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A Tree for a House
Designing for *Super-Mobility*

The Craig VanLaanen Treehouse and Woodland Retreat is for children requiring ventilator assistance and who often need wheelchairs. The unique parameters considered in designing a space for these children gave rise to the concept of super-mobility. Working together with a team of volunteer professionals, the designers developed the concept of super-mobility and its relation to the sensory experience of the retreat. A major component of the project is the branching column, which is the tree for the house.

> *Art and architecture are practices, not sciences. The constructions of science aspire to universal application. Pictures and buildings need only work where they are.*
>
> Dave Hickey[1]

Introduction

Even in an image-saturated world, we still understand space through all our senses in addition to the visual; we comprehend and experience our surroundings by using our tactile, auditory, olfactory, as well as visual senses. When current architectural discourse is strongly influenced by two-dimensional imagery, how can we as architects challenge this cultural emphasis, and how can architecture engage in a physical, tangible, yet visual way?

The Trail's Edge Summer Camp near Mayville, Michigan, is situated on former agricultural land with no large trees. Faced with the paradox of a client who wants a treehouse but has no tree to support it, we designed a treehouse resting on an *ersatz* tree: a steel branching column. The asymmetrical column supports a 300-square-foot treehouse 22 feet in the air, nestled between the trunk and a large branch of the tree.

This article discusses the treehouse project from three perspectives. The first perspective is that of a building and a woodland retreat designed to engage the user in a physical, tangible way and to stimulate multiple sensory experiences, particularly through the concept of super-mobility. Second, this article discusses the process of design with emphasis on digital design methods, supplemented by more traditional design methods. The design of the retreat included several opportunities to investigate digital craft, exemplified here by the branching column. A discussion of design precedents helps to contextualize the branching column and the design process. Third, the article explains the development of the Treehouse and Woodland Retreat area as a community-based, volunteer effort in which conveying the perceived sensory experience of the architecture became crucial in making a volunteer-driven project innovative in design.

Super-Mobility: Moving into Tactile Space

In 1989, the University of Michigan's C.S. Mott Children's Hospital began a volunteer-run summer camp for pediatric ventilator patients, about half of whom need wheelchairs. The first of its kind in the United States, Trail's Edge Camp gives the children who attend it an opportunity to participate in activities from which they are otherwise restricted, including horseback riding, hot air balloon flights, and, once even, a trip on a Harley-Davidson motorcycle. By offering these activities, the camp, spearheaded by a uniquely energetic director, created an environment in which anything was possible. Thus, the camp volunteers were accustomed to perceiving the seemingly impossible as merely another challenge. In this spirit, a group of tree climbers set up harnesses configured to support people with mobility needs, allowing the campers to rope their way up into the woodland canopy. The children were exhilarated by the experience of being in an environment they had only seen from the perspective of their wheelchairs. They wanted to stay up there, to look around. They wanted a treehouse.

After camp ended in 2002, the director, Mary Dekeon, contacted the University of Michigan's Taubman College of Architecture to discuss the feasibility of developing a structure that would allow children with limited mobility to experience the height and excitement of spending time in trees. Moving beyond compliance with the American Disabilities Act, beyond modifying pedestrian-friendly designs to meet the needs of the differently mobile, the design team developed a structure that would allow all users to experience super-mobility, regardless of physical restrictions or limitations.

Super-mobility, or unexpected mobility beyond an individual's perceived capabilities, is made possible in the treehouse through an array of body prosthetics, including harnesses, ropes, tracks, and race car seats. Everyone entering the treehouse uses these prosthetics to be "launched" 22 feet into the air, leaving wheelchairs and other terrestrial implements behind. (Figure 1.) Developing a structure that minimizes differences between users was a high priority for everyone involved. Although wheelchairs allow users greater mobility, they can create problems in social interaction. Difference in eye height, for example, between someone sitting in a wheelchair and someone standing, creates separation between the two people. Recognizing that unfamiliar

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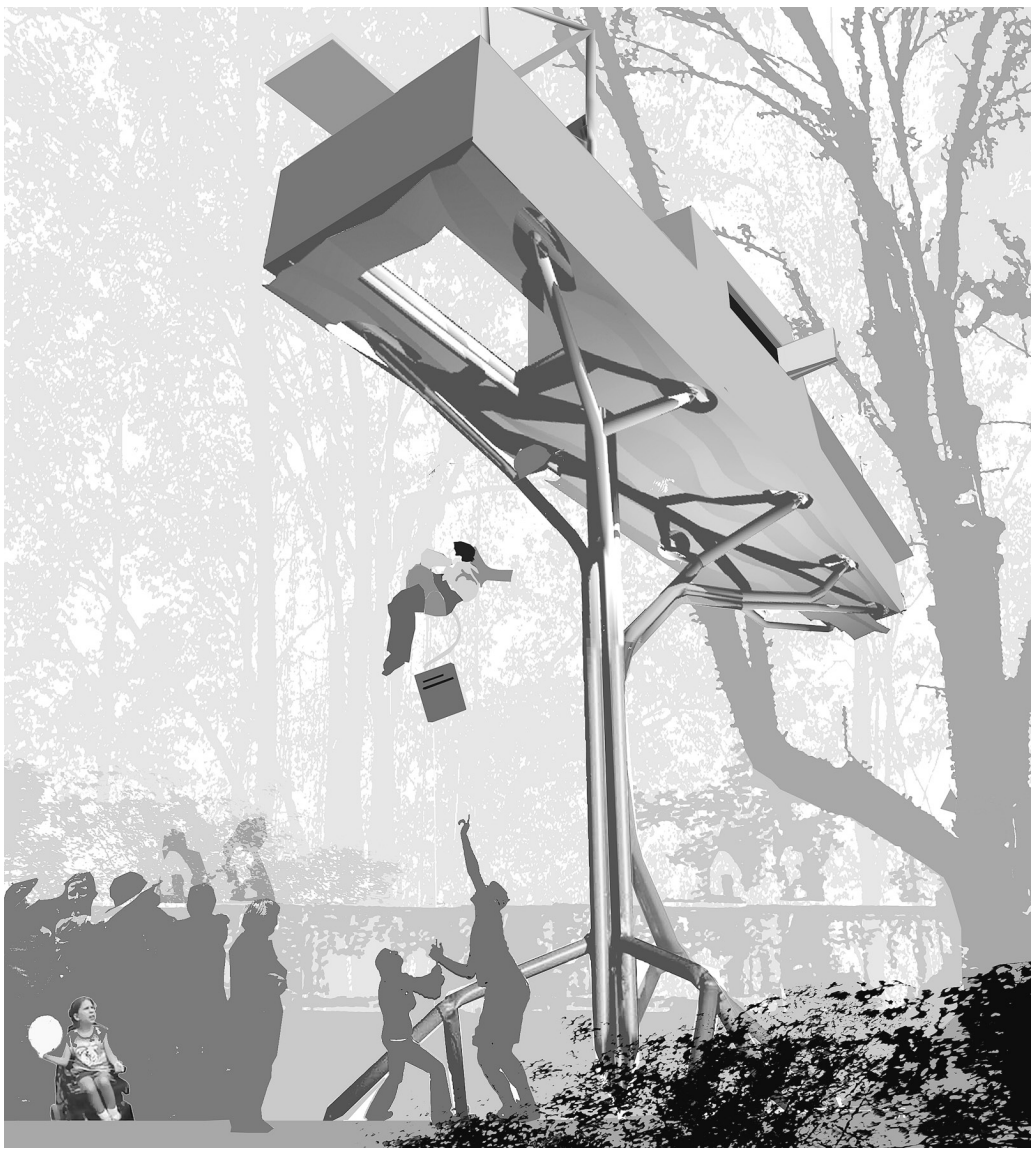


1. The branching column is the main innovation of the treehouse. Constructed of steel pipe, the branching column supports the house and provides the hoisting point for accessing the treehouse. Quadriplegic children as well as others use tree-climbing equipment to access the house.

but similar experiences can help alleviate this disjunction, the team developed a structure that is accessed the same way by everyone and that displaces the body from the normal horizontal orientation of walking or forward motion in a wheelchair to the vertical orientation experienced during a hoisted assent. (Figure 2.) In this way, super-mobility is experienced in the same way by the severely handicapped and the ambulatory.

But super-mobility allows an experience beyond that of being hoisted up in the air; this elevated location provides a new understanding of the surrounding area. Making contact with the surroundings through the senses, kinesthetically and visually as well as in a tactile way, super-mobility allows the climber to enter tactile space.[2] In his 1966 book *The Hidden Dimension*, E.T. Hall describes tactile space by making an analogy with the experience of sailing a boat: "the interplay of visual, kinesthetic, and tactile experiences. A friend who sails tells me that unless he has his tiller in his hand, he has very little feeling of what is happening to the boat. There is no doubt that sailing provides its many devotees with a renewed sense of being in contact with something, a feeling that we are denied by our increasingly insulated, automated life."[3] In the treehouse, the dramatic ascent of the climber being hoisted up into the air alludes to a similar quality of experience. Hovering in the air, above the familiar ground, while safely contained in their harnesses, the children, similar to the sailor at the tiller in Hill's description, have a "sense of contact" with the surrounding woodlands. Similarly, the treehouse resting on its branching steel column blurs the distinction between building and context. It is part house, part tree. The children who are otherwise limited in their mobility become uninhibited, and in this way experience an exhilarating journey to a house that is especially theirs.

Access: Boardwalk as Viewing Prosthetic

As the treehouse is part tree, part house, blurring the distinction between site and context, the Woodland Retreat seeks to do the same. Just as one kinesthetically experiences tactile space while rotating on the rope during the assent to the treehouse, the

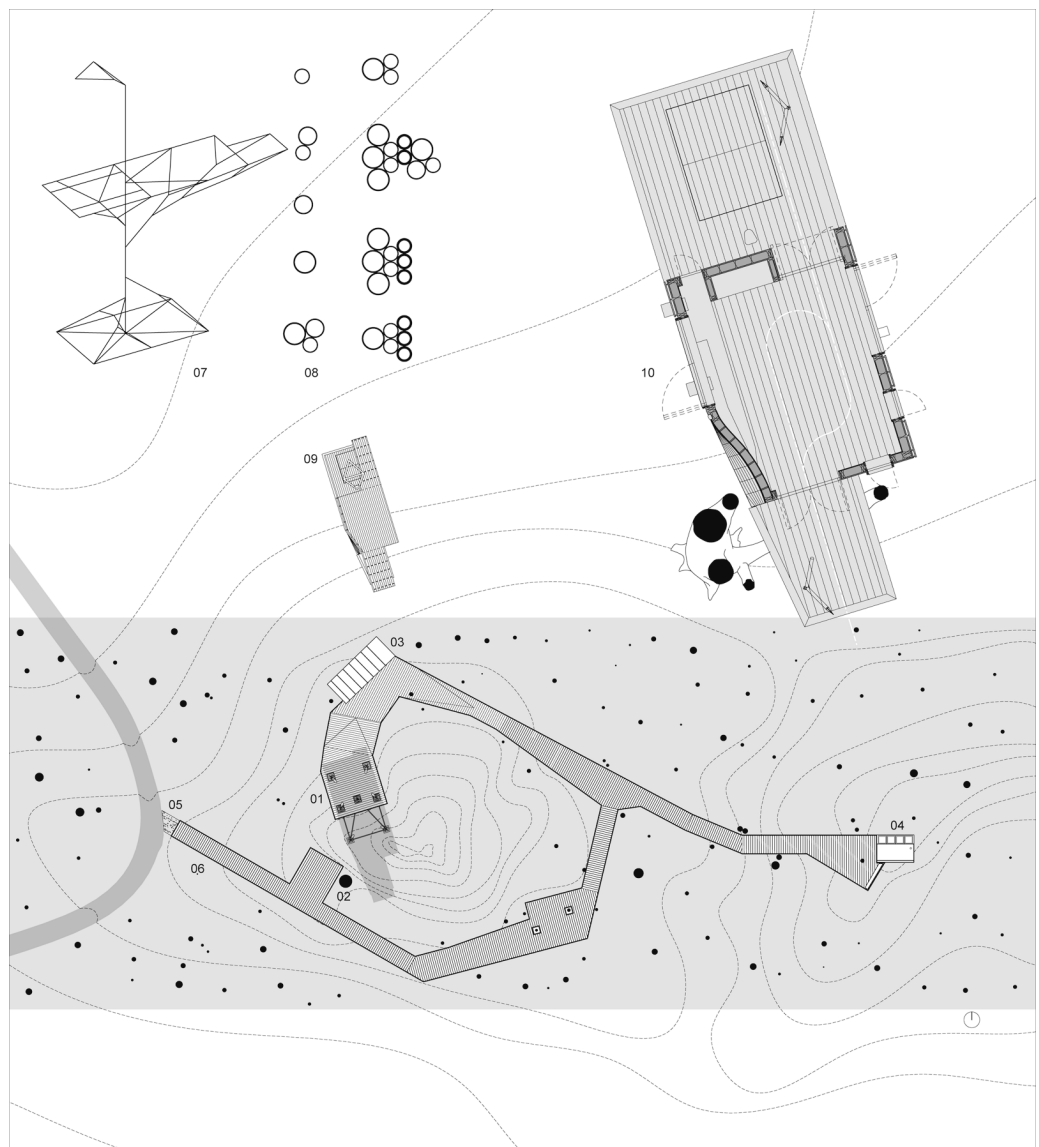
boardwalk approach produces a similar kinesthetic experience. Circumnavigating a bowl-shaped depression and passing beside both the tree and the treehouse, the design of the boardwalk enhances the experience of the site in multiple ways. In the larger context, the boardwalk is a gauge, a level datum that accentuates the perception of an undulating Midwestern landscape. Locally, the boardwalk serves as a sequential viewing platform while encircling the treehouse before arriving at the launching platform. Maintaining accessibility, the boardwalk is separated from the surroundings by its continuous level, but the inclusion of trees and the thin lines of steel and cable railings serve to blur the visual and tactile boundaries between the built structure and the surrounding environment.

The tactile space around the climber extends to include the spectators on the boardwalk. In objectifying the subject, we are reviving an architectural mechanism similar to that of Adolf Loos' in Villa Müller, described by Beatriz Colomina: "Architecture is not simply a platform that accommodates the viewing subject. It is a viewing mechanism that produces the subject. It precedes and frames its occupant."[4] For the camper, who is the occupant in this context, the experience of climbing is as much about climbing as being viewed as a climber. In this way, the boardwalk as well as the treehouse can be perceived as a prosthetic that helps the user to achieve super-mobility. Similar to Colomina's reading of the Müller house, the boardwalk as a viewing mechanism dramatizes the climbing event by wrapping around the treehouse, widening out for spectator viewing and seating, then passing by the wheelchair hangar, before arriving at the launching platform directly under the treehouse.

A Treehouse, but No Tree?

The treehouse is situated next to a red maple that the volunteers named Reta.[5] On the edge of a bowl-shaped depression in the landscape, Reta

2. Installations at the Woodland Retreat: 01 — Treehouse. 02 — Reta (red maple). 03 — Wheelchair hangar. 04 — Moon house (restroom). 05 — Front step (entrance). 06 — Boardwalk with viewing platforms. 07 — Wire frame model. 08 — Member cross sections. 09 — Roof plan. 10 — Floor plan.



3. The initial design concept sketch. This image did much to both convey the design intent as well as to excite the volunteer workers.

stands in the middle of a grove of deciduous trees including aspens, cherries, and an occasional maple. In this context of new growth, where most trees are less than forty years old, Reta stands out in her relative bigness, with her 70-feet-tall canopy and a large branch that cantilevers off of the trunk about 6 feet above ground. During the initial design phase, an arborist tested Reta's condition and found that it could not support the weight of a treehouse.[6]

Faced with the arborist's assessment and perhaps inspired by the unquenchable spirit of the volunteers, the design team began work on designing the treehouse as a free-standing structure nestled between Reta's trunk and branch. Several structural systems were discussed in the interdisciplinary group of faculty and students, but, true to the first sketch, we arrived at a single column structure. (Figure 3.) The single column supports the treehouse branches.

Branching Column

Alluding to the archetypical form of a tree, the spreading "roots" of the treehouse make sense in the context of poor soil conditions. The five-point anchor system leads foundation loads away from Reta's roots while still allowing the column to be placed quite close to the tree. Also, the tree-like structure of the branching column appealed to the volunteers. As an architectural oddity, the form was somehow familiar to them. Perhaps because of its reference to the archetype, it tapped into an understanding of form that lies beyond their everyday understanding of architecture. It is "magic" as one of them said. The enchantment of camp provided the right context to propose this unique structure. The column, in the context of the woodland, underscores its archetypical form juxtaposed to its formal origin. Again, the design of the treehouse is blurring the distinctions between existing context and built object.

Although branching columns are not a particularly new structural type, they are certainly less common in our contemporary, frame-and-truss-

dominated culture. Morphologically, a branching column is an open cell system.[7] Unlike trusses and closed cell frames, the members branch outward but do not come back together to form closed cells. Starting from a base, the members divide at nodes into two or more continuing members. With this outward branching, the number of members increases as they spread out from the origin. The many small twigs collect the load and funnel it back to a single support. Branching systems are usually loaded only at the ends of the highest branches, and transmit the collected load back through the nodes to fewer and fewer members until a single support is reached. At Trail's Edge, however, in response to both the poor soil strength and the cantilevered load produced by the treehouse, the team designed a structure that branches both upward to carry the house and downward with root-like branches to the ground. To avoid damaging the existing maple tree, the upper portion of the treehouse is cantilevered though the branches and the lower portion gives clearance to the tree's root system.

Column Precedents

Although branching columns are relatively unknown in the United States, examples have been appearing in Europe, and in particular Germany, in recent decades. Inspired perhaps by the work of Frei Otto at the Institute for Lightweight Structures (IL) at the University of Stuttgart, several examples of branching columns can be cited in both wood and steel.[8,9] One of the largest steel structures of this kind covers the main terminal building of the Stuttgart airport.[10] Each of the nine branching columns supports approximately 8,700 square feet of roof by way of forty-eight load-gathering "twigs." The base of each column is a bundle of four pipes that split into branches at cast steel nodes.

The branching columns of the Stuttgart airport terminal influenced the design of the treehouse in some of its detailing, in particular the pinned connections and bundled base. A major innovation in our column structure can be seen in the treatment of the nodal connections. Rather than cast connections as used in the air terminal, the branches in the treehouse are joined by continuous, radius bent pipe. This results in more treelike connections and better evokes the image of a tree. The eccentric placement of the central column in response to the hoisting point of the treehouse also changes its support requirements at the base.

Steel tree columns have also been used for support in bridge structures. Examples can be cited in Frei Otto's 1991 study of an elevated track for the Maglev super train,[11] as well as several small- and medium-span bridges by Jörg Schlaich, well known for his long-span, cable-stay bridges around the world.[12] Pragsattel II over the Pragstraße in Stuttgart, Germany, uses four tree columns to carry pedestrians over the divided street. These bridge supports, being close in scale to the treehouse structure, were also shop fabricated and assembled on site. Ease of erection was likewise a consideration for the treehouse project, because of the remoteness and lack of power at the site.

An elegant example of a branching column in wood is the Solamar brine baths at Bad Dürrheim in the Black Forest of Germany.[13] This design uses formed Glulam timber "trees" to support ring beams forming the high points in a doubly curved wooden shell. In the design of the branching column, the nodes as elements disappear as the laminated wood bifurcates to form the smaller branches. This is similar to the technique employed in the treehouse, where the continuous pipe was radius bent, rather than welded to separate nodal elements. Unlike the treehouse, however, in the Solamar tree, the central trunk is a radially spaced column. This technique was found to be unnecessary in the treehouse due to the shorter buckling length and moment-reducing base supports of the structure. Formally deviating from the symmetric Solamar precedent, the bundled section of the treehouse further emphasized the asymmetrical, treelike shape of the column.

Although the treehouse column lends from the steel and wooden precedents just mentioned, it is distinctive and unique in its form and construction method. Constructed using three diameters of continuous bent pipes (4, 5, and 6 inch), the treehouse has both asymmetrical form and bundled sections. A column tailored to a tree makes it a one-of-a-kind structure. Designing it was an inquiry into studying the precedents, digital craft, and testing with physical models.

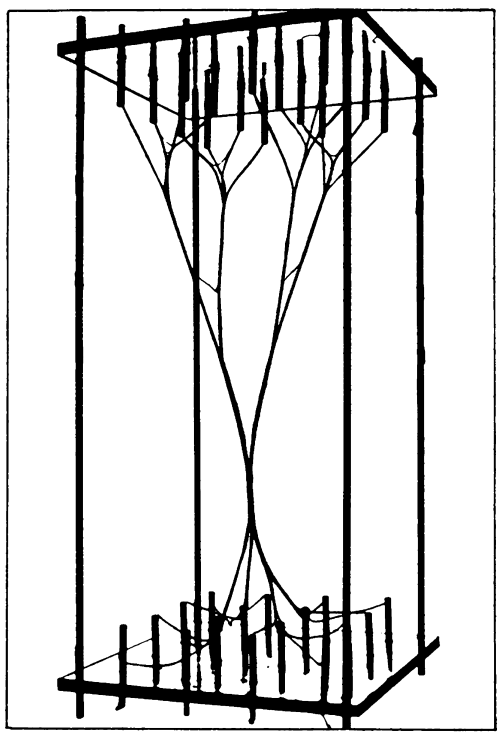
Designing the Column

Designing tree structures blends art and science. Like many structures in which the form is closely linked to the structural behavior, physical modeling techniques provide the designer with invaluable aid in determining the form. More familiar examples of such form-finding models are soap film models used to explore membrane structures or catenary nets used to develop thin shells. For branching systems, one such form-finding technique uses thread models. Although not always as repeatable in the results as the surface modeling techniques previously mentioned, thread models have been successfully used in the form-finding process.[14]

Design exploration techniques using thread models have been explored by Marek Kolodziejczyk at the Institute for Lightweight structures (IL). The models use cohesive threads to generate branching geometries. (Figure 4.) In this technique, slightly over-length threads are fixed between end points. The entire model is then dipped in a liquid solution and removed. The threads then pull together by surface tension to form a branching geometry. This technique can be applied to two- and three-dimensional models, and the generated forms can be controlled to some extent by the amount of slack placed in the threads. The geometries are not entirely unique, particularly when many threads are present, but they do supply a suitable initial form that can be improved with successive analysis.

Jügen Hennicke, another longtime IL team member, has done extensive research on branching

4. Branching structure study model by Marek Kolodziejczyk. (Photo courtesy of ILEK Archive, University of Stuttgart.)



structures.[15] He developed a device that allows both end points and intermediate nodes to be adjusted by the designer. Hennicke's form generator is also based on tensioned threads. It has the advantage of being able to rapidly explore a family of geometries by sliding node points to different positions, but requires more tedious rethreading for changes in topology such as different numbers or arrangements of nodes and members.

Similar techniques to those of Kolodziejczyk and Hennicke were used for the form finding of the treehouse. Students were acquainted with the thread-modeling techniques, which they then used in exploring the column geometry. Several thread models were made to explore the placement of the main column and angles and placement of the branches. Study models were made with tensioned cotton threads and then dipped in resin upside-down to set a permanent form. After finding a trial form, the geometry from the thread model was entered into an AutoCAD 3D model. From this format, the geometry data could be electronically manipulated and read into STAAD.Pro, a structural analysis and design program, which was used for the finite element analysis. By going back and forth between the STAAD and the AutoCAD 3D models, the structural results were rendered to assure that the load-bearing requirements, interference criteria, and formal intentions were all met.

With the geometry designed and analyzed, we built a 1/2" = 1'0" (1:24) structural model to check the behavior predicted by the analysis. (Figure 5.) The tactile understanding of the loads verified the STAAD analysis. The model was also useful in communicating the form of the column to the fabricator.

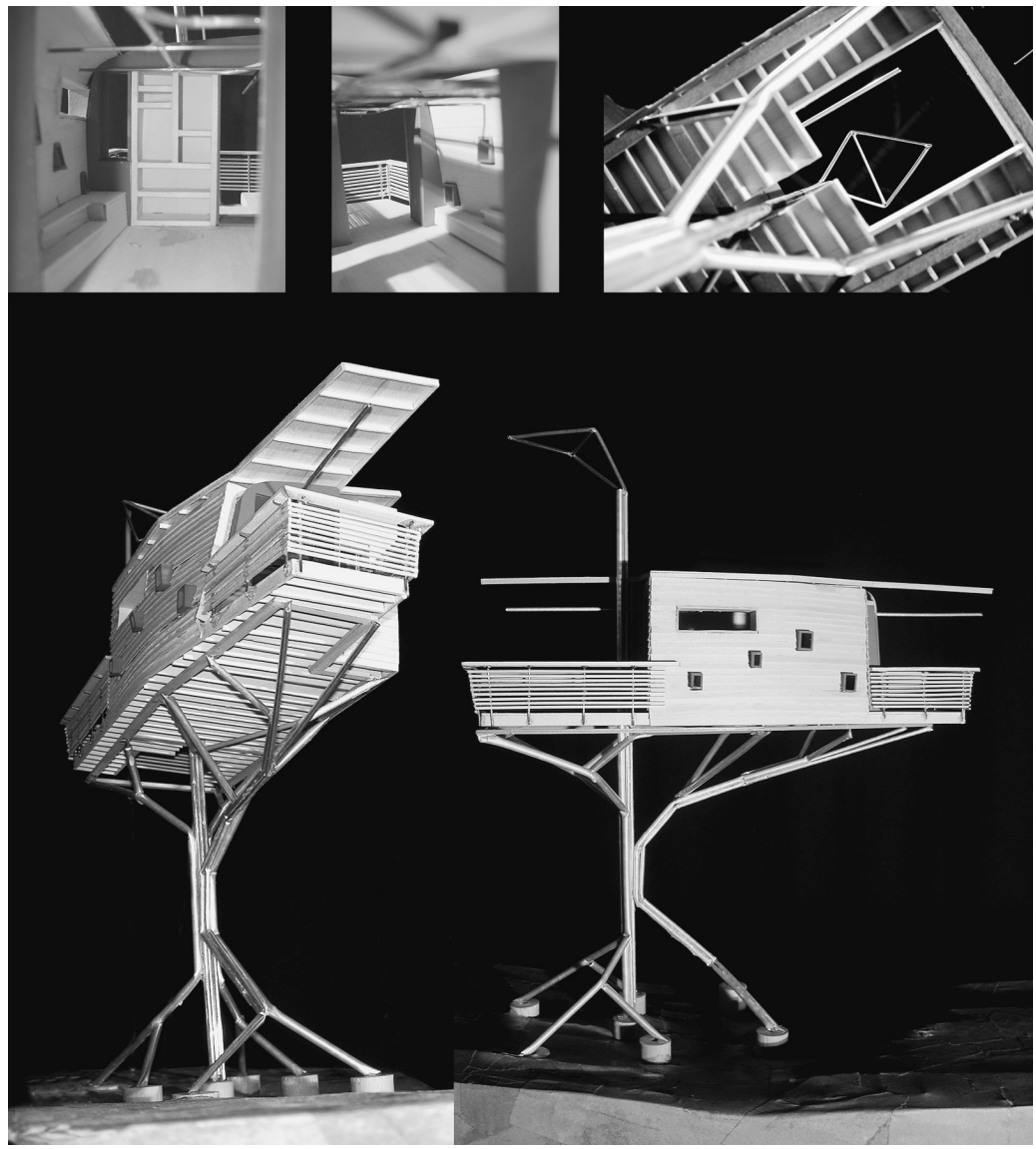
We sized the pipe members of the treehouse to carry both the environmental code loadings for Michigan as well as some not-so-typical live loads. To accommodate the hoisting of visitors into the treehouse, we incorporated a lift point into the top of the column and centered above the entrance. To carry the eccentric load of the house itself, we chose steel pipe as both an economical and versatile material for the connection detailing. The team decided to construct the branching column using continuous steel pipe rather than the more typical discrete nodal connections. In concept, we treated the tubular steel in much the same way as the threads of the initial trial models. We designed the pipes as continuous elements from top to bottom. Where the pipes come together, they form bundles, which are welded full length. The design of the pipe sizes strikes a balance between criteria of stiffness and minimum bend radii as well as economy of size. The three sizes chosen fulfilled these criteria and were compatible with the fabricator's capabilities. Naturally, beyond the pragmatic aspects of actual construction, the overall aesthetic of the column's form and proportions was a guiding factor in the design of the treehouse.

When designing a 40-foot-tall column for a wooded site with limited access, the onsite assembly must be carefully considered. For ease of transport, the fabricator split the tree at midheight. Similar to the procedure used by Schlaich in his bridge erection, the fabricator welded a sleeve joint into the pipe sections, which allowed for precise reassembly onsite. (Figures 6 and 7.) The section of the mast above the deck of the treehouse was also sleeved and welded onsite. The attachments at each end of the branches were pinned. This detailing is again similar to the Stuttgart air terminal, which supports a tubular frame roof grid. In the treehouse, the tubular frame deck became the base of the actual "house" portion, which rests above the branching column.

Academy and Community: Communicating Architecture

The Craig VanLaanen Memorial Treehouse was a community project in which all material and labor were donated, including design, analysis, fabrication, and construction. In this way, the treehouse offered an opportunity to challenge existing conventions of both practice and design process. Because the treehouse was entirely funded by donations and built by volunteers, it offered an extraordinary opportunity to provide a link between the academy and the community. The augmented design team comprised a range of professionals who engaged in a design process that was both open and collaborative.

In biweekly meetings, the resource group provided valuable input into the design process, offering both faculty and students practice in verbal and visual communications skills. A combination of freehand sketches, physical models, and digital



5. Scale study model of the complete treehouse (1:24). Interior details showing built-in furniture and suspended track system. View of hoisting point, upward from launching pad.

renderings were used to communicate. In this environment, volunteer professionals such as medical personnel, landscape architects, contractors, engineers, tree climbers, and camp staff freely shared their knowledge. Not only did the volunteers provide input, they also took part in the design process by surveying the site, building mock-ups, and commenting on project details. Students, faculty, volunteer professionals, and community members all took ownership of the project and made possible the production of an innovative product that exceeded the imagination of any one person.

The design team consisted of two faculty members (the authors) and two graduate students at the University of Michigan. Although the students were working on the project in conjunction with a design seminar, the exchange of knowledge expanded beyond the usual teacher-student relationship and became more collaborative. The role of architect differed from that typically taught in architecture schools: the design team led a collaborative group of professionals from a variety of fields in the production of a complex product. Collaborative design development was absolutely essential to the success of this project. In the tree column itself, for example, the height of the branching structure is tailored to the height recommended as safe by tree climbers, and the choice of a multiple-tube section as opposed to a single section is based on the know-how and experience of the steel fabricator, Weld/Con, Inc., a business that produces tubular cooling elements for steel manufacturing processes. The initial form of the branching column came from the thread models, but it had to be refined by further information gained in the STAAD analysis. In preliminary design meetings, all those present took an active part in the development of solutions and adjustments to the design. Creative ideas and ownership were shared by all project members, a key aspect that encouraged volunteers to devote time and resources toward the community project. In this collaborative atmosphere, existing boundaries between the academy and community, as well as borders between professionals, were blurred. The team-based, open, and collaborative processes allowed for the development of a design that went beyond current notions of accessibility and allowed

6. Second stage of erection: lifting the branches and deck into place. The junction on the central mast was sleeved for assembly and welded. The seam is staggered as can be seen on the rear branches.

7. View of the top half of the column onsite before assembly.

the concept of super-mobility to become a reality for children attending Trail's Edge Camp.

Conclusion: A Treehouse for the Senses

Although the treehouse is multifaceted and complex in its execution, its community relations, and its educational value, its main intent is to create a sensory experience for all dwellers, mobility issues aside. In contrast to a cultural emphasis on the visual, we seek to build the experience through physical, tangible, spatial relationships. In that way, the treehouse seeks to fulfill sensory requirements that are embodied in the project rather than made explicit. This architectural approach is based on an understanding of architecture as material practice in

which contemporary production methods promote innovation in design. An example of material practice is within the geometry of the column that heightened the multifaceted sensory experience through its archetypal form. Within this framework of community and academy, we developed a retreat in which the experience allows architecture to engage the dweller in a sensory way.

Acknowledgments

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Notes

1. Dave Hickey as quoted in Stan Allen, *Practice: Architecture, Technique and Representation* (G + B Arts International, 2000).
2. Tactile space is space that is perceived through more than just the visual sense. It is understood to be an intellectual perception as well as kinesthetic. Although on one level *tactile* means touch, one can also be in "contact" with the space and understand it through bodily movements.
3. Edward T. Hall, *The Hidden Dimension* (New York: Doubleday, 1966), 61.
4. Beatriz Colomina, *Privacy and Publicity: Modern Architecture as Mass Media* (Cambridge, MA, and London: The MIT Press, 1994), 250.
5. The Fowler Center where the treehouse is situated was founded by Jack Fowler in 1957. The tree is named after his wife, Reta. Camp is very much about building myths, and naming the tree is only one of these myths created around the treehouse.
6. Arborist Kay Sichenender of Owen Treeservice volunteered her professional knowledge. Much like a EKG, Kay used a resistograph drill where the motor is connected to a writer that transferred the resistance of the motor on graph paper. With a 12-in. drillbit no more than 1/32 in. thick, she drilled to the core of the tree at several spots to evaluate its condition. Kay found that, although the tree was in relative good health, it could possibly split in its trunk if weight were added. Based on this, we decided to develop a freestanding structure.
7. Siegfried Gaß and Jügen Hennicke, "Truss Work, Tree Column, Space Net: Remarks on Branched Structures in Nature and Technics," *Weitgespannte Flächentragwerke: 3. Internationales Symposium*, Proceedings, Sonderforschungsbereich 64 (SFB 64, 1985): 39–51.
8. Ludwig Glaeser, *The Work of Frei Otto* (The Museum of Modern Art, 1972), 78–79.
9. Renamed the Institute for Lightweight Structures and Conceptual Design (ILEK) and under the new directorship of Prof. Dr. –Ing. Werner Sobek since 1995 (http://www.uni-stuttgart.de/ilek/home/english.html).
10. *Stahl und Form: Flughafen Stuttgart GmbH*, Stahl-Informations-Zentrum, Institut für Architektur-Dokumentation (München, 1991), 1–17.
11. Frei Otto, Bodo Rash, Gerd Pfafferodt, Adelheid Gräfin Schönborn, and Sabine Schanz, *Frei Otto, Bodo Rash: Finding Form, Towards an Architecture of the Minimal* (Edition Axel Menges, 1995), 164–65.
12. Alan Holgate, *The Art of Structural Engineering: The Work of Jörg Schlaich and His Team* (Edition Axel Menges, 1997), 236.
13. Götz Gutdeutsch, *Building in Wood: Construction Details* (Basel: Birkhäuser Verlag, 1996), 45–49.
14. Jürgen Hennicke, "Structural Trees: Comments on Some Fundamental Design and Construction Aspects of Tree-Like Branching Columns," *Bulletin of the International Association for Shell and Spatial Structures* 36/2 (1995): 124.
15. Ibid., 124.