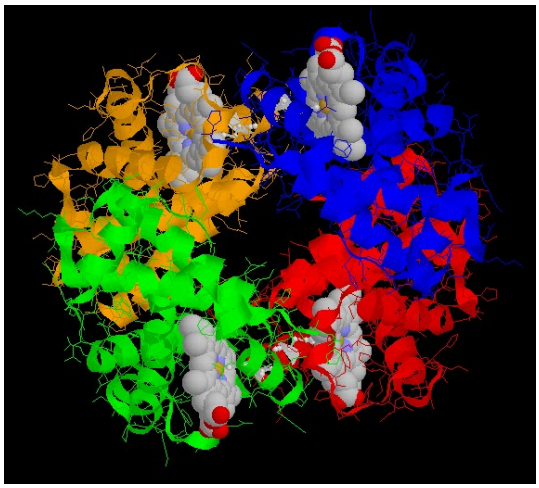


Figure 3 - Coiling protein structures

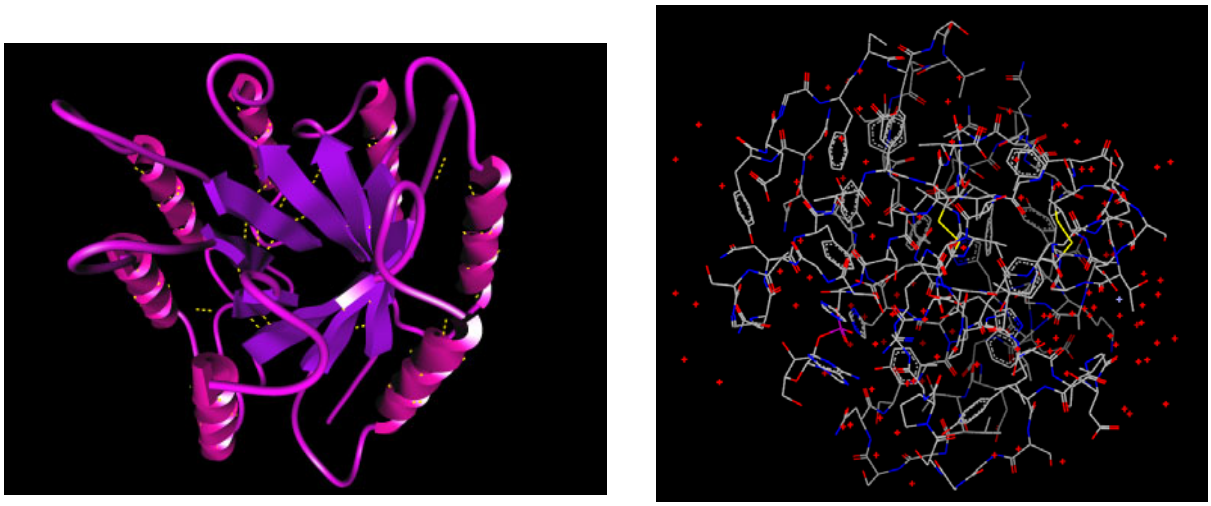


Figure 4 – Protein Structures

CHAPTER 5

PROGRAM

The design project is an approximately 35,000 sf building titled The Motus Center for Kinetic Art Science. The building serves both as an actively used gymnasium and movement studio as well as an interactive museum and gallery of kinetic arts and sciences.

The building is comprised of the following spaces:

Table 1 Program

Space	Level	Square Footage	
Office 1	1	250	sf
Office 2	1	250	sf
Office 3	1	250	sf
Physio therapy clinic	1	1000	sf
Café	1	1500	sf
Mechanical	1	250	sf
Gallery	1	2500	sf
Storage	1	500	sf
Men's Bathrm	1	250	sf
Women's Bathrm	1	250	sf
Jungle gym	1 to 3	5000	sf
Design Lab	2	1000	sf
Movement studio 1	2	2500	sf
Movement studio 2	2	2500	sf
Movement studio 3	2	2500	sf
Exterior courtyard	2	1500	sf
Exterior roof park	2	1500	sf
Men's Bathrm	2	250	sf
Women's Bathrm	2	250	sf
Vertical circulation 1	1 to 3	250	sf per floor
Vertical circulation 2	1 to 3	250	sf per floor
Vertical circulation 3	1 to 3	250	sf per floor
Vertical circulation 4	1 to 3	250	sf per floor
Movement studio 4		2500	
Conference room	3	2000	
Performance space	3	3500	
Virtual training center	3	1500	
Men's Bathrm	3	250	
Women's Bathrm	3	250	
Total		35000	

CHAPTER 6

DESIGN PROCESS AND CONSIDERATIONS

The design process began with the development of an information based ideogram developed from social mapping data gathered from site information sources. Mapping information was drawn from sources such as Census Bureau maps, Google Earth maps, and Virtual Earth maps of relevant social metrics such as languages spoken in the area, income levels, areas of environmental concern, locations and types of businesses, use groups, and zoning. These maps were used to generate data clouds which were then compiled into a three-dimensional spatial ideogram in Rhino.

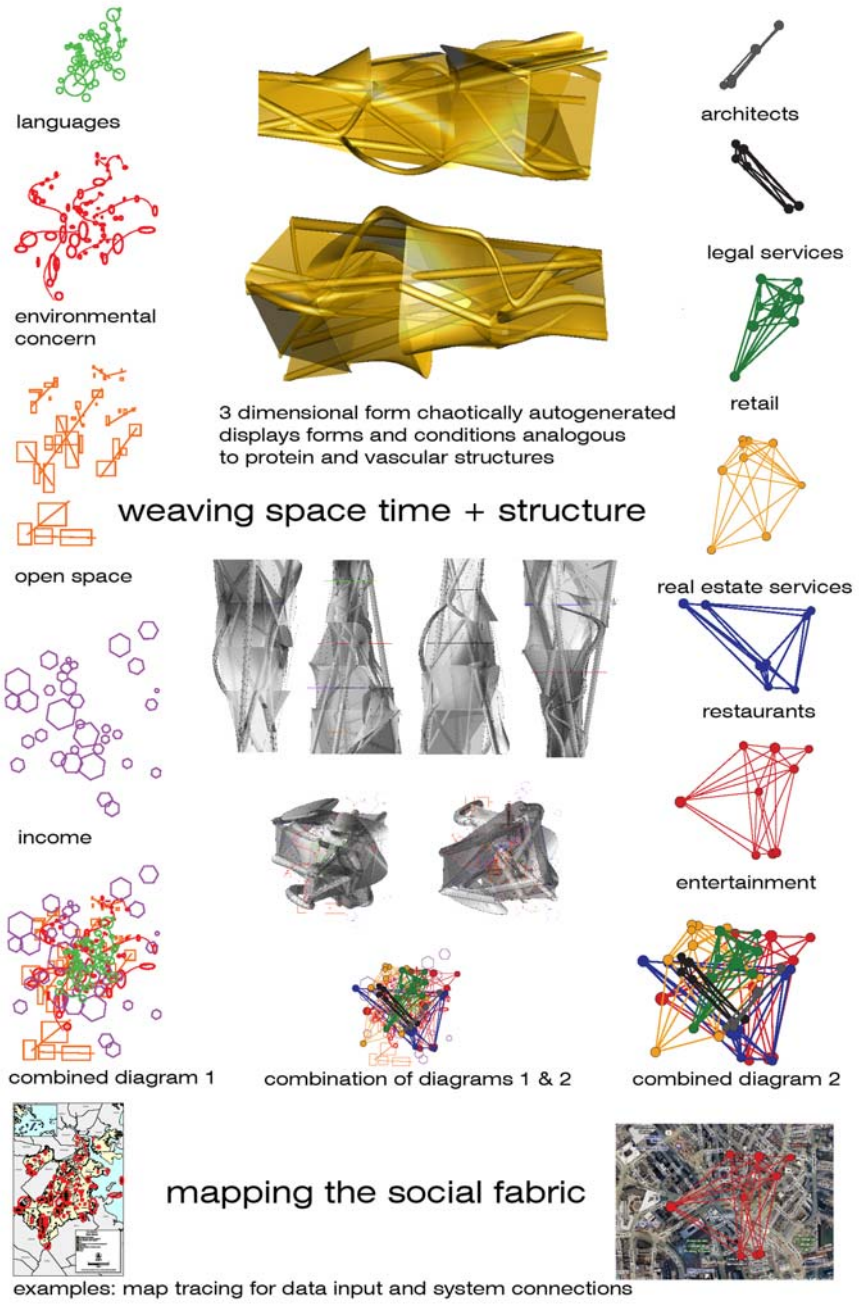


Figure 5 – Diagramming process

The form generated in this process led to the research and study of the protein structures as outlined in the previous section.

The application and utility of this diagram was then explored using a series of pictographic studies of the site to analyze areas for potential infill that would have minimal impact on the surrounding buildings in terms of pedestrian access, views, sunlight, and air passage and how the diagram might be incorporated in these areas.

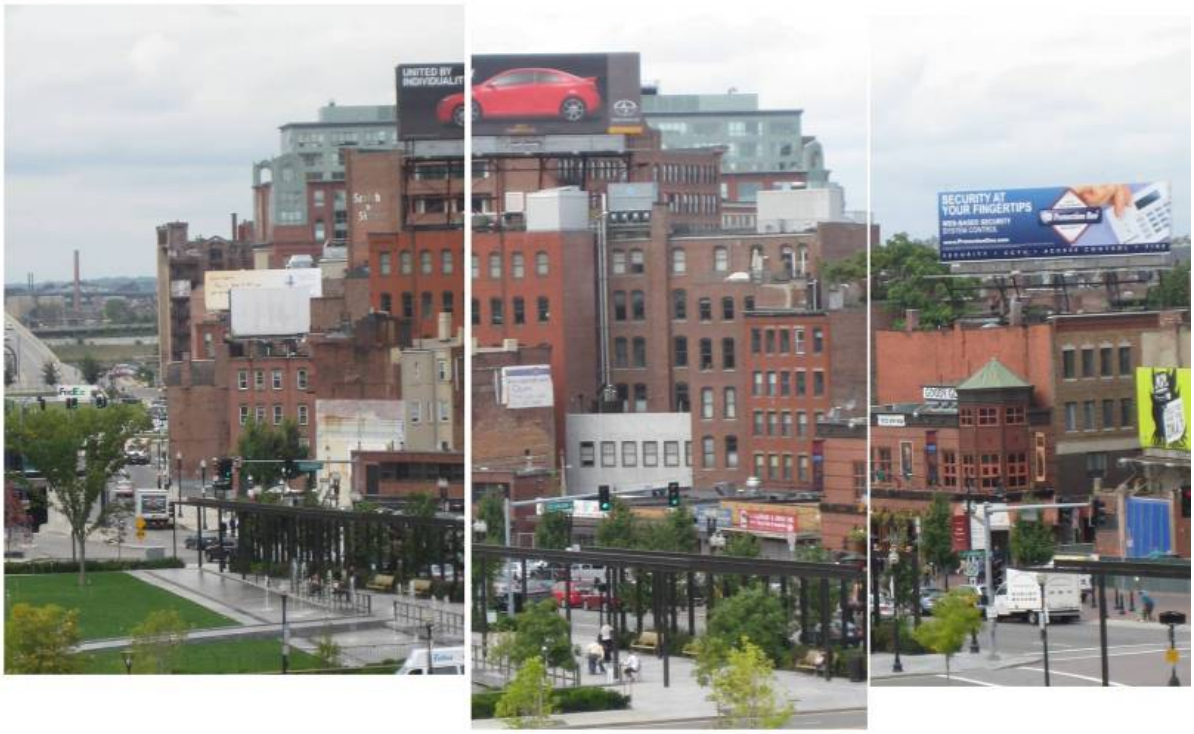


Figure 6 – Panorama of building site

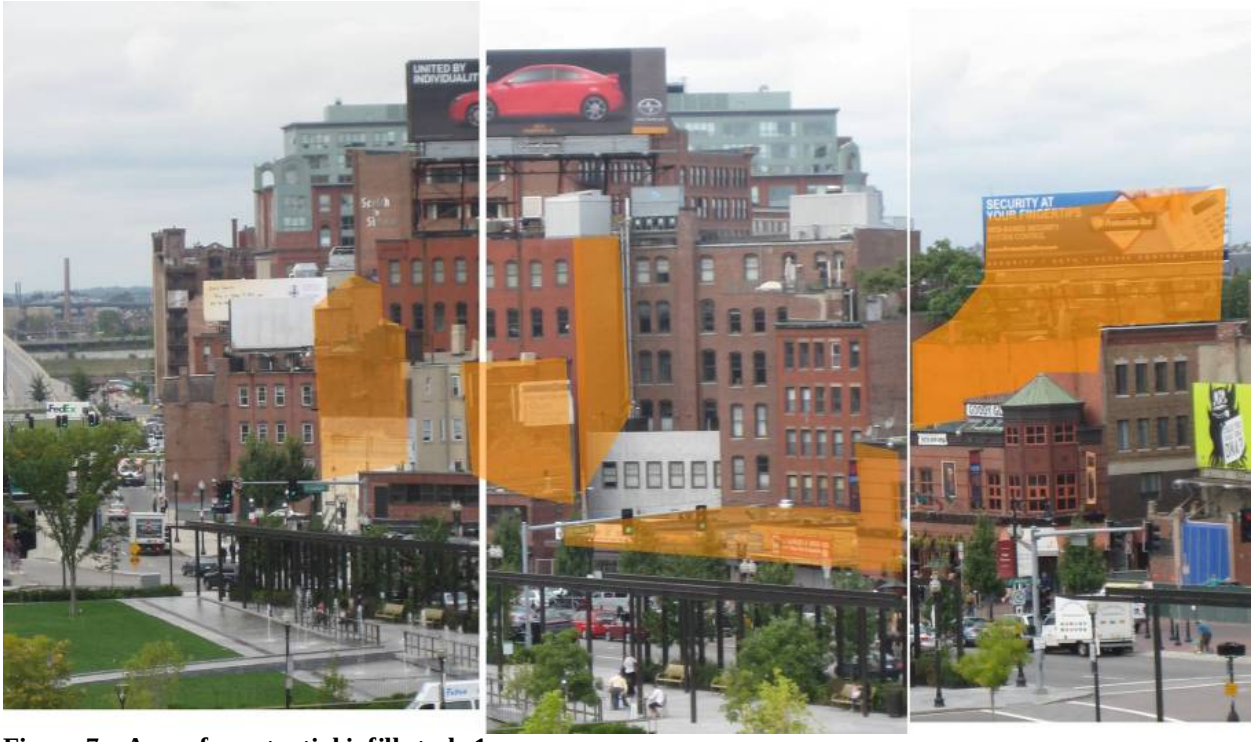


Figure 7 – Areas for potential infill study 1

Figure 8 – Infill areas with diagram applied

From these analytical studies, preliminary massing studies were developed that attempted to incorporate the findings of the infill potential and the concept of coiling structures as studied in the protein visualizations.

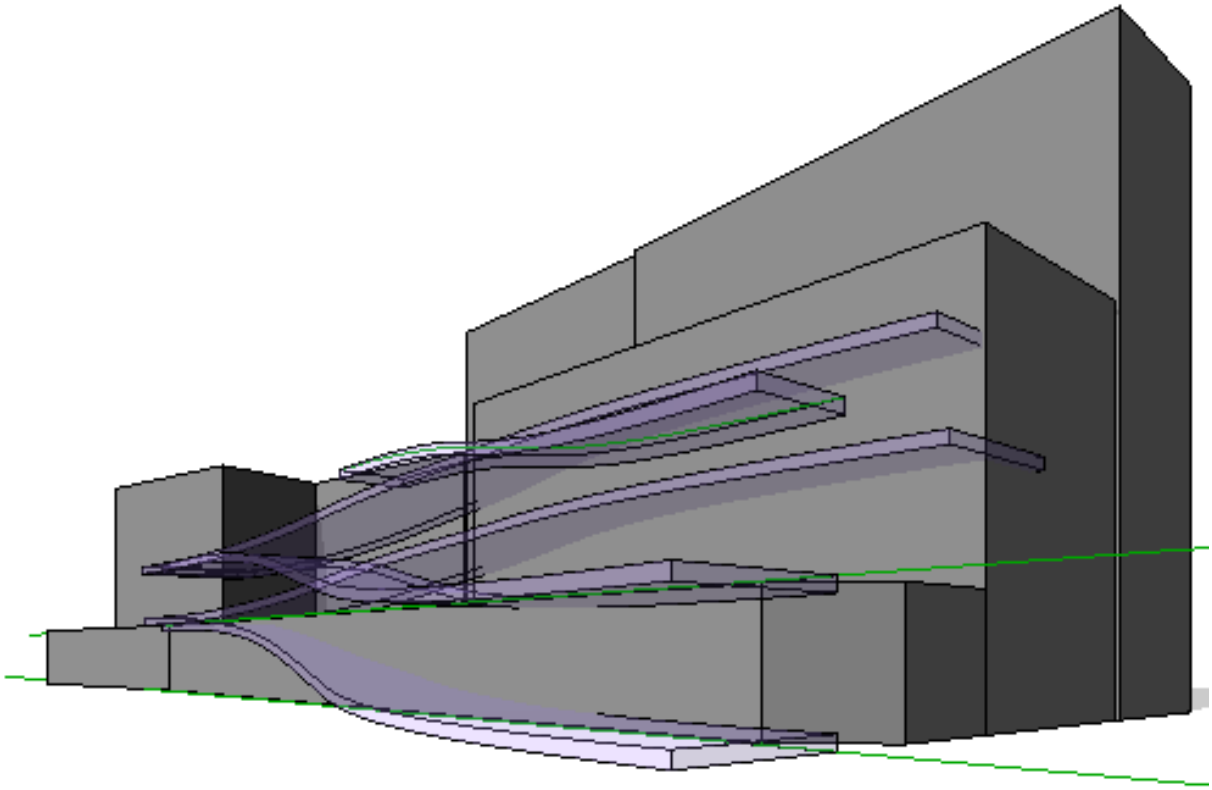


Figure 9 – Preliminary massing study 1

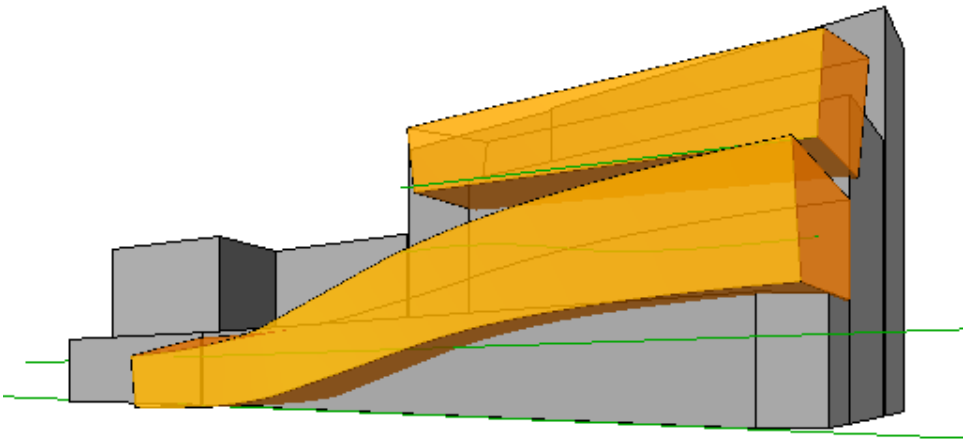


Figure 10 – Preliminary massing study 2

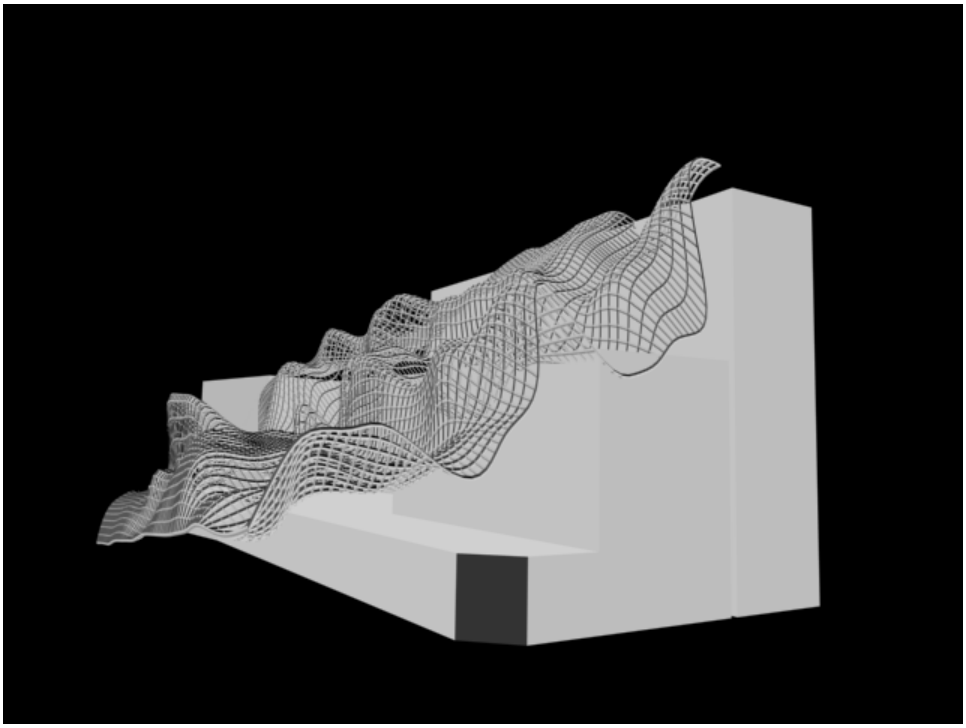


Figure 11 – Form generated from bitmap image of site

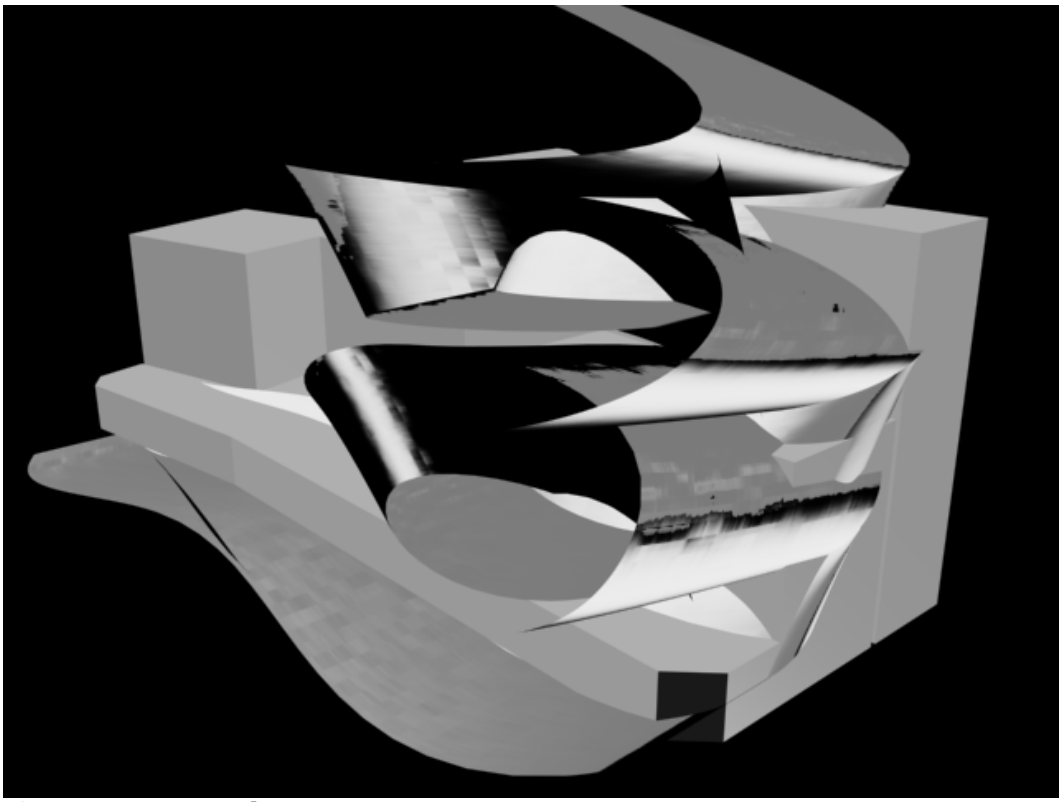


Figure 12 – Form study 2

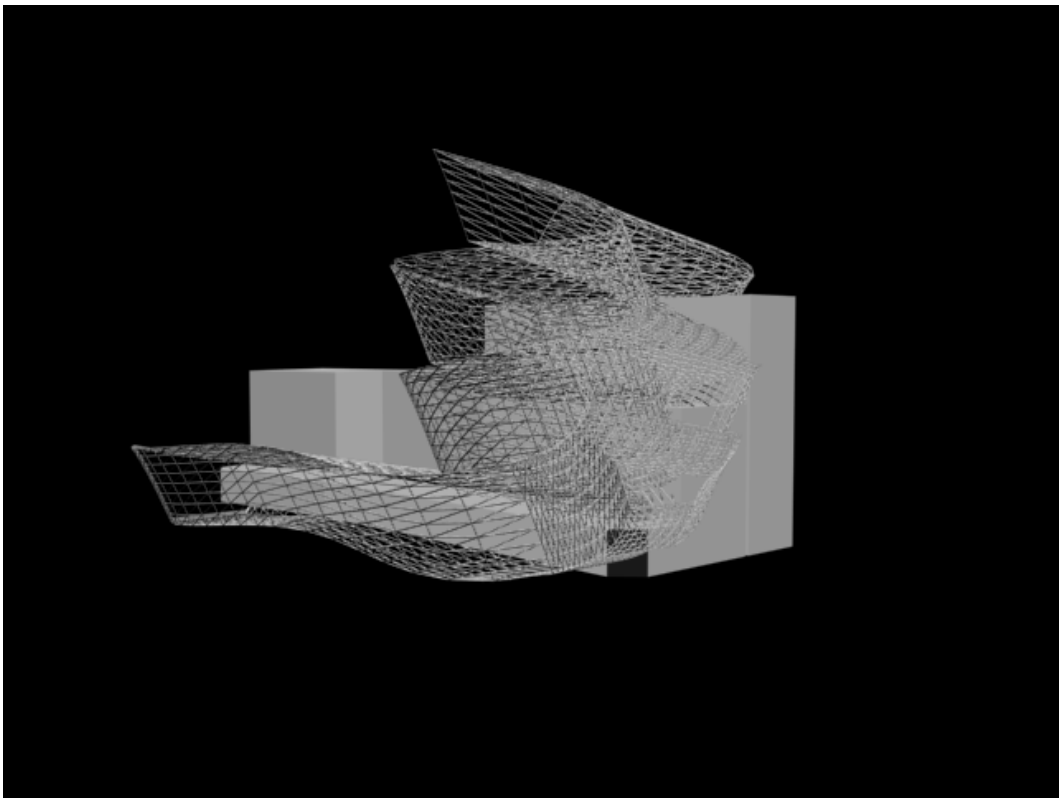


Figure 13 – Form study 2 with geodesic structure

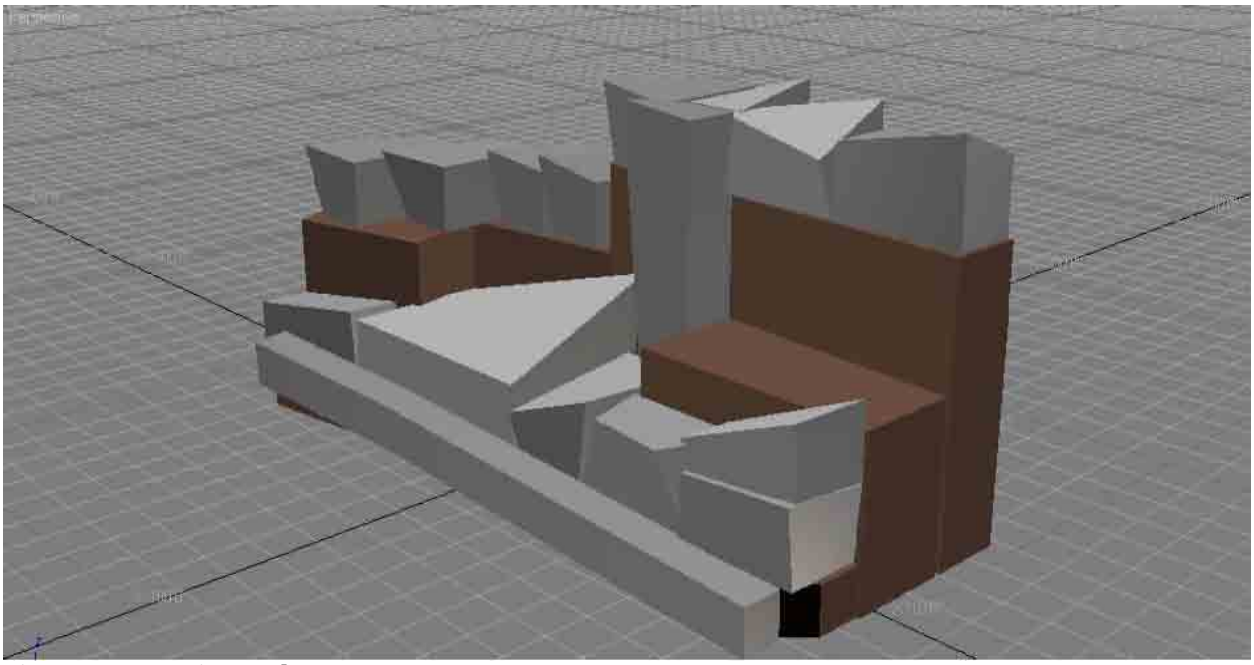


Figure 14 – Massing study 3

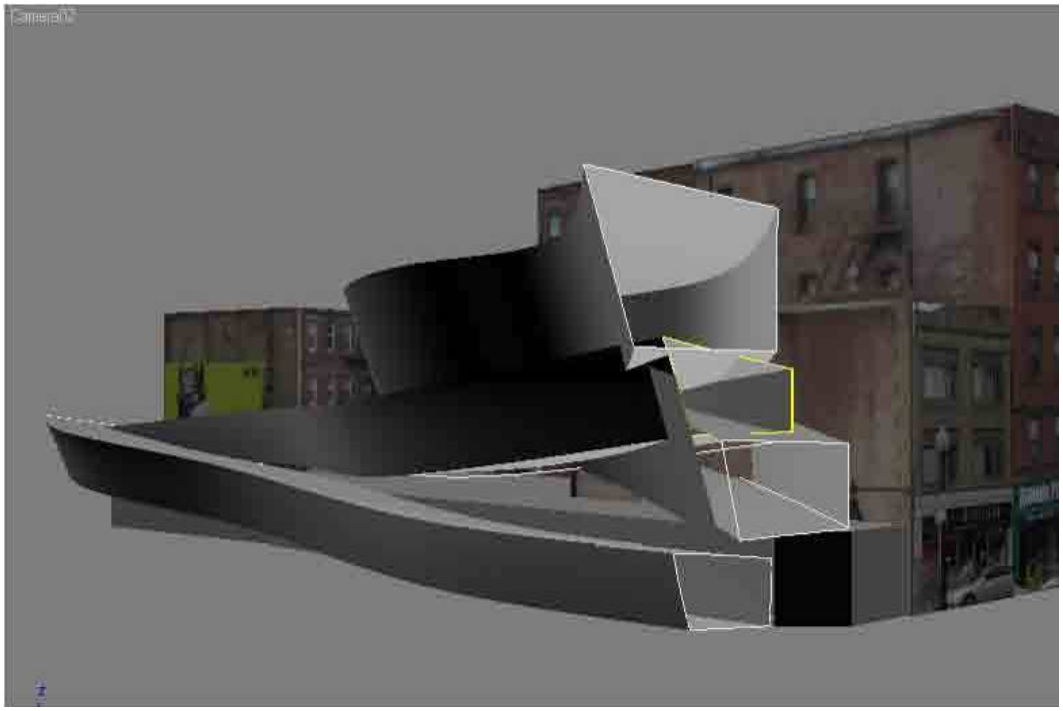


Figure 15 – Form study 4 – solid

Figure 16 – Form Study 4 – solid from southwest

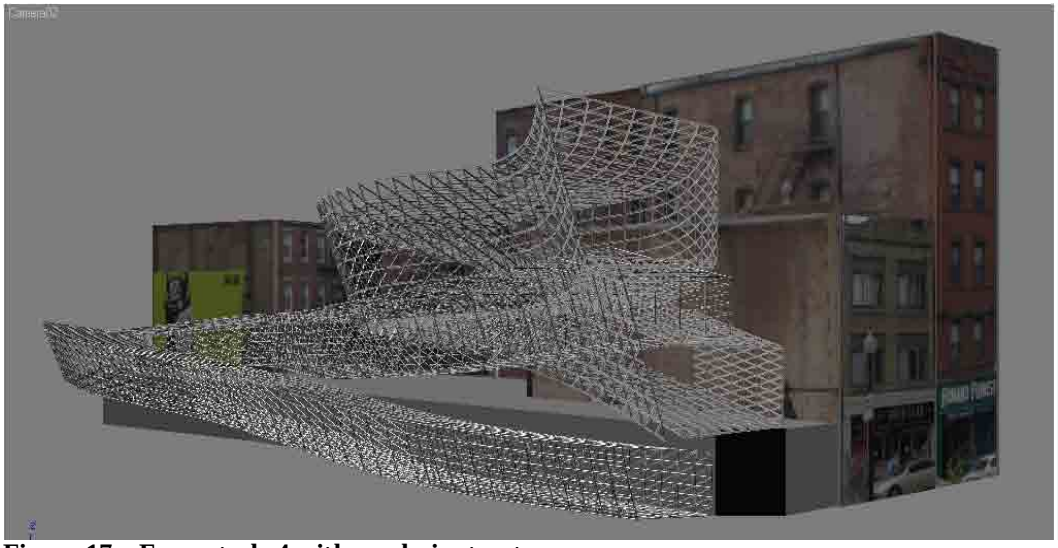


Figure 17 – Form study 4 with geodesic structure

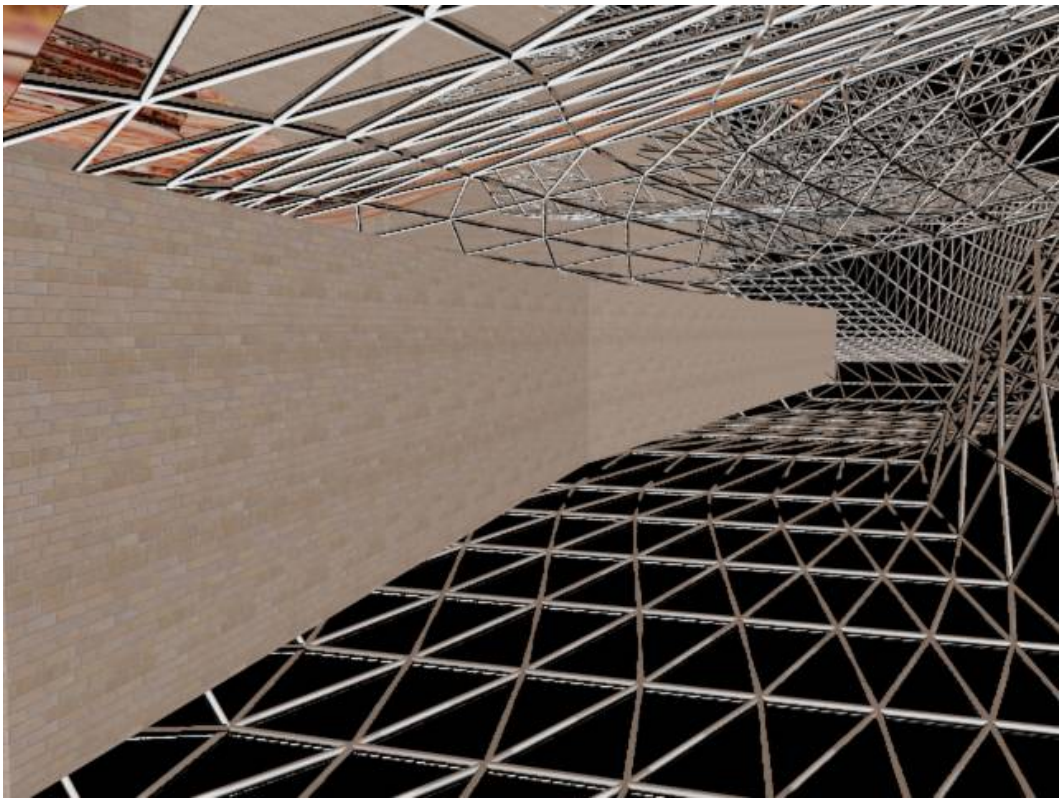


Figure 18 – Form study 4 – Interior perspective

These studies eventually began to coalesce into a building form that is expressive and kinetic. This led to the selection of a program based on physical activity and movement.

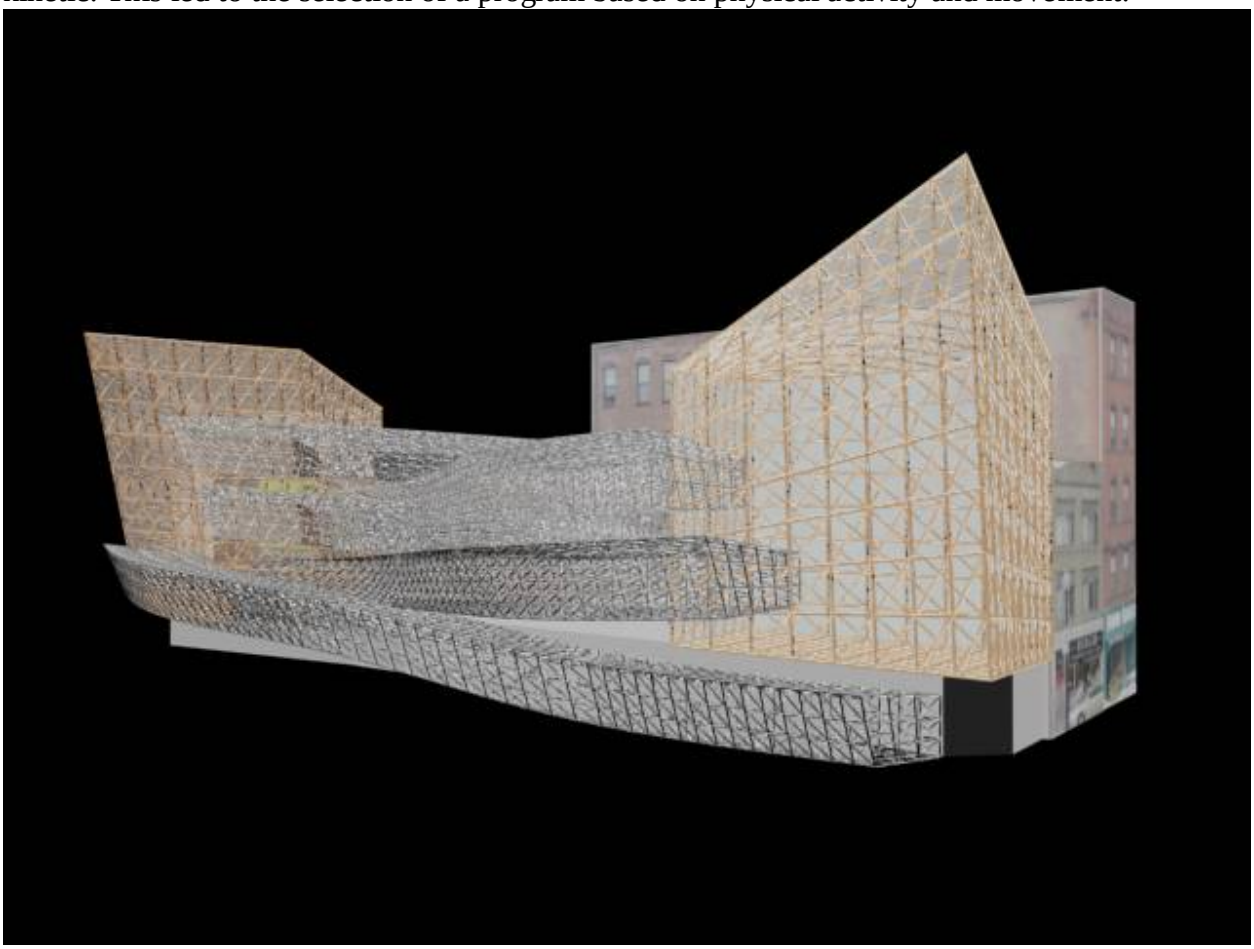


Figure 19 – Preliminary building form 1

Figure 20 – Preliminary building 2 presentation board 1

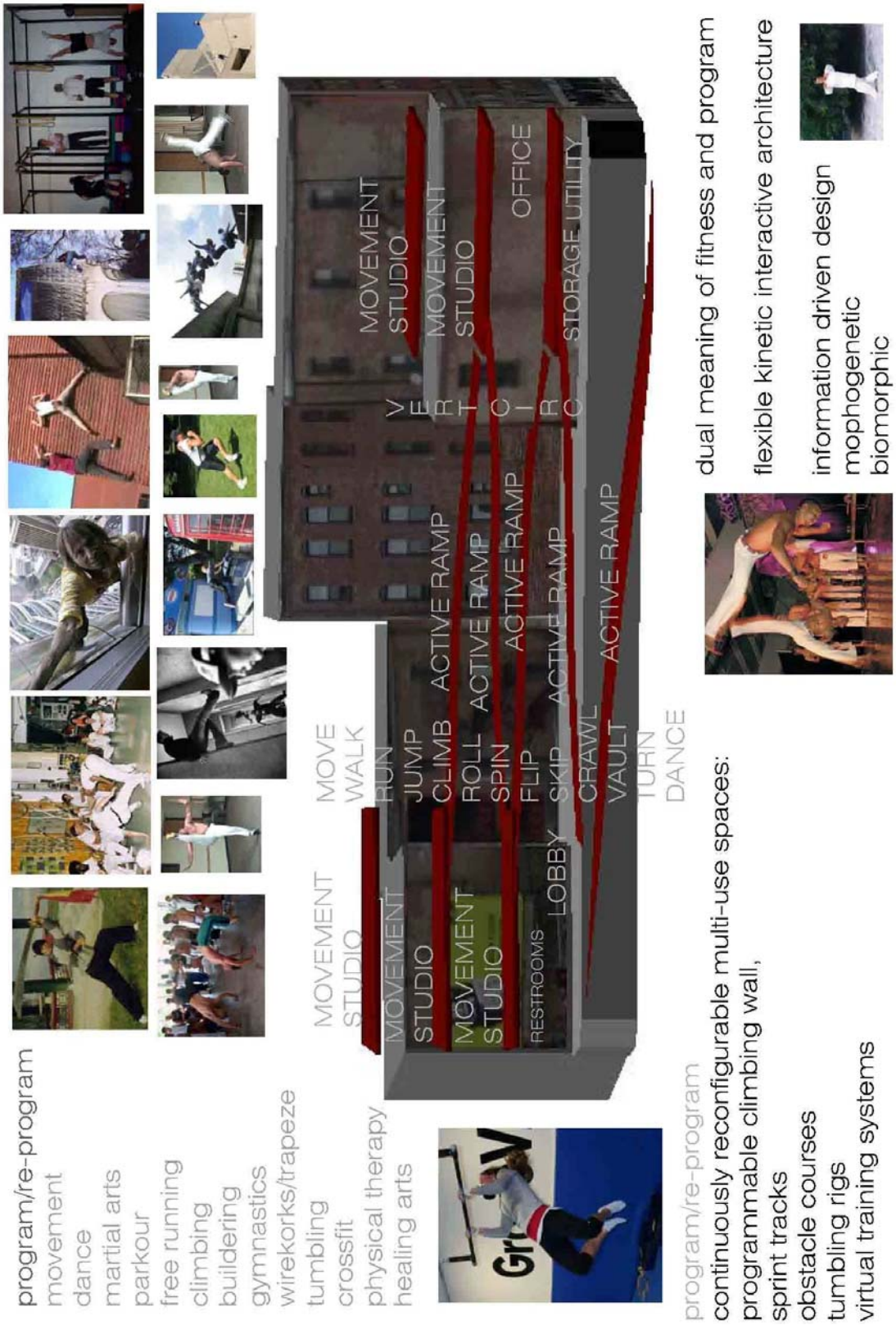


Figure 21 – Building 2 presentation board 2

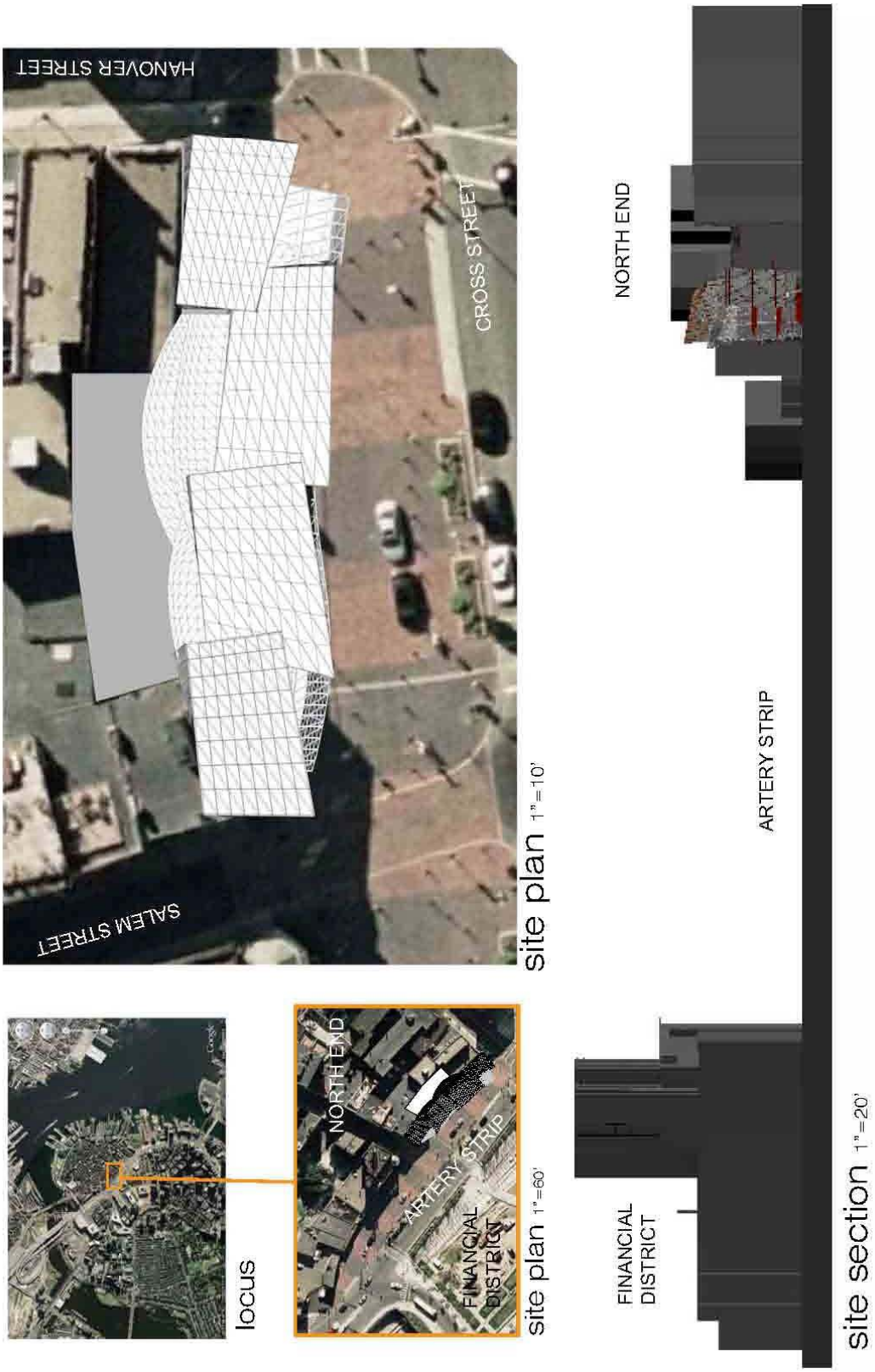


Figure 22 – Building 2 presentation board 3

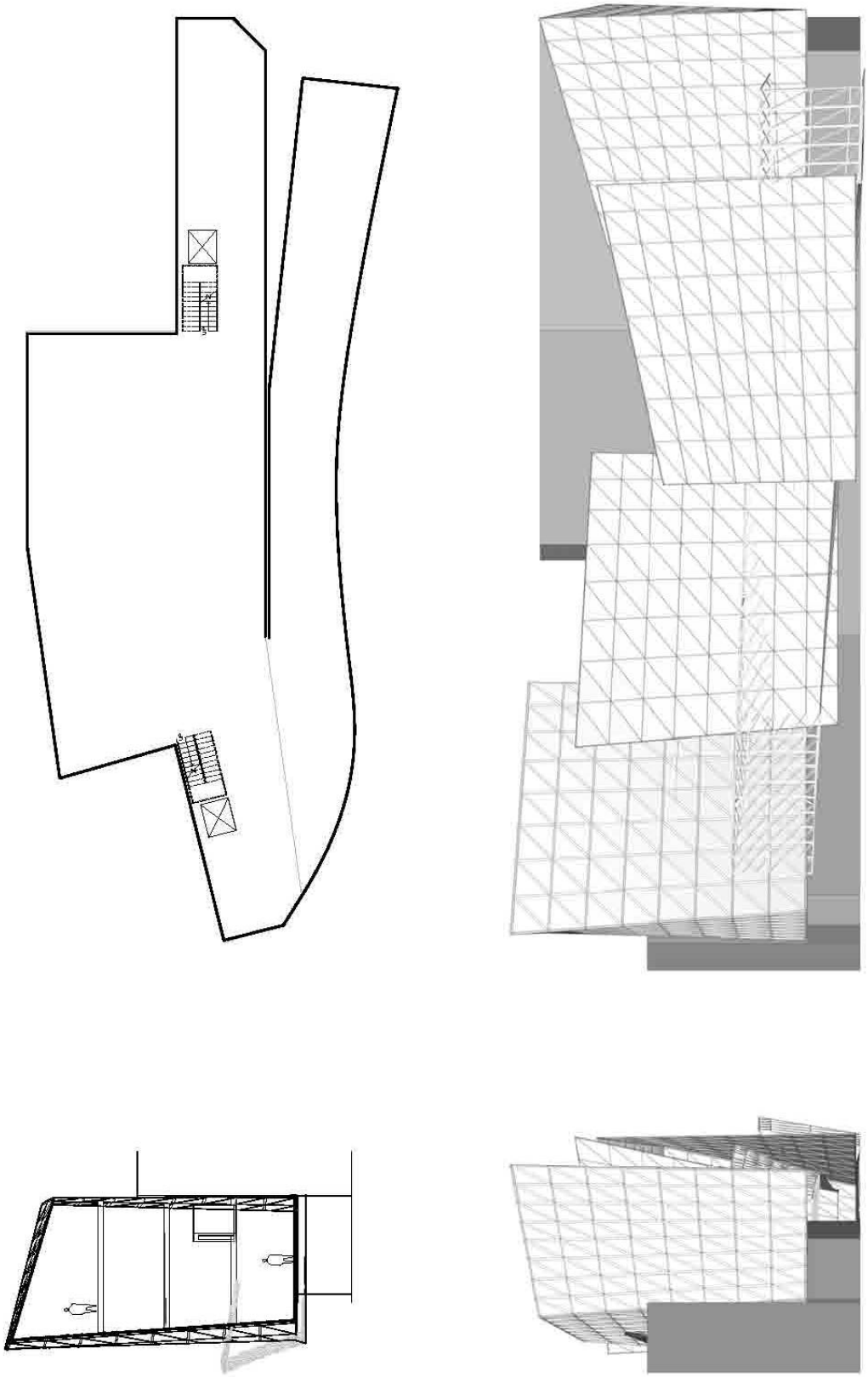


Figure 23 - Building 2 presentation board 4

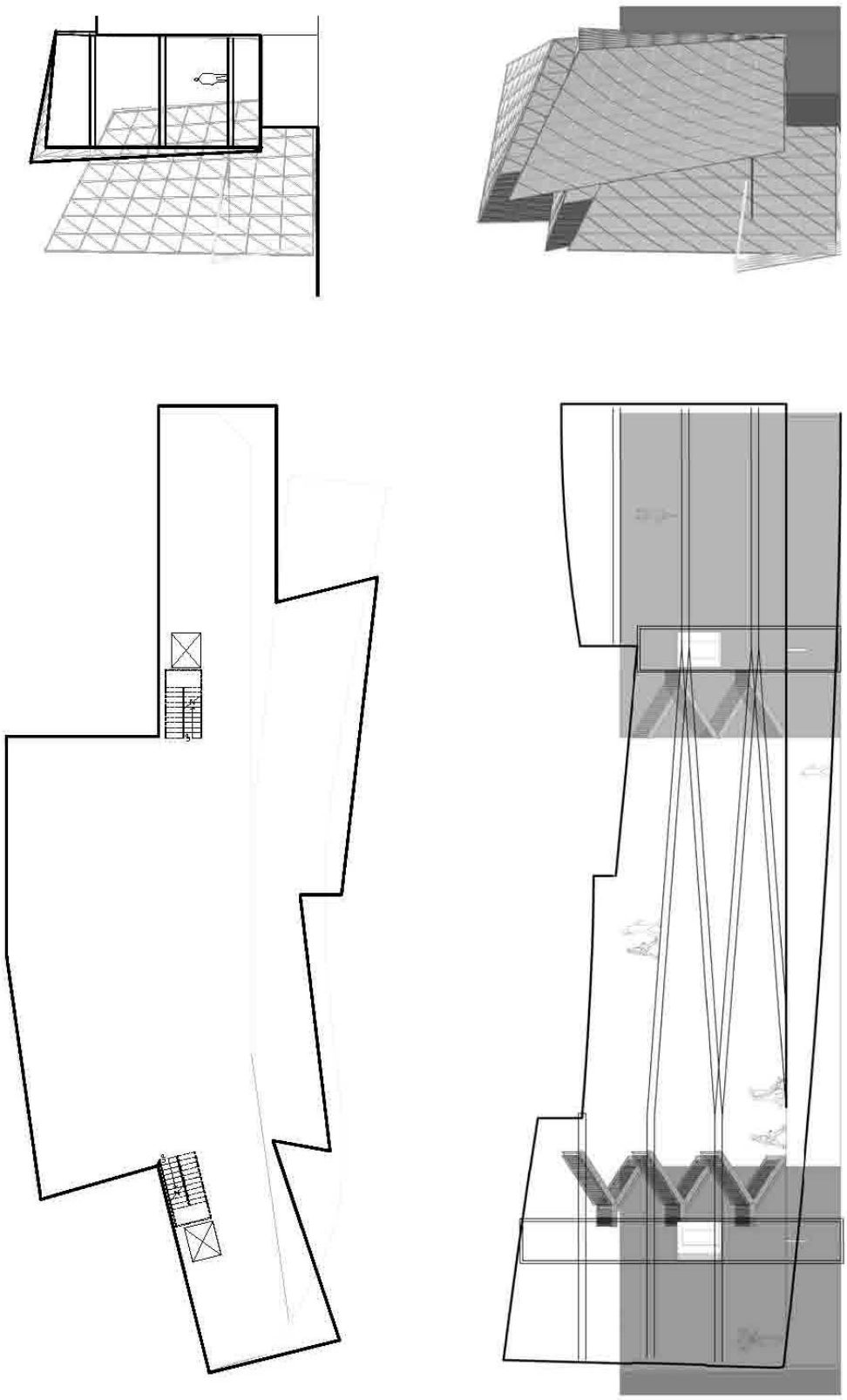


Figure 24 – Building 2 –presentation board 5

After settling on the program centered around movement, the research began to focus on Crossfit and how the concepts of Crossfit could be applied toward architecture. The research then focused further on the practice of parkour and buildering, two activities that develop an interaction and interpretation of buildings and urban space that is drastically different from every day experience. For most people, a wall is an element that encloses and obstructs, for the practitioners of parkour (called traceurs) and builderers, a wall is an element to be climbed over. For most people, a guard rail is an protective barricade; for the traceur, a guard rail is a means of vaulting over a space.

The practice of parkour and buildering was incorporated into the design process by means of series of visual studies that analyzed and traced the movements of traceurs of builders through the site. These tracings were then used to generate spatial forms which in turn informed further refinement of the building form.

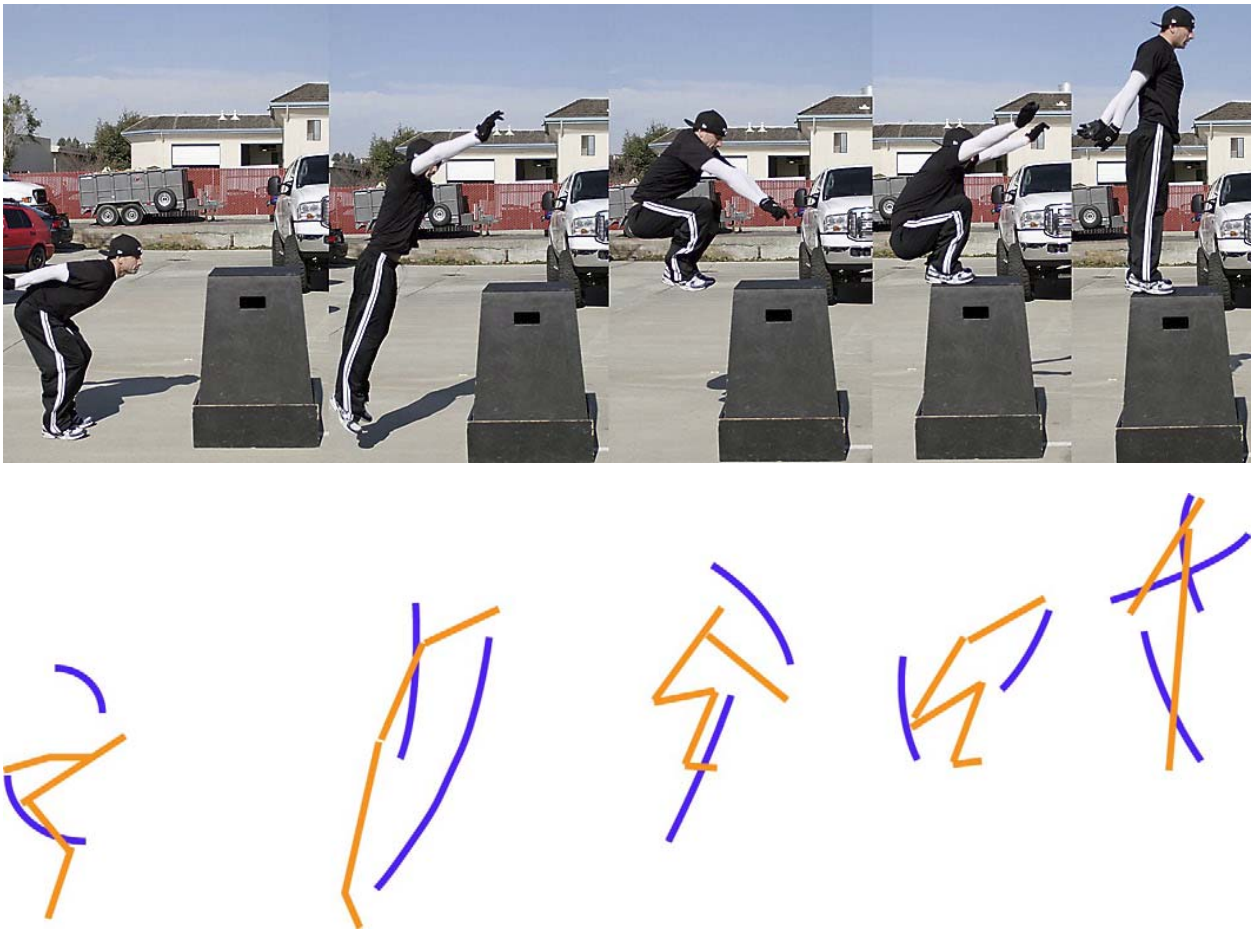


Figure 25 -Visual analysis of parkour jumping movement

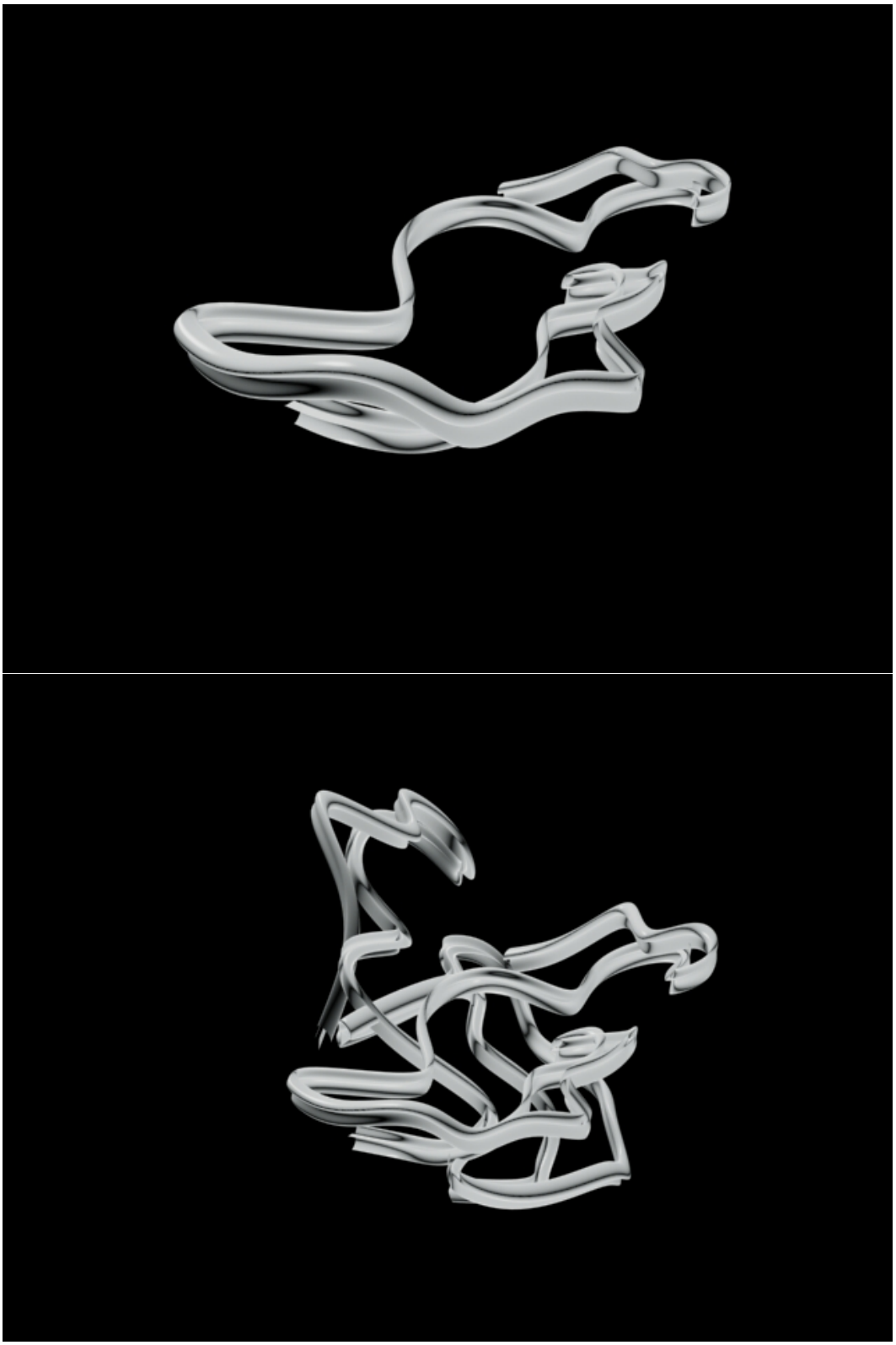


Figure 26 – Visual analysis of parkour movement through site as 4d lines

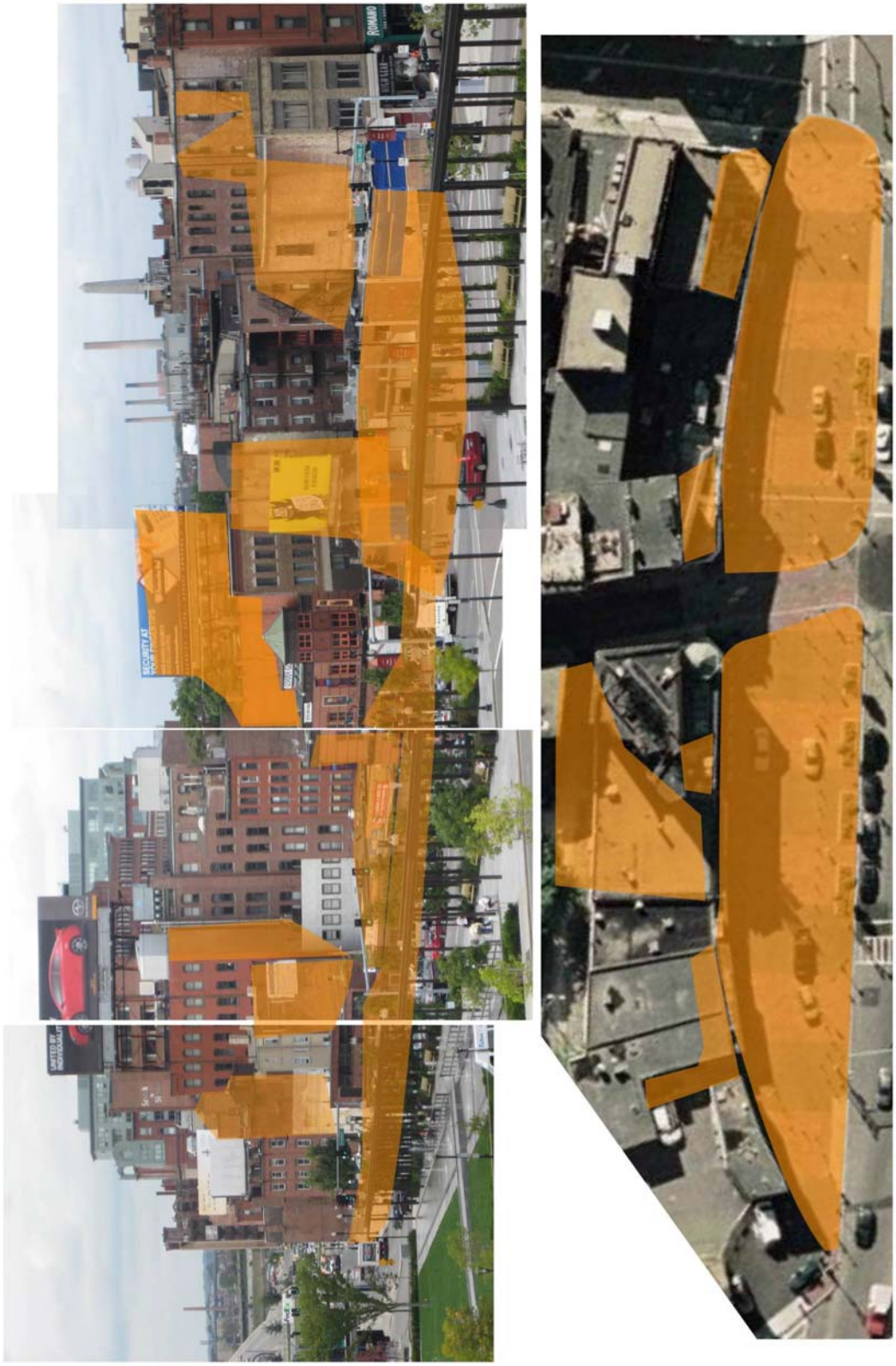


Figure 27 – Revised study of potential infill areas

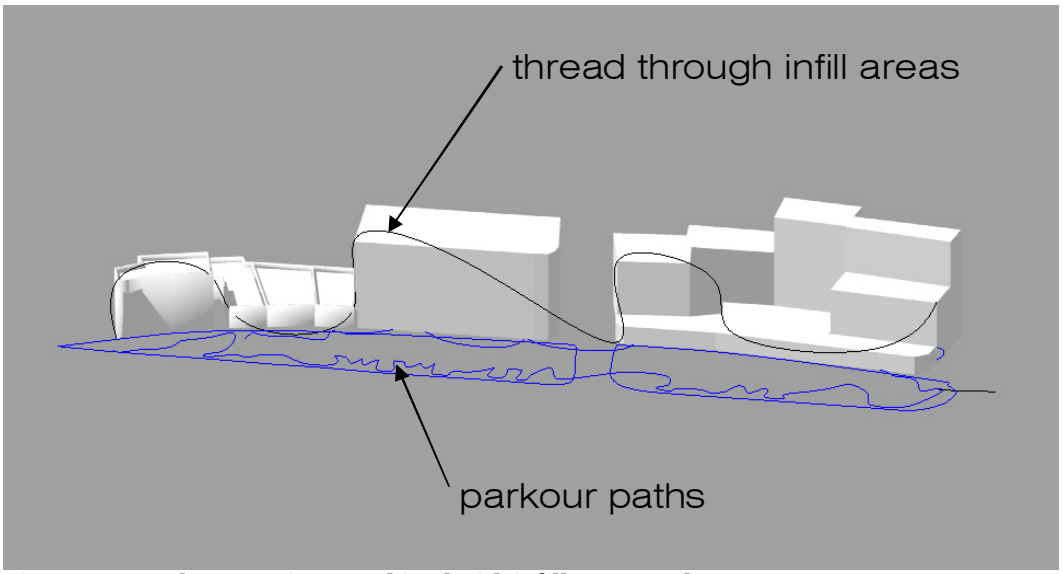


Figure 28 – Parkour tracings combined with infill areas study

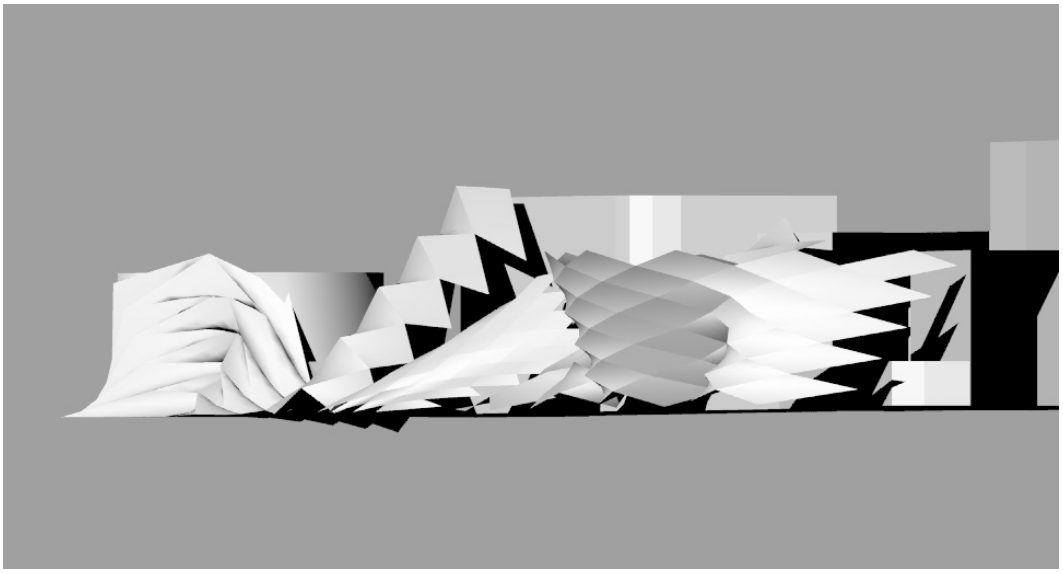


Figure 29 – Parametric form generated from parkour tracings

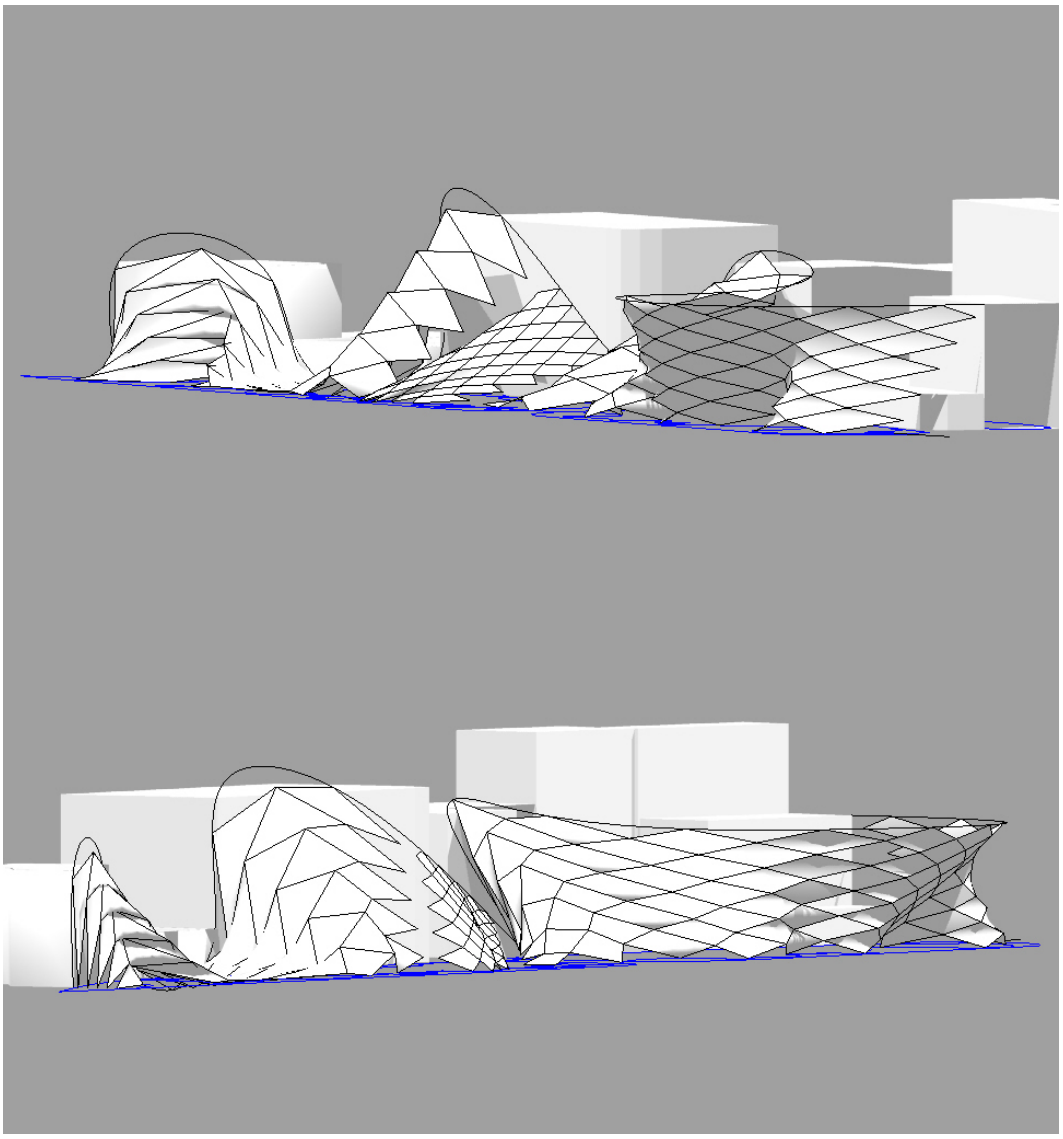


Figure 30 – Parametric form

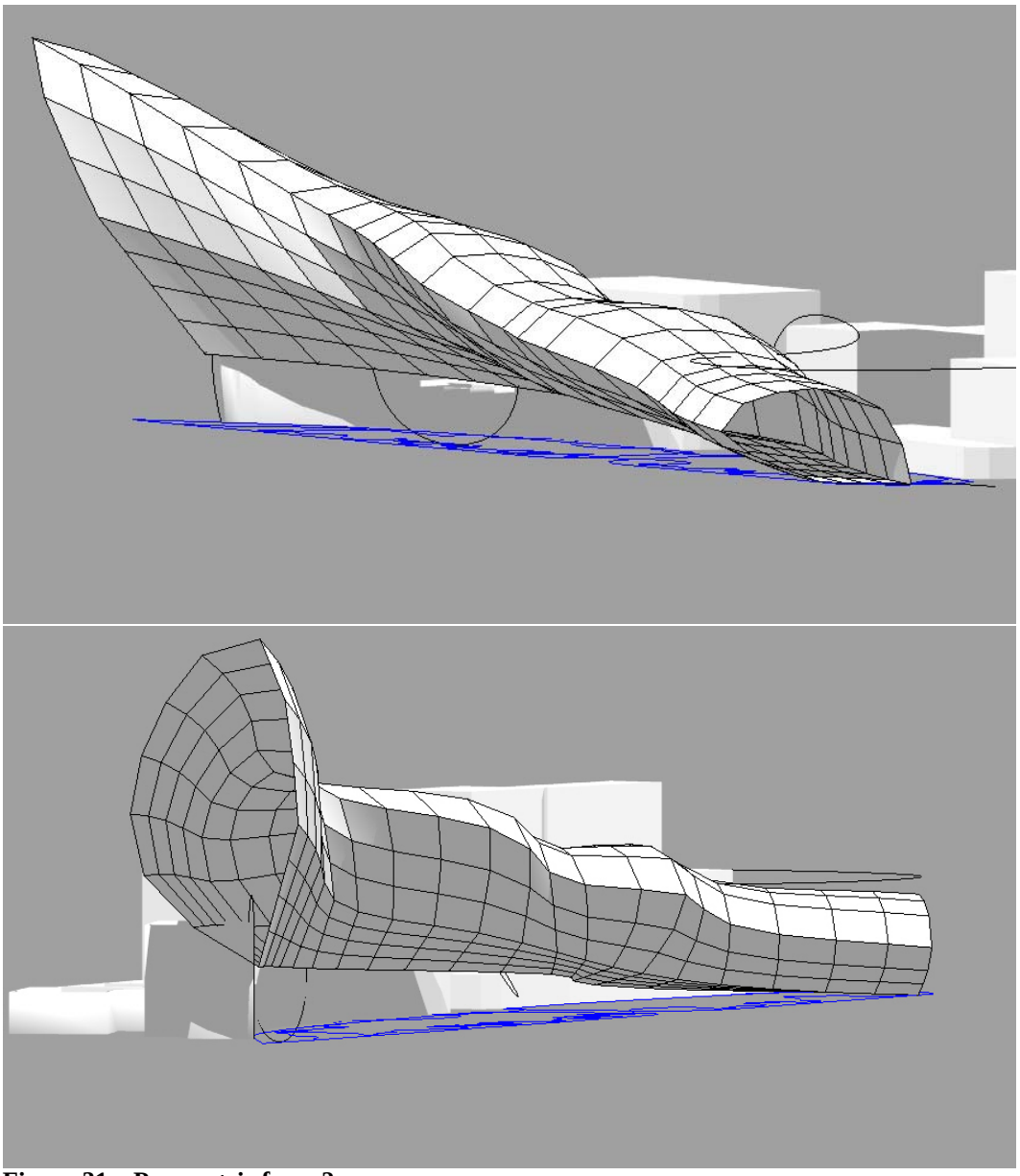


Figure 31 – Parametric form 2

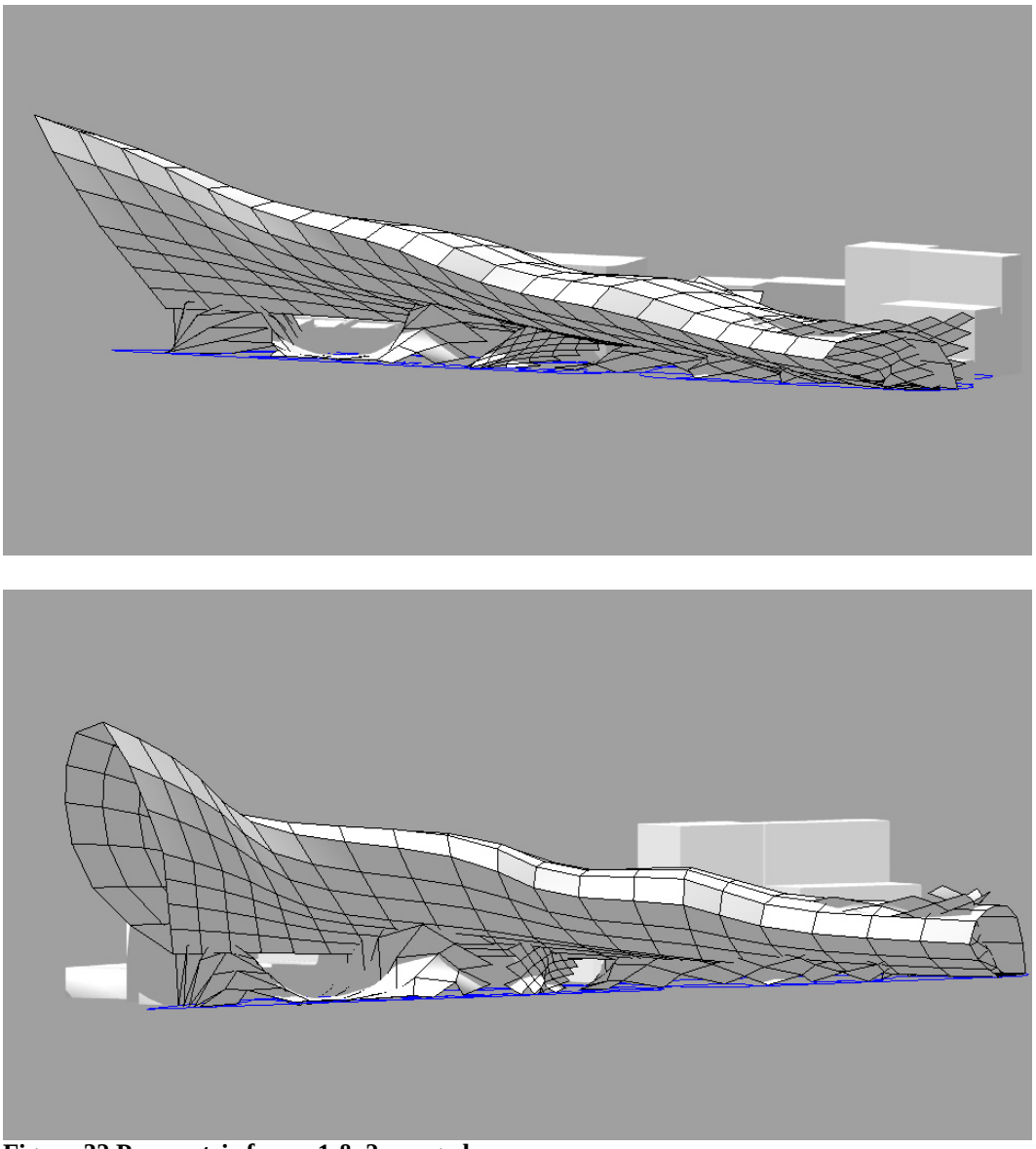


Figure 32 Parametric forms 1 & 2 merged

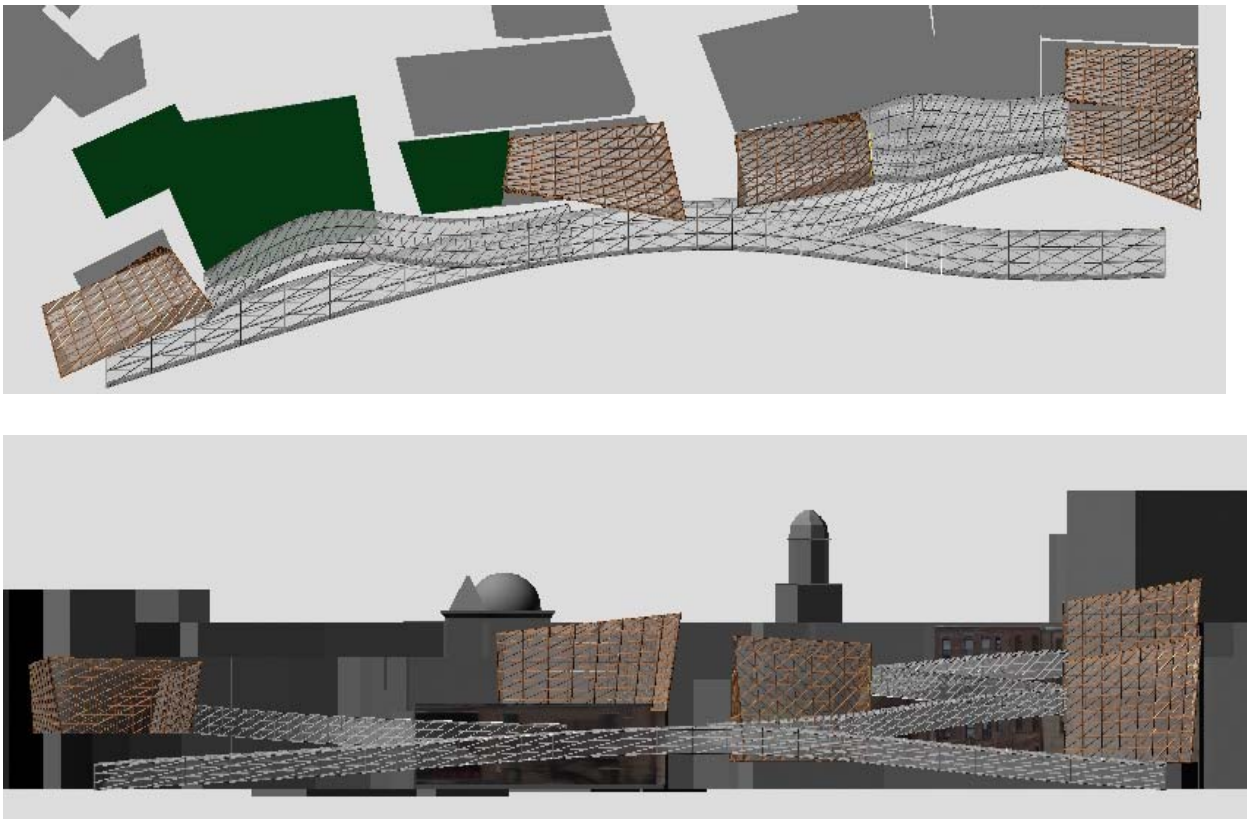


Figure 33 – Building 3 preliminary Site Plan and South Elevation

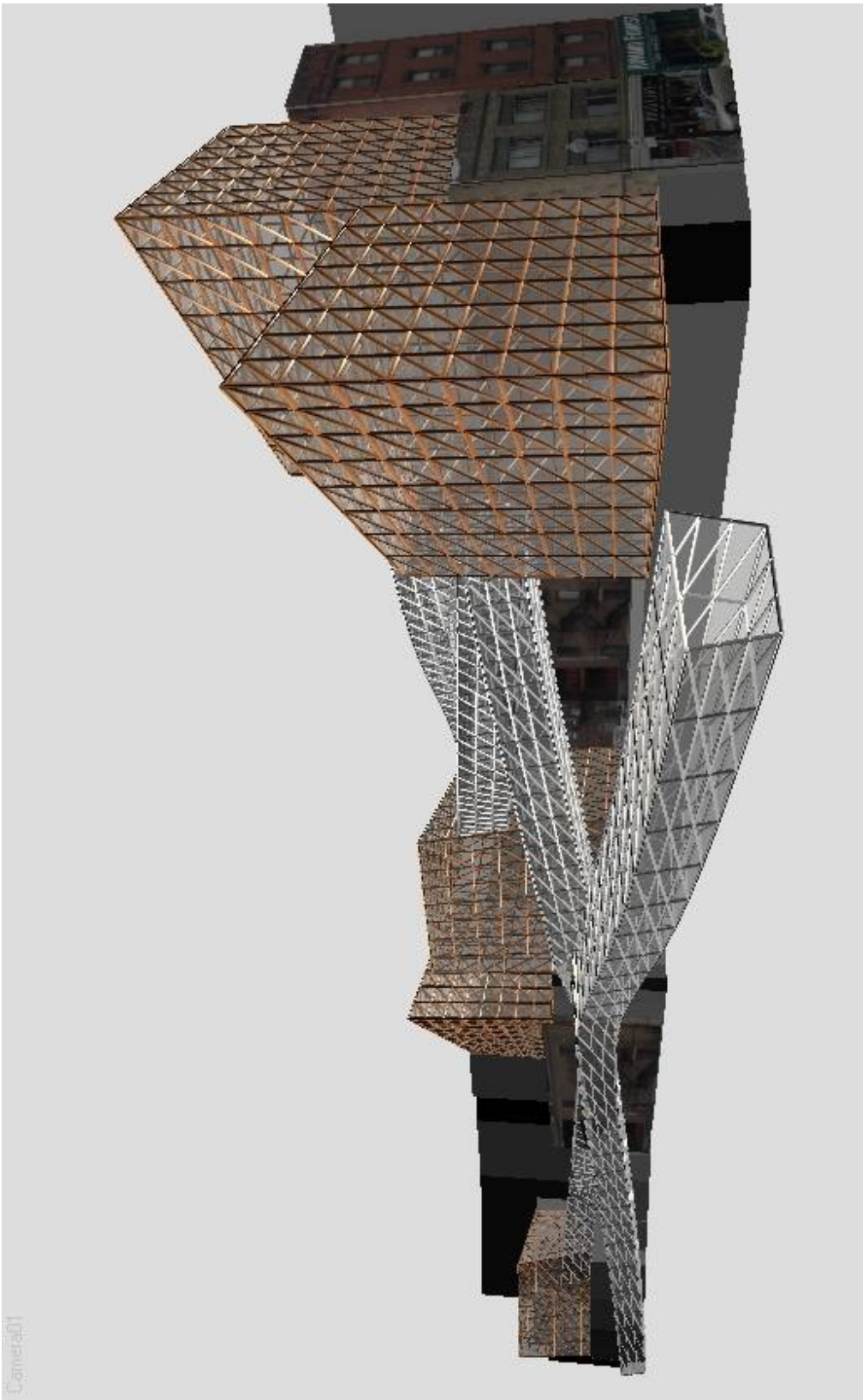


Figure 34 - Building 3 Perspective from SE

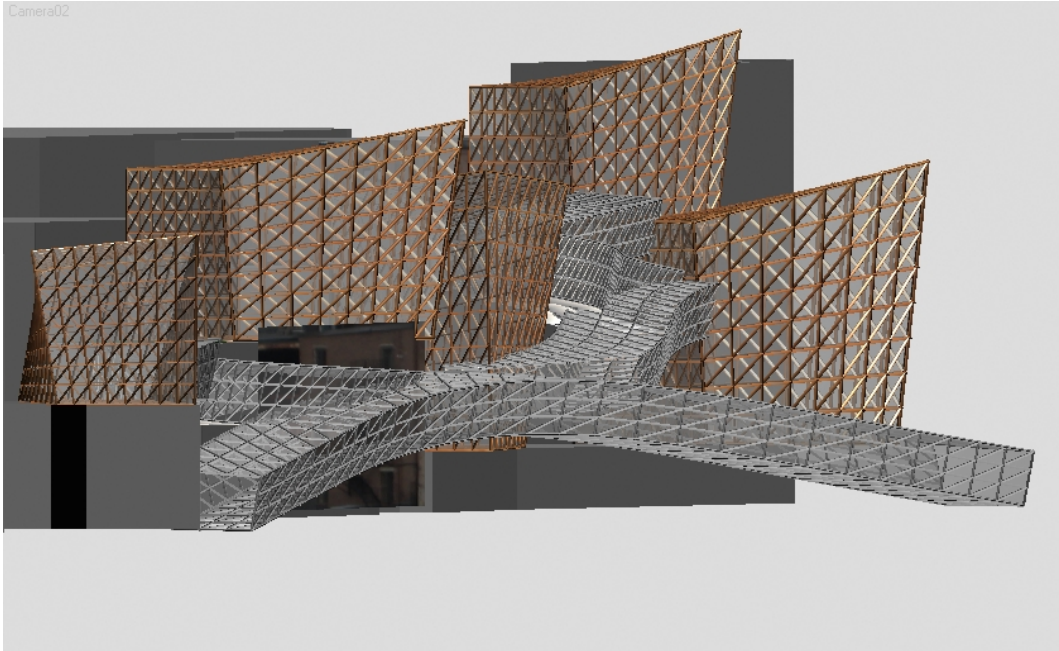


Figure 35 – Building 3 West Elevation

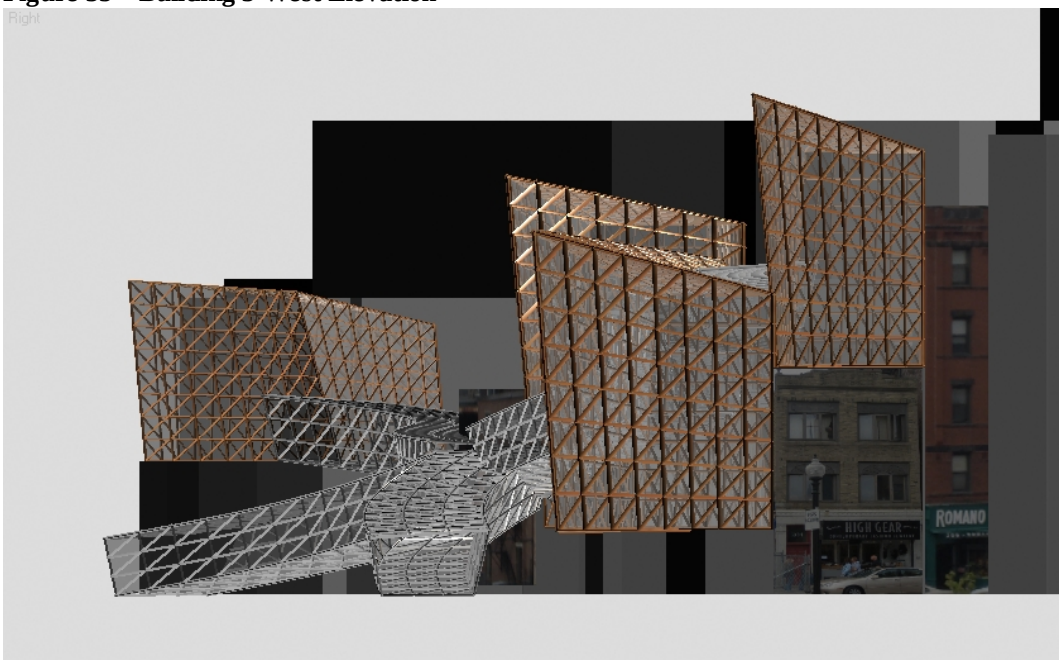


Figure 36 – Building 3 East Elevation

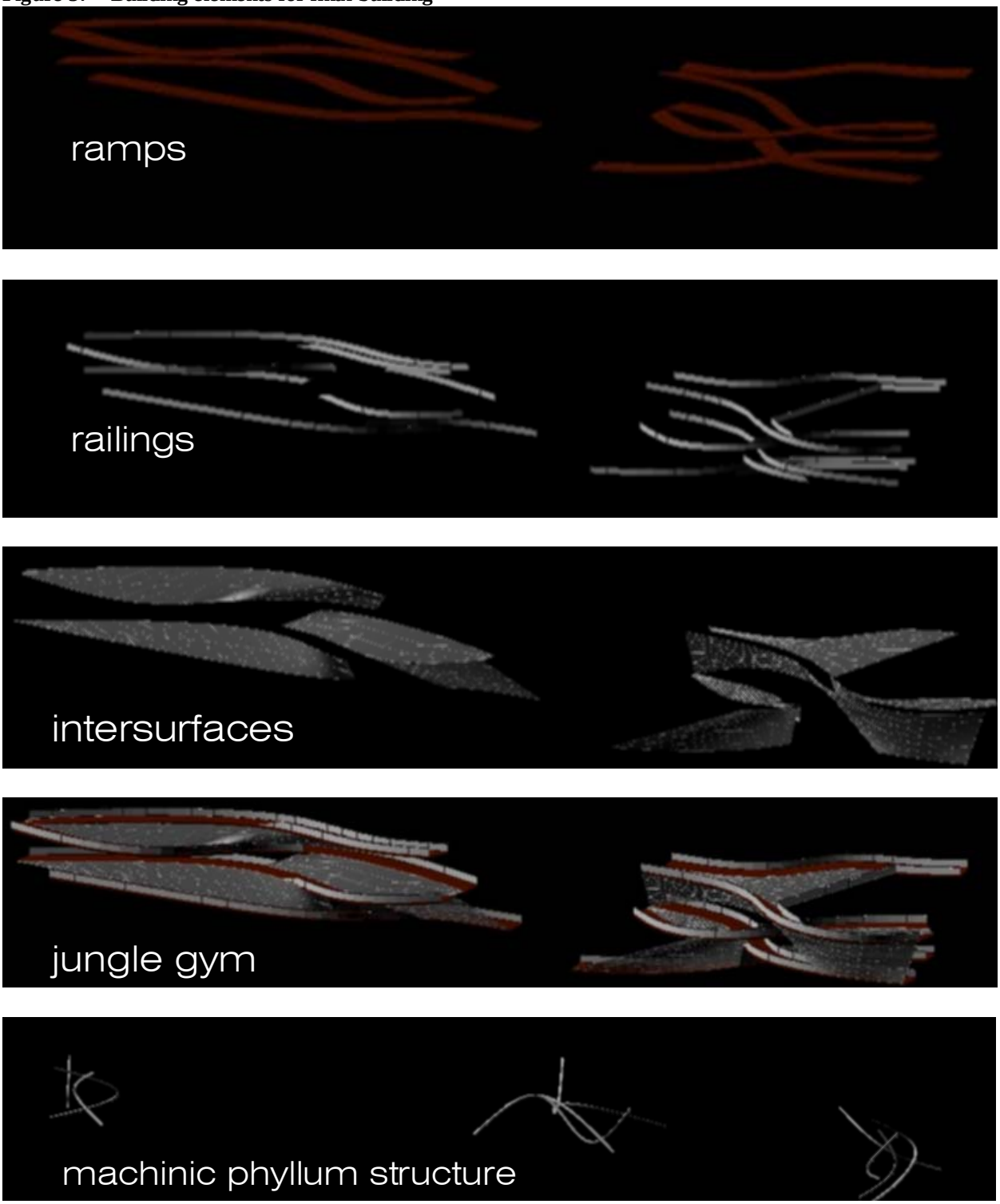
To further explore the design, the major components were developed as a network of interactive, responsive, and kinetic, elements. Elements such as the series of ramps that comprise the indoor climbing structure, referred to as The Jungle Gym, are physically reconfigurable and can be continually re-programmed to change shape. This allows for infinite variation of form that can be used to train specific movement patterns.

The primary structure of the building utilizes a geodetic actuated tensegrity system driven by computer-controlled actuators which can continually adjust the tensile elements of the frame to initiate and/or maintain form and shape.

The tensile skin of the building is made of multi-laminar panels that each have a transparent membrane, a screen, and a shade. The panels are all operable by both manual and automated power. Every panel can swivel in 3 planes and be fixed in position. This allows for optimal building ventilation and solar shading.

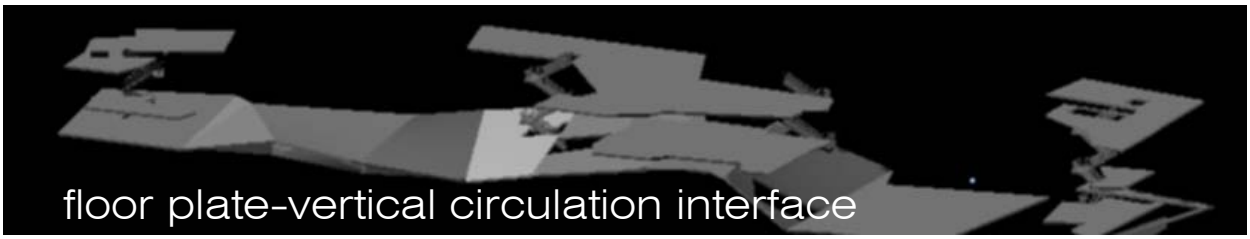
The design of the building seeks to encourage to people to explore movement in and through space. The building is intended to be climbed on, through, around, over, inside, and out. It is a place for the practice not just of Crossfit, parkour, and buildering, but for all modes of movement: walking, running, dancing, kicking, flipping, lifting…it is a place to celebrate and study the meaning of movement of all kinds; human movement as well as that of machinces, robots, buildings, planets, solar systems.

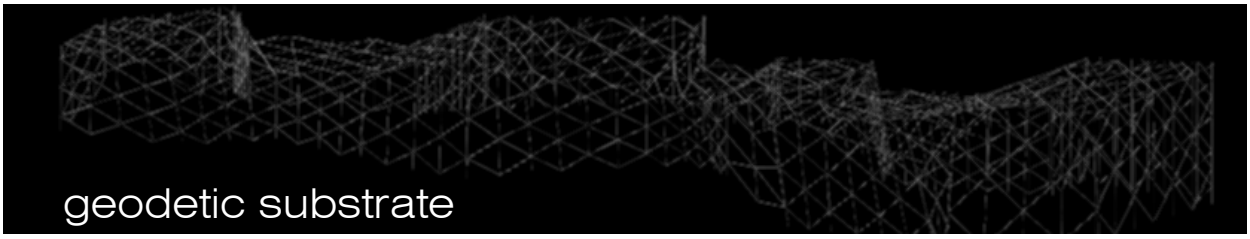
Figure 37 – Building elements for final building

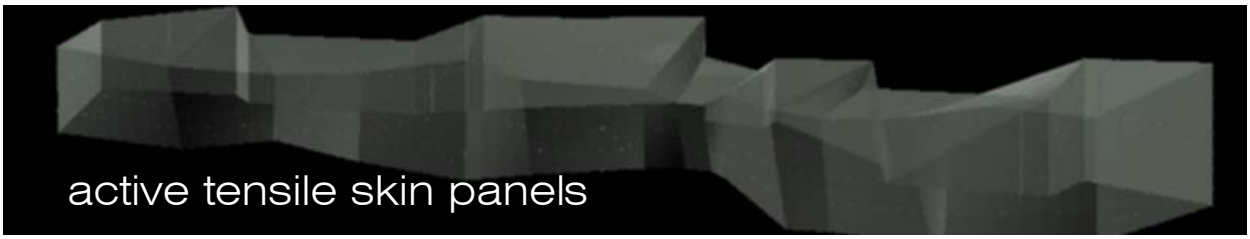



phyllum structure with floor plates


floor plate-ramp interface


floor plate-vertical circulation interface


geodetic substrate


active tensile skin panels

CHAPTER 7

FINAL DESIGN DOCUMENTATION

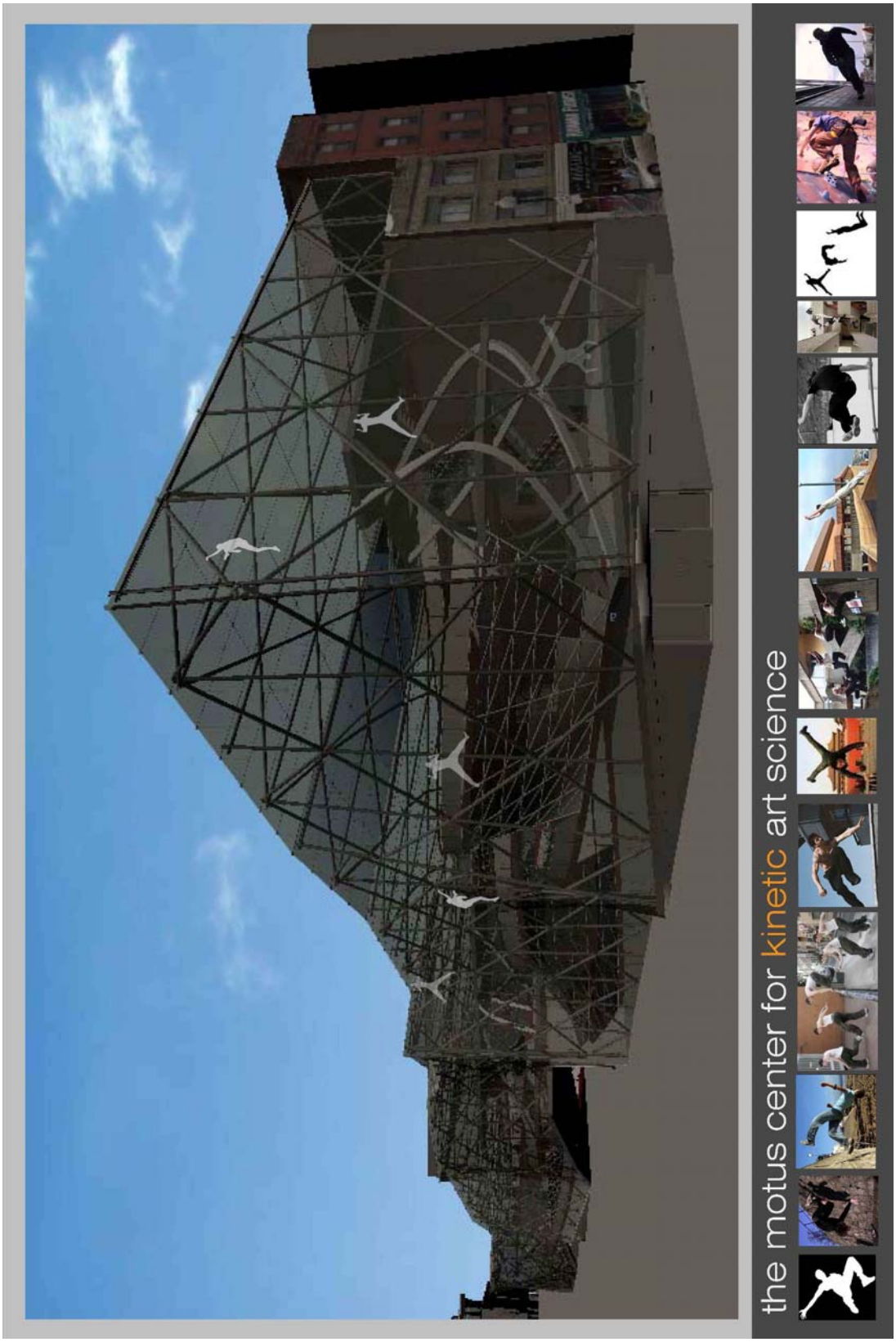


Figure 38 Final presentation board – Title Sheet

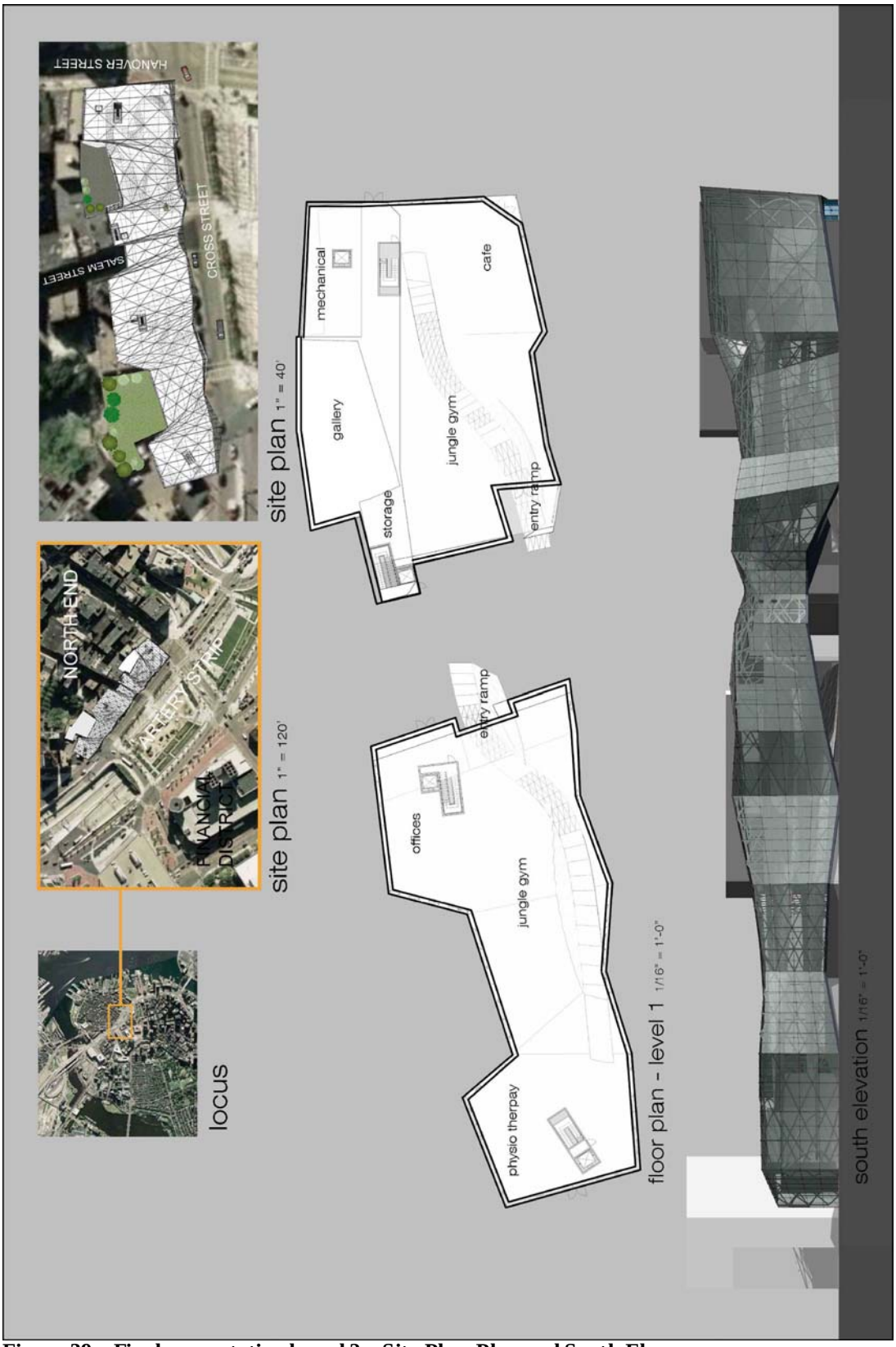


Figure 39 – Final presentation board 2 – Site Plan, Plan and South Elev

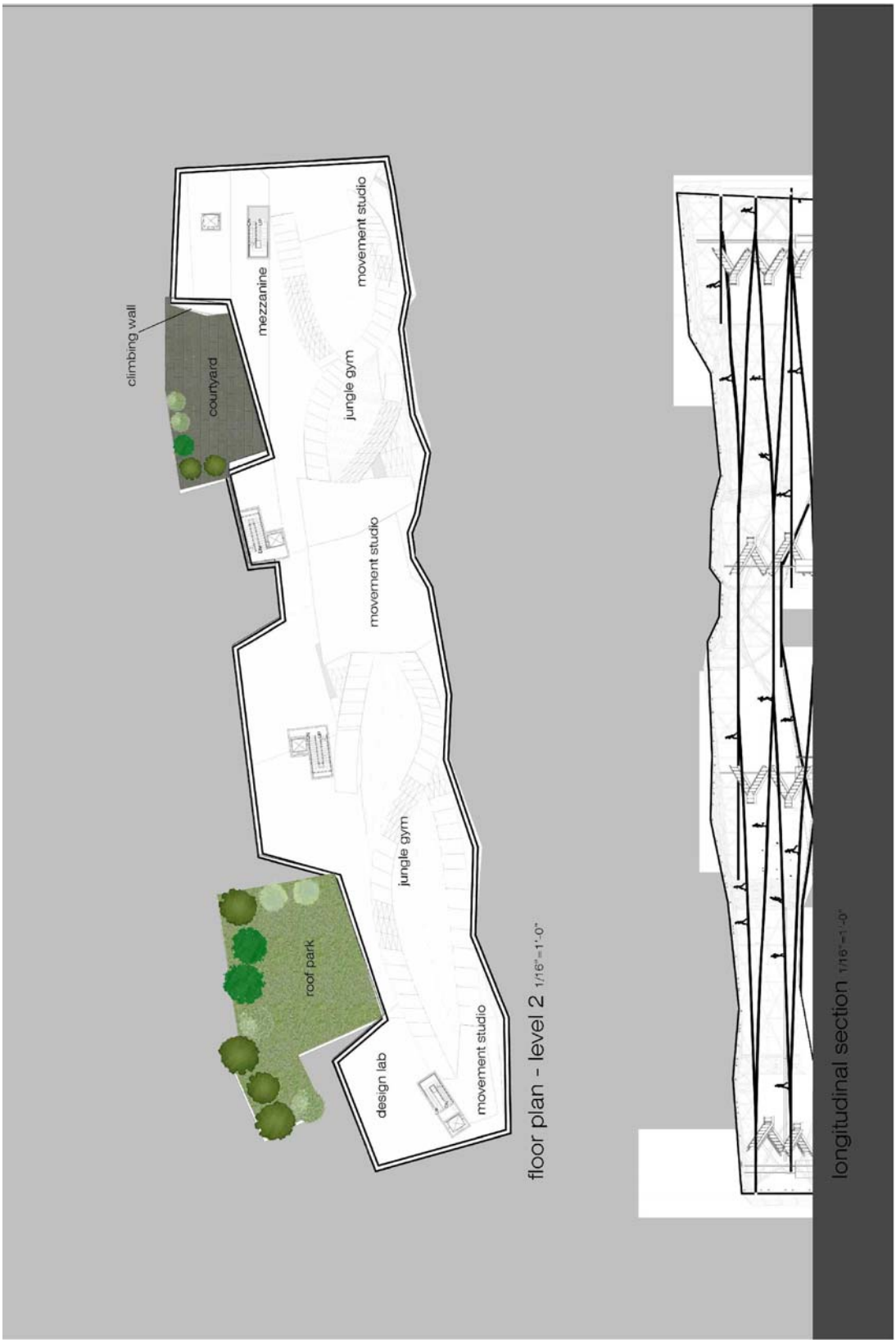


Figure 40 – Final presentation board 3, Section and Plan

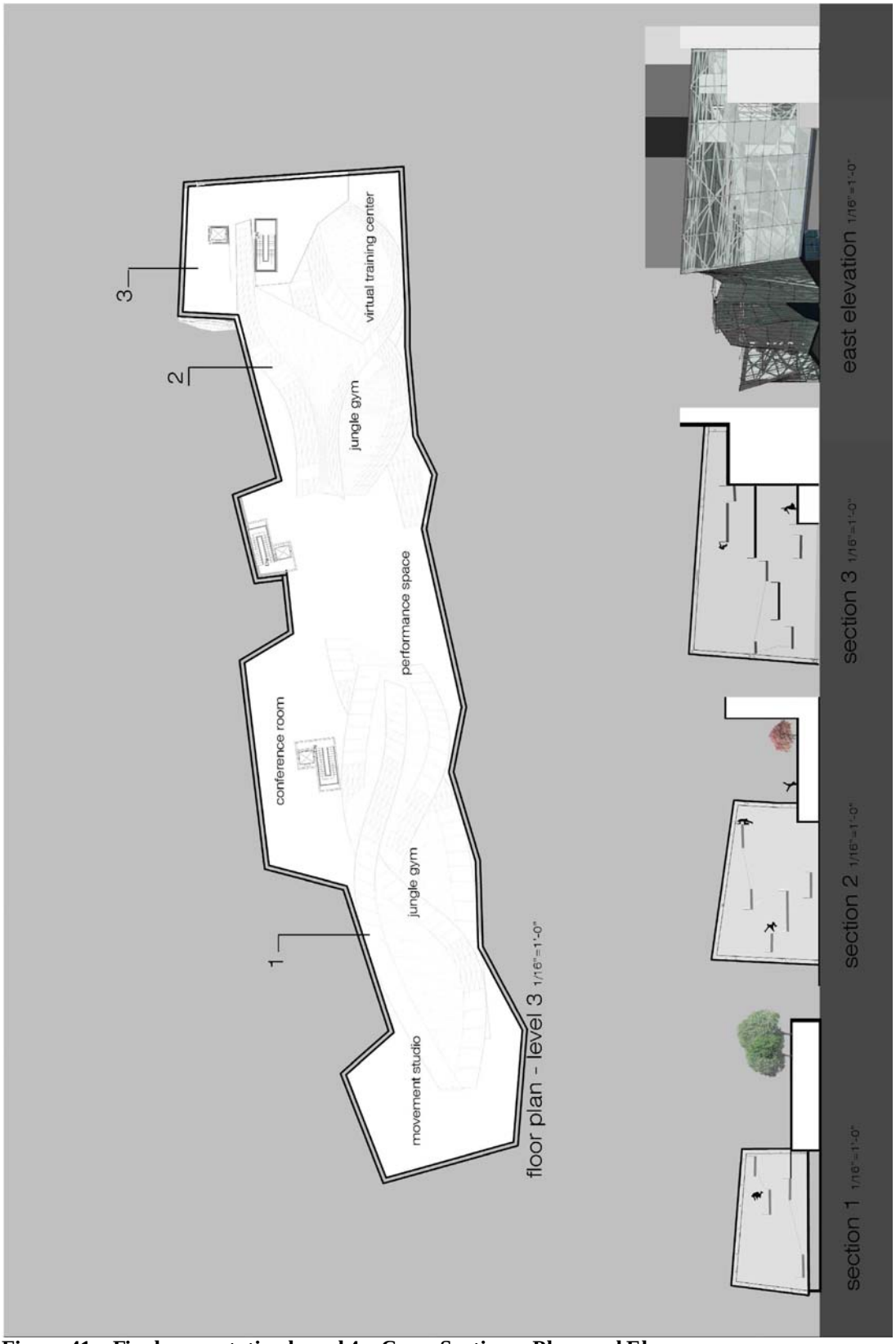


Figure 41 – Final presentation board 4 – Cross Sections, Plan, and Elev

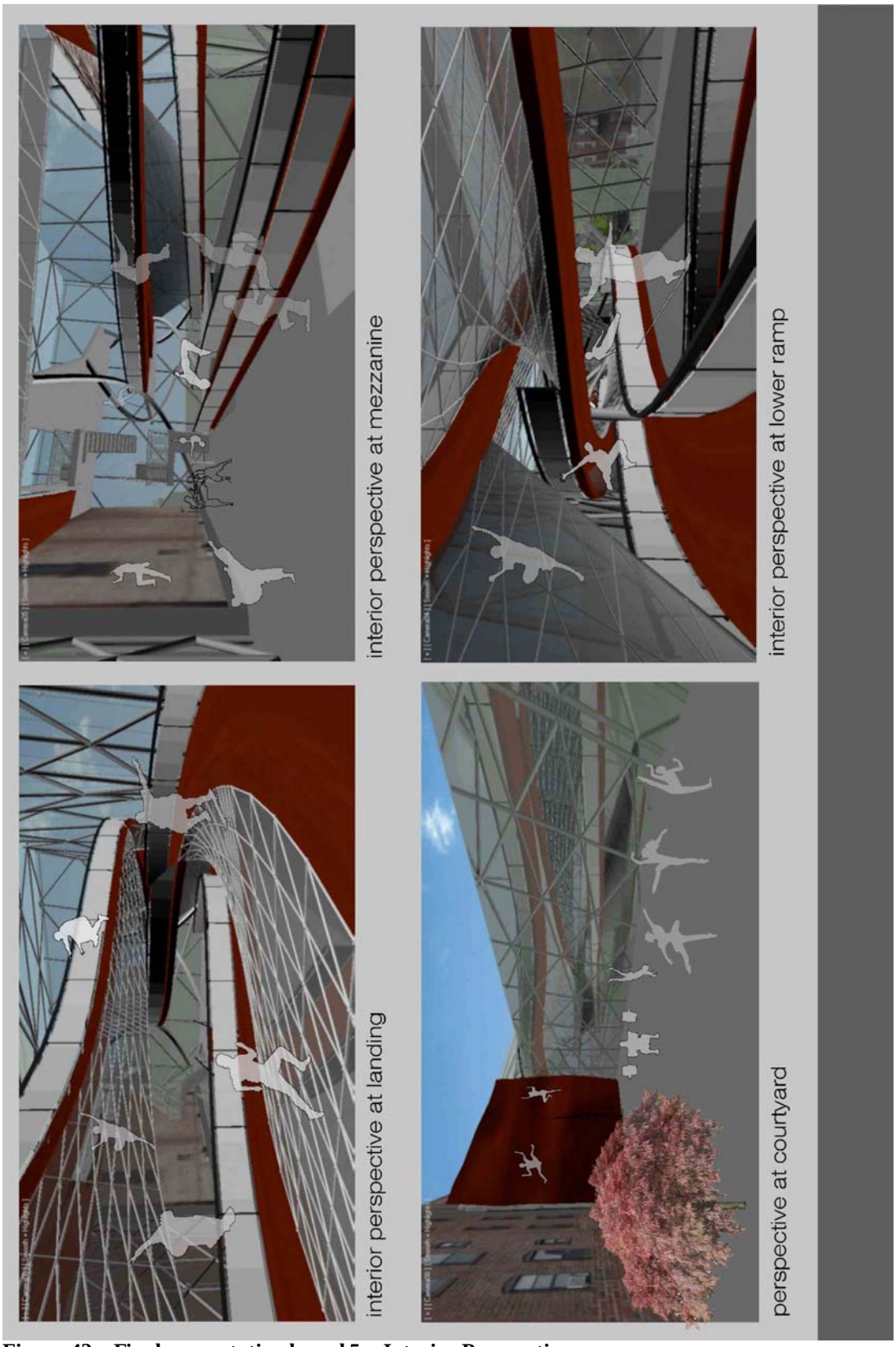


Figure 42 – Final presentation board 5 – Interior Perspectives

CHAPTER 8

CONCLUSION

This project is in certain aspects highly schematic and theoretical in terms of its stated goals of large scale reconfigurability. The thesis has barely scratched the surface of what is necessary tectonically to realize such a project. Most of the comments (which were unfortunately quite sparse due to the fact that I presented first, before many of the jury members arrived) focused on the need for further documentation of how such a building system could be realized. It should be noted that the final presentation included several video animations of the various kinetic elements of the building in action, such as the programmable ramps, and the operable skin panels. Due to the nature of the medium, these animations are not included in this document. Despite the animations, much more work is needed to accurately depict the operable elements of this building. While many ideas for operable tectonic elements were developed in sketch form, none of these ideas were developed sufficiently to include in the final presentation.

The most useful product of this thesis is likely the definition of the stated design goals. While very few of these lofty goals were sufficiently developed in the scope of this thesis, the very definition of the goals is worthwhile. Much of the work done so far in the field of interactive and responsive architecture has been of a primarily artistic or experimental nature. It is my opinion that more work needs to be done to harness the potential of kinetic, responsive, and interactive architecture in a manner that serves ore practical purposes. While artistic installations are perfectly valid and serve a certain purpose of their own, the growth of the field will be limited unless it effectively addresses real world, everyday problems.

This thesis has successfully laid the groundwork for a lifelong pursuit of the development of a kinetic architecture that maximizes living potential of the built environment across broad time and modal domains.

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