Oakland's Amtrak Station

The new C.W. Dellums Amtrak Station capitalizes on Oakland's tradition as a rail center

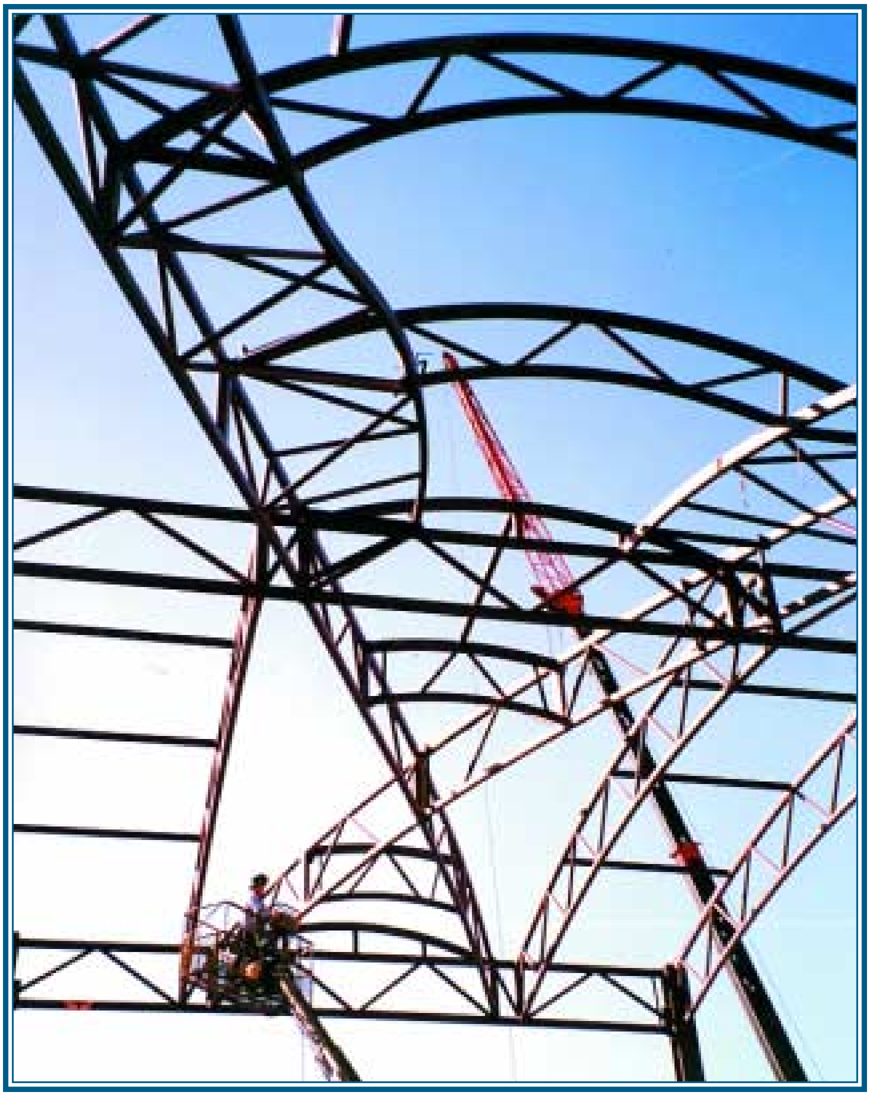
By Mary Williams Goodson, P.E., S.E., and Sam Wilson

DURING THE HEYDAY OF RAIL TRAVEL EARLY IN THIS CENTURY, Oakland's passenger service was located in the Wood Street station. Built in the cavernous tradition of turn-of-the-century station architecture, it was nicknamed "the Mole," and it served admirably for many years. But in recent decades Oakland's center of commerce moved elsewhere, and the Wood Street neighborhood became increasingly inaccessible and intimidating, particularly after the area was devastated by the 1989 quake. At the same time, travel by highway and air had largely displaced passenger rail service. Nevertheless, Oakland remained a vital link in the nationwide rail network, and several entities had interests in seeing the station moved and modernized.

Throughout its history Oakland has existed in the shadow of the more glamorous city across the Bay, and the perception of inferiority has not been just a matter of municipal paranoia. When writer Gertrude Stein, who had grown up in Oakland but lived as an expatriate in Paris, once said of her childhood home "...there is no there there..." it was generally assumed that she meant Oakland was a nowhere sort of place. It didn't matter that she was actually referring to the house of her youth, not her hometown, and the reputation stuck. So Oakland is a city that is acutely aware of image, and saw the chance to build a new railroad station as an opportunity to create a monument to its venerable railroad heritage.

Beyond image building, Oakland viewed a revitalized rail connection as a tool for enhancing commerce and industry. The City's Master Plan speaks of commitment to maintaining the manufacturing, wholesale and commercial character of the waterfront, and the City Central Urban Renewal Plan calls for revitalizing the waterfront as a regional retail center and improving its environmental design. A site along the Embarcadero with proximity to the marinas, shops, restaurants and other businesses of Jack London Square was viewed as optimum to fulfilling the various goals.

As operator of major shipping and aviation port facilities, and as the owner of the site and the adjacent Jack London Square properties, the Port of Oakland found mutual benefit in all the goals of the city. A new station was viewed as a means to consolidate existing rail and bus passenger service. The Port of Oakland saw a unique opportunity to create an intercity transcontinental rail hub station for both the City of Oakland and Northern California. With incor-



To help recapture the grandeur of train stations from the past, the new Oakland station features a double vaulted roof over a 5,000-sq.-ft. atrium.

poration of a pedestrian overpass into the design the Port saw a way to further enhance accessibility to its business interests at Jack London Square.

As the end user and operator of the facility, Amtrak benefited from a more accessible location as well as the opportunity to consolidate its crew quarters with its business and ticket offices. In keeping with a tribute to local history, Amtrak chose to name the station after a prominent figure in Oakland's railroad history, C.W. Dellums, co-founder of the International Brotherhood of Sleeping Car Porters.

Monumental Design

To achieve a monumental character, VBN Architects developed a design inspired by the vaulted, exposed interior truss work of the 19th century, particularly characteristic of the rail stations of northern Europe. The design also recalls Oakland's former "Mole" station, with its cavernous interior. The pedestrian overpass, which provides access to the station from the parking lot on the other side of the tracks, was designed with massive truss members reminiscent of 19th century railroad trestle bridges.

Even as it pays homage to past traditions, the VBN/CH2M HILL design incorporates a modern look with a unique intersecting vault of cylindrical and elliptic forms, whose gracefully curving union gives full play to the plastic potentials of steel. The sculptural character of the interior truss work is displayed with particular effectiveness at night, through the glass exterior of the atrium. Nighttime illumination from within also serves as a beacon, enhancing the aura of destination while providing a sense of security. During the day the panoramic influx of natural light brightens the interior, and the feeling of airiness is amplified by the high, delicate curves of the intersecting trusses.

The project includes three main structural elements: the station building, the pedestrian bridge and tower structure, and the platform canopy. The structures were designed following the provisions of the 1991 Edition of the Uniform Building Code, Seismic Zone 4. The design meets Federal ADA Requirements.

Station Building

The station building consists of two attached sections, the vaulted atrium and a flat-roofed office area. The building is a steel frame structure. A system of wide flange beams and tube steel columns support gravity loads in the office section. An intricate roof truss, set upon steel wide-flange columns, supports gravity loads in the atrium. There are eight load-bearing points around the periphery of the roof, with the load transferred at the four corners and two transverse trusses.

The entire structure is tied together for lateral load resistance. The lateral-force-resisting system in the longitudinal direction consists of moment frames on grid lines C and D as well as a longitudinal masonry wall located along column line A. In the transverse direction the lateral-force-resisting system consists of braced frames along grid lines 1 and 9. All brace members are tube steel. The structure's exterior cladding consists of brick veneer in the rear office portion and full height window wall panels for the vaulted atrium. Front wide-flange members are clad with steel plate to emphasize the size of the members. The building is founded on reinforced concrete spread footings.

The double vault of the 5,000-sq.-ft. atrium consists of an elliptic longitudinal vault intersecting a transverse barrel vault. Plotting the intersection of the elliptic and cylindrical forms was an exercise that structural engineer Mary Williams recalls to have "sent us back to our analytical geometry and calculus texts." It resulted in the following mathematical manipulations:

Equation 1. for the circular arch:

$$x^2 + (z^2 - 25.3542)^2 = 345.3390$$

Equation 2. for the elliptical arch:

$$(y-60.2917)^2 + (z+57.2344)^2 = 10,235.7534$$

where the radius of the circular

arch = 18.5833' and the radius of the elliptical arch = 102.1719'

The procedure for calculating the steel coordinates is to choose distance "y" from grid 1. Input this value into Equation 2 and solve for "z". Input "z" into equation 1 and solve for "x".

It's one thing to derive an equation and another to visualize a form. When it came to planning the connections of the "serpentine" trusses with the four corners of the building, it became necessary to bring CAD into the picture. Once the equations were programmed into the computer, it was possible to plot the barrel vault, the elliptical vault, and the line representing the intersection between the two surfaces. This information was used to create a 3D model of the roof structure. Using the computer it was then possible to rotate the views on-screen, "so we could finally figure out what the thing looked like." This CAD file was used to zoom in on the corner connection and view it from just about any direction. Members could be easily added and subtracted and reviewed with the architect to design the appearance he was trying to achieve. The use of the CAD system was essential to a workable connection detail at the atrium corners. SAP90 from Computers & Structures, Inc., was used to analyze the station building for gravity, lateral, and thermal forces. Members were modeled using beam and strut elements.

The roof truss system was fabricated in a total of 18 sections: 12 circular trusses along the longitudinal axis of the atrium, two elliptical trusses that span the longitudinal building dimension front and rear of the atrium, and two large serpentine trusses that form the intersection between the elliptical and circular vaults.

The circular and elliptical trusses proved to be relatively simple to build and install and provided a good warm up for the serpentine trusses to come. Typically, the circular and elliptical trusses are constructed of a

The project also includes a 140'-long pedestrian bridge spanning the Embarcadero and railroad tracks

TS 6x4x¼ top chord, a TS 4x4x¼ bottom chord and 2½" diameter extra-strong pipe diagonals. The members are connected with fillet welds ground smooth to give the appearance of continuous members.

But the truly tricky part was yet to come. "The serpentine truss was more difficult to build than it was to design," says Mary, and it was an achievement that required close collaboration between CH2M HILL and the steel fabricator. Using the equations for the intersecting vaults, a jig was constructed and anchored to the floor of the fabrication shop. The serpentine trusses were constructed in four three-part sections. Since the equation which defines the serpentine truss has a constantly changing curvature, the fabricator found it necessary to hand bend every piece of steel. Each quarter of the truss system—that is, each element extending from a corner of the building to the center of the roof—was shop assembled from three sections. As it was finished, each quarter section was trucked to the site and put into place. The truss top chord consists of TS 6x6x¼, the bottom chord TS 4x4x¼ and the diagonals are 2½" diameter extra strong pipes. As with the circular and elliptical truss, all joints were welded and then ground smooth to provide the required finish.

Bridge and Tower Structure

This structure consists of a 140' pedestrian bridge, spanning the Embarcadero and railroad tracks, with wheelchair-accessible elevator towers at either end. The tower legs are constructed of TS16x16x⅝ and the cross members are TS16x16x½. The bridge span is made up of two parallel trusses connected with cross bracing. The walking surface is located 35' above grade to allow the curved bottom chord to meet railroad clearance requirements to the tracks below. The truss top chord consists of a W12x96, the bottom chord is a curved W24x104, truss diagonals are TS 6x6x¼, and the cross bracing consists of 5x5x5/16 angles. The lateral force-resisting system consists of moment frames made up of the tower columns and cross members. The towers are founded on reinforced concrete mat foundations. The structural analysis program SAP90 was used to model the structure and to analyze for gravity, lateral, and thermal loads.

The primary logistical achievement of the bridge construction was transporting the bridge span to the site and setting it as a single unit. The tracks below remained in service during construction, which limited working windows to between 2:00 a.m. and 4:00 a.m. on Sunday mornings. The solution consisted of prefabricating the 140-foot-long span and placing it between the two towers as a single unit. The span was constructed in a warehouse located approximately two miles from the building site. The tower legs and cross members were initially set into place, waiting for the arrival of the connecting span. Delivering the span proved to be quite complicated. It involved coordinating a Southern Pacific Railroad two-hour window of opportunity with an Oakland police escort for the trip. The move was accomplished on a Sunday morning at 2:00 a.m. during one of the year's worst driving rainstorms.

Buoyed by their success with the atrium trusses, the fabricator had little doubt that their span would fit snugly into place. Any uneasy feelings the numerous spectators may have had were easily laid to rest after hearing the cheers of the ironworkers when the span was actually seated on the first try.

The feat was made all the more noteworthy by the fact that the bridge and tower members are quite heavy, sized to meet the architect's program rather than to resist the anticipated design loads. That is, most of the members are larger than the loads might dictate creating a 50-ton monolith to transport two miles and raise 35'. The architect wanted to provide the look of a massive trestle to the structure, and this was achieved through the use of oversized members.

The bottom chord of the span was sized to be 24" deep to meet architectural requirements. It was necessary to bend the member on a 500' radius to meet clearance requirements to the tracks below and to provide aesthetic appeal. The fabricator had to look all the way to Arkansas to find a shop capable of rolling the W24x104 beams to the required curvature. The two beams were shipped to Oakland by train in six 60'-long pieces. The beams were cut to size and full-penetration welded in the fabricator's shop. As with the atrium roof, all connections were welded and all welds were ground smooth to give the appearance of a solid continuous structure.

Platform Canopy

The 200'-long platform canopy replicates the form and material of the bridge roof. Expansion joints were included at 80-foot intervals to compensate for up to ¾-inch of thermal expansion. The standing-seam roofing material was detailed to provide for overlapping sliding, and clip angles with slotted holes in the connection allow for the tubes to move. With the exception of the expansion joints, all platform canopy connections were welded and ground smooth.

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