# SONOMA CREEK BRIDGE

## The Widening and Retrofit of a Precast Prestressed Concrete Girder Bridge

BY STEPHEN A. BIGGS, PO CHEN, LICHUN "CARL" HUANG, ALFRED R. MANGUS, MIKE HILLING, AND NICK ABUHAMDIEH

**PROJECT BACKGROUND**

The existing 1800-ft-long (550 m) bridge carrying Highway 37 over Sonoma Creek is located at the North End of San Francisco Bay in Northern California. The existing bridge had two narrow lanes and was partially constructed on a levee that crossed the tidal estuary of the creek. As part of their On-Call Phase II Seismic Retrofit Program,[1] the California Department of Transportation (Caltrans) determined that the Sonoma Creek Bridge was vulnerable and in need of a seismic retrofit. Subsequent to the "seismic retrofit strategy meeting" for the Sonoma Creek Bridge, separate legislation through the State mandated a safety widening of the same structure. Highway 37 was also the subject of Senate Concurrent Resolution 35, which recommended that Caltrans install a concrete median barrier along the highway near the bridge, providing still more justification for widening of the bridge itself.

**SAFETY WIDENING**

In summary, the existing Sonoma Creek Bridge was seismically vulnerable and had several sub-standard features such as its narrow width, limited shoulders, and no concrete median safety barrier.

The practical solution was to delay the seismic retrofit project design and combine it with the safety widening project. The challenge was to widen the bridge and highway while minimizing the impact to the seismic retrofit and the sensitive, tidal marsh habitat (Fig. 1).

**ENVIRONMENTAL CONCERNS**

The Sonoma Creek Bridge sits in an extremely sensitive tidal marsh environment, which provides the habitat for the California Clapper Rail and the Salt Marsh Harvest Mouse which are on the federal list of endangered species. A committed multi-organizational partnership of federal, state, and regional agencies, was formed to assess the impact of the project on the tidal marsh environment and obtain the necessary permits from several agencies. This partnership included the U.S. Fish and Wildlife Service, the U.S. Coast Guard, the San Francisco Bay Conservation and Development Commission (BCDC), and the California Department of Fish and Game

CORTESY OF PARSONS BRINCKERHOFF

FIGURE 1

Early consultation with the U.S. Fish and Wildlife Service and the California Department of Fish and Game alerted the project team to the critical nature of the habitat, and the importance of minimizing intrusion into the marsh wetlands during the widening and retrofit construction.

The San Francisco Bay Conservation and Development Commission (BCDC) Design Advisory Board also assisted Caltrans in suggesting aesthetic modifications to the design to keep the widened bridge in harmony with the natural wetlands. Efforts to address aesthetic and environmental concerns in the widening and retrofit strategy were well recognized, and the design team of Biggs Cardosa Associates and Mark Thomas and Co. received compliments from both the BCDC Design Advisory Board as well as from members of the environmental community, for ability to address these concerns.

## THE EXISTING BRIDGE

The existing bridge is a precast prestressed concrete girder superstructure supported on 20" square precast concrete pile extensions. The existing bridge was constructed in 1968.

The original precast prestressed concrete I girders were fabricated in 1968 by the Basalt Rock Company Inc., Structural Concrete Products Division in Napa, CA, [Now called ??]. See the existing girder cross section from the original shop drawings and the condition after almost 40 years of service as shown in Figures 2 and 3.

The original precast prestressed concrete piling was fabricated in 1968 by the Ben C. Gerwick Inc., Precast-Prestressed Concrete Division, Raymond Concrete Pile Division with H.Q. in San Francisco, CA. [Now called Pomeroy]. ??]. See existing pile elevation & cross sections from their original shop drawings, figure 4, and note the current structure condition as shown in Figure 2.

These original shop drawings were provided courtesy of Caltrans who digitally scans all key shop drawings and stores them in their computer system called "BIRIS" = Bridge Inventory Records Information System.

The biannual inspection records report acceptable performance over 37 years in the high salt environment for both the precast concrete piles and girders.

COURTESY OF BIGGS CARDOSA ASSOCIATES

FIGURE 2

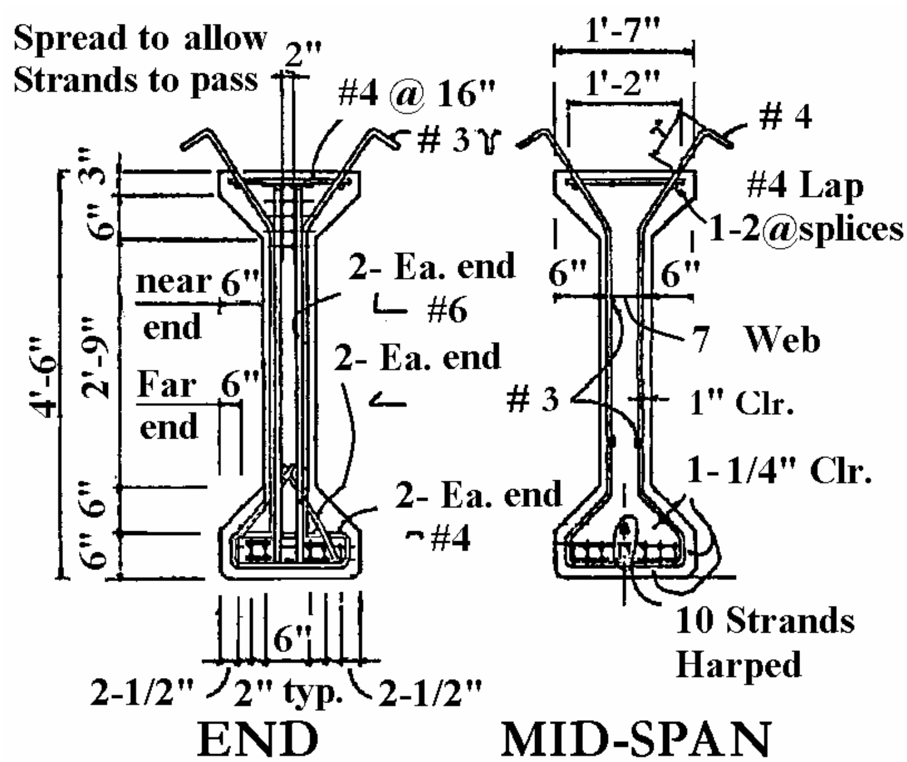



FIGURE 3

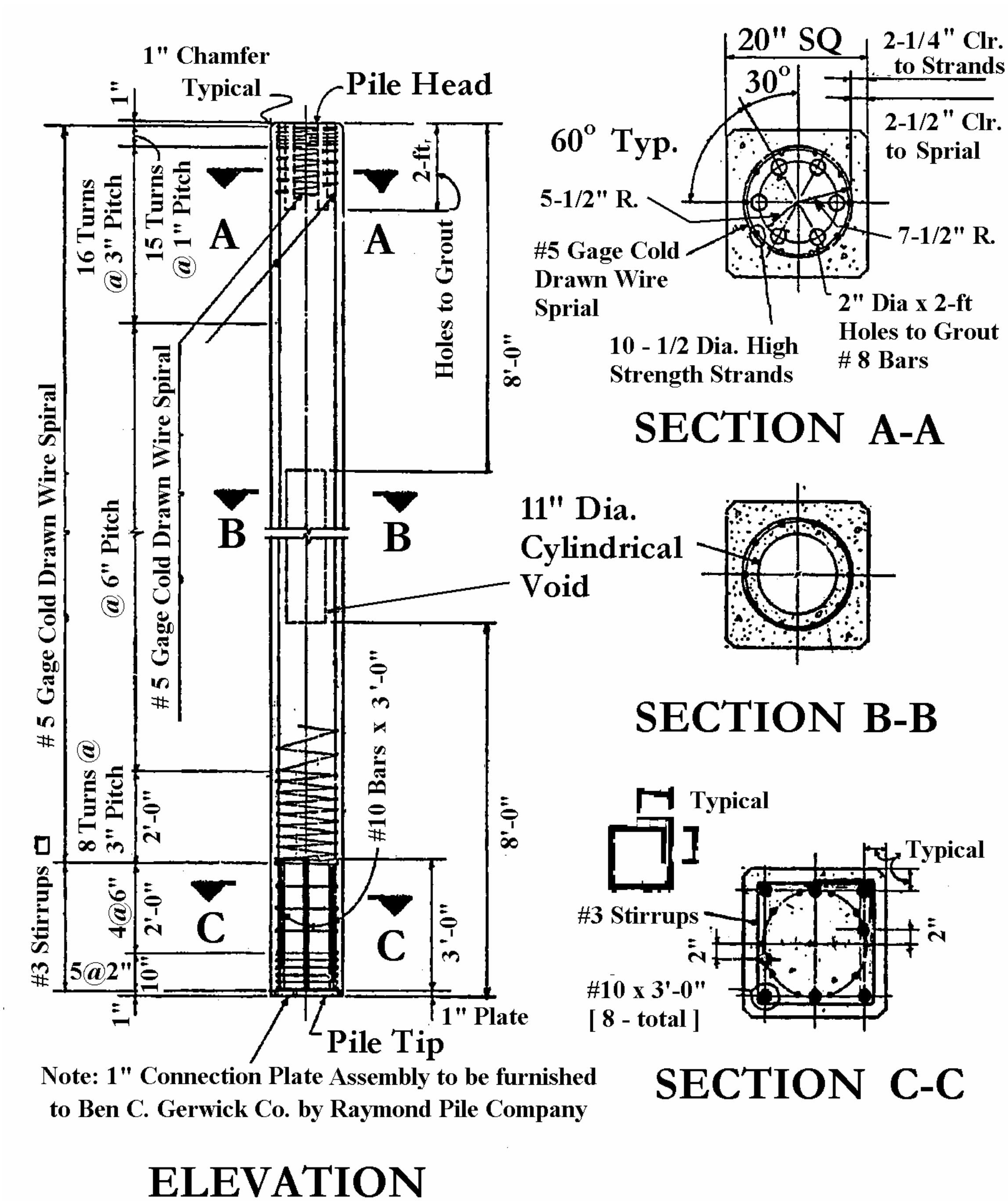

1" Chamfer
Typical
Pile Head
1"
16 Turns
@ 3" Pitch
15 Turns
@ 1" Pitch
2-ft
Holes to Grout
A
A
8'-0"
# 5 Gage Cold Drawn Wire Spiral
@ 6" Pitch
# 5 Gage Cold Drawn Wire Spiral
B
B
11" Dia.
Cylindrical
Void
8 Turns @
3" Pitch
2'-0"
#10 Bars x 3'-0"
8'-0"
#3 Stirrups
4@6"
2'-0"
5@2"
10"
C
C
3'-0"
1"
1" Plate
Pile Tip
Note: 1" Connection Plate Assembly to be furnished
to Ben C. Gerwick Co. by Raymond Pile Company
ELEVATION
20" SQ
30°
2-1/4" Clr.
to Strands
2-1/2" Clr.
to Sprial
60° Typ.
5-1/2" R.
7-1/2" R.
#5 Gage Cold
Drawn Wire
Sprial
2" Dia x 2-ft
Holes to Grout
# 8 Bars
10 - 1/2 Dia. High
Strength Strands
SECTION A-A
SECTION B-B
Typical
Typical
#3 Stirrups
2"
2"
#10 x 3'-0"
[ 8 - total ]
SECTION C-C

FIGURE 4

**PRECAST PRESTRESSED CONCRETE GIRDER SUPERSTRUCTURE**

The FHWA is asking DOT'S and bridge owners to design 100-year life bridges. The key maintenance considerations for selecting the type of superstructure is durability and ease of maintenance to minimize life cycle costs.

The two key design considerations for selecting the type of superstructure for the proposed widening were reducing the construction schedule to minimize environmental impacts and costs and minimizing the dead load of the structure in order to minimize seismic strengthening costs. A precast prestressed concrete I girder superstructure was selected for the widening to expedite the construction schedule, which minimized the impact on the environmentally sensitive marsh lands, reduce structure weight, and provide long term maintenance free service.

Standardized reinforcing steel patterns, and prestressing steel details and call-outs from Caltrans' Bridge memo to Designers and Bridge design Details were used as much as possible (Fig. 5).

Per current Caltrans Bridge Design Specifications at the time, the required cover for I girders in a marine atmosphere was 75 mm. However, adherence to this criterion would have resulted in a substantial increase in the superstructure dead load and consequent seismic loads.

Field review of the existing bridge showed that the existing precast prestressed concrete girders were in excellent condition and showed no signs of corrosion from the marine environment. After performing a value engineering analysis, the Biggs Cardosa Associates design team concluded that the use of Caltrans standard prestressed I girders, without the extra cover required for marine atmosphere, would be appropriate for this project. This "Value Engineering" solution was proposed by the design team and approved by Caltrans.

The bridge widening substructure consists of super bent caps supported on two pairs of 54-in.-diameter (1400 mm) cast in steel shell (CISS) piles, driven outboard of the existing bents in order to straddle the existing battered piles (Fig. 6). These large piles become "super ductile" elements, that in combination with the new super bent caps can support the entire bridge dead load if the existing piles fail due to large lateral displacements during a major seismic event. The new concrete bridge deck was designed to have median barriers, safety shoulders, and lane widths that all meet current safety standards. The bridge and seismic design were developed following Caltrans Bridge Design Criteria and Specifications.[3-6]

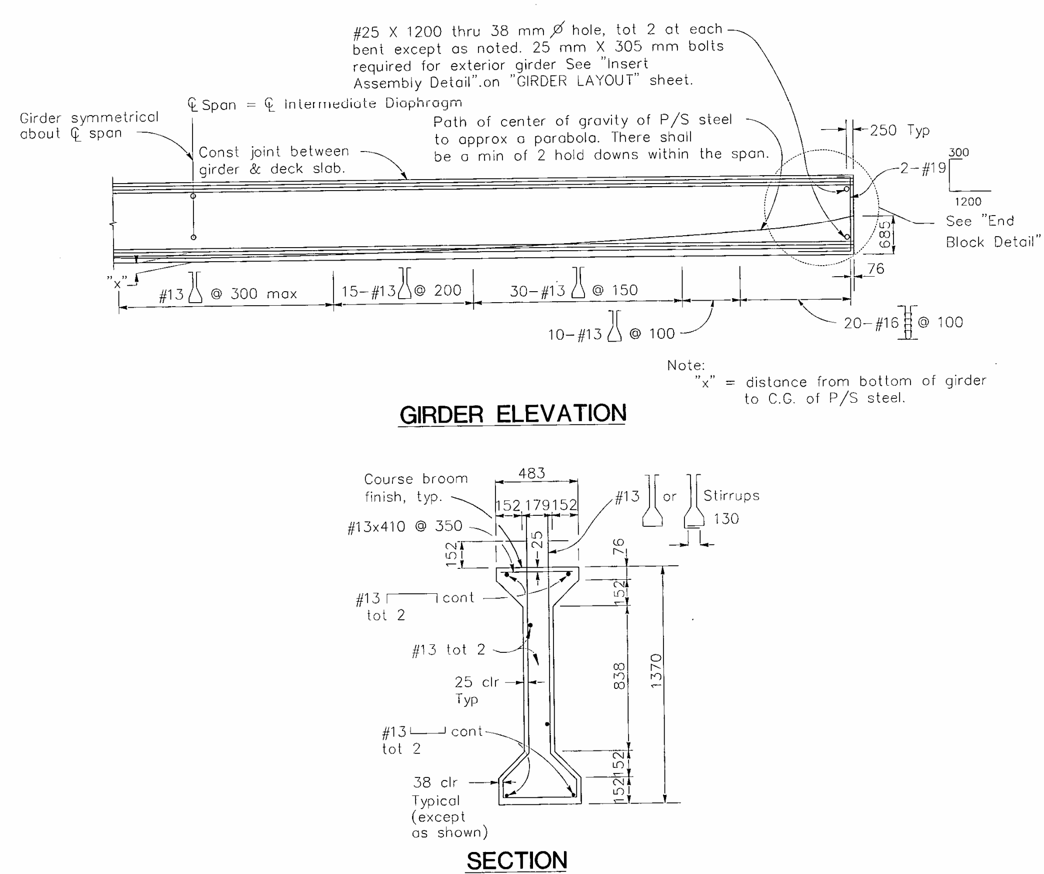



FIGURE 5

**CONSTRUCTION STAGING**

The regulatory agencies involved in the project had a variety of concerns related to construction staging and the construction schedule. The U.S. Coast Guard was concerned about maintaining a navigable channel. The BCDC Design Advisory Board was interested in how much trestle area was needed to be in place during construction.

The U.S. Fish and Wildlife Service played a major role in the scheduling of construction in order to protect the Salt Marsh Harvest Mouse and the California Clapper Rail. Both the U.S. Fish and Wildlife Service and the BCDC mandated that Caltrans provide attachments with their permit applications indicating construction staging areas, temporary structures, and construction methods to assist the regulatory agencies review the proposed construction staging, pile driving, and construction schedule. Schedules were developed for 3 different staging scenarios:

1) assuming no endangered species allowing for a continuous construction window;

2) two-9 month construction windows;

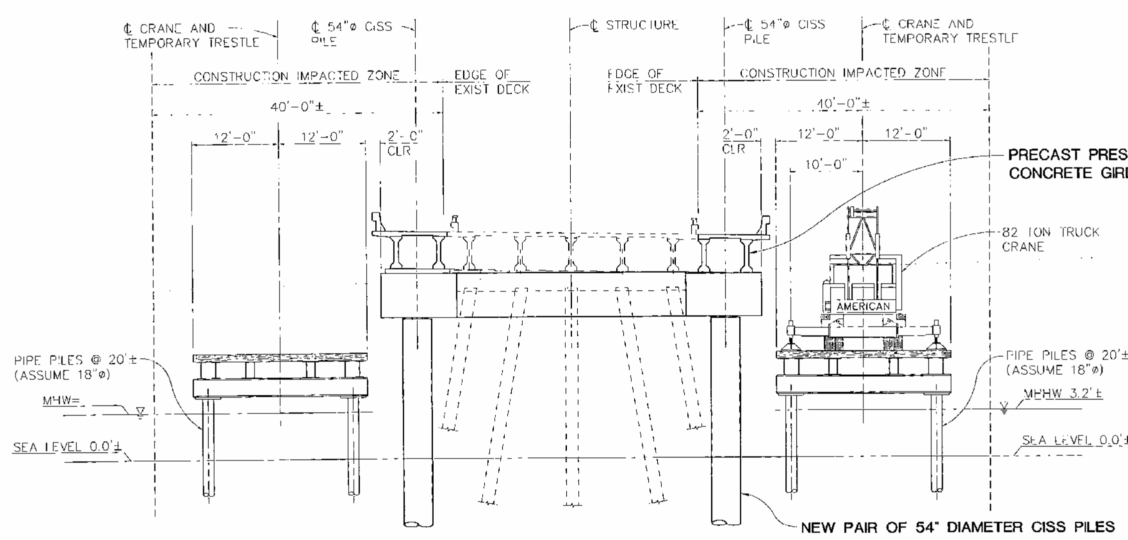
3) three-5 month construction windows.

Each scenario required the team to consider material staging and sequencing of substructure and superstructure construction, as well as mobilization and demobilization costs.

A detailed plan showing the maximum limits of the temporary construction trestle footprint, barge access, staging areas in the navigable channel, and crane layout for pile driving and girder erection by the general contractor was developed. The proposed trestle configuration, figures 6 and 7, allowed the contractor to continue construction at the bridge site as long as a separation distance of 750 ft (230 m) from any California Clapper Rail nesting location was maintained.

A full-time biologist was assigned to the project to monitor construction in order to minimize impacts to the endangered species and the tidal marsh. Based on careful documentation of the annual monitoring for the presence/absence of the endangered birds, Caltrans and the design team were able to maximize the construction schedule.

Construction was completed in only two construction seasons, rather than the three to six construction seasons originally estimated during the permitting phase.




TEMPORARY TRESTLE CONSTRUCTION

FIGURE 6

FIGURE 7

## PILES

Using soil-foundation interaction analyses, Biggs Cardosa Associates collaborated with Parikh Consultants, Inc. to design the CISS piles. The design called for longitudinal reinforcing bars to anchor the bent cap to the pile and to create a reinforced concrete section in the plastic hinge zone (the bars extend a development length plus one pipe diameter beyond this zone). Below the reinforced concrete section, pile forces are resisted by the steel shell itself (stresses are within elastic limits).

Before CISS pile installation, resistance and inclination data obtained using a cone penetrometer were used to find potential conflicts with existing piles. Conflicts were resolved by offsetting the pipe piles and modifying the designs of the bent caps. Pipe piles were driven until dynamic monitoring indicated acceptable bearing. In two cases, however, unanticipated conflicts made it necessary to stop driving the pipe and to drive extension H-piles outside the CISS piles. Pile installation was completed by drilling out the shell, placing a seal course, the reinforcing steel cage, and finally the concrete core within the pipe pile.

## CONCLUSION

Although many agencies and a large design team were involved in the design and construction process, this project was on time and budget. The construction schedule was shortened significantly with the use of precast prestressed concrete girders, helping to reduce the number of construction stages. The new Sonoma Creek Bridge now boasts current lane widths and shoulders, a revised and improved seismic lateral load system, and all was accomplished with minimal impact to the environment.

## References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**DESIGN TEAM**

The bridge design strategy (widening and seismic retrofit) was developed by the Caltrans Bridge Engineering Services of Sacramento, CA. Overall project management was provided by Caltrans "District 4" of Oakland, CA. For final design, Biggs Cardosa Associates, Inc., performed structure project management, foundation and seismic design, geotechnical coordination, while Mark Thomas and Co. Inc., designed the precast pretressed concrete girder superstructure. Parsons Brinkcerhoff created the final plans, specifications, and construction cost estimates for the highway widening using input from Caltrans and other parties, prepared an Environmental Assessment required for compliance with the National Environmental Policy Act, organized the NEPA/404 Integration MOU process, and prepared environmental permit applications to allow the project to proceed to construction. Finally, Biggs Cardosa Associates, Inc., provided construction bridge engineering support after the project was awarded. In recognition of the successful completion of the Sonoma Creek Bridge widening and retrofit, Caltrans presented each team member with the Excellence in Transportation Award.

Key Staff

Caltrans

Lichun "Carl" Huang is a Senior Bridge Engineer with the Office of Structure Contract Manager (OSCM). He was the Caltrans OSCM Contract Manager for Sonoma Creek Bridge Project.

Alfred R. Mangus is a Transportation Engineer (Civil) with the Office of Structure Contract Management of Caltrans. He was the Caltrans OSCM Deputy Contract Manager for the Sonoma Creek Bridge Project.

Mark P. McGowan Caltrans District A, Project Engineer

Gerry Santiago Caltrans, Senior Construction Engineer

Mike Hilling Caltrans Associate Bridge Engineer with the Office of Structure Contract Management

Nick Abuhamdieh is a Senior Bridge Engineer (Civil) with the Division of Structure Construction Management. He was the Caltrans Structures Representative for Sonoma Creek Bridge Project.

Chuck Morton Caltrans, Senior Environmental Planner

Biggs Cardosa Associates, Inc

Stephen A. Biggs is President for the Biggs Cardosa Associates, Inc., Structural Engineers, San Jose, CA, office. He was the Project Manager for the Sonoma Creek Bridge Project.

Thomas L Swayze was the Project Engineer for the seismic retrofit design.

Mark Thomas and Co. Inc.

Po Chen, S.E., is principal at Mark Thomas and Company. He was the Project Engineer for design for the superstructure.

Parikh Consultants, Inc.

Gary Parikh, CE GE, is president of Parikh Consultants, Inc. He was the Geotechnical Engineer on the project.

Parsons Brinckerhoff

Mark Aikawa was the Consultant Project Manager for Civil & Environmental Services.

Diablo Contractors

Larry Brandt was the Superintendent of Construction.