Flexible Ball Joints

San Francisco's effort to seismically upgrade its water supply is big. The $4.765-billion Water System Improvement Program (WSIP) includes 83 separate projects throughout the Bay area.

A critical link in the chain of projects is a comparatively small $75.1 million upgrade to a pair of water pipelines that cross the Hayward Fault in Fremont. In the June 30, 2014 issue of *Engineering News Record*, WSIP calls the upgrade to Bay Division Pipelines 3 and 4 one of the most challenging engineering efforts of the program and symbolic of the success of the program overall.

Two different types of joints — slip joints and ball joints — provide the Bay Dvision Pipeline No. 3 with a fighting chance to survive a major earthquake. The highly innovative ball joints, manufactured by EBAA Iron Sales in Eastland, Texas, rotate up to 12 inches to allow pipe, aided by sliding supports, to displace by up to 6.5 feet during a seismic event. The ball and slip joints both are housed in a 300-foot-long articulated concrete vault made of free-moving concrete segments separated by 6 inch gaps, to allow the vault to flex in the direction of the fault path.

The section of Pipeline 3 rests on sliding supports within the articulated concrete "vault" box, which can flex like an accordion toward the direction of the fault movement. Inside the vault, two massive ball joints rotate up to 12 degrees to allow the pipe to shift. The two identical joints were fabricated specifically for the project. The inner dimension of the ball joints measures 72 inches (6 feet) in diameter. The joint itself measures more than 8 feet in diameter at its widest point. The ball joints are the largest such joints to be used in the Hetch Hetchy Regional Water System.

The water agency procured the 72-inch ball joints, which are the largest known to be manufactured in the world, according to EBAA Iron Sales. EBAA's line previously topped out at 48 inches. The San Francisco Public Utilities Commission (SFPUC) also purchased a full-size prototype and subjected it to rigorous testing.

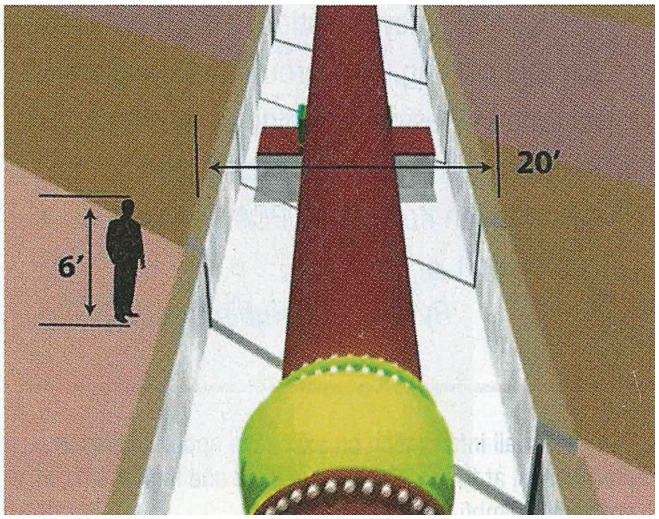
Procuring the 72-inch ball joints took three years. Standard practice requires ball joints to undergo hydrostatic pressure testing with no rotation, so the manufacturers, EBAA Iron Inc. and R&B Co., designed and fabricated a special apparatus to test for rotation while at 200 psi. Tests showed the ball joints can withstand the forces associated with fault displacement.

Composed of ASTM A536 ductile iron, each ball joint weighs over 17 tons and is tested hydrostatically to 200 psi — higher than the pipeline's normal operating pressure of 125 psi. The ball joints were tested at 12 degree displacement, which exceeds the 8 degrees of movement expected during an earthquake. Between the ball joints, two sliding supports allow the pipe to move freely. Mirror-finished stainless steel plates on the bottom of the pipe sit atop the PTFE-coated supports anchored to the floor.

Between the supports over the main fault hazard zone, 1-inch-thick unsupported steel pipe stretches 147 feet. A cladded pipe element that connects the north ball joint with the slip joint was procured. Held in place by steel frames, the 50-foot long continuous piece of pipe is free to compress into the slip joint with no binding.

The articulated box, pipeline and slip joint with the massive ball joints at each end together allow the pipe to compress, move, and even rotate without rupturing during a seismic event. Construction for this project was expected to be complete by the end of 2014.

The 72-inch flexible ball joints delivered to the City of San Francisco were an industry first, as well as a new product for EBAA Iron Sales. The new, 72-inch ball joints are designed for water and wastewater pipelines, with 12 degrees of deflection. The joints are rated at 200 PSI and constructed of ASTM A536 ductile iron. Flange end connections conform to ANSI/AWWA standards. The ball joints have a NSF61 approved coating.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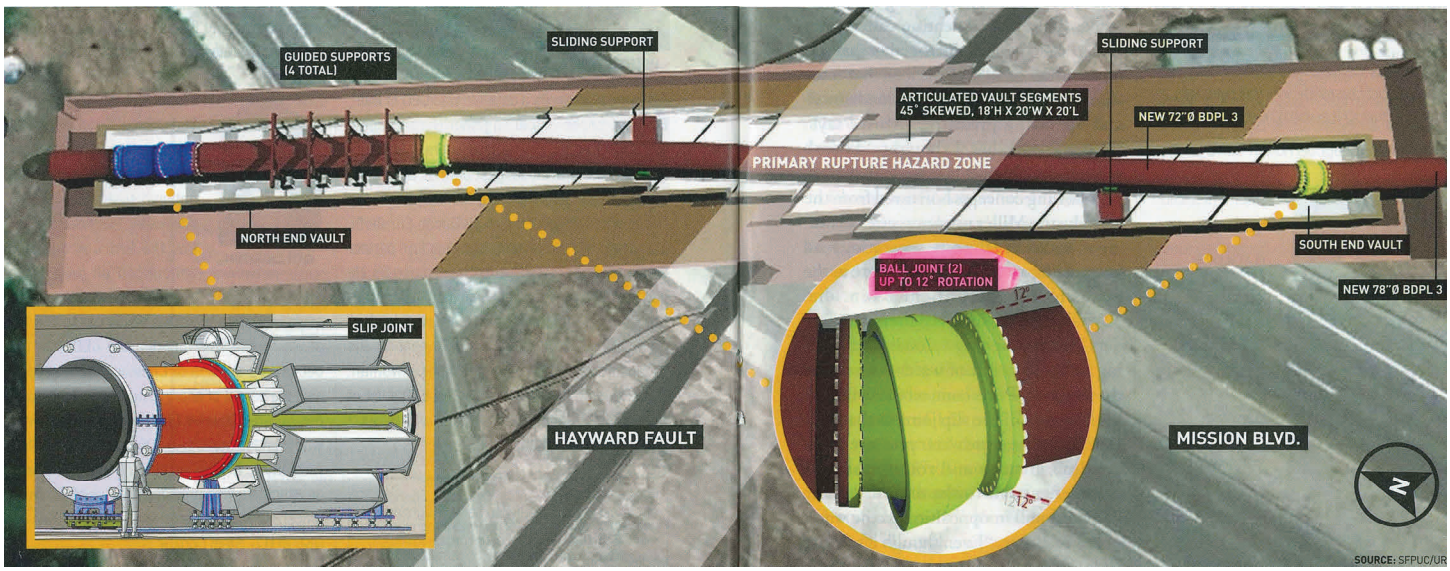
GUIDED SUPPORTS (4 TOTAL)
SLIDING SUPPORT
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ARTICULATED VAULT SEGMENTS 45° SKEWED, 18'H X 20'W X 20'L
NEW 72"Ø BDPL 3
PRIMARY RUPTURE HAZARD ZONE
NORTH END VAULT
SOUTH END VAULT
BALL JOINT (2) UP TO 12° ROTATION
NEW 78"Ø BDPL 3
SLIP JOINT
HAYWARD FAULT
MISSION BLVD.
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SOURCE: SFPUC/UR