Unique office building "hangs" from cast stainless steel lattice

Take away half the foundation from a proposed building and you've got the kind of problem that can make an architect weep. But faced with exactly that situation, the British architectural firm of Ove Arup created a design that combines an elegant engineering solution with great visual flair and drama—a design whose interlocking demands of strength, appearance, and constructability could only be met at reasonable cost by cast steel in a special stainless alloy.

Losing Ground

Bush Lane House, with a proposed site in the heart of London, stood directly in the path of a planned extension to the London subway system. By the time tunnels, air shafts, escalators, etc. were allowed for, about half the foundation area was eaten up and pile locations were restricted. Further restrictions were imposed by the need not to disturb the piles of the adjoining Lloyds Bank Building. Finally, at ground level, a clear headroom of approximately 32 feet was required under much of the building, meaning that a major part of the structure would have to be cantilevered.

Thus, a building of conventional construction would be much too heavy for any foundation the site would allow. The structure would have to be extraordinarily light in weight, while still meeting relevant construction standards.

Carrying the Load

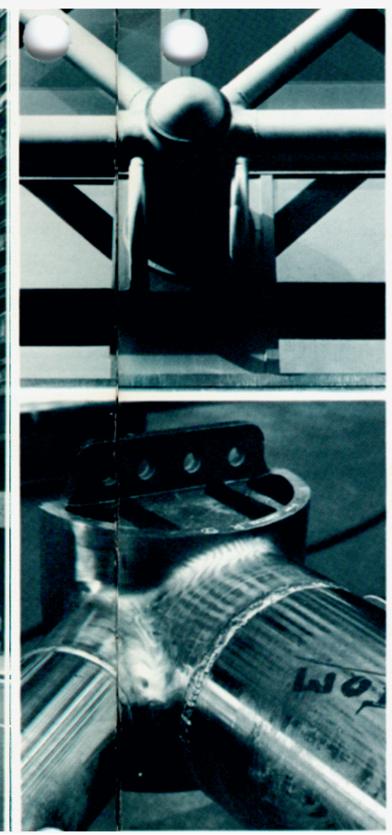
The conventional solution called for huge columns to carry the building load down to a heavy girder in the "plantroom," or first-floor service level. But this would cramp plantroom access and space, and limit the size of air intake and exhaust openings.

So Ove Arup chose the unconventional design: an open lattice rising *outside* the building from the plantroom to the roof, sustaining all the load over that height and surrounding a curtain wall. Assembled from hollow tubes and spherical nodes, the lattice would carry the loads down vertical columns braced by diagonal elements centered around the nodes. The outstanding structural feature of the building thus became its outstanding aesthetic feature, a first-of-its-kind in Great Britain and a striking addition to the London skyline.

Cast Steel Best Choice

To go from concept to reality required tubes and nodes that provided the necessary properties at reasonable cost. The first thought was to use carbon steel elements coated with corrosion-resistant paint. But then the building would be subject to periodic inspection, which the client feared would discourage prospective tenants. Weathering difficulties precluded the use of cladding methods and various special materials. The choice finally fell on stainless steel.

Initially, two alloys seemed to qualify: a cast alloy with a nominal composition of 25 Cr, 5 Ni, 2 Mo, and a wrought alloy, AISI 316 (nominal composition: 18/10/3). The cast alloy, with its tailor-made "recipe," was chosen over the standard wrought alloy for two reasons. One was the unfavorable coefficient of thermal expansion of AISI 316—the cast alloy's coefficient is less than two-thirds that of the wrought alloy —which would aggravate the problem of differential thermal movement. The main reason, however, was the fact that the casting process makes it easy to obtain tubes of many different diameters and wall thicknesses, as well as almost two dozen sizes of nodes. Fabrication of these components would have been lengthy and very expensive.



Lattice-Work

The lattice is composed of 44 prefabricated diagonal assemblies plus nine columns. Each column consists of two welded lengths of tubes, connected by welded crossbars. The tubes have outside diameters of about 7½, 12½, and 20 inches (194, 324, and 512 mm) and wall thicknesses ranging from approximately ⅜ inch (9.5 mm) in the small tubes to 2.5 inches (64 mm) in the columns at the diagonal joint connections. They were cast centrifugally; yield strength at 0.2% offset is 58,000 psi, tensile strength is 105,000 psi, elongation is 35%, and impact strength (Charpy V-notch) is 33 ft-lb at -4 F.

The architects' design of the nodes was modified by the foundry to insure directional solidification and structural integrity without compromising the required performance. Varying in weight from 80 to 650 pounds (36-295 kg) depending on size, the nodes were cast to shape. Yield strength at 0.2% offset is 56,000 psi, tensile strength is 98,000 psi, elongation is 30%, and impact strength (Charpy V-notch) is 22 ft-lb at -4 F.

Assembled, the lattice columns weigh up to 14.3 tons; diagonal assemblies weigh up to 4.4 tons. Compression forces on the bottom of the columns reach about one million pounds (5000 kN) and 100,000 pounds (500 kN) at the K-joints connecting the columns to the diagonals.

As it now stands, Bush Lane House is about 115 feet long and 52 feet wide. The elevator core, above ground, is a long, narrow, load-bearing element that supports the building on one side. Two columns support the building on the other side—and between the columns and the core is the required clear space. The plantroom rests conventionally on the core and columns and supports the lattice; and the lattice supports the rest of the building.

Constructing the Building

The very tight tolerances among the lattice, the curtain wall, and the floor members required construction methods as unconventional as the design. The approach was to erect the floor steelwork first and then attach the lattice. The floors rose on temporary posts; the lattice frames were hung from the floors until assembly was complete. The tubes and nodes were shop-welded together to form the main assemblies, and bolted to each other at the site. Only after all the lattice joints and welds had been made was the load transferred to it.