REPORT ON ALKALI-AGGREGATE PROBLEMS ON PORTLAND CEMENT CONCRETE AIRFIELD PAVEMENTS

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EXECUTIVE SUMMARY

In 2001, Congress passed Military Authorization Bill - Public Law 106-398 (HR 4205) (Section 389), and Military Construction Appropriations Bill - Conference Report 106-710 for Public Law 106-246, 2001 (page 88). The Conference Report directs the Under Secretary of Defense for Acquisition, Technology, and Logistics to assess the overall condition of Department of Defense (DOD) facilities and infrastructure with respect to alkali-silica reaction (ASR). P.L. 106-398 directs the Secretary of Defense, through the Service Secretaries, to assess the damage caused to aviation facilities by ASR and explore available technologies capable of preventing, treating, or mitigating ASR. Service Secretaries may also conduct demonstration projects to test and evaluate technologies capable of preventing, treating, or mitigating ASR. The assessment is to be completed not later than 30 September 2006 at a total cost not to exceed $5 million. This report provides the Services' combined assessment in conformance with P.L. 106-398.

Alkali-silica reaction (ASR) damage has been identified on airfield pavements at twenty Air Force, six Navy, and three Army airfields. ASR is a significant maintenance cost, leads to foreign object damage hazards, and shortens the life of the pavement. Several broad industry trends contribute to the resurgence of this problem and are unlikely to abate. The Services have jointly strengthened provisions in the DOD guide specification for airfield concrete pavements, which should significantly reduce the incidence of ASR on new military airfield pavements. Independent government quality assurance testing of concrete materials is mandatory for these provisions to be effective. The Air Force Civil Engineer Support Agency (HQ AFCESA) has also issued an engineering technical letter that provides comprehensive guidance to Air Force civil engineer units on dealing with ASR. The ASR problem is quite complex and military pavement research budgets are inadequate to deal with the problem. The Services are actively participating in civilian research programs (i.e., Innovative Pavement Research Foundation [IPRF] and Airfield Asphalt Pavement Technology Program [AAPTP]) that are funded with Federal Aviation Administration (FAA) grants to get ASR issues addressed and obtain the most up-to-date technical information to distribute to the Services' civil engineers.

FUNDING

No funding was specifically provided to the Services to comply with P.L. 106-398. This report was sponsored by:

- The Air Force Civil Engineer Support Agency (HQ AFCESA) through operations and maintenance funding.
- The U. S. Army Corps of Engineers, Transportation Systems Center (USACE-TSC), the Tri-Service lead in updating Unified Facilities Guide Specifications (UFGS) through limited Army O&M criteria funding provided by HQ USACE.
- The Engineering Research and Development Center (ERDC) Geotechnical and Structures Laboratory (GSL), that provided limited monitoring of lithium topical application at Ft. Campbell, Kentucky, through limited O&M funds provided by Ft. Campbell.

- The Naval Facilities Engineering Command (NAVFAC) through a fraction of the mission funding for the Pavements Technical Discipline Leader.
- The N46 CNO RPM DemVal Program (PE 63725N) that covered Navy testing and field applications at several Navy activities (indirect support).
- The NAVFAC Engineering Innovation and Criteria Office (EICO) that supported the development and implementation of this report's guidelines into Navy and Tri-Service UFGS (indirect support).
- The Office of Naval Research and the American Society for Engineering Education Summer Faculty Fellowship Program for the visit of a scholar from the University of New Mexico at the Naval Facilities Engineering Service Center (NFESC) during the summers of 2004 and 2005.

Although authorized to spend up to $5 million, less than $1 million was spent (mostly funded by the Air Force) to pay for this report, a state-of-the-art review of worldwide guidelines, and the development and implementation of Tri-Service guidelines to prevent ASR. For such limited funding, very significant changes have been implemented.

NATURE OF THE PROBLEM

There are two types of recognized alkali-aggregate reaction: alkali-silica reaction (ASR) and the much rarer alkali-carbonate reaction (ACR). In each case, alkalis present in concrete from portland cement, fly ash, admixtures, aggregates, or other sources, react with certain siliceous minerals in the fine or coarse aggregate (ASR) or with some dolomitic carbonate aggregates (ACR). This reaction forms a hydrophilic (water-loving) gel around the aggregate particles, and this gel absorbs water, causing internal expansive pressure in the concrete (Figure 1). ASR, not ACR, has been encountered on military airfields and will be the main focus of this report.

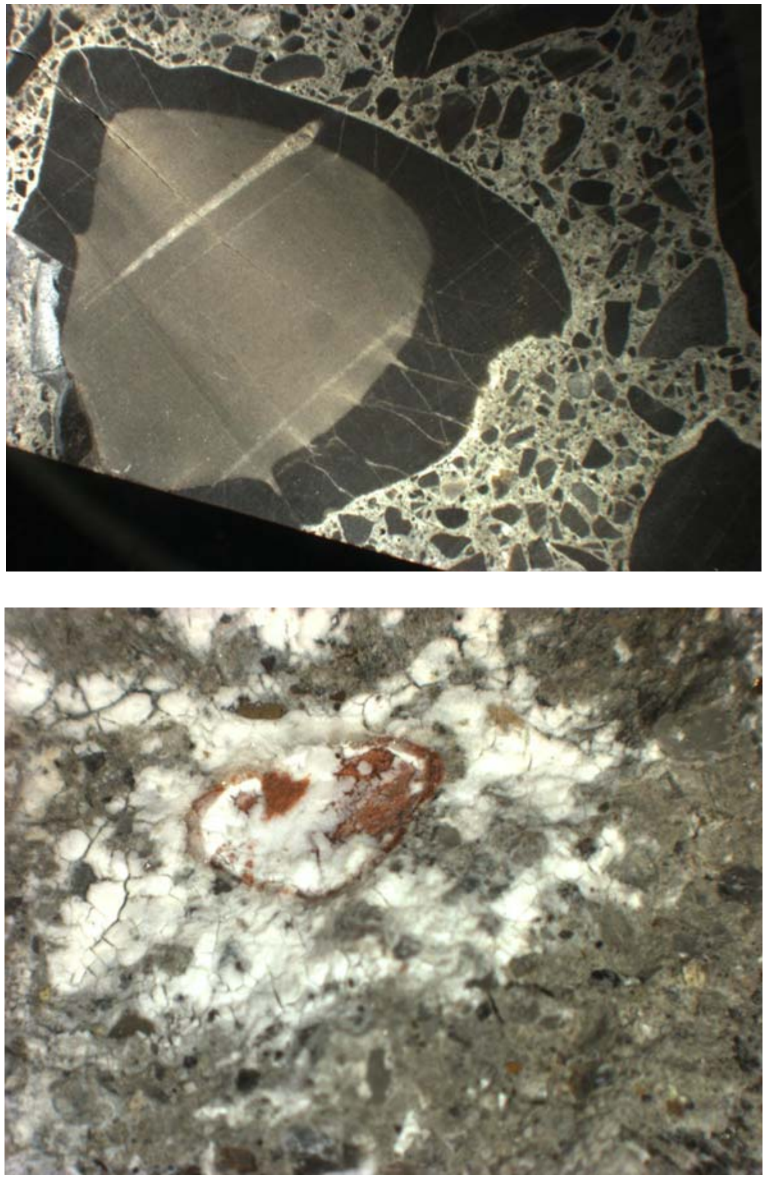

Figure 1. Examples of alkali-aggregate reaction gel. It may appear as a dark rim on an aggregate particle (top) or as a light-colored deposit on or within an aggregate or the surrounding concrete matrix (bottom). Note the cracks developing in the aggregate and concrete matrix from the formation and expansion of this ASR gel.

Alkali-silica can be relatively harmless in some instances, while in others it is very destructive. ASR can cause severe concrete cracking and popouts that pose a potential foreign object damage (FOD) hazard to aircraft engines and can generate concrete expansion that damages adjacent pavement, shoulders, and structures. The vigorousness of the ASR reaction and severity of damage depends on aggregate composition, cement and additive chemistry, local environmental conditions, and other factors as yet poorly understood. Figures 2 through 4 show examples of the types of damage that can be caused by ASR.

Figure 2. Cracking caused by ASR at Channel Island ANG Station (left) and Holloman AFB (right). Note spalling on the trench drain and the expansion joint squeezed closed on the right by the expansive forces of ASR in the surrounding concrete.

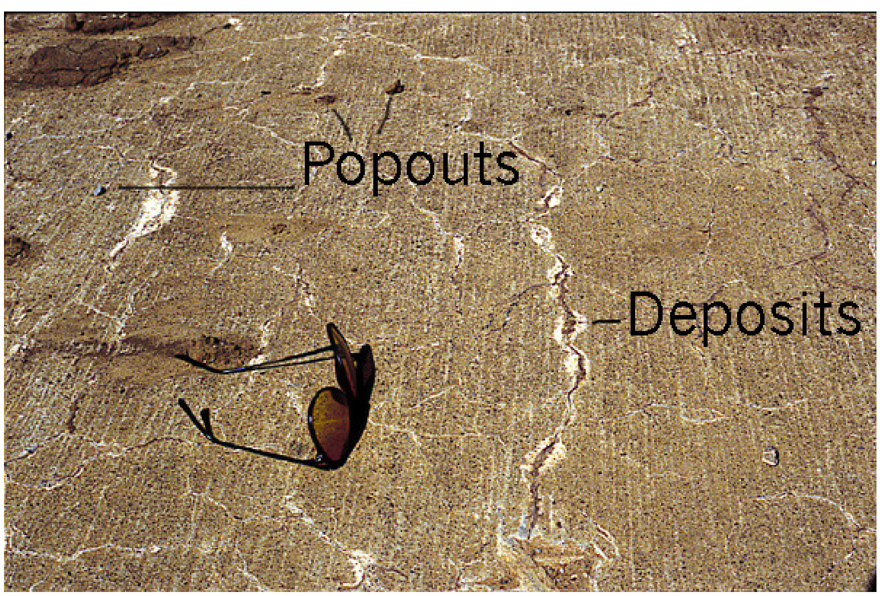

Figure 3. Aggregate popouts and ASR gel deposits in cracks caused by ASR at Tinker AFB.

Figure 4. Shoulder heaving from ASR expansion at Seymour-Johnson AFB (top) and damage from ASR swelling pressures at Kirtland AFB (bottom).

Three items are necessary for ASR to develop: alkalis, reactive aggregates, and water.

Alkalis. Alkalis are the Group I metals in the periodic table of elements. Sodium and potassium are the alkali metals that are of most significance in ASR. These alkalis exist naturally in the portland cement used in portland cement concrete (PCC). They may also be present in other concrete components such as fly ash, admixtures, and aggregates, or the alkalis may be introduced from external sources such as deicing or anti-icing chemicals. Low-alkali cements have often been specified as the traditional defense against ASR when reactive aggregates were used in concrete mixtures. However, military airfield concrete mixtures with low-alkali cements have recently suffered destructive ASR reactions, some in as little as five years after construction. Several industry trends discussed later have resulted in modern portland cement being more alkaline than in the past—even cements manufactured specifically to be low-alkali are produced very near the upper industry standard of 0.60 percent used to classify cement as low-alkali. Simply specifying low-alkali cement alone has not provided adequate protection for all aggregates used in modern PCC.

Reactive Aggregates. Aggregates throughout the U.S. and the world have been found to be reactive. No fine or coarse aggregate to be used in military airfield pavement concrete can automatically be assumed to be non-reactive. The increasing alkali content of modern portland cements also means that aggregates that have not reacted in the past may suffer from ASR in modern concrete mixtures. Hence, past aggregate performance is not a reliable indicator of future performance in modern concrete.

Water. Water is a fundamental component in destructive ASR reactions. Even in arid regions, adequate water is present to support ASR reactions in concrete pavements. Attempts to seal the pavement to prevent water entry needed for ASR development have not been successful.

Ongoing research by the Innovative Pavement Research Foundation (IPRF) at Clemson University found that certain deicing and anti-icing chemicals (potassium acetate, sodium acetate, potassium formate, and sodium formate) can cause increased expansion in ASR-susceptible aggregate. The nature of the reactions associated with these increased expansions remains imperfectly understood and is the topic of continuing research. Observation of distress associated with using deicing and anti-icing chemicals at civil airports corroborate the initial findings of the Clemson laboratory work. Interim results of this IPRF research are posted on their Website (http://www.iprf.org/products/main.html), and new information is posted as it becomes available. Military airfields that use these deicing and anti-icing chemicals could compound an existing ASR problem or precipitate a problem with marginally reactive aggregates.

ASR is a progressive chemical deterioration that evolves through several stages:

- ASR is typically a slow chemical reaction with initial symptoms (Figure 5) appearing five to ten years or more after construction.

Figure 5. Beginning stages of ASR: early-age cracking at Holloman AFB five years after construction.

- As the ASR symptoms of cracking, popouts, spalling, and shoving become progressively more severe, maintenance efforts become more extensive and increasingly costly (Figure 6). There is no way to stop ASR, so maintenance becomes increasingly intense to deal with the worsening damage over time. Initially, increased sweeping may be needed to keep FOD under control. This is typically followed with partial depth patches for spalls that eventually progress to full-depth patches and individual slab replacement. Impacts from ASR-induced swelling may be lessened by cutting full-depth expansion joints in the pavements and resawing these as the expansion closes them up. Heaving can also be cold-milled or diamond-ground to restore pavement smoothness.

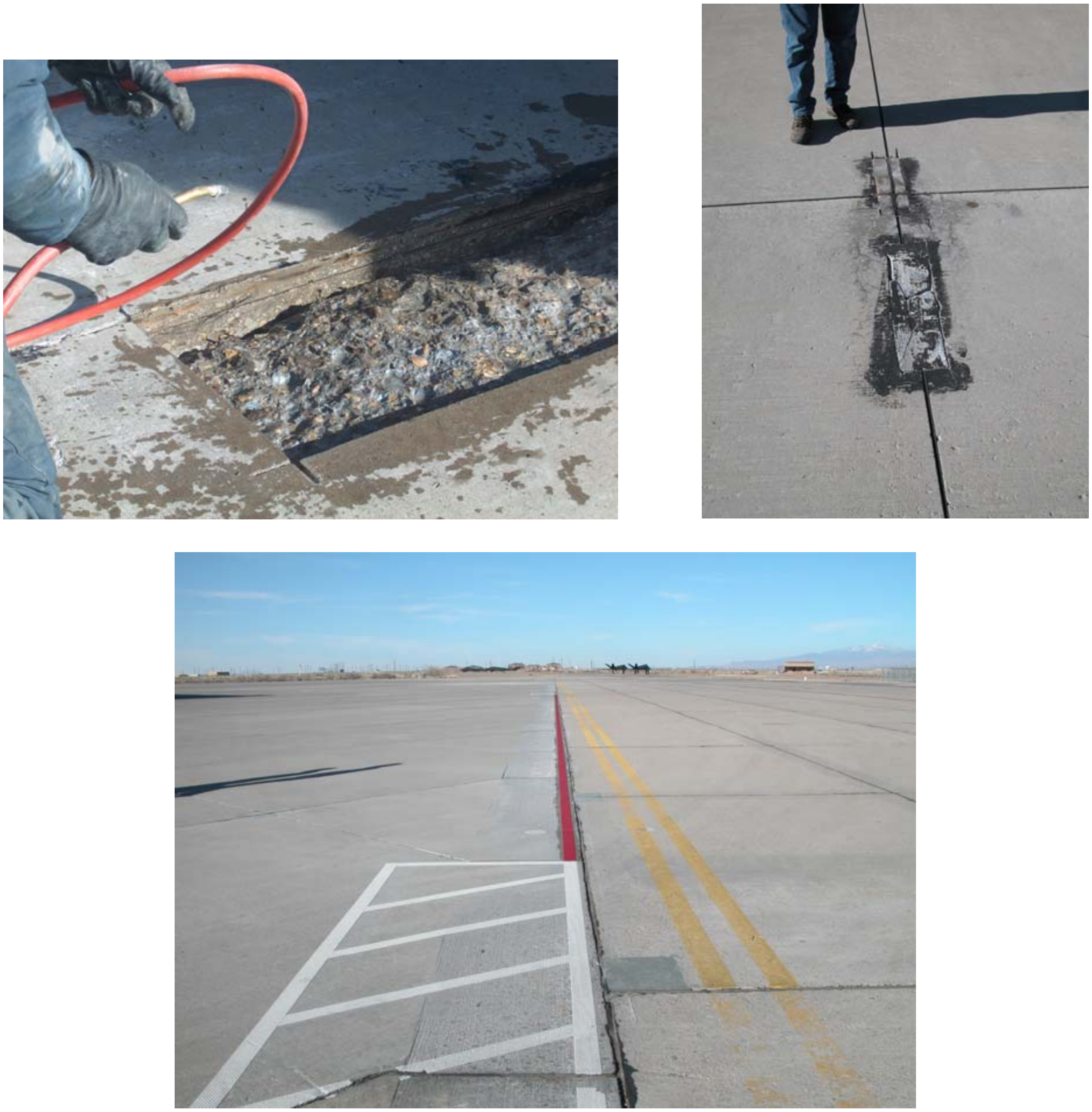

Figure 6. Examples of maintenance for ASR-damaged pavements. Patching (upper left) requires meticulous care to accomplish well, but even with the best technique, patching ASR-damaged pavement is difficult since ASR gel (seen as white deposits in the photograph on the upper left) can inhibit the bond between patch and pavement. Poorly done patches (upper right) soon become a FOD hazard themselves. Heaved areas from ASR swelling can sometimes be ground level (bottom), but such areas are likely to heave again in the future and will require re-grinding.

- When the cost of maintenance, FOD hazards, damage to adjacent facilities or some combination of these become intolerable, the pavement is reconstructed. This might typically result in a 25 percent reduction in expected pavement life as it has for the Bangor ANGB pavement.

The above scenario of effects is considered fairly typical, but there is much variation since this complex chemical reaction depends on the nature of the aggregate used in the individual projects, specific concrete mixture characteristics, climate, and age. In some cases, the ASR reaction may have negligible effect on the pavement beyond some unsightly fine cracking and perhaps minor heaving of the shoulders, or significant problems may not develop until the normal end of the pavement life. In other cases, ASR is a constant maintenance battle and FOD hazard concern. Of the twenty Air Force facilities identified with ASR-related airfield damage, about one-fourth have pavements showing significant pavement damage from ASR, one-half have moderate damage, and one-fourth have relatively minor problems.

WHY IS ASR APPEARING AS A PROBLEM NOW?

ASR was first recognized in the 1930s and is a well-known PCC phenomenon. By the 1950s, the military included requirements for routine testing of aggregates for ASR susceptibility and mandated use of low-alkali cement if reactive aggregates were used in airfield pavements. However, by the 1990s ASR was reappearing on military airfields as a significant problem even when these guidelines were followed. There are several reasons for this resurgence of ASR problems:

- Changes in portland cement manufacturing led to a dramatic increase in the alkali content of commercially available conventional portland cement. This increase was partially driven by the increase in energy costs starting in the 1970s which favored shifting from a wet-grind process to a dry-grind process and partially by stricter modern air emission standards. Portland cements that are specially manufactured to be designated as low-alkali must have 0.60 percent or less alkali content (sodium oxide equivalent [Na_2O_{eq}] as defined in ASTM C 150, *Standard Specification for Portland Cement*). However, previous research recognized that this limit was not completely effective—alkali contents between 0.45 percent and 0.60 percent may react, whereas contents of 0.40 percent or less rarely do. The 0.60 percent alkali limit represents a compromise between economic production and technical considerations. Today, modern low-alkali cements almost invariably crowd this 0.60 percent allowable upper limit for the same reasons the average alkali content of regular cements has increased. Use of low-alkali cements alone is now not considered to be necessarily sufficient to protect against ASR.

- Aggregates that passed the first available tests for reactivity have reacted over long periods of time, causing cracking and expansion in concrete.

- Certain slow-reacting aggregates have been identified that were not previously understood or recognized.

- Modern concrete mixtures typically include a complex combination of ingredients (e.g., admixtures or pozzolans) besides the traditional portland cement and aggregates. These additional ingredients may affect the development of ASR or may contribute to ASR reactions. Alkalis may be provided by internal ingredients (e.g., portland cement, fly ash, admixture, aggregates, and mix water) or external sources (e.g., deicing salts, ground water, and seawater). At present there is no consensus on how to effectively set or even measure a limit on the combined alkali content from all sources (e.g., portland cement, fly ash, and air-entraining admixture). As air emission standards tighten, the alkalinity of products such as portland cement or fly ash will tend to rise and availability of low-alkali cements will decrease.

- Aggregates are increasingly scarce in many areas today. Consequently, there is often pressure to use aggregates from new sources or aggregates of marginal quality. These aggregates may not have been adequately assessed for potential reactivity.

- There is evidence that certain anti-icing and deicing chemicals used on airfield pavements may accelerate ASR and may hinder the effectiveness of some ASR mitigation methods.

- Serious damage to concrete from alkali-aggregate reaction has occurred in places where it was previously unknown. Long-distance shipping of aggregates, diminished availability of good aggregate sources in some areas, recognition that aggregates once thought to be nonreactive can become reactive over long periods, increasing alkalinity of modern cements and concrete mixtures, and contributions from anti-icing and deicing chemicals all contribute to this phenomenon.

- As a matter of policy, the military has increasingly shifted responsibility for concrete and its constituents to the contractor, and the military conducts relatively few independent tests on any of the cement, aggregates, or other constituents used in concrete for military airfields. Previously, government laboratories performed all aggregate testing and approval, identified approved sources of aggregates, and developed the concrete mixture proportions for military airfields. Not all contractors and concrete producers have proven ready for this shift in responsibility. Previously, government laboratories had lengthy periods to carry out laboratory testing and approve potential aggregate sources before construction bids were solicited. In contrast, the contractor now must carry out such assessments very rapidly in order to prepare bids and, if the successful bidder, avoid delaying construction. To meet construction schedule requirements, the current practice is to use accelerated laboratory tests to evaluate materials and mitigation methods. However, the methods used to achieve this acceleration also lead to some uncertainty about the accuracy of the results.

- Alkali-aggregate reactions are relatively slow, and it may take years or decades for symptoms to appear in the pavement. Consequently, it is practically impossible to hold the contractor responsible for placing such defective material. Correspondingly, there is little incentive for the contractor to take adequate measures to protect against alkali-aggregate reactions since such measures tend to increase the construction and testing cost and make the contractor less competitive in the low-bid military construction arena. This is a particular concern for design-build contracts that are becoming increasingly popular in the military for procuring airfield pavements and many other facilities.

EXTENT OF THE ASR PROBLEM

Air Force

Survey. As part of the Air Force response to P.L. 106-398, AFCESA surveyed the individual major command pavement engineers to identify bases with ASR problems. This survey was supplemented with selected field trips and more detailed discussions with personnel from affected bases to gather information, determine the magnitude of the problem, and evaluate current maintenance practices to deal with ASR-affected pavements.

The Air Force surveyed all of its facilities and identified ASR-damaged airfield pavements at twenty Air Force bases. At the bulk of these facilities the ASR damage caused increased Air Force maintenance costs, increased FOD hazard, and shortened pavement life. These pavements were built using guidance that was thought at the time of construction to provide ASR protection, but has proved inadequate.

Figure 7 shows the distribution of the ASR-affected bases located within the continental United States (CONUS). It is clear that the problem encompasses broad geographic and climatic areas.

Figure 7. CONUS Air Force bases with ASR-damaged airfield pavements.

The severity of the damage at any specific base and even between projects on the same base can vary from slight to severe. Pavements with early-age ASR symptoms or that have only a mild ASR problem may be adequately handled with routine maintenance such as sweeping or minor in-house spall repair. As the ASR damage becomes more severe, it requires increasingly expensive maintenance activities, impacts operations, and significantly shortens the life of the affected pavements. The Air Force has estimated that it will cost $87 million to repair only five of its twenty airfields.

> Seymour-Johnson AFB, North Carolina, one of the more severely affected Air Force facilities, has identified twenty-six major contract repair or rehabilitation projects since 1993 for ramp, taxiway, and runway pavements that the Air Combat Command pavement engineer and base personnel determined were caused by or significantly affected by ASR reactions. Rehabilitation projects costs for these pavements at Seymour-Johnson AFB total $28,667,000. In addition, the in-house shop personnel estimate approximately $43,000 is spent annually for slab and spall repair materials to deal with ASR-induced problems.
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> In another example of ASR impacts on pavement budgets, the ANG will spend $825,000 this year on maintenance of a fifteen-year old ASR-damaged taxiway and ramp at Bangor ANGB, Maine. The taxiway is scheduled for replacement in 2007 at a cost of $1 million,

while the ramp is scheduled for replacement in 2009 at a cost of $7 million. Military PCC airfield pavements have a nominal structural design life of twenty years, and it is not uncommon to get significantly more functional life than twenty years from these pavements—occasionally 40 years and more.

Concrete on a runway at Dover AFB is severely damaged by ASR and is planned for replacement. The total cost is $40 to $50 million; a significant portion is the cost of replacing concrete.

Technical Activities. Since FY 2000, AFCESA has annually funded limited technical activities investigating ASR issues of particular interest to the Air Force. These efforts have included the survey of the ASR problem at Air Force facilities; individual investigations at selected bases; participation with the Army Engineer Research and Development Center (ERDC) and industry in an on-going assessment of experimental mitigation for ASR-reacting airfield pavements at Ft. Campbell Army airfield with topical lithium solutions; and limited laboratory investigations. These efforts have concentrated on developing the fundamental information needed to revise the DOD Unified Facility Guide Specification (UFGS) 32 13 11, *Concrete Pavement for Airfields and Other Heavy-Duty Pavements More Than 10,000 Cubic Yards* (formerly UFGS 02753); prepare an Air Force guidance document on ASR (Engineering Technical Letter [ETL] 06-2, *Alkali-Aggregate Reaction in Portland Cement Concrete [PCC] Airfield Pavements*); identify improved maintenance procedures for pavements with ASR; and begin initial work on relating laboratory tests to field performance of airfield pavements. There is negligible research funding available for airfield pavements within DOD, so AFCESA has actively participated in civilian forums where ASR issues are being studied. In particular, AFCESA has actively participated as a member of the program coordination group and funded technical experts to participate on individual task panels for the Innovative Pavement Research Foundation (IPRF). This program studying concrete pavements for airfields is funded by grants from the FAA. Several of the studies undertaken under this program deal with ASR problems on airfield pavements. AFCESA also participates in the Program Coordination Group for the Airfield Asphalt Pavement Technology Program (AAPTP) and provides a technical expert for the panel on using recycled ASR-affected concrete in flexible pavements. AAPTP is also funded by grants from the FAA. By participating actively in the IPRF and AAPTP programs, the Air Force is able to get military ASR issues included in their research efforts and also has access to the most up-to-date findings on ASR issues to provide to the field. This partially counters the lack of ASR research funding within the military.

Inter-service Cooperation. AFCESA provided funding to and worked with the Army Corps of Engineers Transportation Systems Center and Engineer Research Development Center and cooperated with the Naval Facilities Engineering Service Center to establish the causes for this resurgence of ASR problems and to revise UFGS 32 13 11 (formerly UFGS 02753), *Concrete Pavement for Airfields and Other Heavy-Duty Pavements More Than 10,000 Cubic Yards*, to reduce the potential for building new pavements that will suffer from ASR.

Establish Policy for New Concrete Airfield Pavements to Avoid ASR. AFCESA prepared and issued ETL 06-2, *Alkali-Aggregate Reaction in Portland Cement Concrete (PCC) Airfield*

Pavements. This ETL provides the Air Force policy on requirements for new PCC to be used in airfield pavements as follows:

- All aggregates to be used in Air Force concrete airfield pavements will be tested in accordance with ASTM C 1260, *Standard Test Method for Potential Alkali Reactivity of Aggregates (Mortar-Bar Method)*, to determine if they are potentially reactive or non-reactive.
- The preferred Air Force policy is to build airfield pavements with non-reactive aggregates—especially if deicing and anti-icing chemicals will be used on the pavements—but this is not always feasible.
- If a potentially reactive aggregate must be used in an Air Force PCC airfield pavement, then low-alkali cement is mandatory and active mitigation methods must also be used. The effectiveness and amount needed of the selected mitigation method will be shown by testing in accordance with ASTM C 1567, *Standard Test Method for Determining the Potential Alkali-Silica Reactivity of Combinations of Cementitious Materials and Aggregate (Accelerated Mortar Bar Method)*, or equivalent. The recognized potential mitigation methods include use of fly ash, ground-granulated blast furnace slag, lithium compounds, and silica fume.

Provide Guidance to the Field. ETL 06-2 also provides extensive guidance on ASR issues to Air Force civil engineers in the field. This ETL covers:

- Background to alkali-aggregate issues and why it is a problem in the Air Force;
- What is alkali-aggregate reaction;
- Field symptoms of ASR;
- Identifying ASR;
- Maintaining pavements with ASR;
- Avoiding ASR in new construction;
- Impact of anti-icing and deicing chemicals on ASR;
- Impact of fly ash, slag, and natural pozzolans on other properties of the concrete mixture;
- Alkali-carbonate reaction (ACR).

ETL 06-2 recognizes that ASR is a complex field that is constantly evolving and includes the following caution:

> This ETL provides interim guidance and reflects consensus opinions on best practices to minimize and mitigate ASR problems on Air Force airfields. This is an evolving field of knowledge and following this ETL guidance will not necessarily prevent ASR in all cases. Guidance and criteria from older standard texts, reports, references, manuals, and guide specifications may be out of date and no longer valid. HQ AFCESA should be contacted for assistance and clarification on ASR issues.

Current testing technology is not adequate to provide timely assessment of an aggregate's potential for ASR problems or to ascertain what mitigation countermeasures will prove effective. Those tests that are technically considered the most reliable take one to two years to run which is unacceptable for construction, while the ones that can be run in a timelier manner are less accurate. AFCESA is monitoring this on-going research by the IPRF and Federal Highway Administration (FHWA).

Current criteria for allowable ASR test expansion limits are based on accelerated laboratory tests and are intended to limit concrete cracking. The massive volume of pavement undergoing ASR reaction in an Air Force airfield is quite different from the smaller volume of concrete used in civilian studies of the issue; possibly different limits are needed for Air Force applications. The generation of FOD hazards is a major Air Force concern that is not addressed in civilian studies, but no funding is available for further research in this area.

There is poor understanding of how accelerated laboratory tests relate to actual development of ASR in the field. This dichotomy exists because of the slow and complex nature of ASR reactions and the need to accelerate laboratory tests to produce results in a timely manner. AFCESA funded the ERDC Concrete and Materials Branch at the Waterways Experiment Station, Vicksburg, Mississippi, to fabricate large outdoor beam specimens using materials from airfields with ASR problems and to prepare similar laboratory specimens. These large-scale field specimens and the corresponding laboratory specimens are being monitored to develop fundamental information in this area. This is long-term research, and significant results will not be available for years.

There is no proven effective method of maintaining existing pavements undergoing ASR deterioration. A limited cooperative study is underway with the Army and industry on topical applications of lithium salts to mitigate ASR pavement damage; results to date are inconclusive. An IPRF study is also starting in this area, and AFCESA is participating on the technical panel overseeing this effort. Maintenance of ASR-affected pavements is a broad area requiring more study on more aspects of the problem. No further work is scheduled in this area by the Air Force because of the lack of research funding.

Existing ASR-damaged pavement could be used as recycled materials or could be overlaid with asphalt concrete using “crack and seat” or “rubblization” concepts. However, methods of determining how these ASR-affected materials may behave in this new role have to be ascertained. AFCESA supports planned research on this topic by the AAPTP and provides a technical expert to serve on the task oversight panel.

The impact of deicing and anti-icing materials on ASR problems remains unclear. AFCESA supports ongoing and planned research on this topic by the IPRF and provides technical experts to serve on several of the task oversight panels.

ASR does not appear until years after construction. Consequently, it is not practical to hold the contractor responsible for providing defective material nor does the contractor have any incentive to ensure that non-ASR-reacting materials are used if this increases the cost of the bid. At Channel Island ANGB, California, test results for a non-reactive aggregate were submitted to the Navy who was the ANG construction agent for this apron project. When construction began, a reactive aggregate was used in the project and severe ASR developed. This apron was replaced in 2004 when it was fifteen years old at a cost of $16.2 million. Independent government quality assurance testing of project materials is the only way to ensure compliance with specifications and to avoid reactive materials being used on Air Force airfields. However, physical testing by the government is seldom done on military airfield projects because of funding shortages—this needs to be changed.

Army

Three Army airfields are now known to have ASR problems. A comprehensive ASR assessment of all Army airfields was not completed because of lack of specific resources; instead ASR is being addressed as part of pavement evaluations and condition surveys of the Army airfield pavements. It is suspected that additional Army airfields have ASR problems.

In 2001, the Army took the lead in updating Unified Facilities Guide Specifications (UFGS) to include requirements for ASR:

- Draft ASR evaluation/mitigation testing protocol was provided to the field in September 2001.
- ASR evaluation/mitigation testing protocol was added to UFGS 02753, *Concrete Pavement for Airfields and Other Heavy Duty Pavements,* in January 2002.
- Revised and expanded UFGS 02753 ASR evaluation/mitigation testing protocol to comply with current industry knowledge in May 2004 (approved by Tri-Service review committee).
- Revised and expanded UFGS 32 13 11 (formerly 02753) evaluation/mitigation testing protocol to comply with current industry knowledge and added deicer evaluation/mitigation testing protocol in July 2006 (Ref. 1).

In 2002, lithium treatment was applied to parking aprons and taxiways with ASR deterioration at Ft. Campbell, Kentucky. ERDC GSL has been monitoring the pavement at one- to two-year intervals to evaluate the effectiveness of lithium treatment to mitigate existing ASR.

Navy

Six Navy airfields are now known to have ASR problems. The Navy assessment of all its airfields was not completed because of lack of specific resources, but instead is still being addressed as part of condition assessments of the airfield pavements. It is suspected that additional Navy airfields have ASR problems.

The costs of ASR damage are staggering: the Channel Island Air National Guard Base, California, spent $16 million replacing its apron, and Naval Air Station Point Mugu, California, is spending the first $3.5 million (out of about $13 million) to replace a parking apron.

Elsewhere, the costs are similar; for example, the California Department of Transportation estimates ASR-related repair costs in the hundreds of millions of dollars (Ref. 7).

In 2001, the Navy completed a worldwide assessment of specifications related to preventing ASR with Tri-Service support (Ref. 2). This was later published in the Materials Journal of the American Concrete Institute (Ref. 3). This work was the basis for updating the guidelines in the following Unified Facilities Guide Specifications (UFGS):

- UFGS 32 13 13.03 (formerly 02751N), *Airfields and Heavy-Duty Concrete Pavement Less Than 10,000 Cubic Yards*
- UFGS 32 13 11 (formerly 02753), *Concrete Pavement for Airfields and Other Heavy-Duty Pavements More Than 10,000 Cubic Yards*
- UFGS 31 62 13.20 (formerly 02450), *Precast/Prestressed Concrete Piles*

It is expected that these changes will help significantly reduce the problem while also reducing the cost of concrete and protecting the environment. However, these specifications need further refinement to increase cost savings while ensuring high concrete durability. Some additional work has been completed (Refs. 5 and 6) which would allow for the use of more fly ashes, but this only addresses a limited number of ashes and has not yet been implemented in the UFGS. Other areas such as slag and lithium use have not yet been fully addressed.

CONCLUSIONS

Air Force

The Air Force has ASR problems on airfield pavements at twenty facilities. The severity of the problem varies, but it represents a significant maintenance cost and FOD hazard and results in shortened pavement life. Five Air Force facilities with varying severity of ASR-damaged airfield pavement problems have identified rehabilitation and repair projects that will cost over $87 million. Similar data is not available from the other bases, but clearly ASR represents a significant recurring airfield maintenance cost for the Air Force.

The Air Force has worked with the other Services to revise UFGS 32 13 11 (formerly 02753), used to specify PCC for new airfield pavements. The revised UFGS has strengthened requirements to avoid ASR in new pavements.

A contractor has no incentive to avoid ASR-susceptible materials, so independent government quality assurance testing is critically important to avoid future ASR problems on Air Force airfield pavements.

AFCESA has issued ETL 06-2 which provides expanded guidance on ASR to Air Force civil engineer units.

ASR is a complex phenomenon, and several broad industry trends contribute to its resurgence as a problem today. AFCESA has funded several small-scale ASR-related investigations to address some Air Force-specific issues. However, there is no military airfield pavement research funding available to address ASR. Consequently, AFCESA actively supports and participates in civilian research programs (e.g., IPRF and AAPTP) to get Air Force issues addressed and to obtain the best available technical guidance for Air Force civil engineers.

Army

The Army will continue to:

- Participate in IPRF panels related to ASR.
- Participate in FHWA Benchmarking Workshops.
- Coordinate with FAA, FHWA and industry on ASR issues.
- Coordinate with the Navy and Air Force and update UFGS to mitigate ASR.

Navy

In FY08 the NFESC is expected to further develop this technology under sponsorship from the Office of Naval Research. Within a program to look at high-performance airfield pavements, ASR prevention and mitigation will be further studied and results of that work will be used to further update Tri-Service criteria and specifications, ensuring additional upfront savings while maintaining or increasing durability.

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