Between the Intangible and the Tangible

Brian Fireman

Thesis submitted to the faculty of Virginia Polytechnic and State University in partial fulfillment of the requirements for the degree of Master of Architecture.

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Blacksburg, VA
Abstract

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Between the intangible and tangible is the realm in which this thesis investigation takes place. The material presented here in a roughly chronological progression represents an exploration over the course of a year. This organization of thoughts and images will illustrate the processes and discoveries which occurred during this exploration.

In architecture, the realm of the intangible represents ideas. Ideas are catalysts for further study and ultimate action. It was the aim of this thesis to not simply let an idea exist without further action, but to explore the evolution of an idea to the point where it may ultimately manifest in built form.

The realm of the tangible, in this case the physical object, is also not the emphasis of this thesis. It is simply part of the whole, not to be confused with some sort of final end result. The built object, when studied, helps inform the original idea.

The emphasis of this thesis is on the area between the intangible and the tangible. This is where explorations take place, discoveries are made, and where transformations occur. In essence, this is where the multitude acts of design transform ideas into the realm of architecture.
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Approved by Thesis Committee:

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Precedent

Design must have a beginning. For this thesis it began as an inquiry into the relationship between force, structure, and form.

Forces generate structure. Structure is how things are arranged and put together in a larger whole. When this structure is manifest in the form of an object, its inner workings are revealed and can be perceived. Thus, form becomes a reflection of structure and forces.

Structure revealed through form can manifest in an infinite variety of ways. This diversity can be found in many places; formal geometry, joining of parts, the relation and interaction of parts to the whole, material properties, construction in the built world, or growth in the natural world.

“Structure, then, is an abstract quality. It needs presence in the real world to be fully apprehended - what the structure is made of is important, as is where it is, what it is doing, and who is apprehending it.”
- Bill Addis
In architecture, the notion of giving perceivable form to structure through construction is termed “tectonics”. An idea emerged to investigate the nature of tectonics as it relates to the expressive relationships of form to force in architecture and the built environment. Eduard Sekler, in an essay on this topic, wrote, “...structure, the intangible concept, is realized through construction and given expression through tectonics.” Thus, structure and construction imply two different things, although their meanings are frequently blurred. From this was born the desire to understand the relation and interaction between the two.

In order to investigate this distinction, it was decided to experiment with the relationship between a specific material and the process of construction. Using the Cowgill woodshop as a laboratory for exploration, work began with the aim as not to produce an “object” as an end in itself, but to document the process involved in making the object. This was an attempt to gain new insights into both the nature of the object and the process by which it was created. Embedded within this method are two key considerations.

First, the choice of material.
Second, the act of making.

Wood was chosen as the primary material. It is a natural and beautiful substance which possesses inherent qualities such as color, texture, and grain direction which add individuality to a made object. It is relatively easy to manipulate, which is necessary for the act of making to be a thorough and enriching hands-on experience. Thus, working with wood provided almost immediate results and allowed for much to be learned over short durations.
In his essay on tectonics, Eduard Seklar states that tectonics has long been recognized as the “particular manifestation of empathy in the field of architecture.” Thus, a notion of tectonics implies material expression, which wood greatly lends itself to in an investigation such as this. The growth of every tree is unique, yet there are certain characteristics inherent to its structure. Most prominent are the color of the wood, its hardness, its texture, and its grain direction. Each piece of wood will vary in these properties, lending individuality to this material. The experience of wood, how these properties are used in design, became a prime concern in this investigation.

How can inherent physical properties of wood, such as color, texture, or grain direction be used to enhance one’s experience of not only the built object, but also the processes by which it was created?

“I learned that wood has two lives: the first as trees; the second as tables and chairs, beds and cupboards, floors and brooms, bowls and ladles, houses and sheds, cribs and coffins.”
- Jose Zanine Caldas
An essential aspect of this method is the notion of workmanship. As stated by David Pye in his book, *The Nature and Art of Workmanship*, “Design is what, for practical purposes, can be conveyed in words and by drawing; workmanship is what, for practical purposes, can not.”

This distinction is important, for the act of construction is inherently tied to the notion of tectonics. This is not to say that drawing is not an aspect of “building”, or “constructing”. It certainly can be, although there is a difference between how a drawing may inform an idea versus how the process of making informs an idea.

In what ways is design affected if the designer and the maker are the same person?

The photograph below is of a sculptor named Martin Puryear. In his case, a particular expertise in workmanship serves to inform and guide his ideas and sculptures. Without first having had a thorough training in the particularities of wood construction, he could never have made the piece shown below. His work is a great example of how making might inform design.
Theme

Freedom to explore this tectonic idea was provided through flexible boundaries defined by a specific theme, allowing the exploration between material and the process of construction to take place. This theme includes three main principles.

First, take away material where there is no use for it.
Second, show the logic in construction.
Third, show how the piece is made.

In the realm of wood furniture, the works of American craftsmen Sam Maloof and George Nakashima, as well as Danish architect and designer Hans Wegner specifically aspire to this tectonic theme and are used here to illustrate its points. The adjacent figure located top-right is an example by Hans Wegner demonstrating the first principle. This is a well designed detail of the joining of two members, where there is absolute minimum amount of material necessary to perform the required task. The middle figure is an example by George Nakashima. Here, the second principle is beautifully exemplified, where the main point is to express in a given material the inherent qualities of that material. The figure in the lower-right corner is an example by Sam Maloof, a clear demonstration of the third principle, where the expression of joinery explicitly shows how the piece is made.
“The art of structure is how and where to place holes.”
- Robert Ricolais

“To use a material to its fullest extent is to honor it: it is a way of forcibly extracting all its specific qualities to their bursting point.”
- from Gaudi - Furniture and Objects

“More than anything else, a good construction can tell a story about the idea embodied in a design. Telling a story through a construction includes making clear what one wants to emphasize, what the point of the construction is.”
- Hans Wegner
Exploration 1
From the onset, the work of architect and engineer Santiago Calatrava provided much inspiration. In particular, his various tower, bridge, and sculpture projects struck a chord as beautiful and well-designed constructions with obvious tectonic implications. Much time was spent viewing images of his various tower and bridge projects, contemplating their formal characteristics and trying to understand exactly how the various forces involved in these constructions resolved themselves. Upon further reading, it was discovered that this is an essential vision of his work. Calatrava’s notion of form is that the designer can interest the user in the struggle to resolve the forces at work in a given construction, in effect forcing the viewer to reflect and contemplate the resolution of these forces. In essence, his work directly engages the mind in wonder.

From this idea was generated a clear intention. Guided by the established modus operandi and theme, it was hoped that some kind of design language could be discovered which would not merely expose the intangible concept of structure, but celebrate it through construction. If such a design language were discovered, then it could be used to help solve design problems on various scales, from that of a piece of furniture to that of a building.
With this idea in mind, the investigation began in the woodshop. Working from a basis of exploratory sketches, it was decided to construct a canted vertical member rising from a tripod base with a cantilevered top surface. Many questions surfaced...

How might the forces inherently involved in a cantilever be expressed?
What form should it take?
What kind of joints should be used?
How might the shaping of the individual parts relate to the forces flowing through the piece.
What would be the most stable configuration?
How might the parts be joined?
How might they be shaped together?
How does the object meet the ground?
How will the nature of the material affect the overall design?
How, where, and when do certain lines appear, disappear, and reappear in the piece?
What is the nature and relationship of the base to the top?
How do the rear legs join the vertical?
How might formal decisions affect how one might respond to the piece? In other words, how might the difference between a hard edge or soft edge affect where one might want to touch the piece?

With the first tool stroke across wood grain, the first step was taken beyond the realm of the intangible into the realm of the tangible. Through the examination of a few key issues encountered during the process of making this first object, it is possible to see how the idea, method, and theme previously established helped drive and inform decisions in each of these areas.
To begin, prototypes were made of a few conditions to be found in the final piece. Through this process, it was found that grain direction is a very important design consideration. Without attempting to first build the design in this prototype stage, this discovery would never have occurred.

At the junction between the rear legs and the vertical piece, the first attempt at shaping the joint between these two members occurred with the curve taking place within the back leg of the piece. Very quickly, in attempting to shape this piece of wood, short grain was encountered which quickly chipped away. In the soft pine of this initial prototype, the shaping continued until the tenon was visible through the sides of its mortise. Thus, the design changed to incorporate the transition curve within the vertical member so that the long grain would give strength to this joint. This was not an aesthetic decision, but a very functional one based purely on grain direction.
This discovery of grain direction affecting where a curve was to be made also led to a decision as to how the top cantilever would join the vertical piece.

As a result of the previous lesson, it was learned that the curve between these two pieces had to take place within the horizontal long grain of the top piece, but this piece did not possess adequate thickness to create the desired curve. Thus, it was decided to introduce a secondary piece of wood between the top and vertical member. This secondary piece would be oriented with the grain running horizontally, making possible the creation of the desired curve.

“One of the most characteristic qualities of wood is that it has a direction. It makes a big difference whether you go along the grain or perpendicular to it.”
- Hans Wegner
The selection of a single board, cut from the crotch of a walnut tree, was a significant instigator for many formal decisions concerning how the piece would look. The very prominent grain pattern, converging towards one end, perfectly suited the notion of “cantilever”. Contained within this board, the cantilever was visioned tapering in both plan as well as section, with the outer edges following the lines of the grain. This decision was rooted in the initial theme, to take away material where it is not needed. Farther away from the rear support, the cantilever is under less stress and thus needs less thickness in material, both in plan and section.

In the bottom figure, there can be seen a knot on one side of the board which causes the grain to swirl around this spot. Initially, the thought was to construct a purely symmetrical top, yet this swirl ultimately led to a decision to follow the grain and allow the top to be asymmetrical.

The process of making allows decisions like this to be made at the time of discovery. This is just one example. During the act of making, there is a constant exchange of information between the hand, eye, and mind. This process constantly informs and re-informs decisions during the act of making.
To begin, templates were cut for each separate piece. Taken directly from initial sketches and blown up to a larger scale, these templates allowed for approximate initial cuts as well as locating exact joint locations between the individual pieces.

A mortise and tenon joint was decided upon for the connection between the two rear legs and vertical member. Although not visible, this is a very strong joint. Because the mortise would occur in the vertical member, there was plenty of wood around the joint to shape these two pieces together.
Decisions regarding the making of this joint were informed by all three ideas from the original theme. In shaping the curve between these two pieces and angling the shoulder line of the connection, material was taken away where it was not needed while at the same time alluding to the flow of forces through the piece. Additionally, the shaping of the curve in this manner was only possible because of the nature of the material, walnut. If this is difficult to see, simply envision a similar connection between three members constructed in concrete, steel, or plastic. The specific material qualities of walnut, in this case, directly informed the decisions leading to the ultimate form of the joint.
Much trial and error went into the construction of the joint between the top and vertical members. The final joint, a dovetailed mortise and tenon open to one side, was decided upon for three main reasons.

First, the inherent shape of the dovetail provides mechanical strength. Thus, when pressure is exerted in a downward direction at the end of the cantilevered top, the joint itself will help resist this force.

Second, the rear of the joint would be left visible in order to help the viewer interpret how this piece was made and put together, hopefully encouraging them to contemplate the act of construction.

Third, the front of the joint would be hidden inside the mortise. If it was left visible as a through tenon to both ends, then a problem encountering short grain would occur when attempting to shape the curve between these top three pieces.
The Sensual

As the individual pieces were joined and shaping of the piece progressed, it was possible to address questions pertaining to the sensual realm of human experience and interaction with the created object.

What is the nature of the “right line”, and how is this decided? What various factors determine the final form the piece will take? When is a hard edge appropriate and when is a soft edge appropriate? How should the piece be finished?

To understand how these questions were answered, let us examine a particular part of this piece, the top cantilever.

First, the form resulting in the rear of the cantilever, where it joins the vertical member, was largely determined by how the hand controlled the tool, a rasp, over the woods’ surface. Gradually, changing the angle of the tool within each passing stroke, the final form began to emerge.

Second, grain direction also informed formal decisions in this area. In this case, grain direction was used in a different way than previously discussed. Shaping the top piece was a pure formal consideration and had nothing to do with strength of the wood or strength of a joint. The grain flowed in particular pattern around the location of the crotch of the tree. Observing this pattern led to the decision to join the vertical to the cantilevered top in a location such that the rear of the piece would slightly protrude in the opposite direction as that of the main cantilever. It was thought that this would lend a particular “feeling” to the piece, helping to visually counterbalance the prominent cantilever in the other direction.
Third, a soft edge is much more inviting to the hand than a hard edge. With this in mind, a rounded lip was formed around the outer edge of the cantilevered top. This was done with the hopes of inviting the hand to touch and experience the tapering of the top cantilever.

Fourth, lines of force through the piece helped inform formal decisions. As stated earlier, it is obvious to see how the tapered cantilever alludes to the forces acting through it. Maybe slightly less obvious is how the notion of forces informed the shaping of the vertical member.

The two rear legs converge on the vertical piece at an angle. Thus, the back side of the vertical member needed to be wide to accommodate this joint. On the other side, it was possible to taper the vertical member to a point. Translating this point of convergence up and down the this member, a hard line was established, alluding to the force which flows from the tip of the cantilever down to the ground below. In this same manner, each rear leg was shaped in a way largely determined by how forces flowed through it.

Finally, finishing of the piece was a direct attempt to bring the experience of the wood itself to a more sensual level of experience. The final form was sanded to remove all scratches left visible by the construction process. Next, the piece was oiled to bring out the prominent grain patterns as well as help protect the wood itself. In this way, the piece invites the hand to touch the wood in a completely different way than if left in a raw state, with rough edges and tool marks covering its surface.
Discovery:

*Essence of Tectonic*

An unexpected discovery occurred only after having completed the piece. The connecting piece joining the vertical support and cantilevered top produced a distinct pattern in how the converging grain patterns met one another. It bore a striking resemblance to a specific geological phenomena, called an “angular unconformity”, a phenomena produced through geologic *tectonic* activity.

In the field of geology, tectonic activity refers to the movement of tectonic plates. One could say, “Tectonic activity produces mountain chains and ocean basins.” Tectonic processes refer to those processes resulting from tectonic activity. Tectonic forces imply the stresses and strains which give rise to various tectonic processes, etc. So what does all this mean?

What is the relationship between the term “tectonic” used here and in architecture?
To look at it another way, why did geology adapt a centuries old term and use it to describe a newly discovered phenomena?

To help answer this question, it is important to quickly look at what an angular unconformity truly represents. In short, an angular unconformity requires four major events:

One, an initial period of sedimentation during which older strata are deposited in a near horizontal position.
Two, a subsequent period of deformation during which the first sedimentary sequence is somehow displaced.
Three, development of an erosional surface on the folded sequence of rock.
Four, a period of renewed sedimentation and development of a younger sequence of sedimentary rocks on top of the older erosional surface.
Thus, the very physical presence of an angular unconformity alludes to a very unphysical thing, time. More specifically, it alludes to missing time revealed through the rock record itself, or the intangible made tangible. This is where the notion of tectonics enters the picture.

The word tectonic is derived from the Greek word “tekton”, which refers to carpenter or builder. Over time, the meaning of tectonics in architecture evolved to mean more than simply “building”. Fundamentally, tectonics implies the revealing, the making visible of something which inherently is not. Structure is an intangible concept. Through construction, it is revealed and made visible. This making visible of the invisible is what gives rise to varying degrees of tectonic expression, and a particular notion of empathy implicit in the term.
Buildings are constructed through physical effort over the course of time. Tectonics refers to the specific act of making visible some aspect of this condition. In speaking to this condition, Eduard Seklar states that the architect is “the undisputed master of tectonic expression.” Thus, it is a conscious choice of the architect to reveal or not reveal some aspect of how the structural forces resolve themselves in built form.

In Geology, there is no conscious “maker” other than the earth itself. The cooling of the earth gives rise to a multitude of processes over time, which when revealed we call “tectonic”. In this way, the invisible, internal structure of how the earth came to be, or “was made”, is revealed. In essence, although tectonics refer to different things in the respective fields of geology and architecture, its meaning is the same.
It is interesting to note that geology is not the only field which has adopted the term “tectonic” and applied it to its own end. The field of biology has done the same, adapting the term to describe the process of plant evolution and differentiation in much the same way that geology has adapted the term to describe various earth processes. In describing the photographs of Karl Blossfeldt, two of which are shown at left, author Hans Christian Adam states, “It was a question of illuminating the construction, statics, and tectonics of plants so as to show possibilities of comparison and provide ideas from the world of nature to that of art or, rather, architecture.”

After this angular unconformity discovery, it was interesting to notice how awareness of this condition was enhanced while viewing the works of other architects, most notably Antonio Gaudi. It is obvious that Mr. Gaudi was very particular in the design of this column and vault shown in the bottom image. Note the joint where the column meets the vault. This image brings me great joy!
In attempting to understand this first piece and the processes by which it was created, a very important lesson was learned regarding the notion of intentions. Up to this point, the name given to this piece was “model stand”. The primary intention was to express through form, material, and construction some notion of the forces flowing from the end of the cantilever to the ground. After the piece was a physical reality, it was difficult to perceive it in any way other than stemming from this original idea.

One afternoon, while discussing the piece with a professor, it was realized that the intention of this piece and its reality as an object were two different things. I was referring to this piece as a “model stand” while the professor referred to it only as a “form”. What did he mean?

It took a while to truly understand the difference. Judgments were made based on what this piece was intended to represent, not based on what the piece was, a form. Only upon this realization was it possible to begin looking at this piece in a different way.

In her book, Philosophy in a New Key, Susanne K. Langer states, “the treatment of a problem begins with its expression as a question. The way a question is asked limits and disposes the ways in which any answer to it, right or wrong, may be given.” Here was the problem, this piece could not be seen as a “form” because the very nature of the initial questions limited its perception in this manner.
Thus began a process of reexamining and re-questioning some of the original formal decisions. The piece was turned upside-down, on its side, and other various angles in an attempt to see it in a new way.

What different ways might a cantilever be expressed?
What different ways might three members come together and join?
What might be their transitions; smooth, abrupt, angled?
How do the legs spring from the ground?
Is the form animal-like or plant-like?
What is the notion of the “right line”, and how is this decided?

It can now be seen that the act of making may be used as a tool, for if one is aware and conscious through this process, it is possible to perceive the transformation of initial intentions giving rise to new discoveries. Robert Le Ricolais stated this perfectly when he said, “My own conviction is that we can only appreciate and fully possess what we ourselves discover. A fascinating aspect of this is to see that what you find along the way is often more intriguing than what you first set out to do.” If one is not open to this aspect of work, then why work at all? One becomes merely a slave to the task. True joy lies in the discovery and recognition of the unforeseen.

This realization is a very important aspect of this thesis because for any of these discoveries to occur, the process of making must first take place. If at first the initial ideas regarding structure and construction had not been built, then the opportunity would not have arisen to ask the next series of questions, which in turn gave rise to the next created object of this investigation.
Exploration 2
Remaining within the flexible boundaries provided by the original theme and modus operandi, work began on a second piece. Here, the main question driving the design dealt more with the process of making than an idea of “force”. Here, the key questions were...

How might a design evolve through the process of making if the majority of design decisions were made during the process of making itself?

How might both the method and process of construction be made more visible in the final object?

What could be done to a piece of wood to bring to the forefront more of its latent qualities and characteristics, such as grain direction, color, and texture?

In what ways could lessons learned from the first piece inform the making of the second piece?

What unforeseen discoveries might await?

An attempt was made to remain more flexible with the original question and approach the work in a more liberal way. There were not as many preconceived notions as to the final form the piece would take.
Resistance

When making, one is confronted with a physical material which gives rise to pure constructional problems, very tangible issues. A certain amount of resistance is encountered, both physical and psychological. Physical resistance in the sense that work must take place. It takes effort to transform a piece of wood from its raw state to a more refined form. Psychological resistance in the sense that one is forced to slow down patterns of thoughts and actions in order to sense what is truly happening and not ruin the object itself.

Beginning with rough sewn cherry in the dimensions of 10”x4”x10’, work began in slowly removing material. Not being able to entirely visualize the form within, this work was done with a great amount of both psychological and physical resistance. It was difficult to remove material without well-defined guidelines in place, such as in the previous piece. How to remove material, where to remove material, and how much material to remove were all questions which continually surfaced. Proceeding at a slow pace, it was possible to fully experience the relationship between eye, hand, and mind. Thus, it was possible to literally “make” this piece in the moment, allowing the process itself to help inform the design. It was discovered that design happened actively, with each passing tool stroke, and passively, in contemplation of the next.
Working in this way, unforseen discoveries were noticed more quickly during the process of making, as opposed to during the period of reflection after the piece was finished. For example, the initial intention was to make a form with a uniform finished surface throughout, yet this thought quickly transformed into another idea after noticing the tool marks left during the process of wood removal.

These tool marks were beautiful traces of the process of making. The deep gouges produced a beautiful pattern and introduced an unexpected level of depth and texture. Leaving them visible as part of the finished object, they could be viewed in contrast with the refined finish on the remainder of the piece. It was felt that the contrast between two different surfaces on the same piece of wood, one finely finished and the other with visible tool marks, would show more explicitly the inherent qualities of the wood. This decision stemmed directly from the original theme. Leaving the tool marks visible would give clues as to how the piece was made. This was a design decision, unforseen from the start, which took place during the process of making.
After the cherry was carved, sculpted, sanded, and finished, the question regarding how it would be displayed arose. In building a stand to display the cherry carving, it was decided to contrast the piece in as many ways as possible, thus setting up a dialogue between stand and carving. The relationship between the two was used to help enhance and make more visible some of the intrinsic qualities of the carving. Where the carving was a solid piece, the stand would have obvious joints. Where the carving was curved, the stand would be straight-edged and orthogonal. Additionally, the deep red color of cherry was contrasted with the dark brown walnut used for the stand.

The most difficult design decisions arose around questions regarding how the stand would touch the carving. It was decided that the stand should touch the carving as minimally as possible. To accomplish this, the stand touches the carving in only three places, literally “reaching out” with supports to grab its edges. Each of these supports was shaped differently to reflect the form encountered at different locations along the cherry carving. Only at these three places, where the stand touches the carving, did the straight lines of the stand change to reflect the curves of the carving, thus alluding to a specific relationship between the two.
This notion of relationships between individual parts and these parts to the overall whole was an unexpected discovery, unforeseen from the start. After the stand was built, it was possible to further reflect on the relationship between the two.

Alone, both the stand and carving can be viewed as independent objects with qualities inherent to themselves. Together, however, the various relationships between the two become much more apparent. For example, the straight edge of the stand contrasted to the sweeping curve of the carving really draws attention to this curve.

The three points where the stand touches the carving are particularly interesting. Here, material is removed to mimic the form of the carving. Viewed alone, this is the only part of the stand which is non orthogonal and might give clues as to its function, a stand.

How would the relationship between stand and carving change if the orthogonal design language of the stand was carried throughout, including these places of “touch”.

It is not a question of right or wrong, but possibly the design would be better if the above were the case. If this were so, each independent part, the carving and stand, would correspond to their unique design vocabularies. Only when brought together would the relationships between the two be made clear. Here, one plus one equals more than two, and different levels of relationships become apparent.
After becoming aware of these various levels of relationships, it was possible to notice similar circumstances occurring elsewhere. One beautiful example can be found in the formal nature of the “forcole”, shown in the photos on this page. Without knowing the function of these beautiful wood carvings, one would be inclined to see them only for their sculptural qualities, and nothing else. However, these objects serve a specific purpose, having evolved over centuries of trial and error to manifest today in their various forms. A forcole is the device used by gondoliers in the canals of Venice to brace their oars against. The form an individual forcole will take is determined by a variety of factors, including but not limited to the gondoliers themselves, the length of the gondola, the width of the gondola, whether the gondolier will use one or two oars, and whether the gondola will be steered from the front or rear. The form of the forcole, and the relationship between it, the oar, and the gondolier can now be seen in a different way.
Change of Scale

Upon the completion of the previous two projects, the focus of this thesis investigation shifted focus. Thus far, work had been done on a certain scale, with the hand and eye being able to directly and physically control any desired formal result. In the realm of architecture, however, this is seldom the case. In present day architectural practice, the architect is far removed from the act of construction. Design, translated through drawings into construction documents is for the most part physically executed by a multitude of specialized building trades. This separation, in conjunction with the sheer scale of buildings, forces the architect to precisely describe his intentions in order that they be realized in the tangible sense. David Pye speaks to this fact when he says, “In practice the designer hopes the workmanship will be good, but the workman decides whether it shall be good or not. On the workman’s decision depends a great part of the quality of our environment.”

Through the making of these first two objects, the original idea and theme were explored. These investigations gave rise to the discovery of a certain design vocabulary. This design vocabulary provided a method for transforming intangible design ideas into tangible built objects. In making the next piece, the driving force shifted from that of discovery to that of translation. To begin, the primary questions which evolved were:

How might lessons and discoveries from the previous two projects be taken and translated to design on the scale of a building?

How might formal questions be resolved and explicitly described when the act of making shifts scales, with the hand no longer in direct control of formal decisions?

Remaining within the realm of wood construction, what construction method could best accommodate the execution of the given design?
Program and Site

Initially, the chosen theme defined limits for the scope of this investigation. To begin the third piece, additional limits were established to help drive the design; a site and a program. The chosen site is located high in the mountains of western North Carolina. Upon this site, it was decided to design the structure for a house of approximately 2000 square feet. The intention was not to design all elements and aspects of a house, but to focus on resolving structural questions on a scale more appropriate to architecture. Here, formal questions could no longer be decided “in the moment” or determined by moving a rasp over a piece of material.

The site consists of an open meadow which lies along a ridge, sloping up a few hundred feet to the north and sweeping down towards the south. Looking due south, approximately two miles away, is another meadow atop a mountain, named “Max Patch”. The Appalachian trail, straddling the border between North Carolina and Tennessee, bisects this clearing. Beyond Max Patch, stretching a bit east, west, and farther south, unfolds the majestic expanse of the blue ridge and smoky mountains. On a clear day, the view is spectacular, except for one small problem. Blocking this beautiful view from much of the chosen site is a row of trees rising to a height of approximately fifty feet. This fact, along with the spectacular views, led to the decision to design a house in the form of a tower. This way, the living surface could be located at a level higher than the tree tops, thus taking advantage of the spectacular views afforded by this unique site. On the following page are two photographs taken from the chosen site. In the top photograph are the trees which obstruct most of the view. Max Patch can be seen in the distance to the left side of this photograph. In the bottom photograph can be glimpsed just a section of the view, towards the southwest, which would be experienced from the proposed house. These two photographs were taken in late September, just as the autumn leaves were beginning to change color.
“Did you ever see the beauty of the hills of Carolina, or the sweetness of the grass in Tennessee?”
- Lynyrd Skynyrd
Process:
*A Tower is Born*

To begin, design ideas were explored through a series of sketches and study models. During this preliminary stage, formal decisions were made through the freedom that sketches and study models provide. A variety of structural solutions were explored. Using the original theme and design vocabulary discovered through the making of the first two objects, it was possible to arrive at an acceptable structural solution fitting the additional limitations defined by program and site. The primary structural concept for the proposed tower is as follows. Rising from the ground are three primary groupings, each consisting of four vertical structural supports. From each tripod base, two of these supports rise in the same plane, diverging from one another at approximately one third of the total height and reconnecting via a roof beam. In the language of timber frames, this independent, stable arrangement of structural members is referred to as a “bent”.

At the top of the tower, each of these three bents are connected through the addition of a top element, itself consisting of three parts. Discussed in more detail later, the connection between these members is provided through two factors. First is the design of the joints themselves. Second is the combination of compressive and tensile forces provided by high strength steel cables connecting this intermediate element to the ground.

The other two vertical supports rise from the base in opposite directions defined by a plane set perpendicular to its corresponding bent. These vertical members join with a support rising from an adjacent bent, and are then connected via a roof beam to the intermediate element described above. An analogy to this structural concept is three people standing in a triangular configuration, all leaning towards the center of the triangle with heads touching. Their arms are outstretched and hands clasped, providing both lateral and vertical support for each other.
After the main design was established, these rough forms were “reconstructed” on the computer. Hand drawn sketches were redrawn as a series of interconnecting circular sections. In this way, it would be realistically possible to build these forms on a variety of different scales, within reason. Geometry was used as a tool to help describe form. The final model was constructed using templates generated from this computer model. In this way, the “right line”, initially explored in the first piece, could be described and constructed on the scale of a ninety foot high tower using a system of form-work built up of these geometrical circular segments.

Through a reexamination of a few key issues, it is possible to see how discoveries made during the creation of the previous two projects were applied in the structural design for this tower.
Staying within the realm of wood construction, it was decided to use structural glued laminated timbers, or glulams, as primary structural supports. These glulams could be prefabricated in a shop facility and installed on site, with the number of individual structural members being kept to a minimum. Glulams are constructed through the gluing together of numerous smaller wood members. The grain direction of each individual wood member is utilized for its greatest strength, so that when built up their accumulation provide an efficient and strong structural support. For example, at different locations within the supports themselves, varying amounts of tensile and compressive forces exist. When building up these elements, stronger wood can be used where necessary, while weaker wood can be used at locations of minimal stress. Also, it is possible to alternate the grain direction of each individual wood member, analogous to plywood construction, so more strength can be derived with less material.

Furthermore, through the process of construction itself it is possible to curve the glulams, giving additional flexibility to the formal possibilities of the structure. Much like the tool marks left on the cherry carving, the visible glue lines between various wood members are visible traces of this construction process. These lines help direct the eye to see and comprehend the flow of forces from the top of the tower down to the ground. This is a true form of tectonic expression, where structure and construction are intrinsically linked.
Extra strength was needed where the primary vertical supports meet the roof beams. This strength was provided through the accumulation of material at these locations. Using the design vocabulary established with the first piece, the connection between individual structural members were shaped together through a curved line. This curve is formed within the horizontal roof beam as opposed to the vertical support, thus using the “grain direction” of the laminations themselves to provide strength in the same manner that grain direction was used in the first piece. In the making of the final model, these curves were made using machine and hand. In practice, an identical curve could be constructed on a larger scale using similar methods in a shop facility.
Cantilever

The idea of a cantilever was introduced into the tower design at the level of the floor surface, located sixty feet above the ground. The primary beams which support this surface are themselves cantilevered. The ends of these beams are tapered towards the end, taking away material where it is not necessary while elegantly expressing the cantilevered construction. The double-curve of this taper mimics the double-curve of other structural members. This theme is repeated in other parts of the tower as well, such as the ends of the roof beams and ends of the secondary floor joists.
Being able to take apart the final model and store it as an assemblage of individual parts was a driving force in deciding upon which types of joints to use and where they would be located. In a ninety foot tower, as opposed to the final model, the actual joints would be slightly different. Their method of construction, however, would very closely resemble how the model joints were made.

In designing the joints for this tower, discoveries from the previous projects were directly applied. At times, the joints were kept hidden, as in each tripod base where four members converge on a single point. Here, it was felt that the idea of forces converging on a point were more clearly expressed by clean lines, not a visible joint. Other times, the joints were left visible, such as at the top of the tower where the primary vertical supports converge and connect through the introduction of an additional element. Here, the expression of the joint helps tell the story of how the structure works. Let us examine each of these conditions in order to see how the previous projects informed their design.
Using layout lines drawn from one another, establish location.

1. Mark point of cut.
2. Mark length of cut.

Use wood blocks, cut V3 using surface of sidewalk as cutting surface.

(1) Use Japanese saw
(2) Put in Rotclamps
(3) Glue with thin or a regular vaseline. Coat with double-stick tape. V3 to open side, wipe away glue, sand before gluing.
At each of the three bases, four structural members converge. In order for these members to be assembled and disassembled without glue, a hidden and interlocking joint was designed. Two of these members, here referred to as vertical 1 (V1) and vertical 2 (V2), are connected via a simple mortise and tenon joint. The tenon, cut from V2, has additional mortises cut from its side faces. In this way, tenons cut from two adjacent vertical members, V3, lock V2 in place when assembled. This interlocking joint is totally concealed within the mortise cut from V1. Sections cut through this joint can be seen on the bottom right of the adjacent page. To lock V1 and V3 together, brass pins are inserted through V1, passing through the tenon of V3. These exposed brass pins are the only visible traces and clues as to how this joint works.

At this bottom location, forces from above are collected at a single location. It was believed that by hiding this connection, the joint would appear less “busy”, and the resolution of forces at this single location would be made more clear. This idea is similar to the hidden mortise and tenon joint between the vertical and rear legs of the first piece.
At the top of the tower, an additional element was designed to facilitate the joining of all three primary structural members. This is similar to where in the first object an additional element was added to connect the top cantilever with the vertical support. Much sketching, modeling, and trial and error went into the design of this connection. This location, at the top of the structure, represents an important point where forces converge and are redistributed to the ground through high strength steel tension cables. The secondary element introduced here functions as a “keystone” for the entire structure. Concealing this connection did not feel like the correct thing to do. Inspired by the original theme, it was felt more appropriate to make visible this convergence of forces through the design of this joint. This was accomplished by designing a stopped and open dovetail between the tops of the vertical members and the top connecting member. By contemplating this joint, discovering how it works should become apparent.

The top connecting member itself consists of three separate segments. In the side of each segment were cut half of the stopped dovetailed mortise. Thus, when all parts were assembled and this top piece was locked together through the addition of spline connections, all three vertical members were securely locked in place through induced tension being applied through the steel cables to the ground. The idea behind this connection was that the steel cables, attached to the bottom of the spline connections, would draw each of the three top segments together and provide a strong lock on the top of the vertical members. In the actual making of this model, however, there was not enough tolerance to cut these splines in a manner to accomplish this. Thus, where the splines join the top member is the only place where glue was used.

Another important aspect of this top connection was the design decision to leave an open space where all forces collect at a single point. By leaving this location open, the eye is inherently drawn to this point and its importance in the structure is more clearly expressed.
There are a few locations in particular where, upon reflection, the joinery design could be improved.

First, where the roof connects to the primary vertical support, there needs to be additional material to make a stronger joint. The sides of the open mortise here do not possess adequate strength, and the intended dovetail joint could not be made because of tight tolerances. If this connection took place within the entire thickness of the vertical support, neither of these problems would have arisen.

Second, where the cantilevered floor beams meet the vertical supports, there should have been additional material added underneath this beam to make stronger its support. In this way, material need not have been removed from the vertical support itself.

Third, the connection between the secondary roof beams and vertical supports, V3, proved to be a difficult connection involving compound angled cuts and tight tolerances. Although this was a difficult joint to make, I do believe it would work at full scale. The alternative here would be to design an intermediate member, much like the top piece, which would aid in connecting all three converging members.
Through the second project was learned the importance of paying attention to the nature of relationships between individual elements and their relation to the whole. Thus, this idea was applied to aspects of the tower design. In establishing the hierarchy of the structural system, it was decided to more clearly express the different role of each individual member. Although each beam is curved in elevation, the tower itself is derived from the specific geometry of an equilateral triangle. The base for this model was constructed to reflect this geometry. Each of the three tripod bases is located along a line extended from an apex through the midpoint of its opposite side. Of the four vertical structural members rising from this point, two stay within the plane defined by this midpoint while two diverge at ninety degrees and follow a path towards the apex of the triangle. At this apex these columns converge and join with a roof beam.

In designing the tower, this roof beam was intentionally located at a level below that of the roof beam connecting the previously described vertical structural members. By locating these beams at different elevations, their role both visually and structurally was more clearly expressed. Also, the relationship between these two sets of roof beams to each other and to the structure as a whole becomes more apparent. If located at the same level, their diverse roles in the tower would be more difficult to perceive.
Conclusion

Through applying lessons and discoveries from the previous two objects while remaining within the boundaries defined by the original tectonic theme, a particular elegance became apparent in the tower. This elegance was not something intentionally designed, but a logical result of the above process itself. Thus, the elegance and sensual nature of the tower is a direct result of tectonic expression, where the structural concept is realized through a particular construction. This combination has an effect on us because some aspect of the intangible structural concept is tangibly revealed through construction. The resulting expressive form of the tower is a direct product of this tectonic relationship.

The choice of a glulam structural system concentrated supports into a minimum number of elements. In turn, the joinery used to connect these elements used a minimum amount of material, with the natural force of gravity assisting where possible. Additionally, the curve of the glulams themselves lend a certain grace to the structure. These lines are themselves repeated many times within the beam itself, defined by the many individual lines of lamination. The eye is naturally drawn to these lines and follows them to their connections, where they converge and end in a variety of ways depending on joint type and location within the tower.
Reflection

This thesis investigation encompasses work done over the course of a year, yet in no way is it a finite thing. As stated at the beginning of the book, the aim was not to produce a desired object or project as an end result, but to explore the realm between these objects and the ideas from which they evolved. On a personal level, this investigation is just a beginning. It is my hope that the lessons, discoveries, and ideas explored here will continue to evolve and enrich my understanding of architecture.

I am grateful for the time spent in Blacksburg, the many friends I have made, and the unique opportunity to explore these ideas under the “constrained freedom” that this graduate program has offered. In leaving, I make no attempt to define architecture or describe a position in architecture. In no way am I willing or able to be so bold. I do believe architecture to be immensely powerful, having the ability to transform the ways in which we live in and relate to the world. Architecture, done well, is nothing short of magic.
Photographic Credits

5. “Slab of wood and chairs”, The Soul of a Tree, George Nakashima.
* (all other photographs by author)
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