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TechData Sheet

TDS-NAVFAC EXWC-CI-1402

December 2013

High Performance Airfield Pavements (HPAP)

Technology Description

F35-B landing on a high temperature VL pad

The F-35B is the Short Take-off and Vertical Landing (STOVL) variant of the Joint Strike Fighter (JSF). It has been shown that its exhaust has a 50 percent probability of spalling standard airfield concrete pavement during a single Vertical Landing (VL) operation. While the spall depth is limited, it represents the potential of generating foreign object debris (FOD), which can damage the aircraft. The Naval Facilities Engineering and Expeditionary Warfare Center (NAVFAC EXWC) was asked by the Office of Naval Research and the Air Force Civil Engineer Support Agency to address alternate pavement solutions for JSF VL pads. The effort was conducted in conjunction with Lockheed Martin® (LM) and the JSF Program Office. NAVFAC EXWC developed and transitioned a concrete mix design that is capable of performing under the extremely elevated temperatures and pressures generated during a JSF VL. In addition, Alkali-Silica Reactivity (ASR) mitigation was studied on a fundamental level. ASR can also cause FOD damage and dramatically reduce the service life of concrte airfield pavements.

The failure mechanism for the JSF issue is spalling due to the super heating of water in the concrete. When the heat and pressure from the downward facing nozzle hits the concrete surface it vaporizes the water in the concrete exposing the material to stresses higher than it can handle. The solution developed at NAVFAC EXWC was to create a concrete mix that could be produced by conventional equipment and methods that has three unique properties;

Construction of a VL pad

1. All of the aggregate used must be formed at a temperature higher than 1700ºF. This includes igneous traprock, expanded shale and expanded slate. Expanded clays were not used due to their lower strength.
2. Multifilament polypropylene fibers at a dosage of 3lbs/ cubic yard of concrete are batched into the mix. The purpose of the fibers is to melt away leaving behind small voids that act as vents to relieve stress when steam is formed.
3. Topical applications of sodium silicate are made after the concrete has cured. The sodium silicate seals the concrete to minimize the amount of water that is absorbed into the concrete.

The high temperature concrete mixes are made with manufactured fine aggregate which reduces mixture workability due to increased surface area and angularity. The absorptive nature of the expanded aggregates, up to 20 percent for some products, further complicates mixture designs. Other lessons learned during the construction of the vertical landing pads are documented in the High Temperature Concrete Engineering

Technical Letter. A continuous reinforced concrete pavement design in two directions was implemented because there is currently no joint sealant that can withstand constant exposure to vertical landings.

Value to the Warfighter

The developed concrete material was tested at the NAVFAC EXWC Aircraft Engine Simulation Facility (AESF) to 500 cycles. Each cycle simulated 1 vertical landing. The material samples were tested in the same spot for all cycles at a temperature higher than what the aircraft will produce in order to add factors of safety to the testing. NAVFAC EXWC has also collaborated with other government agencies and universities, to further understand the mechanisms behind ASR in order to develop criteria to mitigate its devastating effects.

The value to the warfighter is increased readiness by having a land based platform for the JSF aircraft and technology to extend airfield life through ASR mitigation.

Economics of the Technology: ROI or Payback

The ROI for a single JSF high temperature concrete VL pad was calculated to be 8.15. Expanding value to the ten vertical landing pads that have already been built increases the ROI to 49.96. These numbers take into account the extra initial investment to build and maintain the pads for 30 years compared to having to constantly replace the pads if conventional concrete is used.

The ROI for the ASR part of the project is 36 based on the extension of an airfield pavement life from 12 years to more than 60 years.

Technology Transition Documentation

1. SSR-3608-SHR - HIGH TEMPERATURE CONCRETE FOR JOINT STRIKE FIGHTER VERTICAL LANDING PADS TRANSITION TO EGLIN AFB
2. TR-2355-SHR- EFFECTS OF REPEATED SIMULATED F-35B IPP CYCLES ON EXPEDITIONARY AIRFIELD MATS
3. TR-NAVFAC ESC-CI-1224 - PAVEMENT MATERIALS SUBJECTED TO SIMULATED JOINT STRIKE FIGHTER VERTICAL LANDING EXHAUST Fiscal Year 2011 Progress Report
4. Unified Facilities Guide Specifications – UFGS 32 13 99 (Draft)
5. Engineering Technical Letter – ETL 10-4 (Draft)

Site Implementation and Specific Applications

Thus far a total of ten high temperature VL pads have been built at Eglin AFB, Duke Field, MCAS Yuma, and MCAS Beaufort with another being planned at MCAS Iwakuni. Simulated carrier decks have been built at Duke Field and MCAS Yuma with another being planned at MCAS Beaufort. ASR mitigation techniques are being implemented on all Navy concrete jobs.

As of now the concrete mixes have performed well under laboratory testing. A limited number of vertical landings have occurred on some of the high temperature concrete VL pads and there still has not been damage caused by the JSF. Please contact NAVFAC EXWC with any questions, comments, or concerns related to this topic.

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