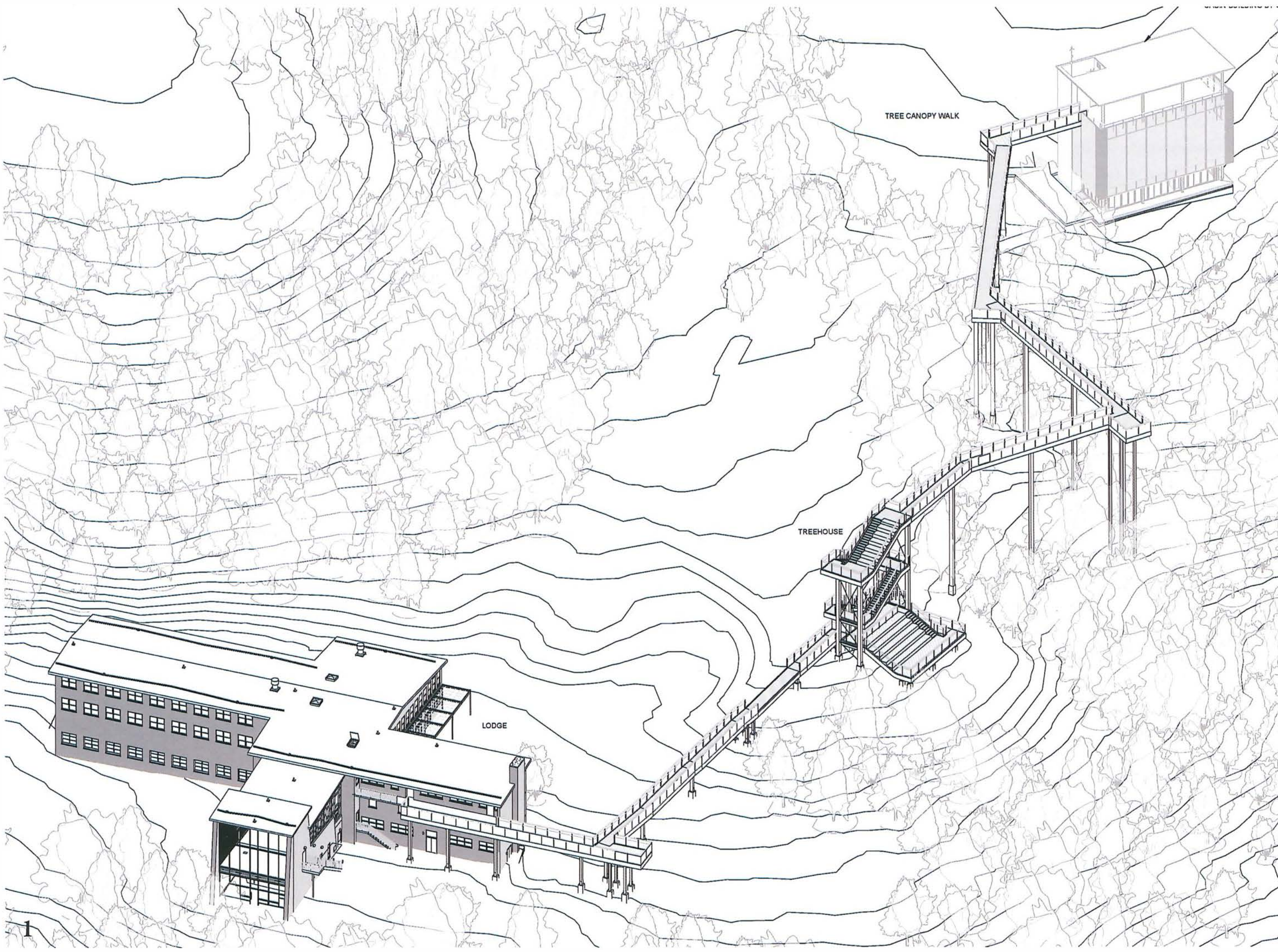

All figures Tim Diener unless otherwise noted

Tree Canopy Walk: No Walk in the Park

THERE'S a kind of sniff test for a proper timber framer. Ask anyone you know who works in the field about the most salient attributes of a timber framer and you're more likely than not to get them talking about "passion," "dedication to craft," and the like in the first minute or two. Timber framers do tend to be a genuinely passionate tribe, and that is never more in evidence than at the prospect of a new project. The Kean Skylands Tree Canopy Walk was just the sort of project to quicken our pulses and get our minds racing.

To be sure, this project wasn't your typical timber frame; in fact, it was more unlike a timber frame than any project we at Lancaster County Timber Frames have ever taken on, consisting entirely of glulam and steel components. It's a sprawling structure, meandering for nearly a fifth of a mile through the treetops on a minor mountaintop (Fig. 1). The owner, Kean University, had purchased an old lakeside monastery complex atop Mount Paul in Oak Ridge, Jefferson Township, in northern New Jersey, to convert into classrooms and offices for its expanding school of environmental studies. The Tree Canopy Walk was to be a major focus of this satellite campus, and a showpiece for the university as a whole.

When we first review drawings for a project such as this, so far removed from our normal fare, our reactions themselves are a study in complexity. On one hand are trepidation and timidity, thinking that we have no business at all getting involved in a project like this, while on the other it's more of a salivating, raring-to-go, lemme-at-'em, more-gumption-than-common-sense kind of attitude. In this case, the latter attitude prevailed. This article is an attempt to document the consequences of that choice.

Some, but by no means all, of the hurdles were in full view even before the ink had dried on the contract. The first was the bid deadline (sometime in October or November 2016)—it had already passed, apparently with no bidders willing to take on the scope sought by the general contractor. As of early December 2016, when the bid invitation landed on our desks, the only parts anyone had bid on were the railing posts and grab rails, and the electrical system. The general contractor was looking for a company that could manage all

1 The architect's conceptual model, showing the existing "Lodge" building (lower left of figure) and the proposed "Cabin" terminus building (upper right), presently under construction, with the "Tree House" tower midway along the Tree Canopy Walk.

other aspects of the project apart from the foundation work. That scope consisted of all the steel components (some 20 tons of post base connections; struts; braces; I-beam assemblies, some over 30 ft. long; etc.); glulams; solid timber joists; more than 6000 square feet of exotic hardwood decking; composite stair and bleacher stringers; and railing caps of the same material as the decking. In all, there were nearly 900 steel assemblies, more than half of them unique in at least some minimal way; 104 glulams (totaling 41,000 board feet), mostly 36 feet or longer in length; and more than 10,000 pieces of hardware—bolts, nuts, washers, threaded rods, and the like.

The first challenge was to wrap our heads around the dizzying complexity of it all and come up with a bid price we wouldn't regret, though there wasn't any time left on the bid clock to carefully consider the project from all angles to find that price. The general contractor thought the two weeks left until Christmas ought to suffice. We tried to hit that mark, but there was just no way to finish accurate bid requests from our suppliers and get the quotes back in-house with the year-end holidays fast approaching. As it happened, it took nearly six weeks to get everything together to tender a proposal.

2 A small sampling of the steel used in the Tree House, shaken out in a field some 1500 ft. from the actual erection site.

3 Some of the S-curved glulams for the Tree House bleachers in our shop. The generally poor geometric accuracy of the glulams, especially these curved ones, left much to be desired, and occasioned a lot of head-scratching during layout.

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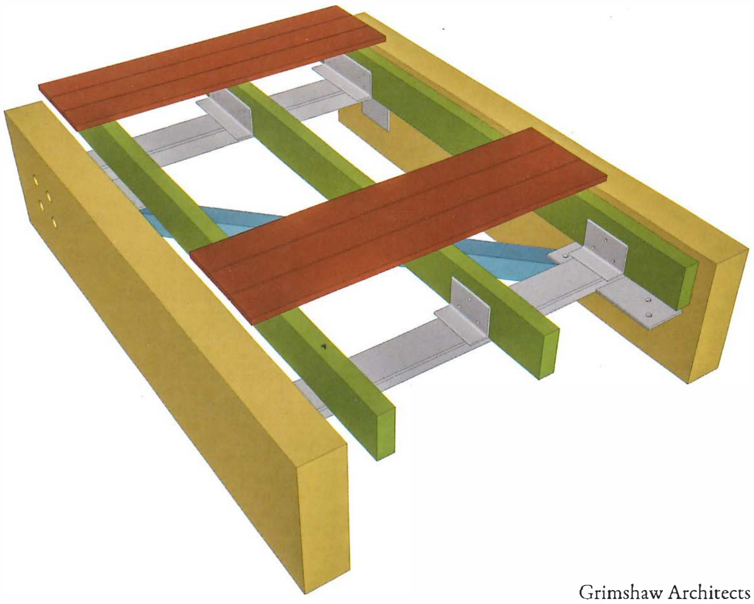
The steel was particularly grueling to bid. We modeled the entire structure—glulams and steel—in AutoCAD to try to get a clearer idea of the steel components' scope and to solicit bids from our suppliers. As much thought as we put into this part of the project, it wasn't enough. An experienced steel detailer might have pointed out the lack of repetition and cautioned against using too-generic steel assembly drawings for bid purposes. But, of course, there was no experienced steel detailer in-house, and no time to flesh out the entire design to a high level of detail (Fig. 2). It didn't come as much of a surprise that the final cost of the steel components for the project ran about 50 percent higher than the steel fabricator's quotation. A big part of that increase was the result of impending tariffs on foreign steel—whether the tariffs had been imposed at the time or not, increases in the cost of steel would end up accounting for at least 35 percent of the overall price increase on that part of the project. Thankfully, our steel fabricator was willing to sit down with us and come up with a compromise, one that inflicted about equal parts pain on both sides of the transaction.

While we were still in bidding mode, the glulams started to look more problematic as well. The architect and engineer of record had previously worked with a Canadian glulam fabricator to develop the design and specification, so, arriving late to the party, we had a lot of catching up to do. The glulams were to be pressure-treated black spruce (*Picea mariana*), but after sending the glulam specifications off to several of our suppliers, we were unanimously informed that black spruce couldn't be pressure-treated effectively, and that the engineer of record's glulam specifications were pretty much unknown to them. It would eventually come down to getting a substitution approved for an alternate species that could be pressure-treated.

The most likely candidate for this seemed to be southern yellow pine (*Pinus* spp.), for which we found a source in Alabama. The problem wasn't so much the species, which the client's design team embraced without any resistance, but in getting the engineer of record to accept that the substitution satisfied the structural design criteria. No grade of southern yellow pine could meet or exceed all the design properties of the black spruce glulams we were trying to replace. We finally ended up assuming the specification of 26F-V5 architectural-grade southern yellow pine glulams as the basis for our quote, and this is the grade of glulam that was, in fact, used for the project ("26F" signifies a maximum bending stress value of 2600 psi, and "V5" denotes a balanced layup of laminae in both the core and outer layers of the glulam). (Fig. 3).

Yet another complicating factor was the architect's selection for the decking material, a Central American hardwood called *machiche* (*Longocarpus* spp.), responsibly harvested with government certification. It's a beautiful wood, as dense and as hard as *ipe* (*Handroanthus* spp.), but more costly and harder to source. We put



Grimshaw Architects

4 SketchUp model of the full-scale segment mockup we were obliged to present to the client and their architect. The glulam stringers are connected transversely with galvanized steel T-beam assemblies. Each of these assemblies incorporated angle brackets to which the deck joists were attached, and clevis plates to which the in-plane braces were bolted.

the word out to several suppliers, and one volunteered to source the material from a government-approved sawmill in Guatemala, which guaranteed that the machiche would be aboard a ship on its way to our shop no more than four to five weeks after placing the order. The price point was attractive—other sources had given us prices that were up to three times higher. Not surprisingly, though, promises of a rapid delivery proved to be illusory, and by time the machiche decking did arrive—six months late—the schedule had already been pretty much tossed out the window.

Speaking of schedule, that was another looming hurdle to clear. In the course of contract negotiations, the general contractor apprised us of the client's expectation: to have the walkway up and ready for its occupancy permit inspection by the end of August 2017, ready for the beginning of the 2017 school year. We were having this conversation in January 2017, so we would have no more than seven months to get the walkway fabricated and erected. Even under the best of circumstances that would have been a tall order, not just for us, but for all the other subcontractors as well.

To make things even scarier, we had just signed a contract to rebuild the Blenheim bridge in North Blenheim, New York (see pp. 8–16), and that project was operating on the same demanding schedule as the Kean Tree Canopy Walk. As it turned out, handling two major projects simultaneously was one problem we were able to avoid. The bridge contract stipulated that at least 75 percent of assembly and erection labor had to be performed by employees of a preapproved in-state contractor and so it was determined that we at Lancaster County Timber Frames, being a Pennsylvania business, couldn't be part of the bridge erection team. We did end up fabricating all of the timber and steel components for the Blenheim project in our shop and shipping them to the site for others to assemble and erect. With the Tree Canopy Walk project in the bag,

5 Partially preassembled components staged in the woods, being readied for erection. A narrow path through the forest provided good access for the all-terrain crane, allowing us to erect the glulam and steel components with a smaller crane than would otherwise have been needed.

6 Once fitted with steel, the glulam columns were moved the 1500 ft. from the staging area to the build site with a material handler.

7 Glulam columns and steel connection members for the Tree House prepared for erection. The column assemblies landed on concrete piers, one of which is visible in the foreground.

8 A braced frame tower along the stretch of walkway connecting the Tree House to the proposed terminus building—column glulams each over 50 ft. long. With post base assemblies and concrete piers, the deck of this tower was almost 60 ft. above the forest floor.

our disappointment at not being able to participate in the bridge erection was somewhat tempered.

By now the reader may have started to infer that we ended up being the only bidder on this project. That was indeed the case, and to some extent we used the leverage that gave us to negotiate hard on some terms of the contract. I'm talking about the pernicious "waiver of subrogation" and the "hold harmless and indemnification" clauses that manage to find their way into a lot of commercial project contracts. These clauses, if you haven't heard of them, are usually buried clavicle-deep in legalese around page 120 or so. Over the years, I'm sure that a lot of subcontractors have signed contracts containing these clauses, even though it should be obvious that they aren't our friends. We've dealt with more than a few contractors unaware that these clauses are in their agreement, or even what they mean.

In addition to getting these clauses stricken, we also managed to negotiate the bit about the completion schedule out of our contract because of the threat of liquidated damages. Nonetheless, as naïve as it might seem, we continued to operate in good faith that the completion schedule was legitimate and somehow doable. It wasn't until two or three months later that we discovered that the client had not even received its building permit yet and that there were environmental concerns (bats nesting in one of the trees that would need to be removed) that would easily push the start of site work well past the original desired completion date. This was actually a welcome reprieve—if we'd been held to the original schedule, things would have gotten even more uncomfortable for all involved. Even though the project schedule terms were significantly relaxed, in one way that advantage backfired on us: the prevailing wage rates under which we contracted went up at least twice during the course of the project.

We felt pretty good about ourselves for having gone over the subcontractor agreement with a fine-toothed comb in order to get some particularly onerous clauses removed. That feeling was short-lived. About a month or so into the process of preparing shop drawings, our attention was directed to a specification that stipulated that the walkway contractor (us) was required to supply a full-scale mockup of eight to ten feet of walkway for review by the architects. We missed that bit in the contract, an oversight that ended up costing us around $17,000—not too auspicious a start.

The mockup consisted of two 8-ft. lengths of glulam 6½ in. wide x 22 in. deep, a few steel connecting assemblies, joists, and the decking (Fig. 4). To this structure, other subcontractors added railing stanchions and the grab rail; lighting fixtures were attached at the bases of the stanchions; and a length of railing cap was fastened to the stanchion tops. There were also wire netting panels attached to the railing assemblies. All of this was set up in a field on top of two bucks of scaffolding so the client and architect could envision the final product. The whole thing—glulams, joists, decking—was finished with a light-gray semi-transparent sealer, and the steel connecting members were hot-dip galvanized. The mockup looked great and went together almost effortlessly, giving us the mistaken impression that it was going to be a walk in the park to assemble the full-size walkway segments.

From the very beginning, even while we were still bidding the project, we had decided to assemble the full-size walkway segments in our shop and ship them to the site. There are 17 such segments, most of which are six feet wide by around 35 feet long (Fig. 5). This strategy was driven by two considerations: preassembly would greatly cut down the amount of time needed on site and, thus, prevailing wage rate labor costs; and working in a controlled environment would allow us to solve problems more efficiently. In addition, there are four braced-frame towers—one over 50 ft. tall—that we also intended to ship to the job site partially assembled (Figs. 6–8). And finally, there is the "Tree House," a grand three-story tower with two sets of bleachers (one at the base and another at the top) and five stair runs

9 The fully erected Tree House, midway along the walkway. Built-up bleacher and stair stringers installed. There is a large set of bleachers at the lower level and another, smaller set at the top. The main glulam columns here are 16x16, up to 45 ft. long.

(Fig. 9). The Tree House and stair runs were assembled piecemeal on site. We decided to tackle this tower first, since it was the connecting node for the walkway section starting at the existing lodge building and another section connecting the tree house to the "Cabin," a four-story classroom building that was still in the planning stages.

From the start the project was billed as "contractor delegated design." There were times when that seemed like a euphemism for "we've cooked up this hot mess of a design, and it's up to you to figure it all out." Of particular concern, at the beginning, was the difficulty of reconciling some of the locational data in the design. After being awarded the project, we started trying to press the impressionistic geometry of the architect's and engineer of record's plans into a regimented and consistent form. Many of the provided working points were inconsistent across the sets of plans, and discrepancies occurred even within a single drawing. The task was to find a reliable point to work from, trying wherever possible to not just respect but to divine the architect's design intent. As one can imagine, this process required a lot of back and forth communications with the architect and engineer of record, even before the shop drawing review submission.

While we're on the subject of back and forth communications, I'd like to beg the reader's indulgence to grouse a bit on the communication protocols of large commercial projects. Here, the protocol for communicating with the architect and engineer of record was the typical arrangement: any and all queries had to be submitted as a formal request for information (RFI) according to a prescribed format. Our RFIs were submitted to the general contractor, who would type them up, again in the prescribed format, then submit them to the architect or engineer. They, in turn, would circulate the query amongst themselves to find the proper party to whom the RFI should be addressed. When an answer was forthcoming, it would be sent back to the general contractor with all the necessary stamps and seals, and then, ultimately, back to me.

No doubt this protocol was originally thought up (by a relative of Rube Goldberg?) and instituted to ensure a complete and thorough record keeping of all communication. The downsides of rigidly implementing this protocol, however, are numerous. First of all, it consumes an ungodly amount of time. If a problem crops up on Monday and you type it up right away for submission, Monday two, three, or even four weeks hence could arrive before you've received a response. And second, there's no guarantee that the response won't be useless, especially if the addressee didn't really take the time to understand the import of the question. Or, if not entirely useless, the answer could beget another question or two or three. Now, all these ill-begotten questions have to be straitjacketed into the same protocol, adding yet more time to the process. We spent countless hours assembling drawings, screen shots, photos, carefully worded questions, and the like in an effort to rein in the vicissitudes of the process when a two- to three-minute phone call with a decision maker could have much more easily put a matter to bed.

In any case, the work of reconciling the layout geometry was

10 View of the partially completed walkway (no railings yet installed) from the existing Lodge building toward the Tree House in the distance.

painstaking and highly detailed, and after multiple face-to-face meetings and follow-up conference calls we were able to convince the design team to accept the new working point coordinates. The outcome of this process was one of the brighter moments of the whole project. We generated a solid model of all the footings and piers that the walkway and Tree House would rest on, and the surveyor responsible for laying out the foundation work fed the solid model data into robotic surveying equipment. With one relatively minor glitch, every pier and anchor bolt was dead-on. The one glitch was the two very last anchors, which, for reasons I will never understand, ended up one inch wide of the mark. This necessitated refabrication of one of the post base fixtures, one of the added expenses for which we were, fortunately, compensated.

There was another glitch, again thankfully not of our making. The final brace-frame tower of the walkway, at its last turn toward the Cabin building terminus, landed right in the middle of a road into a parking area. The road ended up being rerouted to bypass the tower. Still, the fact that—after meandering over hill and dale through the woods and over boulder fields—the walkway piers never strayed more than ⅛ in. off course was nothing short of miraculous. Chalk it up to technology for once actually simplifying things rather than the opposite (Fig. 10).

While we're on the subject of glitches, there was actually a third one, and this one serious, and not noticed until most of the walkway had been fully erected. Following the prescribed height differentials—making sure that the walkway started level with the second-floor balcony of the Lodge building and rose in specified increments as it followed the contours of the land or soared above them—the walkway ended up being more than two feet higher than originally planned. This was because the height differentials on the architect's plans didn't agree with the absolute elevations assumed on those drawings. When the client switched to a different architecture firm for the Cabin building, that height discrepancy was already baked into the project documents, and a fix had to be found. A couple of hare-brained schemes were bruited about, but the remedy we suggested to the client, their new architect, and their general contractor was accepted: cut the final walkway segment and reinstall it with a gentle slope to meet the top floor of the Cabin building. As luck would have it, the final walkway segment—still not connected to the terminus building as of this writing—was long enough that it could be tilted down to meet the Cabin top floor and still satisfy ADA slope requirements, but just.

This problem is still waiting to be resolved, but a litany of other major and minor issues was confronted along the way. The loss of time and effort necessary for their resolution will never be recovered. These included a multitude of promises made to us with regard to site conditions; engineering disagreements that could be the stuff of a new heroic epic; extremes of weather; totally unrealistic scheduling demands; design flaws needing remedy on the fly; material and finish choices that flew in the face of our craftspeople's instincts; and so on, ad nauseum. Each and every one of these minor crises was a course in project management. After we reached the point of substantial completion, my partner asked me if I would ever take on a similar project. My answer was, "We'd be stupid not to, now that we know what we're doing!"

—Tim Diener

Tim is in his fifteenth year as a designer and project manager at Lancaster County Timber Frames. His 40-year career in the architecture-allied trades encompasses work with wood, metals, and glass.