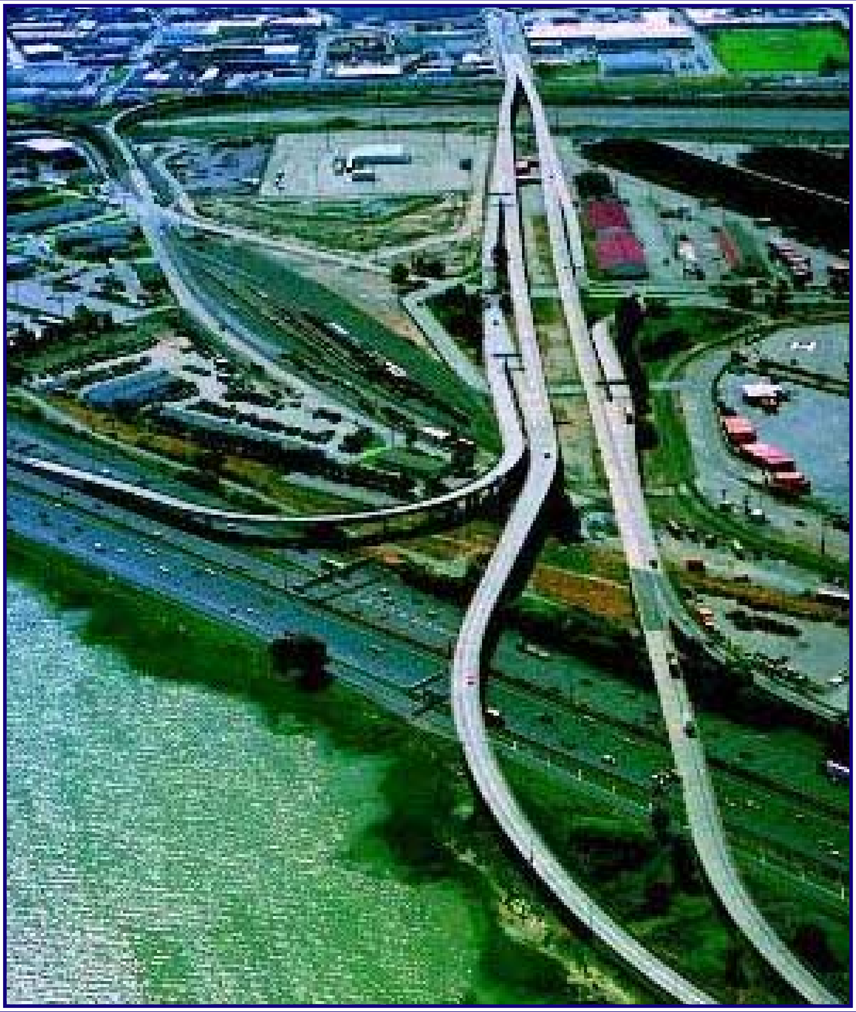
Prize Bridge Award:Grade Seperation

MARITIME OFF-RAMP



The 2,356' long "Maritime Off-Ramp" is one of seven bridge contracts in California's I-880 Replacement Project. The Maritime Off-Ramp replaced a concrete structure on Cypress Street (now named the Nelson Mandela Parkway) in Oakland. The "Maritime Off-Ramp," also known as the Horseshoe Line or "HS" Line because of its 250' radius horseshoe shape, is an orthotropic steel bridge. The remainder of the bridges in the project are steel plate girder bridges with concrete decks or post-tensioned cast-in-place concrete. The "HS" Line becomes California's sixth orthotropic bridge.Loma Prieta Earthquake

On October 17, 1989, the Loma Prieta earthquake (magnitude 7.1) occurred near Oakland and San Francisco, California. The I-880 Cypress Street Viaduct, a two-level reinforced concrete structure completed in 1957 carried I-880 freeway traffic through downtown Oakland. The upper roadway collapsed resulting in 41 deaths and 108 injuries. A portion of the roadway between 7th and 34th streets was removed due to the damage.

I-880 is a critical interstate freeway connecting San Jose and the East Bay Area to San Francisco, Sacramento and the Sierra Nevada. The I-880 Freeway Viaduct was a section of I-880 that carried between 140,000 and 160,000 vehicles per day and provided for eight lanes of mixed-flow traffic.

THE I-880 REPLACEMENT PROJECT

The I-880 Replacement Project was designed and then built in seven separate construction contracts to avoid impacting traffic in this important transportation corridor.

"The Maritime Off-Ramp" is a new unique curved steel orthotropic bridge that provides access to the Port of Oakland through a U-turn from Westbound I-80.

The project's $1.1 billion budget, consisting mainly of federal emergency relief funds from FEMA, is divided into approximately $650 million for construction and $350 million for right-of-way acquisition, railroad and utility relocation, traffic management, transit enhancement, and a number of commitments to the City of Oakland.

An orthotropic steel bridge with trapezoidal ribs was selected to cross over th busy I-80 freeway to minimize travel delays or lane closures during bridge erection to commuters and highway traffic. The bridge utilized reinforced concrete "T" bents with a single column with spiral reinforcing ties. Two special bearings connect the superstructure to each "T" bent. A new joint shear criteria for reinforced concrete design was first used on the project. The level of reinforcement in the design was higher than previous projects.

Special Issues

Some of the details used on the "HS" Line were first utilized on the Golden Gate Bridge. Caltrans provided technical assistance and construction inspection to the Golden Gate Toll Bridge Authority for the replacement of the original reinforced concrete deck with an orthotropic steel deck in 1984. Many welding details for the trapezoidal rib were repeated for the "HS" Line. The transverse flexural stiffness of the orthotropic steel deck is critical for the long-term behavior of the asphaltic overlay. The weight-saving concerns, which guide the seismic design, dictate minimal overlay thickness. This leads to a compliant deck system that is very sensitive to temperature and to local deflections imposed by concentrated wheel loads. The cyclic nature of this loading only increases the problem of compliance between overlay and steel underlayment. The long-term delamination danger of the overlay is greatly reduced by providing a uniform stiffening pattern with relatively closely spaced components and a relatively stiff top deck plate.

Foundation Design

The hexagonal foundations with the seven, "medium size" 42" diameter, steel piles were the result of a structural geotechnical and economical optimization study. The need for pile compliance at the interface of soft mud with the stiff underlayment leads to steel piles. The deep overlying mud layer requires very long piles because of the high seismic loads. Cost is reduced by minimizing the number of steel piles while keeping the pile cap at a reasonable size. Also, the need for pile ductility and elastic pile cap behavior dictates the use of 42" diameter pile with the pile cap dimensions chosen. The hexagonal pile cap shape results from the "isotropic" nature of the seismic loading imparted by the soil structure interaction with the "plastic hinge" load reaction at the pier base.

No welds were allowed to cross over another weld and plates were coped to avoid the occurrence. The details were developed to reduce the number of locations where opposite face welding would occur since laminar tearing could result. The trapezoidal rib is the most popular system used in about 95 percent of all orthotropic deck bridges built worldwide. The ribs were fabricated in tangent chords to accommodate the sharp radius of the superstructure. It was unfeasible to form the rib sections in the same curved configuration of the bridge. The ribs were therefore welded as tangent chords to the top deck plate to approximate the radius of the girders.

An important detail of the orthotropic design is the welding of the closed rib stiffener to the top deck plate. The specifications required this to be an 80 percent

partial penetration groove weld. To ensure that welding would be of the highest quality, the specifications required that the rib welds be made using the automatic submerged arc process. Deck plates were oriented so the grain or rolling direction of the steel plates was centered on the longitudinal axis of the bridge.

To maximize fatigue life and avoid Category "E" details, intersection of rib welds at their juncture with the diaphragm welds were avoided by large copes at the weld intersections. These copes were sealed by injecting polystyrene foam into the rib compartment to prevent entrance of moisture or other corrosion contaminants. An orthotropic steel barrier system using structural steel fabricated in the approved FHWA barrier configuration was designed. To reduce deadload and simplify composite action welded steel was selected. The system was designed to be higher because of the heavy truck traffic using the sharp horseshoe bend on I-80 traffic. The barrier was fabricated in 20' long components that bolt to an internal "W" flange system welded to the orthotropic superstructure. A series of access panels on the exterior allow the removal of damaged barrier after a vehicle collision.

Seismic Detailing Features

The bridge has several unique seismic detailing features including the use of rubber dock fenders as seismic shock absorbers reducing transmission force between completed bridge sections. The rubber delta shaped "dock fenders" were used to absorb kinetic energy occurring during a seismic event at the hinges in the superstructure. Rubber fenders were used as bumpers to reduce forces transmitted in a compression shock wave in the longitudinal axis of the bridge.

Larger delta shaped rubber fenders were used as part of cable restrainer system when the seismic forces would try to pull apart the bridge segments at the two hinge sections. The lower mass of the steel orthotropic superstructure plus the energy damping system reduce seismic forces on the concrete columns and substructure.

PTFE (poly-tetra-fluoro-ethylene) spherical bearings were used to allow for rotation and expansion of members. These bearings can resist higher lateral forces including seismic forces. A central shear key pipe was added for additional lateral capacity.

Fabrication of Orthotropic Bridge Sections

The unusually large dimensions and weight of the orthotropic box girders would limit their fabrication to only the largest fabricators. Consequently, Caltrans directed the consulting engineers to provide detailing to allow for flexible section size. A minimum and maximum section piece size was specified with optional or variable splice locations. Both transverse and longitudinal bolted splice alternatives were included in the design to allow the fabrication of the girders in the smallest sections possible.

The large size and weight of individual girder components created some difficult handling and fitup problems. This was further complicated due to the curved configuration of the girders. The top deck plates with the welded rib sections proved difficult to handle. Once all sub-assemblies were fitted together, most welding was required to be performed in the vertical and overhead positions within the closed box sections. The girder sections were too large to turn to allow welding in the optimum flat and horizontal welding positions.

The contractor fabricated 13 full bridge-width orthotropic sections 7'-0" deep by 35'-6" to 37'-6" wide, with lengths varying from 123' to 219' per section. The sections ranged in weight from 250 tons to a maximum of 459 tons. All sections were shipped with a steel orthotropic deck and with the installed steel barrier rails. The total weight of all fabricated steel equaled 5014 tons.

Erection Process

A creative solution for the installation was conceived by the erector that utilized "SHLHP" (Special Heavy-Lift Hydraulic Platform) which consists of two self-propelled hydraulic platforms braced in tandem with a strut beam. They had the capacity to build the 13 full bridge- width (35.5') sections as one welded unit.

A 20-line, two-file Scheuerle hydraulic trailer with a custom-designed spacer frame was used to off-load the girders at Oakland. The frame between the axles distributed the load over a wider path to meet structural requirements on the dock. The girders were set on temporary cribbing in the staging area. The off-load sequence and staging locations required careful planning since the girders could not pass each other in the staging area once they were off-loaded. Therefore each section was moved three times: first from the fabrication facility to the barge, second from the barge to the staging area beside the I-80 freeway and finally erected. Each section was step jacked to a height on cribbing very close to final bridge elevation.

Closure of I-80 adjacent to the Toll Plaza for the San Francisco-Oakland Bay Bridge was required for setting of the three of the 13 sec-

tions. The sections were staged on the east side of the freeway and crossed over during night erection. This could only take place in a ten-hour window beginning at midnight on a Saturday night. A stiff financial fine was stipulated for each minute exceeding this time limit by the contractor. The first section was erected at the west abutment and allowed the team to practice for the erection over the freeway.

The five mile freeway link, connecting the Nimitz Freeway directly to the Bay Bridge Toll Plaza, opened for business by 5 a.m. Wednesday, July 23, 1997, in time to ease the pressure of the morning commute. The section of freeway opening Wednesday was only the first link of the I-880 Replacement Project. When completed, the freeway section is expected to carry 118,000 cars a day.

Maritime Off-Ramp

Owner:
California Department of Transportation

Designer:
Tudor Engineering, Oakland, CA

Consulting Firm:
ICF Kaiser Engineering Inc., Oakland, CA

General Contractor:
Kiewit-Marmolejo (joint venture) Vancouver, WA

Detailer:
Candraft Detailing, Inc., Port Coquitlam, BC, Canada

Fabricator:
Universal Structural Inc., Vancouver, WA (NSBA Member)

Erector:
Shaughnessy & Company, Auburn, WA