Sala house interior with wooden paneling, built-in bench and counter.

lope. The vertical forces come down through the post and beam. The horizontal forces, roughly speaking, are taken up by the very stiff thin concrete tube that is braced against the columns.

In the Sala house, for example, exterior details are concrete, interior details are wood. There are concrete brackets on the exterior, a poured concrete parapet to form the front of the building. These exterior surfaces are inlaid with marble inserts and the pours are made in alternating colors. The interior post-and-beam work include beautiful corbels, cut out of six-by-six fir; these are bolted to columns, and receive the beams. Main beams are six-by-twelve and six-by-eighteen. The floor is two-inch hemlock spanning directly from beam to beam. Again the beams, bays, corbels are chosen in such a way that each structural bay is felt as a center, and so that the corbels themselves are especially beautiful.

6 / HEAVY WOOD CONSTRUCTION

After years of experimenting with concrete, I also began trying to use wood in a way which made more profound sense than stud construction. My first experiments in wood, the Linz café and the Albany house, were nice but fairly simple-minded. We used six-by-six columns with corbels, beams, wood panelling and wooden ceilings.

In these cases, the field of centers began to exist simply through the structure — because the structural elements — columns and beams — themselves formed centers which supported, am-

Fresno, California: The Fresno Farmer's Market, showing the complex, wooden, arched structure. Christopher Alexander with Carl Lindberg and Gary Black, 1988.

plified, the spaces. As a result the field of centers which was created in the space was amplified and deepened by the existence of smaller centers in the wood itself — and that made the large centers even stronger. This is easily visible in the Linz café (Book 2, pages 408–12).

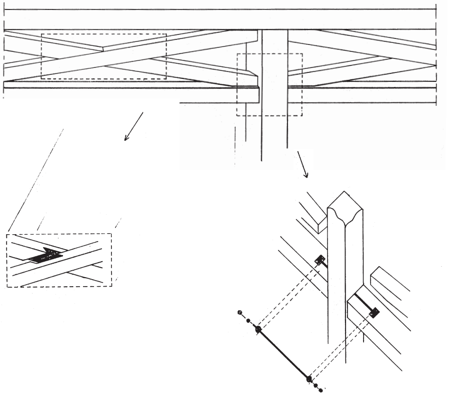
However, although the simplicity of structure made it possible to create elegant systems that one could easily feel in the spaces they created, in the end the wood itself often still seemed like a bunch of sticks, with planes strung between them. There was not enough deep feeling in the wood itself. I began to ask myself what it would mean to make something out of wood, where the substance of the wood — the elements of the wood, the actual pieces of wood themselves — had feeling, and a living field of centers appeared in the very wood itself.

I realized, too, that although I had worked with my own hands in the gunite method for about five years before I began to understand it, all of us together at the Center had spent no more than a few weeks actually making and erecting wooden columns. The direct, physical experience we had working with heavy wood was simply insufficient to tell us what it would mean to create serious substance in a wooden building.

In answer to all this, I began looking very carefully at old Norwegian buildings — stave churches and storehouses, and at certain Japanese temples. In these buildings one feels the wood as a living presence because it has been worked as a three-dimensional substance in very much the same way that is possible in stone — or that I myself had achieved to a small extent in the gunite construction of the Martinez houses.

We first began using very heavy timbers. Luckily we had access to lumber suppliers in Oregon who could cut big members at a rather reasonable price — twelve-by-twelves at the same price

The Fresno Farmer's Market, again showing the complex, wooden, arched structure.



Heavy timbers in the carpentry shop, Martinez, California. The building itself is shown in Book 4, pages 116–17

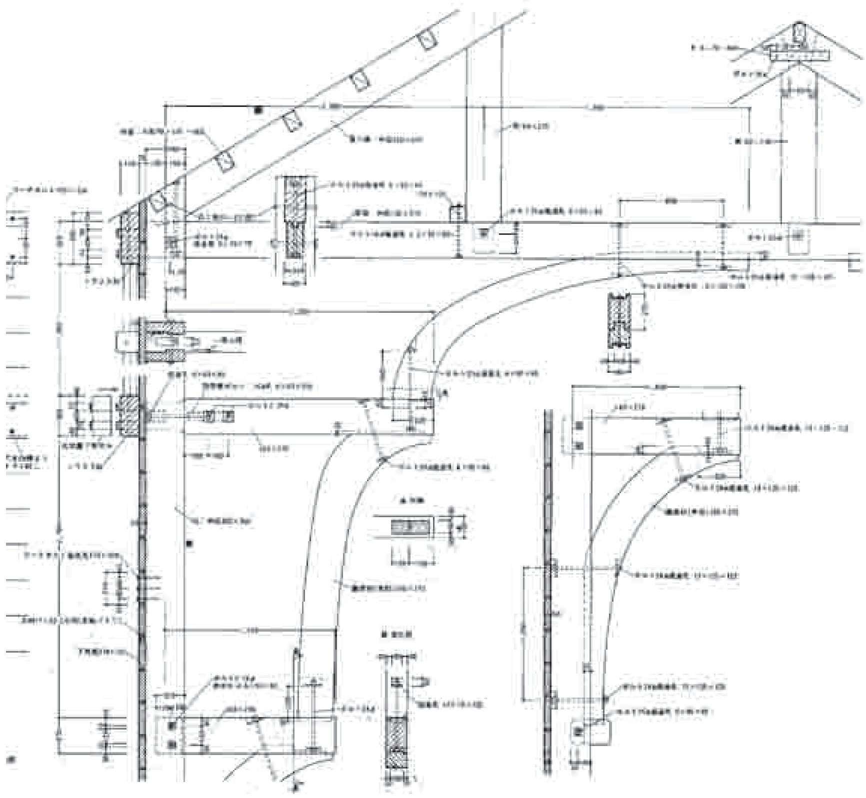
per board foot that we paid for six-by-sixes. We soon began to realize that a building made of heavy timbers would have a life of perhaps several hundred years, compared with 30 or 40 years for a stud house. The apparent cheapness of the stud house was false; the cost of wood in a heavy timber house would actually cost less per year, if calculated per year of its expected lifetime — and would put less of a drain on timber reserves than continued use of small timbers. A similar kind of thinking led us, more recently, to make massive columns and beams from plywood and an inner braced core of small members (page 556-57). In both cases, the most salient issue is the feeling of

A one-third full-size timber model of a low-cost heavy timber house of 800 square feet that we built and were experimenting with in my office. Here the plastic qualities of heavy timber as a material that can be shaped and carved, become clearly visible. The whole house is built as a three-dimensional truss, with a lifetime of many centuries: easily justifying the use of heavy timber as both cost-effective and sustainable. Christopher Alexander, 1986.

the members, and their lifetime, and the extent to which they are experienced as living centers.

Not only material was inspired by the search for living structure in wood. In the Eishin School in Japan, we developed entirely new methods of analysis in order to create wooden trusses. The beauty and efficiency of a truss depends on subtle matters. Placing members in a roof truss in such a way as to create the field of centers quickly leads to beautiful and ornamented trusses containing a variety of subtle forms. For instance, the Gymnasium trusses (pages 542–43) has a stepped form. The Central Building trusses (page 196, page 541, and Book 2, page 428–29) have curved members. The Judo Hall trusses are stepped in form, and follow the line of a stepped flat ceiling.

When we began these works, I sketched each of these trusses intuitively, in response to the latent field which existed already in the building design (most visible in the cross section). Using finite element methods to work them out, these sketches were almost at once confirmed, and encouraged use of unusual and sometimes startling configurations as structural designs. Even the designs intuitively sketched were efficient — *because the intuitive placing of members to create a field of centers produces results in which the forces are beautifully distributed*.



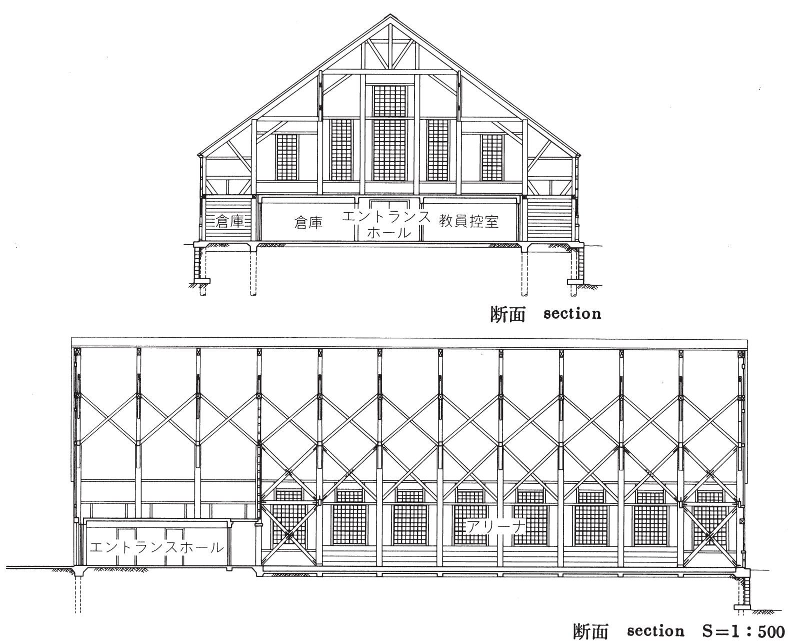
Details of the composite wooden truss with curved members we built for the Central building of the Eishin campus. The truss was designed and calculated by finite element analysis, and uses highly innovative steel bolt tension connections in addition to calculated moments carried in the truss members. Christopher Alexander and Gary Black, 1984.

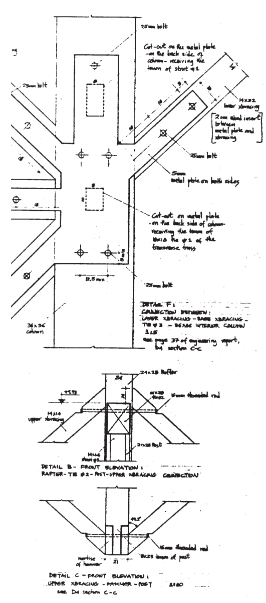
The combined effect of the members is more complex than can be analyzed by traditional methods. In traditional arithmetic methods, a truss used to be analyzed as if it were made up of a series of sticks, each one of which is either in compression or tension. But in the trusses I have sketched over the years, their more complex behavior is similar to that of a basket — where member-to-member interactions are more significant, and where several of the key members get their efficiency from the fact that they work in bending, not only in compression or tension.

In order to design these trusses, we used finite element analysis (as described in chapter 6), a simple method in which the forces are studied directly as a by-product of the geometric distortion of the members. This technique, which was put onto microcomputers in the late 1970's, revolutionized the analysis of structures. First we make a computer model of the truss. Within minutes we can watch its behavior when we put forces onto it. As we watch its behavior, we see that some members are carrying too much force. Others are not carrying any significant force. Then we modify the arrangement of the members. Each time we go through this process, we understand the global behavior of the truss more deeply and have a better idea how to bring the forces into balance. Within a few hours, we can go through several modifications and reach an extraordinary level of balance in the arrangement of the members.

This technique allows us to build wooden members which create a significant field of centers: and it allows us to get building permits relatively easily even for complex configurations, because we can accurately predict the real forces.

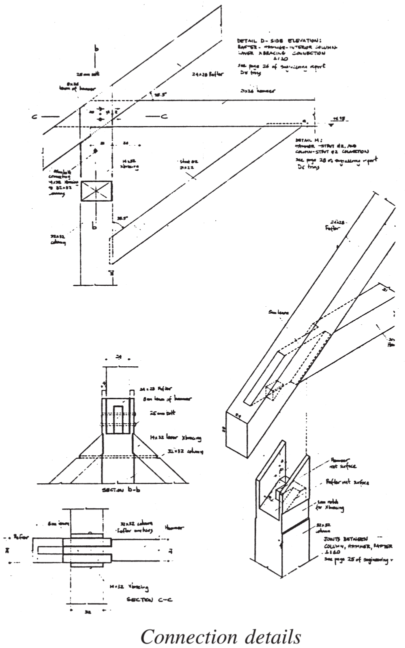
The largest wooden building built in Japan during the second half of the 20th century.
The gymnasium of the Eishin school, heavy timber trusses.



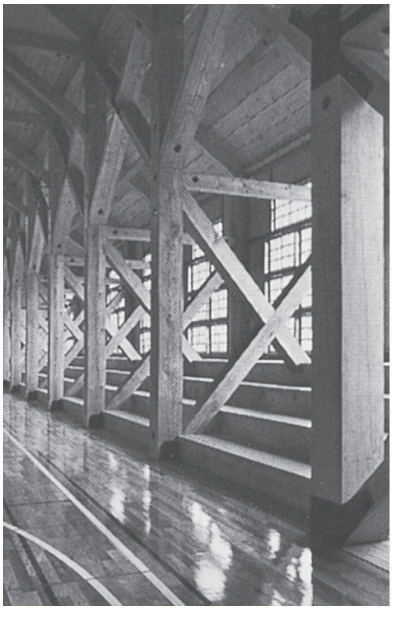


Left: Interior sections of the gymnasium. Right: Specially fabricated steel conections for joints in the stepped heavy-timber wooden truss.

Longitudinal X-bracing inside the gymnasium



Connection details



Floor, columns and cross bracing