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Featured Projects

## California Underpass and Army Storage Sites Benefit from Electro-Osmotic Pulse

*By Ben Craig*

On the morning of February 9, 1971, an earthquake measuring 6.6 on the Richter scale struck Southern California. This famous seismic event, known as the Sylmar Earthquake, was the inspiration for the movie *Earthquake*, starring Charlton Heston and Ava Gardner, and caused serious damage across the southern region of California. But in one Santa Barbara intersection the damage would pose a continuing problem that would challenge California Department of Transportation (CalTrans) engineers for decades.

During original construction of an underpass on Castillo Street in 1964, the interchange was created by excavating below Route 101 in order to leave the eye-catching view of the Santa Barbara Harbor unobstructed. The underpass, though, was depressed below the water table and engineers had to take preventive measures to keep the interchange dry. However, when the earthquake hit, the interchange incurred damage to the seals that were holding water back from infiltrating the intersection. Ever since then, moisture has been causing slick conditions for cars, bicyclists and pedestrians alike, despite numerous attempts to block the water intrusion.

The solution to the moisture problem on Castillo Street came from a technology developed in the late 1980s and early 1990s. This technology, called electro-osmotic pulse (EOP), has the ability to create a barrier that blocks water seepage or intrusion.

According to Steve Hendrickson, project engineer with CalTrans, using the EOP technology was a more effective approach to solving the water problem on Castillo Street. "Instead of reconstructing the interchange, which would have caused a major traffic inconvenience, we opted to install an EOP system," he said.

The Army Corps of Engineers and CalTrans oversaw EOP system installation at the Castillo Street site. The technology is also very effective at keeping basements and underground storage facilities dry, said Orange Marshall, the Project Manager for EOP system installations from the Corps of Engineer's Engineer Research and Development Center (ERDC). "EOP primarily protects against corrosion by drying the interior of a basement or underground structure. This is especially important for mitigating corrosion of equipment and items stored in typically damp facilities, he explained.

### Fort A.P. Hill

The success of projects like the Castillo Street EOP installation has stimulated the application of EOP systems to other sites. One of particular note are munitions storage facilities at Fort A.P. Hill.



*The Castillo Street Underpass is shown 'before' and 'after' an electro-osmotic pulse (EOP) system has been installed. Photo courtesy of Army Corps of Engineers.*



*A marine trains at Fort A.P. Hill. Photo courtesy of Army Corps of Engineers.*

Fort A.P. Hill, located near Bowling Green, Virginia, is a well-known host to military training programs. The site has 27,000 acres of land to support live fire exercises, and also supports the Military District of Washington's installations with ammunition and explosives. Some of the munitions storage facilities at Fort A.P. Hill have severe moisture intrusion problems. The excess moisture in these facilities is causing corrosion of the ammunition and equipment, as well as the steel rebar in the concrete portions of the structure.

Additionally, it has effects on personnel working in the area. For instance, the moisture fosters an environment friendly to mold and bacteria. Both contribute to poor air quality and can activate asthma and allergies in soldiers working in the tight confines of the storage facility.

The storage facilities at Fort A.P. Hill hold a variety of explosive ordnance (weapons and equipment), including small arms and artillery rounds, fuses, shape charges, hand grenades, and pyrotechnics, which are used by soldiers, marines, and other government agents on a daily basis. The water intrusion creates an environment that induces corrosive degradation of these munitions and their storage containers. In order to protect equipment and ordnance from corrosion at the Fort A.P. Hill munitions storage facilities, the DoD Corrosion Office decided to fund a project to install EOP systems similar to the ones used to solve the water intrusion problem for CalTrans on Castillo Street.

### **Could EOP Cause Spark to Occur in a Munitions Storage Facility?**

Before the Corps of Engineer's ERDC and its contractors could install the EOP system at the Fort A.P. Hill munitions storage facilities, they had to investigate if the system would pose a safety risk. For instance, is there a potential for the system to induce an electrical spark or to generate any significant amount of hydrogen, which could create an explosive environment?

To test if the EOP system would pose any safety risks to these munitions storage facilities, ERDC built a small-scale model of one of the facilities. "We conducted a series of tests to evaluate concerns that Fort A.P. Hill and the Defense Ammunition Center (DAC) had about implementing an EOP system," said Marshall. Upon completing the engineering studies, it was determined that there was no risk of spark associated with the use of the system. Marshall added that all of the issues originally identified were no longer a concern. "We didn't see any evidence of adverse effects using the EOP system."



*Ammunition shows corrosion inside the storage facility at Fort A.P. Hill. Photo courtesy of Army Corps of Engineers.*

Now that the testing is complete, Marshall will lead the installation of an EOP system in an empty munitions storage facility at Fort A.P. Hill. To ensure that scaling up the system to the full-size facility doesn't cause any unexpected changes in performance, ERDC will repeat the tests done on the facility model on the full-scale facility. When Fort A.P. Hill and the DAC give their approval based on successful tests, ERDC will install EOP systems on 10 other munitions storage facilities that are known to have water intrusion problems.

### **Avoiding Future Costs**

As mentioned in many government studies and publications, corrosion is a costly problem, but EOP is one technology with the capacity to help avoid future costs. Marshall mentioned that government facilities are looking to use this technology to help protect their assets from corrosion and to ultimately avoid expensive maintenance, repairs, and replacement of equipment and materiel.

"Fort A.P. Hill and the DAC became interested in this technology because there are a lot of ammunition storage igloos, or bunkers, all around the world, where water infiltrates into enclosed areas making it difficult to keep things dry. Some of the newer fuses have to be maintained at a low humidity, for example, to prevent corrosion and accidental loss. So it's a big problem, and they're hoping that maybe this technology might be a solution for them also, worldwide, not just specifically for Fort A.P. Hill."

EOP has won several awards based on its outstanding technical merit and practicality for implementation. The technology received the 2003 Army R&D award and the 2003 NOVA award for innovation, among other nominations.

### **Successful Applications of EOP**

How have previously installed EOP systems performed? At the Castillo Street interchange in California, "Ninety percent of the water is not coming through any more," said Hendrickson. After completing the paving phase, the last step in the EOP project, at the intersection, 95 percent of the water has now been eliminated. "So far, so good, but the acid test will be this winter during our rainy season," he added.

In addition to the system at Castillo Street in Santa Barbara, EOP has been installed at other facilities. Facilities at Fort Sill, Oklahoma, and Fort Drum, New York, for example, have been implemented with EOP systems to protect against excessive moisture intrusion. Tim Noble, a project engineer, was the on-site Corps of Engineers representative during the EOP installation at Fort Drum. "In the 10th Mountain Division Headquarters building, there was a water problem where water was seeping into the basement," said Noble. The EOP installation was completed during summer 2006, and although it's too early to tell for sure, he said the EOP system has been doing its job so far. He also mentioned that the installation went very smoothly, even though the building was occupied at the time. "The construction was noisy but the contractors worked off-hours so as not to disturb the occupants," said Noble.

As for the EOP system installation at Fort A.P. Hill, it is expected that the technology will help to permanently dry the storage facilities. This will ultimately reduce the corrosion of munitions and other equipment and extend their life and the life of the munitions storage structures, as well as improve their safety and reliability.