DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers

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Technical Letter
No. 1110-3-488 | 1 March 1998

Engineering and Design
DESIGN AND CONSTRUCTION MANAGEMENT PRACTICES
FOR CONCRETE PAVEMENTS

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1. Purpose. This engineer technical letter (ETL) provides guidance for managing the design and construction of concrete pavements, including airfield pavements, roads, streets, parking areas, vehicle and tank hardstands, tank trails and similar transportation surfaces

2. Applicability. This ETL applies to all HQUSACE elements and USACE commands having military construction and design responsibility.

3. References. See Appendix A.

4. Distribution. Approved for public release; distribution is unlimited.

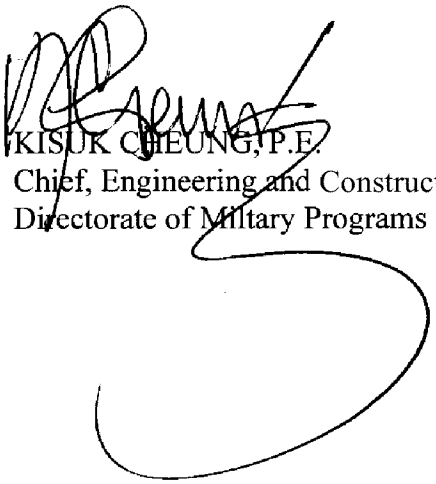
5. Background. The referenced and other USACE criteria documents provide the technical information required for design and construction of concrete pavements. Proper design and construction management practices are essential for high quality pavements, but are discussed in detail only in portions of the referenced documents. Due to declining numbers of personnel trained and experienced in concrete paving design and construction practices, additional guidance is necessary to assist those involved in managing those activities. In addition, using activities are citing recent experience with some less than expected performance from concrete pavements. Using activities are calling on all, including the Corps, to improve concrete pavement performance.

6. Action. Pending publication of permanent guidance, the enclosed information is to be used to assist the HQUSACE, major subordinate commands, district offices, and FOA in the management of design and construction of concrete pavements.

ETL 111 O-3-488
1 Mar98

7. Imulementation. This letter will have routine application for all future military projects as defined in paragraph 8c, ER 111 O-345-1 00.

FOR THE COMMANDER:



IKISUK CHEUNG, P.E.
Chief, Engineering and Construction Division
Directorate of Military Programs

2 Appendices
App A - References
App B - Design and Construction Management Practices for Concrete Pavements

# APPENDIX A: REFERENCES

1. TM 5-822-5 (AFM 88-7, Chap. 1), "Pavement Design for Roads, Streets, Walks, and Open Storage Areas."

2. TM 5-822-7 (AFM 88-6, Chap. 8), "Standard Practice for Concrete Pavements."

3. TM 5-825-1 (AFJMAN 32-8008, Vol. 1), "General Provisions for Airfield/Heliport Pavement Design."

4. TM 5-825-3 (AFM 88-6, Chap. 3), "Rigid Pavements for Airfields."

5. EM 1110-2-2000, “Standard Practice for Concrete.”

6. ER 1110-1-12, “Quality Management.”

7. ER 1110-1-261, “Quality Assurance of Laboratory Testing Procedures.”

8. ER 1110-1-1300, "Cost Engineering Policy and General Requirements."

9. ER 1110-3-107, "Design of Military Airfield Pavements."

10. ER 1110-3-1300, "Military Programs Cost Engineering."

11. ER 1110-34-1, "Transportation Systems -Mandatory Center of Expertise."

12. ER 1110-345-100, "Design Policy for Military Construction."

13. ER 1110-345-700, “Design Analyses, Drawings, and Specifications.”

14. ER 1180-1-6, "Construction Quality Management."

15. ETL 1110-3-380, "Standard Distribution of Military Airfield Pavement Design and Evaluation Information."

16. ETL 1110-3-394, "Aircraft Characteristics for Airfield-Heliport Design and Evaluation."

17. AFR 86-5, "Planning Criteria and Waivers for Airfield Support Facilities" (to be superceded by AFJMAN 32-1013).

18. CEGS-02753, "Concrete Pavements for Airfields and Other Heavy-Duty Pavements."

19. CEGS-02754, "Concrete Pavements for Small Projects."

20. DG 1110-3-204 (AFP 88-7), “Design Guide for Army and Air Force Airfields, Pavements, Railroads, Storm Drainage and Earthwork.”

21. Technical Memorandum 6-370, "Test Data - Concrete Aggregates and Stone Riprap in Continental United States and Alaska."

22. MEMORANDUM, CEMP-ET, 12 Apr 1996, SUBJECT: Military Construction Design Review Policy for Airfield, Railroad and Roadway Projects."

23. MEMORANDUM, CEMP-ET, 12 Jun 1997, SUBJECT: Military Construction Design Review Policy for Airfield, Railroad and Roadway Projects."

24. "Transportation News," periodically published by the Transportation Systems Mandatory Center of Expertise.

# APPENDIX B:

# DESIGN AND CONSTRUCTION MANAGEMENT PRACTICES FOR CONCRETE PAVEMENTS

## B-1. Introduction.

a. *Content.* This document discusses recommended practices for design and construction management for concrete pavements, including design staffing, design studies, preparation of plans, specifications and Engineering Considerations and Instructions for Field Personnel (ECIFP), design review, preconstruction preparation, construction staffing and responsibilities, pavement completion documentation, and Transportation Systems Mandatory Center of Expertise (TSMCX) services. A sample specification requirements for listed aggregate sources, a sample ECIFP, a sample preconstruction pavement workshop agenda, and a list of post-construction pavement materials completion data are included in the annexes.

b. *Scope.* Concrete pavements include airfield runways, taxiways, aprons and related pavements, roads, streets, parking areas, vehicle and tank hardstands, tank trails and similar transportation surfaces. The design and construction management practices described in this document are intended for application to new or replacement pavements that can be classified as medium to large (over 2000 $m^3$ or 2500 $yd^3$), or critical projects. Portions of this document can be applied to O&M projects, hangar floors, and smaller new or replacement pavement projects. Maintenance and repair of pavements are not covered in this document.

c. *TSMCX Services.* ER 1110-34-1, "Transportation Systems Mandatory Center of Expertise," describes the authority, policy and responsibilities of the TSMCX. This document also presents information on mandatory design reviews, criteria waiver policy and procedures, criteria development, and TSMCX services for design and construction assistance. The 12 Apr 1996 and 12 Jun 1997 CEMP-ET Memoranda, Subject: Military Construction Design Review Policy for Airfield, Railroad and Roadway Projects," establish HQUSACE policy for design review by the TSMCX. The "Transportation News" is a periodic publication of the TSMCX to provide information on transportation technology issues. The TSMCX maintains Indefinite Delivery Type (IDT) Contracts for airfield and roadway pavement design, construction management and other related services, that are available for use by Districts. Each FOA responsible for military design and construction should have a POC designated for coordination with the TSMCX. Questions concerning TSMCX services should be directed to:

US Army Corps of Engineers
Transportation Systems Center
215 North 17th Street

Phone: 402-221-7260
Fax: 402-221-7261

Homepage: http://www.mrd.usace.army.mil/tsmcx/tsmcx.html
Omaha, NE 68102-4978

**B-2. Design and Design Documents.**

*a. General.* ER 1110-345-100, "Design Policy for Military Construction," establishes policies, responsibilities and procedures for the design of military facilities, including concrete pavements. ER 1110-1-12, "Quality Management," provides general policy for quality of design services, and describes design documents. TM 5-822-7, "Standard Practice For Concrete Pavements," provides information on the materials and construction procedures for concrete pavements. ER 1110-3-107, "Design of Military Airfield Pavements," sets forth policy concerning design of military airfield pavements with respect to operational or other design information. Corps participation in preparation and review with the using activity of the Department of Defense (DD) Form 1391, "Military Construction Project Data," is a key element in successful pavement design and construction. The TSMCX should be contacted for DD Form 1391 development when possible, and should be kept current with DD Form 1391 and relevant design issues as they arise during the project life. The design process for concrete pavements is similar to conventional military projects, with a few exceptions. Following selection of a designer, early studies for design include geotechnical investigations and a geotechnical or foundation report, materials studies and a materials report, leading to a design analysis report. This is followed by preparation of plans and specifications, an Engineering Considerations and Instructions for Field Personnel (ECIFP), a cost estimate, and design reviews. Full coordination and intensive involvement with the using activity throughout the design process is a critical element for successful pavement projects. Site visits by the designers at the beginning and during design are essential for all projects. A site visit by the designers is mandatory for all concrete pavements. Construction personnel should attend these site visits when feasible. Design Quality Control plans are required for all military projects, including pavements.

*b. Pavement design training for designers.* Training courses, seminars or workshops relating to concrete pavement design, evaluation and/or construction are available from a variety of sources. PROSPECT courses, "Pavement and Drainage Design and Construction," and "Advanced Concepts in Pavement Design and Evaluation," are conducted by CEWES and managed by the Huntsville Engineering and Support Center. The TSMCX provides Pavement-Transportation Computer Assisted Structural Engineering (PCASE) regional seminars, and airfield design and layout workshops for specific projects, when requested.

*c. Design agents.* Designers of concrete paving projects may be in-house or Architect-Engineer (A-E) firms. Design firms specializing in pavement design can provide competent design of military concrete pavements. Most A-E firms that do not specialize in pavements are unfamiliar with pavement concerns and criteria, and may require some time to become proficient

in pavement requirements. The TSMCX generally maintains one or more IDT contracts with A-E firm(s) experienced in design of pavements. These IDT contracts are available for use by Corps Districts. Knowledgeable, experienced design staff, whether in-house or A-E, are critical for successful concrete pavement projects. Typical concrete pavement design teams consist of (several roles may be combined in one person):

Pavement layout engineer
Geotechnical engineer
Materials engineer
Mechanical/electrical engineer

*d. Geotechnical report.* Geotechnical reports are prepared on most military projects as a record of foundation investigations and foundation design for that project. TM 5-822-5, "Pavement Design for Roads, Streets, Walks, and Open Storage Areas," discusses preliminary investigations for these types of pavements. TM 5-825-3, "Rigid Pavements for Airfields," covers preliminary investigation, subgrade considerations, base courses, soil stabilization or modification, and evaluation of foundation support. The results of these and related investigations should be presented in the geotechnical report. TM 5-825-1, "General provisions for Airfield/Heliport Pavement Design," presents geotechnical information that must be included in the design analysis for these types of pavements.

*e. Materials studies.* Early in the design period, concrete materials studies are required to determine the availability of aggregates and allied materials, the quality and durability of the aggregates and other materials, and the properties of these materials in concrete. TM 5-822-7, "Standard Practice for Concrete Pavements," describes concrete materials for pavements, as well as requirements for "approval of aggregates." TM 5-825-1, "General Provisions for Airfield/Heliport Pavement Design," describes materials information that is presented in the design analysis. Information from these studies is generally presented in an office report. Conclusions and recommendations from these studies include the design material properties for the concrete pavement, and provide the basis for specification preparation for the concrete pavement. Description of typical contents of the office report follow.

(1) Project description and concrete pavement requirements. This includes a summary description of the pavement to be constructed, including site requirements, dimensions, quantities of concrete and materials, and special logistical problems.

(2) Environmental conditions. This section contains information on climatic and other environmental conditions at the site which may affect the concrete, including rainfall, hot weather conditions, cold weather conditions, deicer applications, snow plow usage, sulfate attack, and possible jet blast conditions.

(3) Aggregate sources. All potential sources of aggregate for concrete are described in this section, including possible Government-owned sources, commercial sources, and undeveloped sources. Aggregate sources typically may include alluvial deposits, wash deposits, glacial deposits, and rock quarries. Aggregate source names generally refer to a particular reach of alluvial deposit, wash or glacial deposit, or to a particular quarry. There may be several aggregate producers in a particular aggregate source. Aggregate information can be obtained from a variety of sources, including Technical Memorandum 6-370, "Test Data - Concrete Aggregates and Stone Riprap in Continental United States and Alaska," state transportation department resources, USGS reports or maps, state geologist reports or maps, county or state planning agencies, local test laboratories, and individual aggregate producers. Information provided concerning each source might include estimated volume of aggregate available, maximum aggregate size, percentage of sand in the source, general mineralogy of the source, production capacities, percentage crushed particles, sizes of aggregate produced, and costs for various aggregate sizes. Field inspections of the source by a materials engineer or geologist provides valuable preliminary information on the probable suitability of the aggregate. In particular, early identification of deleterious materials in the aggregate can be made during a field inspection. EM 1110-2-2000, "Standard Practice for Concrete," provides useful information and guidance on general aggregate quality and durability, including discussion on the forms of alkali-aggregate reactivity, and similar aggregate problems. Deleterious materials in aggregates used for airfield pavements can create significant Foreign Object Damage (FOD) to aircraft. Detailed knowledge of the potential for FOD from all aggregates considered for use is an essential feature of materials studies for airfield pavements. TM 5-822-7, "Standard Practice for Concrete Pavements," provides information on materials, and specifically on deleterious materials in aggregates. CEGS 02753, "Concrete Pavements for Airfields and Other Heavy-Duty Pavements," provides additional information on deleterious materials.

(4) Cementitious material sources. Likely sources of cement and pozzolan are described in this portion of the materials report. Information provided on available cement sources includes types of cement available at the plants, availability of low alkali cement, haul distance, and delivered cost. Information on available pozzolans includes types available, which generally will be a type F or C flyash, production capacity, typical loss on ignition (LOI, a measure of carbon content), haul distance, and delivered cost.

(5) Water, admixtures and other materials. Available sources of on-site water for construction are described here, including approximate quantity, reliability, and suitability for use in concrete. Use of commercial admixtures is discussed, particularly air entraining and water reducing admixtures. Unusual admixtures or other materials may be considered or required for some projects, such as fast track airfield pavements where existing airfields may be shut down only for very short time periods.

(6) Ready mix concrete sources. For smaller jobs, the use of readymix concrete may be considered, to avoid mobilization of relatively expensive central mix plants typically used on medium to large size projects. When applicable, this section provides information on the sources and distances from local readymix plants to the project.

(7) Aggregate test results. Small bagged samples of potential aggregate should be taken during field inspections, for preliminary petrographic examination. If preliminary examinations and information indicate an aggregate source should be considered for use, then bulk samples are obtained and transported to the test laboratory. The results of aggregate physical quality, chemical, petrographic and deleterious material testing are evaluated together to determine the suitability of each aggregate for the purpose and environmental conditions the concrete will be subjected to. EM 1110-2-2000, "Standard Practice for Concrete," provides guidance on aggregate testing. TM 5-822-7, "Standard Practice for Concrete Pavements," provides additional guidance on aggregate testing, including guidance for deleterious materials testing. The results from concrete aggregate testing should be recorded in Technical Memorandum 6-370, "Test Data - Concrete Aggregates and Stone Riprap in Continental United States and Alaska.

(8) Mixture proportioning test results. Sufficient time is seldom available to complete aggregate testing prior to the initiation of mixture proportioning studies. Both aggregate testing and mixture proportioning studies, conducted by the Government and directed by the materials engineer, are generally pursued concurrently during the design stage. Mixture proportioning studies are essential for concrete pavements to determine the potential concrete properties for design, to evaluate the cost efficiency and suitability of each aggregate source, to establish which aggregates can be used (and possibly listed in the specifications), and to assist in the development of cost estimates for the project. Poor aggregate quality may limit the strength of the concrete to moderate or even low values. Mixture proportioning studies are also used to examine the range of strength obtainable with a particular aggregate. Typically three water-cement ratios are selected for mixture proportioning that will bracket the water-cement ratio expected to provide the strength level desired. These water-cement ratios should be widely spaced so that a full range of strength performance is provided. The same water-cement ratios should be used for all the aggregates investigated to allow for direct comparison of the strength performance of the aggregates. The "efficiency" of each aggregate source can be evaluated by comparing similar mixes using the different aggregates. This can be done by comparing the "cement efficiency" of each mixture, that is, the strength divided by the cementitious material content of the mixture.

(9) Service record studies. Study of the performance of aggregates in existing concrete pavements in the region of the project must be conducted to provide information on the long-term durability and performance of those aggregates. These pavements could include older pavements at the installation, local state highways, county or city roads, or pavements at local airports. Records of aggregates and other materials used in these older pavements are generally difficult to

locate, although many state transportation departments do keep these records. Sometimes the aggregate source can be reliably determined by simple observation of the aggregate in the pavement. Service record studies can provide information on popouts, weatherouts, D-cracking, and other deleterious material-related problems, abrasion resistance, shrinkage, skid-resistance and other aggregate-related performance. Typical data collected during service record studies includes:

Pavement information:
- Pavement designation
- Installation location
- Date constructed
- Contractor and contract number
- Source of fine aggregate
- Source of coarse aggregate
- Source of cementitious materials
- Nominal maximum size of aggregate
- Mixture proportions
- Strength information
- Joint spacing
- Thickness
- Traffic type and frequency
- Latest condition rating, if applicable

Pavement condition:
- Cracking
- Crazing
- Spalling
- Popouts
- Weatherouts
- Soundness
- Abrasion
- Surface texture
- Overall condition

(10) Conclusions and recommendations. The conclusions and recommendations in the materials report are used to prepare the specifications. This section typically includes recommendations on whether to list aggregate sources in the specifications (see Annex 1), what sources should be listed, what cementitious materials to allow, source(s) of water, allowable admixtures, air content, maximum aggregate size, any unusual requirements for aggregates or aggregate deleterious materials, what strength and age to specify, and the like.

*f. Design analysis.* The design analysis of the concrete pavement should be described in an official document, including requirements from the geotechnical report and the materials office report. ER 1110-345-100, "Design Policy for Military Construction," and specifically ER 1110-345-700, "Design Analyses, Drawings and Specifications" addresses policy for design analyses for military projects, including transmittal of the final design analysis to the using activity upon completion of the project. EI 02C013, "Planning and Design of Airfields and Heliports," (draft) provides general provisions, criteria and policy for airfields and heliports. ETL 1110-3-394, "Aircraft Characteristics for Airfield-Heliport Design and Evaluation," provides information on aircraft characteristics for layout, design, or evaluation of airfield and heliport pavement systems. ETL 1110-3-380, "Standard Distribution of Military Airfield Pavement Design and Evaluation Information," provides guidance for the distribution of airfield and heliport pavement design analyses.

(1) The most current design criteria is listed on the USACE internet homepage, and is available through routine channels. Criteria is also available from the Construction Criteria Base (CCB) maintained by National Institute of Building Sciences (NIBS), and from TECHINFO, maintained by the Huntsville Engineering and Support Center. Any special requirements for a pavement project should be coordinated with the using activity and MAJCOM, and with the TSMCX.

(2) The TSMCX should be fully involved during all stages of design, from development of the DD Form 1391, through initial project concept design, to final design development and design reviews. The TSMCX should be contacted during design for any interim design criteria changes that may be in memorandum or ETL form, and not yet a part of more formal criteria. Funding for TSMCX reviews must be included in the project funds.

*g. Drawings.* ER 1110-345-100, "Design Policy for Military Construction," and specifically ER 1110-345-700, "Design Analyses, Drawings and Specifications" addresses policy for design drawings. TM 5-825-1, "General Provisions for Airfield/Heliport Pavement Design," provides an outline of design drawings. DG 1110-3-204 (AFP 88-7), "Design Guide for Army and Air Force Airfields, Pavements, Railroads, Storm Drainage and Earthwork," contains typical details and some example layouts that may be used for concrete pavement designs. Typical design drawings for concrete pavements include the following:

Plan view of project (including contractor work area and concrete plant area)
Pavement borrow areas
Pavement layout
Pavement removal plan
Pavement removal details
Pavement elevations and sections

Pavement profiles
Pavement elevations at all joint intersections
Pavement joint plan
Pavement cross sections
Pavement joint details
Pavement joint sealant details

Joint intersection elevations should be developed and shown on the drawings to insure adequate drainage is provided, and that correct elevations are available to the contractor. Detailed pavement joint plans should be provided in the drawings. Joint plans should not be left to contractors to determine in the field. Use of typical sections has been determined to be an inadequate means of showing pavement design sections. Multiple sections should be shown on the drawings wherever there is a change or transition from one pavement section to another. Designers should coordinate with the using activity and the TSMCX regarding special requirements for each project.

*h. Specifications.* ER 1110-345-100, "Design Policy for Military Construction," and specifically ER 1110-345-700, "Design Analyses, Drawings and Specifications," address policy for design specifications, including policy for deviations from guide specifications. Guide specifications are listed on the USACE Internet homepage, and are available from the CCB and from TECHINFO. CEGS-02753, "Concrete Pavements for Airfields and Other Heavy-Duty Pavements," and CEGS-02754, "Concrete Pavements for Small projects," are used for all concrete pavements. Although guide specifications for concrete pavements are written to address almost all possible features expected to be a part of a project, including notes to guide specification preparation, the project specifications must be carefully examined by experienced engineers to insure that all features are covered, that non-applicable items are deleted, and that specification provisions are appropriate for the specific project. In addition to general information useful for specification preparation, TM 5-822-7, "Standard Practice for Concrete Pavement," contains provisions for use of "listed sources" of aggregate. Annex 1 contains sample wording for "listed aggregate sources" that can be included in the specification special provisions or general requirements. Aggregate sources are not listed on all concrete pavement projects, and are seldom listed on small projects. Where listed sources are not used, the aggregate quality requirements must be carefully and completely specified. Preparation of specifications for concrete pavement, including joint sealants, should be closely coordinated with the using activity.

*i. Engineering Considerations and Instructions for Field Personnel (ECIFP).* Following completion of design (plans and specifications), an ECIFP should be prepared by the designer and the materials engineer. ER 1110-1-12, “Quality Management,” provides a list of design documents, including the ECIFP. The ECIFP is used to convey to the field office special design concepts, assumptions, concerns and instructions required for construction. The document

establishes a basis for communication and coordination between the designers and construction personnel. The document should discuss the design analysis, including geotechnical issues and concrete materials considerations, and should provide recommendations for construction procedures for the construction office, but should not merely repeat the design analysis, other available information or the specifications requirements. Typical ECIFP documents for concrete pavement follow the organizational structure of the specification, and might include the following:

Submittals, particularly concerning equipment and materials
Concrete strength and mix proportions
Concrete slump
Concrete mixing plant and concrete production
Pavers and paving
Finishing
Curing
Pavement thickness and surface tolerances
Pavement repair and replacement
Joints and sealing
Quality control
Quality assurance
Project staffing
Engineering support to construction
Site visits by the designer(s)

An example ECIFP is included in Annex 2. Preparation of an ECIFP should be closely coordinated with the using activity and the TSMCX.

*j. Cost estimates.* ER 1110-345-100, "Design Policy for Military Construction," and specifically ER 1110-1-1300, "Cost Engineering Policy and General Requirements," and ER 1110-3-1300, "Military Programs Cost Engineering," address policy for cost engineering and construction cost estimates.

*k. Criteria waivers.* Most criteria waivers involve airfield pavements. EI 02C013, "Planning and Design of Airfields and Heliports," (draft) provides guidance for waivers for Army, Air Force, Navy and Marine Corps airfields. AFR 86-5, "Planning Criteria and Waivers for Airfield Support Facilities," provides guidance for Air Force airfield support facilities.

(1) General. Waivers are required for any design deviations from published airfield criteria. Waiver procedures have been established to ensure that Corps designs and Army airfields meet Federal Aviation Regulations, DOD directives, Army policy and host nation requirements.

Waivers can be requested by the owner of the airfield or in rare instances by the design District. Examples of conditions possibly requiring criteria waivers include the following:

Siting of all runway, runway extensions, helipads and other airfield features.

Siting of any facility, tower, fixed or mobile object which protrudes into airfield clear zones.

Aircraft operational facilities lighting and marking not meeting criteria.

Air traffic control and navigational aids facilities not meeting criteria.

TM 5-822-7, "Standard Practice for Concrete Pavements," contains information concerning options for "deleterious substances" in concrete aggregates that may be requested by waiver.

(2) Waiver requests initiated by the design District. These waiver requests are sent to the TSMCX for review and approval. Requests not approved by the TSMCX will be returned to the district. Requests approved by the TSMCX will be forwarded to the appropriate office indicated in EI 02C013, "Planning and Design of Airfields and Heliports." Waivers not related to airfields will be forwarded to HQUSACE (CEMP-ET) for review and approval. The project design analysis shall include copies of all waivers.

(3) TSMCX assistance. The TSMCX provides technical engineering assistance to Corps districts preparing waiver requests. Districts are encouraged to use this service.

*l. Design review.* ER 1110-345-100, "Design Policy for Military Construction," provides general design review policy. HQUSACE policy (References) requires TSMCX review of all airfield pavement projects, and review of all projects where the roadway pavement cost is over $3,000,000. The TSMCX should be fully involved with design review from project inception, including preparation of DD Form 1391. TSMCX design review responsibility should be identified in the DD Form 1391 Special Design Instructions (SDI) for all projects meeting the mandatory design review requirements described above under TSMCX services. Cost of TSMCX reviews must be included in the district project funding. Bidability, Constructability, Operability and Environmental (BCOE) reviews, including field office review, are required and are discussed in ER 1180-1-6, “Construction Quality Management.”

**B-3. Preconstruction Preparation.**

*a. General.* Pavement construction practices are distinctly different from military vertical construction, and generally require different expertise in the field. Advance preparation for any type of construction is important to a successful project, but can be considered even more critical

for this type of construction. Since field construction offices do not manage this kind of project on a regular basis, specialized training is important to provide the field staff with the specialized knowledge required to manage a concrete pavement construction project. Preconstruction workshops can also be an important step in providing additional knowledge and understanding of the requirements for a specific paving project. The TSMCX can provide training and workshop assistance and information. Quality assurance planning is discussed in ER 1180-1-6, "Construction Quality Management."

*b. Pavement construction training for field staff.* Training on concrete pavement construction practices is essential for field staff, but can be difficult to schedule without significant advance notice of approaching pavement construction. A PROSPECT course on Pavement and Drainage Design and Construction provides information for both flexible and rigid pavements. Other organizations occasionally offer courses related to concrete pavement construction, such as the National Highway Institute. A PROSPECT exportable course, "Quality Verification: Concrete," on videotape, covers general concrete inspection and verification , including concrete paving.

*c. Preconstruction pavement workshop.* A short workshop on concrete paving conducted at the construction office is an excellent way to provide essential information on design, materials, construction equipment, practices and testing to the field staff, and to gather feedback from the field staff and the contractor on field conditions. These workshops, typically lasting about one day, are generally conducted by TSMCX staff, with the designer and field staff. Subject matter includes design intent, plans and specifications, the ECIFP, discussion of anticipated and proposed construction equipment, activities and procedures, and can include the Contractor briefing Corps staff on proposed equipment, operations, and testing. Discussion and resolution of critical issues with the Contractor can be greatly facilitated by these workshops. A typical agenda of a preconstruction paving workshop is included in Annex 3. The using activity should be invited to these meetings.

**B-4. Construction.**

Excellent designs, plans and specifications alone will not provide a high quality pavement. Without well trained and experienced construction personnel, given adequate resources, given adequate time to consistently and continuously monitor contractor efforts, and the authority to direct those contractor efforts, the concrete pavement product will often be less than satisfactory to the Corps and the using activity. Some key elements for high quality pavement construction management are discussed below. Partnering between all elements, including the contractor, the Corps construction staff, the designers, testing laboratories, and the using activity, can contribute significantly to construction of a high quality pavement. ER 1180-1-6, "Construction Quality Management," provides general guidance for establishing quality management procedures,

including an outline for quality assurance plans, required on all military projects, including concrete pavements.

*a. Construction staffing.* The most important element in producing a high quality pavement is a well trained and experienced construction staff. Construction staffing must be carefully thought out well in advance of the concrete pavement construction, taking into consideration the complexity and demands of the project, experience and training levels of available personnel, the availability of assistance from design staff, contract support, and other staffing resources. For a moderate to large-sized concrete paving project, the following staffing is considered the minimum adequate for during concrete placement:

(1) Field engineer. The field engineer should be dedicated only to the one paving project, especially for medium to large projects. The field engineer directs all quality assurance activities.

(2) Quality assurance representatives (QAR). Depending on the nature and size of the project, two to three full time QAR are required to monitor contractor concrete construction activities and performance. Large slipform paving projects generally require at least one QAR for the paver and one for the concrete plant, aggregate production and related activities. A single well trained QAR may be sufficient for subsurface preparation and construction, depending on the complexity of the work. Use of soil cement or drainage layers may require additional quality assurance, as well as support from the designer/materials engineer. Features other than concrete construction may require other specialized quality assurance. Field engineer and quality assurance services can be acquired through service contracts, but the qualifications and experience of the individuals to provide the services should be carefully scrutinized, and these individuals should be thoroughly trained in the specific procedures and objectives of the specific project. At least one QAR or the field engineer must be experienced and thoroughly knowledgeable in heavy duty pavement construction, particularly for airfield pavements. Field staff that must service multiple projects are not generally able to adequately manage and inspect moderate to large concrete paving projects, such as runways, taxiways and aprons, or large roads and hardstands. Additional quality assurance services are available from TSMCX IDT contracts.

*b. Surveying and smoothness measurement.* A survey party chief and two person crew is generally required on larger projects for checking concrete elevations and alignment, and straightedging where required. These services are normally specified as contractor responsibilities, but may performed by the Government, using either district survey staff or by a service contract. Where profileograph measurements are required on the completed pavement surface, service contracts will usually be required to provide crews experienced with this specialized equipment. Profileograph services are generally included in the specifications as a contractor requirement. TSMCX IDT contracts are available for quality assurance activities.

*c. Quality assurance laboratory.* Government quality assurance testing can be provided by Government personnel, but is more often provided by a service contract. Concrete field testing technicians should all be at a minimum ACI Grade I Certified and laboratory testing technicians should be ACI Grade I or II Certified Laboratory Technicians. It may be useful to require a registered engineer to sign all test reports. A laboratory inspection conducted prior to construction by Corps laboratory personnel is mandatory (ER 1110-1-261, "Quality Assurance of Laboratory Testing Procedures").

*d. Design/materials engineer construction assistance.* On-site field assistance by the design and/or materials engineer or the TSMCX is recommended at critical stages in pavement construction, particularly for medium to large or complex projects. These stages might include:

Preconstruction workshops and meetings
At start of existing pavement removal, if applicable
Base course and drainage layer construction
Inspection of concrete mixing plant and paver prior to placement
At start of concrete paving
At key stages of concrete placement
At start of joint sealing
Pavement completion

The materials engineer should be consulted at the start of mixture proportioning studies, and final mixture proportions should be reviewed by the materials engineer prior to approval or placement. The design engineer/materials engineer and the TSMCX are resources available to the field office for troubleshooting at any time during construction, for pavement workmanship assistance, and for periodic field data review, especially concerning concrete strength data.

*e. Inspection.* Routine inspection of subsurface layer construction, and continuous, full time inspection of concrete placement is required for high quality concrete pavement construction. At least one of the QAR or the field engineer must be experienced and trained in concrete pavement, and should be supplemented by assistance in the field at key intervals by design/materials engineers or the TSMCX. TSMCX IDT contracts are available for construction management and inspection services.

**B-5. Pavement Completion Documentation.**

The collection and retention of specific construction data and information is essential to insure that materials and mixtures used in construction can be evaluated for long-term durability and performance, and to insure that less than successful practices, equipment or materials used by a

contractor become lessons learned and become the basis for criteria changes. Several methods or programs, described below, can assist in the collection of construction data and information for application to future projects and in the correction of pavement standards, practices or criteria.

*a. As-built drawings and design analysis.* ER 1110-345-700, "Design Analyses, Drawings and Specifications" provides policy regarding as-built drawings furnished to the using activity. All modifications to design joint layouts must be shown on the as-built drawings to insure accurate information is presented for future pavement removal or replacement requirements, such as for later installation of utilities. ER 1110-345-700, "Design Analyses, Drawings and Specifications" requires transmittal of the final design analysis to the using activity upon completion.

*b. Pavement construction completion data.* Following completion of concrete pavements, the pavement designer or materials engineer must acquire construction data from the field construction office and must include this data in a "Pavement Construction Completion Data" sheet. A sample of the contents of this data sheet is included in Annex 4. This document summarizes construction information on the pavement, including pavement and concrete data, aggregate physical tests, gradations and allied data, mixture proportions, and concrete strength data. This is an essential document, not only for use in evaluating quality of the pavement product, but more importantly for future pavement service record surveys. Knowing the sources of materials and other information about pavements constructed earlier enables designers and materials engineers to assess the long-term durability of aggregates, other materials, and material combinations, for use on future projects. These documents should be retained permanently in the district engineering office, and a copy should be sent to the using activity and the TSMCX.

*c. Lessons learned report.* Following completion of concrete pavements, a lessons learned office report should be prepared, listing and describing successful and less than successful construction practices, equipment or materials used by the Contractor. This report should be retained in the district engineering and construction offices, with a copy forwarded to the TSMCX. It is understandable why districts are reluctant to describe less than successful pavement experiences, however, unless these experiences are passed on to USACE elements who can make necessary changes to criteria or pavement practices, these valuable lessons will continue to be lost, and the same less than successful practices will likely be repeated on future work.

*d. Design criteria changes.* ER 1110-345-100, "Design Policy for Military Construction," discusses ENG Form 3078, "Recommended Changes to Engineering Documents," for changes to drawings and specifications, and DA Form 2028, "Recommended Changes to Publications and Blank Forms," for changes to criteria. These forms should be submitted to HQUSACE (CEMP-ET), generally by the design or materials engineer, with a copy to the TSMCX, to describe necessary changes in design standards, guide specifications or other documents or criteria for concrete pavements.

*e. Test data.* Technical Memorandum 6-370, "Concrete Aggregates and Stone Riprap in Continental United States and Alaska," provides a compilation of concrete aggregate and riprap stone test data. The use of a specific aggregate source and aggregate test results on a paving project should be reported on the aggregate data summary sheets. These documents must be filled out by the district annually for transmittal to WES, using information provided by the materials engineer, or may be filled out by the design or materials engineer.

# Annex 1: Sample Specification Requirements for Listed Aggregate Sources

## B1-1. Sample Specification for Listed Aggregate Sources

The following language can be included in the specification special provisions or general requirements if listed aggregate sources are desired for a concrete paving project.

"AGGREGATE SOURCES:

(A) Concrete aggregates may be produced from the listed sources listed below:

(1) Sources of fine aggregate:

(a) xxxxxx River, between xxxxx city and xxxxxx city, South of Highway xx and West of Highway xx, T20S R19E, Sections 15, 16, and 17 (list owner or operator for each).

(b) xxxxxxxxxxx quarry, Southeast of xxxxxx, and East of Highway xx, T22S R21E, Sections 17 and 18 (list owner or operator for each)(more specific information, such as ledge or quarry area, may be necessary).

(B) Concrete aggregates may be furnished from any of the above listed sources or at the option of the Contractor may be furnished from any other source designated by the Contractor and approved by the Contracting Officer, subject to the conditions hereinafter stated.

(C) After the award of the contract, the Contractor shall designate in writing, only one source or one combination of sources from which he proposes to furnish aggregates. If the Contractor proposes to furnish aggregates from a source or from sources not listed above, he may designate only a single source or a single combination of sources for aggregates. Samples for acceptance testing from an unlisted source shall be provided as required by Section: xxxxx of the Technical Specifications. If a source for coarse or fine aggregate so designated by the Contractor is not approved for use by the Contracting Officer, the Contractor may not submit for approval other sources but shall furnish the coarse or fine aggregate, as the case may be, from a listed source listed above at no additional cost to the Government.

(D) Listing of a concrete aggregate source is not to be construed as approval of all material from that source. The right is reserved to reject materials from certain localized areas, zones, strata, or channels, when such materials are unsuitable for concrete aggregate as determined by the Contracting Officer. Materials produced from a listed source shall meet all the requirements of Section: xxxxx of the technical sections of these specifications".

# Annex 2: Sample Engineering Considerations and Instructions for Field Personnel (ECIFP)

## B2-1. Sample ECIFP

The following is a sample ECIFP. The ECIFP must be tailored specifically for the individual project plans, specs, and field situation. Some of the considerations in this example may not be appropriate for another project. The ECIFP should not repeat the specification requirements, but should highlight only specific items needing additional discussion beyond the specification wording or what is shown on the plans. ECIFP's must not contain information in conflict with the specifications.

*a. General.* Both Army and the Corps of Engineers consider quality to be top priority for pavements. This is especially true considering that a single defect in an airfield pavement can cause extraordinarily expensive repairs and even complete loss of an aircraft. These special design considerations pertain to all work in the contract involving the concrete pavement and joint sealing. Pertinent specification sections are xxxxx, xxxxx, and xxxxx. These design considerations also refer to pavement joint layout and joint details shown on the drawings.

*b. Pavement workshop.* A short concrete pavement workshop at the project office is recommended early in construction to provide information on a variety of concrete pavement construction topics, and as an opportunity to discuss in detail the plans and specifications with designers and with the Contractor, and to discuss Contractor proposals. The workshop can be conducted by the design office and the TSMCX, with the construction office.

*c. Material and equipment submittals* (para. x in xxxxx). The Government must complete certain tests and reviews for this project prior to construction. The specifications list the submittal and timing requirements:

(1) Materials testing. Aggregates, cement, pozzolan, and admixtures are sent to the xxxxxxxxxxx Lab. Shipping is at Contractor expense, testing is at Government expense. These materials are tested to assure the materials can produce acceptable concrete, and to provide mix proportions for the Contractor's use at their option or for a check mixture testing of the contractor mixture proportions. Contact xxxxx xxxxx at xxxxxxx Lab (xxx) xxx-xxxx.

(2) Mixture proportioning. The selection of mix proportions for construction is the Contractor's responsibility. Make sure the Contractor follows the specification requirements for mix proportioning procedures, as they often forget to proportion the required number of mixtures and run all of the tests, resulting in project delays. The concrete specimens for mixture proportioning strength testing must be cast at the maximum permitted slump and air content.

(3) Joint sealant and lubricant samples are sent to Waterways Experiment Station, Vicksburg, MS. Contact CEWES for more information prior to sending.

(4) Mixing plant and paver. The Contractor should submit information on the mixing plant and paver proposed for use as soon as possible, since this submittal often doesn't initially meet the specification requirements. This is a critical submittal for it directly affects the quality of the project. The paver requirements have been carefully prepared to avoid use of pavers that have not performed adequately on previous similar work. Any paver submitted for use must be carefully checked against the specification.

*d. Concrete strength* (para. x in xxxxx). These paragraphs spell out all of the flexural and other strength requirements. Tests at 1 (accelerated splitting tensile test), 14, and 28 days are required for early information. By comparing strengths at early ages with laboratory curves, the contractor can get an indication of the strength potential at 90 days.

*e. Slump* (para. x in xxxxx). The slump limits in the specification are maximums, not averages. The slump limit for slipform paving is especially critical for acceptable pavement construction. Concrete which has a slump over these limits must be rejected.

*f. Air entrainment*. Air content is a critical parameter for frost areas. Air content below the required limits will result in non-durable concrete. Air content above the required limits will reduce strength.

*g. Materials* (para. x in xxxxx).

(1) Aggregates must meet special grading requirements and special limits on deleterious materials. Deleterious material limits are essential to avoid popouts and other durability problems caused by weak aggregate particles. These have been a serious problem on a number of pavements across the nation. Excessive wood chips can also be a problem with some local aggregates, and must be removed.

(2) Cement and Class F or C Pozzolan. Pozzolan provides many benefits in concrete, but must be carefully evaluated to avoid occasional problems. The source of pozzolan is an important indicator of its performance. Contact the materials engineer for more information on sources.

(3) Admixtures. Note that retarding admixtures are not permitted for slipform paving, but are allowed for fixed-form paving. Retarders are useful in hot weather to provide extra finishing time, but cause excessive edge slump in slipform placements. Any admixture used in the concrete construction must have been the same specific admixture used in the mixture proportioning studies.

*h. Forms and stringline* (para. x in xxxxx). The stringline, used to control the surface alignment of each lane, is crucial to a successful job. The stringline should be used by the Contractor to check the grade prior to each lane placement. A large portion of one airfield apron was recently removed due to inadequate thickness when these checks weren't made.

*i. Batching and mixing of concrete* (para. x in xxxxx). Because of the high concrete production necessary for this project, and the low slump concrete required, an on-site central mix concrete plant is required. No transit mixers may be used. The recorder data should be checked daily to assure that the Contractor is batching materials properly. Improper batch weights is a common problem that has led to inadequate pavement strengths. The Contractor must perform periodic mixer efficiency tests. Inspectors should become very familiar with the plant, how it is operated and how each part should function. Plant calibration should be monitored closely, particularly if load cells are used instead of visible weigh scales.

*j. Placing* (para. x in xxxxx). A few early cores for thickness can be used to insure that the paver is properly consolidating the concrete by observing the cores for voids or segregation.

*k. Finishing* (para. x in xxxxx). A concrete pavement does not require much finishing. If the paver is working well finishers should hardly have to touch the pavement surface. Finishing with cutting straightedges should be almost all that is required. Do not permit finishers to add water to the surface! Also do not let finishers build up edges that have slumped by adding mortar or concrete. While the concrete is still plastic, a straightedge should be laid longitudinally and transversely in the lane to assure surface smoothness of the hardened concrete will be acceptable.

*l. Curing* (para. x in xxxxx). Adequate concrete curing is essential for strength gain and for a durable pavement surface. White pigmented membrane curing compound must be applied as soon as the texturing is completed. Application rate should be checked each shift by placing 1 foot square pieces of cardboard on the pavement surface, and removing them after the curing machine has passed by. By weighing the cardboard before and after application, the amount put down can be calculated. This can be checked by determining the total quantity sprayed during each shift. Properly applied curing compound will appear as a continuous white film with no concrete showing through.

*m. Surface tests* (para. x in xxxxx). For slipform construction, particular attention should be paid to lane edges where edge slump can occur. Straightedge testing must be completed no later than 36 hours after placement. For assistance with Profileograph measurement issues, contact the design office or the TSMCX.

*n. Pavement thickness tolerance* (para. x in xxxxx). Pavement load capacity is heavily

dependent on thickness. The pavement thickness must be checked within 7 days of placement by drilling cores. When deficient areas are discovered, additional cores must be drilled to better define the extent of the deficiency.

*o. Repair and replacement* (para. x in xxxxx). Completed pavement should be carefully inspected for cracks and spalls. Any necessary repairs must be completed before acceptance. Slabs which are irreparable, too thin, or have excessive edge slump, must be removed and replaced.

*p. Joints* (para. x in xxxxx). Many pavement failures occur at joints, making these a critical feature of successful concrete pavement. Joints allow temperature and shrinkage movement in the concrete, while providing load transfer. Joint details shown in the drawings are not trivial and construction should follow these details precisely. Location or type of joints as shown on the drawings must not be altered without written approval of the designer.

(1) Longitudinal construction joint. Where keyways are used, dimensions of the keyway are crucial to assure adequate load transfer across the joint, and any areas which do not match the detail must be doweled for a minimum of one slab length. Dowels are covered below.

(2) Transverse construction joint. This joint is most commonly used for the end of a work day. This joint must be doweled (keyways are not acceptable) and it must be constructed at the location of a planned transverse joint.

(3) Longitudinal contraction joint. This joint is used down the middle (for example) of a paved strip to break it into two lanes. This joint must be sawed.

(4) Transverse contraction joint. This joint must be sawed for slipformed pavements.

(5) Expansion joint. This joint is located in new pavement at changes in pavement direction and around fixed structures, to accomodate temperature and shrinkage movement by isolating the pavement sections. The expansion joint material must be placed full depth for the joint to be effective.

(6) Special expansion joint. This joint is located between new and existing pavements, to provide load transfer and accomodate temperature and shrinkage movement. This joint is difficult to construct properly, and requires extra vigilance.

(7) Joint sawing. Joint sawing timing is difficult to predict, but is critical to anticipate to avoid widespread cracking. 4 to 24 hours after placement is generally the proper time frame, depending on temperature and humidity. This frequently means working in the middle of the

night. Especially at the beginning of the job, all sawing should be closely inspected while it is taking place to make sure sawing is done at the proper time and location. The first placement is frequently where contractors either saw too late to avoid cracking, saw too early and cause excessive spalling, or saw at the wrong locations. All are very obvious problems, and impossible to adequately correct once they occur.

After initial sawing is completed, a rope must be placed in the top of the joint to assure it doesn't fill up with debris, and to provide additional curing in the critical joint area. Curing of this area is critical to avoid joint spalling which has been occurring with increasing frequency on recent concrete pavements.

(8) Dowels. Dowel installation and alignment is a recurring problem in concrete pavement construction. When installing dowels in drilled holes "buttering" of dowels with epoxy (which many contractors will propose doing) and then pushing them in the drilled hole does not provide adequate dowel strength. Epoxy must be injected into the rear of the hole, followed by dowel insertion by a twisting action. Dowels must be installed straight and level to perform adequately. Misaligned dowels will "lock" the joint and not allow temperature and shrinkage movement.

*q. Joint preparation for sealant* (para. x in xxxxx). Premature joint sealant failure is a not uncommon problem with concrete pavements. Joints must have proper dimensions and must be prepared correctly to insure adequate performance. Regardless of how a joint was originally constructed, the slot for sealant must be sawed out. Sealant will adhere adequately only to joints with vertical sides and clean faces. Sandblasting is required to assure all laitance, curing compound, and debris is removed. All joints should be inspected and measured carefully before sealant is installed. For hot poured sealants, sealant temperature when installed is critical for proper performance, and should be monitored closely by the contractor.

*r. Measurement and payment* (para. x in xxxxx). This project has been designed to be bid on a unit price basis, so it is extremely important that accurate accounting is done for proper payment. Concrete is to be measured by the cubic yard (cubic meter) according to the dimensions shown on the drawings. This is not necessarily the same as the number of cubic yards (cubic meters) of concrete delivered to the site.

Paragraph x in xxxxx contains a reduction-in-pay clause for thickness deficiency. This clause has been added to motivate the Contractor to produce quality work. It is not intended to be a crutch or an excuse for building a sub-standard pavement.

*s. Contractor quality control (CQC)* (para. x in xxxxx). CQC in a paving job should be more rigorous than in other kinds of construction. The QC Lab must be an independent lab which has recently been inspected by a Corps laboratory. All Government and QC staff testing concrete

must be ACI certified as Concrete Field Testing Technicians Grade I, or Concrete Laboratory Testing Technicians Grade I or II..

(1) Concrete strength. Strength data should always be immediately reviewed and can be analysed at the construction office, or can be sent to the design office for analysis and rapid feedback to the construction office.

(2) Aggregate tests. Deleterious materials are particles of aggregate which even at relatively low percentages can have an adverse effect on the strength and durability of the pavement. These tests are essential. Only the specific deleterious material test(s) that pertain to the aggregate(s) being used need to be tested at the frequency specified. Deleterious material testing frequency must be closely followed, and may be reduced as specified after initial test results are consistently within required limits. QC and QA testing laboratories should be briefed on the importance and specific tests required for deleterious materials compliance.

(3) Slump and air content. Slump and air content (particularly in frost regions) must be checked at the stipulated intervals, but also any time a concrete batch looks suspect.

(4) Test result actions. All of the QC test results must be recorded on control charts which must be turned in to the Government each day. When any individual tests indicate materials or work exceed specification limits, specific action is required, including doubling the testing frequency or stopping work.

*t. Mandatory government quality assurance.* If government manpower is short, a separate commercial lab should be contracted for QA testing, using ACI certified Field Testing Technicians Grade I or Certified Laboratory Technicians Grade I or II. At the beginning of the job, QA testing frequency should nearly match that of QC testing. After initial QA testing demonstrates the adequacy of the QC program, QA testing can be scaled back to a rate meeting ER 1180-1-6, "Construction Quality Management." Preparatory inspections just prior to each concrete pavement placement should be well documented for use if later problems develop.

*u. Project staffing.* Proper inspection of a paving job of this magnitude requires at least two (three is better) experienced full-time Quality Assurance Representatives (QAR). One to monitor production at the plant and one to monitor placement at the paver. These QAR should be assisted by adequate office staff to process paperwork. A high priority should be put on keeping the project adequately staffed.

*v. District field support.* The design office has a keen interest in concrete pavement construction support. Personnel experienced in concrete paving are available to answer field questions and to assist in the field inspection, to conduct a pre-construction paving workshop for

field personnel, and are available to participate in a preconstruction meeting with the Contractor. The services of an experienced geotechnical/pavement engineer is recommended to assist you during the concrete pavement construction as required. The TSMCX is available to provide paving workshops, to respond to construction inquiries, and to locate additional resources for construction assistance. The resident office is encouraged to contact the design office at (xxx) xxx-xxxx and the TSMCX before paving begins and as it progresses.

*w. Post-construction data transmittal.* The construction office should send a copy of all QA and QC tests results to the design office soon after testing is completed. This data is essential for use on subsequent projects. Data transmittal during construction is also encouraged in order to provide current statistical analysis of field data, particularly strength, according to ACI 214. This kind of analysis can be a significant contribution to the construction process by providing immediate feedback not only on strength performance, but also the quality of testing performed.

# Annex 3: Sample Preconstruction Pavement Workshop Agenda

## B3-1. Preconstruction Pavement Workshop Agenda

*a. Introduction of all attendees, including contractor staff*

*b. Introduction to project, purpose, and layout*

*c. Design considerations*

(1) Foundation investigations and geotechnical report
(2) Materials investigations and materials report
(3) Pavement design and layout
(4) Pavement joint design
(5) Concrete mixture, strength, and durability

*d. Construction*

(1) Equipment (including concrete mixing plant and paver)
(2) Paving procedures
(3) Joints
(4) Dowels and tie bars
(5) Joint sealing
(6) Pavement removal
(7) Base course and drainage layers
(8) Smoothness and profileograph measurements

*e. Quality control and quality assurance*

*f. Plans, specifications and ECIFP review*

*g. Construction staffing and engineering support*

*h. Post-construction data collection and reporting*

*i. Contractor presentation*

(1) Plans and specifications
(2) Proposed equipment

(3) Proposed construction procedures
(4) Proposed QC procedures

*j. Corps discussion of contractor proposals*

*k. Wrap up and record of workshop*

# Annex 4: Pavement Construction Completion Data

## B4-1. Pavement Construction Completion Data

Typical data recorded at the completion of concrete pavement construction includes the following:

*a. General Information.*

Project name
Specification number
Contractor
Source of cement
Source of pozzolan
Source of sand
Source of coarse aggregate
Admixtures
Volume of concrete
Starting date
Completion date
Description of workmanship and pavement quality obtained
Pertinent photographs of equipment used and pavement features can be useful

*b. Agregate physical tests.*

Aggregate gradings
Specific gravities
Absorptions
Mortar strengths
Decantation
Organic impurities
LA abrasion loss @ 500 cycles
Magnesium sulfate soundness
Quick chemical Sc and Rc
Mortar bar expansion
Rapid freezing and thawing in concrete

*c. Petrographic results and deleterious materials tests.*

Petrography on sand and coarse aggregates (from design studies)
Deleterious materials testing:
- Clay lumps & friable particles
- Shale
- Finer than no. 200
- Clay ironstone
- Lightweight particles
- Chert & cherty stone
- Shaley/argillaceous limestone
- Other soft particles
- Total (except no. 200)

*d. Mix proportions (one cubic yard or cubic meter batch).*

- Mix number
- Water-cement and water-cementitious ratio
- Slump
- Air content (%)
- Cement weight
- Pozzolan weight
- Fine aggregate weight
- Coarse aggregate weight
- Water weight
- Admixtures

*e. Flexural or compressive strengths.*

- Ages (days)
- Average strength
- Number of samples per age
- Number of samples per test
- Average slump
- Average air content

*f. Miscellaneous remarks.*