Naval Facilities Engineering Command
Engineering and Expeditionary Warfare Center
Port Hueneme, California 93043-4307

TechData Sheet

TDS-NAVFAC EXWC-CI-1407 December 2013

Quality Assurance of New Concrete Construction

Technology Description

The NAVFAC methodology to enhance quality assurance for new concrete construction is a requirement of the Uniform Facilities Guide Specification (UFGS), section 03 31 29, Marine Concrete. It is expected that military construction will incorporate it to achieve more sustainable reinforced concrete structures. The corner stone of the approach employs a validated software program, STADIUM®, which allows users to predict the service life of the concrete under different types of environmental exposure conditions. Owners and engineers can now have a tool that quantifies the beneficial effects of various chemical compositions provided by specific types and blends of cements, fly ash, silica fume, and blast furnace slag.

A goal of the UFGS section, 03 31 29, Marine Concrete is to delineate the use of quantifiable metrics to evaluate and predict the service life of specific concrete mixtures in a specific marine environment. Doing so will allow the Navy to benefit from a performance-based specifications when used to supplement prescriptive requirements to achieve a specific service life. The development efforts to accomplish this goal have been motivated by the desire to avoid problems associated with premature concrete distress in future military construction by optimizing the material design and strengthening the quality assurance program.

STADIUM® predicts the movement of ions in and out of Portland cement-based concrete is based on ionic transport modeling in saturated and unsaturated concrete and numerical solutions. The STADIUM® model accounts for the complex interactions between the contaminants penetrating the porous network of concrete and the hydrated phases of the cement paste and allows engineers to quantify the effects of various chemical compositions provided by specific local types and blends of cements, fly ash, silica fume, and blast furnace slag when used with specific aggregates. The model accounts for temperature and moisture variations and how these environmental exposure conditions influence the rate of contaminant ingress. It is thus possible to provide STADIUM® with time-dependent environmental conditions and to simulate the effect of wetting and drying cycles on the chloride penetration rate. The description of the environmental exposures provides a realistic estimate of the extent of chloride ingress, as well as concrete chemical degradations, in a structure during its service life.

The methodology for quality assurance of new concrete construction set forward in UFGS 03 31 29 is structured as a three-part process:

Part 1: Theoretical Simulations of Candidate Mixtures. Review the materials, mixture design, exposure conditions, and cover expectations to assess the likely performance of the mixture. STADIUM® contains a concrete mixture database on which theoretical simulations could be based on.

Part 2: Mixture Durability Evaluation. The concrete producer makes test cylinders from candidate concrete mixes. Lab tests for porosity, migration, and drying are performed at 28 days; at 90 days, migration and porosity tests are repeated.

Part 3: Quality Assurance During Production. During construction, the same three laboratory tests used for certification of the mixture are required to test and document the uniformity of the hardened concrete transport properties as delivered to the construction site. Each time the concrete is sampled; six cylinders are prepared for testing. Test results verify if the concrete delivered to the site is being produced uniformly and within the allowable criteria.

Value to the Warfighter

A service life of 75 years for conventional single-deck pile supported piers, wharves, and bridges can reasonably be accomplished when using this quality assurance methodology. In the Marine Concrete UFGS, service life is defined as the number of years before major restoration, with minimal maintenance. Major restoration is defined as repairs requiring jack hammering or other destructive means of concrete repair preparation. By extending the service life of Navy concrete structures, the structures will have increased readiness and availability to support operations.

Economics of the Technology: ROI or Payback

The average military construction expenditure for US Navy projects that could benefit from the methodology is $671 million per year for 2012 through 2015. The benefit to each individual project will vary. A conservative estimate of cost avoidance as a result of implementing the methodology for U.S. Navy construction is $167 million annually. This estimate is based on the expectations that the concrete structure will have a longer life and require fewer repairs and a reduced carbon footprint. Use of this approach by the other military services will have similar benefits.

Technology Transition Documentation

The methodology for quality assurance of new concrete construction including STADIUM® modeling was included in the August 2012 revision of UFGS 03 31 29 Marine Concrete which is available on the Whole Building Design Guide website. Additional guidance for all users on how to implement the methodology correctly and effectively is provided in TR-NAVFAC ESC-CI-1215, A Navy User's Guide for Quality Assurance of New Concrete Construction, available on the NAVFAC portal or from NAVFAC EXWC by request.

Site Implementation

The methodology for quality assurance of new concrete construction has been used successfully on many different projects in the Navy. Projects include:

- Modular Hybrid Pier Test Bed, San Diego, CA
- Kilo Wharf, Guam
- Pier 31, Groton, CT
- Pier 5, Norfolk, VA
- Fuel Pier D, Craney Island, Norfolk, VA
- Wharves Uniform and Tango, Guam
- Pier 12, Naval Station, San Diego, CA

The methodology and tools used for new construction have also been used to predict the remaining service life of numerous existing Navy structures.

Specific Applications

Multi-mechanistic service life modeling is applicable for all concrete construction including plain reinforced concrete and pre-stressed or post-tensioned concrete. When applied to plain reinforced concrete structures, current modeling results are only valid when cracks with widths greater than 0.5 millimeter (0.02 inches) (a credit card is typically 0.5 to 0.75 mm thick [.02 to .03 inches) are repaired or sealed. The model accounts for the presence of concrete micro cracking through the measured ion transport properties of concrete samples. Modeling results are valid for all pre-stressed or post-tensioned elements, or concrete elements in compression, as macro-cracks will be closed.

The methodology is applicable to design-build and design-bid-build contracts. To date, it has been used for the design and construction of several Navy piers and wharfs. It has also been adopted for several public projects including the new locks currently under construction for the Panama Canal, U.S. Embassies, and highway bridge projects, collectively valued at several billion dollars.

Contact: Mr. Justin Foster, EXWC CI10, justin.c.foster@navy.mil 805-982-3766