Structuring Beyond Architecture

by

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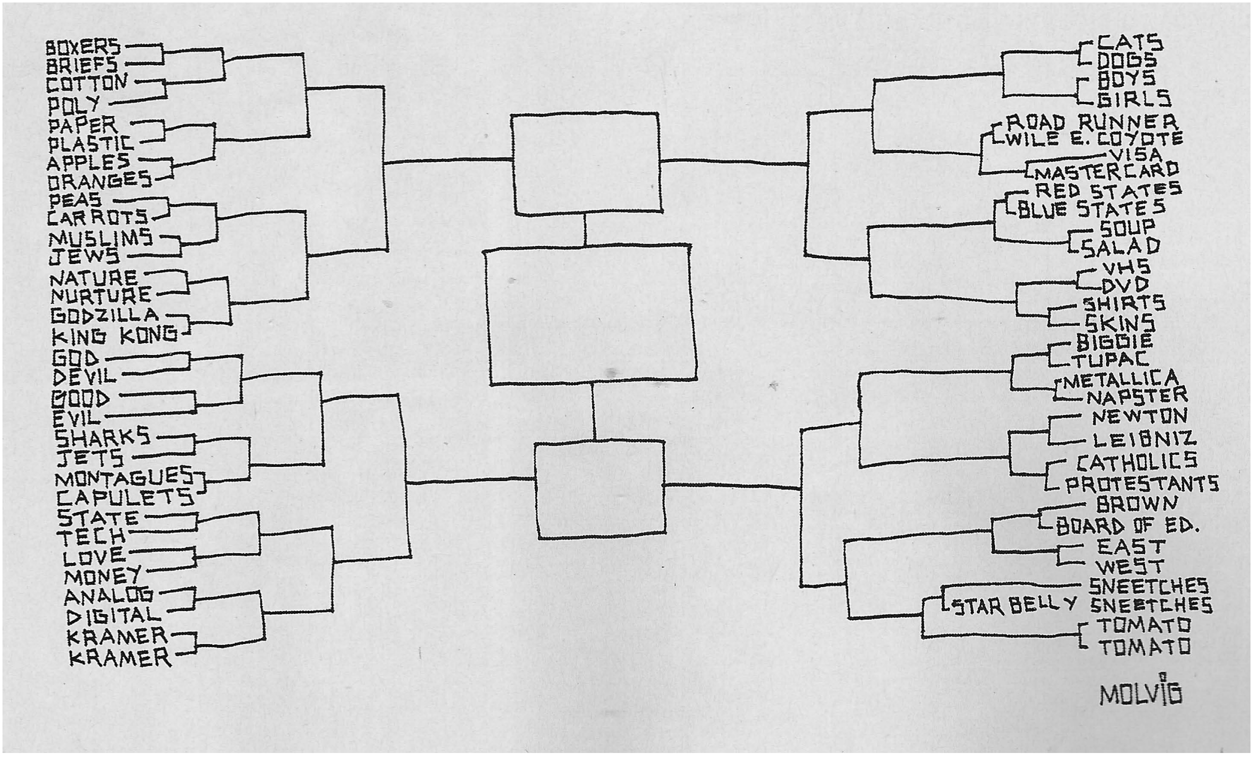

Too often architecture and design are envisioned as problems having winners and losers; this thesis instead explores strategies of negotiation. [Image from The New Yorker, 3 April 2006]

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ABSTRACT

This thesis explores the layering and negotiation of structural devices in urban settings. Its point of departure is a series of patterns of how structural design and urban design interact and overlap, from which are developed design strategies that encourage differentiation and the ability to accommodate change in the future. Therefore, the thesis traces an approach for growth rather than simply specifying a particular isolated solution to a single local set of conditions: a machine rather than a spare part. The overarching structural challenge which I have investigated as a vehicle for this approach is for foundation systems spanning over shallowly buried subway and highway tunnels at a site adjacent to the Fort Point Channel neighborhood in South Boston. This challenge, facing many cities around the world, provokes the problem of designing and creating the structure of support in these areas to enable more – rather than less – creative spatial possibilities above the ground. The subsequent proposal details a system of linear bundles – high-performance concrete beams rooted down to bedrock, along with utilities, walkways, plantings, open spaces, loading conditions, property rights, and implementation strategies bundled together – as well as the bridges, piers, and canopies which articulate the termination conditions at the bundles' ends. This thesis asserts that architecture as a discipline and as a creation can negotiate urban conditions and grade separations with structural gestures, shaping the spaces and volumes immediately above and below the constructed ground, and thus addressing both pedestrian and vehicular movement in urban environments. The project leaps between the scales of internal structure and the external urban realm, and situates architecture at this boundary. This exploration integrates relationships with historical precedents of Technological Modernism as well as connections to biological metaphors, to fiction and imagination, to music and harmony, and to broader principles and qualities for shaping and implementing structures in urban spaces.

This thesis is the final component for the author's completion of the Master of Architecture degree as well as the interdepartmental Urban Design Certificate.

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Study Model

Prelude:
Eleven Negotiations in Design

As once the winged energy of delight
Carried you over those many first abysses
Now build the unimagined bridge's
Sternly calculated arc…
Take your practiced strengths and stretch them
Until they reach between two contradictions

["Da dich das gefluegelte Entzuecken," Rilke 1997 p.177]

This thesis project investigates ways to conceive and design positive relationships between internal structure and the urban realm. In order to accomplish this I shall analyze and propose how structuring individual projects can contribute to the whole of communities and cities rather than remaining isolated resolutions of internal concerns. This thesis therefore addresses how architectural design occurs at the border between the spaces defined within a built structure, and the spaces of the community beyond. In questioning the assumptions of how internal structure and external infrastructure are related, I have chosen to pursue this line of reasoning not only through the design in visual explorations but through the design in verbal explorations. This text therefore consists of a linked series of eleven episodes, each taking as a point of departure a particular dialectical relationship: two elements or ideas which are in tension with one another and are therefore in a condition of **negotiation**, linked in a challenging, complex, and often contradictory manner. There are many seemingly simple relationships which the pairing of issues I have selected might prompt: inside/outside, private/public, and so forth. Instead of these generic pairs of opposites I shall instead explore the concepts and the design through pairs that most clearly illuminate the challenges and benefits of exploring architecture with such an approach.

As a word of caution, this discussion does not follow a classic Hegelian conception of dialectic (thesis/antithesis/synthesis). Instead, the writing takes the broader strategy of juxtaposition, tension and negotiation in order to situate an approach and consider aspects that I believe to be inherently in dialogue when architects build in cities.

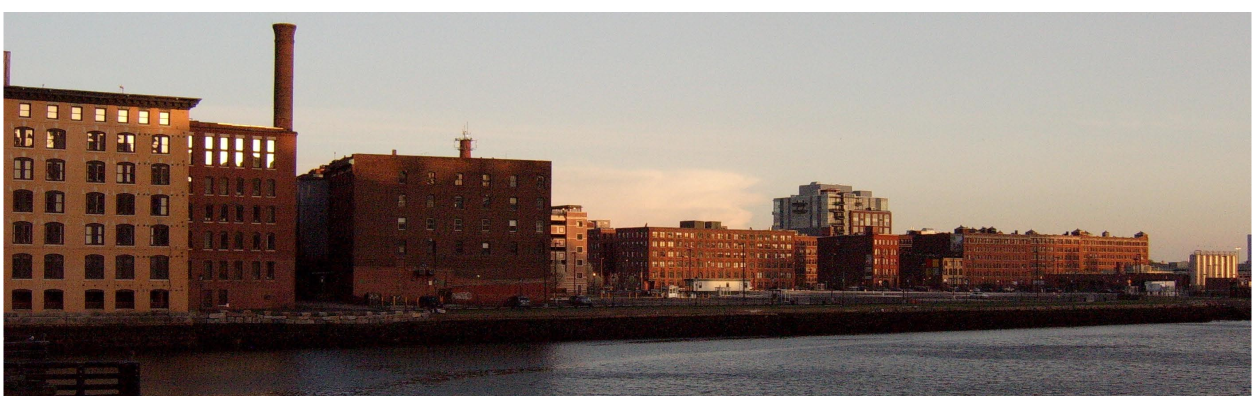
The task at hand is to create an approach that can grow rather than simply specifying a particular solution to a single local set of conditions. The primary overarching structural challenge which I will address at a site adjacent to the Fort Point Channel neighborhood in South Boston is one facing many cities around the world: **How does one reconceive foundation systems for spanning over shallowly buried subway and highway tunnels? How can designing and creating the structure of support in these areas enable more – rather than less – creative spatial possibilities above the ground?**

More specifically, this thesis asserts that architecture as a discipline and as a creation can negotiate urban conditions and grade separations with structural gestures, shaping the spaces and volumes immediately above and below the constructed ground, and thus addressing both pedestrian and vehicular movement in urban environments. Therefore, in the course of the eleven aspects which follow, I seek to further clarify structuring as a means of articulating quality in architectural design and urban communities. This proposal for quality is based on the fundamental belief that it is good for structural devices to contribute as part of larger systems and entities beyond the internal resolution of a design, to be part of a "machine" rather than simply an isolated "spare part." The project leaps between the scales of internal structure and the external urban realm, and situates architecture at this boundary.

The negotiations of this project are as follows, including in parentheses the aspects of the design which they present:

1. **Spare Parts and Machines** (patterns of structures in cities)
2. **Optimism and Progress** (precedent studies)
3. **Objects and Systems** (history of site development)
4. **Sections and Plans** (recent planning proposals for the site)
5. **Conditions and Possibilities** (support strategies)
6. **Foundations and Imaginations** (options to envision)
7. **Shaping and Efficiency** (guidelines for finding form)
8. **Firmness and Utility** (exploration of elements)
9. **Referentiality and Nature** (natural systems)
10. **Risk and Bundles** (implementing combinations of elements)
11. **Markets and Values** (detailed design exploration)

Fort Point Channel and the district of historic buildings beyond, 2006.



Chapter 1
Spare Parts and Machines

Architectural design involves the envisioning and the creation of objects and spaces. These are reciprocal, inseparable tasks, and from the objects and spaces that architects envision and represent, some of these are created on a real site, built at a particular time and place.

This would not yet seem controversial yet it is hardly the convention by which most parts of cities have been or are being created. Architects design such a small percentage of buildings in the United States and around the world that it would hardly be considered typical to have a full architectural consideration of an ordinary building or group of buildings in a development. Many commercial buildings and suburban retail establishments are built from universal models applied regardless of location, and ordinary home builders employ the same designs across widely different topographies and climates [Turkel 1999]. Beyond individual buildings, much of the land and structures of cities are determined not by architectural designs of their spatial character, but are instead the realm of traffic and civil engineers who specify infrastructure, and government officials who determine development regulations.

Furthermore, the notion of architecture as the orchestrating of designed **spaces** instead of the craft of **objects** is a very recent conception, which originated with the flourishing of modern conceptions of space independent from walls, piers, columns, and discrete rooms. [Vesely 2004] One could even assert that such a conception of "space" as an entity in and of itself is a reflection of the greater possibilities enabled by structural innovations at the scale of interior spans and exterior infrastructure.

The central task of this design thesis is to articulate how structure can contribute to the whole of a community rather than structuring the building alone as an isolated resolution of internal concerns. This is what Charles Correa described as creating a component within the city as a "machine" rather than creating architecture as "spare parts." [Correa 2000] He noted how as architects we tend to excel at creating unique works of individual expression and it is often rare to find architects who are expert at inserting parts that are generalized and functional but mute about their individuality. The technological metaphor Correa employs is apt for at least two reasons. First, it highlights the importance of multi-scale systematization, of the city not as a physical form but as an interlocked group of dependent processes: social, ecological, fiscal, political, and so forth. Second, it recalls the heroic optimism surrounding the technological progress of cities as "machines" for living and working, while simultaneously critiquing the

Modernist results that too often stood as disconnected gestures.

But the modern city is more than a large collection of parts, functions, and processes: a rainforest, a wheat field, a copper mine, and an exurban automated manufacturing plant can each be analyzed as having many interdependent functional processes and inhabitants which produce and consume, yet they hardly resemble an urban city or its social spaces. Many cities, however, can hardly be considered uniformly urban in their complexion. Large municipalities in the United States are dominated in geographic area by varying stages of suburban development. For example, cities such as Milwaukee annexed huge swaths of land to include (stereotypically for Wisconsin) working rural dairy farms within its limits until the 1960s, areas which are now known as "the city" even if they are low-density suburban or even rural in nature. Yet if "rural" is equated with uninhabited territory rife with nature, parts of Detroit and New Orleans and other cities decimated by urban decay, unrest, disaster and abandonment, where wild grasses and other "natural" growth occurs across vast tracts of acreage, could be considered as having bizarre twisted "rural" qualities. In the informal settlements which house millions of impoverished people, these areas are "urban" in their density and complexity yet outside the realm of what any official municipality takes responsibility for.

A city can be defined succinctly as a **collection of active people and structures in close proximity who negotiate through various relationships**. These structures are necessary because, in the bluntest of terms, we need shelter. As Edward Allen states in the opening to one of his many architecture textbooks, "We build because most human activities cannot take place outdoors." [Allen 1998] These structures which are so necessary as a barrier between inside and outside do not, however, explicitly determine how the community contained therein inhabits and uses the structures, how its activities fit or do not fit within the container. I emphasize here the language of **structural devices** rather than only architecture, to purposefully include both buildings and infrastructure. Such an approach conceives the layer of structure as distinct from exterior cladding, interior decoration, and easily modified details. In this manner of thought I am indebted to Stewart Brand's seminal book *How Buildings Learn* and his understanding of ongoing temporal change in buildings. Moreover, such a perspective reasserts the earlier observation that most cities through history have had a minority of their constructed fabric designed by professional architects.

Brand's work, like that of Paul Groth, John Stilgoe, and others whose fascination with built culture is focused on "ordinary" buildings rather than only those "architectural" monuments that are typically recognized and lauded. This adds a wrinkle in Correa's analogy; viewing a modern city from a great distance and imagining its pieces categorized by creator would turn countless neighborhoods into a diagrammatic visual stew of structures constructed by builders, families, contractors, and engineers, but with only a sprinkling of designs by architects. This has been invariant even as the technical processes have changed or perhaps "advanced"; Renaissance masters' architectural output formed a potent but nevertheless small portion of Italian cities, just as university faculty and those at the technical forefront of structural fabrication generally succeed at design for the few rather than for the public at large. Therefore an examination of structures' contribution to social space within cities cannot be limited to "architectural" designs.

Furthermore, this position reframes the question of improvement or a positive contribution by a structure, adding to the argument a caveat that individual pieces of architecture (or, more precisely, of structure) made better through technological processes do not necessarily add up to an optimal whole; spare parts do not inherently produce a machine. This is not a generalized notion of respecting "context" but rather an acknowledgment of how the complexities of communities make the positive contribution of "better" architecture comprehensible primarily through experiential knowledge beyond the immediate site of a single structure within a community.

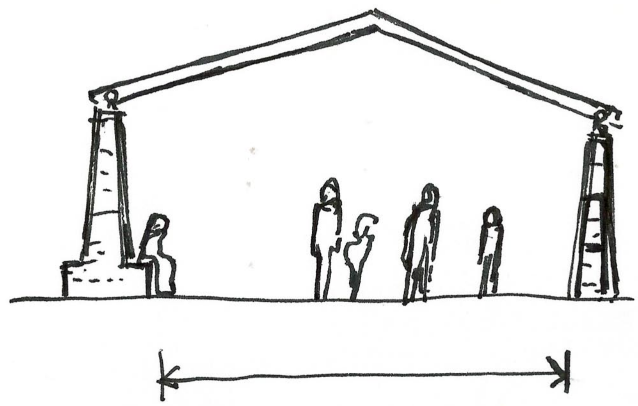
But if individual structural designs tend to envision unique spare parts, while urban design tends to envision machines and assumes that workable constituent parts exist, how can we characterize the moments where the structural and the urban approaches overlap?

Structural and Urban Patterns

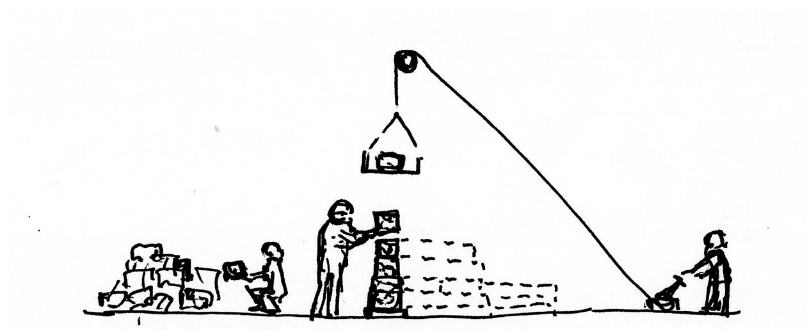
Taking the assumption that physical structures contribute to the social life of a community that inhabits them, this can be characterized more rigorously by working from experiential knowledge toward specific abstract patterns of recurring qualities. These patterns are not all-encompassing nor complete, they are not totalizing in the manner of Christopher Alexander et al in the book *A Pattern Language*; instead the initial patterns presented here offer a point of departure that could be extended and contrasted with other types of patterns.

A preliminary step would be to state what this amorphous "social life" or "urban space" might involve beyond the realm of architecture. Briefly, it includes but is not limited to spaces intended or designed for the public at large, such as streets, plazas, transit systems, and "public" buildings for civic functions. Just as the human paradox of being a "societized individual" captures the dual nature of being both alone and a member of larger groups, I believe that for the purposes of this discussion that this type of life and behavior is characterized by situations which require the need to engage with and negotiate with other people without negating the possibility of individual experience. Such a conception of social experience is constituted by agonic spaces and times, where the density of people requires a capacity for difference or productive **negotiation, conflict, and tension**, rather than autonomy or the repression of differences [Coser 1956]. This idea implies a community where some (but not all) aspects or values in culture are held common, explicitly or implicitly. This is what I shall term the **urban realm**, for it is both spaces and times, events and actions which build the intangible sense that community is more than a sum of discrete persons. It is constituted not simply by inclusion; it requires participation. This realm encompasses more than spaces where accumulated people focus on individual experiences (as in a movie theater); it is possible even in private institutions that are not fully public spaces, and it is not limited by a specific dimension. It is always a potential within a space and a time and it must be sustained, it does not persist detached from inhabitants and their interactions. Aspects of communities that partake in this "urban realm" are rare in technologically advanced cultures where individual entertainment (by iPod) fills the transition between individual transportation (by automobile), individual workstations (each with their own computer), and individual dwellings (single-family detached residences). Yet as this thesis's discussion of technological modernism demonstrates, single-family homes, mass-produced products, and speedy vehicular corridors could still articulate some form of an urban realm through their physicality, their form and more specifically their structures that are experienced by many people. Architecture cannot by its sheer presence "create" community, nor create the ephemeral atmosphere of a vital urban realm (much as its practitioners and champions would love to believe), but physical construction is certainly not mute or inconsequential. This is because the physical fabric of the city exists outside of a single person's experience and perceptions. It can therefore invite or situate a participative urban realm, and several patterns can be conceived as identifiable methods by which this occurs.

Starting at a relatively small urban scale, nearly all human settlements have included some sense of differing parts. Not long after Catal Huyuk (c.6000 BCE) in ancient Asia Minor, there emerged a differentiation whereby houses are no longer interchangeable with temples and other non-residential uses. To fast-forward a few millennia, this is still present in the villages and towns founded by American settlers in the original colonies and states; aside from the earliest of makeshift settlements determined by sheer necessity to brave the weather, meeting-houses and churches became a signal of where a community existed, even if the residences at farms or mills remained dispersed. This is perhaps a minimal scale of urban interaction yet it is a sign that the community assembled material to create a space not for continual habitation or work but for gathering. Often this was a school near the town common or a primary road. In many American settlements, these buildings were constructed as wood-frame containers, humble and stately boxes of a dimension such that at the time of construction they were among the largest spans in their immediate area. The span is larger than that of a parlor or bedroom and it is a complete structure rather than a farm shed.



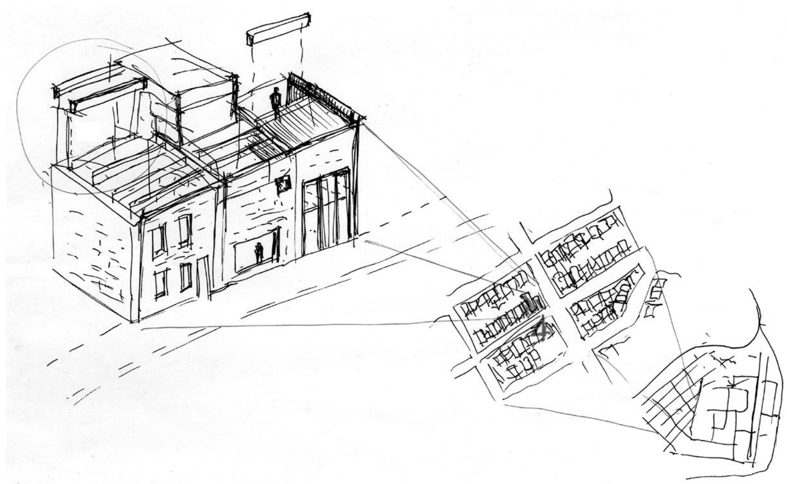
This is an example of a first pattern: **a structure contributes to the urban realm by being large enough to contain a community** (1). This may seem obvious, but finding a space whereby an entire community or sizable subset thereof can fit at the same time requires more than a collection of individual rooms but rather the structural span to enclose somewhere as a unity.



This invites a corollary pattern: **creating structures implies and is evidence of a society's effort** (2). Structures are evidence that some group of persons cooperated and endured the burdens of maneuvering physical stuff, often quite heavy, and placing it into some semblance of order. This effort may be the physical act of constructing, or monetary effort to finance it, or the political effort to back a proposal, but the actual existence of stones quarried and laid, of concrete formed, or of timbers cut and raised demonstrates that some definite effort was made. This is often evidence on the scale of local knowledge that is unbelievably valuable to the community that supported and perhaps sacrificed for a project. An example would be pride and camaraderie based on being able to share in the central brick schoolhouse instead of unheated small wood schools dispersed and disconnected. This sense of structure as a record of effort and therefore a way in which meaning is embodied for a community comes into play when demolition is in view; for those who attended the K-12 brick schoolhouse and decry its destruction, even though it has long been made obsolete by the district-wide “modern” high school campus; the structure is more than a list of assignable spaces or a building in need of repair. Structure that has in the past been sufficiently large to contain a community does not necessarily abandon its relevance even if the size of the community changes in number or age.

The pattern of effort seems distant in the mechanized world where architects and engineers are generally not elevated workmen. Yet the ability to get a structure or a group of structures constructed was a tremendous statement of situating a human community in a physical location ever since the first nomads stopped walking and started to dwell with some permanence. This narrative is also present in the growth of cities like Amsterdam since the medieval period, as each step of creating the city was a further boldly defiant statement against the power of water. Its growth is characterized by the triumph of human engineering motivated most often by economic expansion; the city was a record of the effort required and yet made necessary by trading cultures. Amsterdam’s accumulation of brick structures demonstrated the level of effort and risk that was physically possible and economically sustainable. Across the Atlantic the nineteenth-century flourishing of brick construction in New Amsterdam (by then known as New York City), in Boston and Lowell, and westward to Chicago and other cities, was a major change from the wood structures that had constituted these enlarging villages. Nineteenth century brick warehouses, mills, and other structures were a sign not only of permanence and economic development but a way of expressing the pride and values in such industrial development. Structural brickwork of this time could be extremely restrained and orderly, it could include corbelling and variation, it could express an owner’s or brickworker’s heritage. These buildings were containers for commerce and products being produced or traded or sold, but as a group the collections of brick structures are far richer statements of how a structure is both a container and an expression of social activities.

The principle pattern at work here is one that involves cohesion and difference: **the accumulation and repetition within a single structural typology can accommodate both variety and interdependence** (3). A district of mill buildings constructed as brick monoliths conveys the interdependence of all of the steps in a process; the variation of brick shops along a street, each with their own style and laying of brick encodes the importance of selling and promoting individuality among a group of neighboring merchants. A structure may also be a literal container for varieties in the goods themselves or in the people who gather to sell and buy, as in the countless port markets such as Faneuil Hall and Quincy Market in Boston.



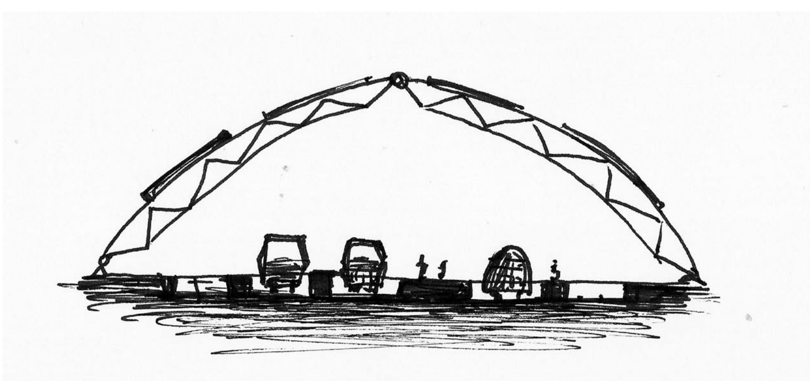
Commercial Row, Milwaukee,, WI, 2005.

The sense of interdependence may be more literal because of construction methods; in many cities the brick dry goods warehouses were constructed with party walls and with some continuous structural elements. For example, a group of structures in Milwaukee, Wisconsin known as Commercial Row (serving an equivalent role to the aforementioned Bostonian market warehouses) has had the issue whereby when one building has sunk or shifted due to interaction between the structure and the soil, its neighboring buildings shift as well. This interdependence can extend beyond historic brick structures: in developing nations' dense urban settlements, informal construction methods and the aggregation of incremental additions make adjacent structures fundamentally interwoven in cases of small individual modifications or large seismic movements. Similar structural solutions embody a shared social destiny through the same lifetime of components whether long (bricks in warehouse walls) or short (flimsy metal frames in a strip mall facade).

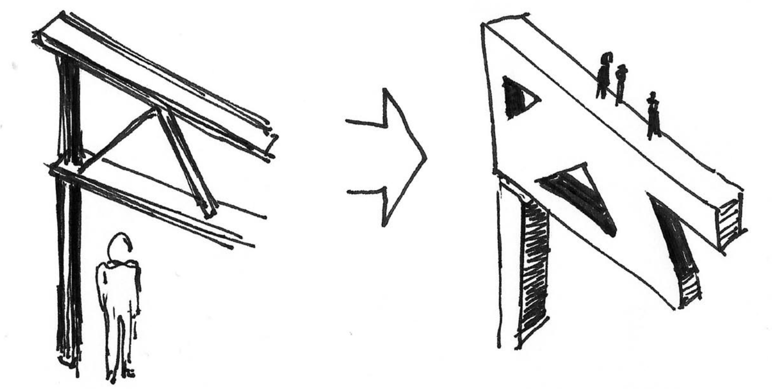
Newbury Street, Boston, 2006.

This extends to a related pattern: the repetition of similar structural solutions and materials articulates the structural elements as **small fragments that contribute to the whole within a mental map** (4). Neighborhoods are formed not only by streets but by the aggregation of a typology or material framework. At a smaller scale, while repetition of structural elements within a building or structure convey rhythm and space, perhaps also light and other phenomena, repetition of structural bays or entire buildings determine the scale at which they can be inhabited and re-inhabited as they outlast their original socioeconomic use. Where repeated structure is constructed with great longevity, the potential for a group of spaces to suddenly be of use to house a new community activity (as in the first pattern) becomes possible.

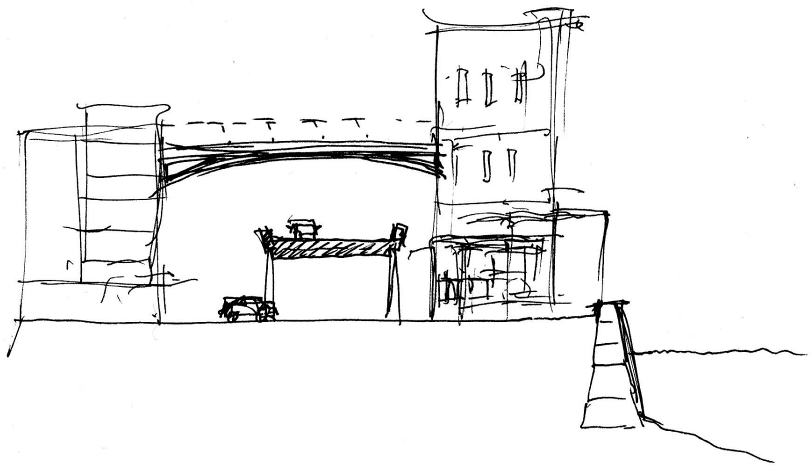
Such a transformation of a structure – in that case a load-bearing brick wall – is not always literal. Sometimes a transformation or transliteration of a structure is to allude to another precedent or typology, for an ordinary space to aspire toward something other than the banal. Back in Milwaukee, across the street from Commercial Row, the new Public Market is a fledgling attempt to rejuvenate the sense of a public market within the urban realm, a downtown destination that seeks to marry a giant suburban supermarket deli counter with a "old-fashioned" farmer's market enclosed by modernist concrete walls and overhead composite trusses. Here the form of the concrete, steel, and wood is unflinchingly that of the twentieth century, but the allusion (in both the competition program's text and the completed design's form) is to a transformation of "old-world" market precedents. In this case this was accomplished through the structure itself. The most lauded (and later lamented) of the precedent markets was of course Les Halles, the grand central market in the right bank of Paris roofed by elaborate ironwork and glazed clerestories, which stood until demolition in 1972. These iron vaults, championed by Louis Chevalier and countless other Parisian writers, situated crowds within the then-modern delicate forms of thin columns to allow for maximum selling area at ground level. The structures and their persistence from the age of iron construction stood for the continued presence of nineteenth-century forms of everyday urban life, of bartering with merchants from around the Ile-de-France to enjoy the foods and goods fresh from the French countryside. That the structures became deemed obsolete due to logistics of traffic meant that the social experience of shopping in such a milieu was no longer available.



The ironwork of Les Halles as a new skylit forum for shopping, the iron and glass arcades which reinvented the definition of commercial display spaces within blocks, and iron trusses which soared over 19th century train stations, are all examples where **structural technology and materials play a significant role in defining unprecedented typologies for new uses within cities** (5). Particularly in the last example, these giant trussed sheds brought the huddled masses of commuters together underneath a single gesture, transforming the act of many people gathering at a particular time from a ritual public event, into a liminal moment within daily transit. The changing patterns of time and work and the socioeconomic divisions of suburban and urban dwellers met within this characteristic new structure. The fascination with these structures and their relationship to mechanized movement and societal transitions is documented through their frequent depiction in Impressionist paintings and other artists who saw how the new structures rife with glazing could present conditions of light and space which captured the ephemerality of the new social conditions contained therein. Furthermore, the "urban realm" notion is particularly present in these spaces because these points of transfer between transportation systems became social places



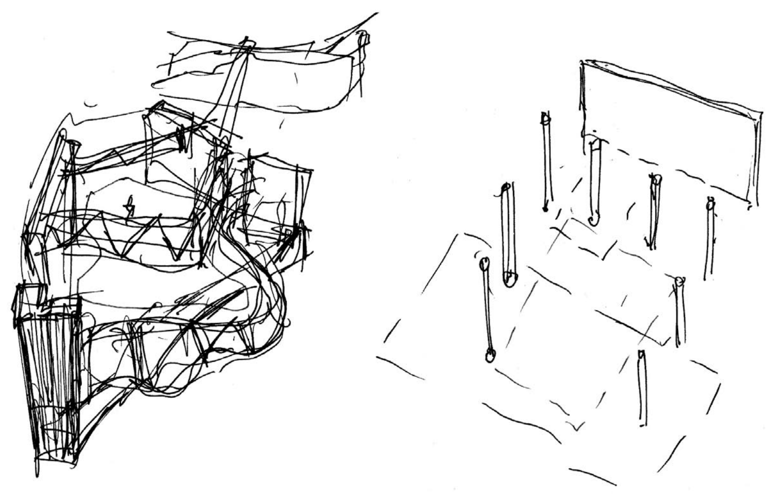
Ironically, the replacement for the demolished Les Halles was a multi-level subterranean shopping mall concourse. Its concrete forms attempt to refer to the structural gestures of iron arches and trusses, transformed into massive elements of reinforced concrete. Structures and materials are inevitably socially constructed and carry associations from where they have been experienced previously to different social groups: exposed concrete decks and beams may connote triumphs of modern architecture and honesty of materials, or the endless reproduction of panels for Soviet housing blocks, or the everyday annoyances of negotiating parking garages and vehicular infrastructure. Annette Fierro's 2003 book *The Glass State* explored these social constructions of materials relevant to late 20th-century structural devices in Paris, focusing on connections between glass enclosure details and social policies of institutional transparency. While not all instances are this literal, **changes of scale or material are not literal translations but rather have definitive social consequences** (6). Shopping within an underground mall under giant sculptural concrete forms analogous to iron or steel pieces is a radically different experience than inhabiting the original spaces with haggling voices echoing under the thin metal roofing panels. The social implications of an open iron shelter over a ground surface, continuous with the surrounding neighborhood, is a different experience of social exchange compared to browsing in the new Les Halles past French and international chain stores, focused not outward on the city but inward on lower level interior courts which are discontinuous with the neighborhood.



Structure has the capacity to frame and enclose the urban realm on a ground displaced from street level, but it also has the ability for such displacements to cause ruptures in physical and social continuity (7). Beneath the mall of Les Halles the Paris Metro stop of Les Halles-Chatelet is a multilevel basement of transportation infrastructure. This nadir is an emphatic suppression of civic transit, opposite from the celebratory scale of the other grand nineteenth-century train stations. Les Halles is therefore the Parisian analogue of New York City's new Penn Station after the original was demolished and submerged beneath the world of the commercial skyscraper.

But the contribution of structures that displace people from the street is by no means definitively negative. The displacement of grade-separated interchanges and urban bridges is a means by which communities can overcome divisions caused by topography and infrastructure. Moreover, it is precisely through infrastructure and its connectivity within and between cities that the urban realm is made viable. The proximity of people is meaningless without access, and access and mobility become requisite for firsthand participation. No matter how inwardly we strive to focus, transit and transportation is not only a means of using structure and infrastructure to allow for social movement, this creates situations whereby one must experience and negotiate some experience of difference with other passengers.

Yet the characteristic urban experience of people and structures in close proximity is no more static than a subway system at its peak flow. Both the social and physical fabrics of a city are in a constant state of flux yet are characterized by snapshots of stability. Yet even when architecture has been built and is temporarily stable as a structure, its configuration may still be changing conditioned by that structural stability. At the same time that Peter Rice's glass details, as traced in Fierro's aforementioned book, proliferated across the state-funded Grands Projets in Paris from the Louvre to Parc de la Villette to the Bibliotheque Nationale Francois Mitterand, the American Center sought a new home on the right bank designed by Frank Gehry. Gehry's sculptural methods of creation, and this project's combination of typical vertical walls faced in masonry and other free-flowing metal and glass volumes are typical of his work, in that a complex system of internal structure negotiates the significant differences between exterior forms and interior spaces. Funding the building and its elaborate configuration of exhibition spaces, combined with the immediate neighborhood within the Bercy District (which at the time of the project's completion in 1994 was not yet at the height of its economic rejuvenation), meant that the American Center could no longer afford to operate in its iconic, custom building. It took a significant amount of time and money to convert the brand-new structure to a new use as a cinema, which has just reached completion in 2005. The pattern made visible in this unique conversion of Gehry's work by another architect is that **there is generally an inverse relationship between the degree of structural specificity for a particular design concept and program, and the ability to easily modify the structure** (8).



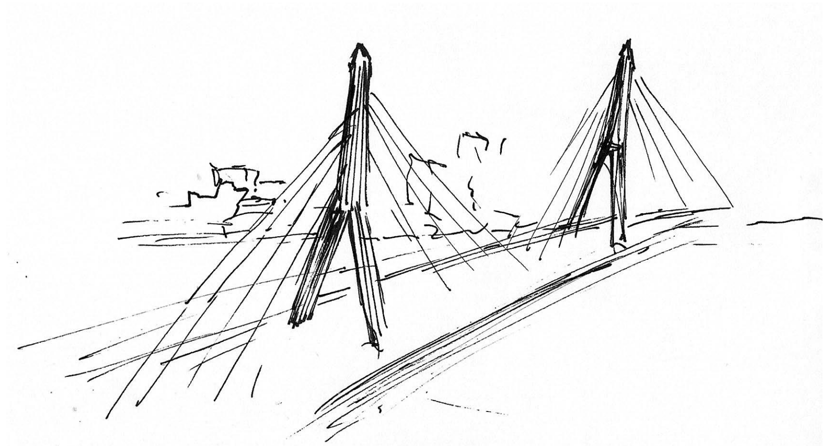
Gehry's "spare part" took a great deal of retooling to take on a new program in a way that far more generic structures admit more easily. A sustainable project, a building which Brand would describe as having the ability to "learn" and change to fit changing social needs, is a stable structural shell which admits many possible uses. I am typing a portion of this text within a century-old brick building, which at some point lost favor as a utilitarian garage and has been refitted as a group of restaurants and shops. The longevity of the structure prevented its demolition because it was economically viable. Contrary to the nature of countless architectural proposals, many structures are remarkably malleable in their use.

The text of a plan or program designating a space does not exert direct influence once ownership or the economy changes, but repetition and systematic redundancy of structural members is one way that structures can increase their resiliency and capacity for change.

More precisely, I believe that this forms the basis for how structures in many scales and manners are able to contribute to urban realms in their many manifestations (a general case of pattern 8): **physical structure encodes both conditions and possibilities for the social acts of inhabiting and changing spaces**. These conditions and possibilities constitute a dialectical relationship, ever evolving as the need for broader possibilities or for more specified spatial conditions becomes more prominent for a time within the effective life of the structure. Furthermore, the more resilient the structure's fundamental conditions are, the more possibilities for habitation and usage exist.

While Gehry's building may have lacked a certain adaptive resiliency, one need look only out of its windows to the adjacent new Parc de Bercy to see a catalogue of structures and materials reused due to resilient materials. The former wine warehouse district, the largest in the Western world at its peak 120 years ago, survives through its cobblestone paths and rows of vaulted storage buildings, their stonework now enclosing restaurants and upscale shopping adjacent to public gardens. But these changes communicate evolving modes of economically viable recreation at Bercy – from inebriated fancies outside Paris's city walls in the mid-1800s to Club Med World and consumptive tourism a century and a half later – and yet are relatively mute about communities of people and their culture as a community.

An example of structure reflecting the community over time, an example to which I am partial, and within which I have formulated many of these ideas, is the main group of buildings completed in 1916 for the Massachusetts Institute of Technology. Mark Jarzombek's recent writings [Jarzombek 2004] trace the role of engineers like John Freeman and designers such as architect William Welles Bosworth who proposed methods of providing institutional space on the newly constructed land facing the Charles River in Cambridge, Massachusetts. It is not a design that is a continuous extension of the city; it is instead a private community. Nevertheless, even for an institution whose members are stereotyped as, well, less than overtly social at times, this group of structures exhibits many traces of defining and influencing the urban realm for the community present. Nearly every pattern outlined in this discussion is present in this design for a community of research of learning; I shall examine this overlap in the section below, but the existence of multiple conditions leads to a meta-pattern that **it is good for a single structural device which is an appropriate solution to many problems to contribute in multiple overlapping ways** (9).

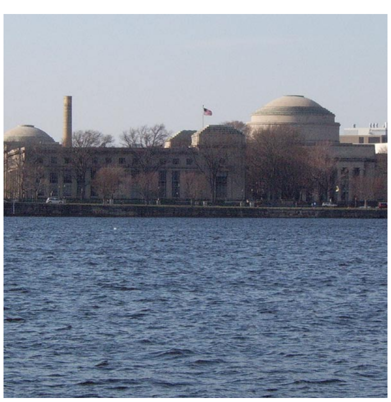


Finally, structural devices can contribute to cities simply through their visible existence: **Structural form and design can be a signature element which gives identity to a city or region** (10). Bridges and related spanning devices from the Golden Gate to the Brooklyn Bridge are particularly memorable and inseparable from the sense of place in those locations. The structures which enable previously impossible connections can even influence the identity of new habitations: near Niagara Falls, the town of Suspension Bridge, New York was named after the engineered span by John Roebling. Such valuable associations for structural devices are facilitated and enabled by the resilience and other properties elucidated in the other patterns in whatever combinations are present in individual examples.

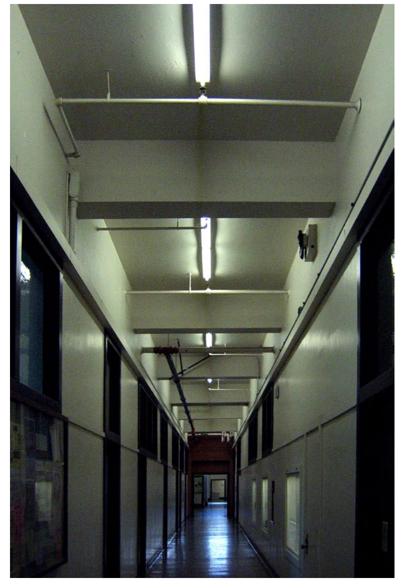
Overlapping Patterns

To state more precisely instances of the general patterns, I turn to the main campus structures at MIT. This contiguous group of interconnected structures forms one large reinforced-concrete frame building, answering the then-unprecedented question of how to house a technical research campus within the urban expectations of higher education. Some of the patterns are evident in its type and form: its response was an innovative combination of an early twentieth-century daylit factory typology with a neoclassical skin and hierarchy (5), topped by a landmark dome (10). It enlarged classical precedents to the scale now necessary and possible through industrialized construction (6). Its focal spaces for lectures and the domed library were the largest spans to contain gathering (1). Its erection of "modern" reinforced concrete and its unflinchingly rationalized ordering and numbering scheme is a material and organizational demonstration of technological effort manifest in an institution's physical container (2). Its three-bay-wide section, supported by sturdily massive concrete columns, has provided the conditions and possibilities (9) for

MIT, View from Charles River, 2006.



myriad changes such that the presence of interior renovations from multiple eras and group decisions provides institutional memory and a record of changing priorities (8). Its absence of internal barriers to emphasize continuity over division is a concrete translation of the social values of allowing departments to grow and inhabit different amounts of space over time rather than providing rigidly separate buildings for each discipline or school (3). Furthermore, the recurring presence of the unchanging columns allows them to be a datum of orientation amidst different spatial conditions surrounding them (4). Between the columns, the corridor at each superimposed level (7) becomes analogous to a street – not a mere path of circulation among related rooms but an inevitable place of meeting between different departments and people in vertical and horizontal proximity.



MIT, Corridor of Building 4, 2006.

These patterns, present with all the imperfections and haphazard contradictions of human communities within the resilient and ever-changing megablock of institutional space at MIT, allow its structure to contribute more than the mere resistance of physical forces. It is a discrete microcosm useful to conceptualize how these patterns can overlap but it is not a city; it is not even particularly indicative of the values present in the rest of MIT's other buildings and exterior spaces within its urban campus that vacillates between its character as a "machine" or as a growing collection of "spare parts." The group of buildings retains aspects of the urban realm when one views it inside of an architectural viewpoint, but this is not sufficient. The patterns themselves require deployment beyond institutions into public spaces to positively influence truly urban places for interpersonal interaction. Therefore the overlap of multiple patterns at a single place may be interesting but is not necessary for a positive contribution because a city is able to accommodate difference and variety in the manners by which its structures facilitate urban quality. When and where these patterns enable structures to not only contain and situate social actions but also become a resilient record of their changes and differences, structuring can not only demonstrate values but can contribute to the inclusive and participative nature of the urban realm.

Biological Metaphors and Patterns of Organic Growth

Implicit in the manner by which I have categorized and described structural contributions to urban life is an undercurrent of organic growth, whereby cities and their constituent structures grow and change over time. This is a model of metamorphosis that emphasizes evolutionary rather than revolutionary change. Such biological metaphors are common in descriptions of vernacular settlements or traditional buildings: "This kind of architecture, one shed after the other, is a little like the propagation of coral, or cactuses." [Laxness 2005 p.17] Peder Anker's recent scholarship has detailed connections between the founders of the Bauhaus and ecologists, both of whom envisioned forward progress in the biological growth and evolution of the environments humans inhabited. Yet we know that such characterizations of buildings' growth must remain limited to the realm of metaphor. Even in cases where the designer describes a process of growth and addition (such as Aalto's Experimental House in Muuratsalo, Finland and its intended pavilions), the buildings have not reproduced, each has been created or added onto through actions of an organism – generally a human, except in the obvious cases such as anthills, molehills, beaver dams, and so forth.

Biological models also recur in not only in the process but in the conception of structures. In nineteenth-century French structural design, Georges Cuvier 1769-1832), Etienne Geoffroy Saint-Hilaire (1772-1844) and their colleagues developed analytical and design techniques motivated by the study of dinosaurs, birds, and other organisms. [Van Eck 1992 p.216]. Cuvier and Geoffroy were diametrically opposed as to whether organisms' form was determined by their function (Cuvier) or that organic forms can be deduced from ultimate types regardless of function (Geoffroy). Skeletal structure and other medical investigations became analogically relevant to determining proper forms for structures inside bridges and buildings as these ideas gained currency with leading architects of the time, including Henri Labrouste and Leon Vaudoyer. Vaudoyer's interpretations of Gothic structures based on "conditions of existence being necessary to the work of man as to that of nature" led him to assert that "one had to proceed in matters of construction in obeyance with the laws of nature, that is, to have vertical posts [like trees] and to attach to them branches and ribs…" [Van Eck 1992 p.221]

The work of Cuvier influenced German architect-author Gottfried Semper (1803-1879) in his examinations of how rich varieties emerge from simple patterns in nature, and advocated that "such a method, similar to the one followed by Baron Cuvier, when applied to art and especially to architecture…could lead to some knowledge of the natural process of invention" based on theories of style and type. [Van Eck 1992 p.228.] This led Semper toward a typology of basic elements in architecture, identified as being combined within patterns of structure. As historian Van Eck states,

> The similarity between Cuvier's and Semper's comparative theories lies, therefore, in the conceptual structure and orientation of the approach: they both attempt to order and understand the variety of created form by trying to detect a few basic patterns, limited in number, and to trace the factors and the mechanism by which all existent modifications or transformations have been generated. [Van Eck 1992 p.229]

A scientific-organicist approach based on natural laws and functions of structure led Gothic Revivalists such as Viollet-le-Duc in France and Upjohn and Eidlitz in the United States to conceive architectural production as a reflection of such natural concepts. Therefore by the end of the nineteenth century, architect and engineer John Wellborn Root, who was famous for designing the massive brick Monadnock Building, an early skyscraper in Chicago, asserted how architects should adhere to principles of typology and ornament, whereby both should be natural outgrowths of the function and structure of building. This is an understanding which permeated future generations of Chicago School architects from Louis Sullivan to Walter Burley Griffin [Kruty and Maldre 2001].

It is only more recently that the *formal* resemblance of natural elements has been conceived as a logical outgrowth of an organic approach. In that manner, the technologically adept forms of designers "inspired" by human or biological forms not only allows for conceptual parallels but literal resemblances. Thus the zoomorphic designs of Santiago Calatrava and many other designers have similarly drawn from formal comparisons of biological precedents, and this is a latest incarnation of the dialogue between actual built structural devices and metaphorical ideas of organic growth and organization.

Yet biological metaphors operate on another level in this discussion beyond biological growth and form. The principle of diversity within a population of given size results in an increased variety of stimuli (and corresponding responses) for that population; this can be metaphorically extended to cities. This can be evident in a formulation where heterogeneity and differentiation are characterized as positive attributes of cities and their constituent structures, in contrast to homogeneity and similarity. Structures such as resilient, changeable buildings that enable changes and diversification to occur are able to house a richer and more stimulating body of activities and possibilities. Therefore borders between different zones are the most varied and thus most stimulating areas, of far greater importance than individual centers. This line of thought can be extended into the sociology of urban life. In contrast to Emile Durkheim's classic approach of understanding unresolved conflict to breed violence in civil society, analysts such as Lewis Coser have recognized that people build community through contrast and conflict. This is at the heart of Coser's *The Functions of Social Conflict* [Coser 1956] and literature in this vein that celebrates the ability of physical urban fabric to situate incompletely resolved clashes of interest, occupation, and use.

This is how and why the structures which are able to embody productive conflicts and accommodate future changes without risk of failure are so potent, by their form and space accommodating diversity, both in uses (who and what) and in associations (memory and meaning). Accommodating diverse possible conditions is what enables for evolutionary growth rather than fracture and rupture. The forms of structures we see and occupy in cities are contested real estate, the result of conflict and negotiation, and a city intended to minimize or restrict the amount of dissonance is not likely to become the most strong and vital place of burgeoning activity.

To return briefly to the aforementioned example of urban markets, they are a place where the abstract concept of productive dissonance in cities is particularly redolent and able to be understood with concrete experiences. Like the original metal sheds of Les Halles, markets contain a wholesale group of competing stimuli, each negotiating and vying for attention in a manner entirely different from retail based on sealed plastic enclosure instead of sensory exposure. The visceral experience of an urban market has the tendency to level peoples' socioeconomic stratification and status because a person's identity doesn't matter when all the raw items are stripped of their architectural and sanitary packaging, and therefore confront each passerby regardless. The former markets of many European cities have now been fragmented and pushed outside to the suburbs, following the trend of pushing cemeteries and butchers and related activities deemed undesirable toward the periphery a century ago. Yet the refitting of Les Halles in Paris, Covent Garden in London, Quincy Market in Boston, and a variety of other places have each explored vastly different strategies toward institutionalizing the concept of productive conflict and diversity into a retail and shopping environment. Given the recent competition to overhaul the redesigned Les Halles in a new architectural fashion barely three decades later, the French are "institutionalizing rupture" [Richard Sennett, 28 October 2005] in an attempt for a more vital environment to be created: the appearance of urban diversity cleansed from disagreement, violence, and dissonance.

Therefore the ability of a structure to accommodate change in a city – such a seemingly simple and practical matter in the patterns identified earlier and a motivation of the design to come – is only the first layer of a much deeper issue: **how the best aspects of cities and the diversity their density can support can be created, while minimizing the undesirable side effects.** The recurring fear of riotous crowds, dirt and decay have been powerful motivators of suburban flight and the abandonment of faith in cities during the twentieth century and earlier, and those trends matched with an inability to change have hastened decline in many cities as well. In such unfortunate circumstances, evidence of a working machine soon evaporates and spare parts are all that remain. Cities are both hell and heaven, Gomorrah and Jerusalem, places of decline and of hope, places with buildings and structures abandoned and being reinvigorated, places of pessimism and optimism, places embodying the worst and the best of what human habitation can enable.

The appearance but not the reality of interdependence: Mural, Porter Square, Cambridge, MA, 2006.


The reality and articulation of structural interdependence, Newbury Street, Boston, 2006.

Chapter 2
Optimism and Progress

Architecture is optimistic in that it envisions a changed future, and it asserts that the changes are improvements [Carl 2004]. This narrative implies progress in some capacity, progress built upon values of what is considered "good," and therefore what should be improved or built or preserved. This fundamental assumption of progress is rarely discussed or questioned in architecture. The optimism that enables new intervention to be "improvements" is not unique to architecture or to design professions more broadly; our educational institutions often state their mission of serving the "advancement" of the arts and sciences, and our government has stated that it seeks "a more perfect union." As optimistic people we envision a better place, design, or world, and then strive to describe and create it. Our imagination, our images, and our words represent these efforts to move toward improvements, solutions and innovations.

It would seem obvious that we as moral humans should be engaged in some capacity with pursuing quality, of working to make things or situations "good." But how is quality or goodness expressed or defined specifically in architecture? How do we make something actually an "improvement" rather than simply a change? To pose a loaded, inherently multifaceted question which requires further qualification, "how can we make architecture better?"

Before returning to more fundamental questions of quality or values later in this thesis, the issue of progress requires closer investigation. In post-Enlightenment culture, on an increasingly global scale within and beyond the realm of design, faith in progress is often linked to technology. First widely used in the nineteenth century, the term "technology" took over from the "practical arts" and the products thereof, including architecture. Whether incorporated into the methodology of design, the production of physical documents or models, in the analysis of proposed structures, or in the fabrication and assembly of building components, technology is increasingly omnipresent throughout the process of architecture. Beyond "traditional" materials of stone, masonry, and wood, the advent of modern steel and reinforced concrete enabled not only construction out of these new materials, but also enabled the education and thought processes of design as a whole to become based on the physical properties (bending, deformation, torsion) characteristic of steel and concrete. With these new material capabilities, works of *infrastructure* – literally something *beyond* the scale of a typical *structure* – became conceived as tasks of structural design to be isolated into discrete, optimized solutions.

Modernist rhetoric surrounding ways in which design could express the spirit and drive of engineered, industrial progress led countless designers toward the systematization of their work. The impulse to systematize, to devise and organize logical processes, is the basis for computational design, modeling, and fabrication strategies that are at the present technological vanguard of architectural practice. Rather than merely cataloging the most recent innovations in such technologies of the past year or the past decade, including Rhino, CATIA and other well-known applications with parametric and generative processes, this investigation's perspective seeks to uncover the essence of mid-twentieth century Technological Modernism toward a more precise statement of how present pursuits of technology and progress can be linked to architectural quality. Contemporary issues of complexity, software, and computation are only limited manifestations of a much larger trend.

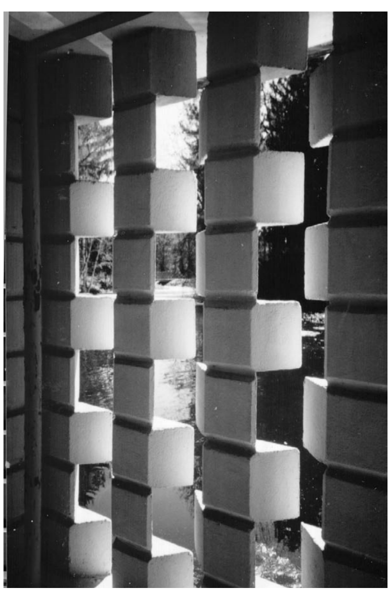
This is a narrative that designers and writers have explored for centuries, often drawing upon Goethe's stunning conclusion to Faust where the title character thrives on (and wrestles with) manipulating technology to develop his world. Building on the approach of Marshall Berman's seminal writings in *All That is Solid Melts Into Air: The Experience of Modernity* and Thomas P. Hughes' recent book *Human-Built World: How to Think about Technology and Culture,* this investigation seeks to conceive the optimism present in historical precedents as an effective tool for improvements in current design. In order to wade through the many narrative streams of historic and current thought with concision, these examples employ what Richard Sennett has termed a selective "post-holing" perspective. Far from being exhaustive or inclusive, this approach will therefore explore discrete precedents and examples of the processes and products of technological progress in architecture, specifically with regard to structure. It is an approach that seeks to be a critical appraisal of technology and progress, yet it also seeks to maintain (or even reclaim) some of the optimism and creativity so emboldened by notions of technological progress.

This era of technological history, from the late nineteenth-century ascendancy of mass-production through World War II and the years following, is filled with an expansion of large, bold creations for commercial, industrial

Optimal long-span thin shell concrete roofs for factories, Warsaw c.1960 [Zalewski 2006]

Terrace, Dow Home and Studio, Midland, MI, 1998.

Water Porch, Dow Home and Studio, Midland, MI, 1998.



and transportation needs. It is rife with massive skyscrapers, interstate highways, and other monuments but it can also be characterized by these less canonical but nonetheless incisive examples. Each of the selected examples here is presented with its strengths and challenges, to understand the methods by which each scale of an intervention allows structural elements to contribute to larger-scale perspectives, from *within* to *beyond* architecture. This scaling process is particularly relevant since the design process necessarily includes the creation and evaluation of elements at each of these dimensions.

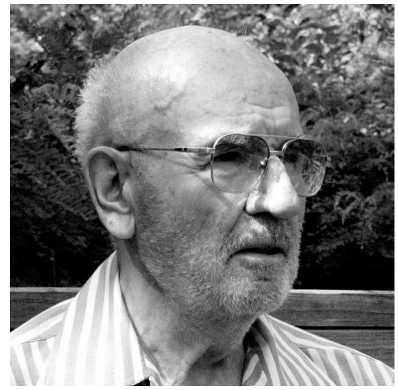
Scale of the Individual Building Block: Dow byproducts in Midland, Michigan

The son of chemical engineer and manufacturing businessman Herbert Dow, Alden B. Dow trained at Columbia University before returning to his hometown in rural Michigan to found an architectural practice that transformed Midland and its environs.

For Dow technology was not an abstract metaphor but rather a reality of modern living; his own practice served the town and its people during a period of rapid economic development, a local byproduct of the role of technology in American culture. Further, throughout his career idiosyncratic experimentations with leftover materials from the chemical plants occupied his spare time. While some experiments resulted in sculptural forms in colored plastic or other small curiosities at the scale of desktop paperweights and puzzles, his first and most prominent experiments was that of interlocked unit block construction. The technology that drove the local economy produced not only materials to be considered for applications in building systems (such as prefabricated insulated panels), but also waste that could be reconceived as a reason for innovation. The use of industrial byproducts enabled Dow's unit block system starting in 1934. This structural solution contributed to defining the unoccupied areas of sites beyond the walls of the unit-block houses through small-scale repetition; the extruded rhomboid building blocks could become disembodied from their structural role as fragments of the whole placed as columns, "folies" in the landscape, steps, or as terraces and extensions of the building. The purposeful omission of unit blocks allowed for pierced openings and screen-like enclosures. This usage also asserts the value judgment of views, the contrast between the structures' appearance from public and private areas in a community. The visibility and scale of the individual building block becomes a common element around the town, a similar technological equivalent to a brick from local soil or a locally quarried stone, yet with new possibilities for manufactured creation and creative reinforcement.

Scale of the Prefabricated Unit: Wacław Zalewski and Inventive Optimization

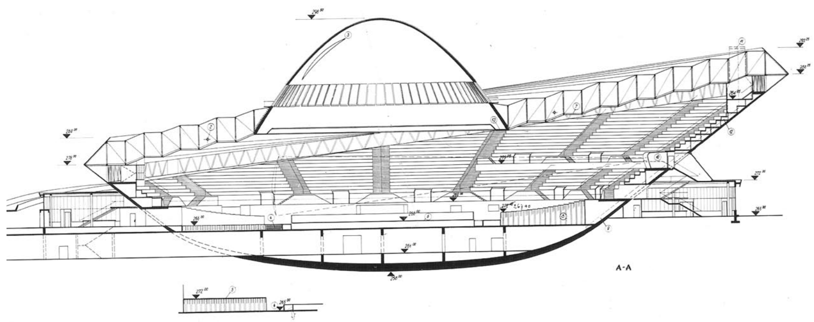
While many examples of architectural innovation attempt to pursue technological means without an explicitly chosen structure to the values behind the design, several potentially more articulate examples can be found in the structural work of Wacław Zalewski (b. 1917, Poland). In 1941, after receiving his bachelor's degree in engineering, while in hiding to avoid conscription into Hitler's occupying army in Poland, he formulated a personal philosophy in which the shaping of structures for optimum performance became his highest goal. His passion for inventive optimization has meant that in his structural designs he has explicitly chosen what particular aspect of a project's form or process of construction to optimize in quantitative or qualitative manners. Throughout his academic and professional career in Poland, Venezuela, and the United States, he has remained highly influenced by his wartime experiences in Poland before and during World War II, and his engineering philosophy reflects two simultaneous goals, of shaping structures according to their internal forces, and of designing efficient processes for their construction. These structures and examples of his teaching have been most recently featured in a 2006 exhibit of his work at MIT [See Appendix A]. Beyond the typical modernist tropes of honesty in material and structural expression, Zalewski's method of structuring, a lifelong pursuit of demonstrating structural truth, is also particularly process-oriented. He has considered in great detail the sequencing and efficiencies of building - as an act, a verb - in each of dozens of locations worldwide. Moreover, his desire to minimize excess material, to speed construction, to incorporate new forms and technological means of producing buildings, is driven not by the technology itself but rather by the moral imperatives of rational accommodation of forces and of material economy.



Zalewski at age 88, 2005, photographed by Paul Felopoulos and Ed Allen [Zalewski 2006]

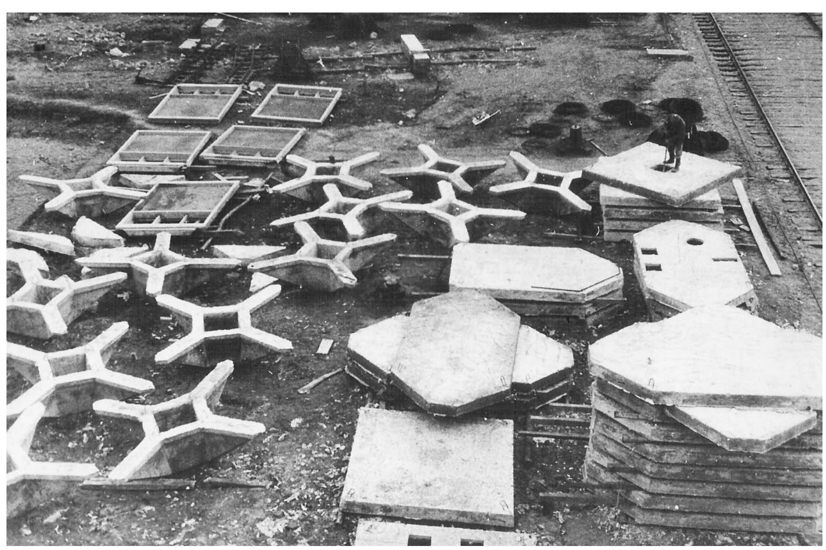
Far from easily categorized, Zalewski's work can be understood on spectrums rather than in pure categories, occupying the continuums spanning architecture and engineering, spanning theoretical mathematics and highly practical innovations. His buildings contain functions that span the continuum from the mundane to the celebratory, and he has enclosed these spaces with structures of an incredible level of quality. The work is truly architectural in that it shows how a master's highly inventive work can elevate constructed tectonics. Zalewski has applied his optimization skills to shape structural solutions that are both rational and inspirational. In describing the potential uses of the structural strategy employed at the Spodek hall in Katowice, Poland (1962-72), he describes this spirit of inventiveness:

Spodek exhibition hall, Katowice, Poland [Zalewski 2006]



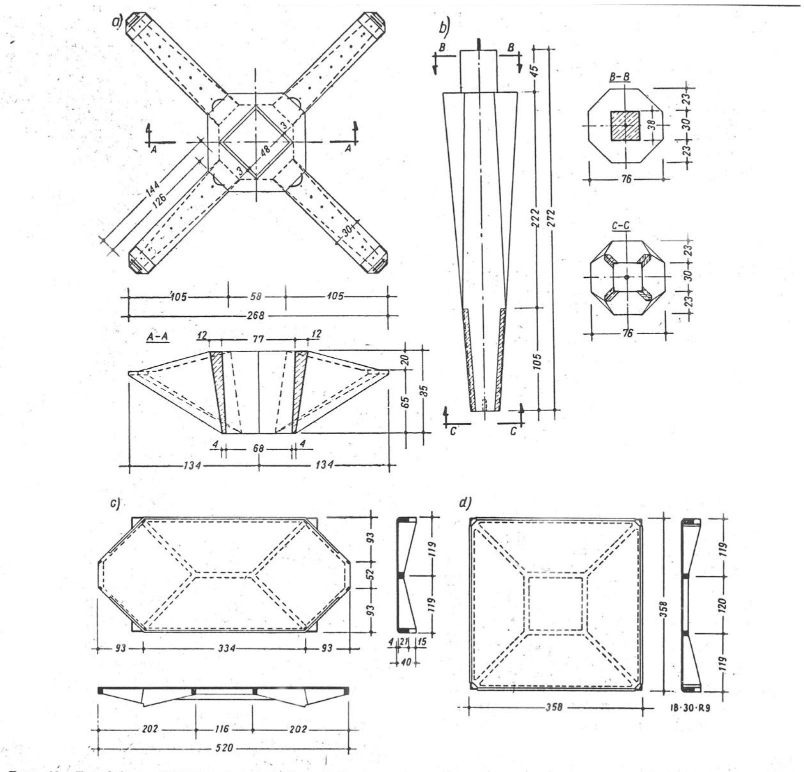
"The possibility for large...forms to be handled free from [ordinary] standing columns, vertical walls, and flat roofs, combined with the simultaneous task of finding a solution for functional and constructive problems, gives an occasion for creative invention. Such inventive possibilities, with both practical architectural tectonics and the artistic thought of antiquity, become the spiritual achievement of modern architects and engineers."

These structures, due to the projects' scope, are necessarily treated largely as discrete objects. Zalewski's solutions, however, are often so formally dynamic that their object-like qualities are highlighted dramatically. While his work and writings emerged primarily before the advent of widespread computing in design, his work is a harbinger for two particular contemporary manifestations of technological progress: that of ecologically optimized "green design" and that of formal complexities based on curvature, parameters, and other methods. These recent trends have been explored more broadly in Chris Abel's recent collection of essays *Architecture, Technology and Process,* but this discussion of earlier precedents in Zalewski's work shows how technical pursuits of minimizing material consumption and highlighting the flow of forces shaped his development of prefabricated concrete columns and capitals.



Concrete components for capital system ready for assembly, Warsaw, Poland [Zalewski 2006]

One can trace trajectories of elements and solutions in his designs across several decades and continents, such as one focusing on construction details of architectural projects that transfer floor loads to vertical columns through articulated column capitals. Such a trajectory is not arbitrary but rather a continuously developed and formally similar group of details, demonstrating the range of applications and solutions that extracted from initial experiments and fundamental structural principles. One of numerous efficiently shaped systems for concrete industrial buildings used a highly articulate capital system, whereby the entire structure could be constructed of four pieces cast on site: a tapering column, a four-armed capital, and two floor panels that spanned between and contained the funicular catenary force curve within their polygonal and tapering shapes.

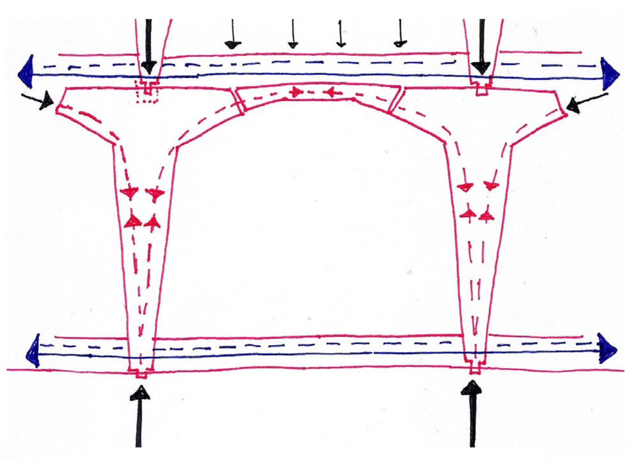


Rys. 10. Zasadnicze elementy konstrukcji: a) głowica G = 2500 kG, b) słup G = 2400 kG, c) płyta ośmiokątna G = 2200 kG, d) płyta kwadratowa G = 2300 kG

Capital System Components [Zalewski 2006]

This structural system, developed in the mid-1950s and implemented until and after Zalewski left Poland in 1962, was a response to the requirements of industrial storage equipment and the heavy live loads which were correspondingly present. The architectural potential of using articulated capitals to accentuate points of load transfer remained present in Zalewski's work over the next two decades. He translated the basic principles from the industrial applications to suit different loading and habitation considerations after the Venezuelan government hired him and he collaborated on many buildings there. Particularly for educational buildings in Merida and Valencia, Venezuela, he integrated the precast capitals into buildings with far wider spans and significantly lower live loads than the Polish prototypes. This allowed for thinner and flatter capitals and for their integration within the coffered floor slabs. Finally, in his collaboration with architect Carlos Villanueva, Zalewski's prefabricated stellated forms were translated out of their role as column capitals into a modular space-frame floor system. This application, for the extension of the Caracas Art Museum, marked a return to substantial loading conditions, designed to support modern sculptures of more than 6 tons. Yet instead of having the role of hidden internal support, in this project Villanueva and Zalewski emphasized the spatial depth of these precast forms and the connections between this system and the exterior walls to create a vibrant backdrop for the interior and exterior spaces.

The details of the prefabricated components can be understood through one variant from the Polish years working as a professional engineer with Buro Bistyp and CEKOP for over 15 years, during which he developed shell roofs, funicular beams, and a variety of other systems and projects. The column-capital system for efficient construction of concrete buildings which he developed with J. Draguła was initially intended for industrial storage rather than factories but its additive potential allowed it to have accommodated a variety of uses within its limited parts. The capital system consists of four discrete types of elements, all of them precast on the building site: a tapered column; two floor slab components, one hexagonal and one square; and the "capital" component, which serves to transfer loads from the floor to the columns. After all these precast elements for a particular floor surface are in place, post-tensioning cables are laid on top of the floor surface. These run in both the principal directions of the building and in parallel pairs, one cable on either side of the bases of the columns. Then a concrete topping is poured over the cables onto the precast piece to create the finished floor. After this topping has cured as a slab, the post-tensioning cables are stressed, causing the finished building to behave as a monolithic whole.



Capital System Force Diagram (red = compression, blue = tension) [Zalewski 2006]

Zalewski envisioned his as a modern reinterpretation, in precast concrete, of stone cross-vaulting techniques pioneered by ancient and medieval masons. The profile of the assembled arms and slabs is a funicular arch, and the horizontal component of the arch thrust is resisted by the post-tensioned cables. A number of variants of this system were produced in a process of development that sought to make the profile of the structure express more elegantly the arch-like structural behavior, and to simplify the formwork and details. Most of the built examples in Poland were for industrial storage, but the system was also extended to far more expressive applications including office and apartment towers and other buildings for human occupation. Buildings of many types continued to be constructed with this system even after Zalewski left Poland in 1962. Zalewski's was certainly not the only precast concrete system for industrial building during the early and middle portions of the twentieth century in developing countries. Indeed, the highly articulate forms of the capital system exemplify Zalewski's work as a critique of the structural inefficiencies and inelegancies present in so many Soviet-era proposals for factory-based prefabrication. Compared to monolithic site-cast floors, this system used a third less steel and concrete, had smaller minimum vertical thicknesses, and had a far more simple assembly due to the small number of elements used.

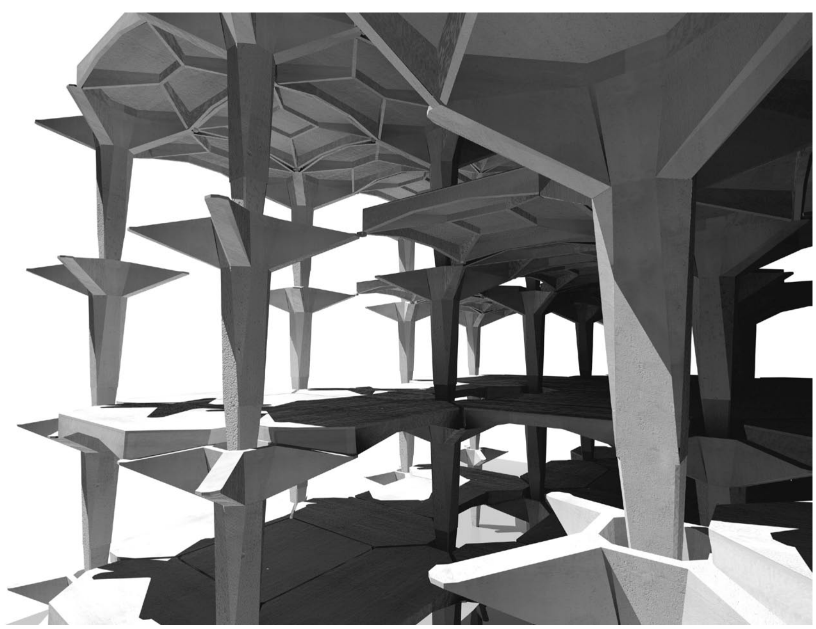
Yet historians such as Brian Knox acknowledge that such experimentation with precasting and other construction techniques to conserve material or achieve other efficiencies are among the most promising yet problematic aspects of Polish Architecture. During the Communist period, Knox notes how "rather wild experiment[s] stick out awkwardly from a great deal of bureaucratic mass construction...[but] there is still, as there has been for centuries, a desperate lack of skilled craftsmanship and good materials." [Knox 1971 p.6] While this lack of craftsmanship is not fully documented or justified, Knox does see potential strength in new buildings. He specifically refers to works with designs by Zalewski (only crediting their architects) as exemplary within Poland, including his factory roofs and his collaboration on the Super Sam market in Warsaw, but Knox is concerned whether exchanging faith in traditional styles for enthusiasm for prefabrication is really a resilient solution for Polish architecture:

> ...Had Polish architects merely exchanged one set of shiboboleths for another? The work of the last dozen years gives an uncertain answer. ...They have developed a remarkable skill in factory design, producing the airy charm...There is [also]...one splendid shop, the 'Super Sam' which Jerzy Hryniewiecki and the Krasinskis build in 1962, just south of the Plac Unii Lubelskiej, its 16,000 square feet covered by an asymmetrical suspended roof in great sweeping folds. This is all the easy stuff. The hard stuff, as everywhere else, is the great boxes in which bureaucracies expect human beings to live and

Super Sam market roof under construction, Warsaw, Poland [Zalewski 2006]

> work. They start off really discouraging; Stalinist housing schemes like Muranow ground their way on for years, covered in rudimentary pilasters and cornices...The idol of 'popular' architecture was cast down, only to be replaced by the idol of 'prefabrication', when the skill and precision needed for its worship were still sadly lacking. [Knox 1971 p.150]

Zalewski's capital system, which neither Knox nor other contemporary architecture writers seem to have been aware of, answers these challenges in two ways. First, the pouring of a thin slab to fill in the gaps and make the system monolithic increased the tolerances allowable in the precasting process. The system did not need to be assembled with watch-like precision in order for it to act effectively. Second, Zalewski saw this system and more fundamentally his approach as not only applicable to sculptural showcase-buildings (what Knox refers to as "easy stuff") but also to ordinary places for working and living. The beauty of this system is not just in the process but in the result: spanning elements could be omitted to allow for greater spatial variety, for atria and lightwells, for a gradual unveiling of spaces as one moves up and around and through the capitals and gracefully tapering columns. This potential was only visible at the time during construction before vertical shafts were enclosed, and recently as computer renderings have permitted visualizations of new spaces built with the same components. Yet the spatial potential is understood in this case as a benefit but not a goal of the engineered system. These designs reframed the role of technology as determined by the values embodied in the process of structuring a design amidst political economies conditioned by material shortages. These values demand the resolution of the project within and without, as inventive possibilities and technological solutions emerge from the world of particular situations.



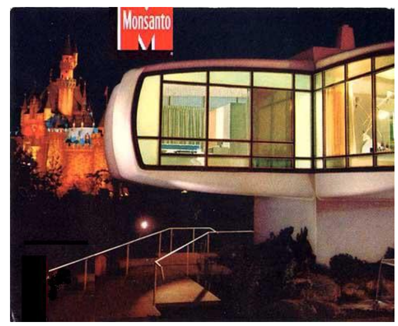
Computational rendering of capital system as shown by Jeff Anderson [Zalewski 2006]

Scale of the Building in a Neighborhood: The Monsanto House and Deployable Habitation

One of the major narratives in the optimistic promise of technology has been the materials and methods that would adapt to change. With flexibility and transformation as buzzwords, domestic and commercial spaces became the ground for corporate proposals like that of the 1959 Monsanto Corporation's model House of the Future and its contemporaries, which showed how entire curvilinear composite rooms, wings, or dwellings could be deployed at will. The will to create in this system, however, required centralized technological standardization and manufactured control, creating a challenging distance between the structural innovation, and the possibilities of how individuals' deployable inventions could exist in a community.


Monsanto House of the Future as drawn [MIT Museum]

Therefore, out of the optimism of technological modernist innovation sprung a prototypical house, designed in collaboration between Monsanto's plastics engineers and MIT's architecture department. While it was one of many ideal model homes set up around the country, prefabricated designs that used exciting new materials and promised to be inexpensive for "do-it-yourself farmers and suburbanites…to buy and fix up in their spare time," the Monsanto example was qualitatively different [Haddow p.69]. Its venue, erected within the Hall of Chemistry exhibit at Disneyland in Anaheim, California, gave it a visibility and a context of fantasy that meant it was both more proximal to great numbers of visitors, but also more distant because it was part of a "Magic Kingdom" rather than a product of vendors at the local fairgrounds. Robert Haddow traced connections between the Monsanto design and Levitt's suburban precedents in his article "House of the Future or House of the Past: Populist Visions from the USA," describing the Monsanto example as follows:



Monsanto House of the Future as built [MIT Museum]

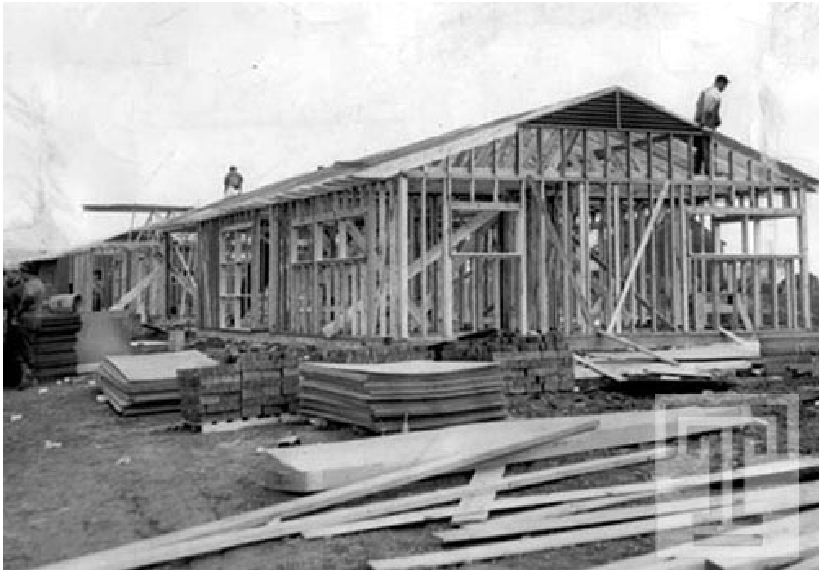
> Its popularity was ensured by a combination of old-fashioned family togetherness and a hi-tech prefabricated structure. The "House of the Future" was the Levittown salt box of the 21st Century, a place where vacationing suburbanites could view their future as envisioned by several American housing corporations. Most post-World War II attempts to transform the housing industry into a more profitable venture were drenched in populist rhetoric by builders who viewed themselves as saviors of the American family and the American dream…That Disneyland would have a model home of some sort was almost inevitable. Walt Disney was to the arts what Levitt was to the building industry, searching relentlessly for the lowest common denominator in rural humour, fairy tales, frontier myths and futuristic fantasies and then packaging his products into the most widely available formats. [Haddow 1999 p.69]

Like Levitt's houses, the Monsanto house emerged from an idealized view of domestic arrangements, providing spaces for a "normal" nuclear family to exist, albeit within spaces made entirely from synthetic materials. The cantilevered design centered around a small but focal kitchen workspace, similar to earlier Usonian designs by Wright in diagram if not materiality, and based its conception of modification around macro-scale changes with entire cantilevered structural bays being demountable based on family changes. Assuming a future market for such bays to be bought, sold, and exchanged, the designers falsely predicted that a market would exist for thousands of these space-age designs where old-fashioned activities like cooking would be eliminated through technology. "The designers of the home assumed that people would not want to cook their own food or decorate their rooms with handicrafts. In the future, products would be 'personalized' through the exercise of consumer selection [Haddow 1999 p.71]."

Hence it is through occupants' roles as consumers – not simply dwellers – that the Monsanto design was both praised and also became irrelevant. The Monsanto house was based on an entirely different characterization of change, where alterations are made by choosing pre-conceived options manufactured and fabricated to specifications by design professionals. The design was purposefully cast as a synthetic prototype inflexible to "tinkering" by ordinary homeowners with additions and changes made with standard, readily-available materials. In this manner the Monsanto proposal is one of countless visionary ideas for houses and housing based on future predictions by professional designers which have promised efficient design through modular units forming spheres, geodesic domes, or other constructions "based on cellular form." Their conception has been based on radical macro-scale changes visible not through layers of traditional materials but through bold new materials and forms. These visionary qualities of Technological Modernism, contrasting the fundamental assumptions of conventional construction in neighborhoods, made homes of the future popular in World's Fairs, in roadside attractions, and in national amusements parks.

Levittown refinished attic [State Museum of Pennsylvania, 2003]

In many ways this period of investigating technological means of creating flexibility of structure had two faces: the flipside of synthetic machines for modular living was the proliferation of balloon-frame construction and other industry-standard forms during the twentieth-century. These low-tech structures' inherent redundancy has now enabled transformation and tinkering by inhabitants. Recent scholarship on Levittown [Kelly 1988, Kelly 1993, Hales 2005] shows its reevaluation after five decades of vast alteration as a precedent for iterative mass customization and users' generational differentiation of neighborhoods. Recalling the patterns of Chapter 1, it is crucial for structure to allow possibilities in time and space by which change and life can occur. This offers insight into the means by which accumulations of structures with comparatively simple



Levittown, PA under construction [State Museum of Pennsylvania, 2003]

technology can grow to positively define urban realms through modification, even if the individual changes are not macro-scale demountable or deployable innovations. The Monsanto example, for all of its optimism in technological solutions, was pessimistic toward individual, gradual, piecemeal modifications. While the Monsanto house envisioned large structural additions to be deployed or removed, the mass-customization potential of innovations within "standard" wood frame construction has enabled older construction to hold far more resilience and capacity for differentiation in the five decades since.

Scale of the Region: Robert Moses' Multimodal Parkways

While Siegfried Giedion championed Moses' pre-World War II parkways as harbingers of the modern expression of "space-time" with automobiles' speedy travel, Moses and his team created innovative regional structures as technical solutions addressing more than vehicular movement. Along with landscape architect Gilmore Clarke and architect Aymar Embury II, Moses' collaborators engineered the earliest multimodal, systematized circumferential parkways such as the Belt Parkway System (1939-1941) in Brooklyn and Queens, NY, based upon "grade separations" for vehicles and adjacent parklands instead of intersections with stop signs or traffic lights. This automobile-centered optimism, for modernizing transportation as a means of contributing to regional improvement, was expressed in the design aesthetic of the roadway alignment, site furnishings, and bridge structures to displace pedestrian, bicycle, equestrian, and vehicular pathways above one other. The modernist approach of superimposed circulation, celebrated from Sant' Elia to *Metropolis* and later implemented in countless shopping centers and campuses with "streets in the sky," found prominent early expressions not in buildings but in roadways and

The Belt Parkway diagram [Loyd 1940]

The Belt Parkway, 1940 [Brooklyn Public Library]

their grade separated interchanges. Dramatic sculptural structures of steel pedestrian bridges (exhibited in MoMA's "Built in U.S.A." exhibit in 1944) and stone roadway abutments formed a design aesthetic which articulated the relationship between regional vehicular transportation and a local network of pedestrian recreation.

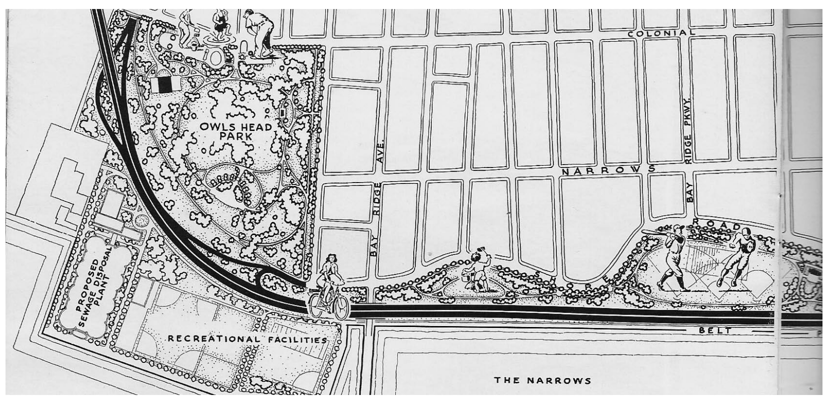


Diagram of Shore (Belt) Parkway near Owl's Head Park, Brooklyn [Triborough Bridge Authority 1941]

The current resurgent appreciation for localized design quality in roadways is not only apparent with respect to historic projects, but also in Jonathan Solomon's Pamphlet Architecture 26 which envisions possibilities for roadways captured by a "post-Fordist infrastructure" of local variation in contrast to the assembly-line sameness embodied in the automobiles of Henry Ford [Solomon 2004]. The Belt Parkway System, Moses' largest prewar regional solution and yet a highly localized intervention, set itself apart by emphasizing a group of distinct structures' designs and forms, distributed to reiterate values of neighborhood access within a technologically optimized framework for landscape and urban design. (Author's Note: I would like to thank Marion Pressley FASLA, Lauren Meier, ASLA, and the rest of their collaborators on the ongoing research and design work for the Belt Parkway, a project for which I was a research intern and contributor during 2004-2006.)

27th Avenue Pedestrian Bridge, Shore (Belt) Parkway, 1940, as exhibited at MoMA [NYC Parks Photo Archive]

Multiple Scales in a Contemporary Work: The Milwaukee Art Museum

The naïve notions of progress which enabled research, funding, and energy to pour into projects like those of Dow and Monsanto, or even those by Moses and his followers, equated progress with a faith in "modern" materials and techno-centric innovation. Given the five decades since, we can identify how such visions are incomplete and that the heroism of highways and prefabricated housing and countless other works is accompanied by a host of challenges. Such proposals attempted to be total systems which were often relatively inflexible in accommodating traditional patterns of living and urban conditions. Reactions to technological modernism have included overt contextualism, deliberate collage techniques and varying incremental approaches that attempted to avoid the quest for mere "progress" in the design of architectural objects (See Chapter 3).

Nevertheless, there are architects and designers who continue to attempt work with bold optimism at many scales without refusing the negotiation with many urban systems and constituencies. Rather than simply fracturing the existing fabric or blending in, this confident optimism allows projects to reach out and create strong relationships with the existing city. One basis for these externalized relationships (steps toward projects acting as components in a working "machine") is through the reaffirmation of pedestrian connectivity as a social value. This explicit value judgment contrasts decades of automotive predominance and has enabled countless cities to invest in streetscaping, bridges, and entire districts focused on active pedestrian areas.

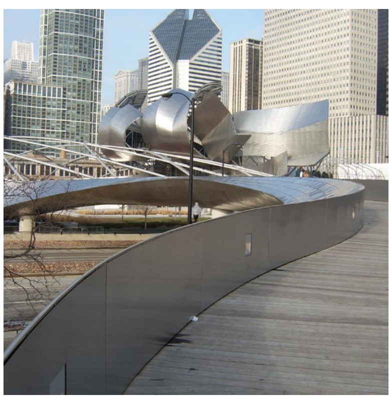
Milwaukee Art Museum, pedestrian bridge with view to central hall with brise-soleil under construction, 2001

A relatively recognizable recent project that is conscious of architectural and urban systems and demonstrates value judgments useful for this discussion is Santiago Calatrava's Milwaukee Art Museum Addition completed in 2001. (Author's note: My first architecture internship was with Kahler Slater Architects, the local firm which partnered with Calatrava to construct the museum addition. While I did not work on the project directly I was able to see construction site visits and appreciated this opportunity immensely.) While most of Calatrava's work, including dozens of buildings and bridges, is hailed for its expressive and highly iconic and figural) formal complexity, those are not the aspects which make this project relevant in this case. Rather, it is the particular fusing of a bridge and a building and the method by which the synthesized whole articulates the relationship between a banal parking garage and a cultural landmark.

When asked specifically about this fusion aspect of the Milwaukee project, Calatrava verbalized his focus on extending pedestrian access along the main urban axis, so that it would terminate not in a parking garage separated from the waterfront by a highway and its grade-separated interchange ramps. [Calatrava 2005] Rather, the bridge/building structures

Milwaukee Art Museum under construction, 2000.

the relationship between the waterfront and the street while emphasizing physical and metaphorical support for pedestrian axes intertwined with iconic landmarks. While the formal dynamics of the bridge and building are exaggerated, the conceptual gesture is most significant. This typology of a cultural landmark being integrated with a bridge is of course not completely unique; Corbusier's Carpenter Center at Harvard acrobatically elevates a pathway through its self-referential grid independent from the adjacent fabric, and Frank Gehry's art center at the University of Minnesota is attached to a delicate aluminum-paneled bridge which curves back toward the campus. Two hours south of Milwaukee Gehry's newly completed pedestrian bridge at Millenium Park in downtown Chicago is likewise an iconic piece of pedestrian infrastructure, one of many exuberantly reflective objects and spatial devices which punctuate the urban landscape above former rail yards and various subterranean parking conditions.



Millenium Park, Pritzker Pavilion and Pedestrian Bridge, Chicago, 2005.

But the bridge/building fusion in Milwaukee is unique among these in its deliberate emphasis of such a wide range of scales. Its double inclined masts are visible from airline approaches to the city and from great distances on land and water as a structural form which has become the characteristic image of the new waterfront on a regional scale. Its bridging aspect is strong enough to compete favorably with other downtown automotive bridges yet it has transformed the heritage of systematized technological modernism and therefore allows one to understand the grade separation not as a negation of pedestrian street activity but rather as a celebration of the span itself and the speeds it allows above and below. All of the repetitious site-cast concrete pieces are shaped with exuberant forms that exaggerate the forces beyond their literal needs to a level of expression that carries from the urban scale to the individual cable connections and individual extruded aluminum roof louvers. The site-cast concrete even extends the aesthetic of sleek skylights to the underground parking. It is a building that is both an iconic, particular landmark and yet also a container for more neutral, skylit repetitive spaces configured for galleries and visitor areas. Its structural acrobatics emphasize its character as an overtly confident object, well-connected to an existing city and essential to the existing museum spaces adjacent. It is visually an architectural “spare part,” to which any cable-stayed or cast-concrete landmark elsewhere in the city will become inevitably compared, yet it simultaneously redefines its role to operate within and beyond the systems of internal and external connectivity for vehicles and pedestrians.

Milwaukee Art Museum with pedestrian bridge connection to parking garage and the city, 2002.

Chapter 3
Objects and Systems

The previous precedents are widely differing manifestations of designed entities, from objects within wall systems to objects in the landscape within regional networks. Extending Correa's assertions about architects' tendencies over the past half-century to create spare parts rather than machines, that statement's allusion to the technological systems of energized, mechanized work implies that objects and systems are somehow opposed. Within a typical professional design and planning framework, either a person or group designs a system or an object, an urban master plan or an individual building within an existing plan. This is the assumption that underlies many academic studio problems, competition entries, and calls for proposals. Yet the responses to such questions are occasionally outside of clear boundaries and occupy the tension between the polarized ends of object-ness and system-ness. Thus we see the following:

- Competitions for master plans won by architects who also show their designs for the constituent buildings and parts even though it is beyond the requested scope (e.g. the World Trade Center proposals including that by Daniel Libeskind, 2003)
- Architectural projects become diffuse scatterings of interventions across a territory, or landscape proposals are inseparable from the architectural works placed within (Parc de la Villette by Bernard Tschumi, 1982-1989; Schouwbergplatz in Rotterdam and other works by West 8 / Adriaan Geuze)
- Building designs become urban places and events within a continuous folded landscape-roof-platform-plane (Foreign Office Architects' Yokohama Terminal, OMA's Educatorium in Utrecht, and so forth)

The prevalence of such ambiguous strategies – outside or blurring the traditional boundaries of design disciplines – points to their power and the impulse to at least conceive of a larger machine than an individual part. But what is the role of architecture when the object and the system are no longer clearly distinguishable?

Reflecting on the changes that have happened since the end of modernist orthodoxy in the 1960s, Spanish architect, educator, and critic Rafael Moneo has written and spoken on the emergence of changing attitudes toward architecture as it faces the issues of objects and systems. He states this fascination as follows:

> To explore the criteria by which architecture constructs

> form, to investigate which rules architects use to construct architecture: these would be the objectives and starting point of a theoretical discussion. [Moneo 2005 p.16]

Moneo conceives arbitrariness as a broad reaction to the dry classicism of modernism. This began in the 1960s and 1970s through combining elementary pieces and forms through collage or superimposition, to question the singularity of individual formal object-buildings in isolation. Particularly in the case of educator and designer John Hejduk (dean of the architecture program at the Cooper Union in New York), the visible presence of the hand and will in the fashioning of forms allowed his "masque" proposals to exude humanistic, surprising qualities rather than seeming a mechanistic result of a preordained system. Moneo traces how widely differentiated architects from Frank Gehry to Zaha Hadid to Thom Mayne explore combinations and juxtapositions toward visually exuberant results. These architectures of juxtaposition recur in a vastly different incarnation through systematic processes in the drawings and built projects of Peter Eisenman, whereby the architecture becomes presented as the design process itself rather than an object, making the designer's work the rules rather than the final result. This approach continues in the computationally equipped explorations of using scripts and programs to "generate" rules and forms, where the result involves choices of arbitrary inventions rather than consciously principled decisions toward the creation of geometrically acrobatic forms and spaces.

Yet in the past decade Moneo would contain that once again architecture is rejecting the previous trend of arbitrariness of form, negating it in a manner by addressing the larger global landscape more than the realm which architecture had previously occupied. Rather than making a "building," more and more projects *intervene* in the landscape and implement an environment which is constructed yet lacks a single recognizable mass or form. In such environments, the designed architectural elements surround those who experience them yet the architecture proceeds in "dissolving the body of the building and taking over the ground" [Moneo 2006]. This characterizes architecture's embrace and colonization of the realm of landscape design, from "objecthood" to "landscapehood" where that landscape is a manifestation of systems: natural systems, infrastructure systems, data systems, and so forth.

Yet for all of the interest in an architecture conceptualized systematically in its shape or organization, many of these projects require intense effort to become built; what we can envision so easily through technological means cannot be so easily or cheaply constructed except for institutions and clients who choose to underwrite experimental projects for their innovative aspirations. The private rules of a designer's system require a careful interaction with economic and physical systems to enable their systematic approaches to be more than a concept and part of the actual working facts of the proposal. Stating a systematic approach does not necessarily imply that a systematic process exists for making it manifest as reality. Moneo would respond to the trend toward systems with his conservative elegance, asserting that "Architecture should reclaim architecture to solve problem[s] rather than invent a new language" and to strive "for a motivated architecture executed with care." [Moneo 2005]

I would agree with Moneo's sentiments, but find it incomplete: I believe that in the case of urban sites shaped by many forces over time their conditions as well as their potentialities can be framed as a **stories of objects as well as stories of systems**. The two approaches are in tension but are complementary, particularly in the many locations where architecture must confront the existence of bold artifacts wrought (for better or worse) within a framework of Technological Modernism, the engineered infrastructure that is omnipresent across the world's developed landscapes. Granted, the tendency toward large structural and landscape interventions is not inherently un-architectural; it is through the crafting of making such systems fully articulated that they become architectural contributive fragments [Vesely 2004, Chapter 7]. Such fragments can therefore contain perceivable aspects of an overall whole, resonate with the deeper order of the city, and therefore be structural devices that deservedly claim (and reclaim) the fullness of architectural and spatial character.

Therefore in proposing a system for dealing with the subsurface conditions through a foundation system interrelated to and with the building superstructures as resulting objects visible above, this thesis extends the proposal by confronting a specific site where the objects and systems present are particularly bold and redolent. This relevant history – the overarching patterns, precedents, and theories at hand, and the particular histories of objects and systems belonging to a place – enables a future proposal for a spatially rich environment. Such a proposal, which spans objecthood and landscapehood, imbues the systematic components with experiential qualities in form and space, and allows the physical, structural, systematic aspects to contribute to the character of the objects themselves.

Site Description and Historical Sequence: Fort Point Channel

The Fort Point Channel Historic District is an area of buildings on artificial land next to a shallow water body, the Fort Point Channel, which borders the downtown core of Boston, Massachusetts. It has recently been designated as a National Register district and much of this context is drawn from its nomination.

Abstracting from the full history, the sequence of key events and actions that have shaped the place are as follows:

- Playing a prominent role in colonial maritime history, including being the site of the Boston Tea Party;
- Ownership by the Boston Wharf Company and decades of building wharf walls along the channel's edges;
- Building railroad causeway bridges and other moving infrastructural connections;
- Constructing the land by filling above the shallow flats and creating buildable lots;
- Creating streets and architectural containers above for profitable uses;
- Investing in one work of a civic nature, the Fire Station as a public safety infrastructure;
- Developing an evolving regulatory framework as the occupants' changed from industrial and commercial tenants to members of a prominent artistic community; and
- Negotiating with the current conditions of widely recognized potential which led to the construction of the "Big Dig" highway tunnels, the Boston Convention and Exposition Center, and the Silver Line underground bus tunnel.

Exit Tunnels beneath the Fort Point Channel Historic District, 2006.

Historic buildings at the rounded corner of Melcher and Summer Streets, 2006

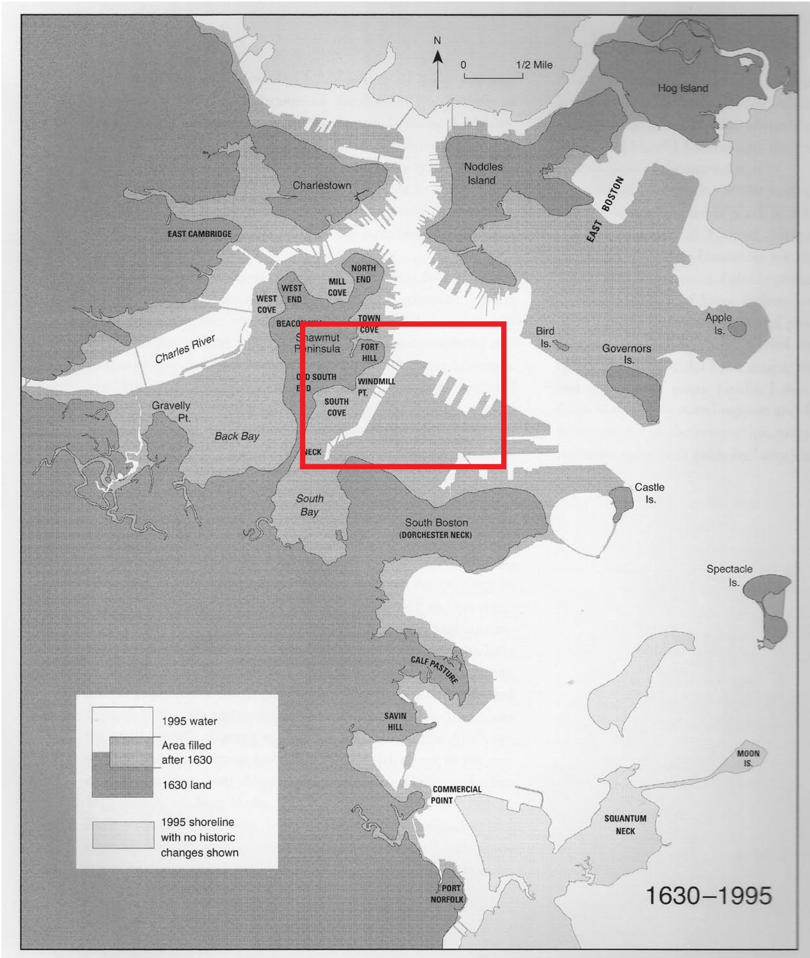
As it currently stands, the neighborhood is a collection of notable objects and structures that are representative of the broader system of urban loft construction:

> The Fort Point Channel National Register Historic District…is a roughly 55-acre site…contain[ing] 103 buildings and 11 structures (Specifically, four bridges, a prominent chimney, and two sections of seawall along both sides of Fort Point Channel, a ca. 1920s Boston Wharf Company roof sign, and a monumental milk bottle built to advertise a milk company). Eighty-nine buildings and 9 structures are considered contributing…Very few buildings have been constructed in the district since 1929. As representatives of original function, period of development, and building form, the area is remarkably uniform and distinctive. [NR Nomination Section 7 p.1]

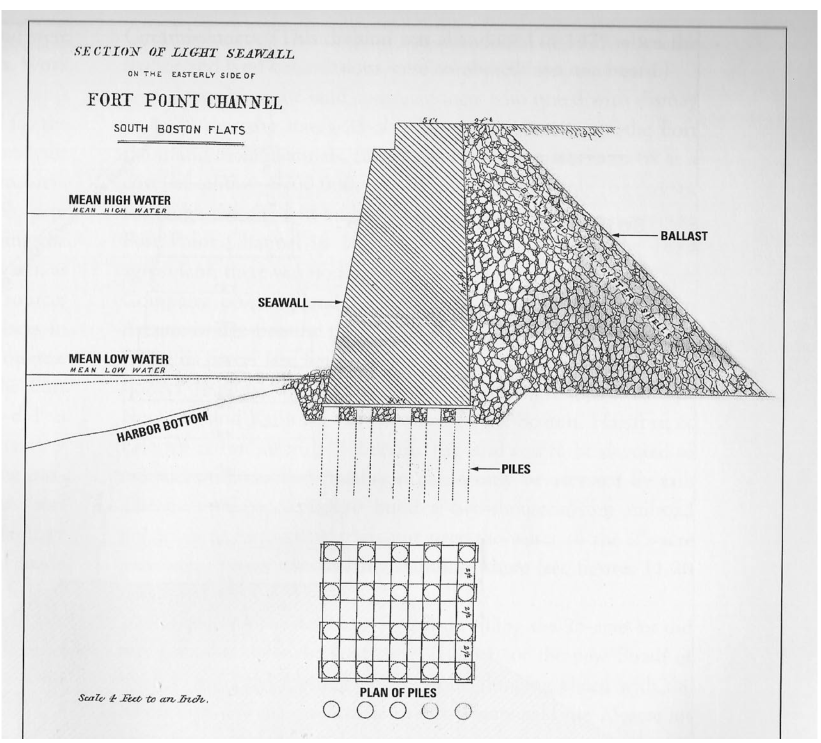
> The district represents the sort of urban loft district on the periphery of the commercial core that was once a standard and vital part of American cities…the district itself, given the many lofts built specifically for the trade the wool trade that are still standing and not significantly altered, embodies this history. …The district's lofts are also fine examples of a method of construction… The buildings of the FPCNRD are significant as excellent representatives of the loft type of structure, for the structural systems used in these buildings, and for the high quality of its design. …The district is architecturally significant as an unusually coherent and well-preserved collection of late 19th and early 20th century lofts. Not only individual buildings, but entire streetscapes survive largely intact and unaltered… [NR District Nomination, Section 8 p.2]

The narrow channel of navigable water across from the historic military site at Fort Hill has long been a desirable waterway adjacent to downtown Boston. Several blocks to the west, in a location adjacent to Fort Point Channel which is now landfill, several eighteenth-century merchant ships were temporarily moored; the vessels and this location became famous for the "Boston Tea Party" which ensued when they were raided by an angry mob of tax-protesting Bostonians on December 16, 1773. The replica of the ship recently suffered a fire but it is projected to be returned to Fort Point Channel along with a new extended museum (2006-07).

As maritime activity continued, the channel was gradually walled to allow for development to be built up to its edge. According to the NR nomination, "the seawalls on both sides of Fort Point Channel were built according to boundaries adopted by the Board of Harbor Commissioners" [NR Nomination Section 7 p.1]. The wall on the South Boston side was "built of large granite blocks, began eleven feet below mean low water, was twenty-seven feet high, battered on both faces, and ballasted at the back with gravel and oyster shells." [NR District Nomination, Section 8 p.5]



Geographic history of landmaking in Boston [Seasholes 2003]



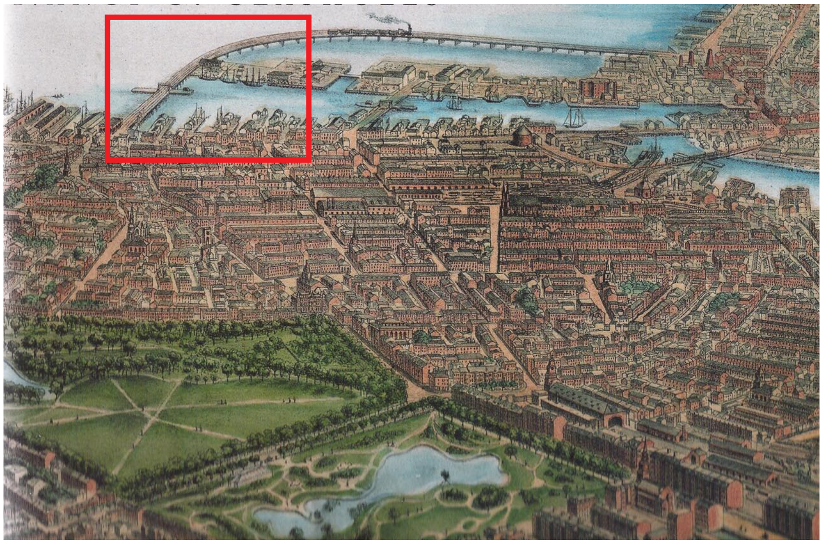
Section of Light Seawall, Fort Point Channel, South Boston Flats [Seasholes 2003]

Behind these continuous stone walls on piles, land was constructed from 1836 until 1880 according to plans by the Boston Wharf Company, which evolved from a shipping to a real estate company.

> The first meeting of the Boston Wharf Company was held on October 22, 1835. The company was founded to provide docking and warehousing for vessels coming into the port of Boston. The company purchased [tidal] flats and built wharves…Making land by leveling hills and filling the marshes and muddy flats that ringed Boston for the purpose of expanding the buildable area of the town is something Bostonians have been doing since the beginning of European settlement. Land-making was encouraged by the Commonwealth's colonial-era riparian law, which 'gives shoreline property owners rights to the adjacent tidal flats down to the low tide line or 1650 feet from the line of high tide, whichever is closest to the shore.' The original intention of this law was not to encourage land-making so much as to encourage waterfront landowners to build wharves. [NR District Nomination, Section 8 p.3]

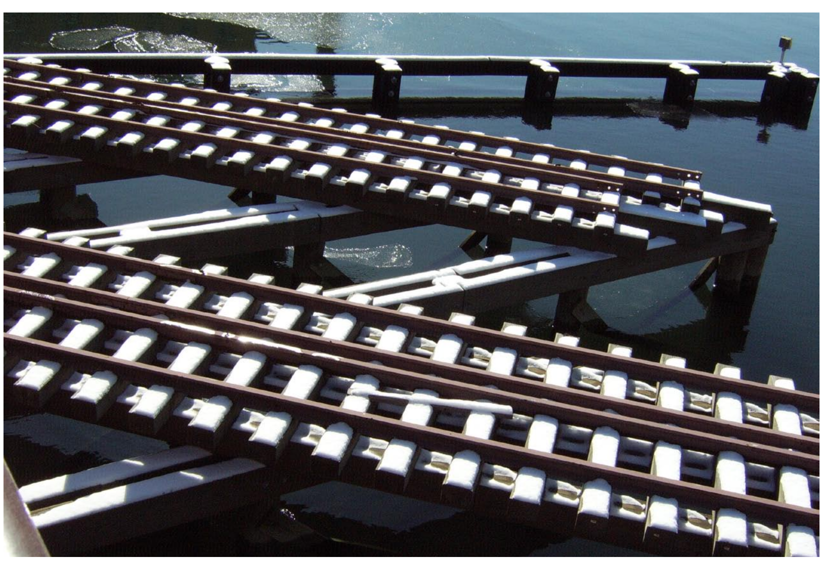
Beginning during the mid-nineteenth century, many temporary and permanent bridge connections crossed the channel. The Mt. Washington Avenue and causeway-like Midland Railroad bridge were constructed in 1855, followed by spans including the Summer Street bridge in 1898 and the Congress Street bridge in 1930. These bridges were crucial not only for daily transportation but also because they provided "four alternative routes for evacuating the city in case of emergency" [NR District Nomination, Section 7 p.2]. These bridges are not only works of resilient infrastructure but also elegant and dynamic designed works of American engineering. For example, "the significance of the Congress Street Bascule Bridge lies in its design as well as its technology. It is an overhead turning bascule bridge, of which only three survive in Massachusetts. The bridge was designed by Joseph B. Strauss, who also [later] designed the Golden Gate Bridge (1937) in San Francisco." [NR District Nomination, Section 7 p.3] The bridges that allowed the creation of Summer Street were particularly important to the urban design transformation of the district, negotiating the grade separations over the since-demolished railroad tracks:

> One of the most distinctive aspects of the district's appearance is the difference in grade between Summer Street, the area's principal traffic artery, and the other streets of the district. Summer Street was built in conjunction with South Station railroad terminals (NR), and the relocation of tracks that formerly crossed Boston Wharf Company's sites along with the removal of the railroad bridge spanning the channel. Summer Street Bridge was erected roughly at the site of the old railroad bridge and the street was elevated so that it could continue above grade on a viaduct over the railroad yards' part of Boston Wharf Co.'s site. The difference in grade is most apparent at the point where Summer Street is carried approximately 25 feet above A street via a small



Aerial drawing showing railroad causeway along what is now Melcher Street [Seasholes 2003]

Congress Street Bridge, 2006



Mechanism of Summer Street Bridge over Fort Point Channel, 2006

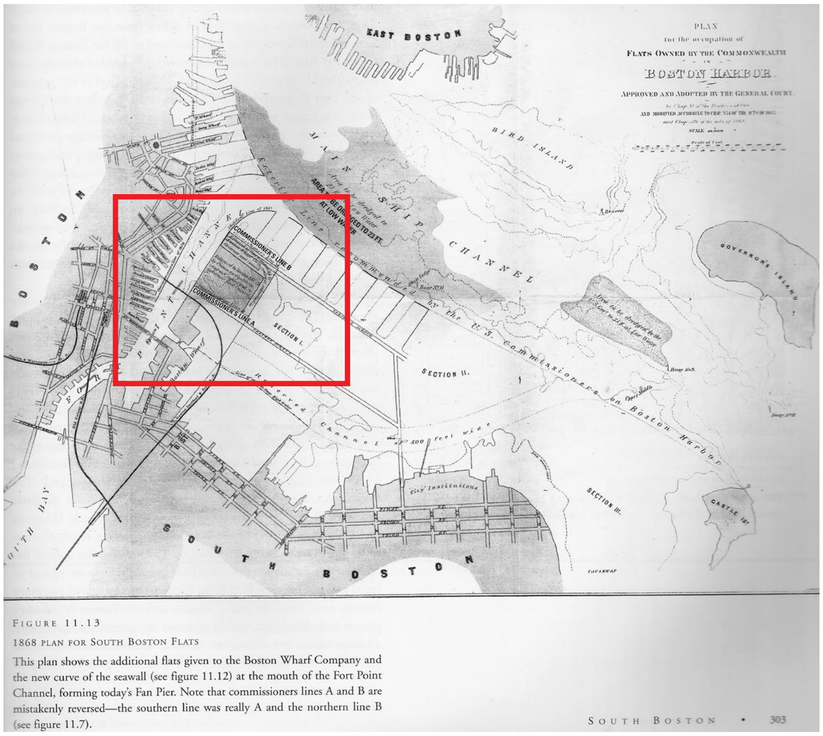
> steel bridge. The summer Street bridge at A street is supported by abutment walls composed of battered granite blocks. Pedestrian access from A street up to the level of Summer Street is gained via a metal stairway located adjacent to the bridge on the west side of A street. Vehicular access is via Melcher Street, which curves and slopes from Summer down to A Street. [NR District Nomination, Section 7 p. 2]

> The raised grade necessitated a bridge over A street and created the most striking urban design feature of the district: a road curving from the elevated Summer Street down to grade at A street. [NR District Nomination, Section 8 p.9]

These complex and dramatic urban streetscapes centered on Summer Street existed alongside a hierarchy of other asymmetrical street and alley profiles, bold infrastructure moves which enabled the architectural fulfillment of the district's primary buildings constructed from 1882-1929. The NR nomination recognizes how the design of street infrastructure systems optimistically drove the architectural potential for objects constructed on the sites: **"[The] Boston Wharf Company laid out streets according to plans for the eventual development of the land 'which anticipated the actual construction in such a manner that the work of building on both sides of Summer Street and adjoining streets was remarkably simplified.'"** [NR District Nomination, Section 8 p.9, quoting the unidentified author of *One Hundred Years of the Boston Wharf Company*, published in 1936]. These streets and passages had great variety in scale and configuration:

> Alleys lined with tall buildings are some of the densest parts of the district…These enclosed places, often framing views of the buildings in the district, contrast with the wider streets, Summer and Congress streets, which have views of areas beyond the district. [NR District Nomination, Section 7 p.15]

By the time when buildings were constructed in the late 19th and early 20th century, the Boston Wharf Company had fully reorganized as a real estate company; "it built structures to suit specific tenants, which it leased or sold to them." [NR District Nomination, Section 8 p.9] The buildings constructed by Boston Wharf Company on its lots near Fort Point Channel exhibit great fluency and variety within conventions of loft design. A great majority of these were designed by the company's two staff architects: Morton D. Safford from 1893-1917, and his successor Howard B. Prescott (1917 to 1939). "The District's buildings are excellent specimens of lofts, and their characteristics can help define the building type." [NR Nomination, Section 7 p.5] They included three types of framing systems: light timber, warehouse with heavy timber, and fireproof concrete floors with a steel reinforced frame.



1868 Plan for South Boston Flats [Seasholes 2003]

A Street, view toward grade separation at Summer Street, 2006

Summer Street Bridge over Fort Point Channel, view toward Boston Wharf Co. sign along Melcher Street, 2006

The heavy timber framing structural typology had been invented nearby: "Warehouse construction is a regional invention, and the district's lofts are valuable examples of the system, which spread from New England to cities around the nation." [NR District Nomination, Section 7 p.2] The street elevations of these loft buildings used a variety of Italianate and Romanesque revival details, as well as the widespread use of tripartite facades in three vertical layers, with simplified classically-styled articulation and a rhythm of arches on the primary facade. The architectural embellishment included unique local traditions of brick detailing:

> More unusual than the choice of the Italianate is the selection of the Panel Brick style to trim an otherwise plain building. This style flourished in Boston's Back Bay during the 1870s. The Panel Brick style expressed the nature of the construction material, and by forming it into decorative panels of projecting and receding brickwork, and laying bricks at unusual angles, created patterns and texture. This style allowed for imagination and freedom of expression without reference to any specific historical style. [NR District Nomination, Section 7 p.7]
>
> Streetscapes in the Fort Point Channel National Register District are characterized by a strong visual coherence stemming from similar massing and other common features. Building mass and density is unusually uniform throughout the area because most buildings are similar in height and are built out to their property lines... Architectural ornament is mostly concentrated at the entrances, windows and rooflines emphasizing these major functional parts. No projecting features other than roof cornices, parapet decoration, and three-dimensional ornamental details detract from the basic boxlike form... [NR District Nomination, Section 7 p.15]

Amidst these commercial real estate investments stands one piece of public investment, the Congress Street Fire Station, which was added to the National Register as an individual structure on September 3, 1987. It is the best preserved 19th century fire station in South Boston and a primary work of city architect Harrison H. Atwood which remains in essentially unaltered condition in its current use as a fire museum. It was the 75th structure of the Boston Fire Department, first occupied May 31, 1891 and serving until its deactivation on November 11, 1977. Its Romanesque front elevation includes an unusual pediment/chimney combination at the focal point of the façade's pinnacle. The interior used specialized structural techniques to hold it in tension from above and leave the space below clear for vehicular use. The NR nomination describes how "The plan of the interior is relatively well intact...The upper floors are suspended from the roof by an elaborate wooden truss system, allowing for an open space on the first floor with no column supports." [Fire Station NR Nomination p.2] **This structural strategy extant in the district is one which this present thesis investigation recognizes as particularly useful not only within buildings but amongst buildings to negotiate complex vertical relation-**

Panel Brick Detailing, 2006

Facade juncture along Summer Street, 2006

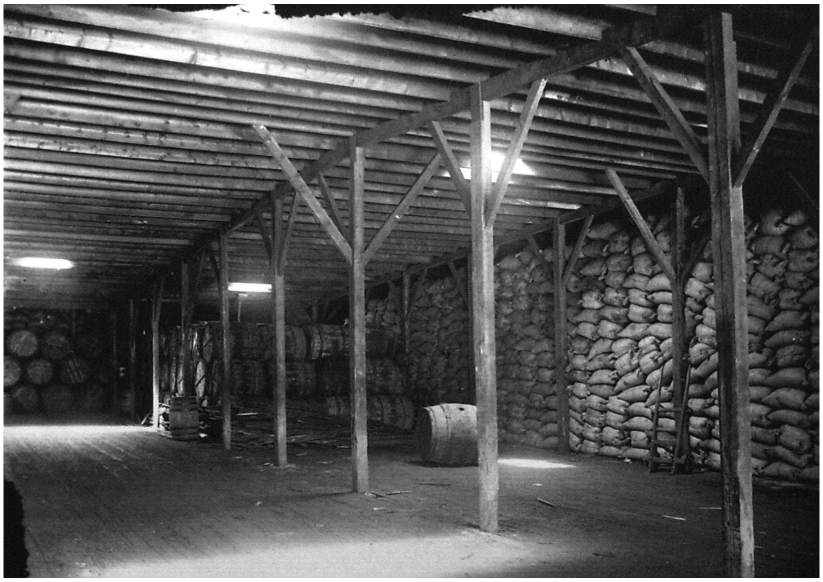
Congress Street Fire Station, 2006

ships of architecture with vehicular areas and access.

The fire station has outlasted the industrial uses originally present in the adjacent city fabric. While Boston's building code had used regulations to determine "the kind of construction that could be used – whether fireproof or timber – depending on a building's height...the city's 1892 law limited the undivided space in brick and timber buildings to 10,000 square feet, so that buildings with larger floor areas had to have brick partition walls." [NR District Nomination, Section 7 p.5-6] These large undivided spaces have served as containers well-suited to new transformations and use by artists, which the Boston Wharf Company allowed through safety modifications to the interiors. The recent trajectory is thus as follows: After goods storage (sugar, molasses, and so forth), general warehousing, and light manufacturing subsided, after this site lost its prominence for housing the largest merchants in the regional wool trade and other tenants, artists began to occupy studios and live/work spaces to take advantage of the well-illuminated and flexible loft spaces.

> "By 1980, so many artists had located in the area that an Open Studios event could be held. In that year, 200 artists joined to organize the Fort Point Arts Community (FPAC), which received support from the National Endowment for the Arts – NEA's first grant to a neighborhood arts organization...Boston Wharf Company cooperated with the artists and helped the artists who set up studios in the district's lofts also lived in their studios, although city codes did not allow this. The artists subdivided floors, put in kitchens and bathrooms, and created live/work spaces. They also provided means of emergency egress from the buildings, which were now partly residential. As their numbers grew, the artists organized to negotiate leases collectively with Boston Wharf Company. Around 1995, artists leased floors in eighteen different district buildings. But as lessees, and often illegal residents, the artists' tenancy was precarious. In the 1990s, the wider world discovered the potential of the district as a place to live and work. Today, when artists' leases expire, the buildings are redeveloped mainly for offices, retail, and high-end residential. ...Nevertheless, many artists continue to live and work in the district and some have secured their continued presence in the district by becoming building owners. [NR District Nomination Section 8 p.13-14]

Countless newspaper and magazine articles highlight the current real estate maneuverings and improvements to museums in the area, including the Children's Museum and the new Institute for Contemporary Art designed by the firm of Diller Scofidio + Renfro. Even before those amenities reach their full potential in the next year or so, the Boston Phoenix chose the area as a destination for regional tourism with easy access to public transportation.



Timber loft interior c. 1900 [Quin 2001]

View of Melcher and A Streets, c. 1900 (compare with middle photo, page 51) [Quin 2001]

Typical historic loft building and streetscape c. 1900 [Quin 2001]

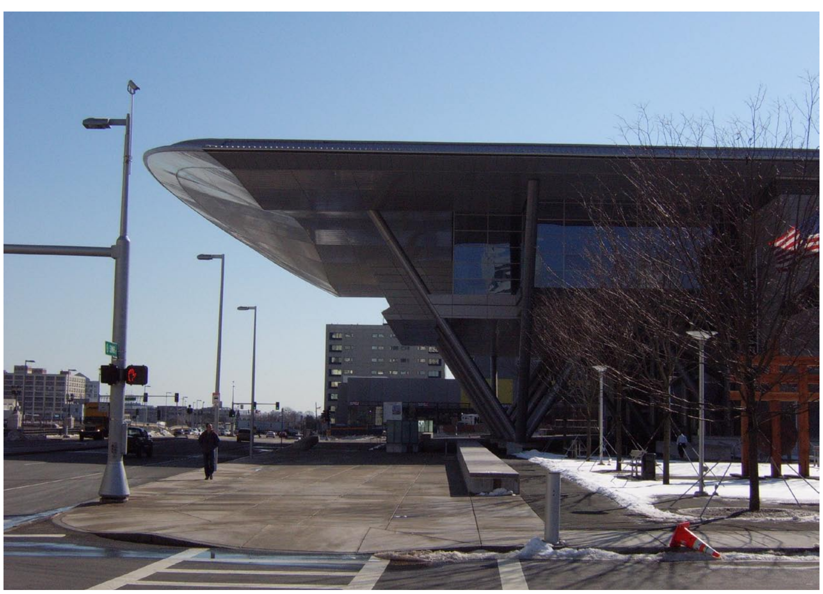
> For a paltry one-time fee of $1.25, you can make your own fun in abundance. The T may not be perfect, but it is rather far-reaching…you can take the Silver Line to the courthouse or the Red Line to South Station and walk around Fort Point Channel for the day. Fort Point who, you might ask? It's only the next up-and-coming neighborhood in Boston. Peppered with funky galleries and some great shops, this relatively undiscovered area is also the perfect spot for a walk along the harbor on a sunny day. [Schwarz 2006 p.31]

The subway and bus tunnels crisscrossing at many underground levels may allow for imminent accessibility but they are also among the long history of subterranean obstacles to consider in developing a strategy for how to occupy the land above. This connectivity has also hastened the escalation of formerly inexpensive rents so cherished by artists. Therefore the thesis project turns next to visions for the future of the area: examining the spatial complexities which have resulted from the many infrastructure moves, and examining the problems associated with approaching these conditions under the current conventions of architecture, urban design, and structural design independent of one another.

Aerial View of Site, 2005 [Google Earth]

Vent Building over Big Dig tunnels, adjacent to Fort Point Channel, 2006

Vent Building over Big Dig tunnels, exit ramp, and Boston Convention and Exposition Center by Rafael Vinoly and Associates, 2006



Boston Convention and Exposition Center entrance canopy, 2006

Chapter 4
Sections and Plans

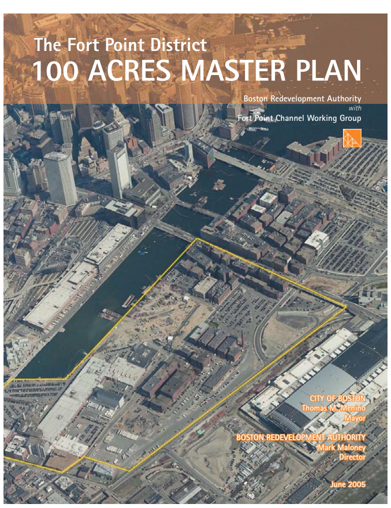
From this sequence of past changes at Fort Point Channel there exist many proposals for its future. Planners at the Boston Redevelopment Authority have been working with the community to solicit opinions for at least five or six years, and real estate pressures have forced the artist communities to reposition and bargain strongly or risk elimination. Yet despite the human complexities involved in developing an overall plan for the area, the physical constraints of the site's structural history often remain hidden, literally beneath the surface in the conversation.

To my knowledge there exist no comprehensive section drawings of existing conditions below grade in the publicly available planning documents for the site. When asking the assistants at the Boston Redevelopment Authority for section drawings showing how they are considering the tunnels and infrastructure beneath, I was told verbally that **''We don't have sections, we are a planning agency.''** [BRA, December 2005]

This sent me on a hunt through highway and turnpike press offices and bureaucratic contacts but the poignancy of that statement is striking. It begs the question, what is a plan? As a young child once answered this question in an architectural studio, "What is a Plan? It is when there is a good guy and a bad guy, and the good guy has a plan." Thus in many situations the word "plan" has the implication not of an image, of a heavenly omniscient view from an infinite height (or a human approximation thereof), but rather the implication of **intentions and aspirations to act upon**. A vision for a city's future cannot simply be a collection of drawings in orthogonal plan view. It is a severe disservice to design professionals and citizens everywhere that the word "plan" now lacks verbal rigor: a plan as an intended strategy and a plan as a hypothetical two-dimensional map are two very different entities, both necessary but not at all equivalent nor to be confused. Furthermore, it is important not to place too much emphasis on elevations or sectional representations; plans and sections are not interchangeable because gravity is not negotiable, but both abstractions of three-dimensional reality are inseparable.

Granted, no one can see a plan or section of the city as a real-life experience. The ability to ascend to a height to view a property or an entire city "as a map" and thus approximating a plan view is a great power made possible by modern technologies of vertical construction and of flight celebrated since the first airships ascended above Paris. The aerial photographs by the Fairchild Airborne company were landmark documents in city planning and understanding [Campanella 2001] even though plan-

BRA Draft Master Plan, 2005



based geometric constructions have permeated Western city and garden planning and representation, especially since the Renaissance and the isomorphisms which allowed plans and perspective representations to be mapped onto one another. Sections of entire cities are somewhat less prevalent historically, with notable exceptions including those cut through Haussmanian boulevards, with all classes of Parisians in different levels of apartments and around the streetscapes and underground infrastructure.

Yet the lines that constitute traditional planning documents and modern GIS data layers, two-dimensional constructions evident in representational conventions, reflect an inherently incomplete communication of reality. For example, dashed lines indicating the presence of a tunnel at some variable depth below are helpful reductions to communicate that there is something below the ground, yet they preclude a fully spatial, designed engagement beyond a generic level. The drawings are necessary representations but no single orthogonal view contains “the plan” and the actual intentions contained therein.

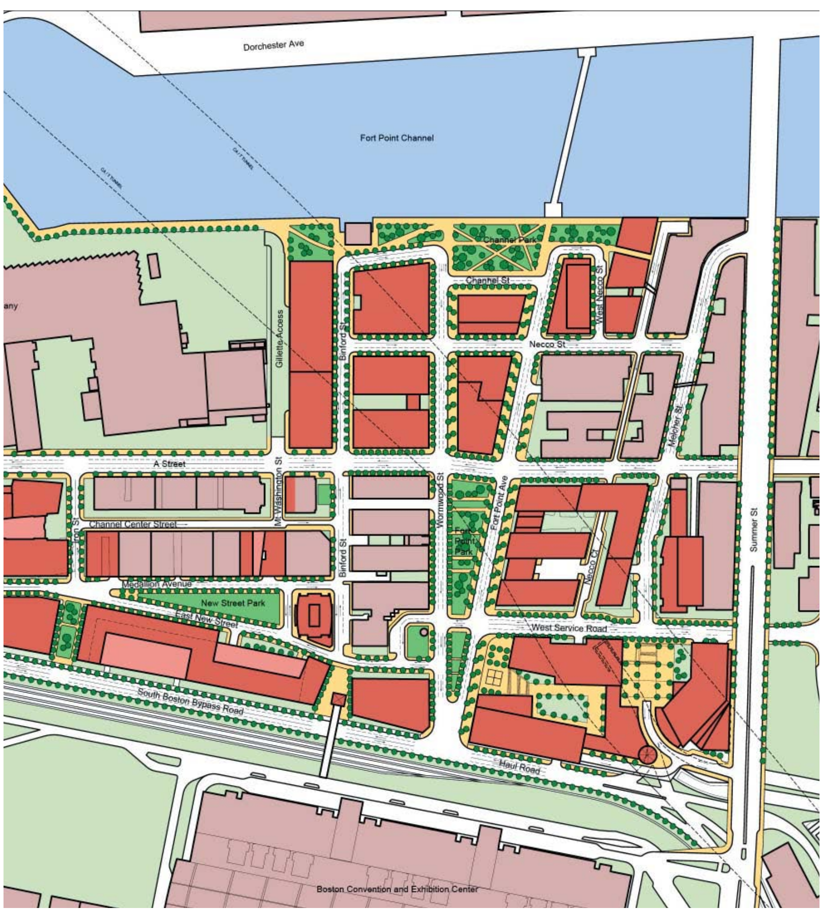
I believe that the danger in plan-based representations – particularly in city planning and urban design but in landscape and architecture as well – is that they assume a naïve lack of conflict. They assume that all of the property lines, access, physical edges of buildings, and underground points of support can be resolved and made sensible in relation to a single flat ground plane. They assume a lack or relative paucity of mismatches, buried surprises, and ambiguities in that geometric idealization of a “plane.” Conversely, this condition of avoiding mismatches or dissonance is the promise of grade-separated transportation from Robert Moses through the Big Dig: once you put the road above or below the surface, it supposedly absolves the need to negotiate complex intersections at the same elevation and displaces the need for resolution. Thus Solomon’s critique of the Big Dig [Solomon 2004] is that it is conceptually identical to the Central Artery in its displacement, merely switching from above to below. Solomon continues to argue for continuous at-grade merging and negotiation of traffic and activities and programs which I would view as a lopsidedly polemical and extreme reaction, but the lesson remains: **most of these urban sites crisscrossed by complex infrastructure cannot be easily cleansed of the dissonances which make their conditions challenging and unique.**

Early image of streetscape planning near harbor [BRA 2005]

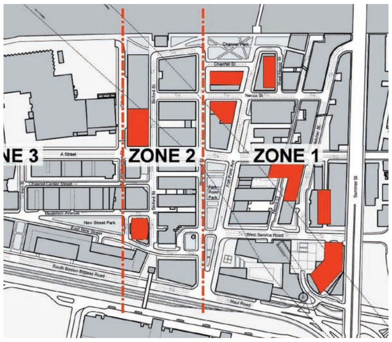
As is evident in the particular history of Fort Point Channel and in the widespread conditions of most cities developed and redeveloped over time, such transformations have resulted in nonuniform subsurface conditions and overhead restrictions based on ecology, flight paths, shadows, zoning, economics, and other aspects. These are but a few of the reasons why building in a city is exponentially more complex than an equally sized site in a suburban former cornfield, and yet these reasons are also the bases for constructing a spatially rich and experientially deep place in a city surrounded by other places of specific (rather than generic) character. In arguing that specific and differentiated environments are not only preferable but more sustainable for communities of people, Rowan Williams (The Archbishop of Canterbury and head of the Anglican Church) has written extensively on issues of aesthetics, development, and other cultural issues. He recently delivered this statement:

> Geography is a set of instructions for responding with this or that song to the visual triggers you encounter. Now of course any landscape, any physical environment, has such triggers. But it seems fairly clear that a physical environment that is repetitive, undifferentiated, can fail to give adequate material for a person to develop. A varied environment with marked features – that perhaps have narratives and memories attached to them – offers multiple stimuli to respond to. There is a local geography that is more than just an abstract plan of the ground: it invests places with shared significance. But for this to happen, places must be distinguishable, differentiated. A landscape which proclaims its sameness with countless others – in its layout, building materials, retail outlets and so on – is a seedbed for problems. If it's true that I can't answer the question 'Who am I?' without at some level being able to answer the question 'Where am I?' the character of a built space becomes hugely important. There will always be small scale domestic answers to 'Where am I?' because we all imprint distinctiveness on our homes and are 'imprinted' by them; but when this is restricted to the domestic, we should not be surprised if there is little sense of investment in the local environment outside the home.
>
> So the first challenge for the building of sustainable community is whether a development has thought through its geography in such a way as to be somewhere in particular. We have been through a good many false starts in the last hundred years or so. So much of the philosophy of the interwar suburban developments and the postwar municipal growth assumed that absolute homogeneity was what was required. Communities were created that looked essentially like warehouses for people, areas which, while not technically anonymous, could have been called anything. And because all the pressure was towards increasing 'zoning', old urban centres became increasingly stripped of any residential element, and retail outlets in new developments were often in unattractive and vulnerable clusters. More recently, we have seen the challenge of massive new developments…offering new opportunities to disadvantaged communities, but with the risk of swamping them and making them more and more anonymous.
>
> Functioning communities need to develop a sense of place, and that means developing variety, a real landscape, not just a territory covered with 'machines for living' [Williams 2005].

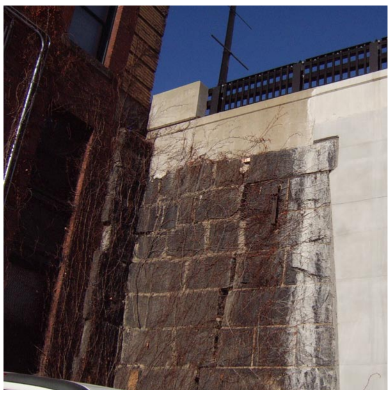
This inspiring formulation of ideas frames my primary critique of the Boston Redevelopment Authority (BRA) plan, not to insinuate a lack of quality in its individual aspects but rather that its solution is too ordinary and placeless. It has safe corners and decent street widths and provisions for small plantings and contextual brick materials on the streets and the buildings, but it is precisely what Williams describes as “a landscape which proclaims its sameness with countless others – in its layout, building materials, retail outlets and so on.” It could work almost anywhere in a medium-density location, but does it fit between towering skyscrapers downtown on one side and a sweeping megastructure-like convention center on the other side? For such a specific location with a deep and bold history of infrastructure moves on the site, and with a modern marvel of engineering emerging from beneath its shallow surface, it seems essential to respond to these given conditions in a strong manner. This requires acknowledging the conflicts between surface and subterranean movement and access, the conflicts between existing artists and recent newcomers, the nearly 2000-foot-long convention center and the monumental vent towers, and all the other aspects which articulate the jumbled but varied and characteristic qualities of the Fort Point Channel district. It requires recognizing the conflicts and making their contrast and differentiation productive rather than negating or minimizing their presence.



Plan for new buildings (red) and park areas added to existing structures (purple) without regard for tunnels beneath (diagonal lines) [BRA 2005]



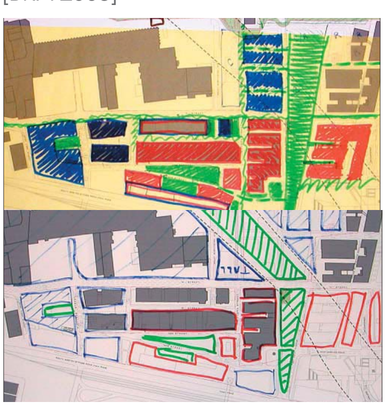
Possible tall building sites [BRA 2005]


Shear failure of new Summer Street Bridge (2004) with respect to historic seawall, 2006

Specifically, the BRA plan negates any connection between the different heights of pedestrian and vehicular traffic on the site because it compresses them all onto a single plan. Furthermore, it outlines plans for an initial 4.1 million square feet of development, with 2.1 million additional in the future, but it divides that space into building lots that each deal with unique contingencies, problems and requirements without coordination. For example, some lots have half or more spanning above the artery tunnels and would thus be far more expensive and difficult to develop and build upon. In addressing these many lots which have idiosyncratic conditions beneath, the actual public draft states that "Future building construction and building heights are restricted by the tunnel underground because of the tunnel's limited structural capacity." [BRA p.29] This is a challenging statement because it would be problematic to actually bear onto the tunnel itself or float above, rather than bear into the ground and fill next to and between the tunnels. The visible site conditions of shear failure in the two-year-old Summer Street bridge, and the adjacent failing stone wall which is now braced heavily, ostensibly due to differential soil settlement and other structural foundation issues, bear testament to the attention required to such foundational assumptions.

The generic planning principles [BRA p.36] for the area are laudable, intending the area to become a vital, mixed use, sustainable neighborhood with 24 hour activity, to minimize conflicts in the mix of uses, to promote access to shared natural resources, and to enhance the South Boston community. Given the adjacency to the channel and the relationship to the ocean, the municipal harbor plan adds the principle of creating "a harbor plan and public realm more in keeping with Boston's urban character and mixed use economy." Yet these value statements are translated into a plan with low overall density (FAR 2-4) and height restrictions far below what is structurally possible and allowably safe considering the flight paths overhead and the existing presence of adjacent high-rise development in downtown and past Fan Pier.

Sketches and community input in brainstorming charrette sessions [BRA 2005]



The community design charette sketches and input demonstrates how much effort has gone into the plan's careful valuing of compromise, contingency, and consensus. It envisions plans – both as intentions and as maps – leading to a planned completion in several decades. If the city rarely changed abruptly this would seem reasonable, but in the course of the past ten years the site has been dug up, submerged under water, had a highway dug through, covered up, and additionally had a massive change in the urban residential real estate market. Given the unforeseen futures and development pressures, there could easily be entire swaths of lots that cannot be built on profitably, or the shallow plantings in tiny shadowed parks could be omitted or delayed indefinitely. Further, the site's historic status could be upgraded and the real boundary that matters would not be the city's planning study area but rather the overlapping historic district border.

Moreover, this critique is of a story rather than of actual plans: I believe the BRA plan is not actually at its heart a vision for what will actually become of the site but rather a tool in and of itself as a way of helping the public imagine a new city (see Chapter 6), imagine a resolute completion, and calm those who see change in cities as unfortunate. In Sam Allis' recent editorial in the Boston Globe, the author bluntly states his surprise in learning from MIT engineering professor and transportation expert Fred Salvucci's statements that the Big Dig consists of anything beyond highway paths and a simple imminent "finished surface."

> The real jolt of [Fred Salvucci's recent Op-Ed] article was its presentation of the true dimensions of the original Big Dig package. It bears little resemblance to what most of us thought it contained. It turned out to never have been simply roads, tunnels, bridge, and green space [sic]. We never grasped the linkage of, say, the Green Line extension to the core project. We assumed that when the surface piece of it is finished, the Big Dig is done and we can all get on with our lives. [Allis 2006 p.A3]

Salvucci views urban movement holistically – cars, subways, politics, and so forth, and is thus able to connect for Allis a tunnel entrance in South Boston with a transit easement in Medford (the Green Line) and a rapid transit bus to Roxbury or to the airport (the Silver Line, using the tunnels and connections mentioned). While Allis may want to be like many commuters and avoid construction so "we can all get on with our lives," the broader view conceives how a broad multifaceted transportation infrastructure can make individual places unique and connected to other memorable locations. It is what makes stops of a subway line a mentally connected topography, but only if the places are themselves, to return to Williams' words, differentiated and "varied environment with marked features" with "narratives and memories attached to them." These memories and stories, whether Allis' or Salvucci's, or any of the community sketch charette design participants, should be embodied in the next physical layer in the Fort Point Channel area.

This is a site where tension and dissonance is present in the physical, political, and social fabric, where negotiation is not only necessary but inevitable. Moving beyond the current plans to my proposed intervention, the accommodation of social and physical conflict and difference, which is so central to cities as outlined in Chapter 1 of this thesis, requires a consideration therefore of looking closely at what the physical limits are that form the conditions and possibilities for building such places.

The entire site dug up 40 to 50 feet down during tunnel construction in the late 1990s [BRA 2005]

Chapter 5
Conditions and Possibilities

For the act of gazing sets limits...

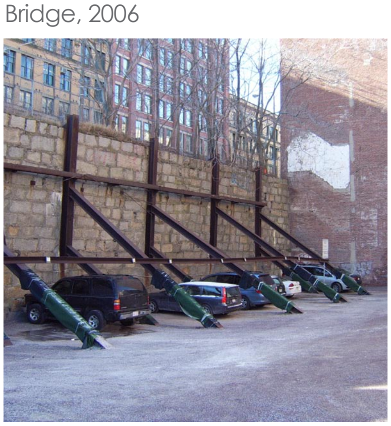
["Wendung," Rilke 1997, p. 93]

This is a thesis that understands design problems as having constraints. Physical forces such as gravity, given conditions of buried infrastructure, and existing human-constructed buildings are all assumptions that are reflected in the analysis and design. As Rilke's poem implies, simply looking and gazing at something, at any situation, begins to imply that it has limits and constraints, that it has a horizon.

Yet design is not simply a response to conditions, it is not a mere solution to a problem or an unauthored fact. It is rather a reflection of how conditions are also the seeds of possibilities. Design is a negotiation of constraints (physical, fiscal, and otherwise) with imagination and the possibility of what does not yet exist.

In the case of the location of this thesis investigation, the primary conditions which are at hand are relatively ordinary and universal for buildings: gravity loads of built components that need to be in a state of static equilibrium. The additional conditions exhibit three dimensional complexities: there are uneven depths and soil conditions down to stable support below the ground, and there are at least six levels of surface roads and pathways bridging and ramping above the ground. **Therefore my strategy was to develop a design that could negotiate with the degrees of known and unknown conditions visible and invisible at the site.**

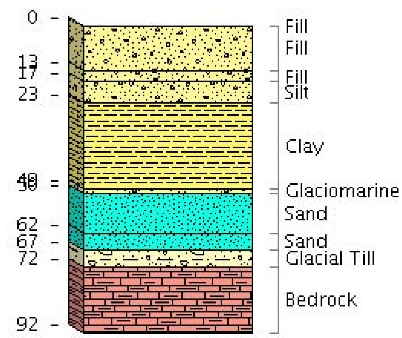
Steel reinforcement along unstable seawall next to Summer Street Bridge, 2006



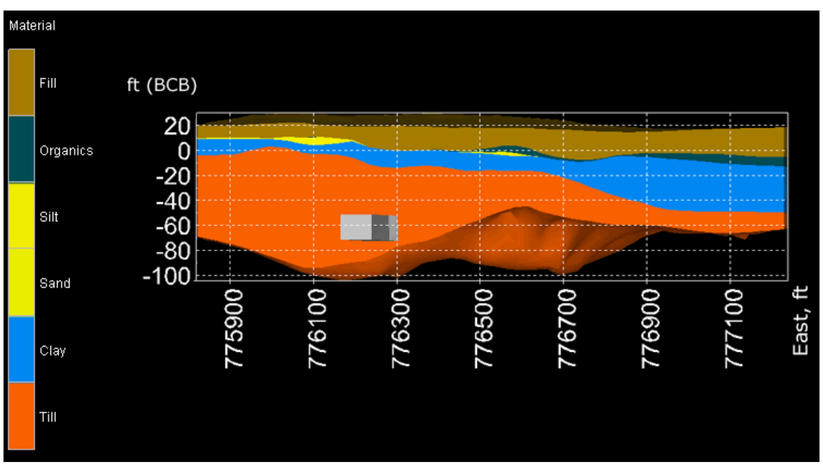
Given the history of the site's land construction, this strategy takes a skeptical attitude toward dirt. It considers the ground not as a homogenous mass to be punctured and removed at will but as a variegated matrix where only discrete supports can be threaded through to avoid the obstacles and constraints. Similarly, it considers the present ground level as only one of many conditional points of reference, not as a precious surface to be preserved except where it meets existing structures and pathways.

This skepticism is justified because within the past decade there have been actual struggles with foundation stability on this site, and not just at the location of the new Summer Street Bridge. Near Congress Street in Fort Point Channel, "In late 1995, an office building in Boston, Massachusetts, constructed in 1983 using concrete pilings produced by San-Vel Concrete Corporation, an inactive Lone Star subsidiary ("San-Vel"), was demolished by order of the City of Boston based upon an engineering report that the pilings were unreliable." [Edgar Online Inc. 1998] The precast concrete piles disintegrated as a result of an alkali-aggregate reaction. Given the soil conditions which these defective piles reacted with and sat up on, the building began to sag without warning, was condemned and demolished in a very short span of time [Allen, correspondence 2006]. This is an anecdote which hints at the challenges below the surface which warrant the attention to broad structural strategies beyond typical solutions.

This is even more apparent when examining the depth to bedrock. The existing historic buildings on the site lie above relatively moderate depths of fill, sand, and clay (60-90 feet). The soil boring studies done through the Boston Subsurface Project in conjunction with the Big Dig [Tufts University Department of Civil Engineering 2004] demonstrate that the depths drop off precipitously in the vast areas of parking, where the bedrock dives down to 120 or more feet below grade. The boring experiments were even unable to reach down to bedrock in some of those locations. Again, these conditions demonstrate that even beyond the areas complicated by buried tunnel infrastructure the ground requires an attentive structural solution to make the sites able to be built upon in a safe and financially soluble manner.



Sample soil section near existing buildings [Tufts 2004]

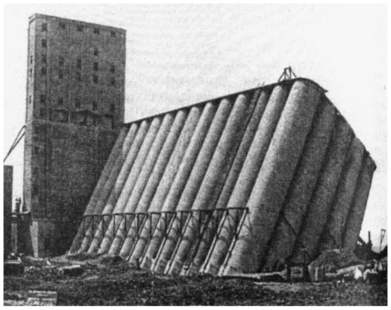


Three-dimensional model visualization with Red Line tunnel running beneath, near Fort Point Channel and South Station [Tufts 2004]

To develop a vocabulary of potential solutions I sketched a chart of conditional properties and characteristics which were desirable, matched with different possible structural foundations, starting from typical solutions and moving beyond them by considering what alterations and alternatives could enable for a single possible solution to accommodate and negotiate a broader range of desired conditions.

Desired Properties and Characteristics

Beyond the capacity to safely support compressive loads from buildings, the extended properties and characteristics I sought and evaluated are my own value judgments, based on the patterns in Chapter 1 and on practical considerations such as the prevalent necessities of parking and vehicular access. They included the following ten criteria:



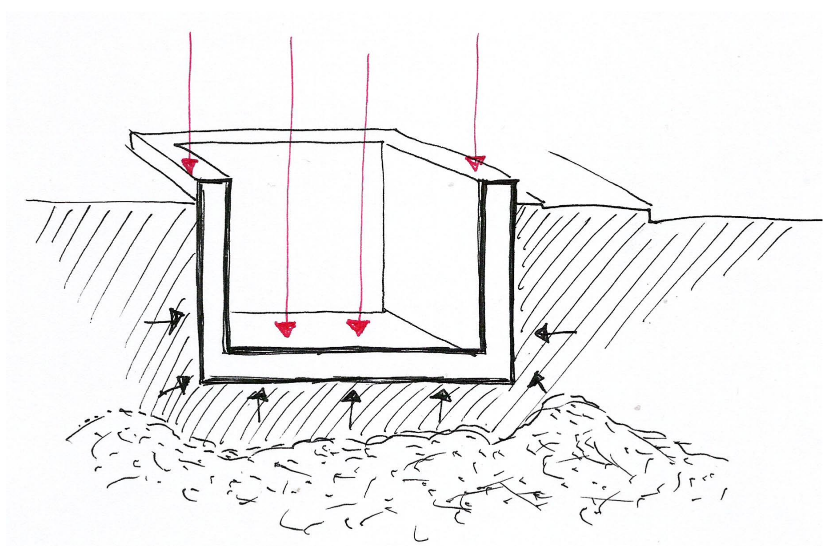
Differential settlement as seen in the Transcona grain elevator [Leggett 1973]

A. Ability to resist differential settlement and shear failure
B. Ability to accept lateral thrust (horizontal component to applied forces)
C. Ability for portions of the site to be further strengthened easily in the future
D. Ability to accept significant point loading at certain places
E. Ability to allow for flexible lot and parcel ownership and redefinition
F. Ability to allow lateral connections below ground between buildings
G. Ability to readily integrate subterranean parking and usable spaces with natural phenomena such as light, air, and sound
H. Ability to be integrated with trees, planting, and drainage
I. Ability to be produced as mass-customized road-transportable components
J. Ability to be readily combined to create varying streetscape dimensions

Range of Possibilities

1. Bathtub foundation (A, B, G)

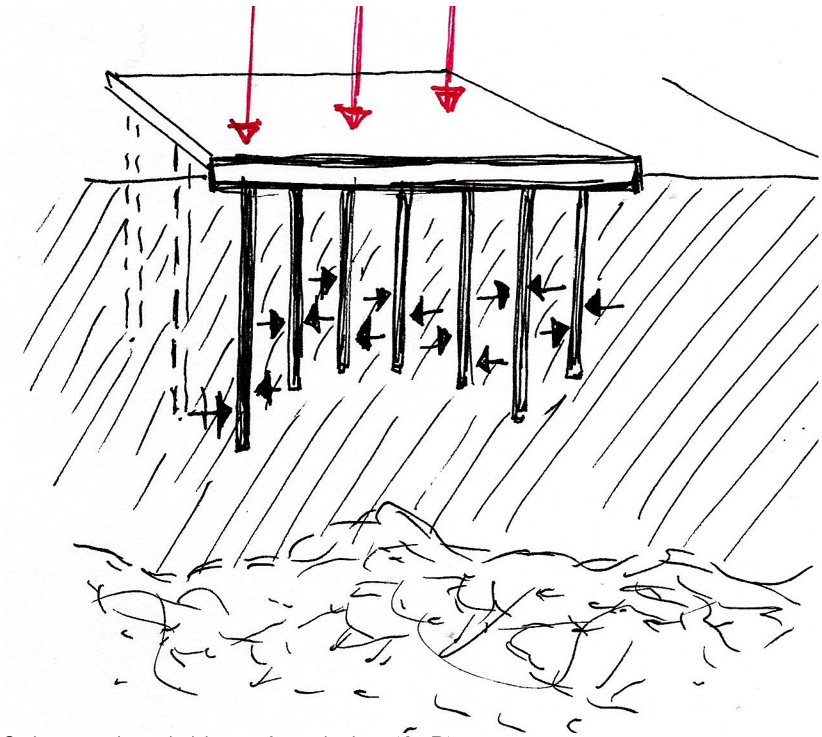
This typical system consists of reinforced concrete slurry walls and a continuous slab at their base. The concrete bathtub that results is composed of rectilinear, orthogonal, continuous planes. It cannot be easily punctured but it accepts a variety of vertical loading conditions and spreads them throughout its base, depending on subsurface conditions below the tub.



For all diagrams: Compressive loads shown in red, tensile loads shown in blue, reactions and support conditions, including friction, shown in black

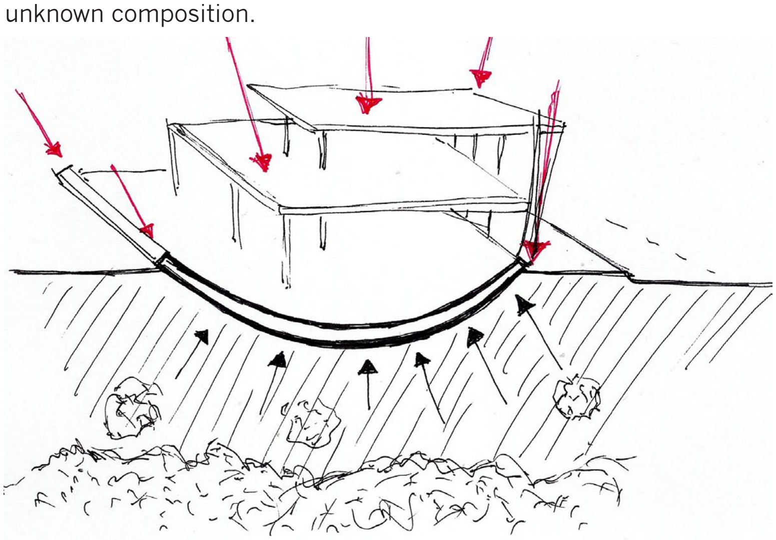
2. Friction piles (A, C, D, E)

Continuous lengths of standard steel sections are hammered into the ground until they stop and no longer can be pounded further, whether or not this means hitting bedrock or simply compressing the soil and till below the surface. This has been used historically on the site.

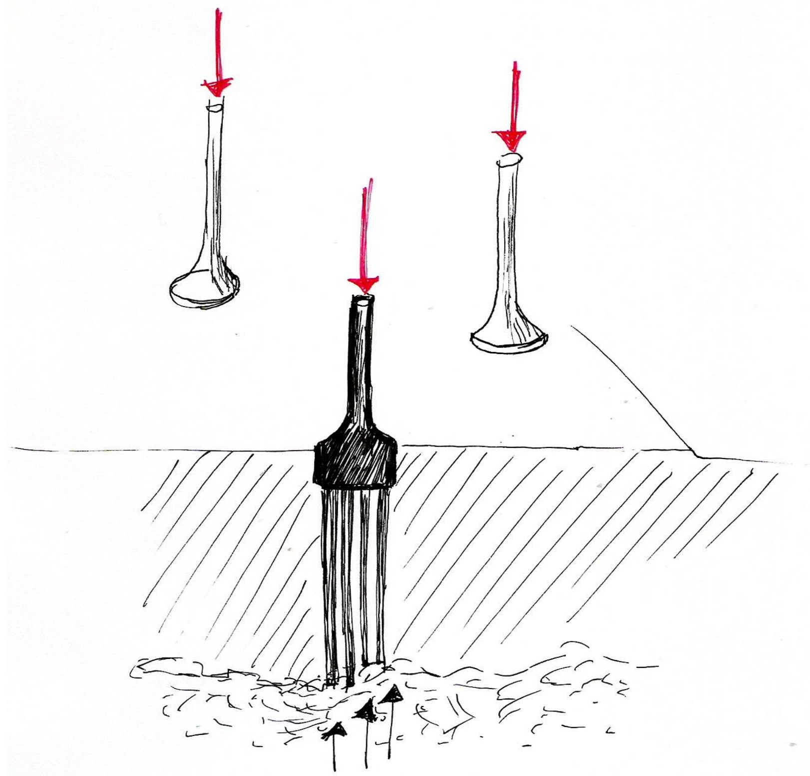


3. Inverted vault/dome foundation (Ã, B)

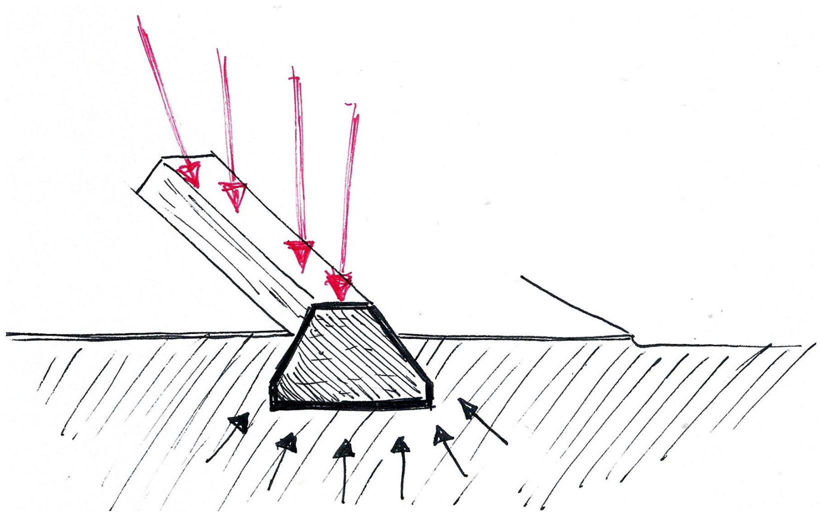
The foundation acts as a continuous underground upside-down vault which can accept vertical loading and non-vertical thrusting conditions, distributing the weight and accommodating extremely uncertain subsurface conditions. One domed version was proposed for the Spodek exhibition hall in Katowice, Poland (Chapter 2) over former mining tunnels of unknown composition.



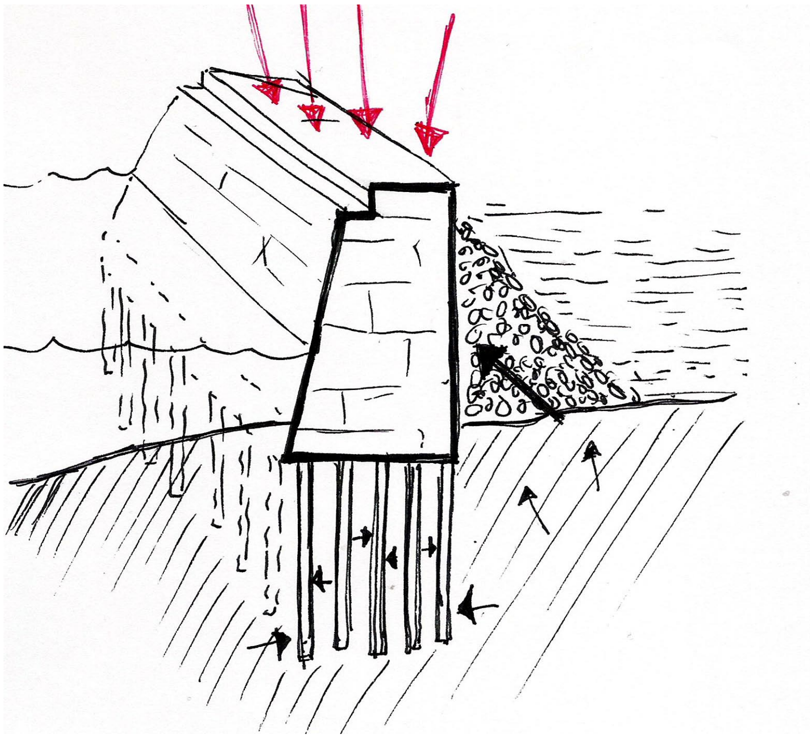
4. Spread-footing/snowshoe (A, C, D, E, F)
Specific point loads reach down to bearing areas of larger size, and then all upper loads are transferred onto the vertical lines above those points.



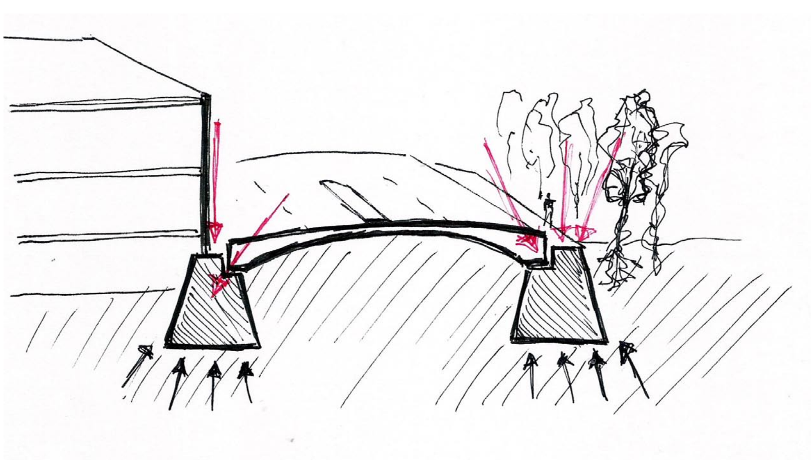
5. Continuous floating wall (B, C, E, F, G)
Massive walls, internally connected through site-casting or post-tensioning, floats at the top of the soil surface, spreading point loads applied to the top of the wall over the wall's length and the area of its base.



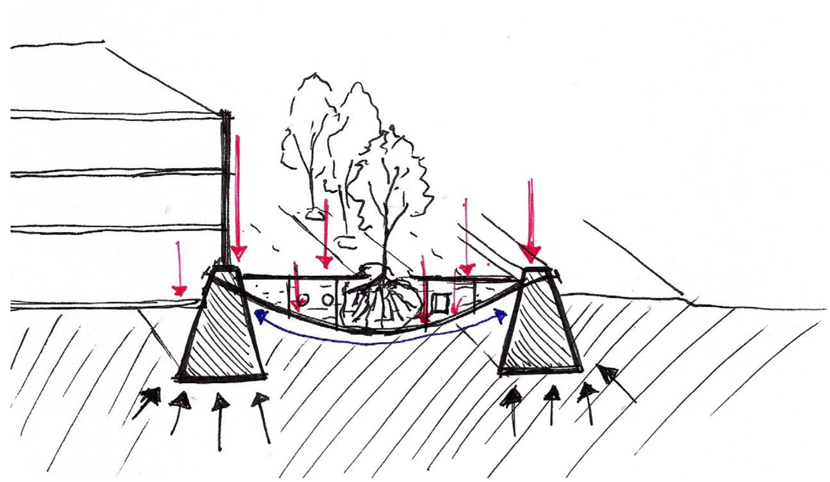
6. Continuous seawall on piles (A, B, C, D, E)
This system is historically present at the site from nineteenth-century construction. Compressive walls, which support vertical loads from streets as well as holding back horizontal pressure from the water and the land backfilled against the walls, are supported on linear piles along its entire length.



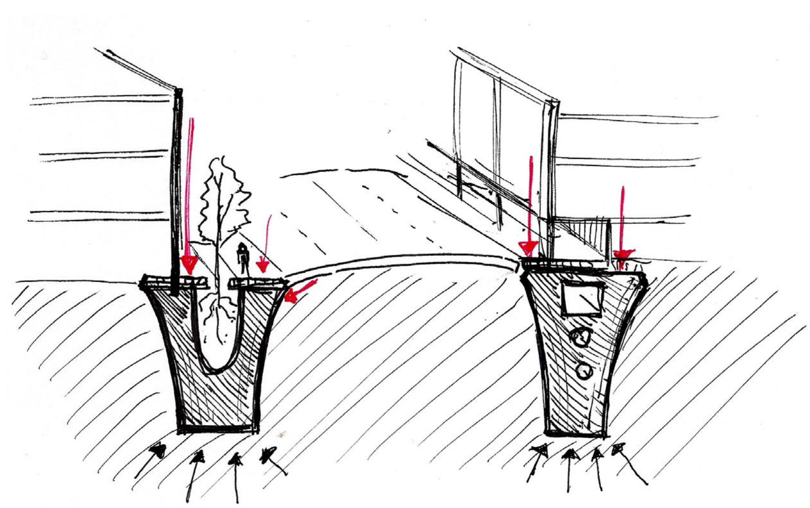
7. Continuous street as positive vault on extruded wall (B, C, D, E, G, H)
A modified example of the above continuous wall examples, where instead of the walls supporting the buildings and the streets floating between, the streets run on top of a pair of walls, vaulting over them and applying a thrust to the top of the compressive walls.



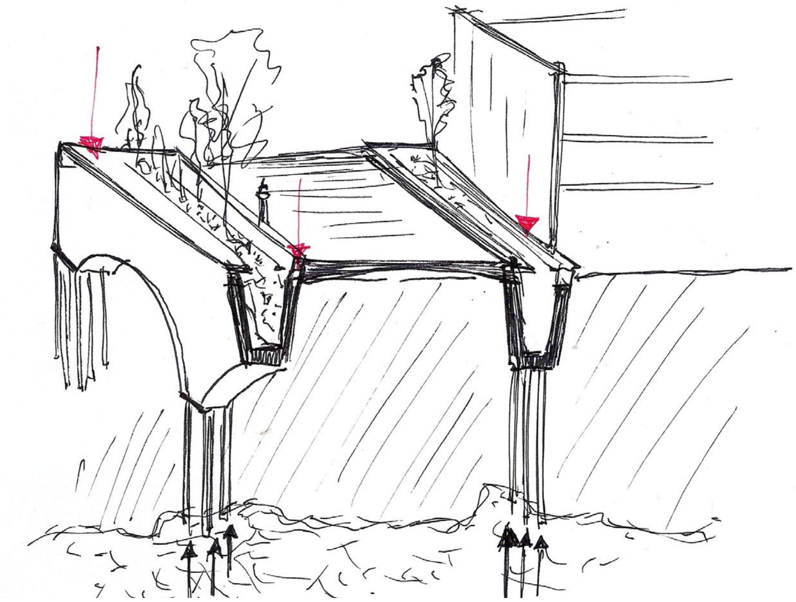
8. Continuous street as inverted vault on extruded wall (B, C, D, E, J)
A modified example of the above continuous wall examples, where instead of the walls supporting the buildings and the streets floating between, the streets run on top of a pair of walls and the street system is hung from the tops; trees and plantings and utilities run in the thickness of the inverted vault below the street.

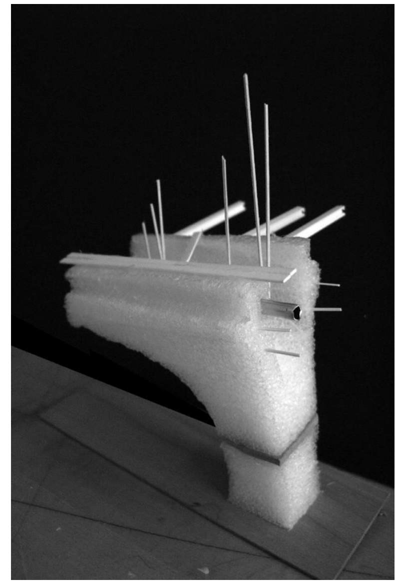


9. Continuous trough beam (A, B, C, D, E, H)
A continuous wall is bifurcated along its length, split so that both the streets and the buildings bear onto the large beam and trees, plantings, and other utilities run in the trough between the two upper halves.



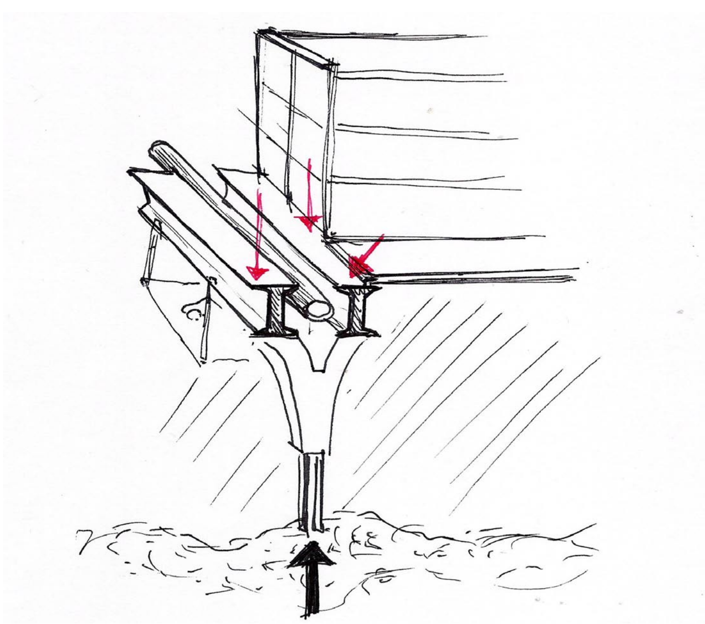
10. Continuous hollow aqueduct (A, B, C, D, E, F, G, H, J)
A modification of the trough beam, where instead of it being a continuous depth beam it is in the form of an arched aqueduct, allowing for varying depths of plantings and services as well as lateral connections underground through the arches. The regularly spaced bases of the arches transfer loads onto columns of varying heights that bear on piles drilled all the way to bedrock.

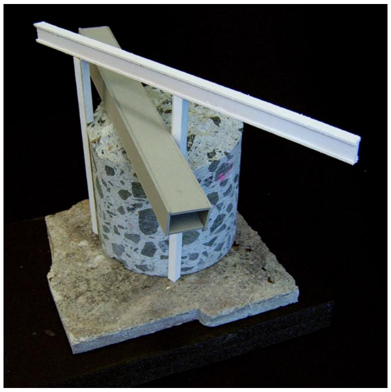




Process model study of hollow aqueduct foundation

11. Continuous double beam on columns / deep piles (A, B, C, D, E, F, G, H, I)
The two halves of the aqueduct are split and configured as two identical extruded beams that bear on paired columns at irregular intervals. Utilities and plantings run in the depth between the paired beams. The columns bear on piles drilled to bedrock.

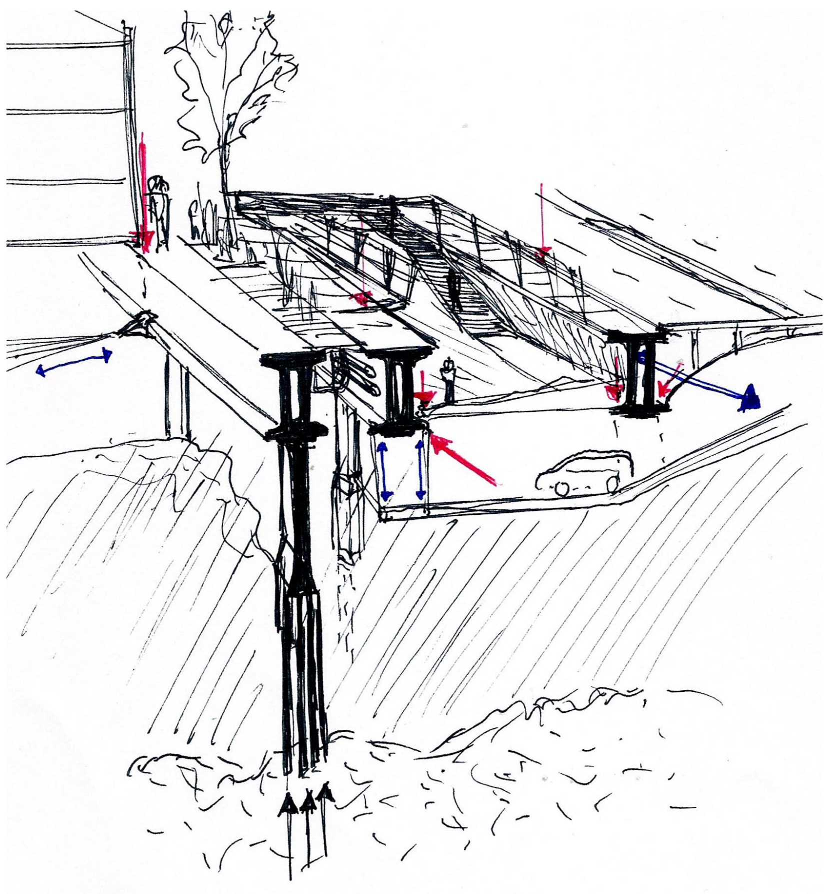




Foundation study model with new boxbeam (white) above bedrock, fill, and tunnel (gray)

12. Continuous bundled boxbeams on columns / deep piles (A, B, C, D, E, F, G, H, I, J)

Linear beams are employed singly, in pairs, or in other combinations, and each bear on individual columns transferring loads to widely spaced piles drilled to bedrock at optimized locations. The I-beams contain vertical slots, boxes which allow for post-tensioning cables to be run continuously through the assembled length of nominally sized components, the height and curvature of the tensioning guided by plastic or fabric tube-like channels hung in each box and grouted from above and below before they are lowered into the ground. The boxbeams resist torsion from uneven loading over their serviceable lifetime and allow for varying widths between building and street bearing conditions. Their depth is sufficient to accept loading on both their top and bottom flanges and to have a person-sized utility corridor, safety passages, and generous planting soil volumes between pairs.



Conditions of Particularity and Universality

To return briefly to a point of generality, these conditions, options, and possibilities for solutions can be (and many of them have been) deployed in a highly particular fashion unique to Boston's history and its given conditions. But the principles to this point and further in the thesis are similarly relevant to highly contentious sites elsewhere.

For example, many attractive development sites around Boston have varying degrees of fill, even if they are now far from the current water line. The Brickbottom area of Somerville (the site of a current urban design competition), the Charlestown Navy Yard, and the Harvard-owned campus land in the Allston area of Boston are among the areas where large infrastructure and challenging subterranean conditions are allied.

In one of the most publicized urban design challenges of recent history, the site of the former World Trade Center in New York is complicated not only by the symbolic areas which many constituencies believe should not be disturbed or built upon, but also by the PATH rail and various bus areas which require connectivity below the surface. The various proposals for Snohetta's design for the Freedom Center/entry pavilion at the corner of the memorial site can only bear down in a very restricted list of locations, and the whole site is subject to considerations of lateral forces on the walls that remained after the skyscrapers above were destroyed.

Early foundation study axonometric drawing with watercolor

Elsewhere, the site of Les Halles in central Paris, already mentioned in Chapter 1, is another site where myriad levels of buried subway and rail connections make construction on the surface possible but not inevitably simple, both in the current mall and in plans for future rehabilitation of the area. This is not just a condition of sites within the center of cities; the filled land on the periphery of Amsterdam, Kiev, and other metropolitan regions are subject to foundational concerns not only with lateral stability but also with updrift due to hydrostatic pressure and flooding from fluctuating necessities of damming and rerouting rivers. Sites with rich development potential along the Nieuwe Meer waterway between Schiphol Airport and Amsterdam, and the Telychka area to the south of Kiev's historic core are places where my previous design and planning work led me to realize the challenges at hand beneath the surface. Therefore while the focus of the design proposal is primarily particular to Fort Point Channel in South Boston, it is only one site which is used here as a vehicle to demonstrate the ways of dealing with challenging conditions through inventive possibilities. Given the heritage of Fort Point Channel as a place where subterranean street infrastructure enabled simplified architectural loading and flexibility above, it is appropriate to continue this tradition for the new development. Therefore, the next task is to imagine what these foundational possibilities can support and enable.

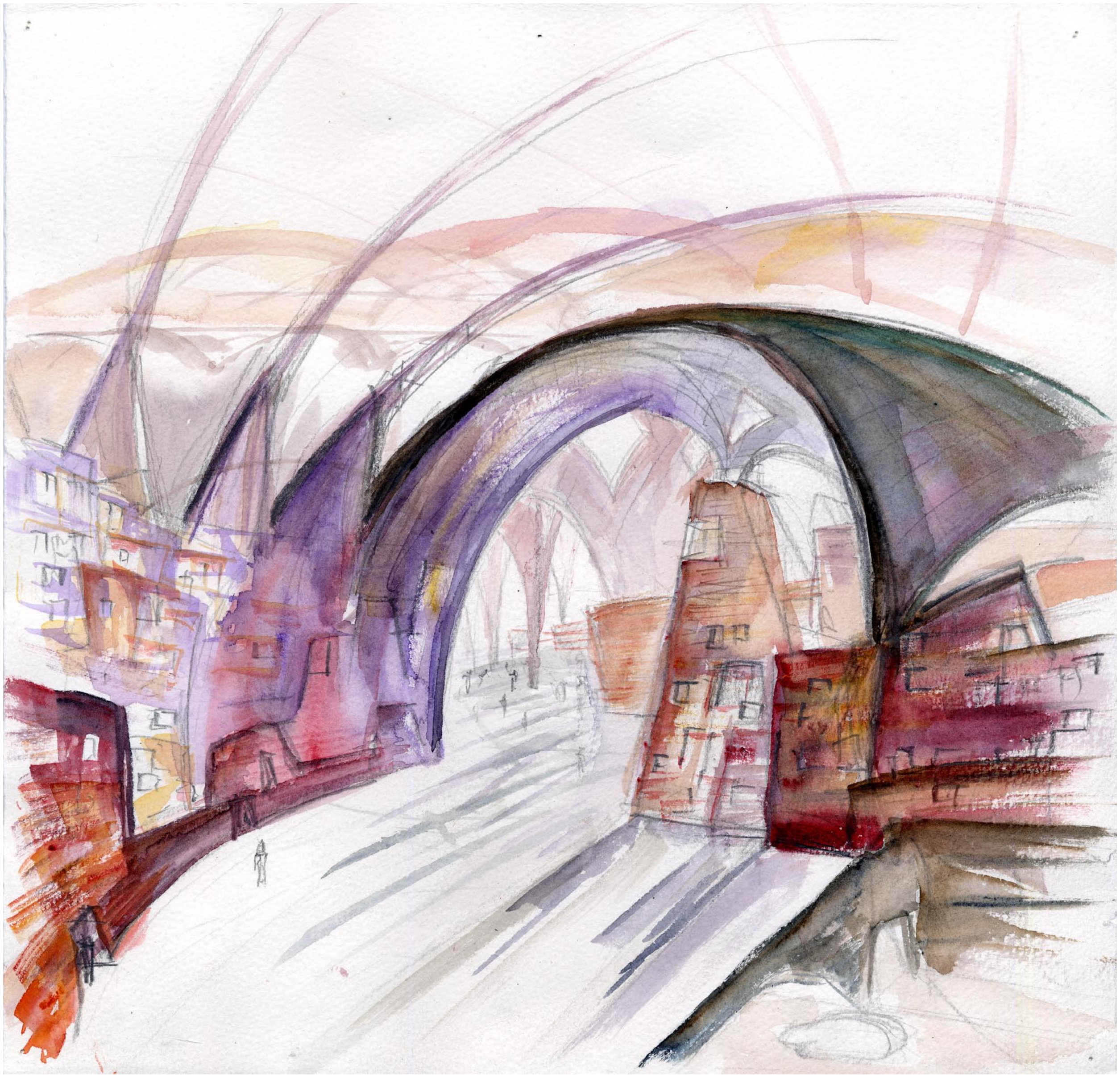
Chapter 6
Foundations and Imaginations

> …like a column […] distributing
> high up, where [it] supports, toward either side
> the light arch of [its] equanimity
>
> [“So angestrengt wider die starke Nacht,” Rilke 1997 p.47]

Design is not simply a tool for showing that which is imminent but also for envisioning that which could be possible. From Piranesi’s etchings of Roman ruins through the rendered grandeur of projects by Ledoux and Boulee, and including the contemporary power of digital representations to show photorealistic images and animations, the notion of imagination is at the heart of what architects and all designers must engage. Imagination is foundational to the creative process. Robert Harbison’s writings frequently engage this point of imaginary projects, either unbuilt or unbuildable, that constitute useful and important “fictions” which point toward deeper desires and impulses for significance and meaning.

> A strong concern with architecture signifies in fiction as it does outside a concern with protection, a desire for established existence and a home for consciousness. If we take place in the narrow sense of a physical envelope for the self, and consider the books which try to provide as literal a shelter as possible, we trace the specially spatial imagination expressing itself in words as it does in buildings through a desire for the reassurance of clear definition, pointing always to the finality of the tomb, a form which appears in many of these books. Unlike more imaginary art forms, architecture boldly does something, and books centered on buildings feel they have made a more definite assertion than another “what if?”…[I]magined buildings embody a more advanced kind of thought… [Harbison 1993 p.73]

While the spaces of Piranesi and Boulee, or the unbuilt projects of Russian Constructivists and of current designers may seem purely fanciful, the proximity of reality is often closer than such wild dreams might seem. We are conditioned by the cities and neighborhoods and worlds we inhabit each day, but learning and traveling and designing are all ways of broadening the range of possibilities at our fingertips. We tend to imagine possibilities that are just slightly different from what we are used to and so re-imagining the foundations of what determines decisions helps to open



Watercolor study for imagined city
in compression

up new ways of being creative. Each of the following possible narratives begins with a factual point of departure, an observation or condition that could enable us to imagine worlds and cities that are therefore fictions slightly beyond our usual experience.

> Where are buildings like the most compelling architectural effects in twentieth-century painting, Monet's endless ponds of wavering edge and uncertain depth, which transform plants into clouds and reflections into solid bodies? It would be an architecture of illusion, where if one identified the liquids and gases, as glass and marble, one would be greatly surprised or confused. It would hardly look like building at all, but then, contrary to what is said nowadays, this is an important part of what this art has always been about, to provide exciting fictions and to show one objects known, even as one experiences them, as facts which cannot really be. [Harbison 1991 p.160]

A City in Compression

Materials requiring complex manufacturing and great energy to produce are becoming increasingly problematic in areas of the globe far from natural resources. What could be built without such cast and formed metals and other elements? Imagine a city where no steel or other materials in tension were used, a city where everything is built to be in compression. Deprived of steel and iron tension rods and cables, a return to vaulting and simple spans creates an entirely new scale of urban life. In this city, the building materials can only accommodate compressive forces; the brick, masonry, and concrete have grown nearly immune to crushing under immense pushes yet are unable to withstand even the slightest pull. Civic regulations prohibit designers from causing tensile forces under punishment of demolition or even death; the citizens realize this seems a bit extreme or Draconian, but they remind skeptics that even Hammurabi had lived in an empire where tension was physically possible. Maintaining civic order and a sense of stability is thus of utmost importance, because civic leaders who sense that they or their structures are being pulled to the left or to the right recognize how it could cause the collapse of a way of life. And humans have lived in compressive structures most of their history anyhow – before fads of iron and steel had become popular for a few centuries – so this is just a minor tweaking back to the normal state of what bricks want to be.

To educate the youngest citizens, children are given miniature blocks that they stack, big plastic ones as infants and more articulated ones as they mature. Some of the kids enjoy playing with blocks and bricks that interlock, learning through play how shapes and forms keep their playful structures from falling down, but at a very early age the kids learn what kind of structures will stand and which will fall. Parents buy their children – boys and girls alike – colorful sets of the blocks, and tell the youngsters fairy tales about other far-off fictional lands where silly people fuss about how they need steel and iron in order to make a modern city.

Yet this city's residents, old and young, know that such claims are only mindless babble because here they can be proud of how elegant and shapely their buildings and structures are designed, always in pure compression. To accommodate their very particular unwavering needs, residents have revived Catalan vaulting techniques like those brought by Guastavino to American urban projects in the early 1900s. They have cavernous spaces surrounded by lightweight vaults; this highly compressed city feels spacious inside. The children watch old movies from a long-forgotten company called Disney, and in seeing the Little Mermaid's underwater caves, they ask their parents if they can go visit the cave-like churches in the old heart of the city, each of them with a central room pierced by an illuminating oculus. The churches, stable for several millennia, are frequented by students in architecture and engineering programs, each of them sketching in amazement as they take a break from their studies of coral growth and cave stalagmites and their assignments calculating the forces in arches.

Therefore the result of outlawing tension is a surprisingly calm and graceful city. It is not a clumsy assemblage of thick stone arches buttressed out of paranoia but rather a fanciful landscape of graceful vaults leaping across and beside each other while residents navigate along aqueduct-like arched bridges and canals. The lateral forces balance when arches and vaults meet in opposite directions, oriented just right so that the line of thrust remains in the center of the wall without causing tension or instability in the walls. It is a great civic ritual when neighbors unveil their proposal for additions, and how they will keep neighbors' houses from collapsing or sinking. The city architects check the graphic static calculations, nod approvingly, and the neighbors begin the shared work since no one person owns the walls or the foundations their properties all rest upon. The city is thus very dense and compact; all of the structural requirements have fostered great camaraderie where citizens pride themselves on being able to coordinate loading conditions on each side of shared party walls. The interdependence, which might have pulled the community and its buildings apart, has instead cemented their relationship with one another.

A City in Tension

Many places where we want to build and live have ground conditions that are relatively inhospitable. Rather than build upon shifting sand and struggle upward, why not imagine a city where every place to live and move and just "hang out" is a place supported from above instead of below. The firmament is a support condition for cables, the earth a distant surface to reach down toward instead of a foundation. This city had been the secret urban prototype planned by Gaudi in Barcelona and long disguised as inverted force models for the Sagrada Familia cathedral project. Elevators are the key modes of transportation, their motors suspended and hung from above, and their cables leading to the passenger compartments so evenly balanced with counterweights like a Calder mobile.

The tensile forces can pull the hammock-like pathways, suspension bridges, and trampoline-like surfaces only so taut; any cable with a finite weight is a catenary in shape and cannot by definition be pulled perfectly straight and horizontal. Therefore everyone's house – a small chrysalis within the constellation of teardrop-like interiors – is suspended from a neighborhood net of cables. To find their way home inhabitants know the topography of how far up or down the main arterial cables to slide or walk before switching to the thinner tightropes. Yet every now and then this world of tension droops slightly further down, the tallest inverted skyscrapers – earthscrapers, rather – allowing for the precarious condition of being farther from the comfort of the sky. The precarious catenaries stretch and reach further and further down, and when inhabitants leave the city they unfurl a delicate rope ladder, which dangles just far enough so that they can leave the city and step down – leaping slightly – onto the uneasy world of solid ground which seems so foreign beneath the hanging gossamer strings.

Only when people leave the marvelous city, its harried pace and urban tension, and its hanging gardens, only when they begin to gaze upward from the earth, do the residents look up at the sky and wonder about the largest cables, those tightly wound braids of steel upon which the entire city's spaces and hopes are hung. After living their lives shopping and commuting and working while climbing up and down the countless ladders and ropes they hesitate and wonder, just for a moment, what those distant cables are anchored to, those tapering thread-like lines which vanish in the seemingly infinite distance.

A City in Bending

It was an accepted structural notion of the twentieth century that architects and engineers analyze beams and other members as if they are bending slightly, calculating deformations, bending stresses, and the like due to specific loading conditions. But this is only the beginning for the city that is always in bending. A city that is never still and never sleeps, the city is instead bending continuously. The idealized fulfillment of fantasies cultivated by years of representations showing blob architecture responding to its users, this would be a city ever able to bend and move, puckering or twisting with each push or pull. Like the Pillsbury doughboy writ large, each person's desire to push a surface would deform it, and just as the doughboy's ticklish stomach bounces back, the surfaces wobble and bend one way and then the other until the next person walks across or touches a building. Everything is therefore constantly in some state of damped harmonic oscillation, moving faster or slower but always somehow bending. Young babies born here discover their own bellybuttons and stomachs, start bouncing in their cribs, and look around their nurseries at the walls and ceilings which are able to bend. These energetic little ones grow up accustomed to this constant sense of flux, and they gasp in perplexed wonderment whenever they see something static, an ancient toy block or some other curiosity which seems to just sit there and not do anything.

Residents of this city remember fondly the dreams of architects who thought that motors were necessary to make their buildings move ever so gingerly, and they have heard rumors of ancient times when entire buildings were solid and unmoving. The heroes in these fables of long-ago are the architecture students who cast their dreams and designs as scale models molded in rubber and woven in fabric, but then kept building out of flexible materials after they left school. These pioneers' faith in deformation baffled their stoic, unbendingly conservative colleagues but eventually won popular approval and became the norm.

Now the city is able to solve countless disputes just by adjusting the stiffness and bendiness of things. Residents wishing to build a slight bay window out into the publicly controlled space along the sidewalk and street are able to reach a compromise; their preferences and their walls are able to bend just a little bit more or less, and the inspectors check the maximum displacement every so often just to be sure, since the inspectors and their measuring devices are selected for properties of only bending very slightly, if at all. In fact the displacement of the bending is not what they are primarily concerned about. They've known for years that if you know the elastic deformation of a material then you know how far it can go before it doesn't spring back to its original shape. The real danger is resonant vibrations. In this city where everything bends, everything, EVERYTHING, has to be bending and flexing slightly out of phase so that one house doesn't start vibrating the same way as its neighbor. In that case the resonant vibrations could induce the whole city to start vibrating sympathetically, with so much force transmitted through the vibrations that residents are unable to walk or drive or do anything without being bounced around. They know this danger and, as they rock their newborns to sleep on cast rubber furniture, they sing lullabies (with lyrics that remind those who listen) about how a little bending, a gentle rocking, is perfectly acceptable – they even feel it whenever they go on vacation to old-fashioned cities with skyscrapers that oscillate in the wind. But no one wants the vibration to get out of control because then everyone would really be inconvenienced and bent out of shape.

A City of Subtraction

We live in rooms and spaces that are possible because there is no solid material filling them. We keep enough material above us to stay stable and create ceilings and floors, but we live in holes. Instead of building by piling material piece upon piece, brick upon brick, stone upon stone, what if habitable spaces were always created by removing and carving solid material away? This displacement of solid material is hardly as foreign as it might seem, not only in cities where soil is removed to create subterranean floors, basements, and tunnels. In fact, the creation of structure and its optimization is precisely this process of subtraction, removing the extraneous and unnecessary material to size I-beams or other elements.

In this worldview we cannot create new material, we cannot bring something into existence. We only chip away and remove and dig. Sometimes people wonder if the material subtracted could be used and reassembled, if the mounds of rubble which surround the city could be reformed into something new. But each time someone mentions this idea, once every few centuries, this whole proposition seems quite tenuous and even scary. The laws and traditions know how to keep people from removing too much material but how would you know when you had stacked too much or built too high?

Besides, building up would somehow obscure the marvelous skyline, the unbroken roofscape which extends as far as the eye can see toward the distant mounds. In this city the identity of everything is identified by its roof, because citizens walk across the tops of buildings and enter by descending downward into the heart of the volumes carved away. Like the archaeological reconstructions of Catal Huyuk in Turkey have conjectured, that original settlement six millennia ago was comprised of homes and shrines packed tightly, sharing adjacent walls but with the top surface pierced by each space's entry. The roofs are each their own shallow vault or span, a second ground with its own topographical definition. Residents traverse them so often in the course of daily life that they begin to forget that streets could have been between buildings instead of above them. The muffled sound of footsteps is a part of living inside, and privacy is measured by how deep into the earth and how thick the roofs are. But the need for light is not only accomplished through the entry-skylights. The roofs are punctured by lanterns, a festive constellation of lights plunging upward and bringing the sky into the interiors.

Each careful subtraction becomes an addition to this dynamic landscape, and each time one citizen imagines something new not to build or enclose but rather to subtract, the entire neighborhood consults to agree on how thick or thin the remaining earth should be. The process of change is constant and slow but extraordinarily elegant, whether accomplished by stonecarvers or by hydrologists. The countless tunnels and niches which twist in a three-dimensional subterranean spatiality are bewildering and stunning for newcomers to navigate, particularly when they see carving marks or where the city's water system is perpetually dripping in certain areas labeled as construction zones. But after a while this becomes most rewarding when longtime residents descend into the earth and lose track of where millennia of pre-human stalagtites end and where the millennia of dripping water has been initiated by the water department to gradually erode the earth in gloriously subtle and supple ways.

A City as an Institute for Learning and Memory

Cities and the buildings and places within urban areas exist outside of our brains. Each person in the city, each visitor from afar, each person who reads about places they have never visited in person, each of us has a particular memory of what we know and think and feel about them, yet the places are more than this sum. The built environment is fully embodied, it exists in physical space, and it therefore holds the capacity to be an instrument of memory. Not only of events which occurred somewhere or people who lived and died, not only history, but an instrument of memory which holds the intellectual history of a society.

A particular city had leaders who realized this and conceived that their city was not only a place for memory but for learning. The buildings that stood and fell and changed were a record of how we learned to accommodate and utilize new technologies, new cultures as our neighbors, new activities and ideas into our society. Children could learn in school about the industrial revolutions of centuries past but they could experience the gravitas of endlessly repeated mill buildings, car factories, silicon chip R&D labs – and all their various global socioeconomic consequences – in ways like no other by experiencing them in all the richness of human perception. The textile mills, with their massive omnipresence in the cities whose growth they fostered, enables one to recall how different and unprecedented they were in their stark contrast to the comparatively humane brick courtyards of colleges, hospitals, and other contemporaneous buildings from times long ago. Seeing the first historic research parks dedicated to computers may be fun for people on vacation purchasing antique technologies as souvenirs at the gift shops, but it also reminds them back when metaphorical "addresses" were first applied to data and online "sites." As powerful as computers have become in being able to transfer and access information from far away, residents of this city were among the first to realize how the physical spaces where originals were stored could show how physical spaces are both tremendously resilient and yet inevitably fragile in the face of deterioration or the human will to destroy.

Living in this city of learning and memory means being conscious that its pieces are physically connected in ways very different from how each resident understands his or her mental map of the same places. If your mental map excludes certain landmarks, no matter how vibrant their physical appearance, you will not really know them. The innovation of applying landmarks and associations of proximity – inherent qualities of physical space but challenging aspects to apply to electronic information – meant that the creative structuring of data and thoughts and ideas became one of this city's biggest industries. Cities are more than linear chains of continuous experience like a personal narrative, more than a single linear street or an undifferentiated sea of files through which to search because their contents – people, businesses, information, services, objects – have a "where" that is more than a written address because it has layers of experience and association we each learn and remember gradually.

Yet the one thing residents of this city cannot seem to remember with confidence, curiously enough, is how their city started to be this way. They know how old the ancient buildings are, they can point to the very oldest ones which experimented with titanium and other materials and date them to the turn of the twenty-first century, but had this new mindset already emerged? The most learned urban scholars – persons of great political thrust and respect – can trace the entire history of human civilization and the key moments in the broad history of urban form and organization, moments from which we have learned as humans: geometric rationalism and axiality in Paris and other parts of France during the Enlightenment, the gridded colonial plans prescribed by Spaniards in their Laws of the Indies, and countless other examples. No, the issue here is not one of dates and facts because the mindset is so pervasive people tend to read their own current interpretations and ways of perceiving cities and their buildings (as functional memory devices) onto the past, whether or not people thought that way at the time. Frances Yates' work on memory and urban theatres since antiquity seems to have something to do with it, and many people believe that an important step came long ago with continuous Internet blogging back when it was simply linear strings of text and images and videos instead of a coherent framework.

Yet amidst the civic amnesia about the particular origins of this understanding of their own city, the preservationists in the city are adamant about retaining the structures which in the future will convey meaning to citizens who will understand their importance in different ways. One of the oldest and most revered places, which for some gives hope that they will someday uncover clues to the early stages of cities as memory devices, is a building whose boldly chiseled forms in stone, steel, and glass bear the name "Institute for Learning and Memory." Maybe its builders realized the significance of the title for the broader world, or maybe they just were naming a neuroscience research facility, but each day walking past this designation the urbanists, designers, and researchers who work inside are reminded that the city they plan and build today is a physical memory device far more potent than any of their hard drives or file storage systems.

Picower Institute for Learning and Memory over railroad tracks, 2005

From Fiction to…

The final description is a fictionalized future account of the Picower Institute for Learning and Memory, which is the new Brain and Cognitive Sciences building at MIT by Charles Correa, Julian Beinart, the architectural firm of Goody Clancy, and engineers at Arup and Le Messurier Associates. It has recently earned the nickname of being the "Brains and Trains" building since its delicate lab spaces leap boldly over railroad tracks.

Its elevated common spaces spanning the tracks and roofed by a delicate glass assembly are at once unfamiliar and strangely calm, allowing spaces within the serenely detailed architecture to surround us, to let us forget the miles of steel buried in the structure above and below the ground, to help us temporarily ignore all of the design components which minimize vibration, and then to tempt us with the daring presence of train tracks and a prow-like massing which pop back into view and recount the drama of negotiating complex infrastructure.

Charles Correa (right) giving a tour of the building, 2005

View from interior common space above the railroad corridor, 2005

For all of the fiction in imagining cities wildly different from our own, from Edward Bellamy's *Looking Backward 2000-1887* to Italo Calvino's *Invisible Cities,* the worlds people write and imagine as fiction are actually quite possible – if not in totality, then in cherished moments of surprise. Bellamy's account of Boston in the year 2000 imagined the following as fiction:

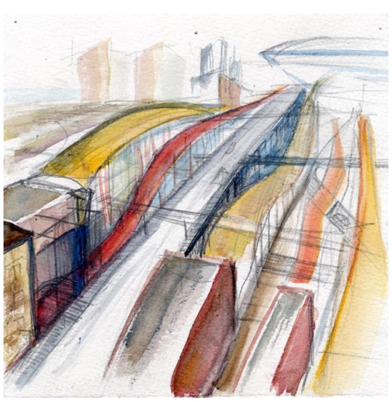
> At my feet lay a great city. Miles of broad streets, shaded by trees and lined with fine buildings, for the most part not in continuous blocks, but set in larger and smaller enclosures, stretched in every direction...Public buildings of a colossal size and an architectural grandeur un-

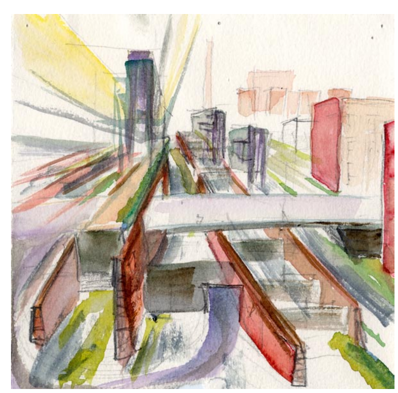
> paralleled in my day, raised their stately piles on every side. Surely I had never seen this city nor one comparable to it before... [Hunt 2005 p.420]

Bellamy's text allows the reader to envision these qualities as potentials for cities in the young American nation, even as it is written as futuristic fiction.

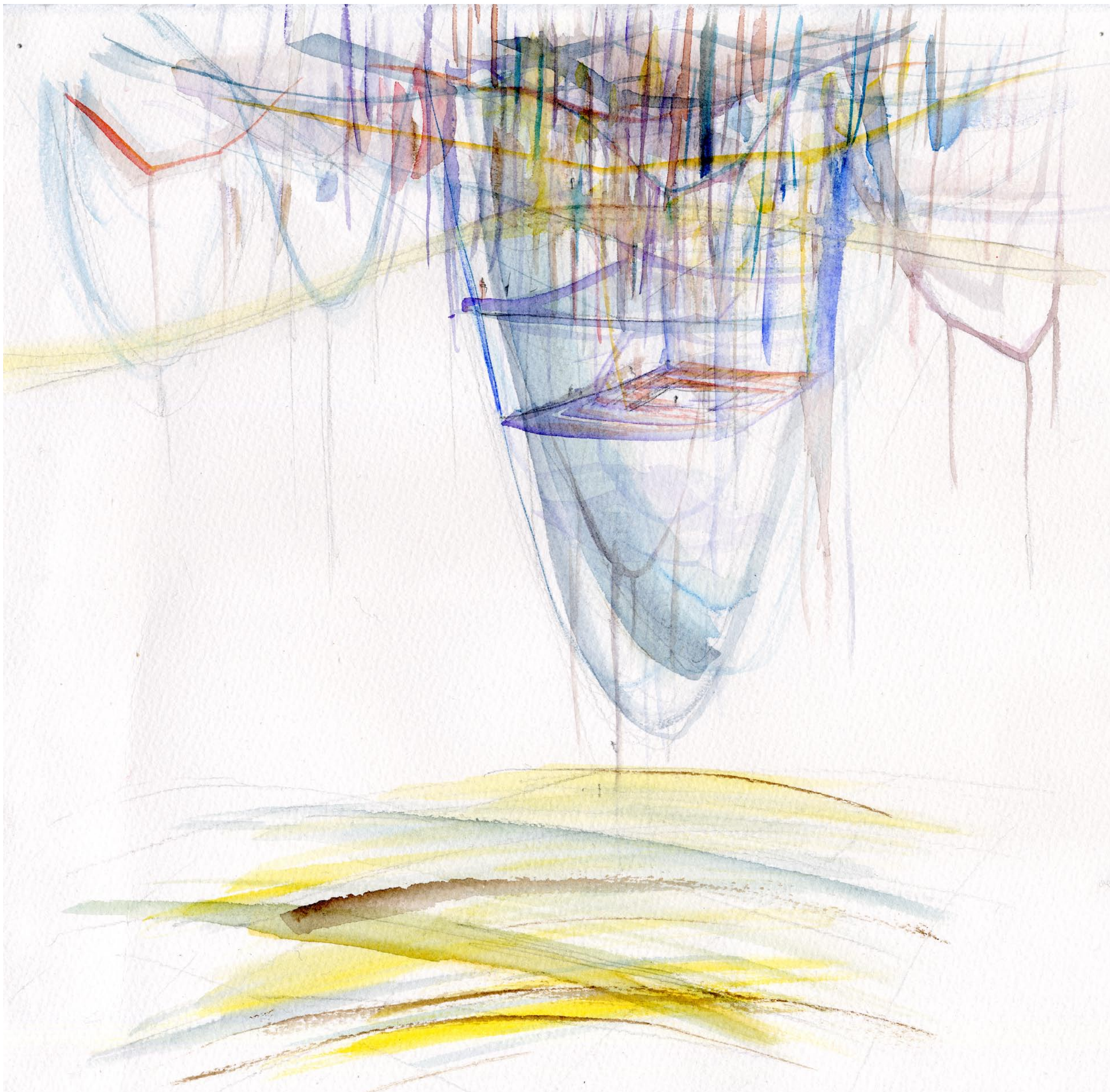
Considering this viewpoint, the stories in this chapter are not unlike the plans for countless cities which have done the impossible by wrestling land from inhospitable swamps and oceans, building cities such as Venice, New Orleans, Mexico City, Amsterdam, St. Petersburg, and even many parts of Boston. These urban projects were no less fanciful until they were actually built; once St. Petersburg had finally been built out of the swampland, the official government corrector of books exclaimed that this improbable feat had been achieved through human rationality because now, out of the mucky mess "Geometry has appeared...nothing on earth lies beyond measurement." [Berman 1982 p.177].

Once we allow ourselves to negotiate between our imagination and our foundational backgrounds of experience, the capacity for fiction to someday become real can be gradually recognized as an optimistic potential aspiration for the future. Once that is achieved, what remains is for architects and others in society to envision and design the necessary processes and products of construction and implementation.





Watercolor studies for imagined city proposals



Watercolor study for imagined city
in tension

Chapter 7
Shaping and Efficiency

> …[Their] structural prerequisites coincided with the reason for its being, so that of themselves, without supplement, they grew to the purest expression.
>
> [“Kopf des Amenophis IV in Berlin,” Rilke 1997 p.75]

> There wasn’t much material [that] went into you, but what was there rang true.
>
> [Laxness 2005 p.176]

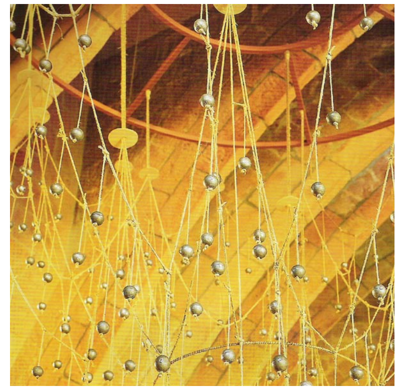
Great leaps of creativity have been made with limited means. Sometimes these means have been limited by available materials or by technological understanding of safe construction. The elegant structural devices of Antonio Gaudi, Robert Maillart, Eladio Dieste, Zalewski (Chapter 2) and others are all examples where projects were often chosen for construction because they used the least material and were therefore the least expensive in economies where material was expensive and labor was cheap. Beyond safety and economy, the constraints and conditions that hovered beneath the surface of the discussion in Chapter 5 include conditions of fabricating, transporting, and installing the structure (See Chapter 5, Criteria A-J, particularly Criterion I).

Not only for its economic implications, efficiency is often primary among many values which can influence decisions. It is an often unquestioned compliment to “optimize” an “efficient” system, without specifying if that efficiency is in terms of embodied energy, overall volume, mass, weight, or other measures. Most construction materials in the United States, however, are no longer so expensive so as to deter overstructured and attentively shaped designs. In comparison, labor is so expensive that a design that is easier to install but uses too much material wastefully may still be far more economically efficient.

Therefore the careful shaping of an object or structural device to save materials is still at present a rare strategy toward achieving efficiency. However, given the current architectural trends toward new strengthened and composite materials, the techniques of efficient shaping can be viewed as not only useful but of great importance in making these innovative materials a viable alternative by using their specific properties to inform optimized ways of incorporating them without prohibitive costs.

Nevertheless, my approach is considerably informed by the tradition of engineers and architects for whom structural shaping and geometry is a primary concern, a tradition that includes Gaudi, Maillart, Guastavino, Nervi, Dieste, and Zalewski. Zalewski and Allen's 1998 textbook *Shaping Structures* opens by quoting Dieste's assertion that:

> The resistant virtues of the structures that we seek depend on their form; it is through their form that they are stable, not because of an awkward accumulation of material. There is nothing more noble and elegant from an intellectual viewpoint than this: to resist through form. [Eladio Dieste, La Estructura Ceramica, Bogota: Escala, 1987, quoted in Zalewski and Allen 1998 p.ii]

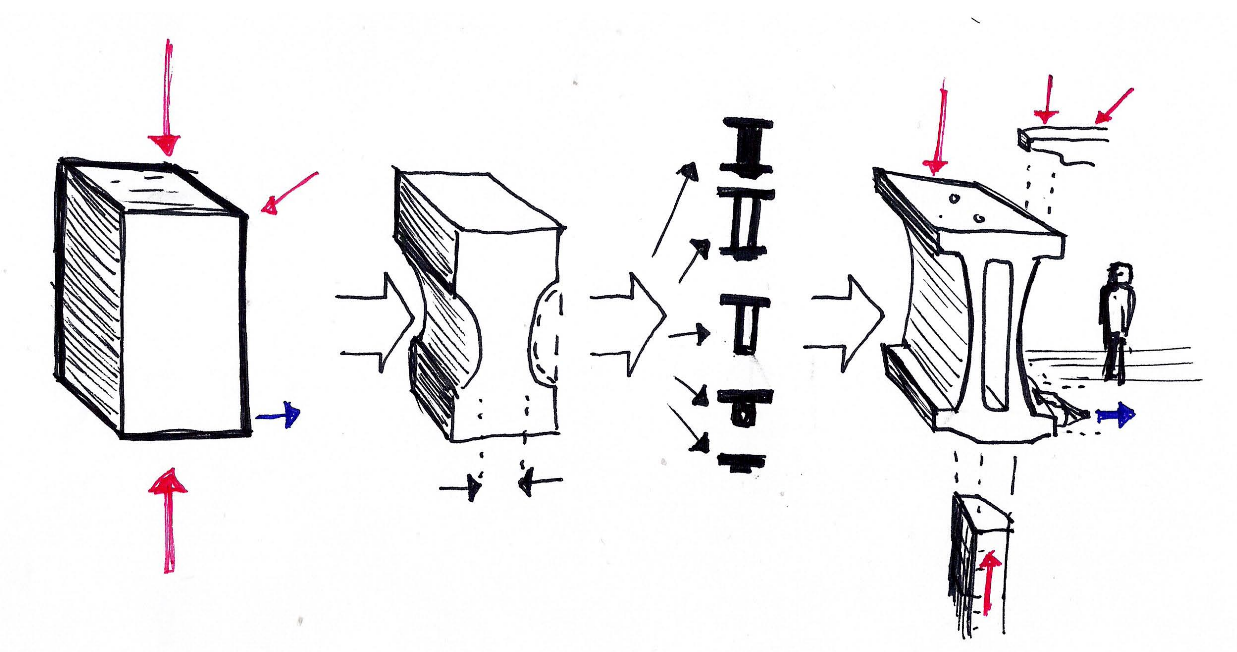


Weighted chains as catenaries to be inverted for Gaudi's optimally shaped vaults [Bergos 1999]

Articulated column shape by Gaudi [Bergos 1999]

The rules for structural shaping that I employ in this design process are as follows:

- Start with a reasonably sized chunk of material with known properties;
- Determine the loading conditions to which it will be subject;
- Remove excess material;
- Keep enough excess material to avoid undue risk...
- ...but don't keep so much that you obstruct future use;
- Shape the resulting material so that it and other pieces can be molded and fabricated from a limited number of pieces;
- Then **inhabit** the space defined by the material remaining, occupying it with uses and services and places, and puncturing it to allow for light and air to travel through the spaces defined by the structure.



Beyond this process of decisions, additional criteria for structural design are borrowed from CEKOP's industrial Polish architecture publications. This book featured designs by Polish engineers and architects such as Zalewski and his colleagues, and cited the following criteria:

- Amount of material
- Amount of formwork
- Resilience [under loading]
- Vertical depth
- Simplicity of assembly
- Small number of types of elements
- Optional dimensions due to flexibility
- Low weight of individual elements [CEKOP 1960 p.40, within Zalewski 2006]

At this point I return to the essential difference of negotiating with known and unknown forces and conditions. In places where the future development loads and specific underground conditions are at present estimations rather than facts, the system tends to prioritize avoiding risk rather than minimizing mass. The bundled boxbeams have great flexibility in their ability to bear down at irregular intervals because of the shaping of their internal post-tensioning and related individualities that will become clearer in application (See chapters 8 and 10). The element of shaping becomes far more apparent where known conditions and forces exist; decisions and negotiations in these cases, such as at the terminations of the beams and where it meets existing road and building infrastructure, become expressions of compressive and tensile forces where the architect has freedom to accommodate those forces within components, objects, and systems.

The above criterion of inhabiting the structure is crucial because it makes the efforts and the results palpable, perceivable, even if only at several moments. It is too easy to encase and protect all of the structural elements so that they recede so far into the background and disappear. Particularly in the case of underground structure we tend to ignore the shaping and amount of material in below-ground structure; it is often equal to or greater in mass than the amount of steel or concrete above ground and is therefore deserving of care and attention. However numerical its many attributes, structural shaping – just like urban design and the creation of cities at many scales – is not all about quantitative efficiency. "Geometry is the mathematics of structural imagination" [Zalewski 2006], and this quality of imagination is crucial toward acknowledging the designed-ness of structure. Whereas geometry in the previous chapter was evidence of human ingenuity to measure land and cities, geometry in the design of structure is likewise an integration of humanizing qualities with factual quantities. And even efficiency should never be encapsulated in simply quantifiable terms:

> Economy has always been a prerequisite to creativity in structural art...Minimal materials and costs may be necessary, but they are not, of course, sufficient. Too many ugly structures result from miminal design to support any simple formula connecting efficiency and economy to elegance. Rather, a third ideal must control the final design: the conscious aesthetic motivation of the engineer...the freedom that engineers actually have to express a personal style without compromising the disciplines of efficiency and economy. [Billington 1983 p.6]

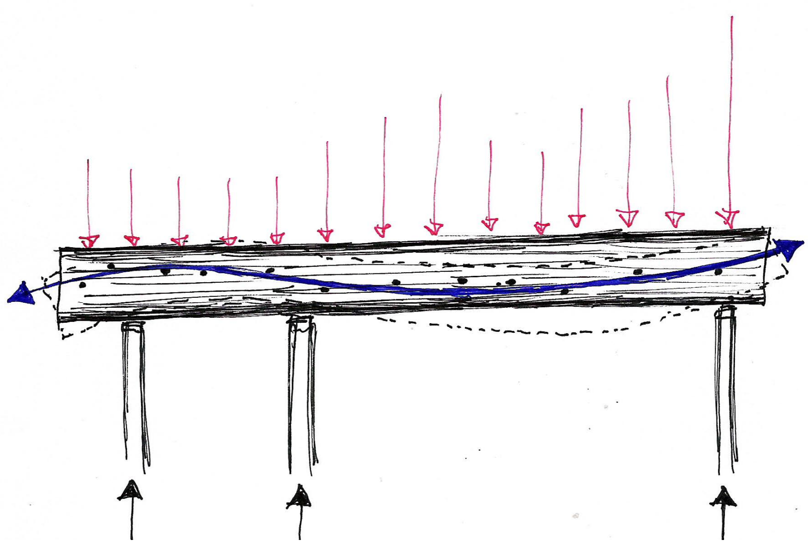
Internal view of capital floor system design by Zalewski with tapered column capital arms and open light wells [Zalewski 2006]

Edward Allen and Wacław Zalewski concludes their textbook *Shaping Structures* with the following quote that reaffirms the creativity and design implicit in structural design.

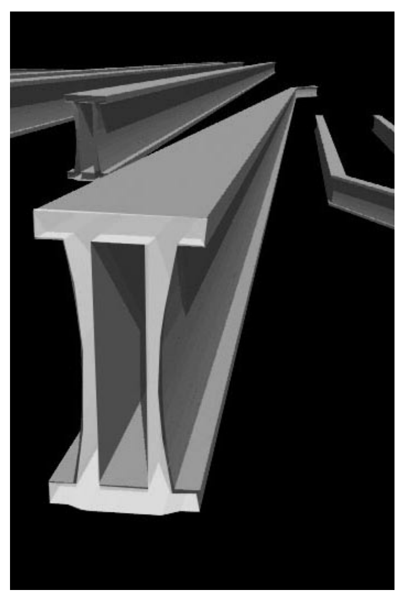
> [Structural Design] is not a science. Science studies particular events to find general laws. [Structural] design makes use of these laws to solve particular problems. In this it is more closely related to art or craft; as in art, its problems are under-defined, there are many solutions, good, bad, or indifferent. The art is, by synthesis of ends and means, to arrive at a good solution. This is a creative activity, involving imagination, intuition and deliberate choice. [Ove Arup 1986, p.9]

Therefore the proposal for a bundled boxbeam is shaped to accommodate a variety of unknown loads and to allow for individuality at distinct places of known loads. The shaping of the beam section enables its material to be reduced to only 36% of the unshaped rectangular sectional area it occupies. The structure's relationship to the site and to utilitarian needs between the bundles shall be the next point to explore.

Internal Post-tensioning cables (blue) based on loading (red) and support (black) conditions



Visualization of beam profile for site proposal near Summer Street



Chapter 8
Firmness and Utility

> While automation prospers, our roads, bridges, and urban civil works rot. Children control computers while adults weave between potholes. The higher that high technology sails the worse seems our earthbound services for water, transportation, and shelter. Yet civilization is civil works and insofar as these deteriorate so does society, our high technology notwithstanding. We forget that technology is as much structures as it is machines, and that these structures symbolize our common life as much as machines stand for our private freedoms. [Billington 1983 p.3]

Engineer and educator David Billington has written, worked, and taught with the firm belief that "structures, the forgotten half of modern technology, provide a key to the revival of public life." [Billington 1983 p.4] He sees a decline in the civic importance of firm, resilient, well-maintained structures as a capitulation to negative characterizations of infrastructure. While he affirms the role of "design" in the creation of such structures for utilitarian purposes, he reinforces a distinct separation between this approach and that of architecture:

> Structural designers give the form to objects that are of relatively large scale and of single use, and these designers see forms as the means of controlling the forces of nature to be resisted. Architectural designers, on the other hand, give form to objects that are of relatively small scale and of complex human use, and these designers see forms as the means of controlling the spaces to be used by people. ...structural engineers and architects learn from each other and sometimes collaborate fruitfully, ...but the two types of designers act predominantly in different spheres. [Billington p.14]

I would agree that some of his distinctions make sense for a limited number of engineers and traditions but we are confronted by more and more architects and engineers whose bridges, factories, terminals, and other devices are less clearly categorical. Some of this is merely cosmetic, as the landscape-like systems which Moneo critiqued in Chapter 3 are only architectural visions supported by another engineer's internal strategy. However, I am optimistic in the future of well-designed utilitarian devices by architects and other designers to succeed in particularly visible urban contexts not because of their works' mere appearance but because of their firmness and utility, their intentional resilience and broad lifespan combined with their present usefulness for various modes of occupation (recall patterns 1 and 9 from Chapter 1). Billington even hints at this urban role: "Most people would agree that the ideals of structural art coincide with those of an urban society: conservation of natural resources, minimization of public expenditures, and the creation of a more visually appealing environment." [Billington 1983 p.20] Contested urban problems don't always come with clear labels as to whether an engineer or an architect or a landscape architect or a city planning official has the most helpful perspective, and to achieve true usefulness in most urban sites requires a negotiation of all of these (and many more) disciplinary representatives.

Therefore the structural devices proposed in this thesis are explicit in their intention to be not only a boldly identifiable and readily understood intervention – **they are a series of bundled beams which run from elevated connections to bridges and the convention center down to the water with piers** – but also a proposal which integrates building services, utility connections, and parking as changeable elements within a resilient framework. In this role the bundles constitute "A negotiated hybrid between infrastructure and landscape." [Solomon 2004 p.33]

Yet given this hybrid role in an urban setting, therein lies the negotiation of firmness and utility: the lifespan of an element needs to be gauged to its potential usefulness and need for change. The overall structural solution already allows for future strengthening beneath or between the individual beams, but **the solution is never just a single beam but rather a bundle. It is a bundle of beams, spaces, rights, responsibilities, obligations and possibilities,** the combined effects of which shall be explored more fully in Chapter 10. The point for now is that the space between bundles allows the continuous beams to contain and support utility corridors and connections to service future buildings and yet be able to be changed without removing the entire street surface, support beam, or other disruptive actions.

Beyond the reasons for using careful shaping for the bundled beams stated in Chapter 7, the intended longevity of these beams and their scale across the hundreds of acres in South Boston reinforces reasons for employing a material less prone to degradation and decay than ordinary reinforced concrete:

> High performance concrete (HPC) is generally characterized by the following properties; [sic] ease of placement, compaction without segregation, early age strength, long-term mechanical properties, permeability, high density, toughness, volume stability and long life in severe environments generally due to the lack of connecting capillary pores. To achieve these properties the formulation of HPC is carefully regulated to maximize compaction and homogenous distribution of all constituent materials in the mix. High performance concrete has generally replaced high strength concrete as the designation of the array of concrete mixes that achieve performance well beyond that of normal concrete. ...Recently, successes in developing a ductile concrete have led to entry into the marketplace. Ductile concrete is a material for

> which the inherent improved fracture toughness of the concrete results in a material that does not necessarily require steel reinforcement. This is a huge breakthrough. The concrete developed has greatly improved strength (compressive strengths up to 200 MPa, flexural tensile strength beyond 40 MPa), is self-compacting, and demonstrates a mode of failure that rivals ductile structural materials such as steel and timber. The ramifications of this development will most likely be very substantial because it begins to answer the desire for a ductile ceramic material…currently the only drawback is the cost, substantially more than regular concrete. [Fernandez 2006 p.220]

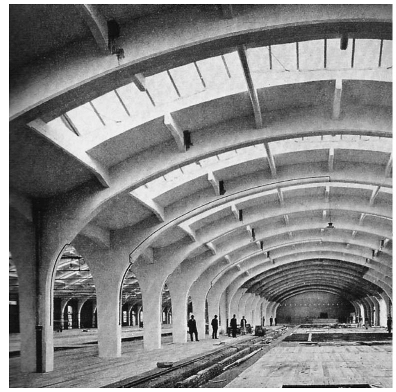
One of the prevalent products using HPC is, as Fernandez cites, the Lafarge corporation's Ductal concrete, named in an allusion to its high level of bending resistance, its great flextural strength, and its ductility [Lafarge 2006]. Its internal composition includes either organic fibers for moderate load applications or steel wire-like fibers for most high load applications. Its increased capital expense is more than balanced in its longevity and durability compared to traditional aggregate-based concrete, and it is particularly well-suited to the highly visible foundation applications envisioned in this urban project.

> Ductal® is also extremely resistant to external stresses, such as abrasion, pollution, bad weather, and scratching. Constructions made with Ductal® resist abrasion as well as the best natural rock, such as granite. These properties provide Ductal® with outstanding durability, guaranteeing less maintenance throughout the lifetime of the structures. Furthermore, Ductal® provides a wide range of uses and great workability, since it can be used as a self-placing concrete (very fluid concretes which fill out every detail of the form work) or as a dry concrete…its ductile property enables the construction of beautifully sleek proportions and long spans. [Lafarge 2006]

On Beauty

In referring to the negotiation of firmness and utility, I inevitably draw upon Vitrivius' formulation of the tripartite relationship between these two aspects and **beauty**. Since the Enlightenment, most modern conceptions of aesthetics tend to exclude beauty based on intrinsic content and meaning; "beauty – as a sign of transcendence, as an intimation of the glory of a hereafter, whose figure is hinted at in the splendour of nature and of art – has not been the focal point of art for the last two centuries, and even less so in the case of architecture, which has striven generously to build new cities – cities that are more hygienic, more rationally organized – for mankind. [Crippa introduction to Bergos 1999] While discourse on beauty may not be one of prime importance in everyday urban life, its presence in art and design is no longer quite as marginal as other times in post-Enlightenment culture, and I believe that it is relevant to address beauty in physical design at least briefly. In the opening of his new book on materials in architecture, Fernandez notes that "To 'afford delight and service' (Louis Kahn, 1944) is an optimistic phrase that captures well the best aspirations for making buildings." Fernandez continues:

> In articulating this pair, Kahn gives us a remarkably succinct statement of the ultimate goals of architecture. In doing so, he also enlivens a practice that concerns itself with the symbiotic linking of the pragmatic and the poetic – the technical and the intuitive – in the material works of our built environment. We are reminded of the articulation of the essential parts of architecture by Vitruvius; *firmitatis* and *utilitatis* define the service rendered by buildings and *venustatis*, the delight, or grace, that results. [Fernandez 2006 p. 1]



Enamel and Metal Goods Factory in Liget falu, Slovakia, 1912 by Heinrich Zieger, Wayss & Freytag AG [Goessel 2005]

But is delight and beauty all about results? In the case of structural art and infrastructure, many modernist designers and critics (Le Corbusier, Siegfried Giedion, et al.) glorified a functionalist aesthetic achieved through idealized engineers' reliance on scientific knowledge, allowing their results to approach the elevated plateau of architecture. G.H. Edgell stated in 1928: If an engineer, meeting a special problem in a purely scientific way, produces a building of beauty, he has produced architecture...He becomes – temporarily, at least – an architect. [Slaton p.168]

This is a simplistic and inane trope of modern culture that depicts engineers as calculating automata who occasionally produce something of merit. It is a view that has encouraged the splintering of architectural and engineering discourse which permeates education and practice: engineers are stereotyped to rely on calculative methods while architects focus on formal beauty, and no one in either camp can do both.

Due to the growth of urban preservation policies since the 1950s, beauty has now become quantifiable and protected under law according to preservation author and urbanist Anthony M. Tung. Yet even given the broad range of Tung's analyses and characterizations of preservation and urban aesthetics around the world, he tends to focus on that which is physically visible. Rather than reverting to the subjectivity of taste, his writings fall into a tradition of discourse that (without stating so explicitly) takes on implied assumption that underlying conceptions of beauty are innate and therefore common to all of us. This is what enables the possibility for discussion toward agreement and consensus, and it very much grows out of the tradition of Leon Battista Alberti's conceptions in fifteenth-century Florence, whereby architecture exists as both a profession and as composed objects that are the products thereof. Alberti's delineation of beauty outside of taste lays the foundation for affirming lasting beauty even in embodied creations such as architecture.

Granted, any notions of commonality are controversial because they hint toward universality; such implications therefore clash with pervasive relativisms permeating the current cultural and academic climates of discussion. We rightfully thrive on affirming and acclaiming diversity in our creations and stories, in individual relative sensory perceptions and viewpoints, rather than dogmatic authoritarian canons.

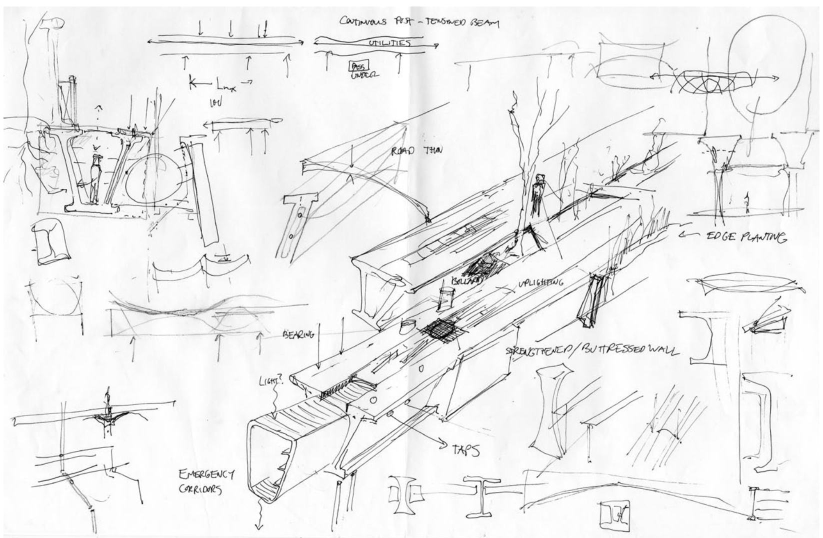
Yet one of the key elements of urbanism is that the city, its objects and its spaces, exist outside of individual experience and thus holds a potential for commonalities. Therefore the city can be conceived as a possible topography for notions that are held common between people. In order for it to present this potential, the physical objects need to be perceived and reassessed as having the capacity for inherent beauty, even if as fashions and personal tastes for their stylistic embellishments change over time.

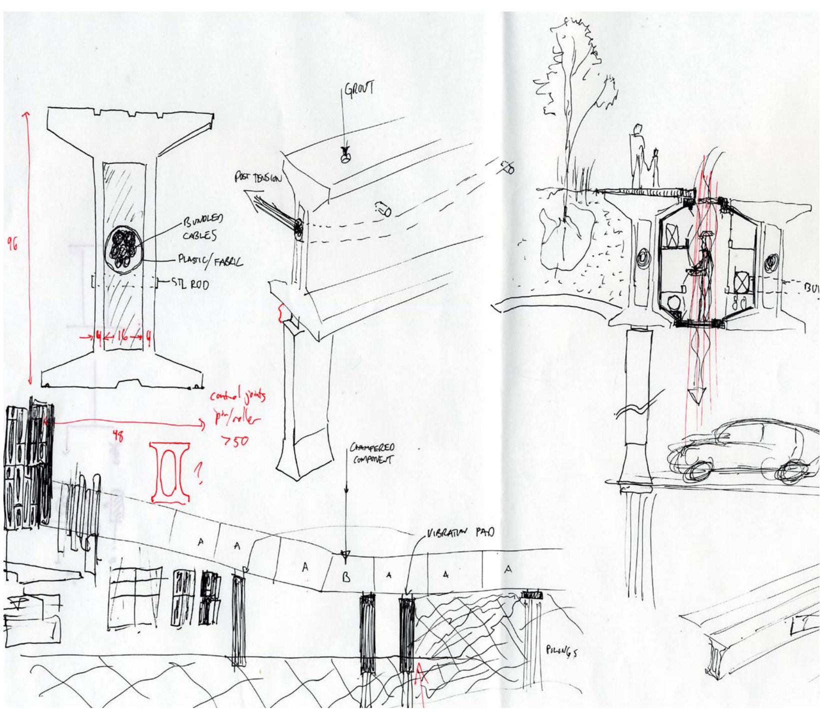
Yet I would argue that there is more to beauty than this affirmation of physical objects. It is also not enough to simply acknowledge that beauty can also exist in that which is obscure or invisible – the details in cathedral corners whether or not anyone can see them, the hidden construction within walls that are crafted preciously even though they will be covered as the building is completed. Rather, the concept that beauty can exist in the typology and organization and workings of the "machine" (Chapter 1) allows us to get beyond the appearance of "spare parts" toward a more holistic concept of elegance. Similar to its use in mathematical discourse, **elegance** implies a tightly woven relationship devoid of extraneous additive accumulation. This conceptual elegance is embodied in the beauty of Dieste's structures in pure compression, in the Zalewski examples with arch and cable action producing a net constant force, in Dow's unit blocks which are both enclosure and an expression of assembly and human scale, and in the typological transformations of structural elements which are present in these and other architects' works.

Designing firm, useful, elegant solutions allows the Fort Point Channel problem to be approached not simply for its physical appearance or visualizations, but also how elegantly it responds to and transforms the process of creating land, streets, and architectural systems which created the existing fabric. Therefore the unusual prerogative to design utility connections becomes a way of expressing the allegiance of one linear system of vehicular and pedestrian circulation above ground with circulation systems of cables and pipes beneath.

I have designed this corridor not only to allow for human occupation for service and repairs, but also to minimize the cost of running a new system (next generation fiber optics, changing materials for ecologically sensitive building services, etc.) to the buildings in the future. Furthermore, the material qualities and translucency of the corridor allows it to express connectivity not only laterally but vertically from subterranean passages up to the surface.

If it were only to hold utilities, cables, pipes, and other pieces of mute necessity, the bundles would hardly seem to justify their heroism in scale, form, and deployment. Yet they can do so much more, and this potential to accommodate not just man-made creations but also natural creations which are alive – trees and other vegetation and the hardy urban organisms they support – enable them to populate the asphalt wasteland with an ever-growing linked to deeper, broader issues in human experience. The potentials for firmness and resilience, for utility and practicality, for beauty and wonder, can only really matter if we can relate them into the range of things, experiences, places, ideas, and relationships we already hold and refer to in our minds.





Process sketches for shaping beam and connections along with planting and light conditions

Chapter 9
Referentiality and Nature

> All the great images…the landscape experience far off, cities and towers and bridges and un-suspected turns in the path…
>
> [“Du im Voraus,” Rilke 1997, p.87]

I have already introduced how the structural devices in this thesis create a hybrid negotiated landscape, one with a spatial character that allows it to build relationships within its parts and also to the surrounding city. One of the key elements of perceiving structural relationships – not only those in physical form but in physical space and also in narrative – is that of **referentiality**. That is, the manner by which an individual component or instance of the structure is able to be perceived in relation to – in reference to – a larger whole. This is in one sense the heart of this thesis: articulating and situating how individual works of architecture can contribute to the city.

Yet in another sense the issue of referentiality seems trivial because there are structures holding up buildings and highways and countless other weight-bearing items all around us; structural devices seem ubiquitous. Is it not obvious then that any structure would be one part – a subset of – the whole body of structures that compose human civilization?

This question exists inside a wider discussion. The descriptions in this thesis purposefully meander extremely close to a hyperarticulated reading of the phenomena of everyday life in the tradition of writers and philosophers like Martin Heidegger and especially Maurice Merleau-Ponty, making explicit the elements of life which are so often part of our unconscious background. But as an exercise in this thought experiment, let us retain the discussion of structure and referentiality, but instead temporarily switch the vehicle of discussion from architectural composition to something purposefully obscure: twentieth century European classical music and opera composition. Hold onto your composure, we shall return to stone and steel after not too long of a detour…

A Musical Interlude

Music does not have quite the same obligation to be structurally stable, but its integrity of construction is no less prized – or challenging – in the work of musical composition. [In this and the following discussion, as well as in many insights about cultural production and structure, I am indebted to my teachers with whom I completed a degree in music at MIT, focusing in composition, including John Harbison, Charles Shadle, and Ellen Harris.]

Two particularly useful operas with which to begin are among the most significant works in their genre: Wozzeck by Alban Berg (Vienna, 1924-5) and Peter Grimes by Benjamin Britten (London, 1946). They are highly articulated and complex musical compositions and texts. At the level of the narrative, both works possess fascinating stories with regard to the way cities are perceived and inhabited in relationship to the landscape beyond, and their librettos are adapted from literary works that could be their own subject of cultural critique at present, independent of the music. In the case of the source material for Peter Grimes (*The Borough* by George Crabbe) and Wozzeck (*Woyzeck* by Georg Buechner), the poetic original works detail worlds where cities are one and the same with the onstage crowds of cluttered, overlapping voices. Investigating these imagined cities further and their settings, one could trace the patterns of structural interactions simply within the narrative and point to how the plot's events are inextricably linked to structures. For example, the size of civic structures articulates the difference in community and group actions in the operas, between public judicial hearings, church services, shelter from storms, and semi-private pub gatherings. One could contrast the way characters in the operas inhabit individual apartments in the city versus barracks out in military encampments. But this is too general an understanding. While it is true and it demonstrates that structural conditions of ordinary buildings happen even in the background of fictional stories about provincial life during the nineteenth century, this reading doesn't illuminate the role of referentiality with the richness that music offers.

The music of both Berg and Britten in these operas is characterized by the precise use of a musical language which **negotiates** – one that is not merely the accepted conventions of tonal music in the Western tradition since the eighteenth century – but which has been created to have a coherent structure and vocabulary that negotiates both tonal and non-tonal components. To extend this metaphorical comparison to language, these pieces' composers use musical landmarks that are like punctuation marks, sounds that anchor the listener by starting and ending ideas. This created system of punctuation appears throughout the music to connect events and themes in the story that would be unable to be perceived otherwise. The same melody that Peter Grimes sings as an act of defiance becomes repeated lower and lower until it is the ominous bass line underneath the "passacaglia" interlude (F-D-B-C-F). This interlude repeats that same 11-beat bass line underneath ever shifting and disjunct harmonies at this critical juncture in the story (Act II scene 2), until the single transposed repetition of the bass line at the close of the scene provides a desolate and mournful landmark to the listener.

In Wozzeck these vertical relationships – those which are "vertical" on a score because they are happening at the same time and creating harmonies rather than just being a "horizontal" melody – are tightly constructed as well. Through an equivalent instrumental interlude where the orchestra laments the death of the title character in Berg's opera, a single chilling interval (a major seventh with an added middle note, generally a third) becomes a landmark whether as a single sustained chord or as a group of moving ones. This interlude, an extended tonal variation on the key of D minor, builds to a stacking of these intervals jumping around unrelated keys and areas until the listener is plunged back to the major seventh intervals cascading in octaves. This leads immediately into the final scene, which is entirely a variation on a single continuous rhythm. In fact, every scene of this opera is a highly articulate piece of a larger structure: The first act is a sequence of character pieces, the second an extended symphonic form, and the third a group of six variations (on a rhythm, on a pitch, and so forth).

The start of referentiality in these pieces is that they are coherently self-referential; they set forth a language with a few elements that are repeated so that they have a greater potential of being perceived as being an overall structure. Yet for Berg's Wozzeck, the incredibly precise underlying structure and its incredible strictness is also glossed over because Berg creates the opera not as an intellectual exercise but as an expressive medium; operagoers (or listeners to recordings) pay attention to the emotion of the drama rather than marveling at the hidden thematic inversions and other techniques, transformations which occur "behind the scenes" as it were.

This is the broadly pertinent situation whereby we understand music in the duality Manfred Bukofzer articulated: music has both **audible form and inaudible order** (i.e. structure). Yet Bukofzer penned this analysis in the first half of the twentieth century while writing about Baroque musical traditions, specifically how composers like Bach did not place audible form and inaudible order in opposition but rather emphasized their synthesis.

This is why it is so crucial that in his final work, the Violin Concerto, Berg not only refers outside of his own music to the tradition of Bach but openly quotes a Bach chorale ("Es ist genug") for the conclusion of a highly synthetic and integrated work. It is beyond the scope of this discussion to fully appreciate the tight construction of this piece and its audible expression, but the essential aspect is that its structure is multivalent: it is simultaneously a twelve-tone piece in the tradition of Arnold Schoenberg's atonal music, but is also solidly grounded in the key of G minor and effortlessly integrates Bach's carefully crafted precedent. The pattern of twelve notes which opens the work and occurs throughout is somehow also therefore the first line of the Bach chorale and refers to the overall structure which ties all twenty-five minutes together as one continuous structure. It is not only self-referential and referential to other musical experiences but it is accomplishes this within an elegantly assembled framework.

It is this kind of multivalent referentiality that Douglas Hofstadter enunciates in his Pulitzer Prize-winning "musico-logical" work *Goedel Escher Bach: the Eternal Golden Braid* (1979), demonstrating how mathematical theories by Goedel that underly computation logic can be understood through the impossible visual conundrums of Dutch artist M. C. Escher and the contrapuntal music of Johann Sebastian Bach two hundred fifty years earlier. In this whirlwind of analysis and humorous wordplay in the tradition of Lewis Carroll, Hofstadter arrives at many incredibly clear statements of how seemingly obtuse mathematics and logic statements can map onto everyday life and the way humans process complex structures into something that can be understood. He defines the condition of an **isomorphism** as a transformation whereby there is congruence between an abstracted symbolic statement – such as an equation or a diagram – and a condition elsewhere in the world. This condition of isomorphism allows the complex geometry of Escher or the interwoven musical lines of Bach (or Britten or Berg) to undergo transformations but to still retain all of their information without being so distorted that they are unrecognizable.

Hofstadter also later extends this directly into an example of cities and locations within the place we live, a notion he terms Alternative Structures of the Union (our own reflected versions of the USA). In imagining this mental cartography exercise, he reminds us that each of us build our own mental maps that are unique referential structures not at all identical in their content or relationships, even if individual names and locations map consistently onto specific places in the real world. This recalls Rowan Williams' affirmation of uniqueness in the creation of memorable rather than generic places, and it also informs the use of topography to orient cityscapes, particularly those which give pedestrians a conscious experience of ascending or descending while on a path. The significance of why a given city or a specific location is memorable or referential in our own mental maps is not just a property of what physically exists there but what we associate with and understand to be connected to a place, building, piece of music, or idea.

This does not resolve the issue of communicating referential relationships, however. One of the consequences of understanding the qualities of isomorphisms is that they confront the problems of achieving understanding and communication. These are problems to be resolved not only in music and architecture but in cultural production more broadly. If the music includes thematic material that is being carefully transformed and massaged to create a work of great artistic accomplishment and tightly crafted construction, of internal and external referentialities, it presumes that the listener is being more attentive than simply realizing there is classical music with a violin somewhere in the background. For architecture, such communication requires not only that people who inhabit and observe spaces develop an understanding of what the details and proportions refer to in culture – stories and precedents – but that there would at a more fundamental level need to be a body of buildings and works that people can agree has meaning at all. The music needs both an instrument and an ear willing to listen; the architecture needs something that is communicated beyond and it also needs people to understand it, to make the leap of wondering if a heap of bricks with a handful of other ingredients can actually mean something greater than an assemblage of parts.

This is the problem that confronts architecture today, and it is a broad Post-Enlightenment challenge. The freedom of pluralistic globalism carries the challenge of what to do when not everyone shares the same background of stories and associations and meanings. The Bach chorale "Es ist Genug" which has a text on a familiar Christian (specifically Lutheran) subject of looking beyond death toward heavenly life is several times removed from someone listening to Berg's Violin Concerto, because it requires knowing and perceiving that the solo violin has the melody in this many-instrument work, that the melody is a tune being quoted from something called a chorale, that this chorale has words, that they are originally written in German, and that they have a specific meaning on theological terms besides their literal translation as "it is enough." There is further associative knowledge one might uncover or bring to the piece: the concerto was written in memory of a recently deceased friend of Berg's, and the deceased young woman was Manon Gropius, the daughter of architect and Bauhaus founder Walter Gropius and Gustav Mahler's widow Alma Mahler-Gropius; a few months later Berg himself became ill and died before the concerto was ever heard. Yet all of these layers are opaque and removed from the listener who is not an expert or student of these specific works – in other words removed from almost everyone. Yet this opacity is not just a property of musicological context but extends to the architects and their work in this same story with something as obvious and ubiquitous as factory buildings. Few people now recognize the deeper meanings and aspirations embodied in the industrial works of Gropius and Behrens and other German architects of the early twentieth century because they "just look modern" and not too different from other factories which are now obsolete relics. The fact that scholars can analyze something perceptable doesn't mean the rest of the world knows what – if anything – is there for them to perceive.

One partial approach toward recovering the possibility of meaning in the realm of architecture exists in the work of Dalibor Vesely and his colleagues with regard to “communicative space” through the metaphor of language [Vesely 2004, Carl 2004]. Communication occurs with articulated meaning; it should be placed alongside articulation in the many reciprocities that we have established in our understanding of architecture and also the natural world: the reciprocity between what is given and the many possibilities, the reciprocity between embodiment and articulation, and so forth. Language can thus have meaning in more particular and articulate ways, or in more embodied and broader ways. And this language only has meaning because of how it represents the world. Such a language cannot be the private scribblings of an individual; it must connect to meaning and representation in the wider world.

Yet with the loss of societally common values of vertical hierarchies – theological, monarchical, patrimonial, or otherwise – it is challenging for large bodies of people to have the same underlying value structures and assumptions to agree that a certain work has any clear referentiality. It is easier within small communities, sometimes also within campuses, for limited times because there exists commonality within a bounded condition.

This is why it is a challenge to simply “make buildings that people like.” This seemingly innocuous goal, which a local former university president expressed as his desire for what design students should learn to design in graduate school, is not clear-cut or obvious. The commonality of cultural conditions which enabled agreement over materials and scale to be predominant in the past – the countless ordinary buildings which were built for millennia without architects needing to question their assumptions but rather to make them simply elegant and stable – this stability is not present. We can have shared background through direct experience and indirect association, but the same building that carries the positive connotation of having the densely rich experience of an Italian town as an energetic new place, may for another person carry associations of oppressive new buildings that remind them of poorly maintained housing of their childhood made of the same material. Skyscrapers that are designed to embody freedom and progress may be built upon security bunkers or desolate plazas that communicate paranoid isolationism to those who have not been told “what the buildings mean” because architecture and cities don’t come with the designers’ verbal intentions spelled out. The same highways are instruments of progress to one neighbor and the decline of landscape into “gray goo” for another neighbor. Even ordinary suburban single-family homes carry simultaneous associations of idealized familial aspirations, along with the sprawling wastefulness of industrialized consumption.

This is why the ubiquity of buildings and structural devices does not make them simple. As a society, even when we are aware that architecture exists in the background of our daily experience, we cannot currently speak of them in terms of commonality, of public agreement or commonly, because they either operate within vastly different referential structures (they mean different things to different people) or we choose to ignore our capacity to understand them as more than instruments, objects of a certain monetary worth and usefulness that we can build or change or demolish at will.

That which can be held common

There are two alternatives to this problem of unstructured referentiality, two intertwined topographies that I believe are held common and that can ennoble architecture and cities themselves with a rehabilitated cultural significance: one is that of **nature**; the other is that of **physical forces**. They could even be conceived as subsets one of the other, since gravity and wind loads and other aspects are in many regards inseparable from the environment we inhabit at the edge of the earth's crust. Among the precedents in chapter 2, Zalewski's work and writings, the expressive bridges and structures along Shore (Belt) Parkway, and Calatrava's museum hint at how the fundamental qualities of forces can be foregrounded and not only dealt with but expressed, at how structure can be viewed as the optimization with respect to chosen loads and conditions. Yet this return to a consideration of physical forces is fundamentally not a rejection of arbitrary "art" in favor of rationalist "science," or of the triumph of instrumental knowledge gained through calculation to determine a design. This approach does not regard science as a self-contained belief structure to be followed slavishly but rather as a **common point of departure** through which to make humanistic goals possible and buildable.

Physical forces and the wonder of soaring, daring structural moves that do not merely solve problems but accommodate forces with elegance are thus able to stand as bold landmarks of "mighty" engineering and design. This awesome might of a structure found musical expression centuries ago in the text and music of Dufay's motet Nuper Rosarum Flores written for the dedication of the domed cathedral in Florence in 1436. [Foxe 2004] This ability to be full of wonder and inspiration is perhaps the underlying potential subtext beneath and beyond all the patterns in chapter 1, as each design that is able to transcend the facts of its conditions allows future generations to attach their own meanings to the artifact.

Similarly, the use and relevance of landscape in this thesis proposal can be conceived not as trying to reify and solidify specific meanings but rather to provide a topography of places which can become receptacles for meaning to develop. I believe that carefully designed and articulated inclusions of constructed nature have particular potential to accumulate meaning specifically because of their latent referentiality. The nature of meaning – emerging from the "latent…silent background of the natural world" – is such that the meaning of *nature* is polyvalent enough to accommodate a range and depth of meanings for individuals in an urban society. [Vesely 2004, Architecture… p.379]

Meditating on this point in her reflective narrative *The Language of Landscape,* Anne Whiston Spirn develops the poetics of conceiving landscapes, their phenomena and structure as being able to contain such meanings:

> Landscape has meaning…Some meanings are human inventions, and yet significance does not depends on human perception or imagination alone. Significance is there to be discovered, inherent and ascribed, shaped by what senses perceive, what instinct and experience read as significant, what minds know. [Spirn 1998 p.18]

The nature of meaning does not imply that every person who visits the design will understand or consider important specific intended meanings, but that the phenomena present within the site's constructed nature of plantings, its created slopes and topography, its relationship to the water, and its weathering over time, hold latent meanings as a microcosm with the tension between order and disorder which permeates life in nature and in cities.

Landscapes as evidence of negotiations between human order and natural forces, Cambridge, 2006

This complex relationship of order in natural elements and objects enables a simple pattern, such as branching on a tree, to be inextricably linked with complex phenomena: delicately dappled light beneath, details of texture and variation. Therefore the relationship between the tree's structure (roots, trunk and branches) to manmade structures is not one of competition or mere imitation but rather two aspects of how the physical environment can be understood at many levels. Therefore structuring – the act of resisting the gravitational pull of material into a heap of rubble, resisting chaotic multiplicity, resisting the tendency for entropy to increase, has the capacity to be a common point of shared background, literally a shared "topography," the ground upon which discussion can occur toward commonality. We can share in the wonder of structures and natural objects, at their heroic massivity or their delicacy, at their elegance in accommodating many challenges in a complex urban site.

Addressing the meaning of nature within the built environment can result not in theoretical complexity, but rather in distilling projects to their basic essences which can be understood commonly within cities. This is evident in the processes and physical fabric of cities, in the values and forms with which architects, landscape architects, planners, designers, and other actors engage, even though defining meaning remains an open-ended challenge:

> Meaning is a difficult concept, for it means too much. Meaning begins with the correspondence of sensate form to invisible idea, logically links intention and response, then expands through private association to join all a thing is with all it can be in the minds of its creators and perceivers. Finally, meaning carries through the shared experience of form and idea to philosophical bedrock. Most crucially, meaning is that which joins people through things, transforming forms into values, values into forms. [Glassie 1982 p.33]

Therefore meaning becomes a orienting principle, however latent, toward a conception of urban design as the intersection of values, forms, and meanings – and toward an understanding of nature as a fertile topography for the deep and challenging human desire for meaning and referentiality.

This implication of structuring beyond architecture has the tendency – particularly in excursions into broad cultural theorizing – to seem totalizing, to seem to aspire toward a complete world. Gustav Mahler, the bold symphonic composer and master conductor of operas in Vienna around the turn of the twentieth century, whose work is a musical predecessor both Berg and Britten, reveled in the desire that each of his monumental symphonies encompass a complete musical universe, or more audaciously, encompass *the* world. This is the "beyond" which human creativity in the arts and sciences and other realms seems to verge upon, and it makes the title of this work wonder how far its aims extend "beyond architecture." The "beyond" is not infinite – architecture and its appearance, its structure, its form, its physical existence, cannot fully shape or determine human life. For all of the values embedded and embodied within architecture, for its precariously amazing qualities as a Weltanschauung – an overarching worldview – and thus as a way of approaching and perceiving the world, structuring is not implied to be in any respect a theology nor a deterministic tool.

Rather, structure is something far simpler – **it uses everyday ordinariness to allow people to imagine themselves as they fit into something shared.** Structuring is a means whereby that which is latent in everyday life and shared among many people can be brought to the foreground, so that people who see and experience and occupy the structural devices can place these constructed entities within their own unique referential way of ordering and understanding the world and yet understand the city as grounded in something common, beyond their own personal experiences, and with an inescapable size and scale to its structure.

> Of all arts architecture is the one which consistently detrivializes, though it can't de-relativize, scale. The size of the human organism doesn't have much bearing on

> literature or even on music. When we talk about a novel's size we mean its length, but a symphony fills space as well as time. More people than Erich Mendelsohn have experienced music as a series of structures, which grew and collapsed and reformed again according to a logic not available to an architect. But the essential point for architecture is that the perceiver is a building already, that as well as the inhabitant he is an ideal rival of the contemplated structure matching himself against it not just to see how well it will fit him, but how well it measures him. [Harbison 1991 p.162]

Natural Components and Systems

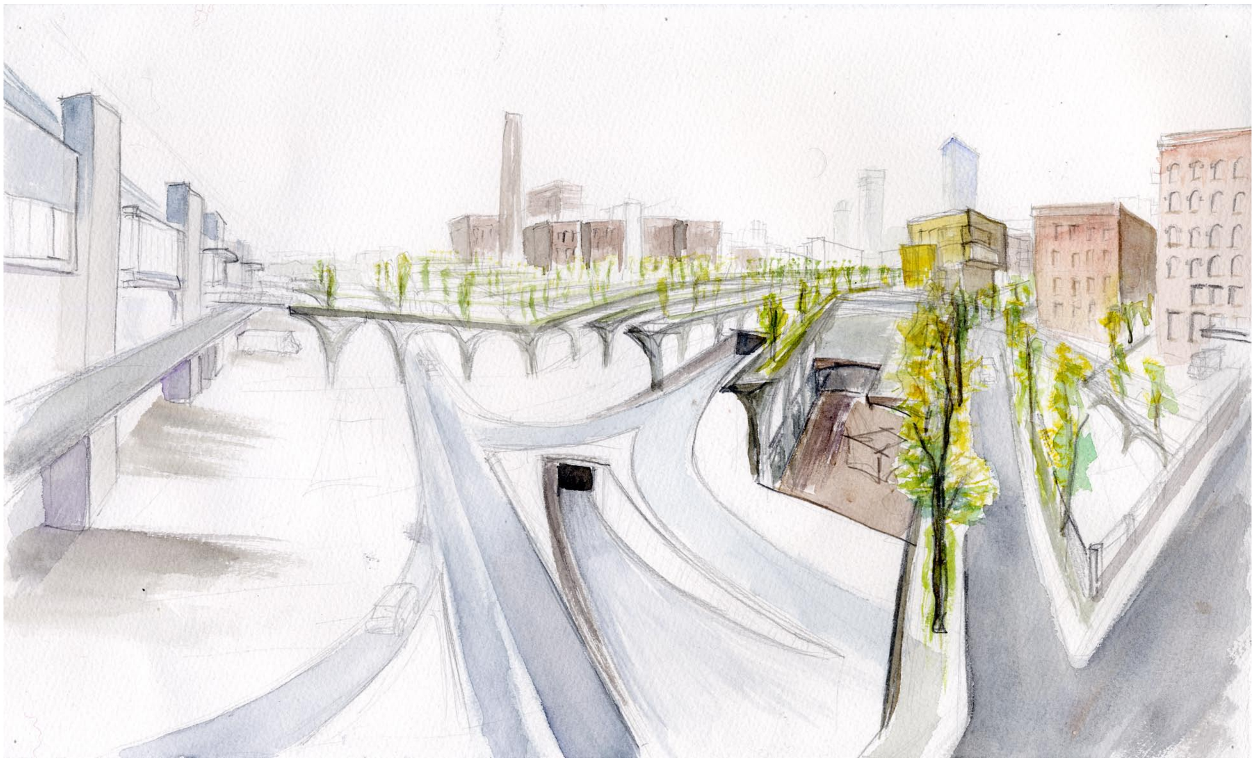
Within this proposal the issues of nature are a key manner by which it approaches something referential, something which has the potential to grow in the meanings this place has for those who visit and dwell nearby.

This structural landscape thus includes natural elements and systems in at least three ways:

- Vegetation: Continuous tree plantings, linear open space networks, and vegetation
- Topographic inclination: Slopes and drainage, relationships to termination conditions up in the air and down in the water
- Weathering: changes in materials over time

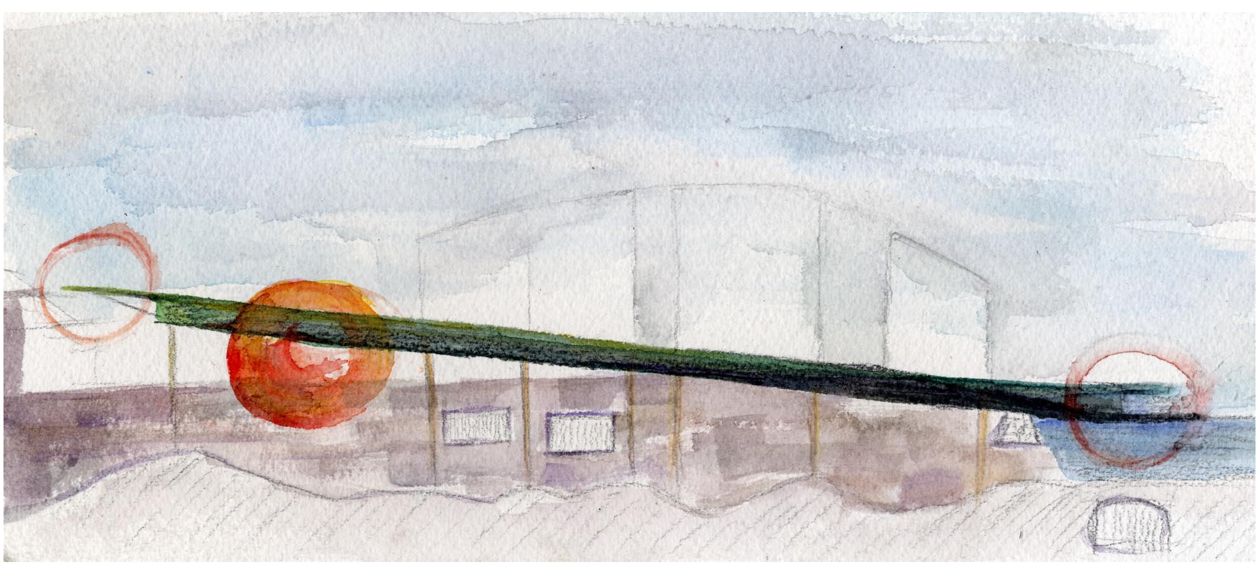
The vegetation strategy includes trees planted not only in the earth but also in the depth of the bundled beams. Based on the struggling condition of trees planted in the shallow, poor soil existing on the site, the choice of 8-foot planting depths and resilient street trees such as Honey Locust (*Gleditsia triacanthos*) will help to make the landscape components not only an imageable work of expressive identity for the site, but also an amenity. The trees on the site will pre-exist when any parcel is developed; the developer can therefore not value-engineer landscaping out of the project, and the trees will be strong and healthy before tenants move in.

The topographic condition allows for variation in height and slope related to the complexity of subsurface conditions. While some of the bundles are relatively flat and constitute the "background" of typical blocks, the "foreground" of expressively sloping blocks and streets crescendos toward the most geometrically intricate areas near the on and off ramps' tunnels. The streets and pathways ascend to bridge to Summer Street and the Convention center, and allow the entire neighborhood to act as a mediation between these existing megastructures and the strip of water which is so important to the area's geographic identity even if it can only be actually perceived at close distance due to its narrowness. The designed inclination allows natural phenomena of light, height, and water to become readily apparent to pedestrians and enables a mental map based on topography, analogous to Beacon Hill and the other historic hills (and those



Watercolor study of view from Summer Street Bridge toward Boston Convention and Exposition Center (left) and new elevated plantings running along new streets before future buildings are constructed.

Watercolor study of section with inclined landscape gesture from convention center to Fort Point Channel (left to right)



which have been razed to fill lowlands) in Boston.

While the high-performance concrete is intended to have hundreds of years in its serviceable lifetime, the striated surface materials that compose walkways and paths are a combination of luminous and opaque materials of varying lifetimes that can be fabricated by artists in the community and allowed to age with varying degrees. This extends the tradition of the composite crushed-pottery sidewalk art elsewhere in the neighborhood and allows for the seasonal growth of trees and other vegetation to accompany quicker and slower rhythms of material change, privileging materials that gain character with age rather than appearing simply worn.

Concluding notes on Ives, inclination, and water

To conclude this discussion of landscape components, I shall point out an atypical condition in this proposed city and analogize back to the vertical relationships in music that began this chapter. It is now readily apparent that in this bundled system, trees and plantings and all sorts of other possibilities are able to float above the existing surface of the earth. This happens in roof gardens, and green-roof systems are widely acclaimed for their ecological benefits, but these ideas of planting in elevated soil can be integrated with structural conditions such that the largest trees can align with the columns bearing down to bedrock. A relatively simple and logical choice – planting larger trees above the strongest supports – can therefore articulate points of vertical relationship between the subsurface tunnels and bedrock, through the negotiated landscape of the proposed bundles, and up through the built environment so that the tallest trees decades from now can tell visitors of the hidden conditions below. The irregularity required of the columns and vertical supports can now punctuate moments of alignment and emphasis above.

This is reminiscent of a final musical example, one quite famous and local to this piece of geography: American composer Charles Ives' "The Housatonic at Stockbridge" from *Three Places in New England* (1912-1917). It was his attempt to capture the ephemeral drama of a walk with his wife near the Housatonic River in Stockbridge, Massachusetts. As with so many of his works, it exists in many alternate forms, including a chamber orchestra version and a 1921 song for voice and piano, opening with the following text by Robert Underwood Johnson:

> Contented river in thy dreamy realm
> The cloudy willow and the plumy elm:
> Thou beautiful! from ev'ry dreamy hill
> What eye but wanders with thee at thy will.

Ives' concept for the orchestral work centers on a lyrical melody which is immersed and surrounded by a shimmering combination of at least five other simultaneous patterns which comprise instrumental layers. Within a long lineage of musical pieces intended to be evocative of place and landscape, Ives crystallized the impulse to design a piece which is a "landscape" of independent layers, superimposed and heard simultaneously. Ives not only combines layers in different pitch registers, but composes them to be of entirely different rhythmic units and harmonic relationships, so that they are constantly juxtaposed in different combinations.

These layering techniques are punctuated by moments where vertical harmonies suddenly align and shine as points of punctuated emphasis, analogous to the vertical punctuation stated for this thesis's proposed literal landscape, inclined and punctuated in its articulation.

Ives' layered, punctuated landscape takes us on a journey of draining water, from the Housatonic high in the New England hills through rushing crescendos in the watershed, concluding as it reaches the Atlantic:

> By fall and shadow to the adventurous sea

The simple physical force of gravitational attraction and the landscape phenomenon of water drainage allowed Ives to imagine his place in the landscape as being connected to the broader context of places great distances away, **places which by their ''up'' and ''down'' are made a part of his experience of the immediate environment**. This is a poignant illustration of the referentiality described throughout this chapter.

Finally, why not use everyday natural phenomena to our collective benefit rather than as simply a problem to avoid? Spirn's aforementioned writings often remind us how water drains in cities and deeply affects and threatens their stability, even when human engineering tries to struggle in the creation of something that disregards soil and water conditions. In this thesis project's imagined cityscape water will inevitably drain (albeit imaginary water!) across the bundled beams and into the channeled areas of linear planting, leading people visually and experientially from high to low, from the air to the water. **Physical forces and natural forces align in symbiosis along the bundles and infuse spatial character and meaningful experiences within this new urban landscape.**

"The Housatonic at Stockbridge" from Three Places in New England by Charles Ives, revised as a song for voice and piano (c.1912-1921); this is the first page of a transcription for solo piano by David M. Foxe (2005) as performed at the MIT Architecture Department Concert.

Chapter 10
Risks and Bundles

> ...What no one yet has dared to risk and warrant
> will be for me a challenge I must meet.
>
> ["Ich glaube an Alles noch nie Gesagte," Rilke *Book of Hours,* Tr. Anon.]

At this point the thesis now fully engages the specific implications of the designed objects and systems, the bundled boxbeams and the architectural elements supporting and bearing upon the bundles, the utilities and plantings and connections between and around the bundles. As I have stated earlier, the bundle is never just a beam: **It is a bundle of beams, spaces, rights, responsibilities, obligations and possibilities.** It is also bundled with issues of **implementation, ownership, and risk**.

The omnipresence of risk and safety considerations are rarely foregrounded in most architectural proposals, in studio problems or competitions or elsewhere, because we assume that if anything were built it would be done safely. Even in public competitions or proposals there is an underlying premise that what the architect shows can be built and engineered safety. We also apply similar language of safety and risk to how buildings and development projects exist as investments. Therefore the broad concept of **risk** can be understood as a major component that drives large-scale development and small-scale details within a project and the manner by which it is implemented.

Implementation tools themselves are a bundle of possibilities, often each described as analogous to a "bundle of sticks." [Schuster and de Monchaux 1997] **This chapter will therefore trace not only the manners by which the physical bundles become manifest in spaces in places, but also the implementation strategies to negotiate multiple interests and minimize risk.**

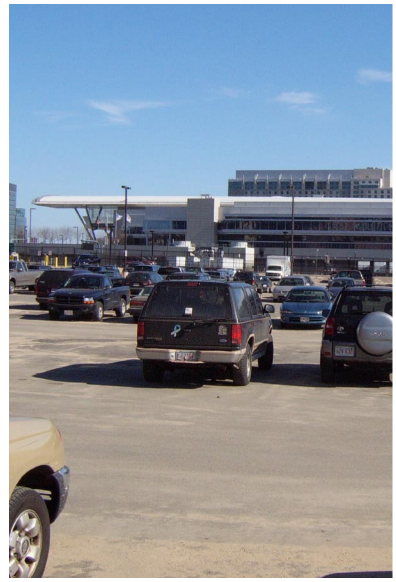
The Risks

One of the great risks for this site is uncertainty about the time frame of future uses, operators, tenants, and necessities. This uncertainty causes areas to lie fallow or with low-intensity occupations such as parking. In an exploration of new materials able to be erected and altered quickly in a temporary installation within the Fort Point Channel Historic District, Fernandez identifies these uncertainties:

> Currently, in south Boston [sic] a great deal of land is vacant. Great swaths are owned by the city, others by

an array of private investors and real estate developers. Several large buildings have been located in this area of the city, including the new convention center and a courthouse. However, it is common to see undeveloped parcels of land idle for long periods of time, sometimes generating some income as a parking surface. In these locations, uncertainty about the various zoning, financial, ownership and infrastructure issues is very high. However, it is known that the city is in a planning phase for the area and that substantial change will be forthcoming. Certainly, the lack of a binding plan has generated a great deal of uncertainty about the status of all of the major factors, financial, physical and otherwise. This has placed a threshold for development that is much higher than typical and created a scenario in which a "wait and see" option is common…as a result, a part of the city remains mute, unused and lacking vitality.

This research project proposed the construction of buildings that would serve to "test" the viability of program uses on these various sites without permanently committing the parcel to a particular building. Temporary, or short-life, construction was sought as an appropriate solution because these kinds of buildings are inherently at a lower risk of allowing a substantial portion of their lifetimes to the uncertainties in this context. Providing the site with a temporary building allows the option to the owner to extend the life of the building by investing in more permanent building systems at some point in the future. ...In fact this particular building scenario brings forth the possibility of alternative owner arrangements including the possibility that the owner of the development parcel simply "leases" the building just as one would lease an automobile – with an option to purchase parts or all of it at some future time. The leased building could then act as an urban full-scale trial of the possible highest uses that the building could serve. The developer would be generating income from the site while providing the city with much needed productive space in an area in transition. Therefore, the scenario provides a buffer against the kind of uncertainty that plagues many cities today. Allowing for a less permanent physical construction provides a lower investment threshold while gathering useful information about the success of particular uses....serv[ing] as the onsite materials workshop for the building. [Fernandez 2006 pp.71-2]



Vast areas of parking on existing site above fill and tunnels, 2006

Fernandez responded to these uncertainties with bolted steel structural columns supporting a built-in crane system, slabs, pultruded polymer sections that can be disassembled as needed, and a multilayer textile envelope for the exterior envelope which changes the most. While in past projects my focus has been on short-term occupation and definition of rapidly changing sites (Kiev, Amsterdam, etc.), this thesis project instead takes the view that the foundation system should allow for a wide variety of future buildings, including and beyond the innovative configurations in Fernandez' examples.

Small pocket park on shallow soil near A Street, view toward highway tunnel vent building, 2006

The existing Boston Redevelopment Authority (BRA) master plan responded to in Chapter 4 tends to envision neither immediate occupation strategies nor long-range implementation strategies to guarantee future coherence rather than merely contingent developments. The current pocket parks sited just off the edges of the tunnel corridor risk being overshadowed – literally and figuratively – by that which ascends to meet different development needs. Therefore implementation must address not only construction and ownership of architecture but also of open spaces in the public realm.

Since the vast majority of the land area is owned and operated entirely by the Gillette corporation and by the United States Postal Service, the typical problem of parcel aggregation and assembly is not nearly as difficult and risky due to uncooperative or dissenting owners is less problematic than other situations.

The rest of the Big Dig has taken over two decades to become reality from its first conceptual proposals, and during that time politics, technologies, and countless other aspects that affect the use of public space have evolved rapidly. The engineering of the physical proposal is solid but the matters of financing change with political and real estate climate shifts: "How civil constructions are financed demonstrates the fragility of the functionalist paradigm prevalent in civil engineering [Dunster 2000 p.64]." Furthermore, the types of uses and programs envisioned for downtown Boston have evolved from offices to lively mixed-use condo and residential development. If the proposals for buildings and open spaces on this site were to be contingent on specific outcomes or assumed that buildings could bear on top of the tunnel areas, it could be disastrous for future alterations to those plans, and would limit the use of new tools developed in the coming years of post-Big Dig development. Therefore the deal I propose negotiates the public and private desires and obligations, the known and unknown physical and fiscal conditions, as follows.

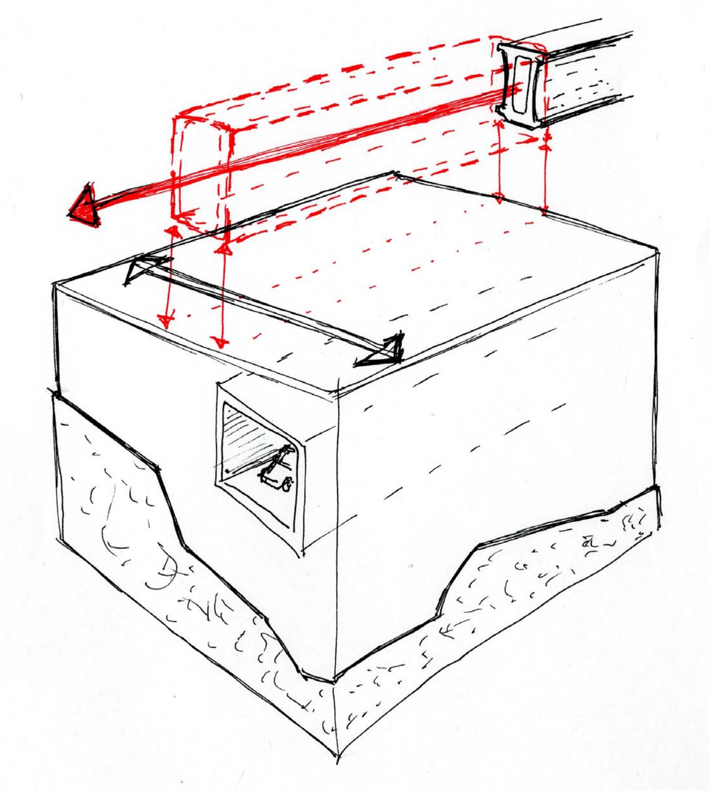
The Deal

This proposal is not simply the work of a single actor, nor simply an unachievable vision that would require authoritarian command. It can be envisioned as a deal, a negotiation between the public and private parties with existing land holdings and major interests in the land, and a deal which enables significant profit through development while ensuring the provision and sustenance of public goods such as various forms of access, quality street design and landscaping, civic and neighborhood identity.

The city government understands that the land, between the Fort Point Channel and the Boston Convention and Exposition Center, is a valuable resource rich in the history of American infrastructure. This place deserves and indeed requires significant structural attention to make it the next great transformation in Boston's long history of creating neighborhoods upon filled land. The city, through the Boston Redevelopment Authority, shall expand the existing Fort Point Channel Coalition of which the Fort Point Arts Community is already a part [National Register District Nomination, Section 8 p.14] to administrate this process of changes, hereafter abbreviated as the FPCC.

Existing historic fabric with elevated bridge connections; Federal Reserve Tower downtown visible beyond, 2006

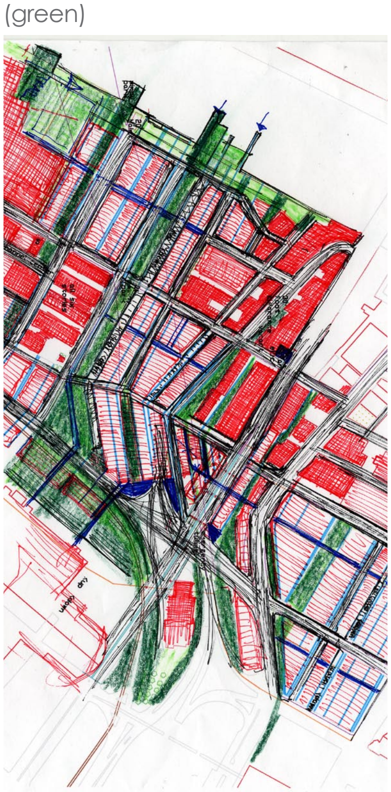
The current state of the property is that it is difficult to build upon and highly fragmented, though owned by only a few entities: The US Postal Service, Gillette Corporation, and a few parcels by Boston Wharf and its lessees. The FPCC will make at-grade and elevated utility easements comprising approximately 3-5% of the property, easements which are defined in three dimensions and limited in depth, generally 9 feet deep except for discrete bearing columns on deep piles. Given these new easements, in addition to the existing easements and rights such as the Massachusetts Turnpike Authority easement around the subsurface tunnels, the property owners retain ownership of the current land surface at the Haul Road level (+15.00 ft) as well as subsurface access beneath the utility corridors. These easement corridors shall be preserved as public right-of-ways and landscaped at the FPCC and city's expense; maintenance and expansion of streetscaping and landscaping shall be funded by the taxes generated within the FPCC-administered zone. The area of land (the 3-5%) which is taken for public utility corridors shall be granted to the landowners such that if, prior to these actions they were allowed to develop approximately 65% of the property, they shall now be allowed to develop 65% plus their share of the 5%.



Easement diagram in three dimensions (red) with tunnels, fill, and bedrock below. Property owners retain rights to "ground" level (black arrows)

Sketch model of bundled box-beam and columns (white) going down to bedrock and negotiating around tunnels (gray)

Early sketch diagram of physical implications of bundles, buildings (red) and open space network (green)



This gives the property owners a far greater value so that development can be structurally less acrobatic and less expensive, spatially continuous along streets, and supplemented by incentives to locate, incentives such as surface amenities visible to tenants and buyers, and incentives in the manner of subsurface infrastructure. These measures also give the property owners and the city a significantly decreased risk of costly future change, because the system is flexible and able to accommodate future alterations in utilities and their maintenance, program, access, and emergency conditions. Land which is adjacent to the utility corridor easements as above, but particularly unsuitable to standard development due to the close proximity of tunnels or grade-separated interchange infrastructure, shall be negotiated for public use and transformed in collaboration with the MBTA, Boston Fire Department, Homeland Security, and other civic and federal agencies with justifiable interest in public safety and welfare in this area as it densifies.

This proposal has a robustness whereby the city takes on the burden of designing and building infrastructure, and allows the landowners to have architectural freedom while maintaining a continuous street wall – not through textual regulation but through physical necessity. This proposal also does not prevent future buildings from supplementing the existing structure with their own intermediate supports if necessary in the future.

This is a deal which assumes that new people, tenants, and uses will come to the area that are not already a part of the historic district's artistic community. Given the challenges of this socioeconomic and cultural nego-

Sketch model of hybrid negotiating landscape with multiple levels of access and columnar supports

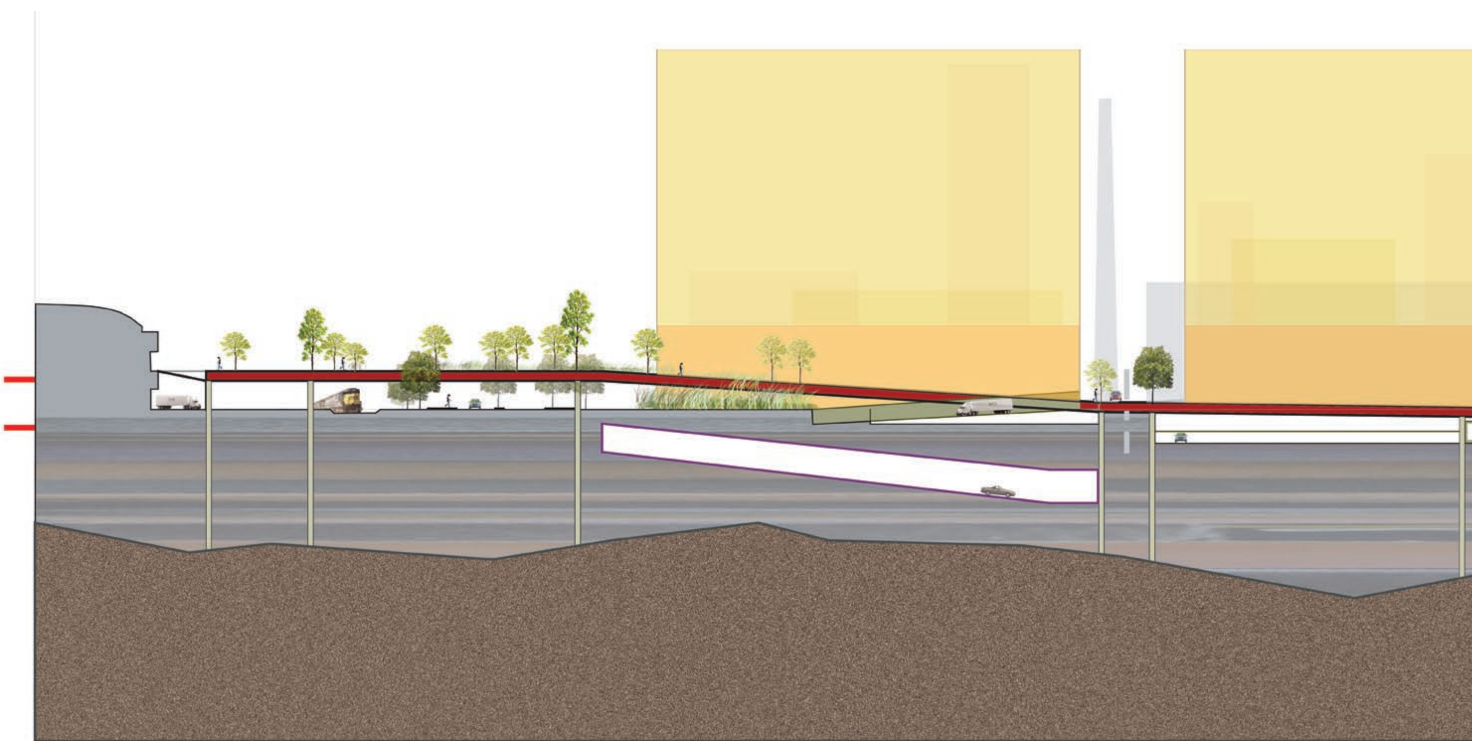
tiation, working toward a solution is not simply in reserving spaces in the new development for token pieces of art by someone in the community, as in past proposals for this site. Rather, the FPCC with its existing artist constituency shall be empowered to manage and negotiate this deal between the city, the existing landowners, and new commercial investors.

This deal parallels the historic development of the site and builds upon its bold innovation over a century ago: (Recall Chapter 3)

- Affirming the connection to the water and its historic importance for access and views
- Strategizing based on large-scale private ownership rights
- Building linear infrastructure across the site for accessibility and transport first
- Allowing for land to be filled and constructed at various levels within the lots made buildable by the primary infrastructure;
- Creating further pedestrian paths, vehicular connections, and architectural containers above for profitable uses;
- Investing in and allowing designated space for public safety infrastructure and for civic design (see the public market in Chapter 11);
- Developing an evolving regulatory framework to accommodate occupants' changing programs and uses; and
- Negotiating with the conditions and possibilities of the "Big Dig" highway tunnels, the Boston Convention and Exposition Center, and the Silver Line underground bus tunnel which make this such an important part of Boston's new cityscape.

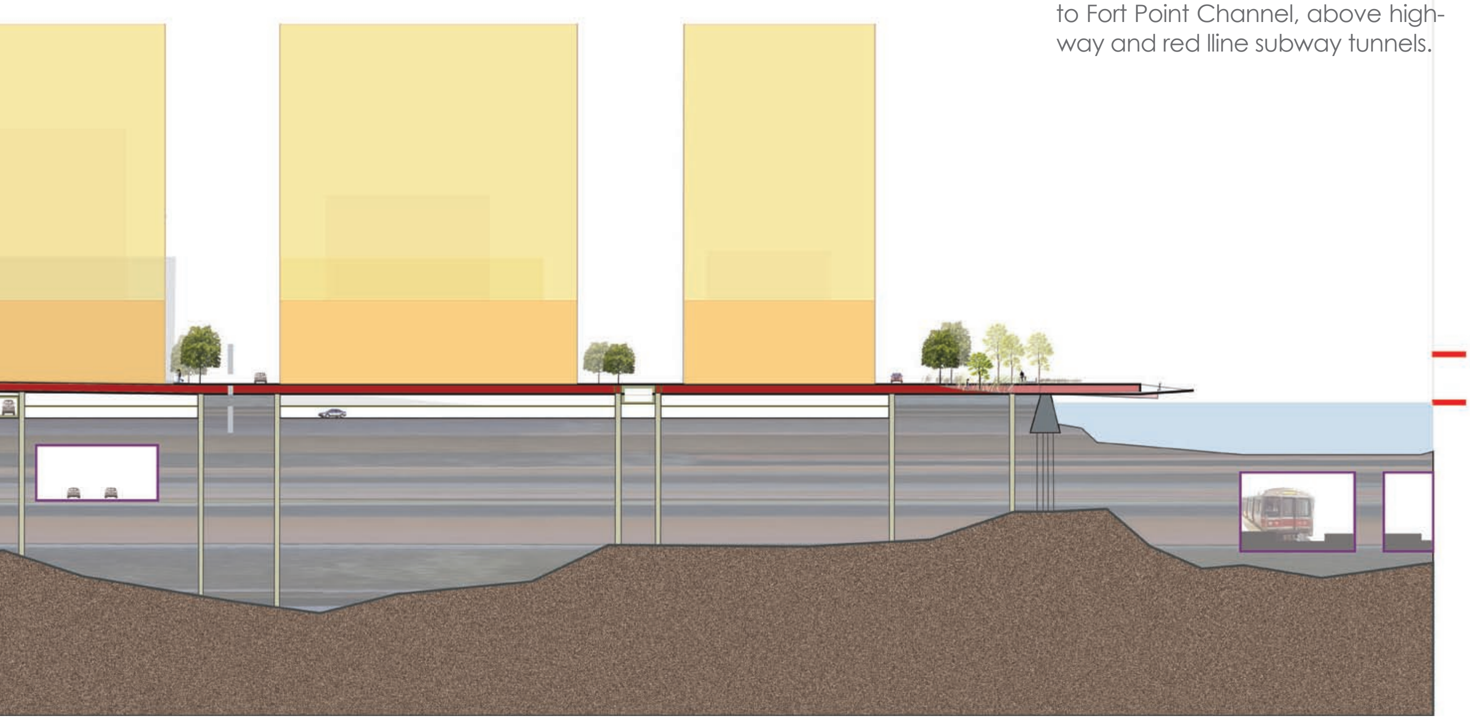
The Section

Revisiting the essential qualities of three-dimensional space captured through sectional views (Chapter 4), this project's vision is primarily not expressed through a single map but rather through a **gesture in section**, from high to low, from the elevated Boston Convention and Exposition Center and Summer Street platforms (+40 ft) down to the water at Fort Point Channel (water level +0 ft). It is a section that is massaged and modulated to have slightly different profiles along the site but the overall gesture remains consistent for these areas given grain and orientation through the linear connections from the existing structural devices built 2000-2004 and the historic seawalls of the nineteenth century.



Watercolor sketch of gesture through the land

Measured section from Boston Convention and Exposition Center to Fort Point Channel, above highway and red lline subway tunnels.



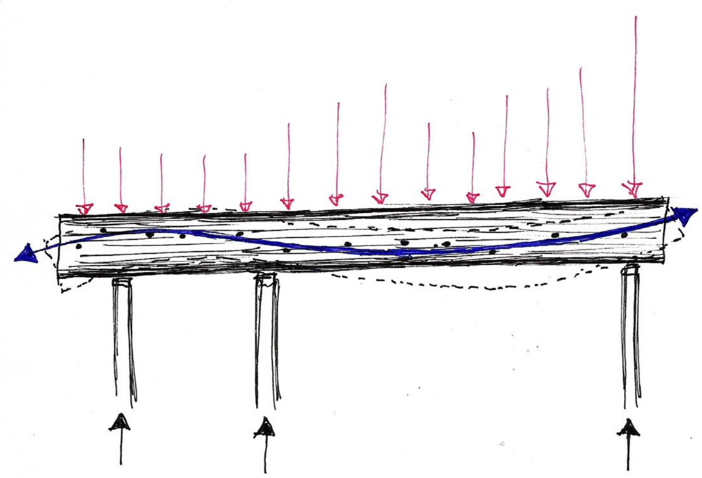
The Bundle

To recall the aforementioned discussion (Chapters 7 and 8) the bundle consists of beams, spaces, rights, responsibilities, obligations and possibilities. The Ductal high-performance concrete beams are a maximum 9' depth and are precast in a cast steel form allowing for multiple adjacent lengths to be cast vertically. The overall form can have mandrels and blocking inserted to create beams with less depth and with varying conditions of internal subtraction to minimize time needed in on-site adjustment, grouting, connections, and to minimize the overall amount of material consumed.

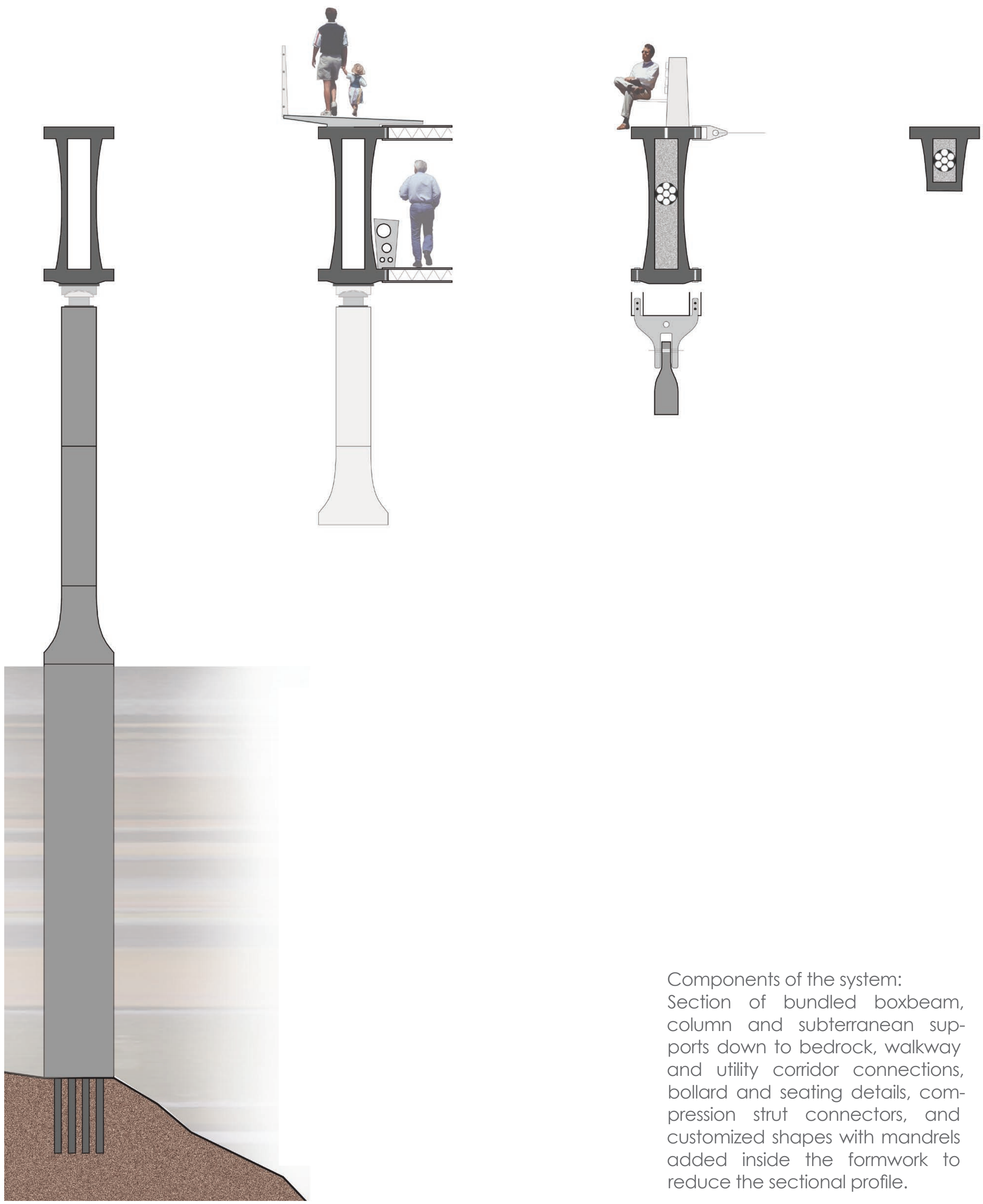
The spaces between the beams are allowed to vary greatly but are nearly always parallel so that consistent interstitial joists or secondary supports can be inserted, including tubular configurations for utility corridors.

The city and the landowners have the right to bear on the bundled beams up to an allowable stress in the beams, subject to review before construction by the FPCC and its engineering consultants. They have the right to build adjacent to and up to the limit of the three-dimensional easement while not bearing on the bundled beams as well. The landowners have the responsibility to be truthful in their proposed loading conditions, and the city has the responsibility to be truthful in the communication of structural capacities such that the realm of physical safety – an absolute right – is not endangered by political bargaining.

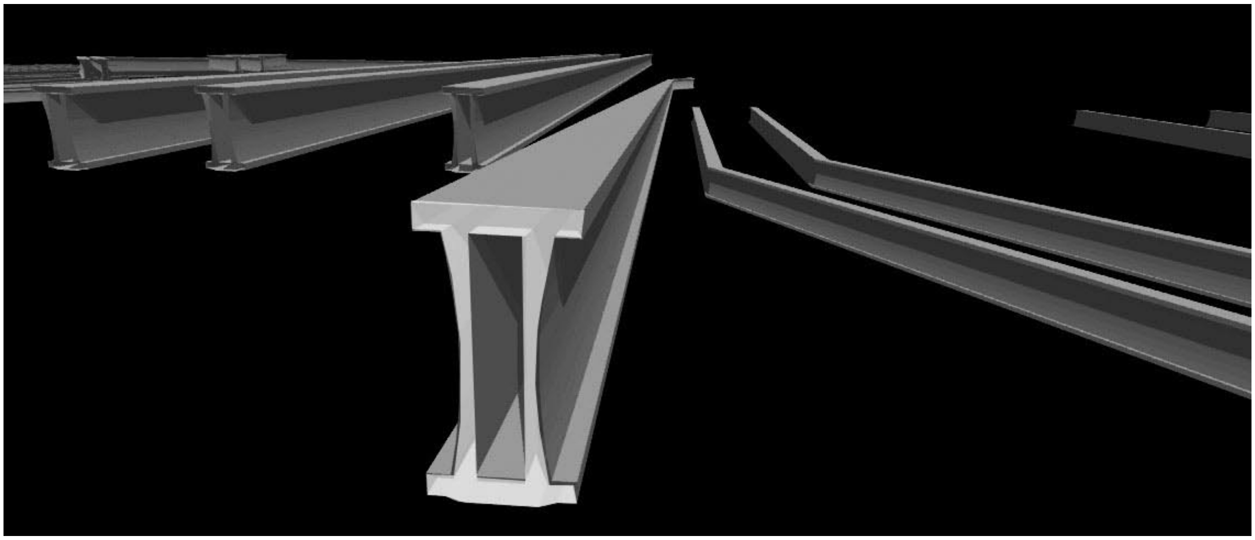
The city is obligated to monitor and maintain the bundle and the termination details under its ownership (see succeeding sections in this chapter). It is also obligated to consider unforeseen possibilities not contained in this proposal but which may be invented in the future as unique and useful ways to make these structures a growing, changing part of the cityscape.



Post-tensioning diagram

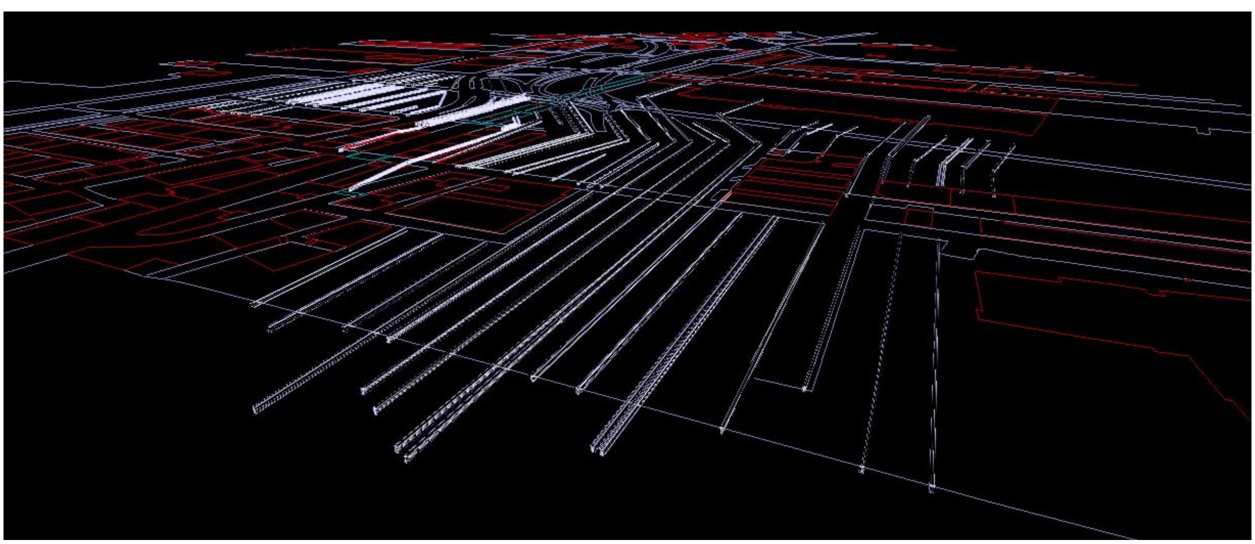


Components of the system:
Section of bundled boxbeam, column and subterranean supports down to bedrock, walkway and utility corridor connections, bollard and seating details, compression strut connectors, and customized shapes with mandrels added inside the formwork to reduce the sectional profile.



Three-dimensional model of extruded boxbeam bundles near Summer Street

Aerial view of bundles as seen from above Fort Point Channel looking southeast



Aerial view of bundles as above, with existing buildings and lots shown in red

A Plan

While the essence is contained in the section, the map-projected image in plan view is only one possible formulation of the sectional gesture and support conditions. It responds sympathetically to the scale of buildings and streetscapes in the historic district as would be required by federal regulations if projected funding associated with federal sources were to be in any way involved in planning or constructing parts of the new development. The essence of the plan is in its primary qualities of streets, followed by the public spaces and private building envelopes which exist between the vehicular and pedestrian pathways.

Plan of bundles (red) with existing buildings (gray), existing vent buildings (ochre), new envelopes (orange) and open space network (green); true north is vertical

Streets

The bundles start by defining linear streets first and then the spaces between. This entire project is predicated upon the firm belief that the creation of streetscapes is fundamental to the longevity and uniqueness of urban life over time: "In terms of urban history, the longest time span is exhibited therefore not by the buildings of a city but by its road pattern and the way that pattern is constructed." [Dunster 2000 p.73] This requires a bit of background along with explanations of what the bundled street construction implies.

In her introduction to a Festschrift of essays in celebration of the work of UC-Berkeley architectural historian Spiro Kostof, Zeynep Celik states this eloquently:

> Streets are a primary ingredient of urban existence. They provide the structure on which to weave the complex interactions of the architectural fabric with human organization. At once the product of design and the locus of social practice, streets propose rich questions to historians. Their conception ranges from the most incremental and spontaneous interventions, such as leftover space between buildings, to superbly contrived public works, detailed in plan and section, involving sophisticated engineering and landscaping. The unique characteristics of any street derive from what Spiro Kostof often referred to as "the urban process," that intriguing conflation of social, political, technical, and artistic forces that generates a city's form. The urban process is both proactive and reactive; sometimes the result of a collective mandate, at others a private prerogative; sometime issuing from a coordinated single campaign, at others completely piecemeal; sometimes having the authority of law, at others created without sanction. One thing is certain: although historical moments in the life of a city can be isolated, the urban process never stops. Unlike works of art – or even certain buildings, which have a more determinate existence – streets are as mutable as life itself and are subject to constant alterations through design or use that foil the historian's desire to give them categorical finitude. [Celik 1994 p.1]

While the design of complete streetscapes with their aesthetic and functionally engineered components is typically achieved through a variety of separate disciplines and technical solutions, this infrastructure-rich zone immediately above and below "ground" level builds on the seminal sectional designs of Haussmanian boulevards in 19th century Paris. There are other precedents for this rich multilevel approach: just as the multilevel Wacker Drive in Chicago unified the boldness of Daniel Burnham's vision for Chicago, with City Beautiful aesthetics, and with street transportation and service access, this proposal for Fort Point Channel includes considerations not only of street surfaces, walkways, vegetation, and street furnishings, but also of access at many levels.

Wacker Drive perspective [Celik 1994]

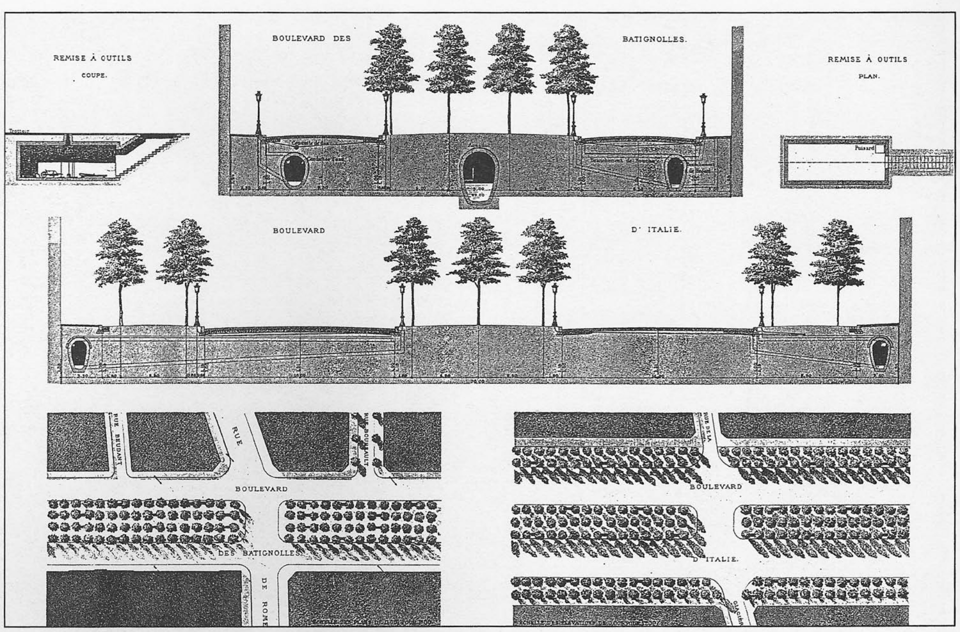


Figure 4. A plate from Alphand's *Les Promenades de Paris,* showing the Boulevard des Batignolles and Boulevard d'Italie in plan and section. The technology of Haussmann's streets includes regular planting, gas lighting, water mains, drains, and sewers.

Haussmanian Boulevards with integrated plantings and utilities [Celik 1994]

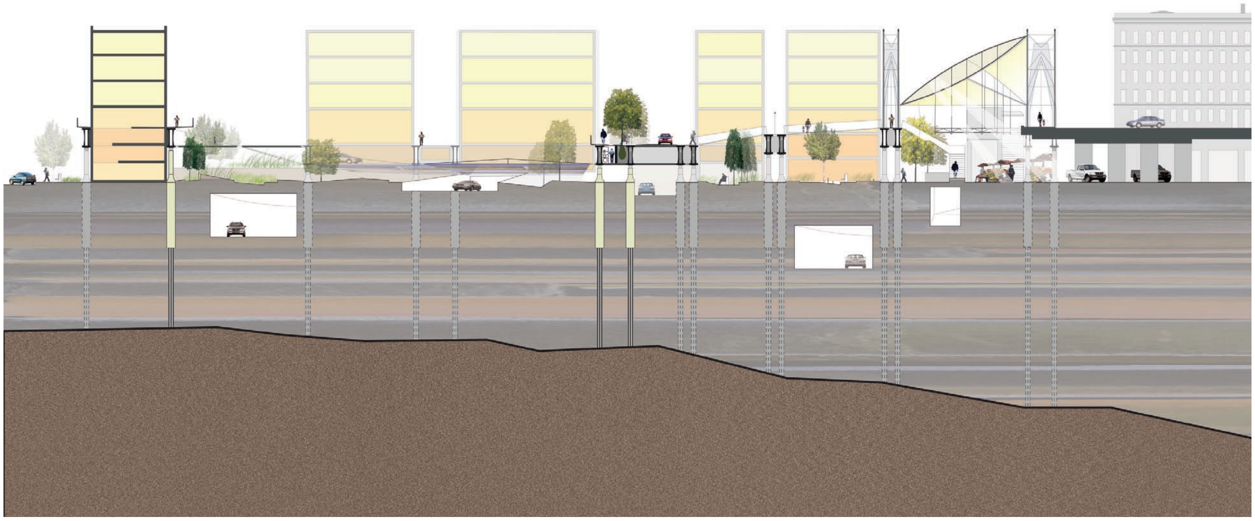
For example, Melcher Street has been extended to return upward to Summer Street's southeast-bound lanes, and it is one of many streets that give multiple "first floors" to various lots on the sites. The conflict of grade-separated roads is turned into a productive conflict whereby street access is an amenity given to multiple levels of multiple sites.

Examining more closely the existing streetscapes of the NR district, they are significantly asymmetrical. This gives articulation to the more active public zones and enables a hierarchy of scales and characters from dramatic, tall passageways to broad arteries. As Grange states bluntly in his philosophical explorations of urban cosmology, this condition of variation is fundamental to our understanding of the measure of our dimensional relations to the spaces around us because "what is missing in narrowness is width [Grange 1999 p.91];" narrowness and broadness each have their advantages in a differentiated city in terms of access and experiential qualities.

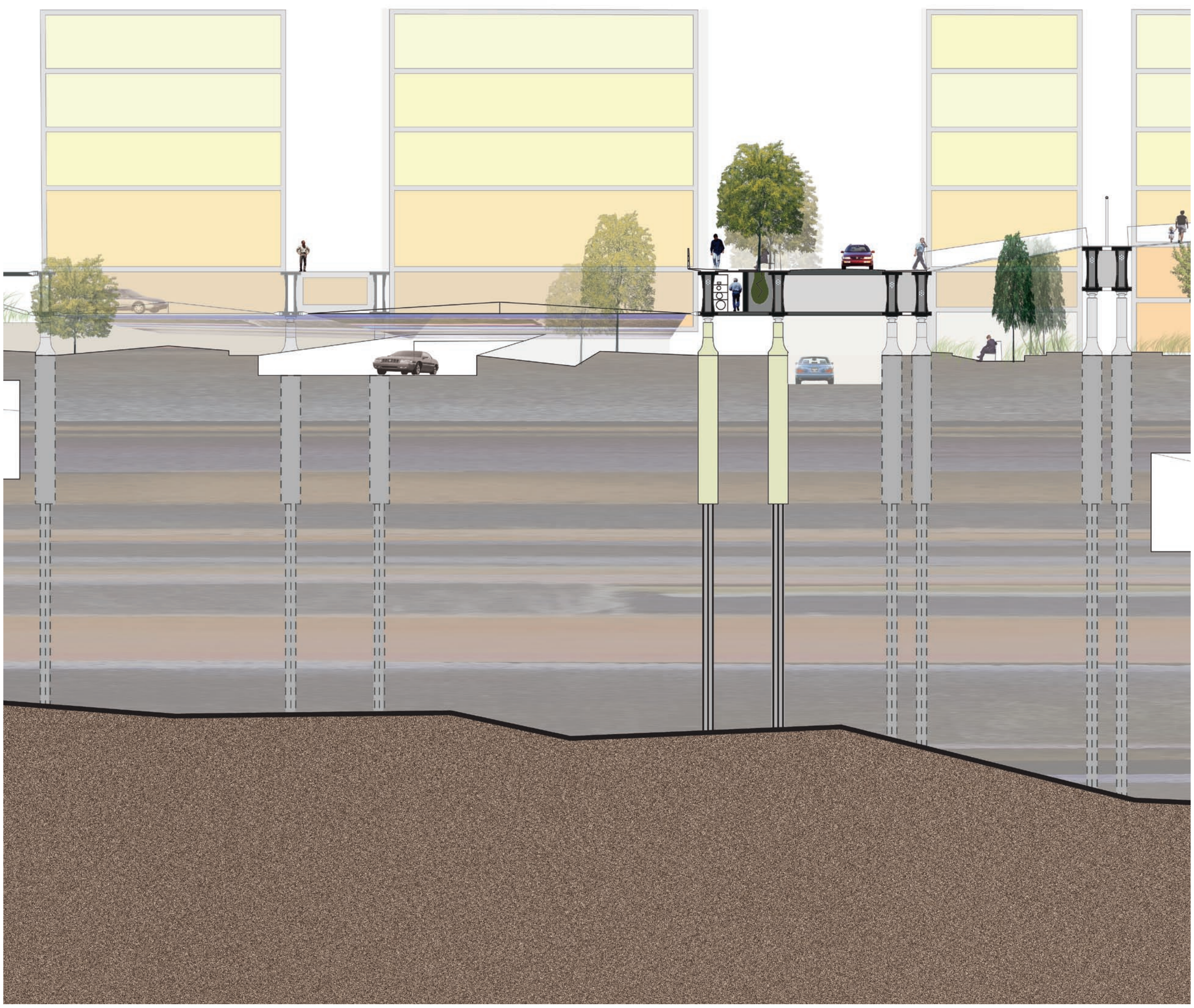
While historians from Spiro Kostof to Stanford Anderson have authored masterful analyses of streets, one of the aspects of streets employed in this proposal is that of extensibility. Generally extensible systems are relatively gridlike and neutral, able to keep extending and incorporating more lots as potential urban real estate. They also tell those on the street about relationships to other areas within an extensible system; the alphabetically named streets of Boston's Back Bay are one example, and the Jeffersonian grids across the Midwest are another. As another instance, when one reaches 238th Street in rural Galesburg, Michigan the street begins to imply a relationship to a point of reference even if not every one of the hundreds of intermediate streets are ever built; these naming systems are forms of referentiality (Chapter 9).

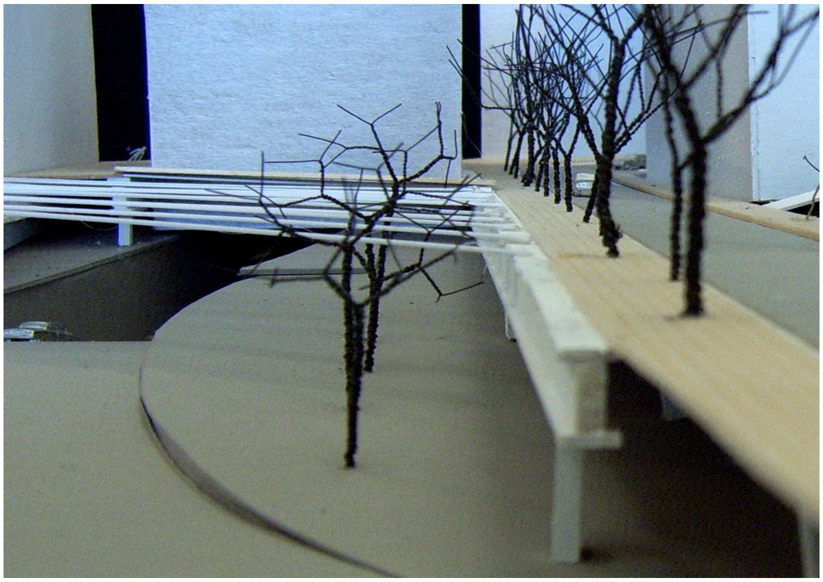
For the bundled streetscape proposals, however, the grid is far from neutral because every extruded streetscape holds the capacity to connect mentally from the convention center to the channel, even if not all of the individual bundles which support the asymmetrical sidewalk profiles actually continue that far. As is visible in the plans, the bundled system can even be employed farther afield from the buried highway tunnels to define compatible streetscapes sympathetic to (and in counterpoint to) the historic fabric without the same degree of inclination and geometric complexity. Boston and its environs are defined by scattered nodal squares and areas of "background" between, so it follows that this new area would be able to contribute to active places of emphasis as well as background blocks elsewhere. These emphatic points in the "foreground" become the public spaces of specific negotiating known conditions, whereas the extensible and hierarchically varied background allows for deft, efficient negotiation of typical, often generic but unknown development considerations.

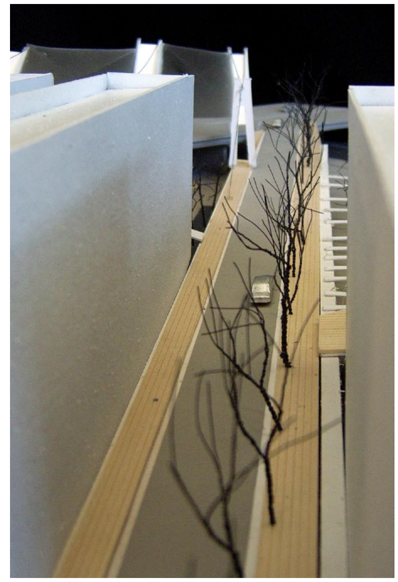
Current views of Summer Street toward Fort Point Channel and downtown Boston (above) and toward the Boston Convention and Exposition Center and vent buildings (below)



Section through multi-level streetscapes on bundles above highway tunnels, including detail of New Melcher Street with street tree plantings and lower level parking connections (below)







Streetscapes with multiple relationships to plantings and access in 1"=16' model

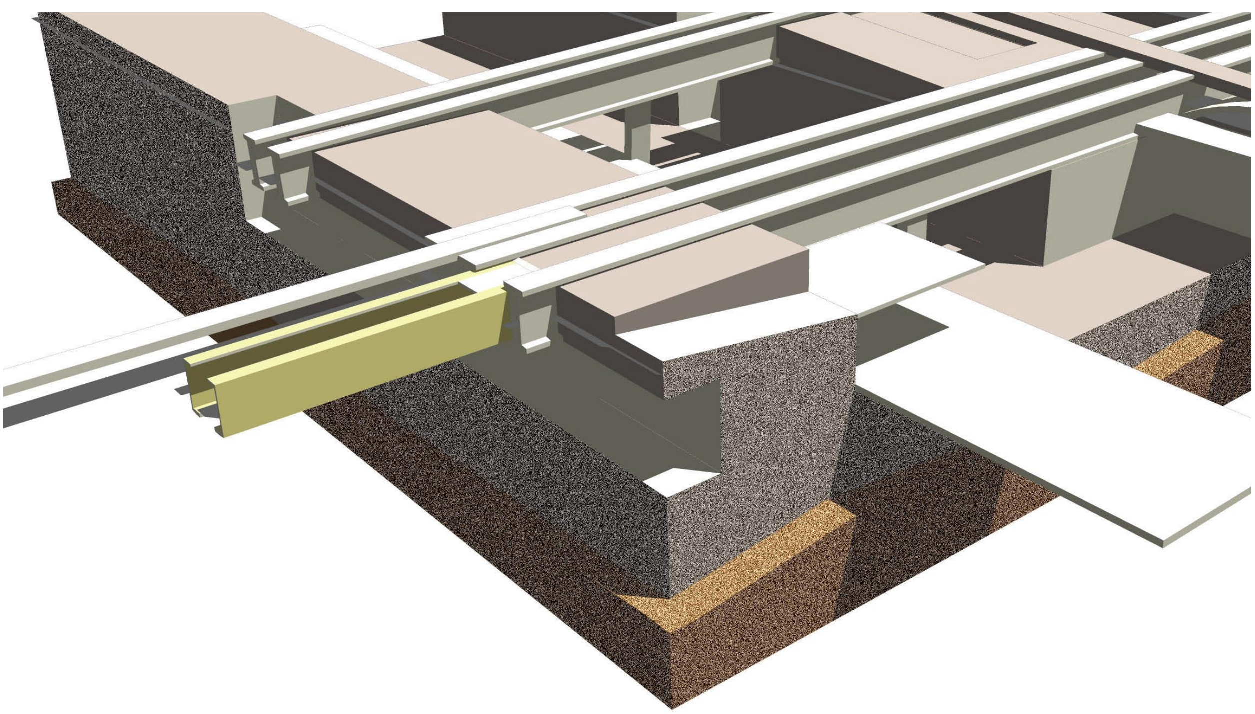
Skylit underground parking at the Milwaukee Art Museum, 2003

Service Access

Given these potential architectural possibilities, the fact that the bundled system is conducive to subterranean parking levels allows the grade separations on the site to be used productively. As past theses have asserted [Schiamberg 1996 etc.], these height differences could be used constructively to accommodate service functions and access. I have actually figured this out for the sample plan by demonstrating how parking could continue under every building with the simple V-shaped ramp configuration for parking access already employed under the Boston Convention and Exhibition Center. These ramped connections would continue street pathways and linear definitions of space much like the alleyways of the Back Bay, rather than using undesirable spiral ramps or similar devices. There are also other existing precedents for architectural definition of underground parking with dramatic character.

The design of the underground levels would also be made elegant through natural lighting and connections to multiple levels of habitation. Instead of being marginalized, the parking conditions would be one more of many superimposed levels. Furthermore, in counterpoint to the parking decks spanning between the bundles, the overall configuration allows for a second depth of service access to penetrate parallel to the parking. These service access areas would serve every block, could be customized to allow for specific commercial tenants above ground, and would remove the need for unsightly and temporarily used loading areas to detract from valuable street frontage.

Diagrammatic representation of bundles through fill with utility corridors and connections



Architectural Envelopes

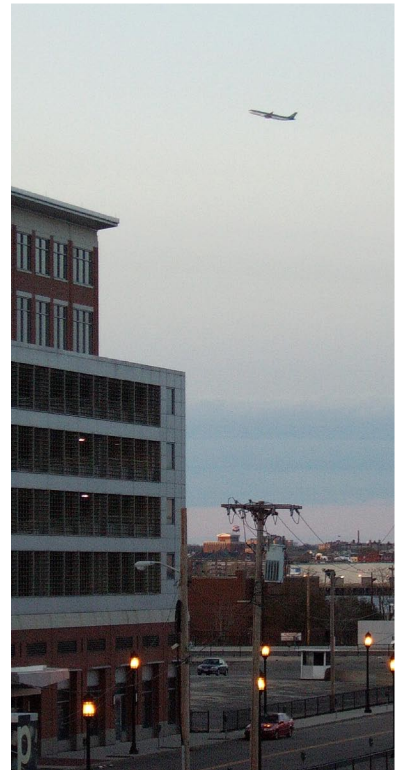
Beyond the public components whose design is presented in this document, the private architectural developments for the various lots along the streets are not designed in this exploration. This is in part to provide a degree of focus but it is also an exercise in recognizing that the bundled system already embodies many productive qualities toward the encouragement of architectural qualities through envelope definitions and requirements.

Perhaps architecture is often optimistic (Chapter 2), but regulations are rarely so; they are generally written to avoid the worst possibilities rather than to encourage that which is superlative.

The existing BRA master plan (Chapter 4) deals with architectural envelopes through faith in a massing model. I state this explicitly because it is faith rather than simply confidence or hope that drives such envelope proposals. Particularly given how they are decoupled from structural notions, there is no guarantee that architectural developments within such envelopes would include continuous street walls and other positive pedestrian qualities already found in the historic district.

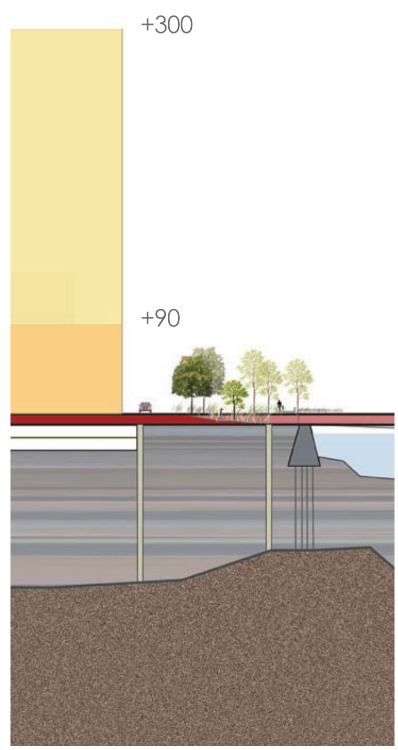
The typically limited envelopes which are informed by harbor height setbacks, and other considerations hoping to avoid bad light and ventilation considerations are not sufficient for an area of this significance and with so much existing richness. The potential scatter of "bonus" heights bargained through other public amenities at ground level would further muddle an already ambiguous overall gesture. In most other places in Boston the surrounding context is so varied and fractured that such strategies might seem appropriate, but at this location there is a very striking datum at approximately +90 feet which the convention center and most of the historic district buildings set. This height implies a bulk which could be readily accepted by the bundled structure, so the proposed expansion of the FPCC would be able to regulate architectural massing to acknowledge this datum as a **minimum** height. Therefore, the maximum height limit of the envelope proposals is the slightly sloping 300'-310' elevation for airplane flight paths set by federal aviation requirements.

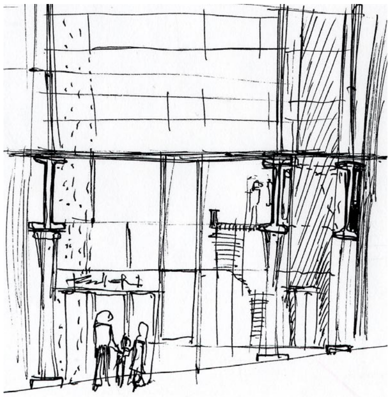
For the volumes of potential buildings between 90 and 300 feet, the FPCC should regulate not in terms of sheer height but rather bulk and light/ventilation/etc. performance guidelines. The use of performance guidelines rather than prescriptive requirements allows for greater creativity while allowing community groups to actually understand the effects (rather than just the appearance) of proposals. Furthermore, the structural system by the very nature of the bundles encourages a higher level of attention to the street wall supports and the internal structural system so that typical rubber-stamp proposals from low-intensity suburban precedents cannot



Airplane flight paths over the site

Section showing architectural envelope height relationships:





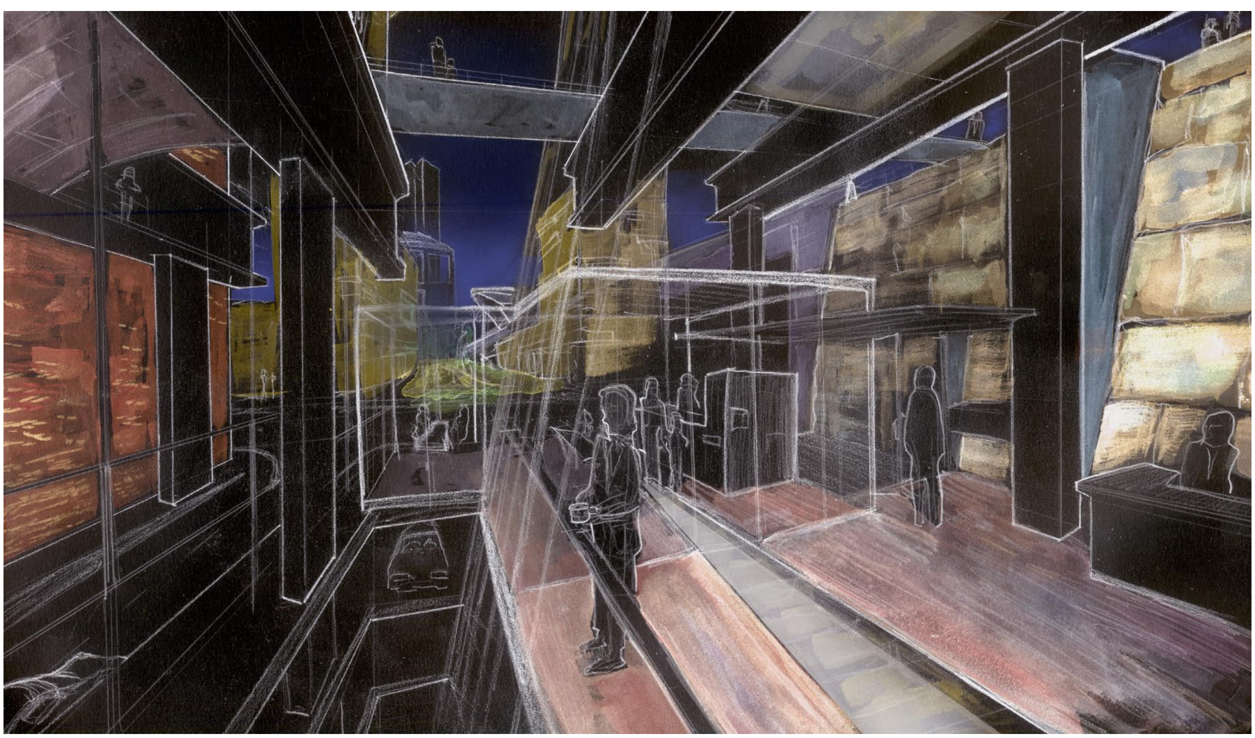
Sketch for midblock building elevation detail

simply be replicated. The structural conditions allow not only for flexible lot and parcel definitions but also for creative architectural possibilities at mid-block and end-block conditions, building on the precedents for such conditions set by the buildings built by Boston Wharf over the past twelve decades.

The architectural character envisioned for this site will therefore not only have shallowly formal beauty but deeper elegance and continuity with the nature of historic precedents for construction, such as the hanging floor structures in the Congress Street Fire Station (Chapter 3).

Site adjacent to Summer Street

Transformation of site into entry lobby of multilevel hotel with parking and service access below



Public Spaces

The crossroads of the body, the divine streets
Which form us, are city squares where obscurity gusts,
Entering without mass and
Turned out into pure Space.

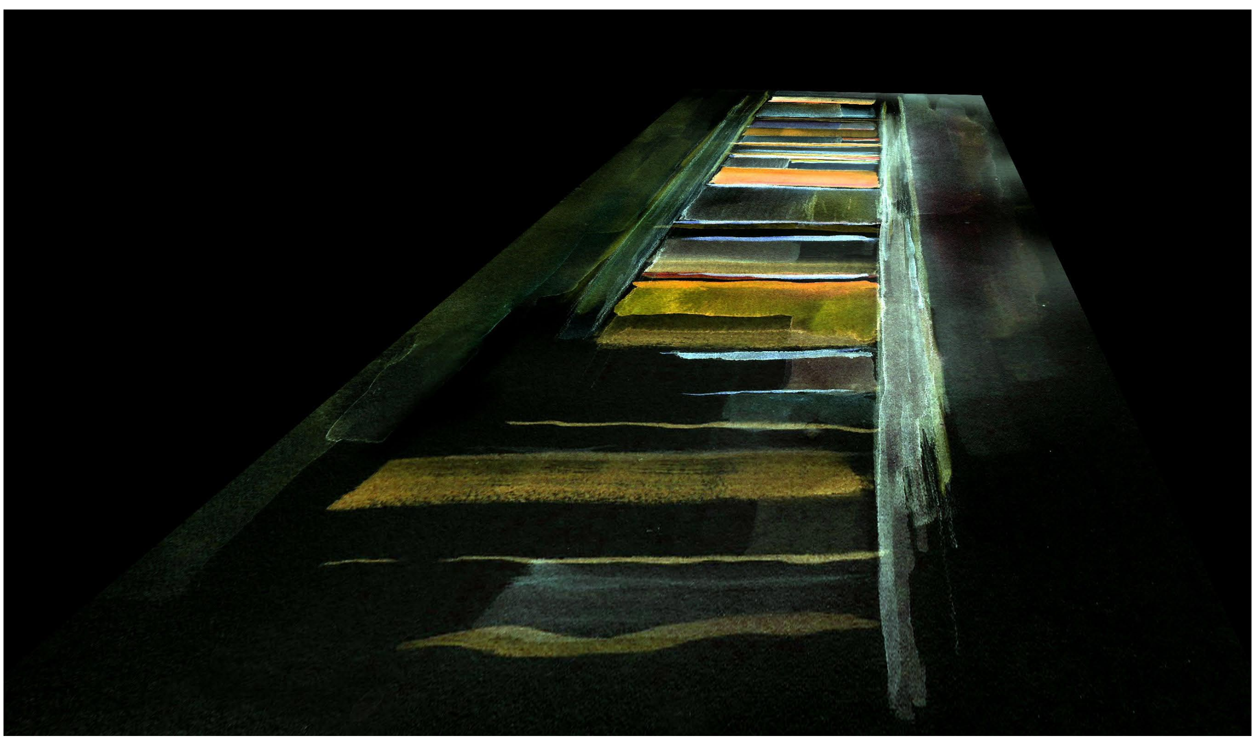
[“Kreuzweg des Leibes,” Rilke 1997 p.120. This excerpt tr. Foxe]

The points of public space emphasis are the primary places where urban differentiation and productive conflict (Chapter 1) are embodied not only in the systems but the objects of the city (Chapter 3).

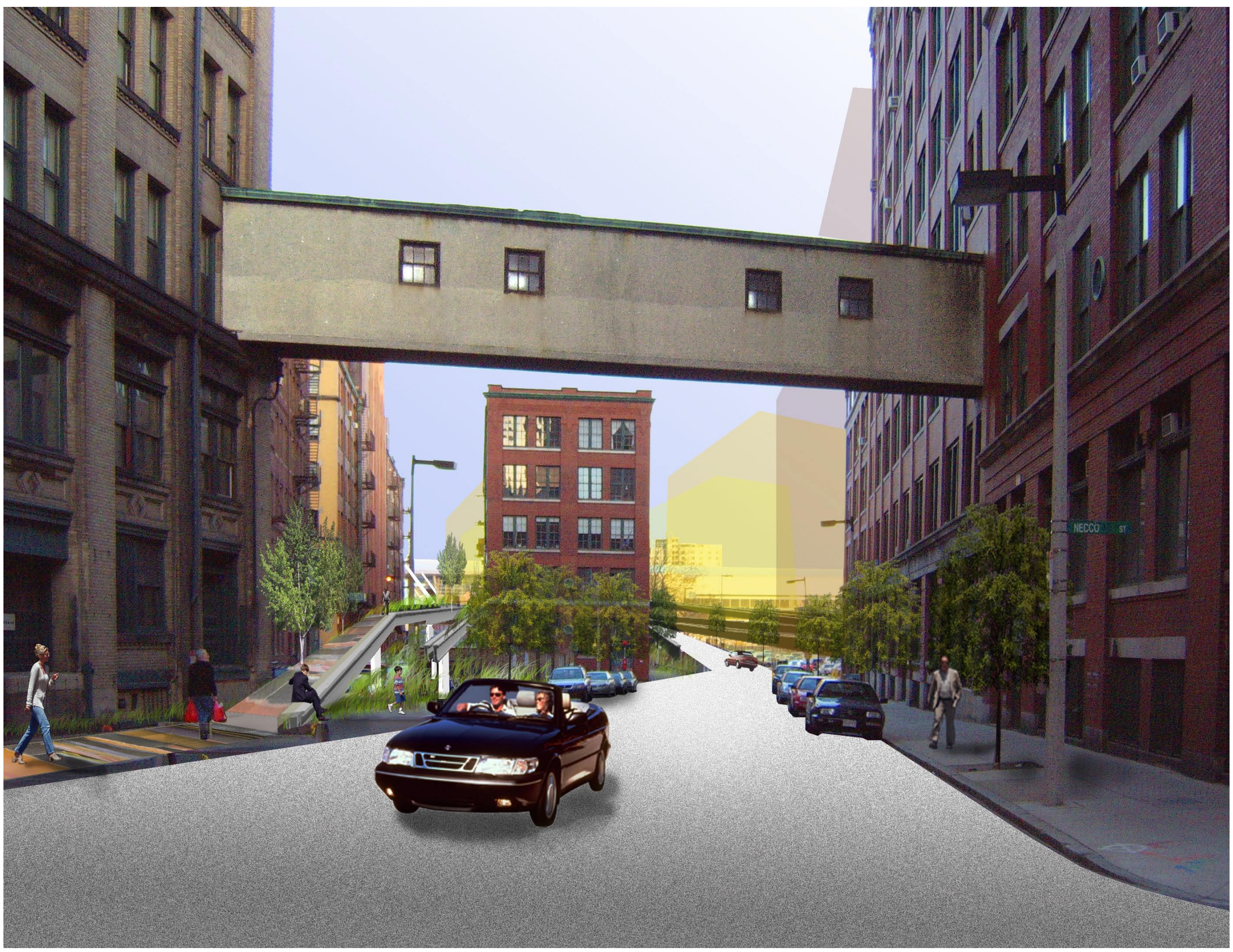
The public spaces include linear shoestring parks along and between the streets (cf. Shore Belt Parkway, Chapter 2) as well as land and structural devices at their ends (see termination details later this chapter). But the primary place where the “divine streets” give form to a new city square, a crossroads of “pure space,” is a semi-enclosed public market at the juncture between, alongside, and underneath the Summer Street Bridge. This public component will be shown in greater detail in chapter 11.

The public pathways along the continuous bundles, many of which are elevated or contain hollow utility corridors, could therefore be lit from below to express their lightness. Furthermore, as the bundles negotiate their way into the existing alleyways and street systems, they enable the landscaping and path amenities to be integrated within the historic fabric.

Linear path along bundles, lit from below



Existing conditions with underground utility repairs underway and trees dying



Proposed design for Melcher Street and its extension, with view toward linear garden spaces (image on opposite page) between the historic loft buildings at center left of this image.

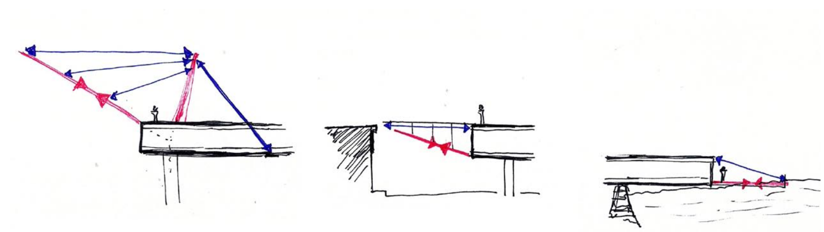
Linear path along bundles in garden slot leading up toward beams over A Street and public market beyond.

Termination Detail: Pedestrian Bridge

Zakim Bridge with obelisk-like upper termination detail

The concept of a termination detail is a pattern of structural design drawn from Allen's structural detailing texts [Allen 1992] whereby any extended element needs to be ended with some shape or detail. This is a pattern particularly resonant with Boston's urban design controversies because the Leonard Zakim / Bunker Hill bridge, the majestic cable-stayed vehicular bridge which emerges from the Big Dig to cross the Charles River, has had its concrete stays topped by miniature pyramids in a bizarre, superficially contextual relationship to the Bunker Hill Monument visible beyond. Swiss bridge designer Christian Menn did not originally imply his design to have this termination detail, and yet this small chunk of material alters the appearance and significance of the civic landmark greatly.

Since the linear bundled system is not infinitely extensible, its termination details must therefore be specified. They are three incarnations of a single design strategy: one at the upper edge approaching the convention center (center), one at the water's edge (right), and another at the upper edge as a dramatic canopy over the highway tunnel on/off ramps and a canopy over a public market (left).



Existing side of Boston Convention and Exposition Center

At the convention center edge the depth of the bundle is used to a differently expressive experience. After the depth has housed soil for the trees which fly through the air twenty feet above the ground, the bundles taper to a single pair toward the convention center. With compressive struts attached to the lower flange and tensile cables along the walkway extending from the upper flange, this bridge detail articulates the lightness with which the bundles approach – but do not bear upon – the existing convention center with its exterior circulation and meeting spaces. These bridges make the neighborhood continuous with the megastructure to its southeast, and also enable development opportunities within the new system to capitalize upon the proximity of hundreds of thousands of conventiongoers just across the bridge.

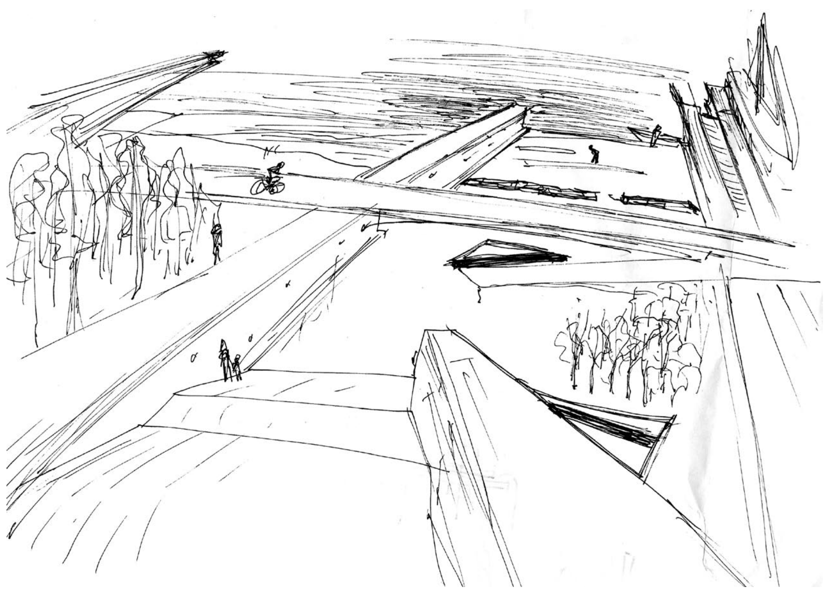
Section through convention and loading dock levels and connection to bundles with plantings and pathways

Existing view of shoreline with stone seawall

Termination Detail: Pier

As the bundles approach the water, they lose their necessity to enclose building utilities. They also continue their descent past the historic seawalls to the water itself. The water is so diagrammatically important yet hard to view from the center of the site that this termination provides a memorable experience to which the "upland" bundles are continuously linked. At this point the pedestrian walkways and ground surfaces dive so that visitors can walk down and inhabit the depth of the structural system to the fullest (Chapter 7) and then walk out on piers along both levels of the bundled beams' flanges toward water transport. The lateral system between the cantilevered bundles also allows pedestrians to reach the level of the water itself.

Given how Boston continues to pride itself on the cleanliness and ubiquity of its revitalized waterfront, this designed completion of the sectional gesture will make the space not only a well-designed waterfront park but also an experientially rich moment, bringing the heroic urban scale down to the physical phenomena of touching the water, in all of its tantalizing wetness as it meets an outstretched finger or toe.



Sketch perspective from existing ground level with land descending through the height of the beam

Pier section with shoreline bicycle path occuring overhead and adjustable tension cable for platform leading to watercraft

Existing view of exit ramp with abundant glare

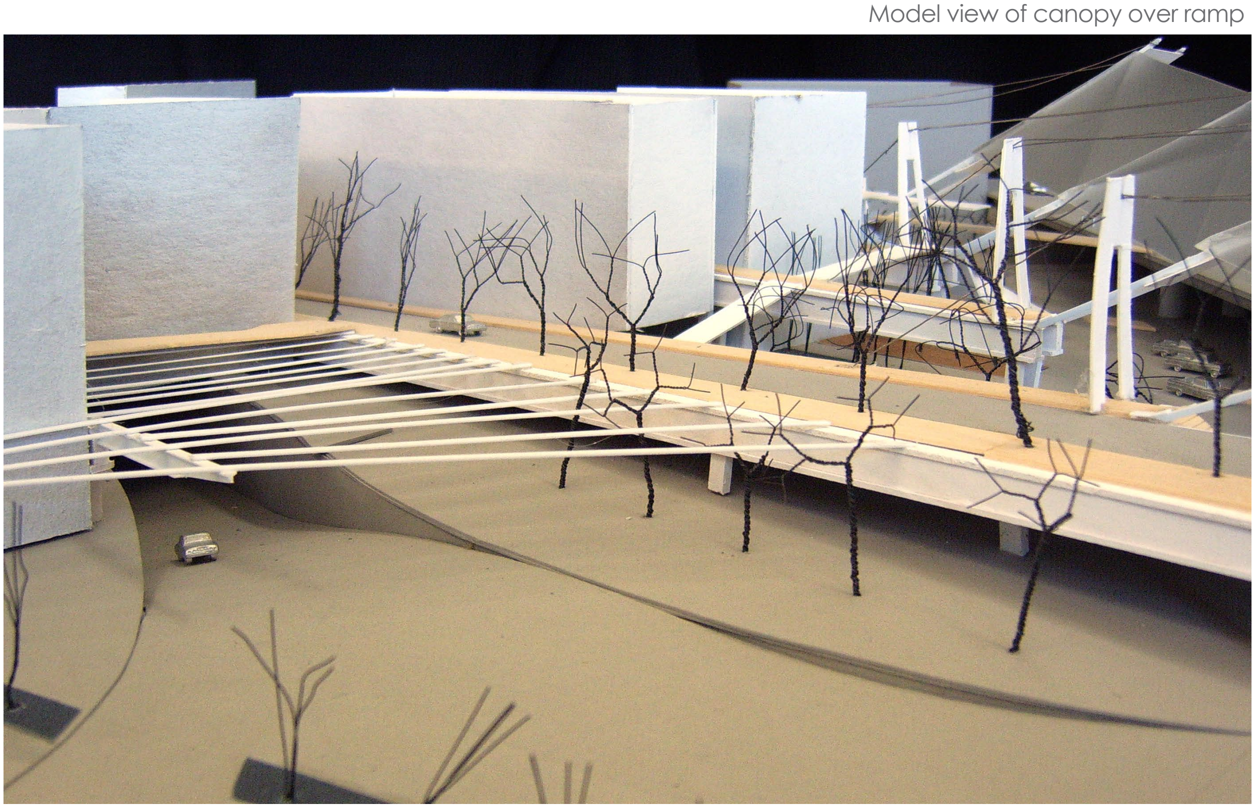
Termination Detail: Canopy

The current condition as one enters or exits the buried highway is one of unmodulated contrast: one goes from total enclosure to total exposure and vice versa. Given the complexity of the intersections and street geometry, such light conditions are far from preferable, but any programmatic use of these spaces would simply provide an extended distraction. Therefore the lateral system is extended in this termination detail not to allow for pedestrian experiences but instead to provide a gradual transition of light conditions for motorists. This points to the broader attitude of how the bundled system is sympathetic with a rehabilitation of vehicular experiences – cars aren't just problems to be solved or hidden away but are rather to be treated with the same level of specificity as their radically different pedestrian counterparts.

The idea of a partially enclosing surface extending from the terminated bundles is the concept which the final design exploration takes on in the design of a canopy for the public market in the next chapter.

Transformed view with canopy and plantings

Model view of canopy over ramp



Existing view of well-lit but underutilized space beneath the Summer Street Bridge, 2006

Chapter 11
Markets and Values

> But may I, when again I have the city's crush
> And tangled noise...and furor
> Of its traffic wrapped around me, alone
> May I above that thick confusion
> Recall sky...
>
> ["Die Spanische Trilogie," III, Rilke 1997, p.33.]

Given the boldness of the structural bundles weaving through the site, the moments where they end and allow for light to descend are important points of mediation and negotiation between the new insertion and the existing context. It is at these points that the 'thick confusion" of the city pauses for a moment and we are given the chance to "recall sky."

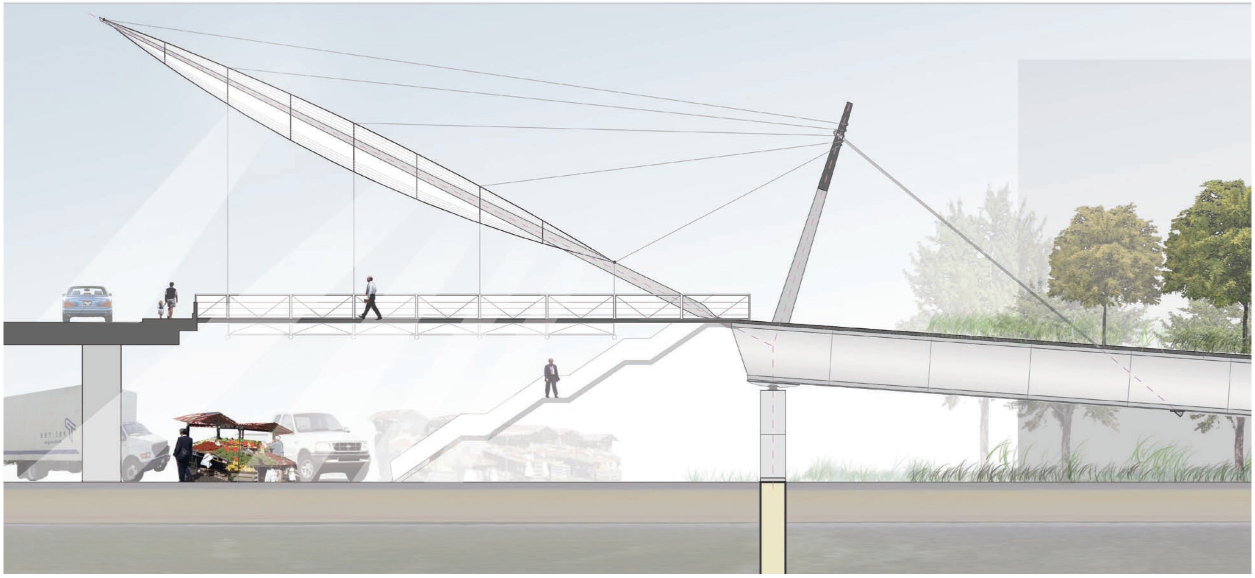
I have chosen to develop a particular point of negotiation and its vertical relationship to enclosure and light through a public market, in the tradition of many markets mentioned in Chapter 1. More specifically, this proposal for a public outdoor market above the Big Dig's tunnels is an attempt to ameliorate the way that current construction and future plans for the surface above the Big Dig in Downtown Boston have marginalized and now erased the spaces for the vibrant Haymarket.

The market area takes advantage of the well-lit but underutilized space adjacent to and beneath the south-facing side of the highway-like Summer Street Bridge completed in 2004, a structure which has at least four different types and configurations of support conditions (columns, continuous walls, etc.) that demonstrate its lack of fluency in negotiating different ground conditions.

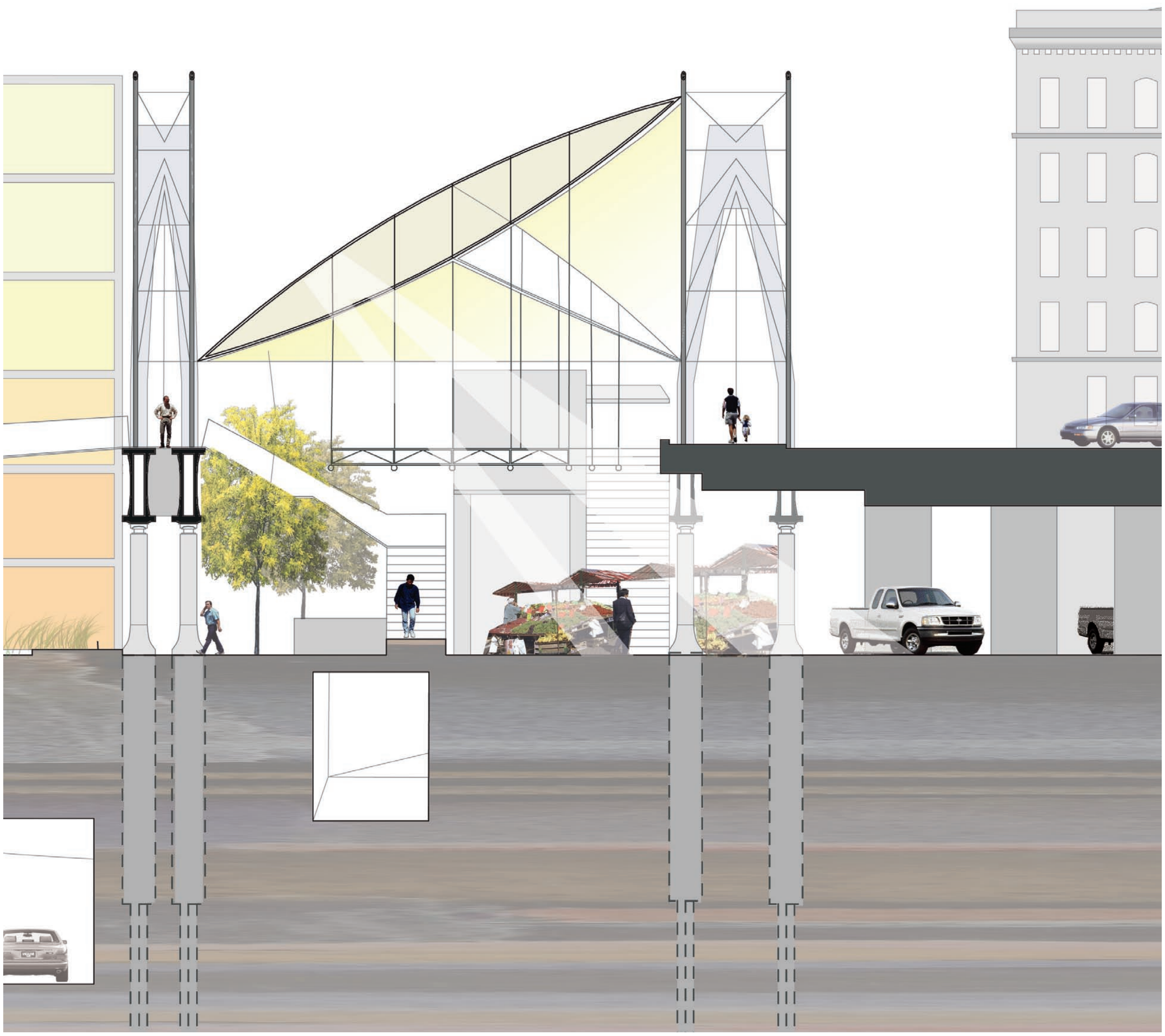
Various uncoordinated support conditions for Summer Street Bridge, 2006

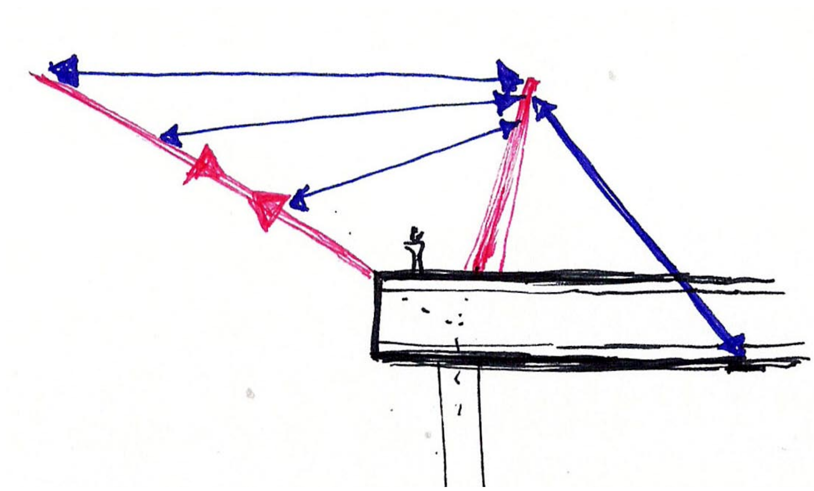
In contrast, the new market canopy employs a consistent and elegantly light structural system. Thin tapering compression struts are held in stable equilibrium by a series of cable-stays connected to an inclined mast; each mast is tied back with a single balancing cable. The northernmost mast is larger and supports not only the roof but the suspended walkway connection to Summer Street.

The masts support pairs of compression struts and the pair of tensile cables in each level of the fan, combined with the thin opaque steel shear plate between the struts, provide lateral stability and resist racking.



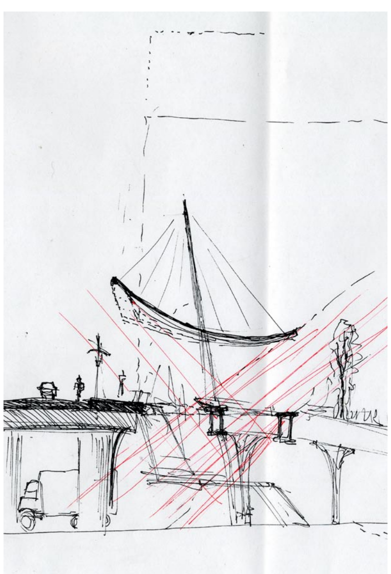
Longitudinal and cross sections through the double lenticular truss for the Summer Street Market and plazas





Early watercolor sketch of tensile connection to masts

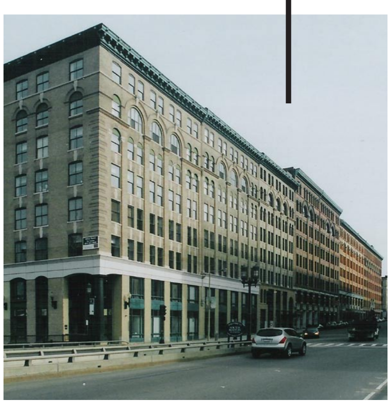
Process sketch of market canopy



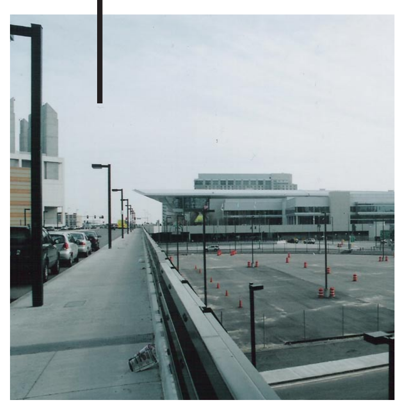
Resting on the inclined compression struts is a thin air-filled translucent membrane structure shaped like a pillow – tapered to a single line on each edge but with depth in the center. This is accomplished through a double lenticular truss, chosen for its structural efficiency, its ability to be stable without internal diagonals, and for its resulting light effects on the market area below.

This market structure is not necessary for the rest of the bundling system to be complete, but it provides an open, welcoming gesture for a location that serves as a primary point of entry and visibility for pedestrian and vehicular traffic. Therefore the raised canopy is not only a solution to providing shelter but also creating a recognizable landmark that makes sense in the urban context of how Summer Street's edges are treated. Summer Street has one tightly held "harder" edge and another that is "softer" through the existing curved entry to Melcher Street, the open space at the corner with A Street, and the monumental canopy of the Boston Convention Center further southeast.

Therefore the proposed market canopy negotiates the geometries of the bundles' grain and the existing street frontage while providing a suitably strong gesture to answer in dialogue these other site conditions that define the asymmetrical street profiles. The canopy could therefore not only emphasize the visibility of goods sold below through its architectural gesture but also through its potential to have signage hung from its cables and for images to be projected from below on its translucent surface.



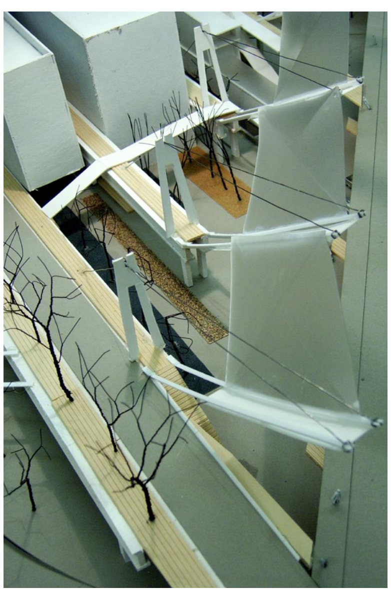
Hard Edge to Summer Street

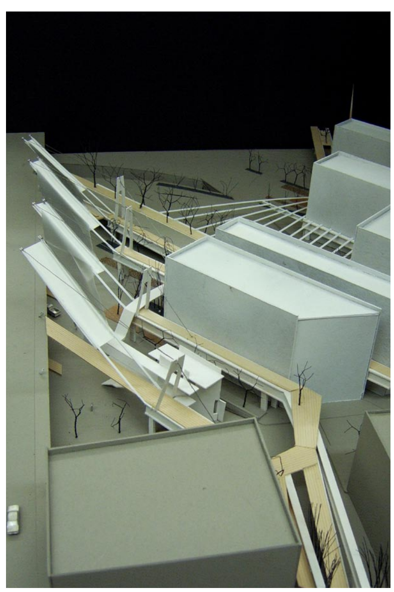


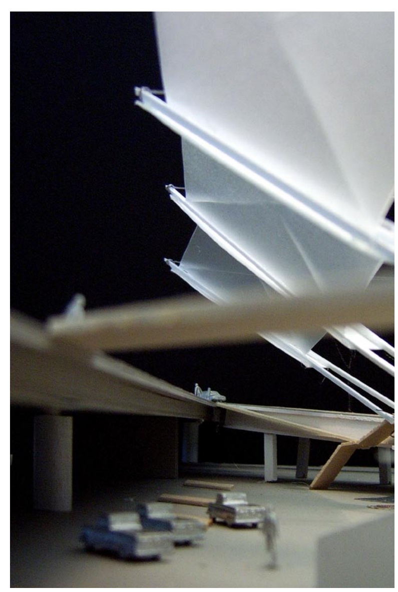
Soft Edge with convention entry canopy beyond; market site at right

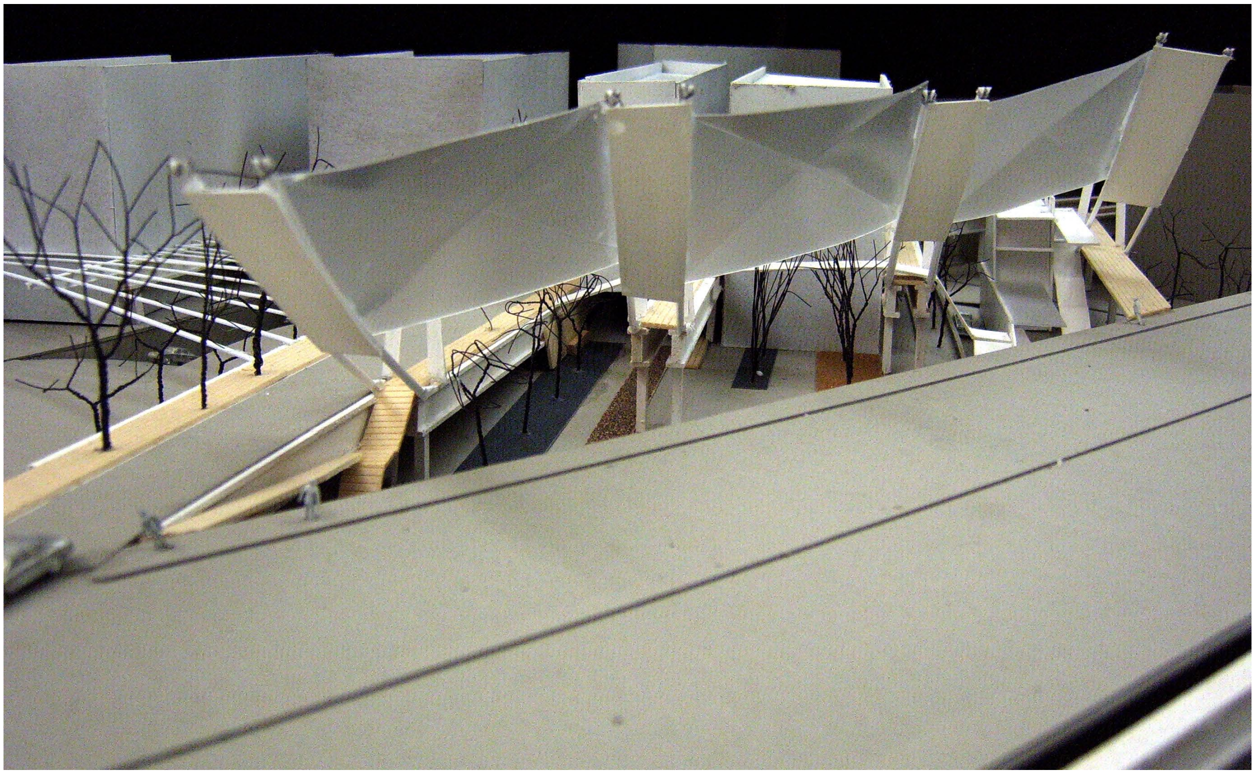
Rendering of new Summer Street Market between Boston Convention and Exposition Center (left) and historic fabric (right)

Views of physical model: from above New Melcher Street, from above Summer Street, and from within the market



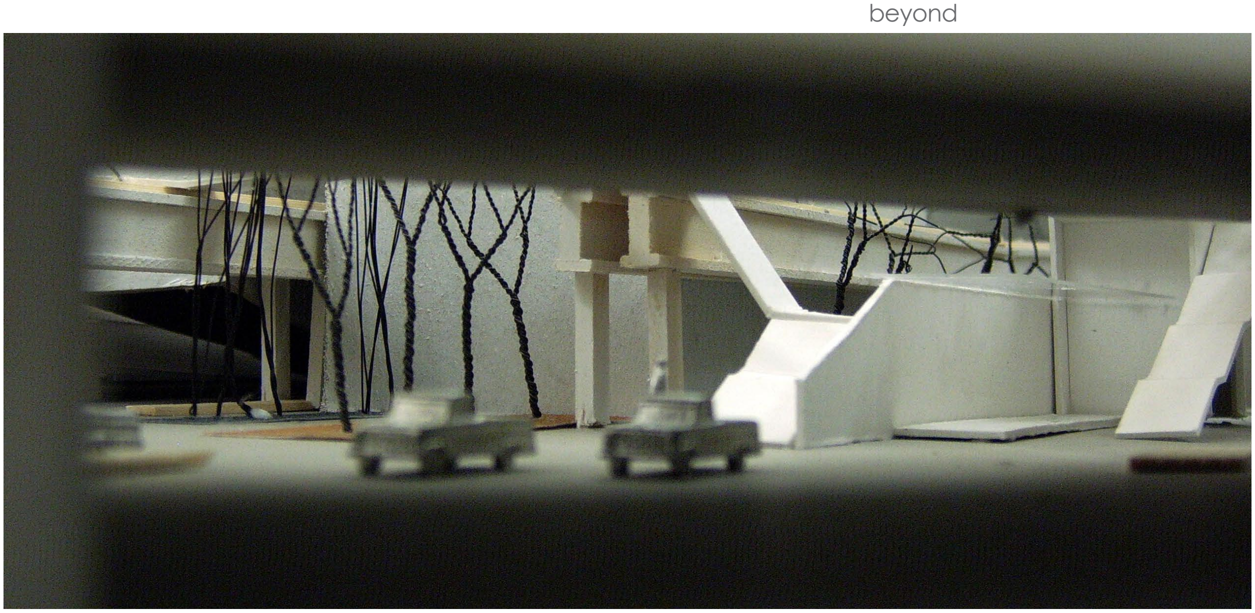


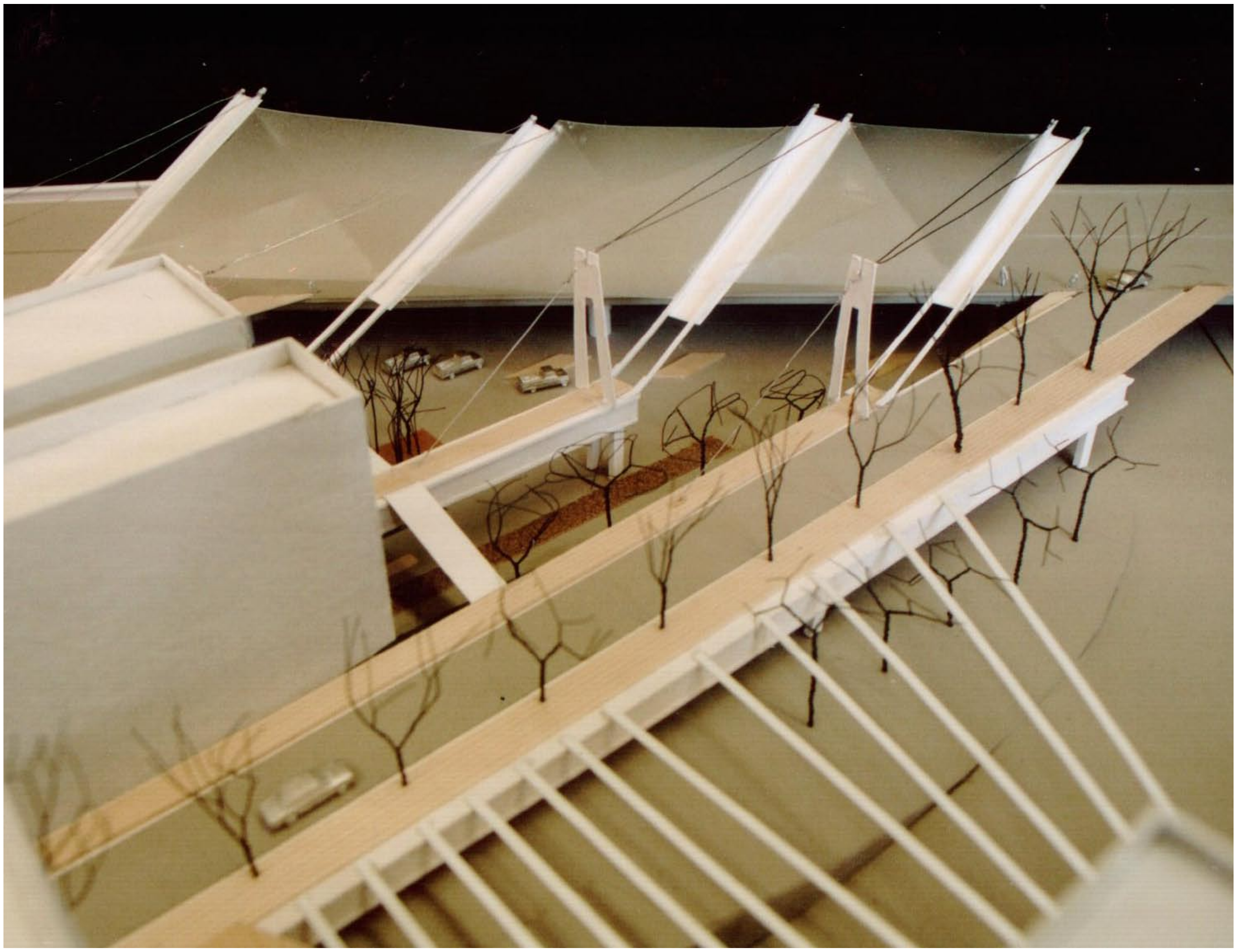




Model view across Summer Street Bridge into market and plantings beyond; New Melcher Street at left

Interior view from underneath Summer Street Bridge toward market stalls, parking, plantings, plaza, and vertical circulation beyond





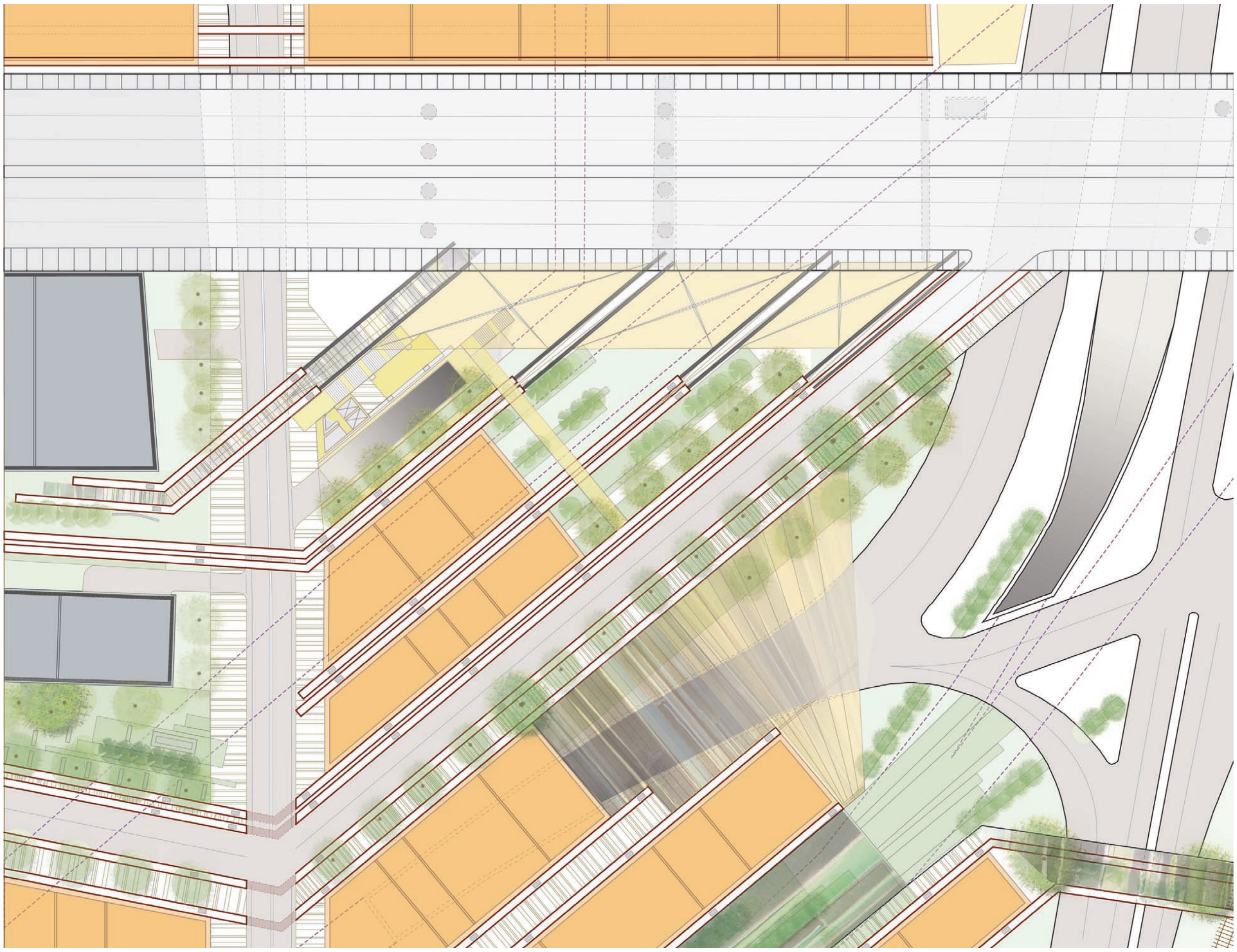
Physical model view from south looking north toward exit ramp canopy, New Melcher Street angling up toward Summer Street Bridge, and the cable-stayed market structure

Situating the Market

The market site is at the place where the tunnels and on/off ramps require the bundled boxbeams to be at their most exposed and exuberant. This segment of the site became the basis for a highly detailed exploration not only of the market itself but of the adjacent streets and blocks, drawn (1”=8’) and modeled physically (1”=16’).

Within this focal area, the lightness and dexterity of the bundles becomes readily apparent compared to the awkwardly overstructured Summer Street Bridge. The new flying beams are an elegant overhead infrastructure that is not banal but instead lithe and expressive. It recalls the spatial complexity of the former elevated Central Artery in downtown Boston but transformed within a new scale, material, and structural language.

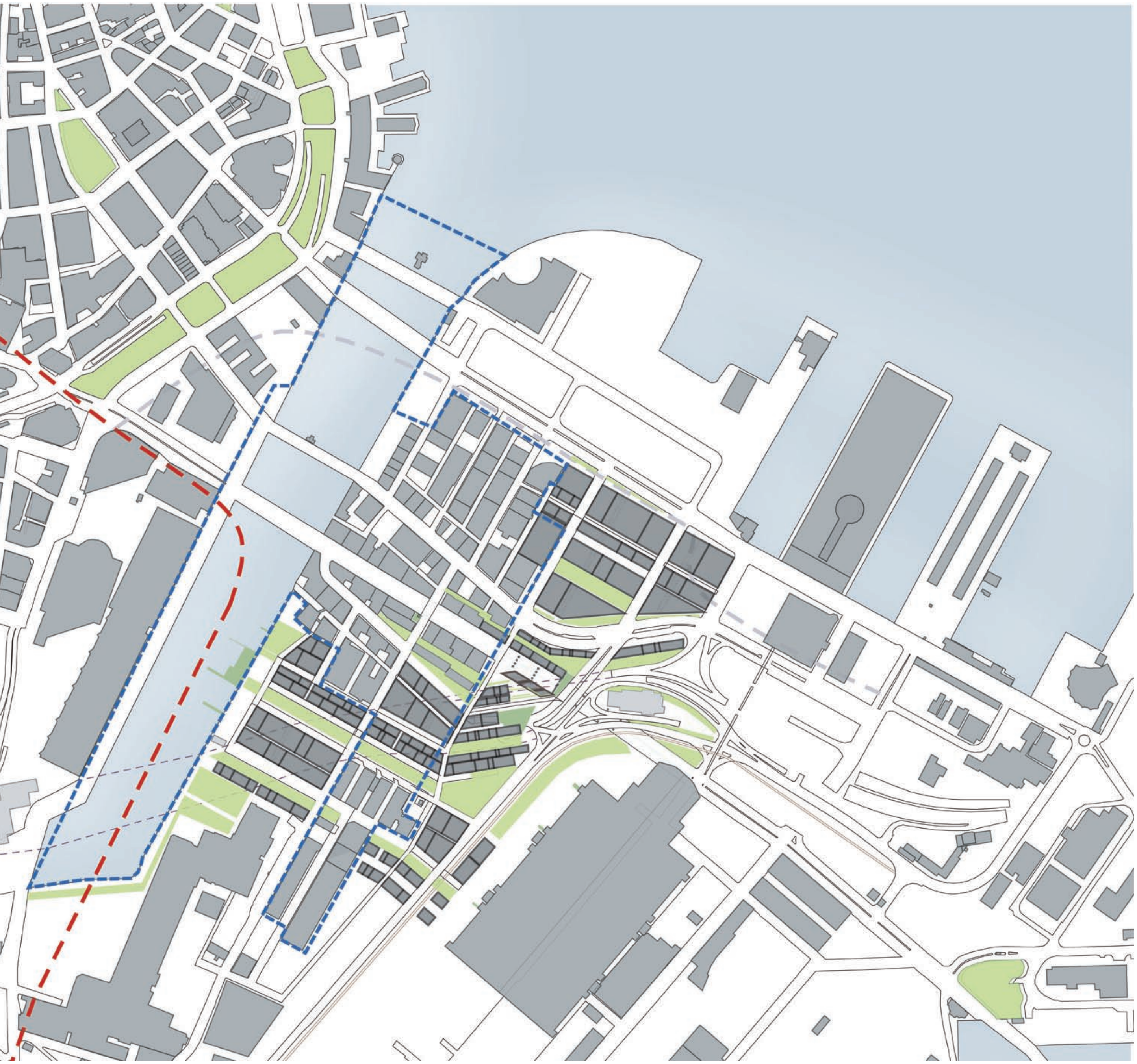
The focal area includes the diagonally extended New Melcher Street with its multilevel pathways and plantings, the small pocket parks which play off of the linear grain of the bundles, the canopy over the exit ramps, and nearly every other typical condition and configuration of streetscaping, access, and other public amenities which the system allows for throughout.



Illustrative plan of detailed portion at the juncture of the highway ramps and Summer Street; historic fabric in gray at left, new envelopes in orange (geographic north at top left)

Broader Visions

If one zooms out to examine what this proposal might imply at the scale of all of downtown Boston, the articulation of the bundles takes on a radically different character. Whereas the paths twisting, dramatic linear character enables them to be a highly unique places in the spirit of Williams' earlier description in Chapter 4 [Williams 2005], the scale of blocks and streets and open spaces is quite comparable to those of the Back Bay and other massive earthworks which created and added to the land of the city over a century ago.



Illustrative plan of proposal within overall context of Boston

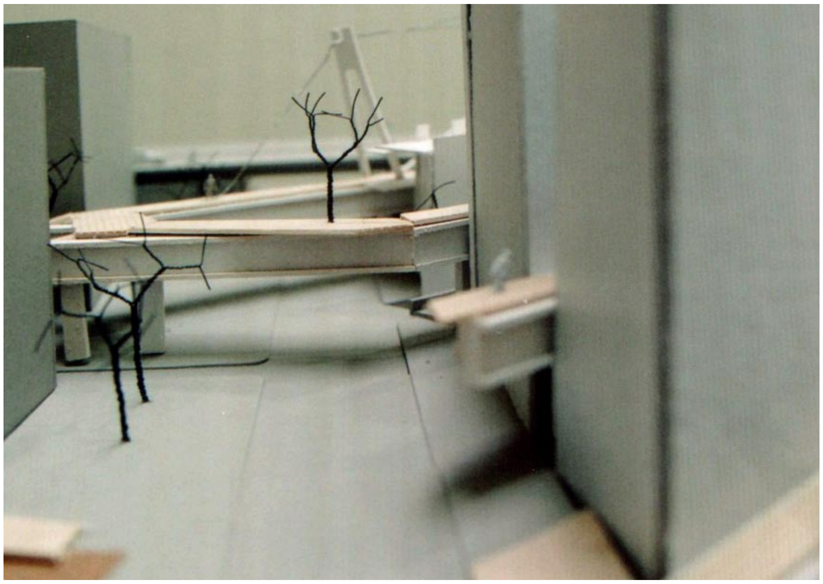
Furthermore, for all the boldness this bundle-infused negotiating landscape near Fort Point Channel undoubtedly takes on, given the scale of the proposal, it is readily apparent to be quite modest compared to the massive precedents of landmaking, wharves, and other urban transformations. While the most oft-discussed effects of the Big Dig involves the swath of land through downtown, this adjacent topography capitalizes on the areas where the subsurface highway tunnels are now more hidden but are no less influential in the future conditions and possibilities which undergird the site's urban and architectural potentials.

Choices and Value Judgments

Now that the design proposal has been envisioned to a level of detail with which one can imagine walking and driving amidst streets, trees, buildings, and other structures in the built environment, the choice of an open marketplace is a clear example of a **choice** rather than a **result** within the physical structural system.

Such choices and value judgments are often implicit within designs and only become evident with the perspective that time and distance are able to give, but in this case I wish to observe and make explicit some of the choices and values which this proposal encourages and promotes.

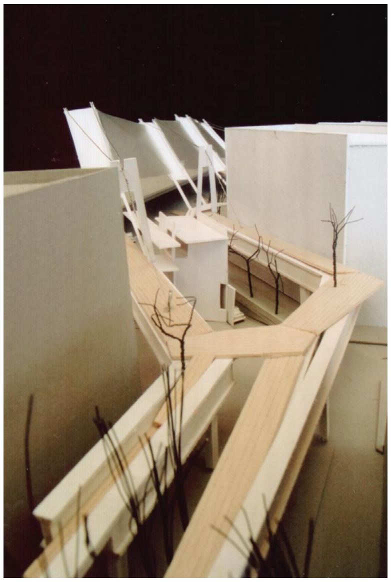
- This project chooses to be based on typical real estate market assumptions rather than requiring the state to fund the entire venture, but it values many public components far beyond their literal market values. The proposal thus negotiates between the market's notion of value as income-generating property and the value judgments of what is good and preferable, such as the elegantly roofed community marketplace adjacent to Summer Street.
- This design values the complexity and vibrancy of urban centers; "Vibrant civic life has always been fundamental to an intellectually adventurous society" [Hunt 2005 p.9]. Stated even more boldly, "The city is the place where human being sexpress to the fullest degree the perspectives on importance that their culture has bequeathed them. ...It is, par excellence, the place where human values come to their most concrete expression. The city is the form of the good for human civilization. It is therefore an exceedingly complex, nuanced, and even delicate cultural instrument." [Grange 1999 p.xv]
- This design values growth and capacity for change, that a city is a living entity rather than a fixed image; "It is not sufficient to merely say that the city is a place where types of interesting life take place. That is to deny the city its own unique form. What must be done is to win for the city a radical vision of its living structure." [Grange 1999 p.1]
- This design values the boldness of radical visions, that can inspire us to imagine places we want to live rather than places we simply trudge through. It also values the ability for those visions to be implemented over time and to adapt to known and unknown human challenges, without requiring an autocratic heroism to accomplish a single perfect incarnation in the abstract, and without being merely a tentative accumulation of incremental decisions.
- This design values the inherent goodness of living organisms, including trees and other plantings, and places them with great importance in the city so that urban places can be healthy places



Elevated plantings and multilevel streetscaping

for all sorts of organisms – not to mention pedestrian humans – to live and thrive. It even places the trees and other plantings at unexpected elevations to allow for spatial experiences of being at street level while in the treetops and so forth.

- This design values light and other natural phenomena, not only to make the outdoor spaces habitable and pleasant but also to make the indoor spaces of relatively narrow buildings well-lit and well-ventilated.
- This design values pedestrian connections as not only healthy for the humans but also as healthy for the commercial viability and safety of the city around them.
- This design values safety and the mitigation of risk not through reactionary means of enclosure nor through unreasonably over-structured bulk but through careful stewardship of resources to make investments that allow for safe infrastructure to support cities long into the future.
- Within the visible components of structure, this design values the elegant use of forms that are shaped according to the physical forces they are designed to accommodate; "Efficient structural forms are almost invariably elegant" [Edward Allen, 24 April 2006]
- This design values the particular treatment of paths based on users and speeds. The new streets with their frequent pedestrian crossings are scaled to be of a safe moderate speed entirely separate from the unhindered speed of limited-access highways beneath. The South Bay bike trail and other routes weave through the site along streets and open space corridors to allow for a multimodal conception of separate but interwoven continuous paths.
- This design values continuity, including continuous utility corri-



View of bundles running between historic buildings and extending toward new buildings (white) and market canopy in model

dors, continuous paths from the bridges to the piers, continuous street walls built along the boxbeams, continuous access below grade. The continuity is valued because it allows for uniqueness in urban architecture to be perceived within an overall framework rather than simply being a collection of dispersed spare parts (Chapter 1).

- This design values historic precedents and preservation efforts not simply as nostalgic information about the past but rather conceives such research as informing innovative uses and future transformations of places, buildings, structures, and typologies.
- This design values uniqueness and specificity in the physical environment [Williams 2005]. Moreover, it places a positive value on making the intangible, hidden, invisible, buried aspects of cities and their physical supports visible aspects of their unique spatial character.
- This championing of uniqueness means that responding to and creating highly particular geographies requires equally particular considerations of the tools to imagine their implementation. In this pursuit, structural design can become re-envisioned not only as the means toward solving individual owners' discrete needs but can also be conceived as another complementary tool in the bundle: the conditions and responsibilities made physical, where incentives, regulations, and negotiations of priorities are not simply verbal policies but material properties embodied in (and inseparable from) a designed piece of enabling infrastructure.
- This particular championing of uniqueness privileges creativity and fluency for accommodating variation rather than mere formal beauty and unusual shapes. It values structural solutions that are simultaneously elegant places and spaces to inhabit.

In his May 2005 commencement address at the Boston Architectural Center, Edward Allen made a similar concluding point in stating that current students have the assignment to replace previous generations' mistakes "with an architecture of QUALITY." [Allen 2005, emphasis original] He continues:

> My generation has no clue what architectural quality is. NOVELTY rules the day. Being different is how you get famous. IF A BUILDING HAS A NEW AND DIFFERENT SHAPE, IT WILL GET PUBLISHED. But does new and different mean better quality? Do buildings in novel shapes work better? Are they more economical? More efficient? More pleasant to live in and work in? More interesting over the long term, once the novelty has worn off? Do they make their occupants happier? There's no evidence to suggest that they achieve any of these qualities. The main result of our obsession with novelty is that we've made a visual mess of our once-beautiful cities!

Each new building we build is different from those on either side. Each new building that we build in our cities SHOUTS RUDELY for attention: It yells, “Look at me! I’m the latest and greatest set of shapes! And by the way, isn’t my architect a clever person!” All the new buildings in every city shout this message at once. And as with a group of people in which everyone is shouting, nobody can be understood, so it is that in a neighborhood of shouting buildings, no single building can be appreciated. Our urban neighborhoods are confused jumbles of shapes rather than cohesive units. Our cities look like absurd junkyards of cast-off architectural fads. This is the result of my generation’s single-minded quest for novelty. This compulsion to do something new and different has infiltrated our schools of architecture and infected generations of students, including mine and yours.

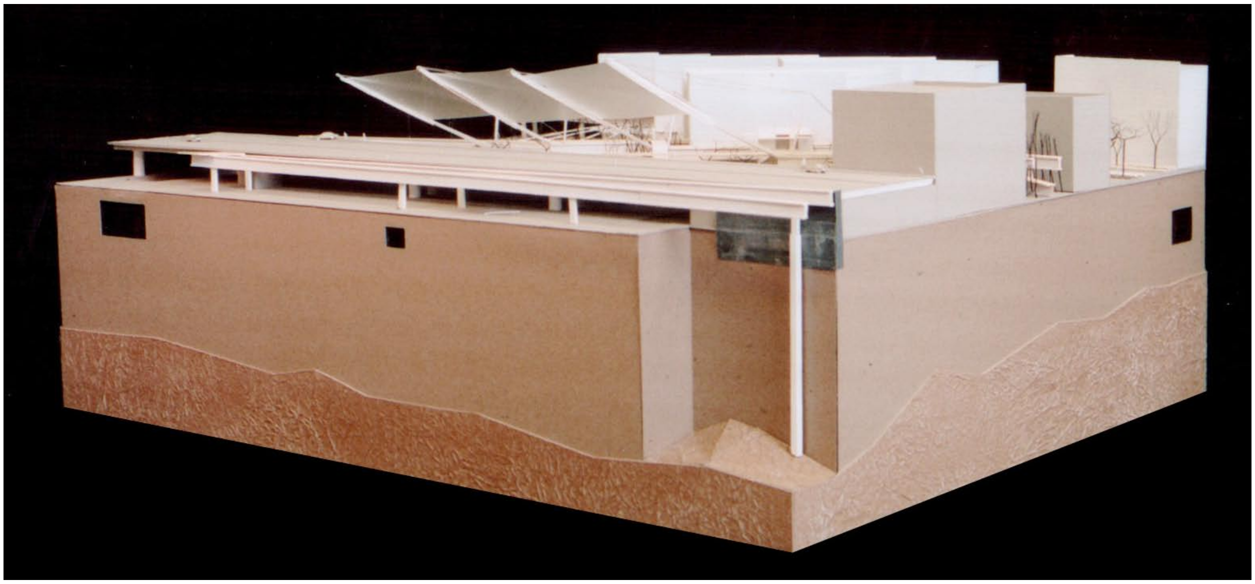
How can we develop criteria of goodness for our buildings? Where can we turn to learn to design buildings that are truly good? [Allen 2005, selected excerpts]

Allen notes the endless possibilities in color and variation and overall design harmony evident in continuous streetfronts of brick and other materials like those on Newbury Street (and like those in the Fort Point Channel area) which accomplish “both overall unity, and individual variety,” doing their part “to create a beautiful street.” He describes how the structural devices act in concert: “These buildings don’t shout rudely, ‘Look at ME!’ Instead, they murmur gently, ‘Look at US.’ Look what a lovely street we have made…so as to touch our imaginations and stir our emotions in pleasing ways.” [Allen 2005]

Finally, the design proposal of this thesis situates these issues of goodness and quality as they relate to broader narratives and moral values of building. This has been the challenge ever since modern technology gave the physical ability for structures to be erected and for the Goethe’s epic Faust to conclude with the bold transformations of earthly development and construction. The recent film version of “The Hitchhikers’ Guide to the Universe” opens with the central character’s house being demolished to make way for a highway bypass just as the entire Earth is being destroyed to make way for intergalactic construction. The stereotyped earthly designers in the movie are befuddled by those who question the necessity of the construction. To them, a commitment to progress and technological development requires construction without questions of whether optimistic faith in such structures actually matches the way they improve communities.

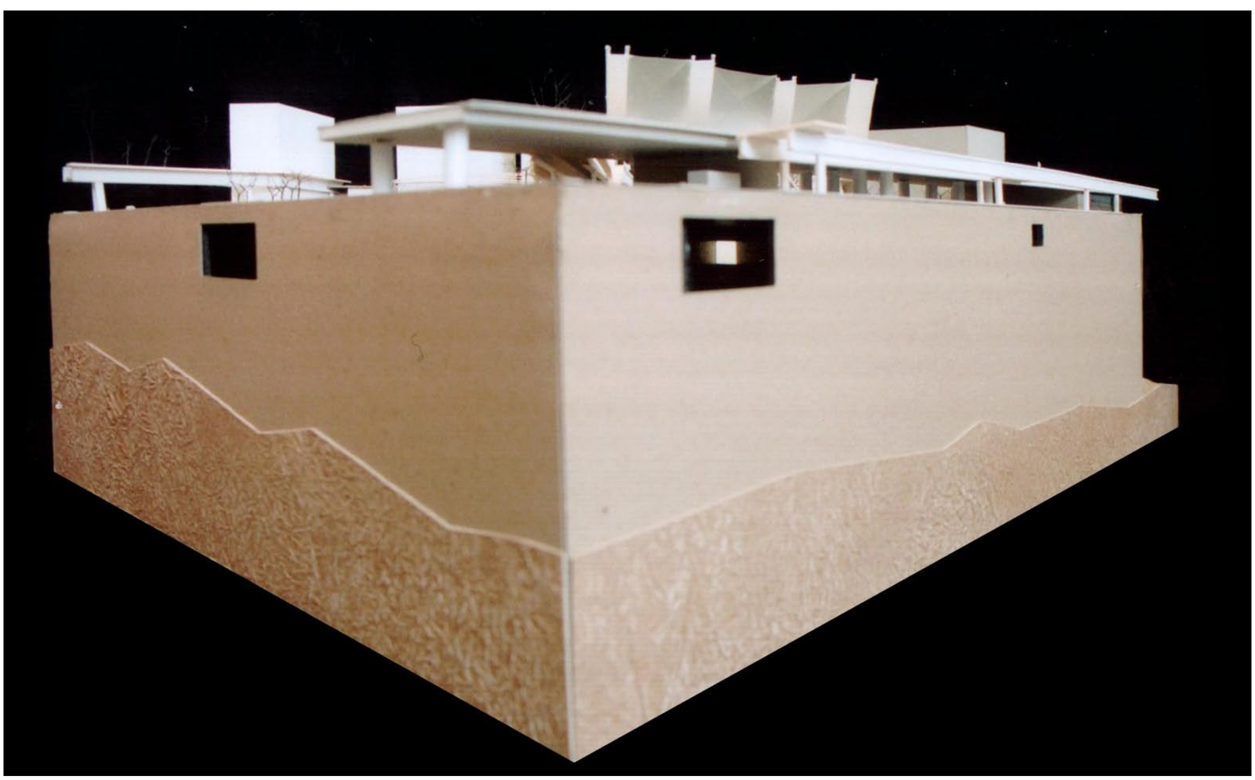
While cities have represented the accumulated pursuits of both good and evil, of ideals and squalor, of heaven and of chaos, the **construction** of cities – the largest human creation comprehensible as a whole – is largely an optimistic endeavor. Places are built for the future, for hopes of increasing business and profit, for housing and transporting people, building to support solutions to problems **within** and **beyond** the realm of architecture. Even though countless cities and settlements have often been variously described as archaic and obsolete, and therefore disordered, the human capacity to create order (and to subvert one ordering principle for another) is reflected in both the processes of structuring communities and constituent buildings based on value judgments.

Values, concepts, ideas, decisions, stories, and other nonphysical elements are all latent aspects of cities and their buildings, often so latent that they fade into the background to our experiences of people and events and times within the spaces that have been created. Therefore it is possible to understand the optimism and "goodness" in cities as best present in the **intersection of these values and physical structures** in perceivable spaces and objects. At this intersection, the built and unbuilt projects we design and experience, including those in this work, communicate the cultural values, patterns, ideas, stories, and the technological creativity which have made human-built creations possible.



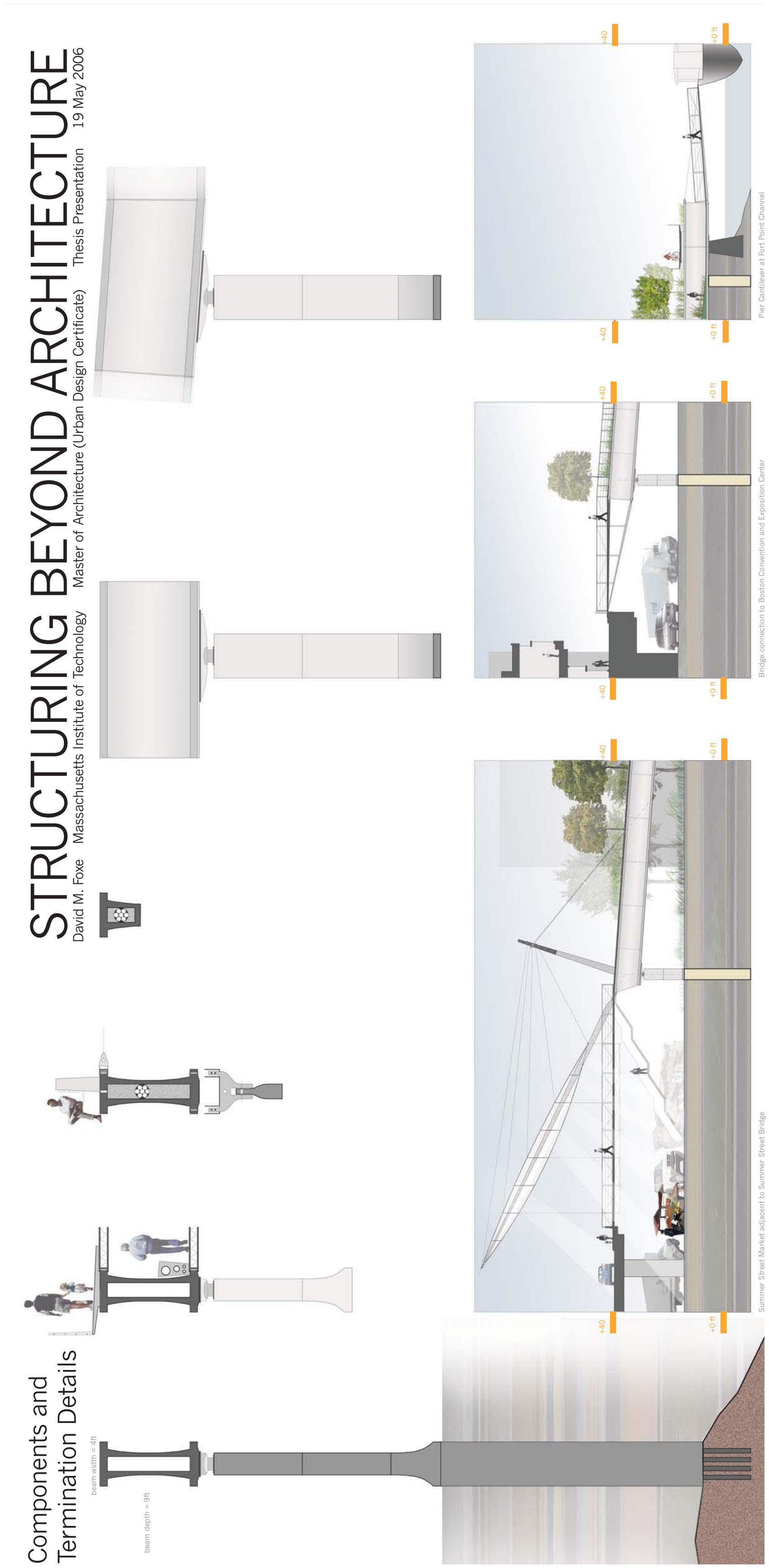
Overall view of model showing diagrammatic cutout with new column descending to bedrock (center)

View of model showing tunnels beneath Summer Street Bridge and new bundles



Presentation Boards

Originals 36"x72", two columns of three boards each, totaling nine feet tall and twelve feet long, the profile of the smallest single cast segment of the bundled boxbeam profile.



Top Left Board

Sectional Gestures Through the Land

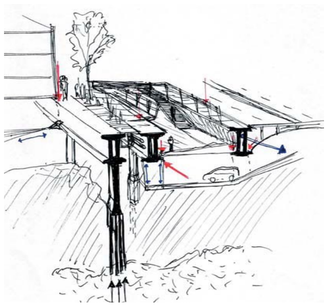
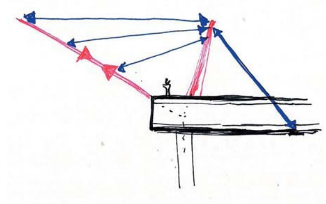
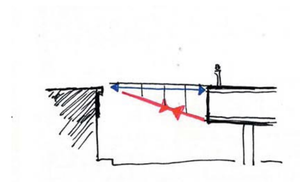


Diagram of conditions and possibilities with bundled boxbeams

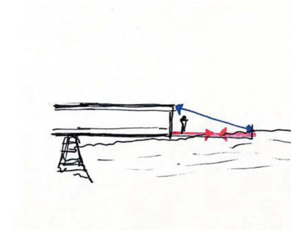
Force Diagrams:



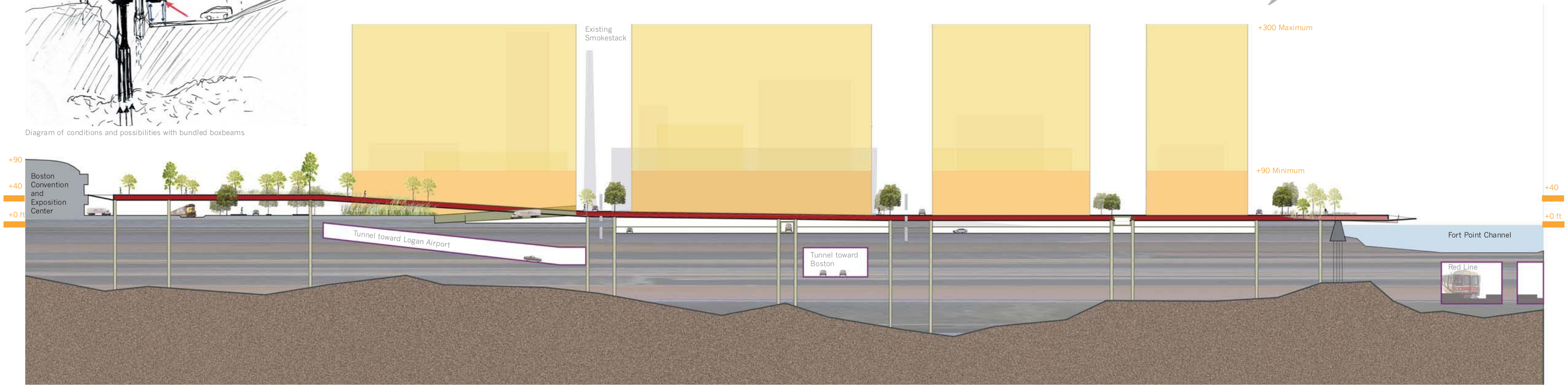
Market with lenticular trusses supported by a cable stayed cantilever



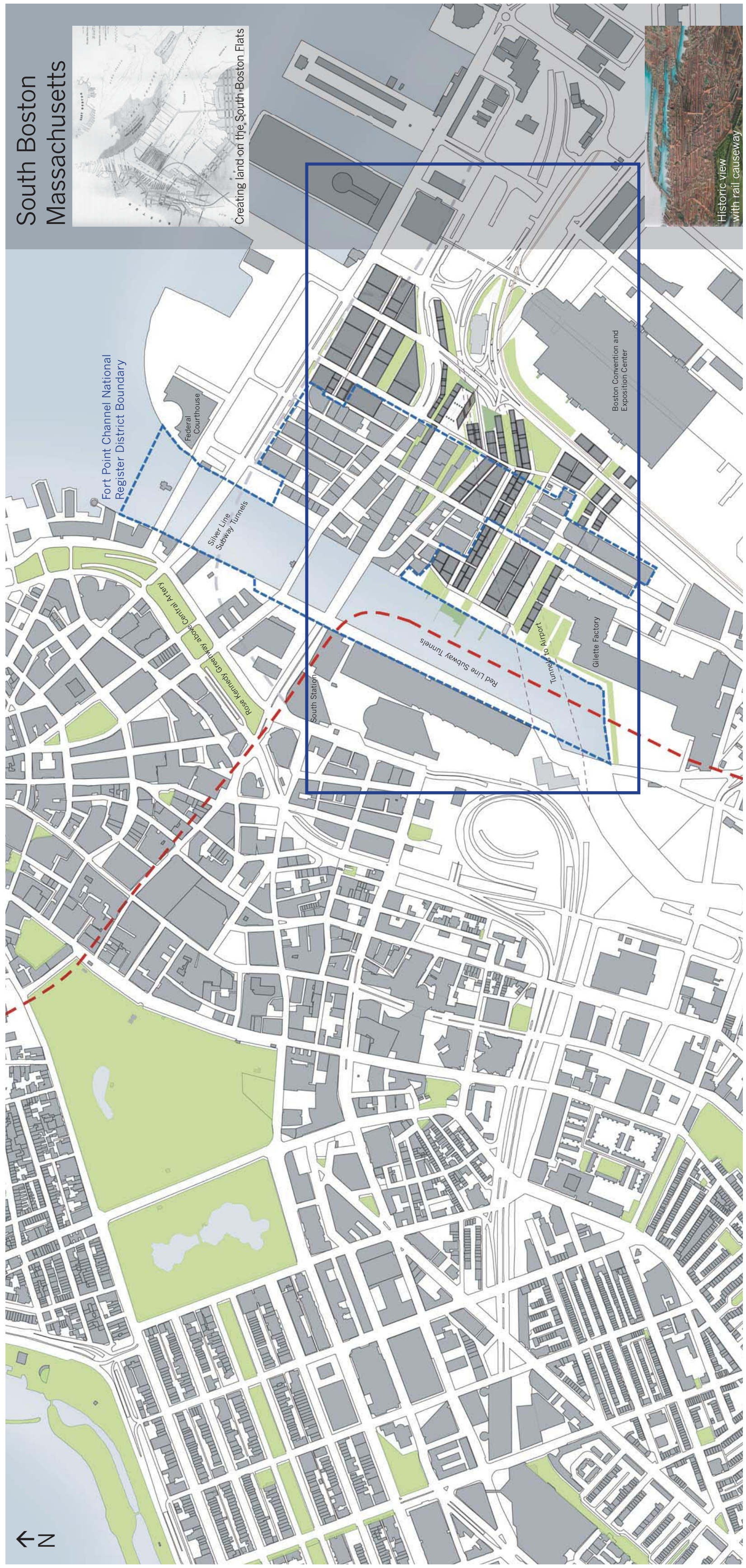
Bridge with tapering compression strut and deck



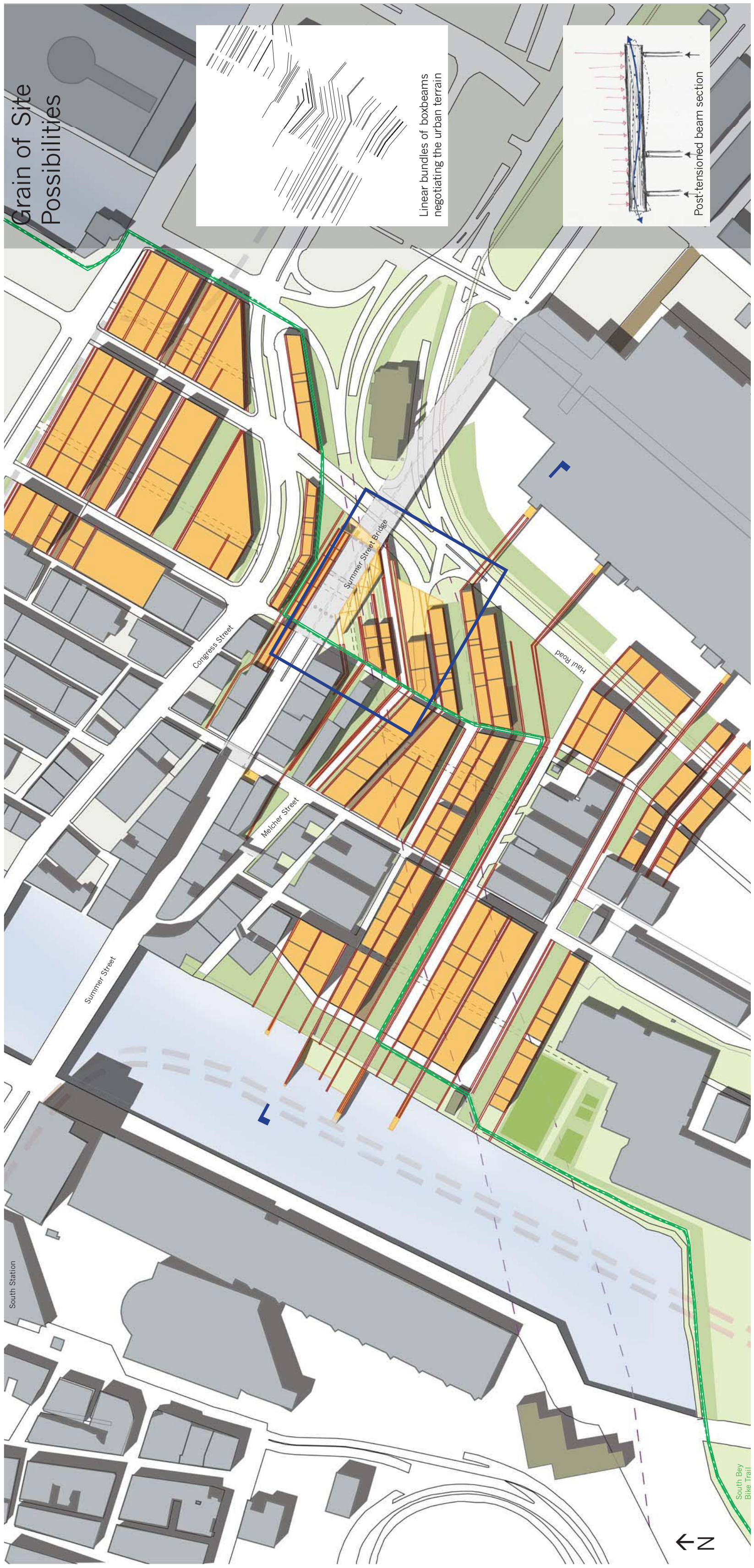
Pier cantilevered beyond seawall with adjustable tensile cable



Middle Left Board



Top Right Board



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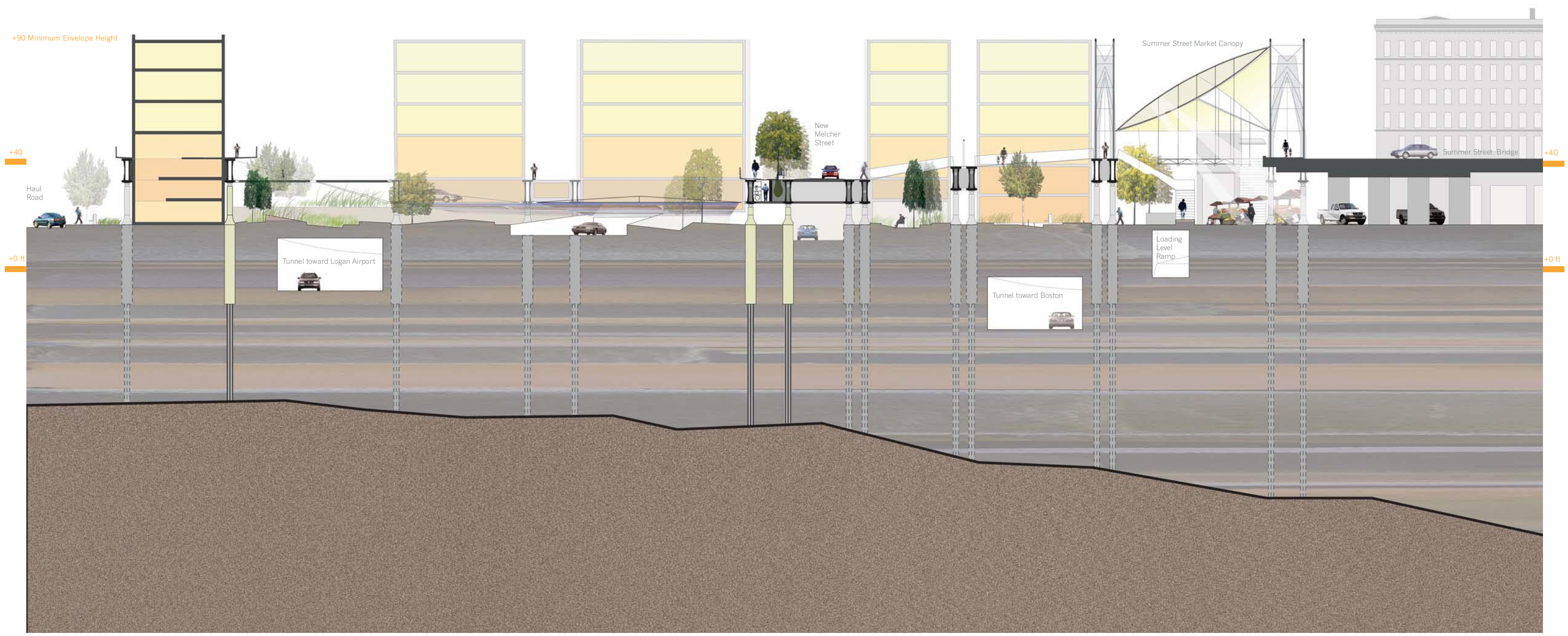
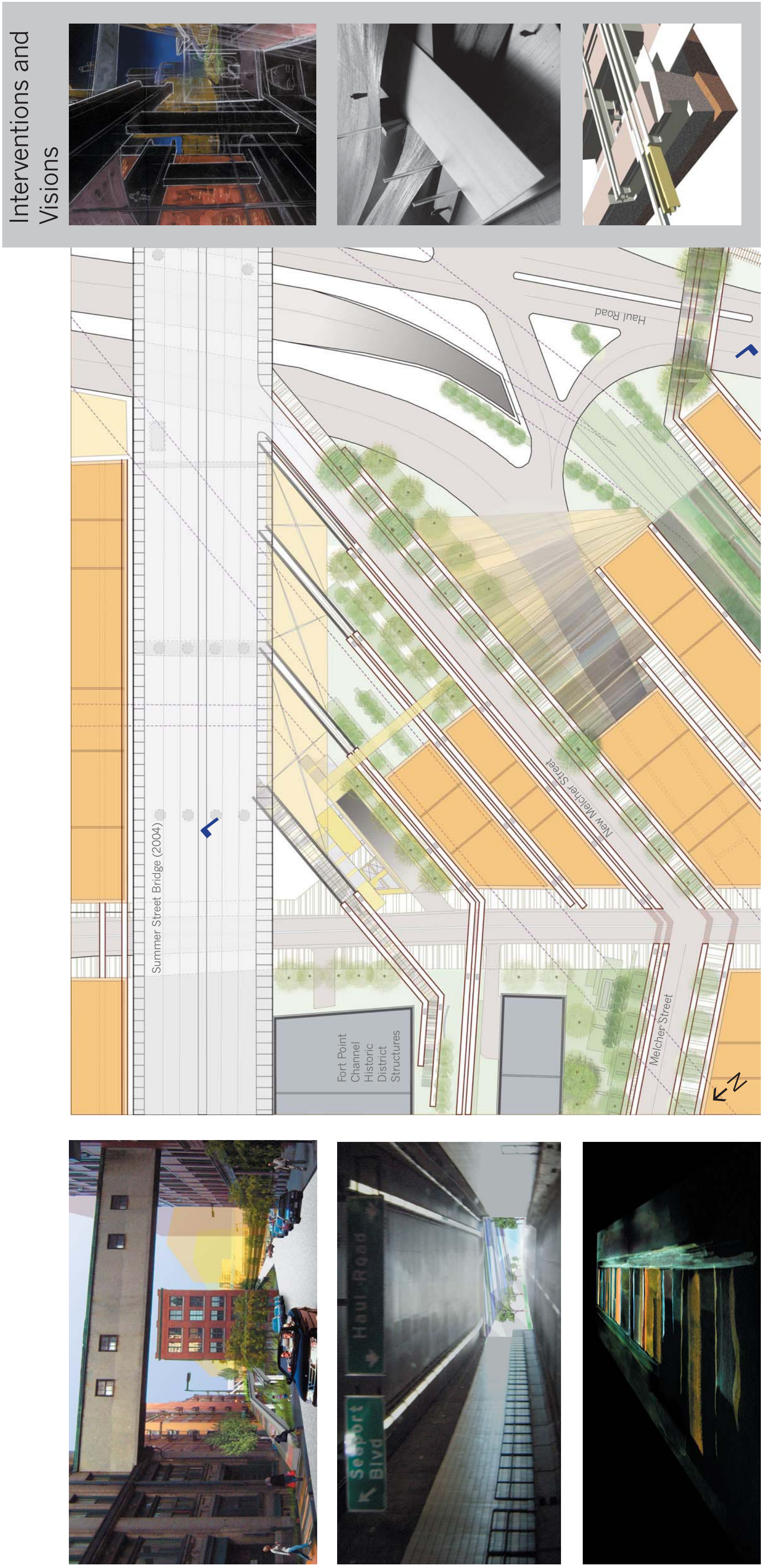
Bottom Left Board

Differentiated Bundles and Spaces





Bottom Right Board

Postlude: Introductions, Tension, and Compression

> ...Through the tensioning in space we will, in time, complete ourselves. That we will tension it...
> ...That we will span between the endpoints of inverting strength...
>
> ["Schaukel des Herzens," Rilke 1997 p.162, this excerpt tr. Foxe.]

This thesis and the negotiated tensions that I have introduced herein point to many larger realms that are beyond the scope of this academic framework. In ending with an introduction, I am borrowing a page from past thesis students such as Paul Schlapobersky [Schlapobersky 2002] in recognizing that a graduate thesis is not simply a completed project but rather the beginning of larger pursuits.

It is an introduction to the work of Wacław Zalewski and his colleagues Edward Allen and John Ochsendorf, who are among those who recognize Zalewski's contributions in terms of both executed projects and processes for design and analysis. It is an introduction to Alden Dow and other architects whose work is often under-recognized due to the scarcity of publications that deal with his work in depth. It is also a compressed introduction to the work and ideas of many other scholars, professors, and designers whom I have met and learned much from; this is inevitably indebted to Anne Whiston Spirn, Dalibor Vesely, Peter Carl, Wendy Pullan, Julian Beinart, and my current thesis committee. It is an introduction not only to the structural possibilities of understanding tension and compression to create bold structures, to the force diagrams so essential to the Zalewski exhibit and the work contained therein, but also to the less physical forces and tensions which have been such a formative part of my thought processes the past few years. These ideas and projects have therefore been an attempt to stretch in space, in drawings, and in words between the constellation of works and contradictions which have led me to this point of concluding the thesis content even as I acknowledge the open-endedness of the issues I have engaged. Even though I have only imagined roads and structures and built models rather than engineered a whole city, I am often reminded of Marshall Berman's note from Dostoevsky's Underground Man that "man is pre-eminently a creative animal, pre-destined to strive consciously toward a goal, and to engage in engineering, that is, eternally and incessantly, to build new roads, no matter where they might lead." [Berman 1982 p.241]

View of final presentation with boards, final model (center right) and process models (lower right)

The Last Introduction

On Friday 19 May 2006 I had the opportunity to introduce this work to my committee, a group of final reviewers including Nasser Rabbat, Sarah Whiting, and Kyu Sung Woo, and other guests and colleagues.

The reviewers were complementary of the bold narrative of graphical and verbal presentation, and recognized the challenges and strengths involved with presenting such a wide range of media and visualizations from poetic, evocative sketches to explanatory planning drawings executed within recognizable conventions. Whiting noted how important it was to approach this problem from such a comprehensive array of perspectives. Several reviewers including John Fernandez wondered what motivates and results from increased density of urban infrastructure and how the more exuberant moments of “foreground” in the design, such as those modeled around the market, fit alongside the “background” of surrounding sites. This led to a variety of ideas surrounding how the system would start and stop, how extensible it would be and how much of it is necessary to begin. Whiting noted that the prevalence of didactic components within the design, of making typically invisible support conditions visible and emphasizing them with vertical connections, larger plantings and trees, and a certain articulation of structural expression.

Within the few minutes it was evident that the reviewers had become familiar with the forces of compression and tension, the known and unknown conditions at the site, the factual basis for many design components, support conditions, and other choices. That having been said, Whiting emphasized that the system needed to always be conveyed as more than a collection of solutions – "You learn from the factual to make the design proposition." In this regard the precedents bearing the heritage of Daniel Burnham such as Wacker Drive in Chicago was helpful because of how Burnham conveyed strong urban gestures and how individual projects operated within the broader vision. The discussion eventually also included reflections on what the role of the architect would become in this system of objects, with Fernandez noting the importance of how cities are beginning to understand the need for coordinated management of their densely built urban cores and stewardship of their built resources. Several of my student colleagues and guests appreciated how the presentation was legible and compelling even to those who were not from a background in design; it enabled them to imagine a system that seemed quite thoughtfully worked through. Nevertheless, they wondered what would have been created if the imaginary cities of Chapter 6 became more fully envisioned and overlaid upon this proposal for flying beams and elevated trees and the other improbable components made fully imaginable through being shown many of the same images printed in this book.

Polyvalence and Relevance

This is a project which over the past ten months has become polyvalent: it has been perceived and understood as being relevant to practitioners and academics, each from their own perspective. These people with whom I discussed the project would remark, after they began to see more of the design, that they realized something they could latch onto and respond, "Oh, it is all about ___." Given the diversity of their responses, I often wondered whether this meant I was unclear and unfocused, or if I had struck upon a hint of a project that really was able to be understood and perceived as actually relevant to people. I began to realize that while I endeavored to negotiate the concerns of civic bodies, neighborhood concerns, potential users, and my own biases, I had stumbled upon a parallel set of constituents from realms of preservation, real estate, and so forth. Therefore I have attempted to collect some of those perspectives not because they are all holistic nor all my own approach, but ways in which the story of this project could be told:

- It is a **historic preservation project**, which concerns questions of how to build next to and within a National Register district without lapsing into mere incremental contextualism.
- It is an **implementation project** concerned with the tools for urban design and real estate, because it is not simply interested in the architectural forms but with processes for enabling their creation.
- It is a **policy project** reframing of issues surrounding air rights, particularly over highways.

- It is a **streetscaping project** which starts with the definition of urban streets and works toward creating development strategies for lots.
- It is a **gestural landscape project** of running trees, on a broad scale approaching the rural Smithson and Christo projects which are such an iconic part of twentieth century art.
- It is a **mass-customization project** which attempts to reconcile the production of infrastructure with individualized conditions, post-tensioning, and so forth.
- It is an **accessibility project** which envisions ways to use broad landscape and streetscape grading to accommodate grade separations without inserting separate ramps and elevators.
- It is an **ecological critique of typical construction** with bathtub foundations and other systems that displace huge amounts of water and wreak havoc with groundwater. The bundled boxbeam system that touches all the way to bedrock in relatively few places is thus far more delicate in its environmental impact and therefore holds the potential to be far more efficient in its use of technologically manufactured materials that have high amounts of embodied energy.
- It is a highly **particular reinterpretation** of Rafael Vinoly's Boston Convention and Exposition Center and its broad sweeping roof gesture (from the canopy at Summer Street to the low residential buildings in South Boston) transformed into landscape with streets.
- It is a **generic solution** to a ubiquitous post-industrial urban situation of ground conditions and risks, rendered visible in one particular place; it is equivalent to a general equation with one numerical solution substituted as a check.

Given the temptation to look at all of these at once, I am reminded of the wise caveat that "what is interesting is not necessarily relevant, and what is logical is not necessarily true." [Lydia Chilton, Cambridge, 21 December 2005] The facts that I have presented as the reasoning for this thesis don't make the proposal any more inherently likely, and the variety of representations and ideas presented – from music to biology to fiction to foundation engineering to utility easements – will not all be understood as relevant to the different constituencies and professions concerned. This project is not simply the logical conclusion of facts – it is a designed system which embodies choices and value judgments about how creativity should be directed in urban proposals, about how individual fragments can contribute to an overall whole.

What I have therefore shown, from its utility corridors and street supports to land use policies and suspended tree plantings, is not in the realm of

Baker House, MIT, view along Memorial Drive, 2006

architecture as the discipline currently operates. This is intentional; just as the current mode of studio education within a university is only one of many models throughout the history of the discipline, it is essential to recognize how and when a design diverges from conventional disciplinary boundaries. This thesis situates architectural design as not only the design and imagination of the total system but also the manner of its implementation. It does not place a rigid separation between architectural and landscape design, and it purposefully juxtaposes joint details down to individual cables and bolts with the full planning-scale view of the overall cityscape at stake, even though the same professional actors rarely engage or attempt to influence all of these realms.

It envisions architecture not simply as an abstract inhumane system but, in the concluding example of Rafael Moneo's recent lecture, as a "respectful" work like Aalto's Baker House at MIT that humanely composes material and geometry as "**something deserving the name of architecture**" in its most inclusive sense [Moneo 2006]. Having had the privilege of living in and learning from Aalto's design from 1999 to 2003, this is a characterization of architecture to which I hope I am able to aspire.

View of Baker House reflected in puddle on stone terrace, 1999

I began this thesis by asserting that architecture could be situated at the intersection of structural design and urban design, at the interstices of internal resolution of physical forces and the external resolution of a structure's role in a community. At the final presentation, Professor Nasser Rabbat offered a concise response that is a fitting twist to this introductory perspective: Architecture has for most of its history understood itself as a discipline that, instead of existing between structural and urban design, encompassed and contained all of these scales of practice and realms of influence. This is a fundamental insight which situates the significance of structural and urban design at the scale of centuries and millennia during which the objects, utilities, systems, and networks we now recognize as fundamentally urban were gradually created and transformed.

This project therefore has the capacity to allow us to imagine cities and the built devices within them as complex, unique, varied, differentiated systems with the capacity for growth and change – elegant human creations structured together. The ongoing process of structuring and imagining new creations and places can extend beyond the scale of individual buildings, but even in doing so such designs are contained within the broader realm of architecture.

Watercolor sketch of bundles, paths and variations

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Pressley Associates: Lauren G. Meier, Marion Pressley, Swaathi Joseph
Boston Landmarks Commission: Roysin Bennett Younkin
Boston Redevelopment Authority: Jeffrey Lin, Kairos Shen
Paul Lukez Architecture: Paul Lukez, Mike Gibson, Sam Verrill, Tanya Paz
Alden Dow Archives, Midland, MI: Daria Potts
New York City, NY: Nikki Johnson, Anthony M. Tung, B. Jon Aceto
Chicago, IL: Jenny Hereth
Sussex, WI: Gary and Katie Foxe

Biographical Note

David M. Foxe (b. 1981 Milwaukee, Wisconsin) completes the Master of Architecture degree at MIT with the submission of this thesis document.

Foxe designed and co-produced the new exhibit "Wacław Zalewski: Shaping Structures" at the MIT Museum's Wolk Gallery with Edward Allen FAIA and Jeff Anderson M.Arch '07, and he continues to contribute to other upcoming exhibition projects beyond MIT.

During his thesis term he also assisted in the Institute's creation and teaching of a new preservation class in urban studies and architecture led by visiting lecturer Anthony M. Tung.

While completing graduate school at MIT Foxe worked as an intern for Marion Pressley FASLA and Lauren Meier ASLA at Pressley Associates Landscape Architects in Cambridge, Massachusetts on a range of landscape history, design, and preservation projects from August 2004 until January 2006. The primary projects he contributed to at Pressley included historic preservation work for the Belt Parkway (Brooklyn, NY) for NYC DOT and NYC Parks; Revere Beach Parkway (Revere, MA); the University of Pittsburgh (Pittsburgh, PA), and the Green-Wood Cemetery National Historic Landmark Nomination (Brooklyn, NY). He gave a presentation on the history and management of the Belt Parkway for the international 2006 Historic Roads Conference in Boston, MA.

As a Marshall Scholar he studied the history of architecture and landscape with Dr. Wendy Pullan at Clare College at the University of Cambridge in England, earning a research masters degree (M.Phil) in the History and Philosophy of Architecture and co-teaching a summer design studio course at Jesus College, Cambridge.

He holds previous undergraduate degrees in architectural design (BSAD) and music (BS) from MIT. He has both worked for architecture firms and has been writing for articles and other publications on architecture since 2000. His musical compositions have been performed in the US and Europe by orchestras, choirs, chamber groups, and soloists, and he studied composition with John Harbison and Charles Shadle at MIT. His most recent musical work "Voluntary Kaleidoscope," a short orchestral fugue based on fragments of Baroque organ works by Henry Purcell, was composed in January and February 2006 for conductor Dante Anzolini and the MIT Symphony Orchestra, who subsequently performed the work in Spring 2006.

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Colophon

This thesis was typed in Microsoft Word 2003, with editing, layout, graphics, and design in Adobe Indesign / Photoshop / Illustrator CS. The fonts are News Gothic for the body and Century Gothic for the headlines and captions. Drafting is in AutoCAD 2006, Sketchup 5.0, Rhino 3.0 (rendered with Flamingo), and B/H/2H/4H pencil and drafting leads with watercolor. All diagrammatic sketches and force diagrams drawn with three Pilot Precise V5 pens: red for compression, blue for tension, and black for everything else .

Appendix A - Work of Wacław Zalewski

These are reduced images of the exhibit panels shown at the MIT Museum's Wolk Gallery from April 20 - September 15, 2006. They are reprinted here for reference because there does not yet exist a full published account of his life and works beyond this exhibit, which was produced by Edward Allen FAIA with David M. Foxe and Jeff Anderson, under the direction of Gary Van Zante and Laura Knott of the MIT Museum. The images and texts contained herein remain the copyright of their author (i.e. Zalewski) and all other copyrights applicable to the original exhibit remain.

The original panels, generally 30"x40," are shown here as a graphical overview; please contact the MIT Museum and the MIT Department of Architecture for further information if desired.


Wacław
Zalewski:
"...Geometry
is the mathematics
of structural imagination..."

Wacław Zalewski: Shaping Structures

Wacław Zalewski (VAHTS-wahff zah-LEFF-skee) was born in 1917. In 1935 he began his studies of structural engineering in Warsaw. Just before he was to receive his degree in 1939, German armies invaded and occupied Poland, making further academic work impossible. He joined the Polish underground army, as a result of which he was frequently forced into hiding for extended periods. These interludes provided ample time for him to reflect on his studies and read extensively about structural behavior. He soon looked beyond the narrowly mathematical curriculum he had been provided in engineering school to develop a strong interest in how the flow patterns of forces through structures might suggest more efficient structural forms.

In 1944, he took part in the ill-fated Warsaw Uprising against the Nazis. He escaped capture when this effort collapsed, but two members of his immediate family were killed in the punitive German bombing of Warsaw that followed. In 1947, he was able at last to take up work as a designer of structures. As his first projects were built, he developed another aspect of his philosophy of engineering: a strong concern for minimizing the difficulty and cost of construction. The dual goals of shaping structures according to their internal forces and designing efficient processes for their construction have been primary themes in Zalewski's work throughout his academic and professional careers.

In 1947, when academic records had been retrieved and reconstructed from the wreckage of the war, he received a master's degree in civil engineering from Gdansk Polytechnic Institute. After earning a doctorate in 1962 from the Warsaw Polytechnic, he accepted an invitation from the Universidad de los Andes in Merida, Venezuela, where he taught and worked as a structural designer for a period of three years. In 1966, he was invited to join the faculty of the MIT Department of Architecture, where he taught as a tenured professor until his retirement in 1988. He retained his connections in Venezuela for many years, however, and continued to design structures there during academic holidays and sabbaticals. He was awarded an honorary doctorate for his professional achievements by the Departments of Architecture and Civil Engineering of the Warsaw Polytechnic in 1998.

Zalewski's ongoing career as a designer of innovative structures is documented in this exhibition. He has been equally innovative in the classroom, where his teaching is characterized by its nurturing of imagination and creativity and its orientation toward finding good form for structures based on funicular forms and flow patterns of internal forces. He is coauthor with Edward Allen of an introductory textbook, *Shaping Structures* (Wiley, 1998), that is based on this approach.

In describing his design methods, he has stated that "The intellectual delights of...analytical procedures are very different from the sensuous pleasures of giving a structure its shape...Geometry is the mathematics of structural imagination." This exhibit is a celebration of his imaginative and richly diverse work and ideas.

This exhibition was organized for the Wolk Gallery at the MIT School of Architecture and Planning by:

Edward Allen, Visiting Professor of Architecture and Building Technology
Exhibit Direction

David Foxe, M.Arch. Candidate
Design, Imaging, Text, & Coordination

Jeff Anderson, M.Arch. Candidate
Digital Project Reconstruction

With special thanks to:

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School of Architecture and Planning

Yung Ho Chang, Head,
Department of Architecture

Gary Van Zante, Curator of
Architecture and Design, MIT Museum

John Ochsendorf, Assistant Professor,
Architecture Department
Building Technology Group

Nancy Dalrymple, Administrator
Architecture Department
Building Technology Group

Rotch Library of Architecture
and Planning

and many students for their
insights, comments, and memories

1950s	1960s	1970s	1980s	1990s	2000s	**Years**
Poland	Venezuela	United States	South Korea			**Location**
Masonry	Unreinforced Concrete	Reinforced Concrete	Steel			**Primary Material**
Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication				**Prefabrication**
Structural principle specific to each project						**Structural Principle**

← This chart will provide an index to highlight the diversity of the various projects and buildings shown in the exhibit.

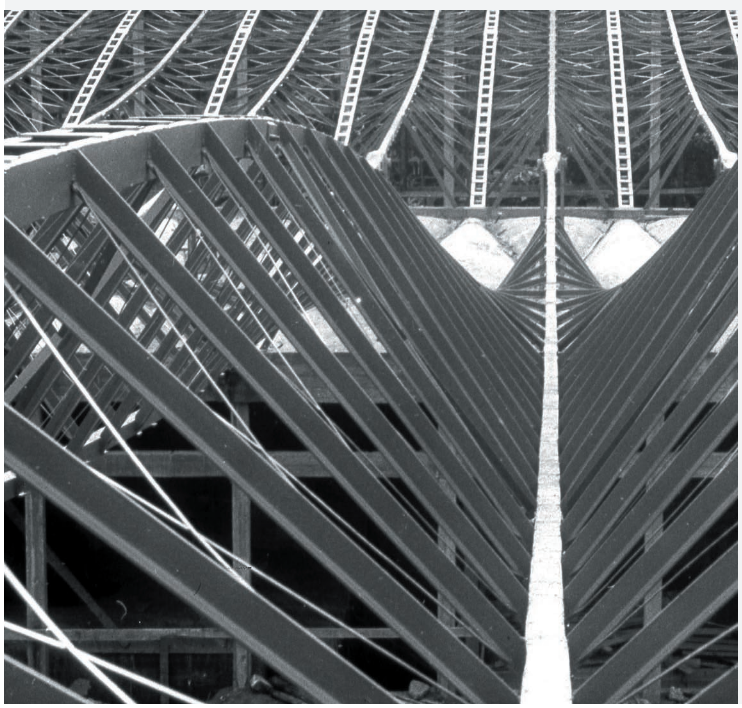
Inventive optimization in Wacław Zalewski's structures

introductory notes by David Foxe

Physical, visible form is both one of the strongest and the most deceptive aspects of Wacław Zalewski's incredibly varied body of work. For the past six decades of his professional practice as a civil engineer and a professor of structures, he has explored the shaping of structural form to solve specific problems of structural stability, conservation of material, and optimizing efficiency of construction processes. The work shown here gives an initial glance at some of the ways in which he has met these structural challenges. In pursuing such optimization and finding rational ways to bring these solutions to physical form, his work exhibits highly engaging uses of pattern, proportion, and light.

In his built projects and in his writings, Zalewski demonstrates a conscious acknowledgment of visual form and its influential nature, its power to captivate by providing a readily recognizable and memorable visual effect corresponding to abstract structural principles. Yet his work goes further in offering a perspective on how creating rational structure is not primarily a task of calculation or a mere result of unchanging rules, but rather a truly creative process that champions personal invention. He has often chosen to use ordinary projects and spans as vehicles for exploring mathematical and structural principles; he uses each project's particular requirements to investigate the underlying principle of optimization in shaping structures. Supermarkets can be places to experiment with funicular roof forms that eliminate the need for cable backstays, and industrial storage warehouses and factories can pioneer highly articulate and flexible prefabrication systems.

Zalewski's early works in Poland became widely known through his international publications and lectures from Paris to Berkeley, and were the foundation for his extensive projects in Venezuela, South Korea, Spain, and elsewhere. His method of structuring, a lifelong pursuit of demonstrating structural truth, is also particularly process-oriented. He has considered in great detail the sequencing and efficiencies of *building* – as an act, a verb – in each of these locations worldwide. This is highlighted in this exhibit by the preponderance of construction photographs and documentation which exist for these projects, and the relative scarcity of images of completed buildings.



His work is also the foundation for his inspirational teaching. In nearly four decades of teaching at MIT, Professor Zalewski's students and collaborators have benefited from both the basic and the advanced concepts in his work. His work with MIT students in the 1980s and early 1990s with deployable structures led him to be chosen to work as one of the designers of the Venezuelan pavilion at the 1992 Seville International Exposition, and his deployable truss for the pavilion hall and theatre was subsequently folded and taken back to South America so it could be redeployed for another use.

Zalewski's teaching and textbook collaborations with Edward Allen capture major portions of his ideas about how students should learn; he remains highly critical of both engineering and architectural education that all too often result in "passive attitudes toward research of rational forms...which constitute the essential task of studies and of construction projects." He has witnessed how problems relating to forces and construction processes can be the "Achilles' heel of architects" and has directed his teaching toward improving the ways in which students understand the inventive potential in shaping structures. At age 88, his wit and energy continue to inspire students with the fundamentals of geometric solutions to finding form. With the wisdom of a lifetime, his energetic pencil sketches, elegant mathematical simplifications, and demonstrations with objects as humble as umbrellas make for memorable teaching.

The architectural community has widened over time, and innovators who span architecture and engineering have gained increasing recognition for their structural art: Robert Maillart, Rafael Guastavino, Felix Candela, Eladio Dieste, and Santiago Calatrava are among these designers. Zalewski's work across the globe, in its many responses to local material and site constraints, shows his personal focus on inventive forms with diverse systems. Unlike the aforementioned designers, most of whom are known for their particular formal emphasis or their lifelong investigation of particular systems (unreinforced masonry in compression, in the case of Guastavino for example), Zalewski is far less easily categorized. His work can be understood on spectra rather than in pure categories, occupying one continuum spanning architecture and engineering, and another spanning theoretical mathematics and highly practical innovation. The buildings shown here, containing functions that range from the mundane to the celebratory, enclose spaces with structures that are truly architectural in that they show how a master's highly inventive work can elevate constructed tectonics. Zalewski has applied his optimization skills to shape structural solutions that are both rational and inspirational. In explaining the potential uses of the structural strategy employed at the Spodek hall in Katowice, the first project to the right, he describes this spirit of inventiveness:

> "The possibility for large...forms to be handled free from [ordinary] standing columns, vertical walls, and flat roofs, combined with the simultaneous task of finding a solution for functional and constructive problems, gives an occasion for creative invention. Such inventive possibilities, with both practical architectural tectonics and the artistic thought of antiquity, become the spiritual achievement of modern architects and engineers."

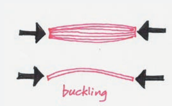
← This view of the "Supersam" supermarket, under construction in Warsaw, Poland, shows the funicular roof system of tensile cables and compressive arches, with connecting members at various angles.

Structural Actions

Any structural action, no matter how complex, can be reduced to just two types of forces, pushes and pulls.

A push is generally referred to as **compression**, and a pull as **tension**.

Compression can cause a slender member to buckle, so we will represent it with the color red to warn us of that potential problem.

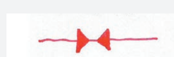


Members in **tension** cannot buckle; they only grow straighter as the pulling intensifies. We will represent tension with the color blue.

For each project in this exhibition, there is a simple diagram in the upper left hand corner that shows in red and blue how the structure utilizes pushes and pulls to support its load. In these diagrams:

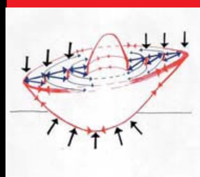
Black arrows indicate **external forces**.

Red lines indicate pushes (**compression**).



Blue lines indicate pulls (**tension**).

Spodek

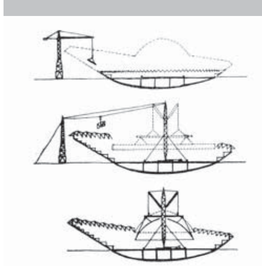


This multi-use hall in Katowice, Poland became nicknamed "Spodek," literally "saucer" in Polish, meaning "flying saucer" in popular usage. Its form developed in response to several factors: The bowl-like configuration of the seating area, which acts as an inverted dome, reduces the contact area between the structure and the ground. This would allow the entire building to settle as a single unit if the soil, which is honeycombed by old coal mining tunnels, should subside. The bowl exerts an outward push that is balanced by the inward pull of the roof cables at the perimeter. This balancing of pushes and pulls is a hallmark of many of Zalewski's structures.

The roof is the earliest known proposal for a cable structure based on the tensegrity principle, in which compression members are connected only to cables, and not to each other. A number of wire models of this structure were made to assess feasibility. After Zalewski's departure from Poland and prior to construction, the roof structure was changed to relatively conventional trusses.

The asymmetrical interior of the arena was designed to accommodate dozens of different interior configurations of both seating and event space to accommodate the wide variety of programmed uses. Since its opening the dramatically lit Spodek has hosted countless shows, sports events, and exhibitions, as well as concerts of popular music by international celebrities, including many American rock music groups. Collaborators on this project included architects Maciej Krasinski and Maciej Gintowt, as well as engineers Andrzej Zórawski, Aleksander Wlodarz, and Stanislaw Kuś.

↑ The half-constructed roof is viewed here from the interior of the building, looking up toward the center ring.



↑ This diagram of the proposed construction sequence was made prior to simplification of the roof structure.

↑ A scale model in wire was used for early load testing of the concept.

↓ Construction hoisting was done by a crane riding on a perimeter track.

↓ These short columns are among those that balance the concrete bowl.

Years: 1950s | 1960s | 1970s | 1980s | 1990s | 2000s

Location: Poland | Venezuela | United States | South Korea

Primary Material: Masonry | Unreinforced Concrete | Reinforced Concrete | Steel

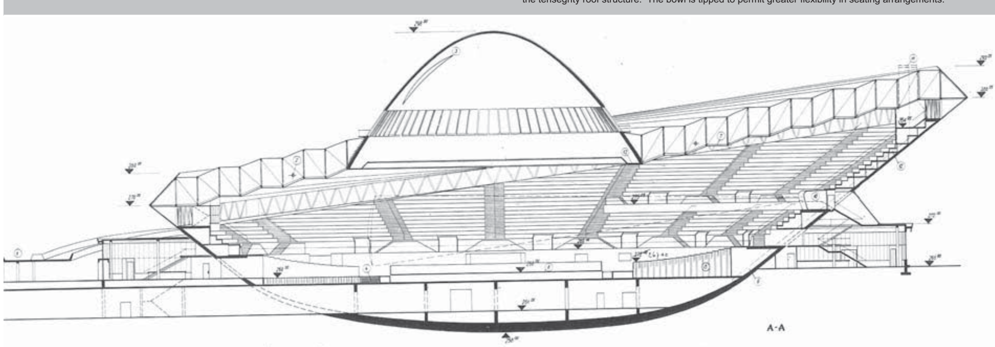
Prefabrication: Minimal Prefabrication | On-Site Prefabrication | Factory Prefabrication

Structural Principle: Discontinuous compression/tension cable roof on inverted dome

↓ This nighttime view was photographed shortly after the building's completion.

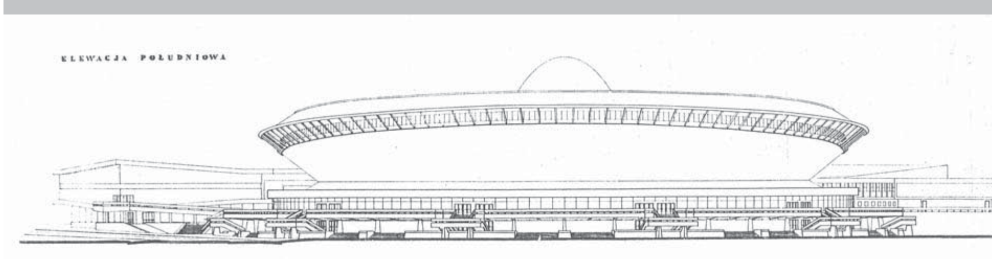
↑ A view of the underside of the bowl (computational rendering).

↓ This section drawing shows both the bowl of the seating structure and the original, more complex version of the tensegrity roof structure. The bowl is tipped to permit greater flexibility in seating arrangements.

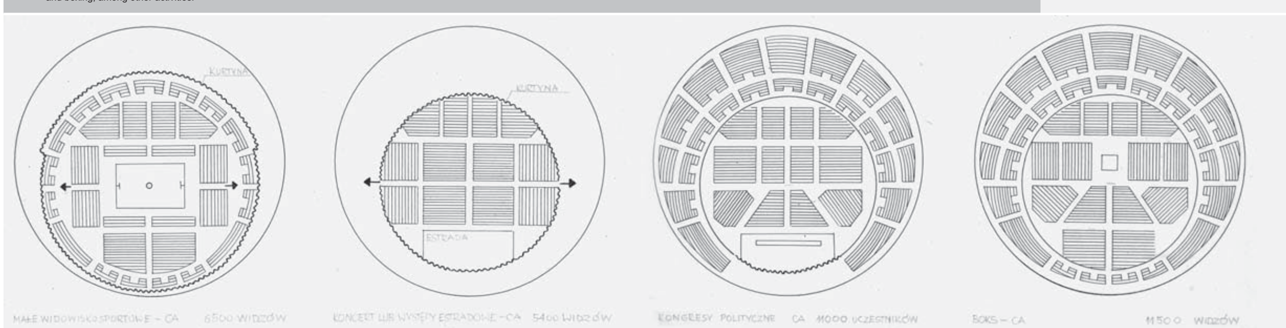


↑ This computational rendering shows Spodek before later additions were appended.

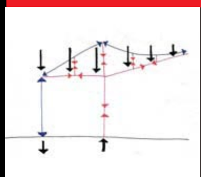
↓ An elevation drawing shows the taller end of the arena (as seen from the left in the above rendering).



↓ The tipped bowl configuration permits many different seating layouts for basketball, stage shows, and boxing, among other activities.

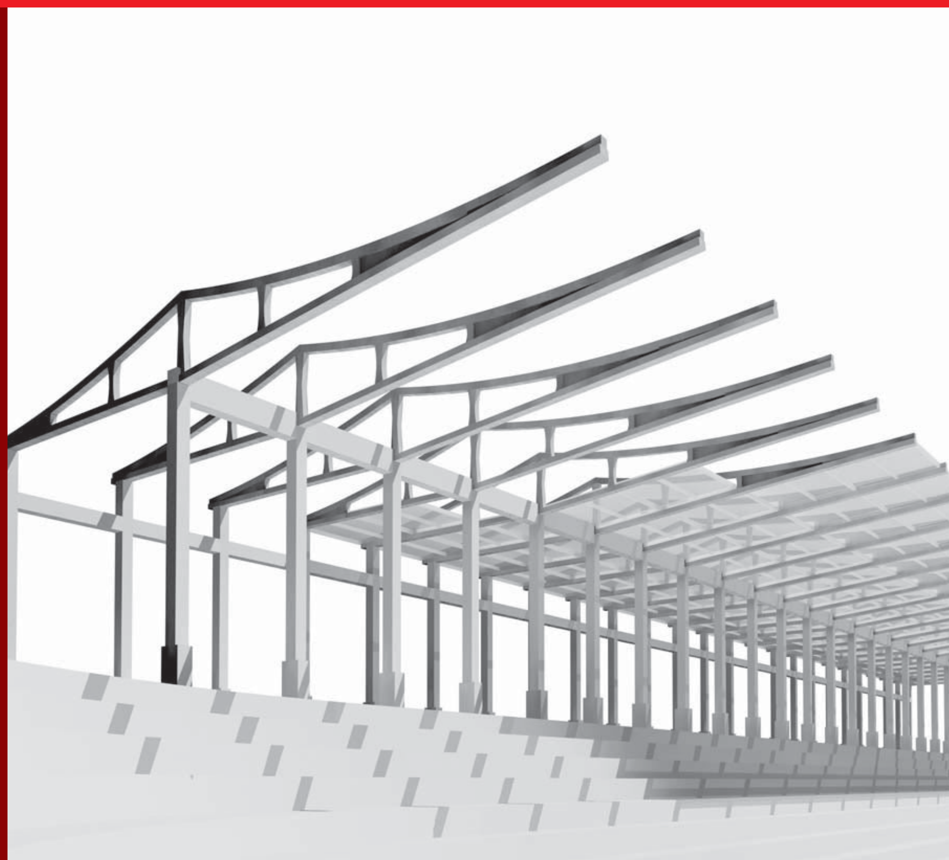


Torwar



Zalewski invented of a system of structurally efficient roof beams whose profiles are based on the funicular shape, that taken by a chain under the same conditions of supports and load. Beams of funicular shape do not need interior diagonals or a web. The beams he designed in collaboration with Stanislaw Kus were intended to be cast on site, using rising formwork, in stacks of six. The stacks were left to cure for several weeks before the beams were lifted and installed.

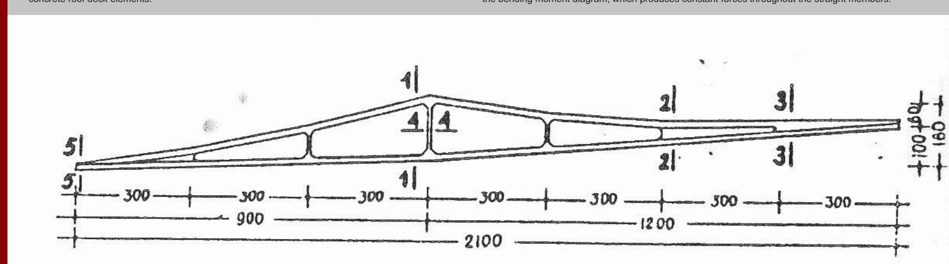
Torwar, the structure shown here, is a grandstand roof for a stadium for ice hockey and other uses built in Warsaw in 1960. It features an expressive cantilever of 12 meters (almost 40 feet). Tensile reinforcing cables along the tops of these long funicular beams were post-tensioned after being lifted into place. This type of beam? is one example from a family of analogously-shaped beams that were widely used in industrial construction in Poland. Although this may appear to the casual observer to be a Vierendeel truss design, it is fundamentally different. A Vierendeel truss is arbitrarily shaped and is made stable by bending action in its nodes. In contrast, this truss is funicularly shaped, which therefore results in an absence of bending.



↑ This computer rendering shows how the beams for a stadium roof are covered with precast concrete roof deck elements.

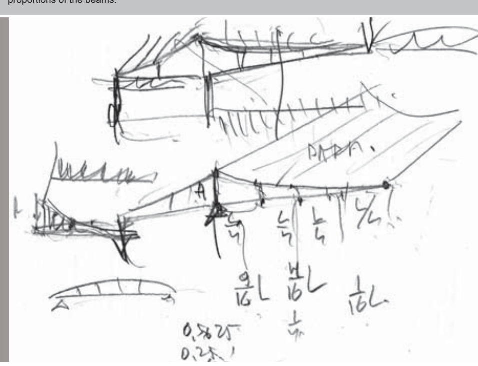
↓ An elevation of a typical beam is dimensioned in centimeters. The shape of the element follows the shape of the bending moment diagram, which produces constant forces throughout the straight members.

↑ The roof trusses for Torwar soar above the area where the seating was constructed.



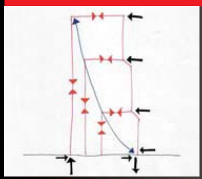
↓ Zalewski's sketches show the concepts and proportions of the beams.

→ Post-tensioning cables in the top chords carry tensile forces.



Years	1950s	**1960s**	1970s	1980s	1990s	2000s
Location	**Poland**	Venezuela	United States	South Korea		
Primary Material	Masonry	Unreinforced Concrete	**Reinforced Concrete**	Steel		
Prefabrication	Minimal Prefabrication	**On-Site Prefabrication**	Factory Prefabrication			
Structural Principle	**Truss with no interior diagonals**					

Funicular Skycraper

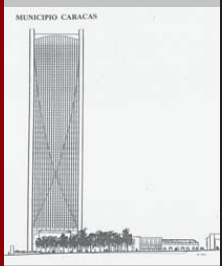


In these explorations, elements arranged along funicular lines act as both cables and arches to resist the lateral forces of wind and earthquake that predominate in tall buildings. In the same way that cable and arch bridges can span farther than truss bridges, funicular bracing is more appropriate for taller buildings than the wind-resisting trusses commonly used. The curves resemble those of the Eiffel Tower, which was designed on a similar principle. However, the full profile of the Eiffel shape would require a very broad building. The arrangement shown to the right uses just one side of the Eiffel shape on each facade. The arrangement below shifts the two sides of the Eiffel structure inward so that they overlap. Both arrangements permit a more slender tower.

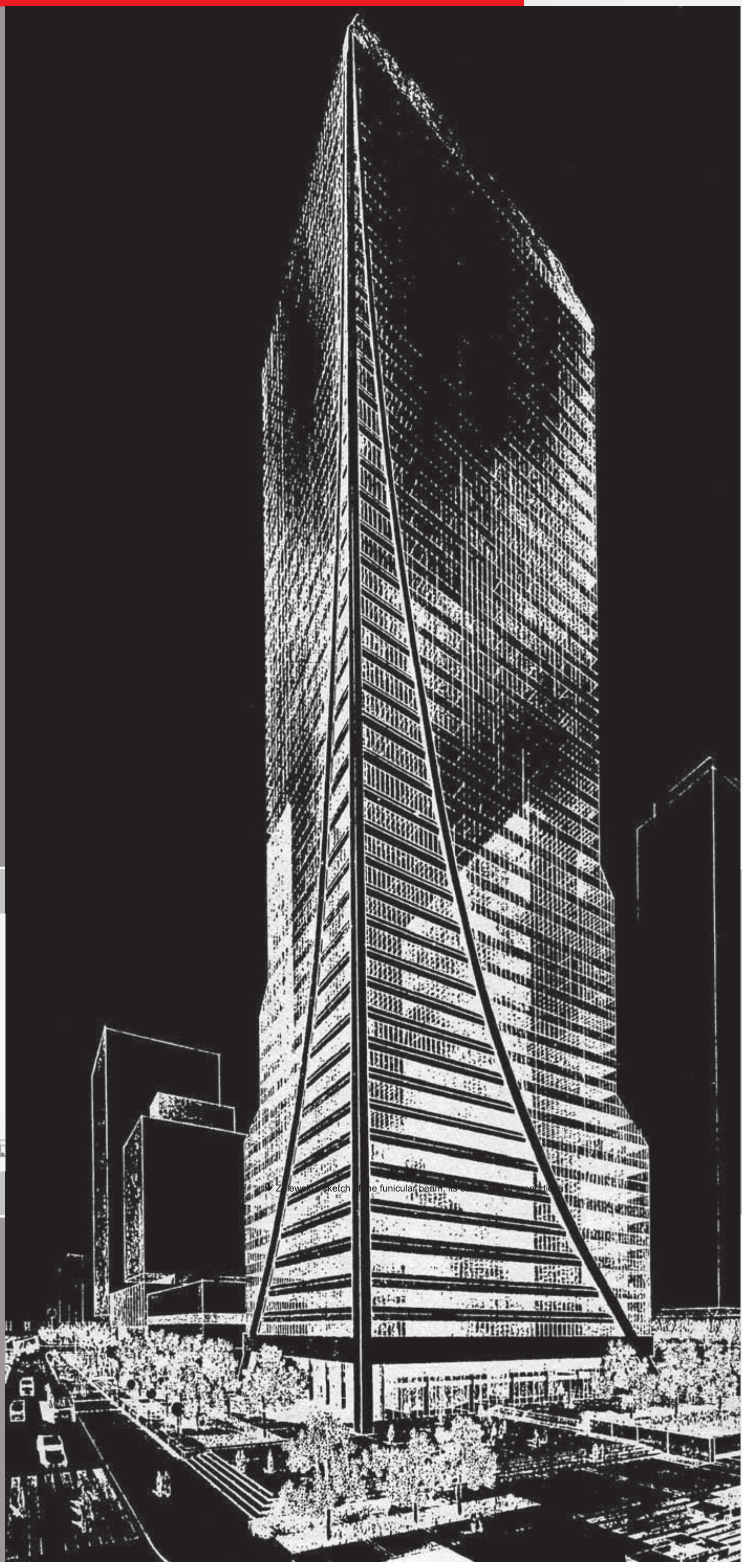
Both examples are applied to buildings with very standard glass curtain walls. Either could become the basis for truly original skyscraper architecture. The symmetrical bracing scheme below was developed in collaboration with architect Manuel Sayago in Caracas, and the asymmetrical scheme to the right, with architect Jerzy Jakubowicz in Boston. The buildings' facades are enlivened by the gesture of the curved elements; the bracing emphasizes the relationship between the top of the tower and the foundation at ground level along the street.

↑ This structure would use even less material if the funicular braces ran to the ground.

→ This rendering shows a single funicular brace on each building face.



↑ Paired funicular braces create a graceful symmetry of curves.



↓ Zalewski's sketch of the funicular beam, its [illegible] and proportions

Years	1950s	1960s	1970s	1980s	1990s	2000s

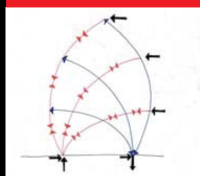
Location	Poland	Venezuela	United States	South Korea

Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	Steel

Prefabrication	Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication

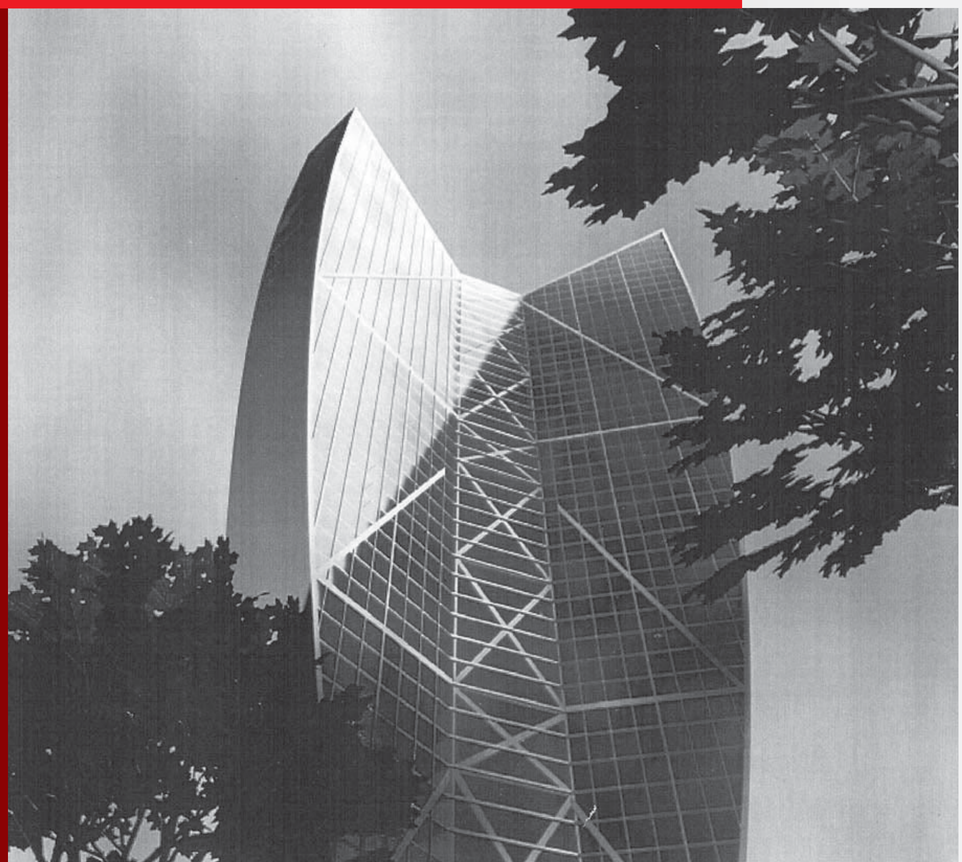
Structural Principle	Funicular arches and cables

Michell Structures

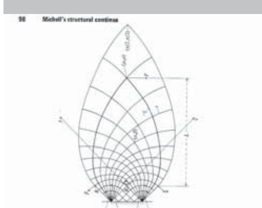


These unbuilt studies are directed toward finding optimal forms for structural bracing in tall buildings. As structures increase in height beyond 200 feet (60 m), accommodation of wind forces requires more structural material than is required by gravity forces, and the design of more efficient lateral bracing systems becomes increasingly important. In these theoretical investigations, Zalewski drew upon research completed a century ago by the Australian mathematician Michell. Michell developed shapes that require the absolute minimum of material for a given applied force. The flame-like shape of an ideal cantilever truss, shown below, would use less material than any other shape for a wind truss in a tall building, and would have the advantage of placing a building with very large total floor area on a compact base, thus minimizing foundation costs as well. But without architectural interventions, the floors would become very large in extent, too large to be daylit and with too much windowless space, especially for apartment buildings.

Working with the architect W. Zablocki, several ways of resolving this problem were developed. The solution shown here is a Y-shaped plan that opens up the deep interior of the building to natural light and air. The Michell "flame" configuration is applied to the geometry of the lateral bracing elements, which are expressed in the facade geometry. Zalewski's hand-drawn comparison at the lower right shows that the last two alternative bracing schemes for tall buildings, both Michell-based, use substantially less material than conventional systems.



↑ This architectural rendering of a building of approximately 50 stories uses a simplified pattern of Michell bracing. The overall building form is a Y-shape with three wings on a central core; Zalewski notes this could also be further braced with enclosed elevated walkways between wings.



98 Michell's structural continua

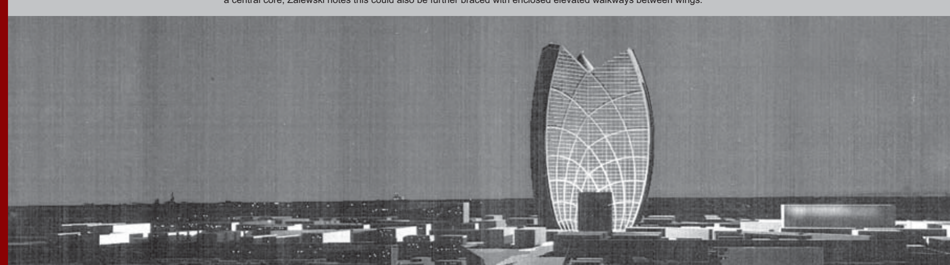
The boundary conditions for A and B are

$$A = R \text{ on } \beta = 0, \quad B = R \text{ on } \alpha = 0, \qquad (4.118)$$

and with these (4.50) integrates, just as (4.90) did, to give

$$A(\alpha,\beta) = B(\beta,\alpha) = R\{I_0\{2\sqrt{(\alpha\beta)}\} + \sqrt{(\beta/\alpha)}\,I_1\{2\sqrt{(\alpha\beta)}\}\}. \qquad (4.119)$$

↑ Mathematical field of low-weight solutions to end-loaded cantilevers (W.S.Hemp, "Optimum Structures")

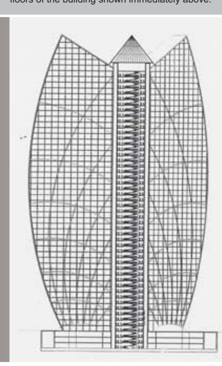


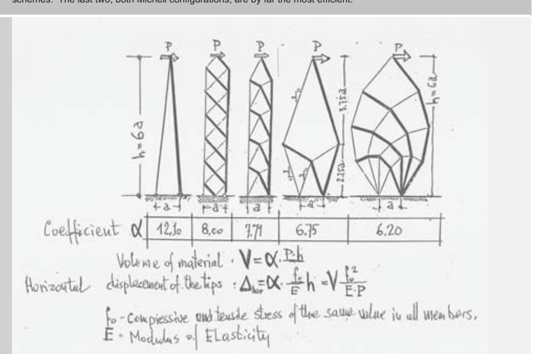
↑ This version uses a more literal pattern of Michell bracing

↓ This section drawing illustrates the core and floors of the building shown immediately above.

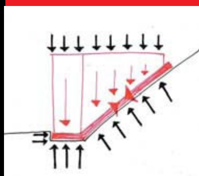
↓ In this handmade sketch, Zalewski compares the relative amounts of material in five different bracing schemes. The last two, both Michell configurations, are by far the most efficient.

Years	1950s	1960s	1970s	1980s	1990s	2000s
Location	Poland	Venezuela	United States	South Korea		
Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	Steel		
Prefabrication	Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication			
Structural Principle	Trusses of optimal shape					

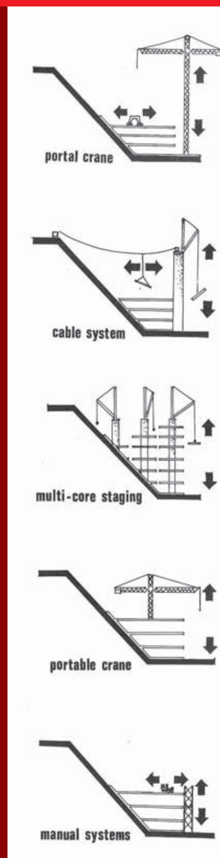


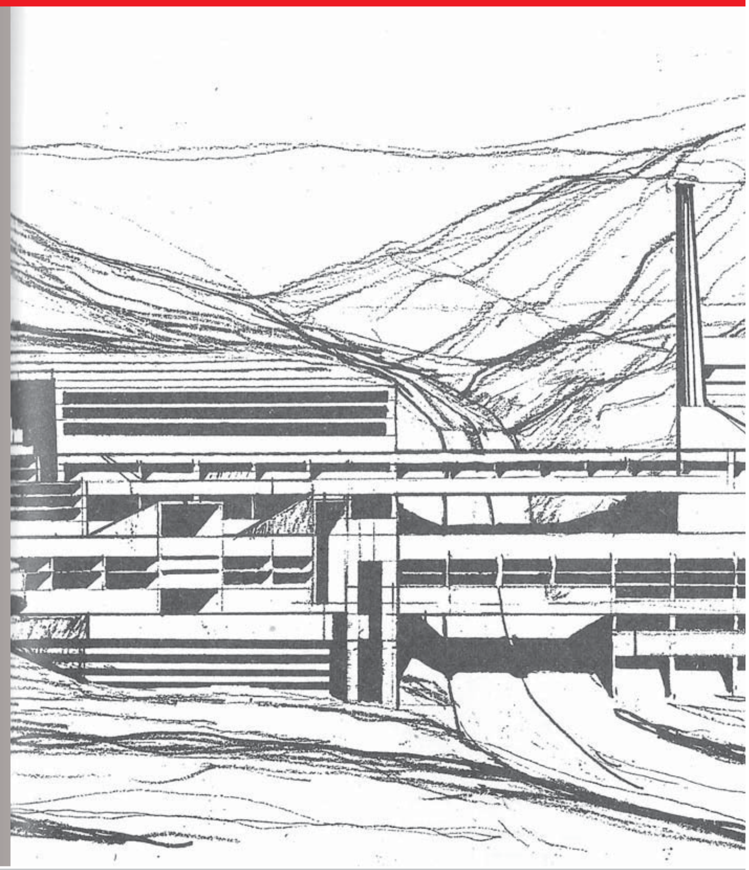


Buildings on Slopes

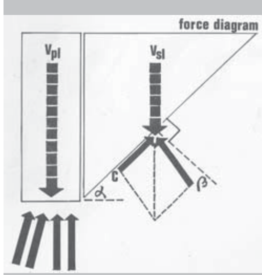


This unbuilt research exploration was conducted at MIT during the spring of 1969 and published soon after by the MIT Press. Zalewski was aided in this project by research assistants W. Robert Kirby and Reinhard K. Goethert, and the drawings were produced by student collaborators. Based on the premise that the growth of many dense urban areas is restricted by precipitous valley walls, the drawings demonstrate simple strategies to build on steep areas with challenging soil conditions. Applications were proposed for places such as Los Angeles, Rio de Janeiro, Caracas, Hong Kong, and Honolulu. The most developed example, the one shown here, explored the possibilities in Pittsburgh, Pennsylvania. The overall strategy is to concentrate the major foundation elements (driven piles, caissons, or a foundation mat, depending on soil conditions) in a small, flat area at the foot of the slope. From this is constructed a strong slab, a concrete carpet that reaches up the slope as far as the highest portion of the site. This slab, which works primarily in axial compression, carries inclined components of loads to the foundation at the foot of the slope. The forces in the slab compress and thus stabilize the soil beneath it. This strategy avoids having to construct independent foundations of questionable stability under the difficult working conditions and uncertain soils presented by steep terrain. The design is for an underlying, innovative construction process rather than a single final form. The amalgamation of structures such as these at the urban periphery holds potential for expanding many of the world's densely populated cities at reasonable cost.

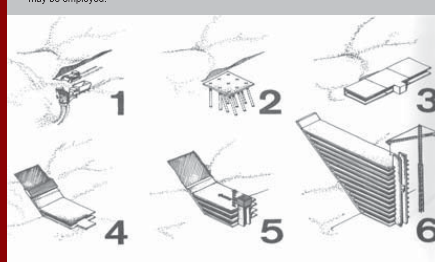




↑ Any of several construction methodologies may be employed.



↑ Loads on the inclined slab are supported by compression of the slab and the earth beneath.

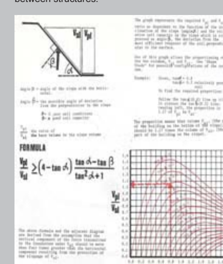


↑ (1) The base is prepared and (2) piles are driven to support (3) the first level; (4) The compression slab is slip-formed up the slope; the (5) utility core and (6) floor plates proceed.

↓ The same underlying principles may be applied to other shapes.

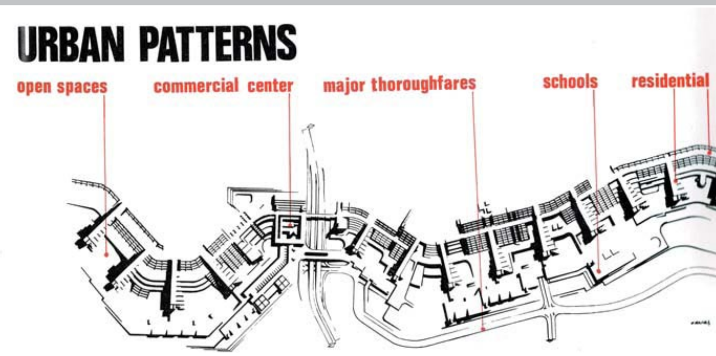
↓ A prototypical plan for a large-scale development on formerly unbuildable slopes.

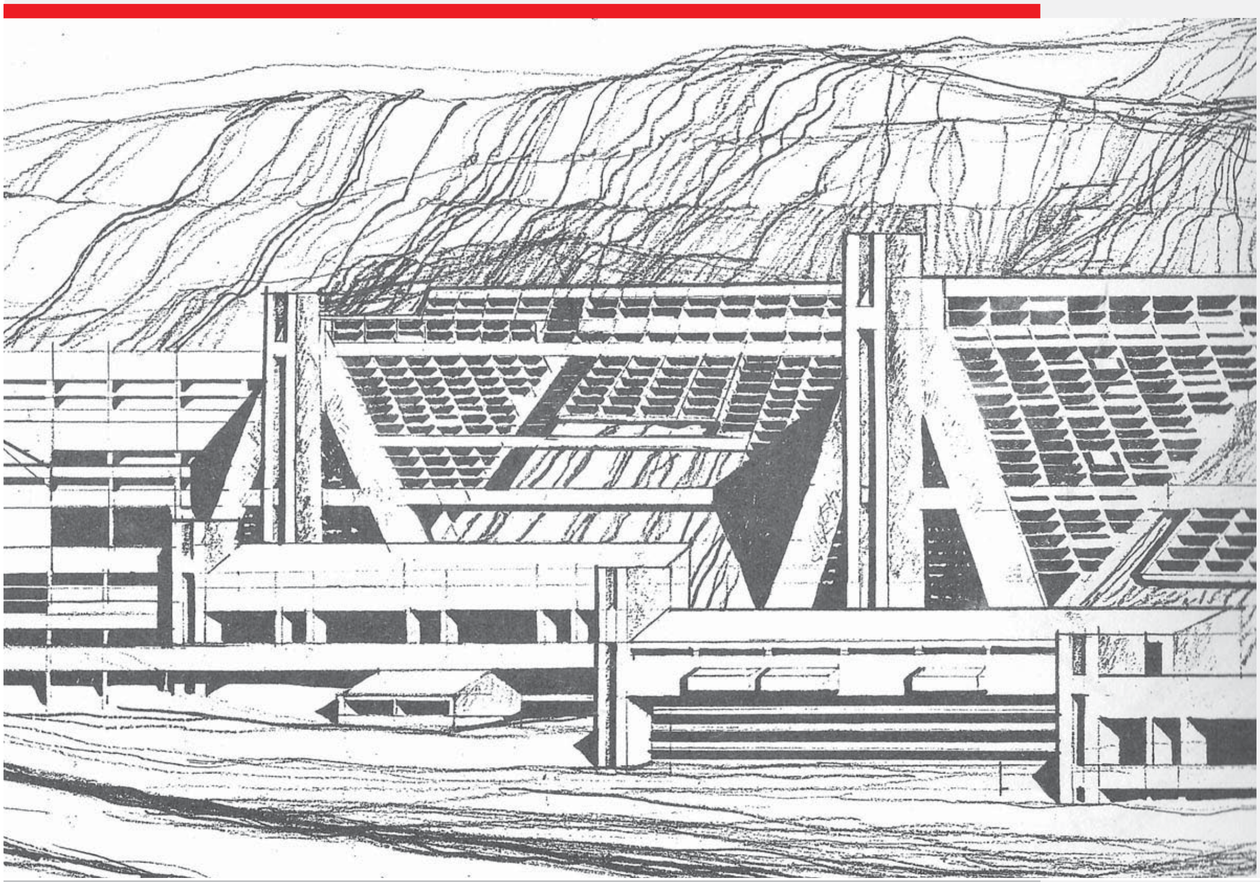
↑ Roads and pedestrian ways ascend the slope between structures.

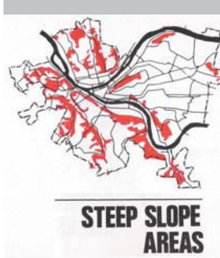


↑ Structural strategies vary, depending on local soil conditions.

Years	1950s	1960s	1970s	1980s	1990s	2000s
Location	Poland	Venezuela	United States	South Korea		
Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	Steel		
Prefabrication	Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication			
Structural Principle	Inclined compression strut					

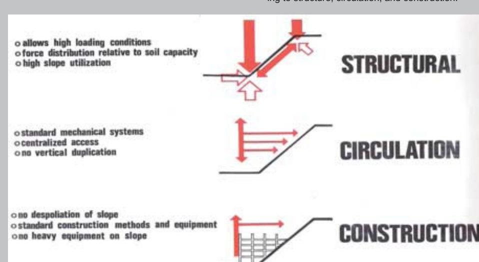






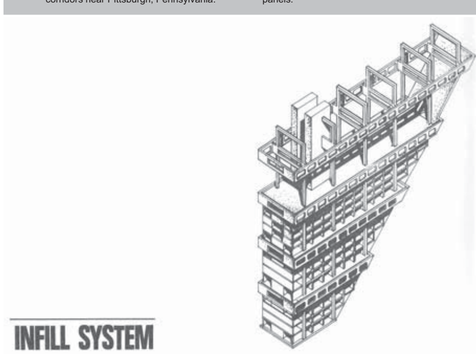
↑ Red areas show steep slopes in river corridors near Pittsburgh, Pennsylvania.

↓ The proposed system has advantages pertaining to structure, circulation, and construction.

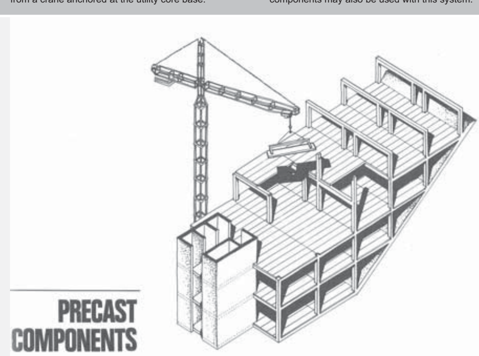


↑ This sketch perspective shows how box-type components may also be used with this system.

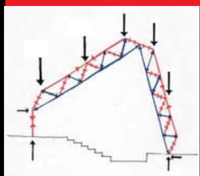
↓ The frame may be infilled with precast concrete panels.



↓ Structural components are hoisted into place from a crane anchored at the utility core base.

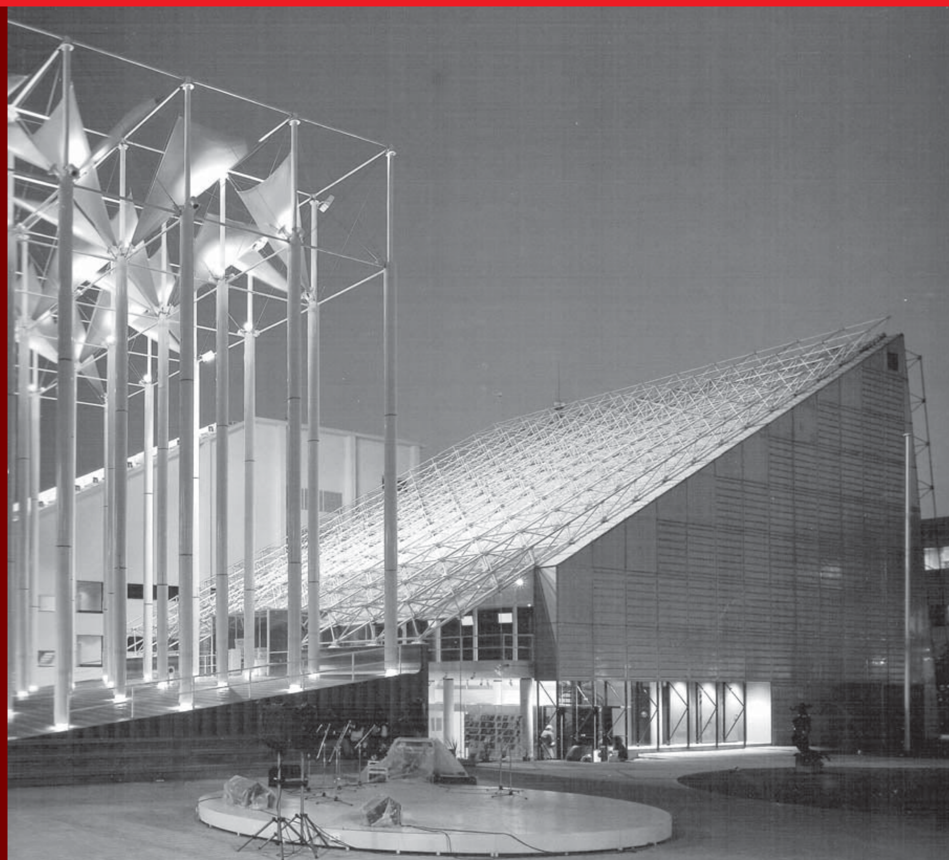


Seville Pavilion

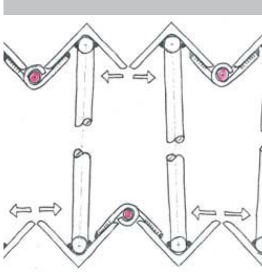


There existed a compelling reason to design a deployable structure for the Venezuelan National Pavilion at the 1992 International Exposition in Seville, Spain: The exhibition was deliberately temporary. If the structure were deployable (able to fold and unfold), it could be made in Venezuela, where costs were lower, transported in its folded form, and unfolded quickly in Seville. At the conclusion of the exposition, it could be taken down promptly, refolded, transported, and unfolded again on other sites.

Zalewski was selected to design the frame of this structure because of his work on deployable structures at MIT and his ongoing participation in the design community of Venezuela. Collaborators on this project included architects Henrique and Carlos Hernandez, the latter of whom also collaborated as structural engineer, with supporting work by IDEC (Instituto de Desarrollo Experimental de la Construccion). There were many collaborators who designed special artistic elements.

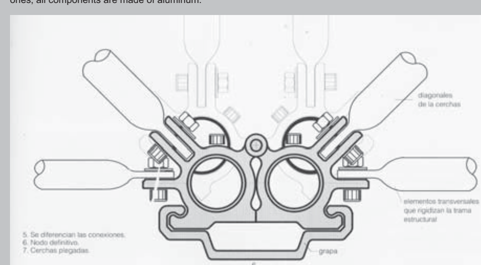


↑ A view of the completed pavilion shows the deployed roof trusses.



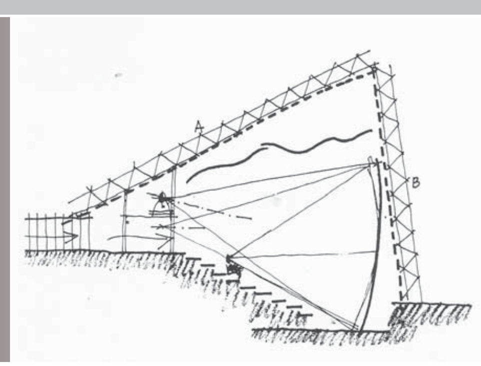
↑ An early concept sketch shows the mechanical principle of the roof.

↓ In this connection detail, the folded position is shown with light lines, and the unfolded position with heavy ones; all components are made of aluminum.



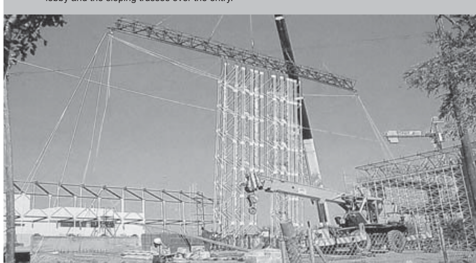
↑ The trusses were lifted in their folded position.

↓ A section sketch shows how the trusses relate to the auditorium space inside.



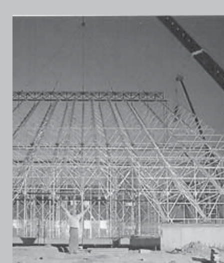
Years	1950s	1960s	1970s	1980s	**1990s**	2000s
Location	Poland	**Venezuela**	United States	South Korea		
Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	**Aluminum**		
Prefabrication	Minimal Prefabrication	On-Site Prefabrication	**Factory Prefabrication**			
Structural Principle	**Deployable truss**					

↑ This interior view shows the auditorium lobby and the sloping trusses over the entry.



↑ The roof is unfolded with the aid of an auxiliary beam.

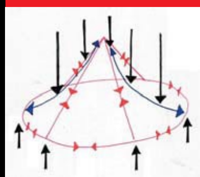
↑ The unfolded truss is tilted into place.



↑ The fully deployed roof is anchored to the foundations.

↓ The trusses lie side by side when the roof is in its folded position.

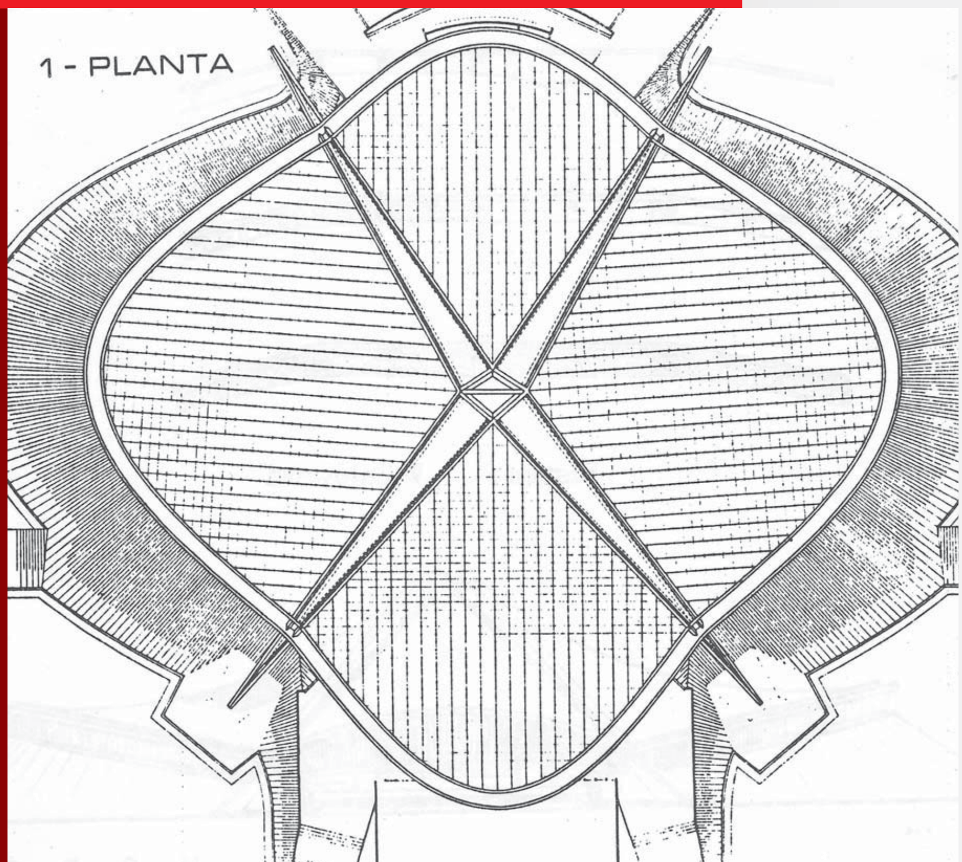
Venezuelan Arena



After moving from Poland to Venezuela in 1962, Zalewski worked for the Venezuelan Department of Public Works. In this capacity he designed a number of civic structures, including several dramatic enclosures for athletic facilities. These sport arenas enclose column-free spaces over 80 meters (260 feet) wide.

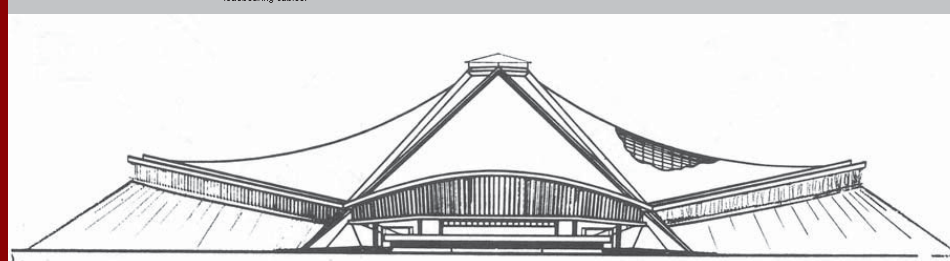
The example shown here, at Barcelona, Venezuela, designed in collaboration with Adolfo Peña, is spanned by steel cables that stretch from a quadripod – four large reinforced concrete compression struts – to curved perimeter edges, also of reinforced concrete. The parallel loadbearing cables are stiffened by secondary cables of opposite curvature that wrap over them and exert a downward pull.

The arena is naturally ventilated by convection currents that enter at low perimeter openings and exit at a large roof cap vent at the apex of the quadripod. The roof deck was created by first attaching simple sheet metal pans to the secondary cables, then placing insulating foam panels in the pans before installing steel reinforcing fabric and pouring concrete over the entire roof.



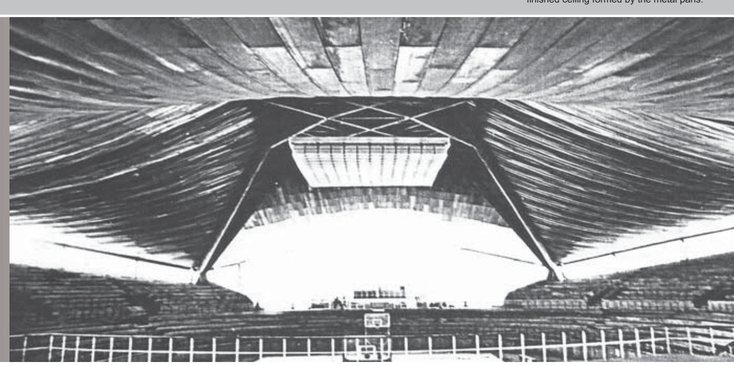
↑ The roof plan shows the "X" of four compression struts, the curved perimeter edges, and the parallel loadbearing cables.

↑ Successive roof deck sections show the installation sequence of metal pans, foam insulation, and concrete fill.



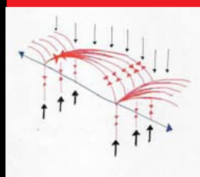
↑ An elevation drawing shows the curvature of the main cables and the secondary cables that wrap over them.

↓ The completed hall, over 80m wide, has a finished ceiling formed by the metal pans.



1950s	**1960s**	1970s	1980s	1990s	2000s	Years
Poland	**Venezuela**	United States	South Korea			Location
Masonry	**Unreinforced Concrete**	**Reinforced Concrete**	**Steel**			Primary Material
Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication				Prefabrication
Cables suspended from concrete struts						Structural Principle

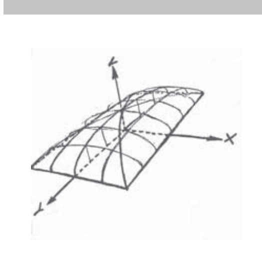
Shell Roofs for Factories



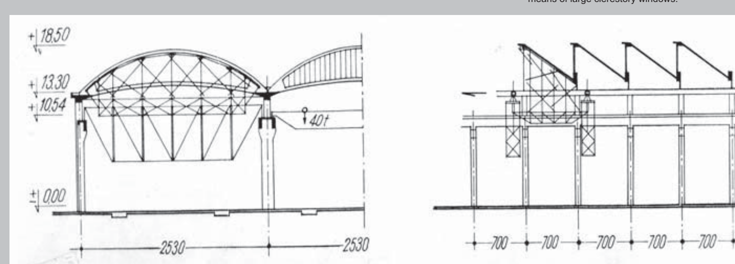
This diverse series of buildings, of which only a sampling is presented here, explored the repetitive use of thin concrete shells as roofs for industrial buildings. Once the overhead crane rails were constructed on the beams spanning between the columns, they became tracks that allowed a single, wheeled module of formwork to be used to form one shell. This was then lowered, moved down the rails, raised, and used anew for the next shell.

The shells' funicular forms allowed them to act largely in compression, which minimized the volume of concrete used for the vaults and gave an overall feeling of lightness to the roof. Large clerestory windows are featured in all the variant designs. They admit generous quantities of north light to provide even, diffuse illumination within.

↑ All the shells feature generous daylighting by means of large clerestory windows.



↑ A diagram of a double-curved surface, a portion of which was used as a roof shell.



↑ The extreme depth of the trusses used to support the formwork kept member forces very low and allowed the use of small, economical sections for the members.

↓ An exterior urban view of the shells whose interior is shown above.

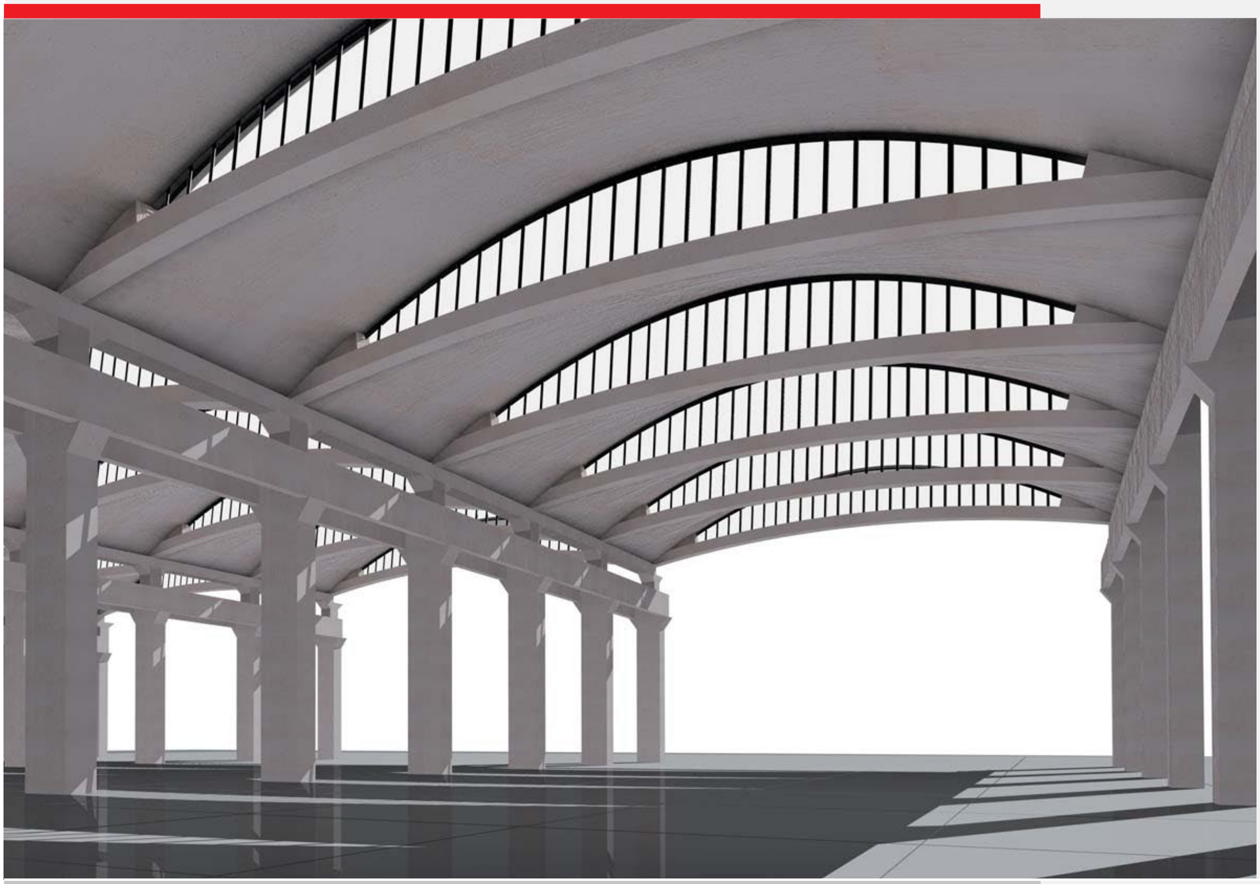
Years: 1950s | 1960s | 1970s | 1980s | 1990s | 2000s

Location: Poland | Venezuela | United States | South Korea

Primary Material: Masonry | Unreinforced Concrete | Reinforced Concrete | Steel

Prefabrication: Minimal Prefabrication | On-Site Prefabrication | Factory Prefabrication

Structural Principle: Funicularly shaped thin shells



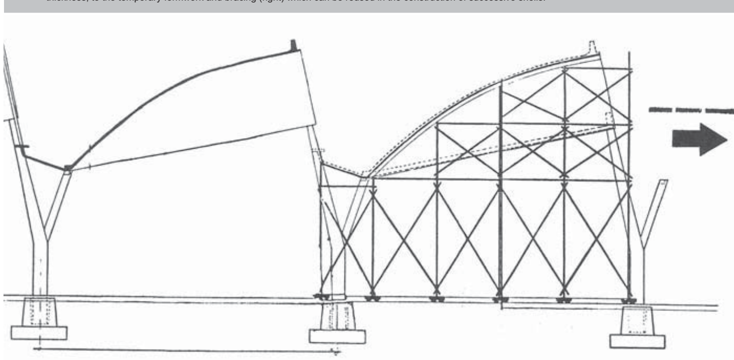
↓ The north-facing crescents of glass make up a compelling rhythm.

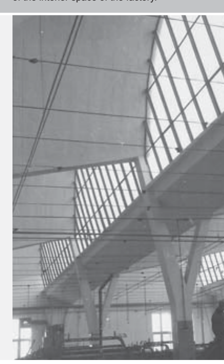
↑ This computational rendering shows the effect of the repeated clerestory windows.

↓ The clerestory windows are framed with thin steel mullions.

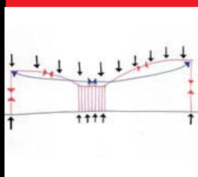
↓ This sectional diagram, for the variant with Y-shaped columns, shows the relationship of the final poured concrete shells (left) shown with their actual poured thickness, to the temporary formwork and bracing (right) which can be reused in the construction of successive shells.

↓ The Y-shaped columns are a prominent feature of the interior space of the factory.





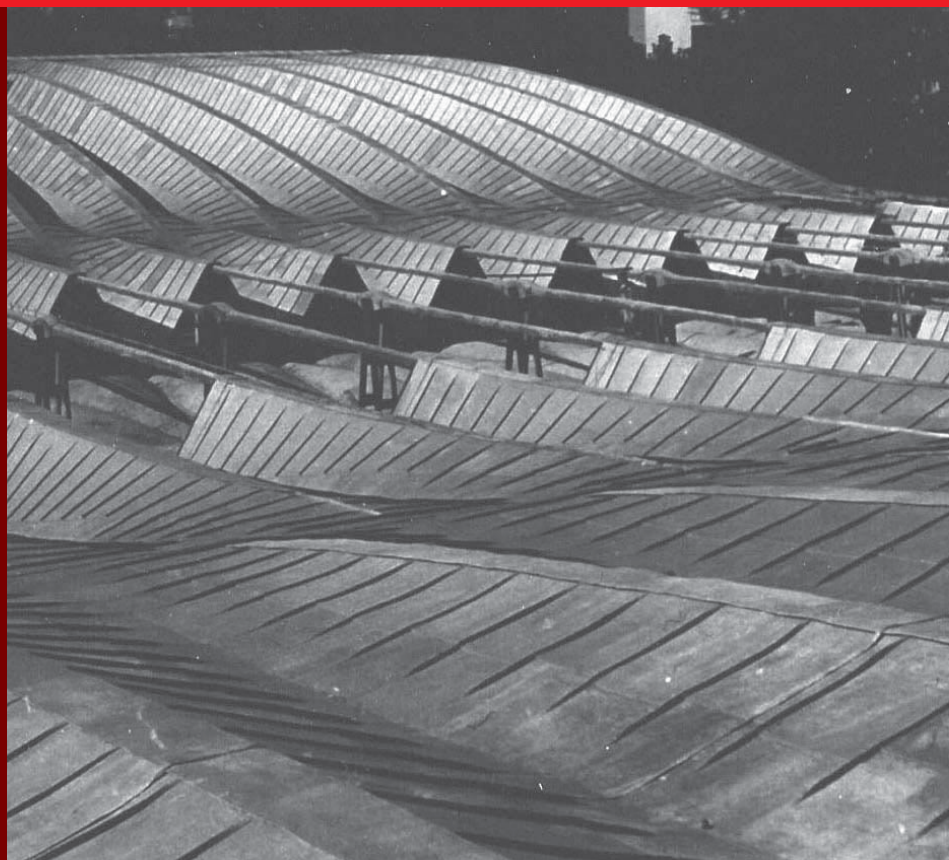
Super Sam



The Super Sam building in central Warsaw houses two supermarket self-service food areas ("sam" means "self" in Polish) that flank storage and preparation areas in the center. The problem addressed in the structural solution for this prominent urban site was to create a "signature" roof that would also express the tripartite configuration of interior spaces.

A hanging roof was favored from the start of the design process. However, this design would ordinarily require sloping cable backstays that would consume valuable land area and, because of their outdoor, ground level exposure and small cross-section, could be particularly vulnerable to catastrophic damage caused by vehicular collisions or vandalism. Through progressive design iterations, a solution was developed that eliminates backstays by alternating cables and arches of similar curvature. The outward component of arch thrust exactly balances the inward component of cable pull at each end, leaving only the vertical components of these forces to be supported by columns. The steel angle components of the roof were fabricated in pieces 3 meters (10 feet) wide so that they could be transported through the city streets.

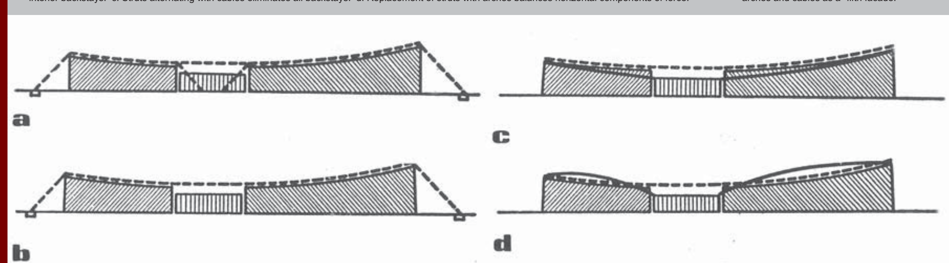
The alternation of cables and arches produces a pleasingly rich, pleated form for the roof. Inside the market, the roof structure is covered with wood slats that visually reinforce the pleated geometry. Collaborators on the project were architect Maciej Krasinski and engineers Andrzej Żórawski, Aleksander Wlodarz, and Stanislaw Ku .



↑ The completed roof displays the forms of the arches and cables as a "fifth facade."

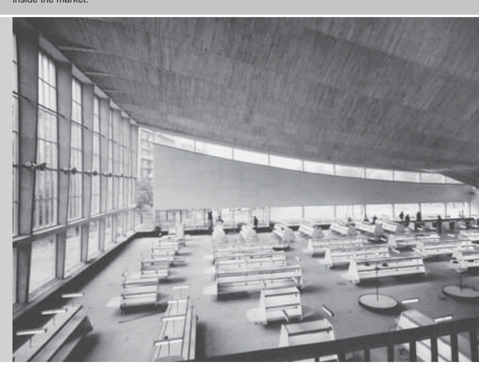
↑ An aerial construction view shows the site within central Warsaw.

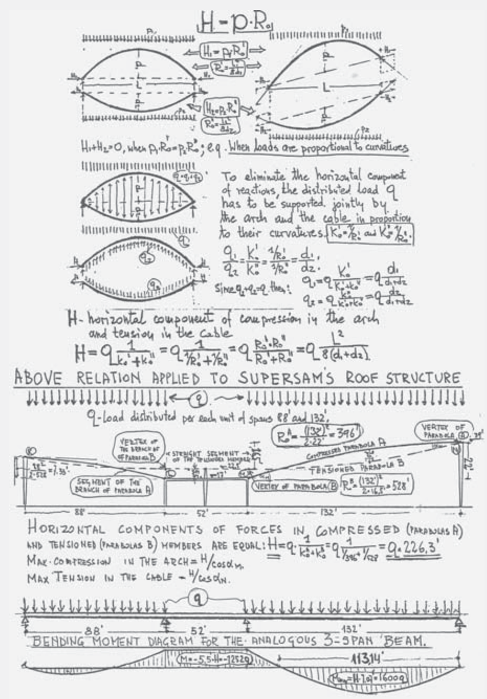
↓ How the structural concept developed: a. Separate cable roofs for the two sections would require four sets of backstays. b. A single cable span eliminates interior backstays. c. Struts alternating with cables eliminates all backstays. d. Replacement of struts with arches balances horizontal components of force.



Years	1950s	1960s	1970s	1980s	1990s	2000s
Location	Poland	Venezuela	United States	South Korea		
Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	Steel		
Prefabrication	Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication			
Structural Principle	Mirror image arches and cables					

↓ A wood slat ceiling reveals the form of the roof inside the market.

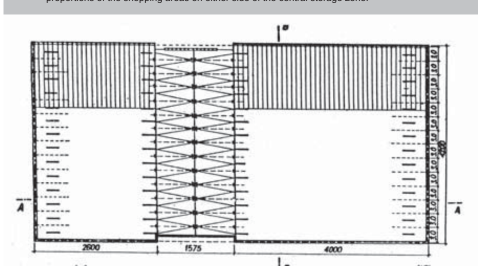




↓ The dimensions of the roof are shown in centimeters on this plan, which also shows the unequal proportions of the shopping areas on either side of the central storage zone.

↑ This construction view shows the alternation of cables and arches.

↑ Zalewski created these notes on the design of Super Sam for his MIT classes.

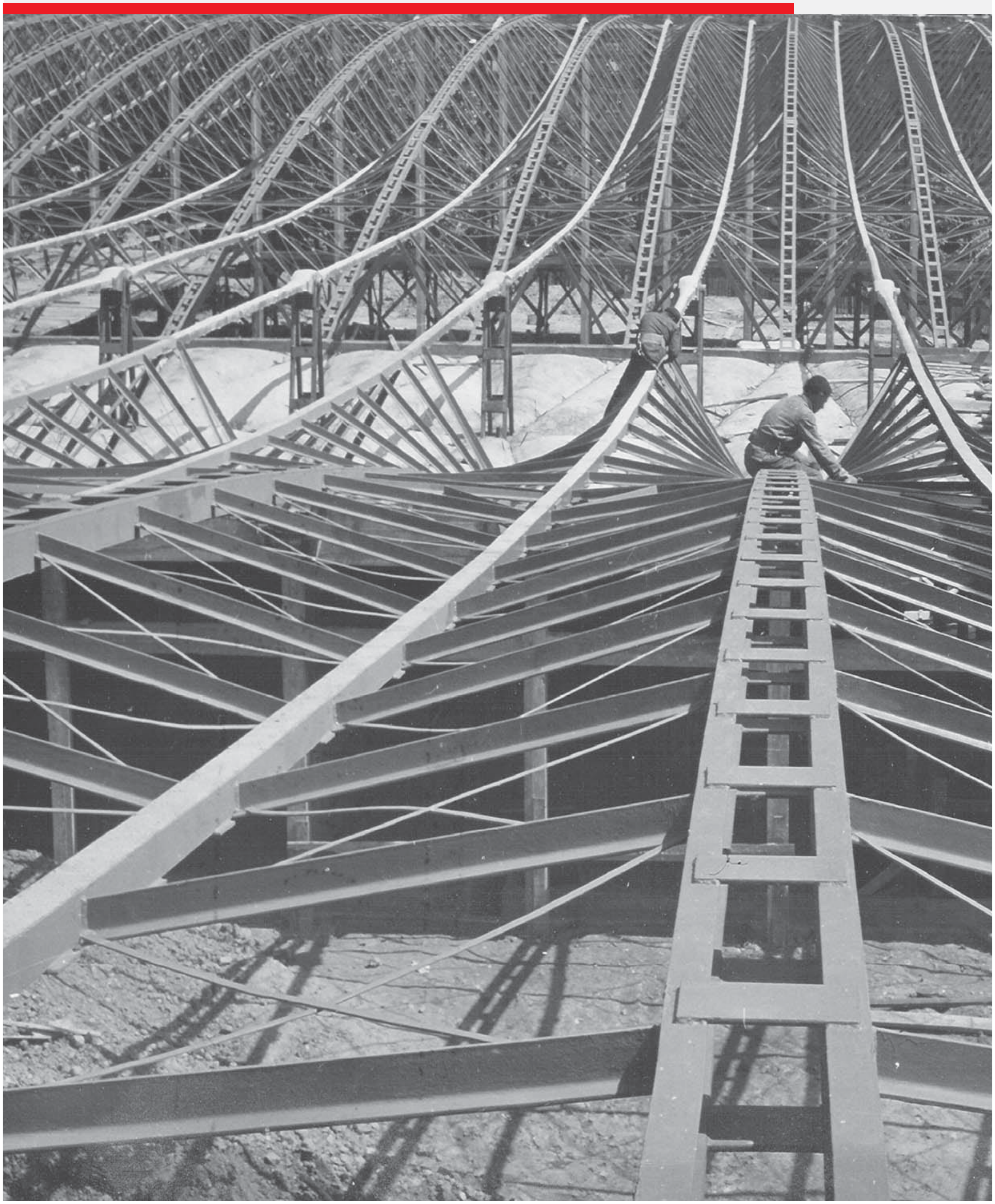


↓ The roof terminates with a cable rather than an arch at each side for a more unified appearance.

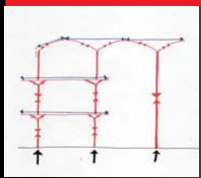
↑ The columns taper toward the bottom, allowing them to flex with small roof movements.

↑ Steel bipods resist differences in cable tensions caused by asymmetrical wind or snow loads.

→ To protect them from weather, cables were grouted into channels created by paired steel angles.



School in Valencia



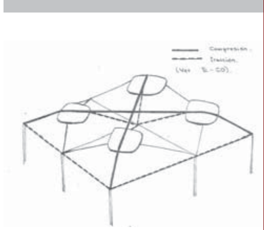
This building for a Jesuit Lyceum (high school) in Valencia, Venezuela, was designed in collaboration with architects Iñaki Zubizarreta and Felipe Montemayor and engineer Josè Adolfo Peña. It includes the further development of precast concrete capitals for the floors, and precast concrete roof vaults. This combined strategy capitalized on the need for the floor spans to have flat-topped slabs while the roofs had sloping surfaces to shed water.

Taking advantage of the light floor loading for schools, Zalewski designed a slender cruciform column capital that lies within the thickness of the floor structure. The capital and floor slabs are designed on a two-meter grid with eight meters (26 ft.) between columns. The columns are square with chamfered corners.

Roof vaults are precast in four identical segments per bay. The oculus at the top of each vault is sheltered with a cap that permits free airflow but excludes rain. The school, which has no windows, is naturally ventilated by convection currents that rise through the vaults and out each oculus. At the perimeter of the roof, saddle-shaped vaults provide scuppers at their low points to drain water from the integral gutters between the lines of vaults.

↑ At the entrance, the multilevel nature of the building is revealed, together with the vaulted roof.

↑ Each vault is made up of four identical precast segments.



↑ This explanatory diagram shows tensile and compressive forces in the roof vaults.

↑ A canopy shelters each oculus but allows free convective airflow.

↓ A view of the central courtyard features the scalloped edges of the roof.

↑ The floor capitals appear delicate.

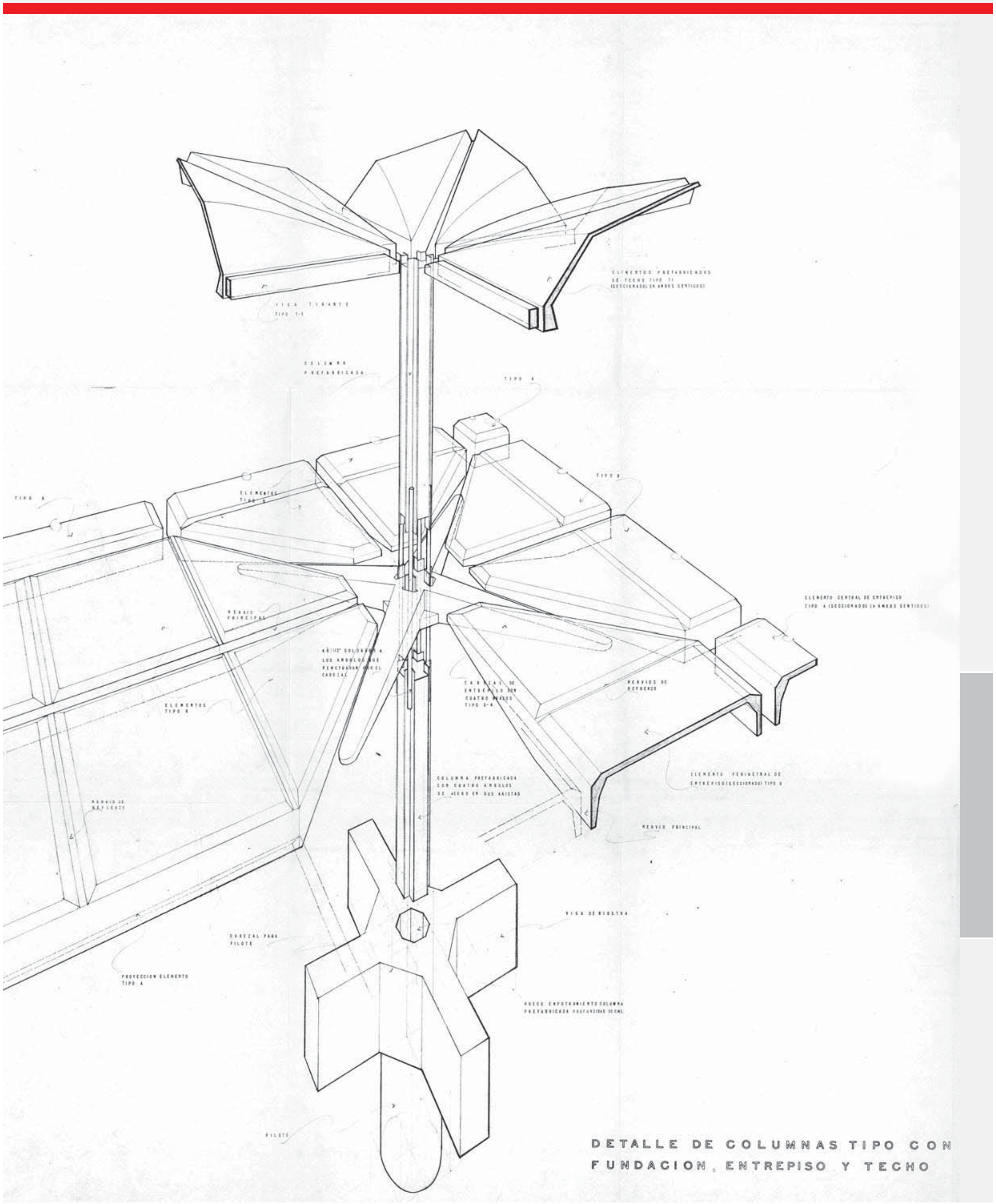
↓ The precast roof vault elements are as thin as 4 cm. (1.6 inches) in places.

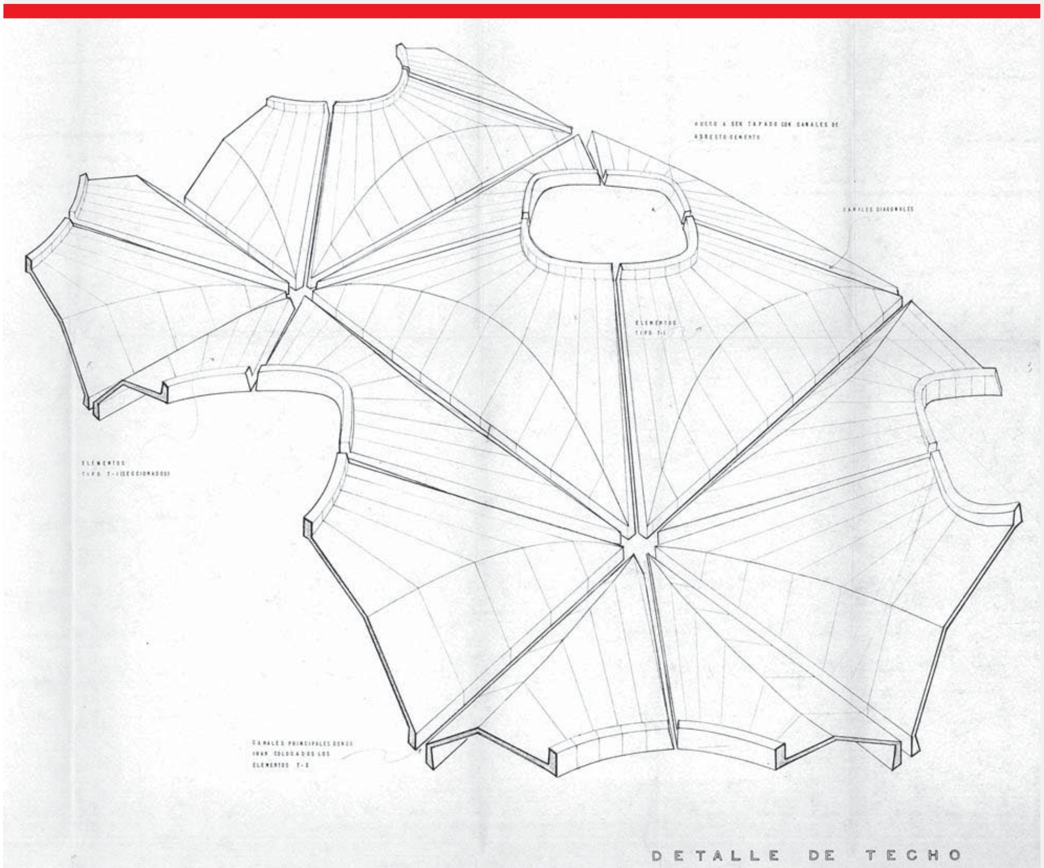
Years	1950s	1960s	1970s	1980s	1990s	2000s

Location	Poland	Venezuela	United States	South Korea
Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	Steel

Prefabrication	Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication

Structural Principle	Two-way floor slabs; Vaulted roofs in compression


VIGA TIRANTE
COLUMNA PREFABRICADA
TIPO A
ELEMENTOS PREFABRICADOS DE TECHO
ELEMENTO CENTRAL DE ENTREPISO
NERVIOS DE REFUERZO
ELEMENTO PERIMETRAL DE ENTREPISO
NERVIO PRINCIPAL
DETALLE DE COLUMNAS TIPO CON
FUNDACION, ENTREPISO Y TECHO



← This exploded perspective by the architect shows how components connect, from roof to foundation.

↓ The forms of the shells are echoed by the hills beyond.

↑ The mode of assembly of the roof shells is shown in this reproduction from the blueprints.

↓ The formwork for the roof vault segments includes pipes through which water is pumped to separate the concrete from the form. These produce a ribbed pattern on the interior of the shells.

↑ This photograph of the uppermost floor was taken before the canopy was installed.

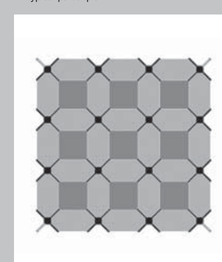
Capital System

This system for efficient construction of concrete buildings consists of four discrete types of elements, all of them precast on the building site: a tapered column; two floor slab components, one hexagonal and one square; and the "capital" component, which serves to transfer loads from the floor to the columns. The arms of the capital decrease the effective length of each of the spans in this two-way system and facilitate intentional omission of individual floor components to create circulation shafts, atria, and other multistory spaces. After all the precast elements are in place, post-tensioning cables are laid on top of the floor surface. These run in both the principal directions of the building and in parallel pairs, one cable on either side of the bases of the columns. Then a concrete topping is poured over the cables and precast pieces to create the finished floor. After this topping has cured, the post-tensioning cables are stressed, causing the finished building to behave as a monolithic whole.

This system might be envisioned as a modern reinterpretation, in precast concrete, of stone cross-vaulting techniques pioneered by ancient and medieval masons. The profile of the assembled arms and slabs is a funicular arch, and the horizontal component of the arch thrust is resisted by the post-tensioned cables. A number of variants of this system were produced in a process of development that sought to make the profile of the structure express more elegantly the arch-like structural behavior, and to simplify the formwork and details. Most of the built examples in Poland were for industrial storage, but the system was also extended to far more expressive applications including office and apartment towers and other buildings for human occupation. Buildings of many types continued to be constructed with this system even after Zalewski left Poland. This general type of system also became a precedent he drew upon and revised for other applications in Venezuela including those in this exhibit from Caracas, Merida, and Valencia.

↑ Omitting hexagonal panels allows for multistory utility shafts.

↑ The columns were prepared for upper floors.
↓ Typical partial plan.



↑ Each floorplate component had internal reinforcing bars.

↓ The construction process required allowances for tolerances and assembly; the post-tensioning cables under the final pour of the concrete slab for the finished floor made the system monolithic and filled tolerance gaps.

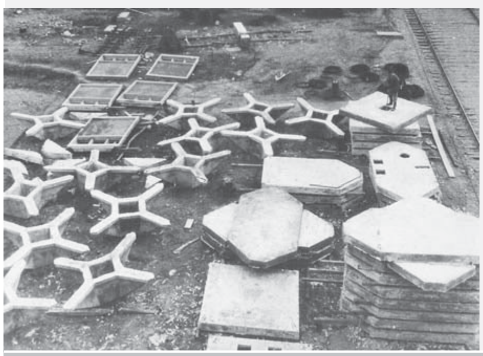
Years: 1950s | 1960s | 1970s | 1980s | 1990s | 2000s

Location: Poland | Venezuela | United States | South Korea

Primary Material: Masonry | Unreinforced Concrete | Reinforced Concrete | Steel

Prefabrication: Minimal Prefabrication | On-Site Prefabrication | Factory Prefabrication

Structural Principle: Two-way floor slabs and vaults



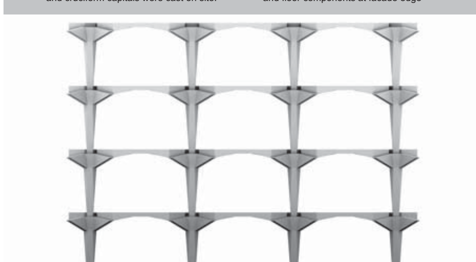
↑ Square and hexagonal floor panels, and cruciform capitals were cast on site.

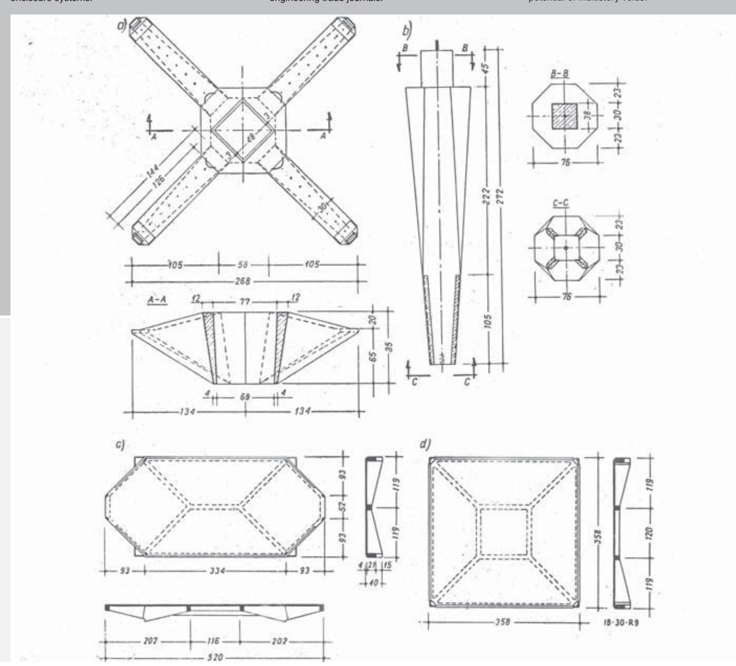
↓ Elevation showing exposed concrete capitals and floor components at facade edge

↑ This construction view shows potential panel enclosure systems.

↓ Construction drawings were published in engineering trade journals.

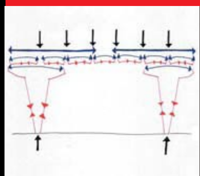
→ This computational rendering shows the spatial potential of multistory voids.





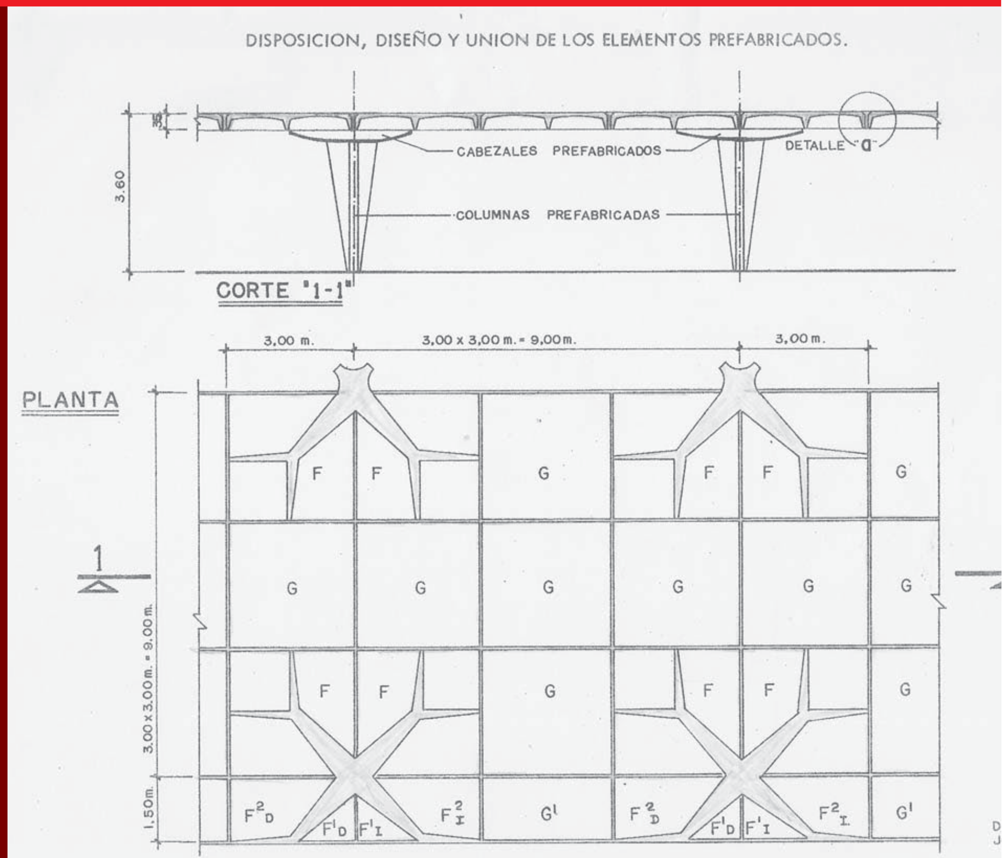
↓ Precast elements were guided down onto columns within the constrained site context.

University Building in Merida

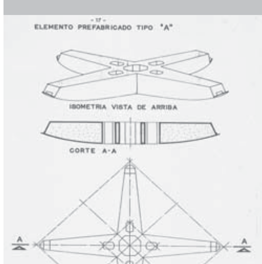


This building was constructed at the campus of the university (Universidad de Los Andes) in Merida, Venezuela where Zalewski taught from 1962- 1963. The building was designed in collaboration with architect José Adolfo Peña, and housed the Department of Forestry Engineering. It constitutes another step in Zalewski's long development of precast concrete column capitals. In this case, the architectural concept required a slab with a rectilinear grid of beams to facilitate a modular system of partition panels. The capitals, which lie entirely beneath the slabs, have long arms that reach out to become part of the grid at their extremities. The cruciform columns are shaped to accept wall panels on their indented faces.

This system was far lighter and spanned wider bays than the earlier capital designs, because the institution's academic spaces had floor loadings far lower than those in the industrial factories and warehouses in Poland. Capitals in the lower columns within multistory spaces are shorn of their arms where they are not carrying floor loads. This truncation articulates the versatility of the system and its potential for enclosing multistory spaces with the same limited number of discrete floor, column, and capital elements.



The section and plan drawings for a typical bay demonstrate how the three components–slabs, capitals, and columns–work together to create a floor structure.

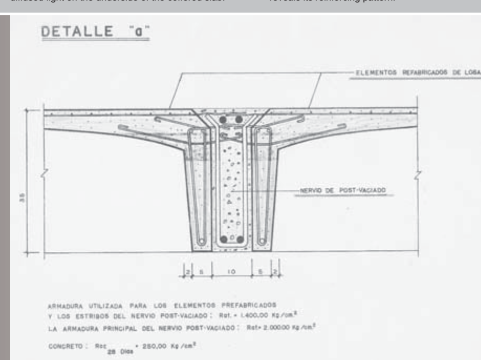


Isonometric, section, and partial plan views show the prefabricated capital with curved arms.

The upper lobby shows effects of reflected and diffused light on the underside of the coffered slab.

A detailed section through a typical capital reveals its reinforcing pattern.

The lower lobby features truncated columns that support full columns for the floor above.



Years
1950s | 1960s | 1970s | 1980s | 1990s | 2000s

Location
Poland | Venezuela | United States | South Korea

Primary Material
Masonry | Unreinforced Concrete | Reinforced Concrete | Steel

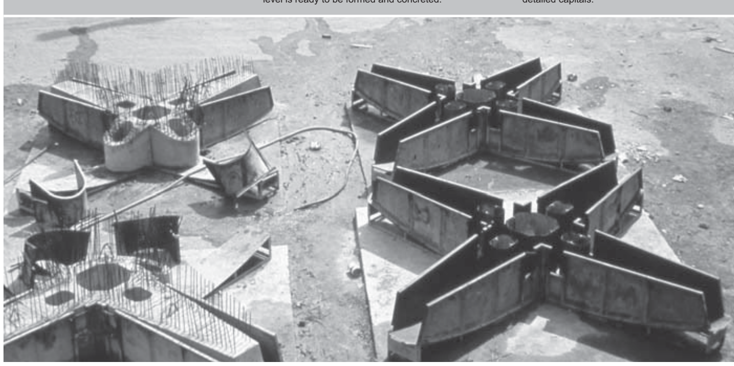
Prefabrication
Minimal Prefabrication | On-Site Prefabrication | Factory Prefabrication

Structural Principle
Two-way post-tensioned concrete slabs

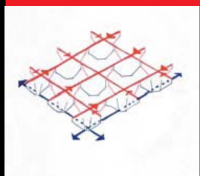
↑ This construction view shows the two-story columns that are without arms on the lower level.

↑ With the upper story columns in place, the next level is ready to be formed and concreted.

↓ Reusable steel forms produced precisely detailed capitals.



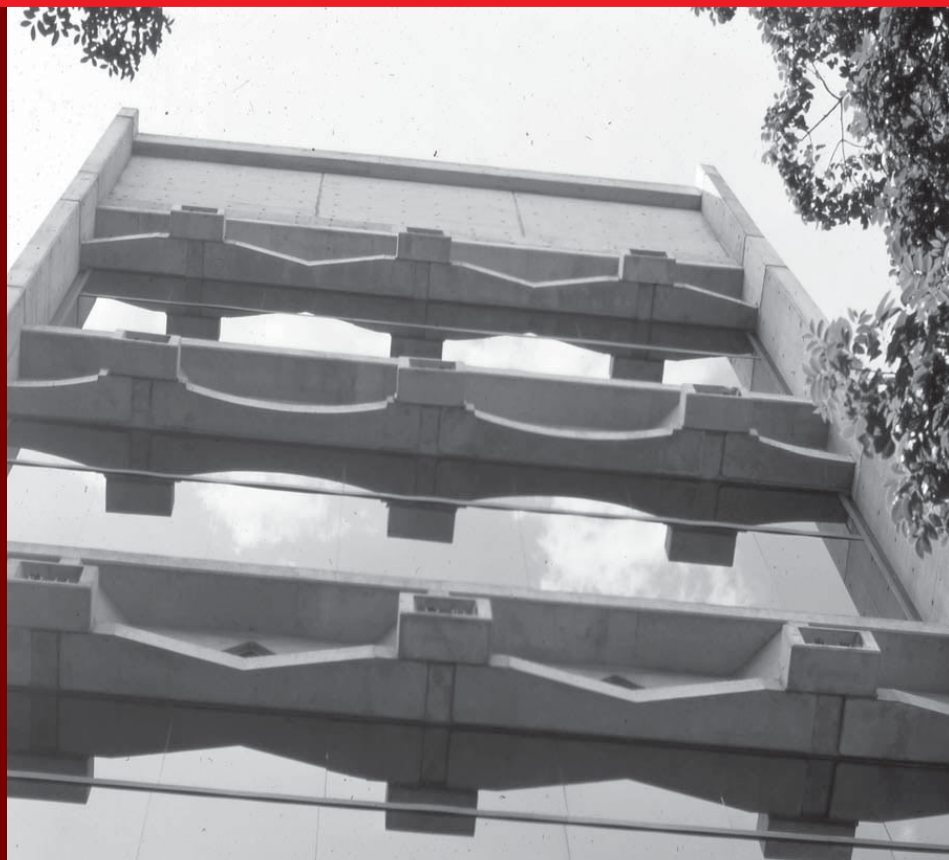
Caracas Art Museum



While working and teaching in Venezuela, Zalewski's work attracted the attention of Carlos Raul Villanueva, one of the country's most renowned architects. Three decades earlier, Villanueva had designed the original art museum in a classical style. Now he was designing extensions to the museum, including this wing for modern art and sculpture. He asked Zalewski to develop an innovative, sculptural floor system for this five-story building, one that could be exposed to view.

The primary challenge was to provide 450 square meters of floor space on each level with the capacity to support heavy sculptures weighing several tons, while not distracting from the sculptures or creating a strong directionality. Zalewski's solution satisfied these requirements and also enabled the floor system to be exposed without a false ceiling. Visitors from the building and design trades throughout Venezuela flocked to the project during its construction in the late 1960s and early 1970s, noting its efficiency, elegance, and the way its post-tensioning system made the assembled kit of parts able to act as a monolithic structure. Here Zalewski's early explorations of precast capitals for industrial uses informed this architectural work which was completed and opened in 1973.

The structure is made up of three components: a precast concrete slab element on top, a star-shaped concrete element in the middle, and an open rectangular plate of concrete on the bottom. These were assembled on temporary supports and grouted together. Then prestressing cables were laid and tensioned and a topping was poured. The system acts as a space frame and presents a pleasing, coffered appearance as seen from below.



↑ In this view looking upward along the facade, exposed concrete boxes mark the anchorages of the prestressing cables. The indentations of the slabs' edges express the manner in which compressive forces radiate from the anchorages.

↓ Steel formwork was used repeatedly to form all the elements of the system.

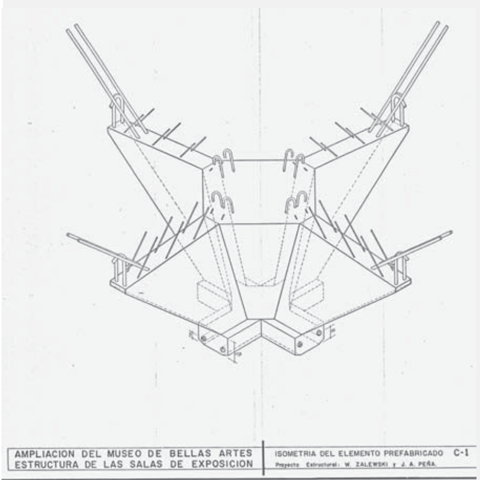
↓ Workers install a floor panel.

↑ A model (ca.1967) of the main addition (left) and the rest of the museum wings.

↑ Workers assemble reinforcing for the structural elements.

↓ This interior view of an upper-level gallery shows the coffered ceiling and narrow slit windows offering views out above the surrounding foliage.

Years	1950s / **1960s** / **1970s** / 1980s / 1990s / 2000s
Location	Poland / **Venezuela** / United States / South Korea
Primary Material	Masonry / Unreinforced Concrete / **Reinforced Concrete** / **Steel**
Prefabrication	Minimal Prefabrication / **On-Site Prefabrication** / Factory Prefabrication
Structural Principle	**Prestressed concrete space frame**

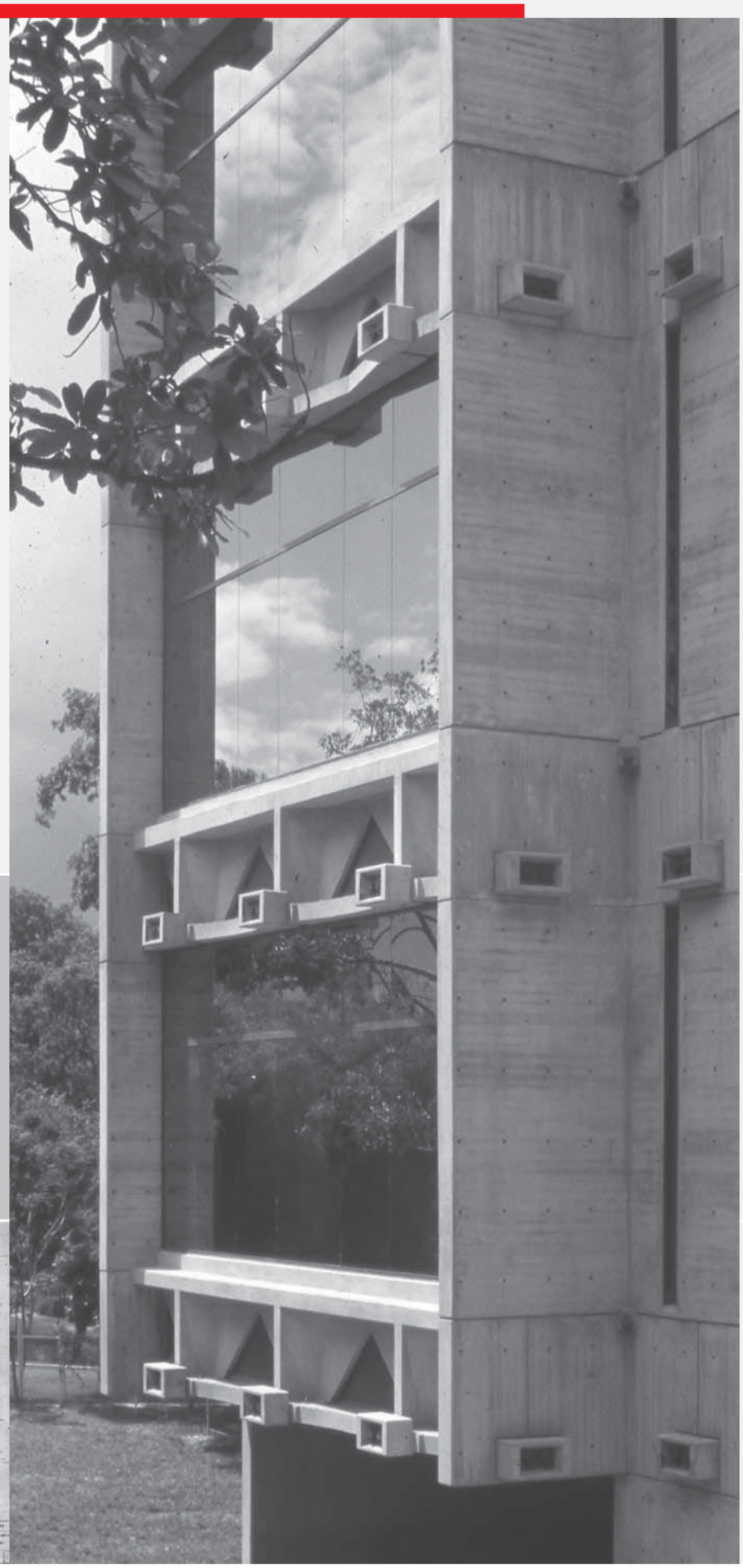


↑ Zalewski's proposal for details of the reinforced precast concrete capitals.

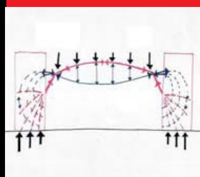
→ The cable anchorages are strong visual elements in the facade of the building.

↑ A component being hoisted during construction.

↓ This plan shows the layout of the floor panels and the prestressing cables that relate to the irregular cantilevers.



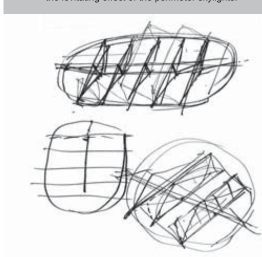
Keum Jung Sports Park



Awarded by the metropolitan government of Pusan, South Korea through a national competition, this project, the Keum Jung Sports Park and Stadium, was designed by Kyu Sung Woo Architects Inc. of Cambridge, Massachusetts, with Zalewski as structural consultant for the main roof. The building was constructed as one of three major sport venues built for the 2002 Asian Games. The site continues to serve as an athletic facility, community center, and park for the surrounding Keum Jung area. In particular, this 4000-seat gymnasium functions as both a sports venue and as a hall for gatherings and performances.

The structural solution for the roof is a three-dimensional truss that is similar in profile to a lenticular truss of funicular profile, tapering towards brackets that connect to masonry supports at the edge of the roof. What appears to be a main girder truss on the long axis of the building does not continue to any vertical supports, but rather is a device for connecting the shorter trusses that carry the load to the walls. This shaping of the structure, combined with the central and perimeter skylights, allows natural light to filter through the center and at the edge of the roof, creating a dramatic illusion of levitation.

→ This view of the gymnasium demonstrates the levitating effect of the perimeter skylights.



↑ Zalewski's early sketches show exploration of several alternative roof structure schemes.

Years	1950s	1960s	1970s	1980s	1990s	2000s
Location	Poland	Venezuela	United States	South Korea		
Primary Material	Masonry	Unreinforced Concrete	Reinforced Concrete	Steel		
Prefabrication	Minimal Prefabrication	On-Site Prefabrication	Factory Prefabrication			
Structural Principle	Steel pipe delta trusses					

↑ The large inclined tubes carry the weight of the roof to the walls; two smaller tubes brace each large tube laterally. The tubes midway between the large tubes are for roof drainage.

↓ This axonometric drawing shows the form of the roof structure. The entire structure forms a lenticular shape, which is highly efficient in supporting uniform loading conditions.