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New San Francisco Steel Viaduct

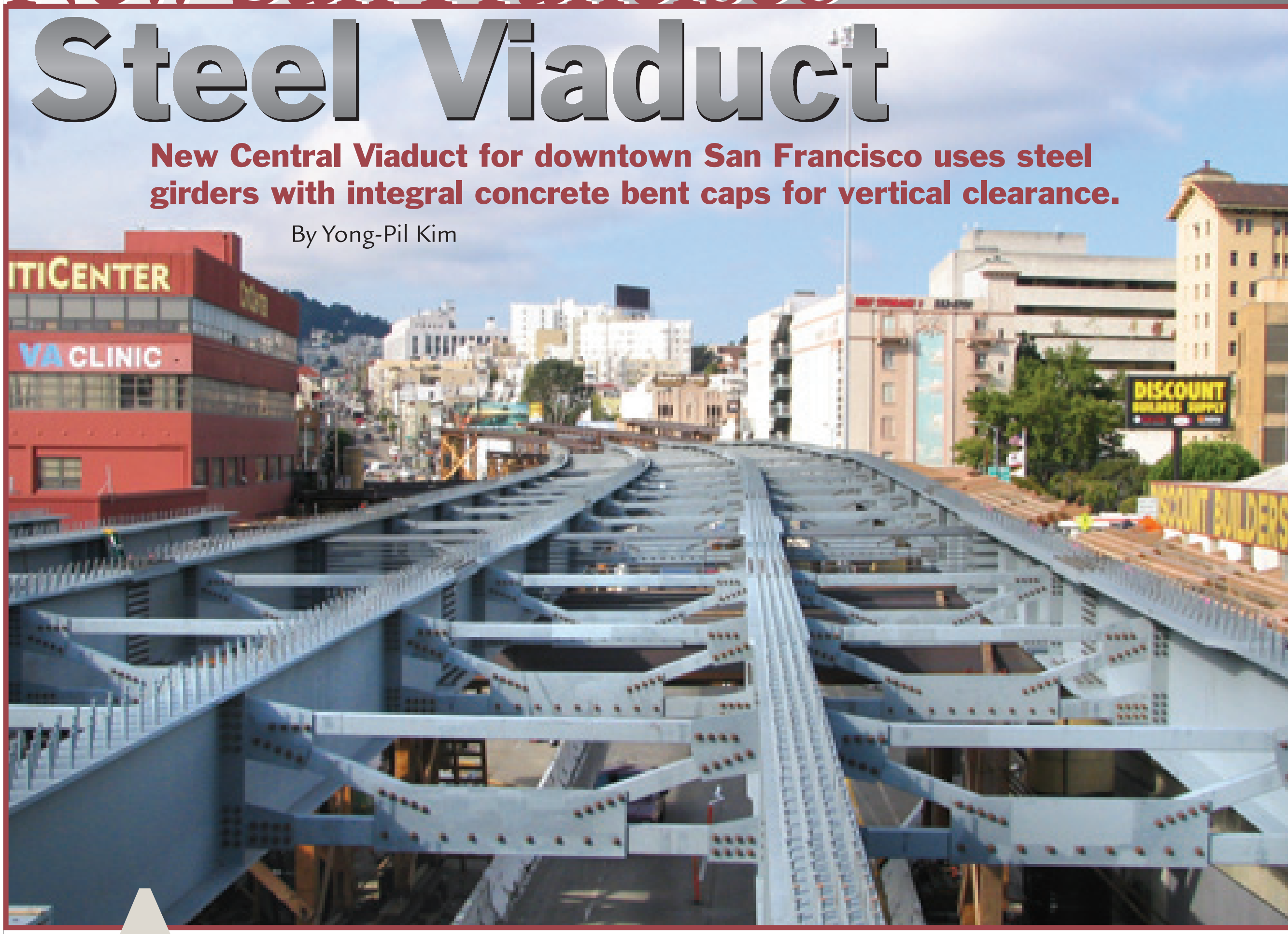
California's Seismic Bridgework Update

FOCUS:
Bridge Work

New San Francisco Steel Viaduct

New Central Viaduct for downtown San Francisco uses steel girders with integral concrete bent caps for vertical clearance.

By Yong-Pil Kim



A new Central Viaduct will soon direct traffic into San Francisco from the Bay Bridge in the east and from Highway 101 in the south. The new steel viaduct replaces a previously retrofitted viaduct whose structural integrity came into question after the 7.1-magnitude Loma Prieta earthquake in 1989. After the earthquake, Caltrans removed the upper deck portion of the viaduct in the interest of safety.

The new steel viaduct replaces the lower elevated deck, and touches down on Market Street, a main thoroughfare within the city. The viaduct provides two lanes in each direction, plus shoulders. The steel superstructure has a hybrid girder design, combining high-performance grade 70-ksi steel with standard 50-ksi steel. The steel girders are integral with the concrete bent cap to maximize vertical clearance. The contractor post-tensioned the partially built bent cap to eliminate need for falsework during the deck pour. After the deck concrete reaches its strength, additional post-tensioning will be applied to each bentcap for final service loads.

Challenges

Various factors for this project dictated steel for the viaduct's superstructure. The streets below run parallel to a major portion of the viaduct and had to remain open during construction. One intersection below the viaduct in particular required a long span with a limited area for falsework. Space was sufficient only for falsework to construct the bentcap beam. Vertical clearance requirements, a curvature in the horizontal alignment, and one particularly long span where falsework was prohibited virtually ruled out either cast-in-place or precast concrete design. Oregon Iron Works fabricated the steel for the project.

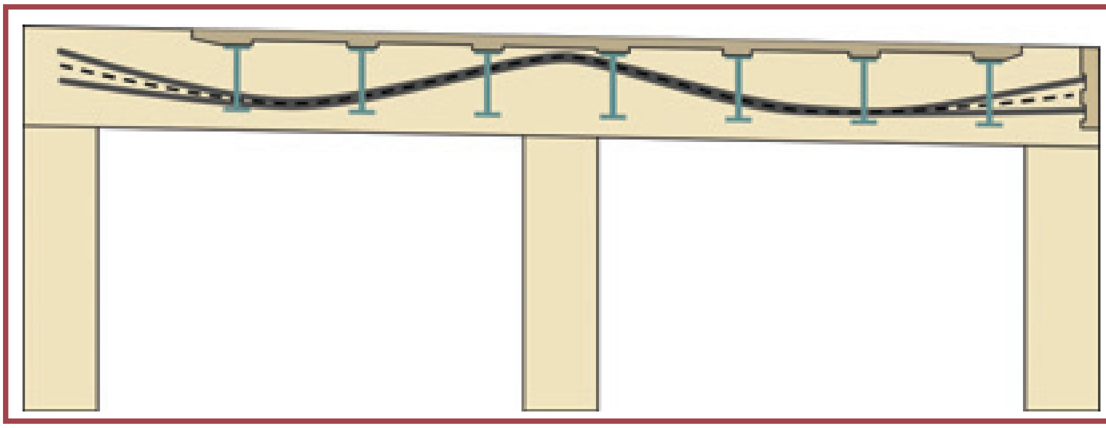
Viaduct configuration

The new portion of the Central Viaduct consists of 10 spans that achieve a total length of 1,424 feet. The longest span stretches to 190 feet. The design follows LFD specifications. Contractors bolted underlying girders end to end via field splices to create a set of continuous parallel girders that matched the entire length of the viaduct.

San Francisco Central Viaduct superstructure

Number of continuous steel girders	**7**
Weight of steel girders	**2,362 tons**
Number of crossframes	**376**
Weight of crossframes	**392 tons**
Number of spans	**10**
Longest span	**190 feet**
Viaduct length	**1,423 feet**

Three concrete columns topped by a transverse concrete bent cap support the viaduct's superstructure. The columns



Opposite page: Tight vertical clearance called for a steel, rather than precast concrete, superstructure.

Left: Steel tendons weave through the steel girders in a parabolic curve within the bent cap. Rendering: National Steel Bridge Alliance.

extend from concrete pile shafts that run as deep as 94 feet below the surface. Columns are supported by cast-in-place drilled concrete pileshafts, 6 feet and 7 feet in diameter.

Some interruption of traffic could not be avoided. The contractor set up falsework adjacent to bents to set the girders in their final configuration and to bolt-splice the steel girders together, making them continuous. This required closing a portion of the street below. A minimum set number of hours were allowed for this operation.

Seven continuous steel plate girders support the concrete deck. The spacing between the girders varies, as does the width of the viaduct, but averages about 12 feet. The depth of the girders varies from 4.26 feet to 6.23 feet, depending primarily on span length. Standard V-shaped crossframes connect the girders laterally.

The girder top and bottom flanges consist of both high-performance and standard steel, depending on loads. Flange widths range from 1.5 feet to 3 feet, while flange thicknesses range from 1.2 inches to 3 inches. Web thickness is sufficient to require stiffeners only near the support columns. To accommodate expansion, CalTrans specified PTFE bearings on top of the columns at two bents adjacent to the beginning and the end of the structure. Lateral movement of the superstructure is restrained by internal shear keys embedded on top of these columns.

Oregon Iron Works fabricated the steel superstructure. The curves in the plate girders made normal trial assembly nearly impossible. The fabricator fully assembled bridge sections and bunked them to elevation to replicate field conditions, minimizing the possibility of fabrication and erection errors. Adams and Smith, Inc., Lindon, Utah, erected the viaduct superstructure.

The contractor elected to use stay-in-place metal forms for casting the deck. Installation of wooden forms can compromise safety with traffic underneath. The standard deck thickness is about 9.5 inches.

Attaining Vertical Clearance

The conventional system of erecting steel girders over dropped cap bents was not acceptable due to vertical clearance requirements. As a solution, integral concrete bentcap construction was chosen, where the steel girders are embedded within the concrete bent cap – a relatively unusual configuration. The bottom of the bent cap is just 6 inches to 9 inches below the girder bottom flanges. This system achieved a final vertical clearance of nearly 17 feet

> "The new steel viaduct replaces the lower elevated deck, and touches down on Market Street..."

The continuous steel girders are integral with the concrete bent cap to provide vertical clearance near 17 feet at the lowest point.

above the street traffic below, and 14.5 feet during construction.

For this system to work the contractor had to post-tension the integral bent cap. Four steel tendons for the post-tensioning run transversely through the concrete bent cap, and they are placed through holes in the web of the steel girders. The path of the tendons follows a parabolic curve, a shape that is opposite to the natural sag of the concrete beam.

The deck pan varies from about 9.5 inches to 10 inches thick, depending on the girder spacing. The contractor chose stay-in-place metal forms for the deck pour.

Post-tensioning of the bent cap takes place in two stages. The first stage stresses the tendons for a structure that consists of plate girders and partially built bent caps. This permits the viaduct to carry the load during the wet concrete deck pour plus the live load from construction crew and machines. With this technique no falsework is required.

After deck concrete achieves its specified strength, the contractor stresses the tendons in the bent cap a second time. This additional post-tensioning permits the structure to support the dead load of the viaduct plus the live traffic load. Caltrans expects to complete the Central Viaduct in July of 2005. ■

Editor's Note: Yong-Pil Kim is senior bridge engineer for Caltrans. Photos courtesy of Caltrans.

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