CASE HISTORY

Farrell Solves Liquefaction & Lateral Spread for Cal Maritime

Foundation System

DDC

Geologic Hazard(s)

- Soft/Loose Soil
- Lateral Spread
- Liquefaction
- Slope Stability
- Contaminated Soil

Location
Vallejo, CA

Owner
California Maritime Academy

Geotechnical Engineer
KC Engineering

Structural Engineer
Forell/Elsesser

General Contractor
McCarthy

California Maritime Academy expanded its campus to include a new dining center and renovations to the bookstore in 2012. The new Dining Center features breathtaking, waterfront views from two stories and a mezzanine. The 26,000-square foot Dining Center seats 400 for meals and 272 for banquets.

The subsurface conditions are challenging, Dave Cymanski, GE with KC Engineering, the GEOR, identified undocumented, contaminated, fill over loose sand and soft, compressible bay mud, over bedrock. Geologic hazards include soft, compressible clay, liquefaction and lateral spread with the sloping bedrock toward the bay. KC estimated 1 to 3 inches of static settlement plus 7 to 9 inches of liquefaction settlement could occur during the MCE seismic event (PGA=0.6). The CSU needed a strong foundation and ground improvement system to mitigate settlement from static loads and the liquefaction and lateral spread.

Farrell was selected by McCarthy Building Companies, Inc. and the California State University Chancellors (CSU) to provide a design-build ground improvement solution to mitigate the geologic hazards. The Cal Maritime project is an excellent example of state-of-the-art geotechnical engineering and ground improvement contracting delivered by a design-build contract within the requirements of the current CSU Seismic Policy.

Project Details

KC Engineering recommended stone columns, rammed aggregate piers, soil cement mixing, or compaction grouting. After Farrell's additional borings, CPTs, and testing, Farrell proposed the Drill Displacement Column™ (DDC) ground improvement method to install strong "composite ground." DDC can be installed in rocky, colluvium, and fill, unlike an aggregate pier or stone column that requires pre-drilling. DDC were installed to depths of 38 feet into the fill, loose sand layers, bay mud, and bedrock. Farrell worked with KC Engineering, Forell Elsesser, and AMEC (CSU seismic peer review) to design

FARRELL DESIGN-BUILD

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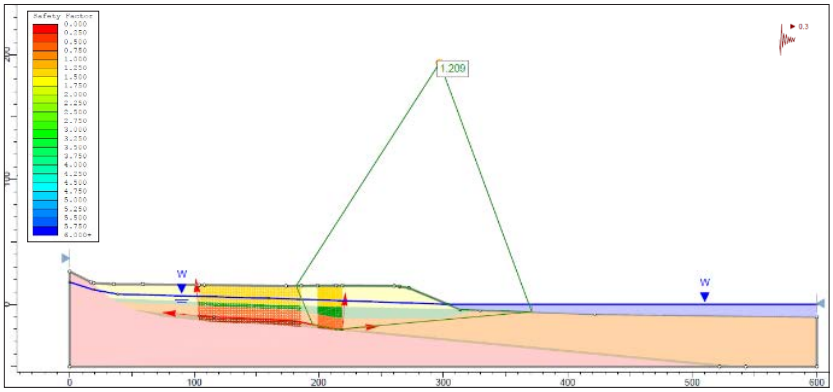
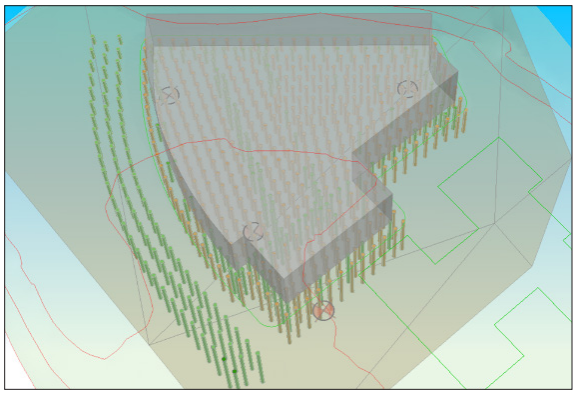


Psuedo-static model of Cal Maritime site. The material layers include Yellow=Fill, Green=Bay Mud, Orange=Loose Sand/Bay Mud, Pink=Claystone Bedrock. Model shows DDC "composite ground" stiffened condition (kh=0.3) with FS>1.2.



Farrell engineers prepared this 3D model to colaborate with AMEC and KC and to coordinate lateral spread butress, foundation support, slab support, utility trenches, and DDC layout.

and build DDC for the lateral spread buttress, liquefaction mitigation, and foundation and slab support.

The DDC design had to address structure settlement and liquefaction and lateral spread at the shoreline. AMEC and KC required a psuedo-static slope stability analysis to demonstrate that DDC would mitigate the lateral spread hazard. Due to the soft bay mud and loose sand deposits below the fill, the DDC were designed to provide "composite ground" with increased shear strength thru the lateral spread zone and increased sand density. Lateral spread threshhold displacements from SP117A were used to determine the seismic coefficient (kh). The unimproved condition was computed with kh = 0.2. The "composite ground" has increased stiffness which was modelled with a kh = 0.3. Farrell engineers collaborated with AMEC and KC to refine the psuedo-static model using Slide 6.0. DDC spacing was adjusted, engineered grout mix strengths tested, and Farrell ran the analysis to an acceptable safety factor > 1.1 for the seismic coefficent with a threshold displacement of 5 to 15 cm.

Farrell installed over 500 DDC that ranged in depth from 10 feet to 38 feet. The DDC were advanced with a 165,000 ft-lb drill on a 75 ton LRB 155 piling rig using an 18-inch diameter drill displacement tool. During installation, the drill tool pinged when advancing thru the rocky fill zones at depths of 20 and 25 feet, then it was easy drilling thru the bay mud and loose sand to the claystone bedrock. The DDC process displaced the soil and rocky fill in the ground eliminating drill spoil. After drilling to bedrock, grout was pumped at pressures of 75 to 150 psi (5 to 10 bar) to start the compaction grout process. The replacement volume of grout below the rocky fill was targeted at 1.2x and reached up to 1.5x the neat 18-inch displaced volume.

Ground improvement was achieved by the 18 inches of displaced and compacted soil and then the compaction grout effect resulting in strong "composite ground." The displacement and compaction grout effect raised the site 3 to 5 inches, confirming increased density and improvement. The dining hall opened in October 2013.

2014 Napa Earthquake

About one year after opening on the morning of August 24, 2014, the Napa earthquake (M6.0) was felt 100 miles from the epicenter. The Cal Maritime site sits about 11 miles south of the epicenter. Approximately 1.2 miles south of the site, two seismic stations measured the PGA at the Carquinez Bridge abutments with values of 0.34g and 0.7g with acceleration spikes nearly 1.0g recorded in the Geotechnical Array No. 1 in the north-south direction (GEER 2014). After the earthquake, Farrell performed a site review to assess the structure and butress. Visual inspections showed no ground cracks or signs of lateral spread at the DDC buttress and in service structure condition.

DDC "composite ground" strengthened the site to support the new structure, control static and seismic settlement to less than 1 inch, and mitigated liquefaction and lateral spread during an M6 earthquake. The Cal Maritime Dining Center performance exemplifies Farrell's motto of ***Go Vertical with Confidence.®***