I have the best client in the world. He likes only the simplest designs for the projects he commissions. And let no degree of complexity stand in the way of those projects.

One particularly interesting project was the stairway in his new home on Nantucket. John, a k a "best client," claimed that a standard set of stairs supported with framework underneath not only would destroy the character of the hallway entry but that a closed-in stairwell would also make the hallway narrow and claustrophobic. So John suggested eliminating risers between the stairs to let more light pass through (photo this page).

I've always been intrigued with the idea of stringerless stairs and ways of supporting tread load by other means. So I suggested going one step further and getting rid of the stringers as well. The stair

A Stair in the Air

Southern yellow-pine treads hide welded-steel brackets that make these stairs appear to float in space

BY GLEN STEWART

would then be reduced to its three basic elements: treads, handrails and balusters. Could it be any simpler?

Engineering support

Several designs of stringerless stairs use steel cantilevered from a wall. But most of these designs have an angle brace under the tread to transfer the load back to the wall. We agreed that this brace interfered with simplicity, the visible steel brackets adding another structural element. Plus, we wanted to keep the treads to a minimal thickness and keep all the structural elements hidden. What to do?

Lucky for me, John, in his role as "best client," has wonderful taste in wine, and we decided to drink some, and have dinner, too. Have I mentioned that any candidate vying for position as best client in the world should have a gracious spouse who is a talented cook? At dinner, we let the wine and food help us to explore our options.

Before I go any farther, I should explain that John is an engineer, the kind who drinks coffee before he goes to sleep. The next morning, John called with a potential solution. He described a system of steel brackets made of flat bar stock that could be attached to the wall framing and be buried in the treads and balusters. The top of each bracket would be bolted to the nose of the tread above while the bottom of the bracket was bolted to the heel of the tread below. The idea sounded reasonable to me.

That afternoon, a fax arrived at my office with the load-deflection calculations, a finite-element stress analysis with bending modes and, of course, graphic interpretations in a gray scale. Unfortunately, I don't have a color fax. Does anyone?

As a well-trained carpenter and surfer used to hiding my ignorance with chameleonlike grace and mimicked terminology, I called John back, thanked him for the fax, mumbled something unintelligible about error analysis, asked if he thought he carried his transforms through enough iterations and, by the way, "How thick was that steel?"

"A quarter-inch."

"And how wide?"

"Inch and a quarter."

"Oh, good, that's what I came up with, too."

Testing begins

A week later, the prototypes of the steel brackets arrived from the fabricator, and we built a test section in my shop. Armed with a stringline, a story pole, a tape measure and a rather skeptical 200-lb. test subject, we measured deflection. We were aiming for zero.

"Three-sixteenths? Yikes! How could that happen?"

Careful observation showed that the steel itself performed as expected, but there were two unexpected problems (drawing pp. 72-73). First, the wall studs were deflecting in an S pattern, and second, the cantilevered ends of the steel brackets were twisting out of plane.

We eliminated stud deflection by replacing the standard 2x6 studs with 1¾-in. by 5½-in. laminated-veneer lumber (LVL). Also, the plate that fastened the steel box bracket to the stud was lengthened to 48 in. with ½-in. dia. through bolts in zero-clearance holes. We also decided to glue and screw a ¾-in. plywood skin to the backside of the studs so that the load was distributed to more than one stud.

The other contribution to deflection was more subtle, a result of the steel twisting out of plane when load was applied. The addition of balusters and handrail would keep the cantilevered end of the steel bracket from twisting, eliminating this movement. The handrail-baluster system was no longer just a code requirement and concession to safety: It became a structural necessity.

With these modifications, we now had a working model and were able to say, "See, it works," to all those skeptics, my dog being in that

Stairway skeleton. The bones of this stairway are welded-steel brackets bolted to laminated-veneer lumber studs.

OPEN-TREAD STAIRS AND BUILDING CODES

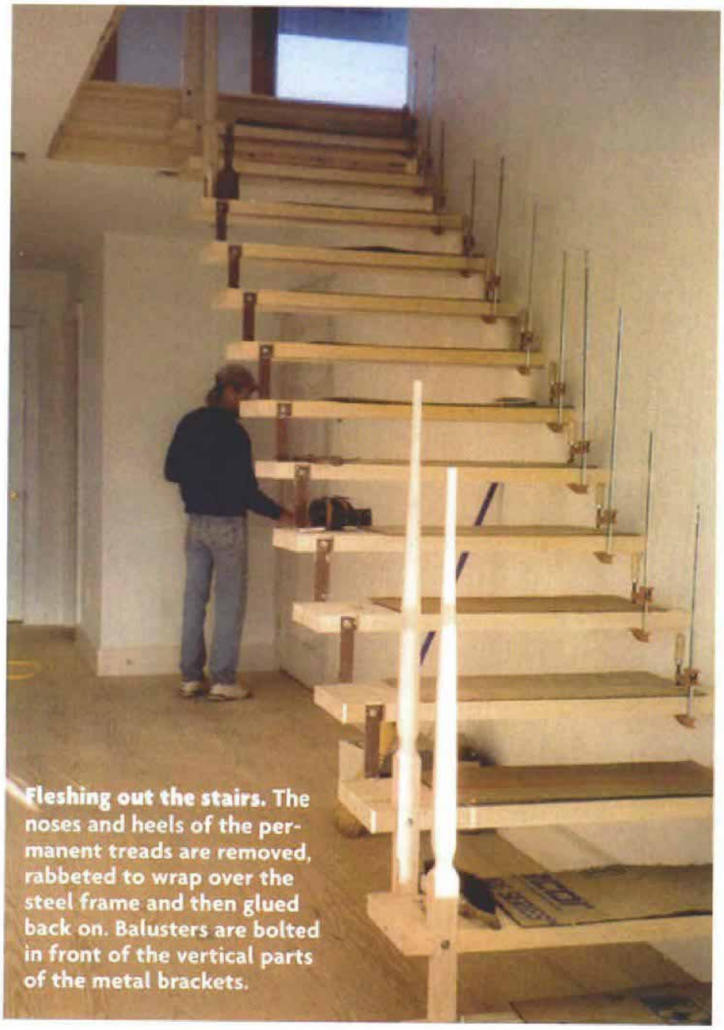
At the time we designed and started these stairs, Nantucket was using the 1988 UBC codebook, which required that the maximum opening in the stairs could not allow a 6-in. sphere to pass through. The new code decreased the size of the sphere to 4 in. and was adopted by Nantucket during construction of this stair.

The issue of baluster spacing never came up during any of the inspections. But we did have a contingency plan to add ¾-in. dia. dowels between the balusters if the problem arose; fortunately, it never did because the dowels would have complicated the aesthetics of the stair.

The building code treats open risers the same as the openings between balusters, so the 5^{11}⁄16 in. between treads satisfied code at the time. We didn't have a strategy for changing the openings between treads, but with my client, the engineer, I'm sure we would have come up with an elegant solution.

—G. S.

Photo facing page: Roe A. Osborn

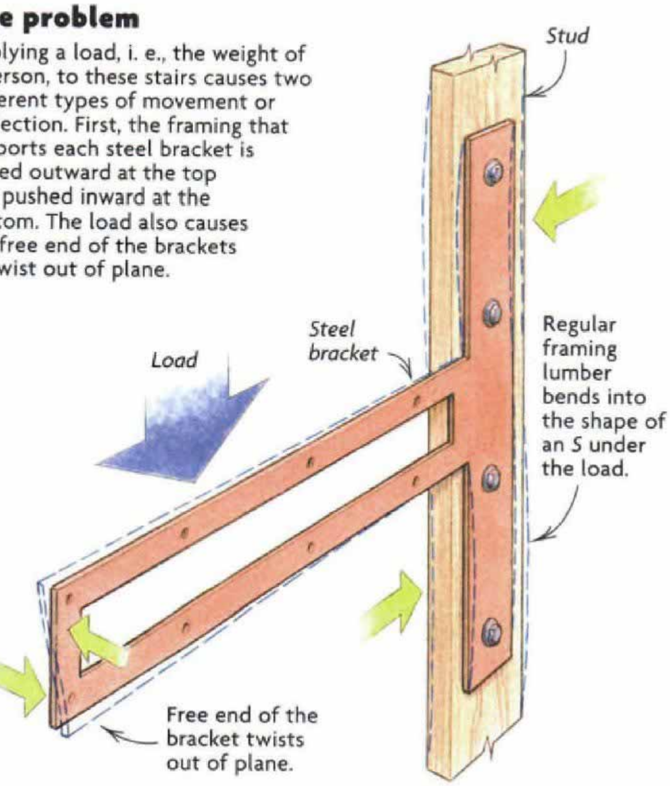


Fleshing out the stairs. The noses and heels of the permanent treads are removed, rabbeted to wrap over the steel frame and then glued back on. Balusters are bolted in front of the vertical parts of the metal brackets.

STIFFENING AND CONCEALING A STEEL SKELETON

The problem

Applying a load, i. e., the weight of a person, to these stairs causes two different types of movement or deflection. First, the framing that supports each steel bracket is pulled outward at the top and pushed inward at the bottom. The load also causes the free end of the brackets to twist out of plane.



category, while the cat remained consistently aloof. The okay went out to the fabricator for a complete set of the steel-bracket sections. All the brackets were identical except for slight variations in the brackets near the top and bottom of the stairs.

Installing the brackets was easy

We were now ready for installation of the framing and steel at John's house. The framing of the wall required precise layout. The face of each stud had to be located exactly $1\frac{1}{2}$ in. back from the finished nose of each tread, $9\frac{5}{8}$ in. o. c.

Likewise, the steel frames had to be bolted carefully to each LVL stud to produce the $7\frac{3}{16}$-in. rise (photo p. 71). After a painstaking installation of the studs and steel brackets, we bolted temporary treads in place and went away while the real work was being done. God bless all electricians, plumbers, plasterers, floor guys and painters.

Steel brackets disappear behind wood

The flooring for the house was southern yellow pine, a common choice for the area, so we chose the same for the treads. Cherry handrails and ash balusters were chosen to match John's furniture.

I had wanted to use solid $1\frac{1}{2}$-in. thick stock for the treads, but working on an island has its own special problems: This stock just wasn't available. So I convinced myself that two layers of $\frac{3}{4}$-in. stock were better than solid stock because the opposing grain patterns would counter each other's stresses and make the treads more stable. An inch and a half was cut from the nose and heel of each tread and carefully labeled to be put back on the same tread later. I clamped the middle part of each tread between its nose and heel brackets and marked them for the bolt holes. The treads were then taken out and drilled through from both sides with a self-centering drill guide.

To my surprise and relief, most of the holes actually lined up. Quarter-inch threaded rod with a nut and washer on each end captured the treads between opposing steel-bracket sections. I rabbeted the nose and heel pieces to house the steel and counterbored holes for the nuts and washers. The pieces were then glued back on (photo above).

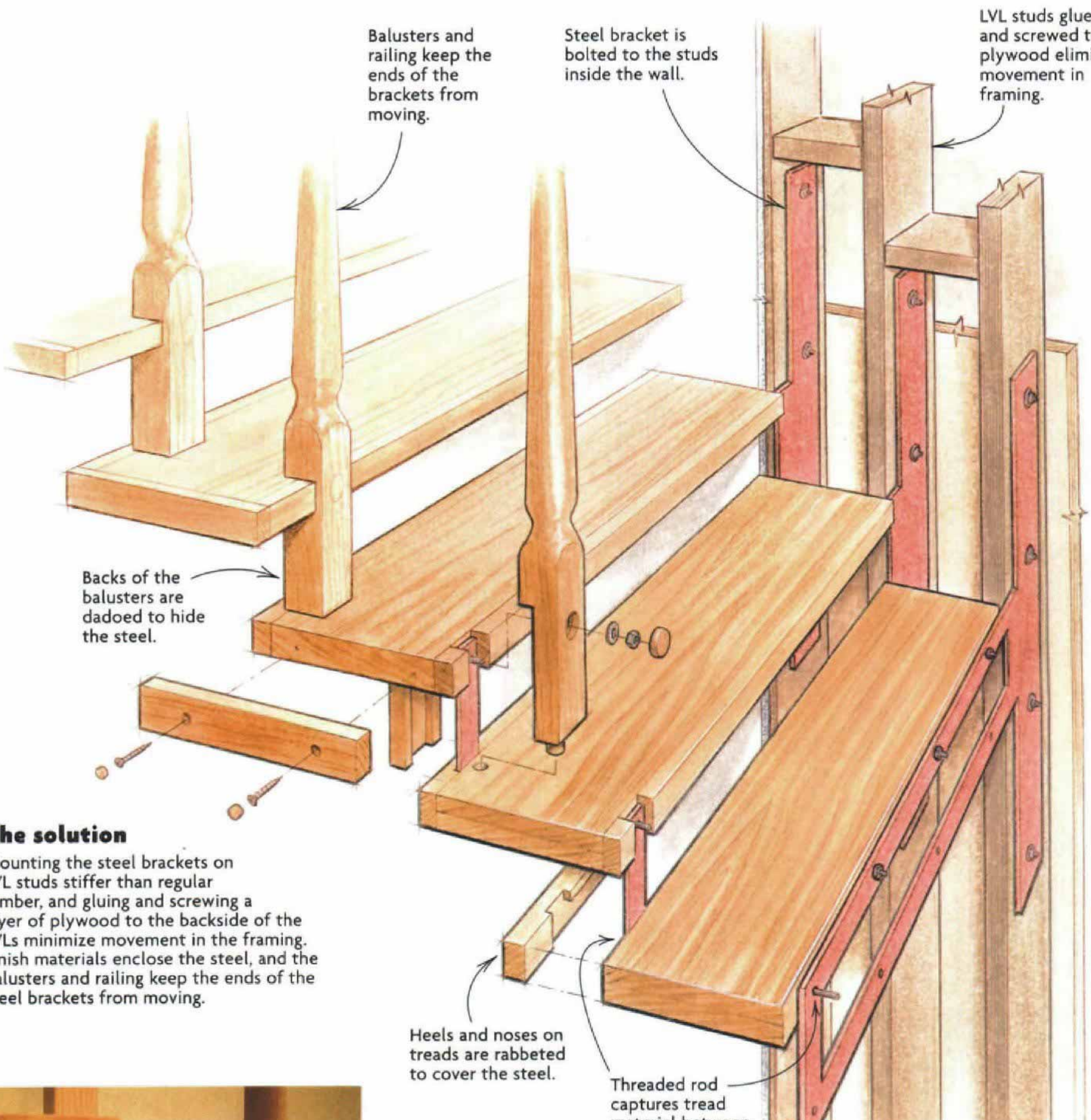
We turned the balusters from 2x2 ash blanks. We left the baluster bottoms square for 9 in. and then cut a $\frac{3}{4}$-in. by $5\frac{11}{16}$-in. section (distance between the treads) from this square part (photo facing page). These pieces that we cut off the balusters were dadoed to cover the steel and then glued back on in one of the final steps.

Again, we paid careful attention to getting each of these pieces back on the baluster that it was cut from, which left the joint pretty much invisible. The outside tread bolt also passes through the baluster. We counterbored a hole for the nut and washer, which was then hidden by a plug, or bung as my new friends on the East Coast have insisted on calling it.

The finished stair seems simple, but as rewarding as it was to meet this challenge, I don't think I'll build another one. Some things are better left as one of a kind. □

When not surfing, Glen Stewart is a carpenter and furnituremaker in Encinitas, California. Photos by the author, except where noted.

Drawings: Dan Thornton. Photo this page: Kris Stewart.



The solution

Mounting the steel brackets on LVL studs stiffer than regular lumber, and gluing and screwing a layer of plywood to the backside of the LVLs minimize movement in the framing. Finish materials enclose the steel, and the balusters and railing keep the ends of the steel brackets from moving.

Stealth balusters. Back sections of the balusters are removed, dadoed to conceal the metal bracket and then reattached. Special care was taken to match the cutoff with the correct baluster.