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# Government Engineering

The Journal for Public Infrastructure

## Hillside Tank Blends into Neighborhood

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# Hillside Tank Blends into Neighborhood

## Burgeoning San Francisco Bay area populations are looking for increased water storage capacity.

As the cost of purchasing a home continues to rise in the San Francisco Bay area, many citizens are looking to the outlying suburbs for a piece of their American dream. This has fueled the substantial and sustained population growth Brentwood, CA, has been experiencing over the last several years. Located about 45 miles east of San Francisco, Brentwood's population has been rising dramatically every year. To handle increased water storage capacity demand associated with increasing population, improve reliability, and provide emergency water storage, the city investigated several options for installing a new four-MG water storage tank.

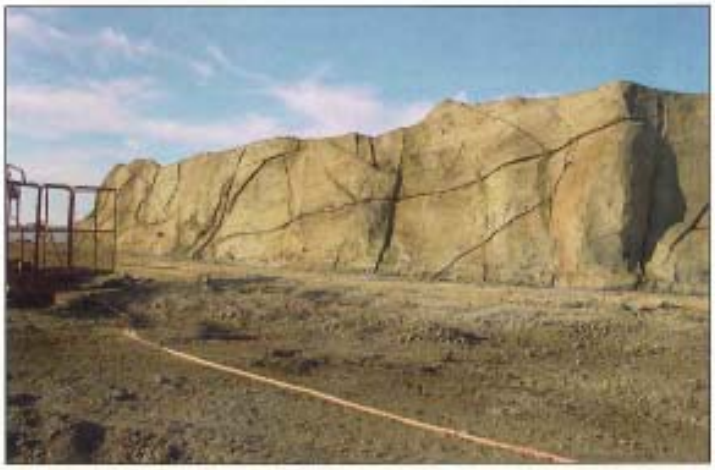
Several locations were evaluated for the new storage reservoir and the current location was chosen due to topographical requirements, adjacency to existing infrastructure, and adequate property rights. The only concern for the city was that the location was immediately adjacent to existing residences. Due to this proximity, the city had to consider other alternatives, such as a prestressed concrete tank that could be completely or partially buried. In addition, a prestressed concrete tank could readily accept architectural treatments.

After their evaluation, Brentwood officials determined that a prestressed concrete tank was the most efficient configuration for the city's needs. Prestressed concrete tanks had been used successfully in similar applications for decades, providing reliable performance even under adverse conditions such as earthquakes and fires. Given this proven track record, Brentwood officials felt confident that a prestressed concrete tank would offer the reliability and durability they were counting on and that the structure would be virtually maintenance-free because it has no coatings.

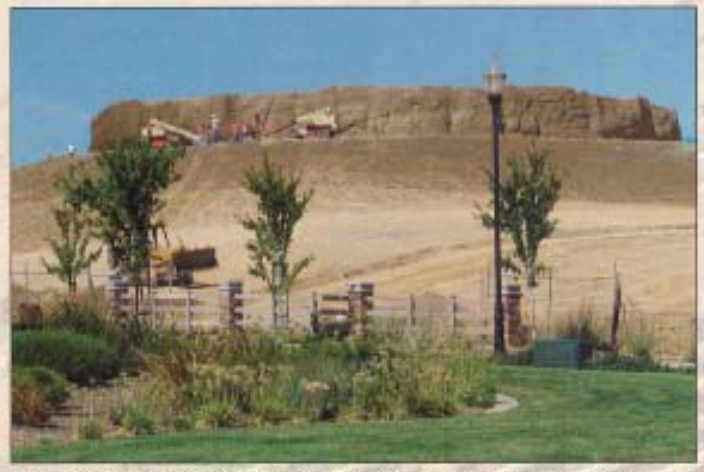
*Now you see it. Housing developments adjacent to the new tank presented visibility problems.*

### Advanced Techniques

The project exemplified the most advanced construction and prestressing techniques in the industry. The floor,



*Architectural rock wall facade and landscaping of the rural hillside softens the transition from the tank to the surrounding residential neighborhood.*



*Now you don't. Partially buried and camouflaged with an architectural rock wall facade, the new tank is less intrusive.*

footings, columns, wall, and roof were all designed and built with concrete. The four-MG reservoir, constructed in just five months, has an inside diameter of 154 ft and a water depth of 30 ft. The reservoir incorporates a 10-in. thick poured-in-place concrete core wall, which was prestressed both vertically and circumferentially to achieve a residual compression of 200 psi. Vertical post-tensioning was achieved with 121 vertical threadbars, 1 1/4 in. in diameter. More than 22 miles of seven-wire galvanized strand was used for the circumferential prestressing of the wall. The strand was applied to the wall exterior at a tension of 14,950 lb and then covered with 2 in. of automatically applied shotcrete.

The tank has a reinforced concrete membrane floor that was cast monolithically. Flexible connections at the wall base and top, combined with the core wall in compression, maximize the structure's ductility during static loads and the high seismic forces typical in the Bay Area. The tank has a flat, 10-in. thick, two-way reinforced concrete roof supported by thirty-two 24-in. diameter, reinforced concrete columns. The roof, like the floor, was cast monolithically.

Because of the presence of housing developments in the area, a major concern was the visibility of such a large tank in the neighborhood. To encourage community acceptance, understanding, and support of the project, the city developed several concepts for blending the tank into the hillside. The option selected was to partially bury the tank and use an architectural rock wall facade from Boulderscape, Inc. (www.boulderscape.com) on the upper portion of the tank wall to completely shield it from view and landscape the hillside to mimic the rural hillside surrounding the city. The result was a softer and more natural transition from the tank to the scenic beauty of the surrounding residential neighborhood. Trying to be sensitive to the concerns of nearby residents, a significant amount of time and effort was put into the architectural and landscape plans. The city was pleased the project was completed on time and without any complaints from the neighboring residents.

Working with Brentwood on this project was a cohesive partnership of firms—Kimley-Horn and Associates, Inc. (www.kimley-horn.com), civil engineering consultant; GSE Construction Co., Inc. (www.gseconstruction.com), general contractor; The Covello Group (www.covellogroup.com), construction manager; and DYK Incorporated (www.dyk.com), tank designer and contractor. Technical advancements as well as the combined qualifications and experience of these firms were important ingredients in the successful design and construction of this project.

The completion of the water storage tank makes a vital contribution to the well-being of the community. It ensures that Brentwood will be able to provide safe and reliable water to meet not only current demands, but future ones as well. The tank will be a welcome addition and a good neighbor. CE

*Shotcrete sculpted rock wall is installed and finished by sculptors and chromatic artisans.*

# Building a Better Tank for Brentwood

Like many urban communities in the San Francisco Bay Area, the city of Brentwood, Calif., has experienced explosive growth with the influx of new residents over the last several years. To handle increased water storage capacity demand, improve reliability, and provide emergency water storage, the city investigated several options for installing a new 4-mil-gal (15-ML) water storage tank.

After their evaluation, Brentwood officials determined that a prestressed concrete tank was the most efficient, cost-effective, low-maintenance configuration for the city's needs. Prestressed concrete tanks had been used successfully in similar applications for decades, and their performance and reliability were unmatched, even under adverse conditions such as earthquakes and fire. Given this proven track record, Brentwood officials felt confident that a prestressed concrete tank would offer the reliability and durability they were counting on and that the structure would be virtually maintenance-free because it has no coatings.

Working with the city of Brentwood on this project was a cohesive partnership of firms—Kimley-Horn and Associates Inc., civil engineering consultant; GSE Construction Co. Inc., general contractor; The Covello Group, construction manager; and DYK Incorporated, tank designer and contractor. Technical advancements as well as the combined qualifications and experience of these firms were important ingredients in the successful design and construction of this tank.

**The city of Brentwood's new 4 mil-gal (15-ML) prestressed concrete tank incorporates the industry's most advanced construction and prestressing technologies.**

## Team takes advantage of tank technology

The project exemplified the most advanced construction and prestressing techniques in the industry. The floor, footings, columns, wall, and roof were all designed and constructed with concrete. The 4-mil-gal (15-ML) reservoir, constructed in just five months, has an inside diameter of 154 ft (46.9 m) and a water depth of 30 ft (9.1 m). The reservoir incorporates a 10-in. (254-mm) thick poured-in-place concrete core wall, which was prestressed both vertically and circumferentially to achieve a residual compression of 200 psi (1,379 kPa). Vertical post-tensioning was achieved with 121 vertical threadbars, 1 1/4 in. (32 mm) in diameter. More than 22 mi. (35.4 km) of 7-wire galvanized strand was used for the circumferential prestressing of the wall. The strand was applied to the wall exterior at a tension of 14,950 lb (6,781 kg) and then covered with 2 in. (51 mm) of automatically applied shotcrete.

The tank has a reinforced concrete membrane floor that was cast monolithically. Flexible connections at the wall base and top, combined with the core wall in compression, maximize the structure's ductility during static loads and the high seismic forces typical in the Bay Area. The tank has a flat, 10-in. (254-mm) thick, two-way reinforced concrete roof supported by thirty-two 24-in. (610-mm) diameter, reinforced concrete columns. The roof, like the floor, was cast monolithically.

## Tank ensures safe and reliable water for years to come

Because of the presence of housing developments in the area, a major concern was the visibility of such a large tank in the neighborhood. To encourage community acceptance, understanding, and support of the project, Kimley-Horn and the city developed several concepts for blending the tank into the hillside. The option selected was to partially bury the tank and use an architectural rock wall facade on the upper portion of the tank wall to completely shield it from view. The result was a softer and more natural transition from the tank to the scenic beauty of the surrounding residential neighborhood. The city was pleased the project was completed on time and without any complaints from the neighboring residents.

The completion of the water storage tank makes a vital contribution to the well-being of the community. It ensures that the city of Brentwood will be able to provide safe and reliable water to meet not only current demands but future ones as well.