U.S. Army South Regulation 415–4

Construction

Design Criteria and General Construction Specifications

Headquarters
U.S. Army South
Fort Buchanan, Puerto Rico
June 2001

SUMMARY of CHANGE

USARSO Regulation 415-4
Design Criteria and General Construction Specifications

This revision –

?? Deletes references and procedures that were applicable when USARSO was based in Panama.

?? Adds reference to USARSO standard designs (paragraph 2-2b).

Department of the Army
Headquarters
United States Army South
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June 2001

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Design Criteria and General Construction Specifications

FOR THE COMMANDER:

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History Statement. This printing publishes a revision of United States (U.S.) Army South (USARSO) Reg 415-4.

Summary. This regulation describes policies and procedures regarding design considerations and construction specifications for U.S. military engineer exercises conducted in Latin America and the Caribbean.

Applicability. This regulation applies to all U.S. Army active and reserve component troop construction in Latin America and the Caribbean.

Proponent and Exception Authority. The proponent for this regulation is the USARSO Deputy Chief of Staff for Engineers (DCSENG). The proponent has the authority to approve exceptions to this publication that are consistent with controlling law and regulations.

Supplementation. Supplementation of this regulation is prohibited unless specifically approved by the proponent.

Suggested Improvements. Users are invited to send comments and suggested improvements on DA Form 2028 (Recommended Changes to Publications and Blank Forms) directly to Commander, ATTN: SOEN-ED, PO Box 34000, Ft. Buchanan, PR 00934-3400.

Distribution. Distribution of this publication is made in accordance with USARSO Pam 25-50, Command Distribution Scheme, and is intended for USARSO A1; B1; C1; D1; SOEN-ED – 5; SOIM-IT-RP – 2; AFSA-PS-HHD (MDC) – 5; AFSA-PS-HHD (PUBS) – 5; and the USARSO Intranet.

*This regulation supercedes USARSO Regulation 415-4, May 1994

Contents (Listed by paragraph number.)

Chapter 1
Introduction

1–1. Purpose
This regulation establishes policy, procedures, and guidance for developing and implementing design criteria relating to the USARSO troop construction program in Latin America and the Caribbean.

1–2. References
Required and related publications are listed in appendix A.

1–3. Explanation of abbreviations and terms
Abbreviations and terms used in this regulation are explained in the glossary.

1–4. General
a. Engineer exercises conducted in the United States Southern Command (USSOUTHCOM) area of responsibility (AOR) consist of vertical and horizontal construction projects. Vertical projects include schools, clinics, community centers, latrines, and water wells. Horizontal projects include roads, airfields, site preparation, bridge repair or replacement, and site access maintenance and repair.

b. USARSO has developed standard designs for schools, clinics, and latrines that can be easily site adapted as required. The Task Force (TF) shall use the USARSO standard design to the maximum extent possible. Doing so will save significant design time, expedite the design approval process, and expedite materials procurement.

c. The Mobile District Corps of Engineers provides technical expertise for water well development to include site selection, design, materials procurement, and Quality Assurance**.**

1–5. Responsibilities
a. The USARSO Deputy Chief of Staff for Engineering (DCSENG) will:

(*1*) Establish overall design policies, goals, and objectives.

(*2*) Conduct engineer reviews and approve all engineering plans, designs, and specifications.

(*3*) Make modifications to design criteria as required.

(4) Update and maintain the USARSO standard designs.

b. The USARSO Deputy Chief of Staff Operations (DCSOPS) will:

(*1*) Evaluate host nation project proposals against Department of Defense (DOD) military construction standards and USARSO standard designs.

(*2*) Participate with DCSENG reviews of engineer plans, designs, and specifications.

c. The TF Commander will:

(*1*) Implement this regulation during project planning and execution.

(*2*) Submit required project engineering documents for review and approval in accordance with established exercise milestones.

(*3*) Ensure quality control (QC) personnel and equipment are on hand to ensure compliance with design criteria.

(4) Develop designs and bill of materials (BOM) for assigned projects or site adapts the USARSO standard designs.

Chapter 2
Specifications

2–1. General
The technical specifications outlined in this regulation reflect specifications, policies, and guidance from related military and civilian publications that are pertinent to the type of construction troop units performed in Latin America and the Caribbean.

2–2. Specifications guidance
a. Detailed guidance is provided in the areas of:
(1) Clearing, grubbing, and disposal
(2) Excavation, fill, and preparation of sub-grade for roadways
(3) Crushed aggregate base course
(4) Reinforced concrete pipe culverts
(5) Erosion control
(6) Concrete
(7) QC

b. Detailed guidance and specifications for vertical projects (schools, clinics, and latrines) are incorporated in the USARSO Standard Drawings for Humanitarian Civic Action (HCA) Engineer Exercise Construction (ERC).

Chapter 3
Clearing, Grubbing, and Disposal

3–1. Clearing
Clearing shall consist of the felling, trimming, and cutting of trees into sections; and the satisfactory disposal of the trees and other vegetation designated for removal, including down timber, snags, brush, and rubbish occurring within the areas to be graded or constructed. Trees, stumps, roots, brush, and other vegetation in areas to be cleared shall be cut flush with or below the original ground surface, except such trees and vegetation as may be indicated or directed to be left standing. Trees and vegetation to be left standing shall be protected from damage incidental to clearing, grubbing, and construction operations, by the erection of timber barriers or by such other means, as the circumstances require. Such barriers must be placed and approved by the quality control officer before construction operations can proceed. Clearing operations shall be conducted so as to prevent damage by falling trees into trees left standing, existing structures and installations, and those structures under construction, and so as to provide for the safety of workers and others.

3–2. Grubbing
Grubbing shall consist of the removal and disposal of stumps, roots larger than 3 inches in diameter, and matted roots from the areas to be cleared. This material, together with logs and other organic or metallic debris not suitable for foundation purposes, will be excavated and removed. Excavation shall be to a depth of not less than 18 inches below the original ground surface in embankment areas and not less than 24 inches below the finished earth surface in excavated areas indicated for grubbing and construction. Such areas are those for buildings, roads, road shoulder areas, and sidewalks. Depressions made by grubbing shall be filled with suitable material and compacted to conform with the original adjacent ground surface.

3–3. Disposal
Disposal of all trees, branches, snags, brush, stumps, etc., resulting from the clearing and grubbing shall be disposed of by burning (when permitted), removal from the construction area limits, or a combination of both. Material disposed of by burning shall be burned at authorized locations in a manner that will avoid all hazards such as damage to existing structures, construction in progress, trees and vegetation. The TF shall be responsible for compliance with all local laws and regulations relative to the building of fires. Disposal by burning shall be kept under constant attendance until the fires have been completely extinguished.

a. The TF QC officer shall establish and maintain quality control for clearing, grubbing, and removal operations under this section to assure compliance with project requirements and the approved quality control plan. The QC officer will maintain records of quality control for materials, equipment, and construction operations.

b. QC shall include but not be limited to the following:
(*1*) Preparatory inspection (to be conducted prior to commencing work).
(a) Review of approved plans and specifications including work checklists.
(b) Establishment of clearing and grubbing procedures with the project officer in charge (OIC) to assure protection of existing structures and trees designated to remain.

(c) Discussion of safety precautions with the project OIC, especially in regard to building fires, if applicable.
(d) Establishment of environmental measures to prevent pollution of stream or river waters.
(*2*) Initial Inspection (to be conducted after a representative sample of the work is completed).
(a) Check clearing to see that trees left standing, if any, are trimmed and protected properly.
(b) Seeing that grubbing is done to proper depth and depressions are filled satisfactorily.
(c) Seeing that cleared and grubbed materials are disposed of properly and safety requirements are observed.
(d) Checking effectiveness of environmental measures for work adjacent to streams or rivers.
(*3*) Follow-up Inspections (to be conducted daily to assure compliance with results of initial inspection).
(a) Check items mentioned in preparatory and initial inspections.
(b) Ensure correction of any damage, defects, or deficiencies.
c. The above inspections, including results of any corrective actions taken, shall be documented in appropriate forms. Reports, forms, and completed checklists shall be filed with the daily quality control reports.

Chapter 4
Excavation, Fill, and Preparation of Sub-grade for Roadways

4–1. Definitions
a. Satisfactory materials, in accordance with MIL-STD-619B.
(*1*) In-place materials for sub-grade. Satisfactory materials for natural in-place soil for sub-grade shall be limited to materials classified as well graded gravel (GW), poorly graded gravel (GP), silty gravel (GM), clay gravel (GC), poorly graded sand (SP), well graded sand (SW), clay sand (SC), silty sand (SM), lean clay (CL), and fat clay (CH).
(*2*) Fill or back-fill for sub-grade. Satisfactory materials for fill or back-fill for sub-grade shall be limited to materials classified GW, GP, GM, GC, SW, SP, SM, SC, and CL.
b. Unsatisfactory materials, in accordance with MIL-STD-619B.
(*1*) In-place material for sub-grade. Unsatisfactory materials for natural in-place soil sub-grade shall be materials classified as Pt, OH, OL, ML, and MH.
(*2*) Fill or back-fill for sub-grade. Unsatisfactory materials for fill or back-fill for sub-grade shall be materials classified as Pt, OH, OL, ML, MH, and CH.
(*3*) Material determined to be too soft or too wet to provide a stable fill, back-fill, or sub-grade shall be aerated and reconditioned to provide the necessary stability. If reasonable efforts do not produce a stable condition, over excavate the problem area 2 feet and back-fill atop the un-compacted exposed sub-grade in 4-inch loose lifts and cohesionless materials back to finish sub-grade compacting each lift as specified herein.
c. Cohesionless and cohesive materials. Cohesionless materials include poorly and well graded gravel (GP and GW) and poorly and well graded sand (SP and SW). Cohesionless soils are generally regarded as free draining. Cohesive materials include GC, SC, CL, CH, silt (ML and MH), and organic materials (Pt, OL, and OH). Materials such as GM and SM will be considered cohesionless only when the fines have a plasticity index of O; otherwise, they will be considered cohesive. When the results of compaction tests for moisture density relations are recorded on graphs, cohesionless soils will show fairly flat or reverse-shaped moisture-density curves; cohesive soils will show normal moisture density curves. Very silty soils may exhibit narrow ranges of moisture content within which optimum compaction can be obtained.
d. Degree of compaction required is expressed as a percentage of the maximum dry density obtained by the test procedure presented in FM 5-530, chapter 2.
e. Maximum dry density is the maximum density when the soil is compacted in accordance with the American Society for Testing and Materials (ASTM) D 1557, Method D, or FM 5-530, chapter 2, section IX.
f. Optimum moisture content (OMC) is the moisture content of the soil corresponding to the maximum dry density obtained by the test procedure in ASTM D 1557, Method D, or FM 5-530, and as shown on the DD Form 1211 (Soil Compaction Test Graph).

4–2. Excavation
Excavation of every type of material encountered shall be performed within the limits of the project, to the lines, grades, and elevations indicated and as specified herein. Grading shall be in conformity with the typical sections shown on the drawings and as discussed in paragraph C-8, Finishing. Satisfactory excavated materials shall be transported to and placed in fill or embankment areas within the limits of the work. Unsatisfactory materials encountered, within the limits of the work, shall be excavated below grade and replaced with satisfactory materials as defined in paragraph C-2*b* above. Surplus satisfactory excavated material not required for fill or embankment shall be disposed of in areas approved for surplus material storage or designated waste areas. Unsatisfactory excavated material shall be disposed of in designated waste or spoil areas. During construction, excavation and fill shall be performed in a manner and sequence that will provide proper drainage at all times. Additional material required for fill or embankment shall be excavated from approved borrow areas.

4–3. Back-fill

Back-fill adjacent to any and all types of structures including culverts and headwalls shall be placed and compacted to at least 90 percent laboratory maximum density for cohesive materials or 95 percent laboratory maximum density for cohesionless materials. Compact in such a manner as to prevent wedging action or eccentric loading upon or against structures. Ground surface on which back-fill is to be placed shall be prepared as specified in paragraph C-5, Preparation of Ground Surface for Fills.

4–4. Preparation of ground surface for fills

a. Ground surface on which fill is to be placed shall be:

(*1*) Stripped of all organic material, rubbish, debris, and other unsatisfactory material.

(*2*) Plowed, disked, or otherwise broken up, pulverized, moistened or aerated as necessary.

(*3*) Thoroughly mixed, and compacted to at least 90 percent laboratory maximum density for cohesive material or 95 percent laboratory maximum density for cohesionless materials.

b. The prepared ground surface shall be scarified and moistened or aerated as required just prior to placement of fill materials to assure adequate bond between fill material and the prepared ground surface.

4–5. Fills

Earth fills shall be constructed from satisfactory materials free of organic material and rocks with any dimension greater than 3 inches. The material shall be placed in successive horizontal layers of loose material not more than 6 inches in depth. Each layer shall be spread uniformly on a soil surface that has been moistened or aerated as necessary, and has been scarified or otherwise broken up in such a manner that the fill will bond with the surface on which it is placed. Fills shall be thoroughly mixed then compacted to at least 90 percent laboratory maximum density for cohesive material or 95 percent laboratory maximum density for cohesionless materials. Compaction requirements for the upper portion of earth embankments forming sub-grade for pavements shall be identical with those requirements specified in paragraph C-7, Sub-grade Preparation. Care shall be exercised not to allow any loose material to be deposited over finished and compacted side slopes of embankments, otherwise, removal of the loose material or re-compaction of the slopes will be required.

4–6. Sub-grade preparation

a. Construction. Sub-grade shall be shaped to line, grade, and cross section, and compacted as specified. This operation shall include plowing, disking, and any moistening or aerating required to obtain specified compaction. Unsatisfactory material shall be undercut 2 feet and replaced with satisfactory excavated material or other approved material as directed. Low areas resulting from removal of unsatisfactory material shall be brought up to required grade with satisfactory materials, and the entire sub-grade shall be shaped to line, grade, and cross section and compacted as specified.

b. Compaction shall be accomplished by sheepsfoot rollers, pneumatic-tired rollers, steel-wheeled rollers, vibratory compactors, or other approved equipment that is well suited to the type of material being compacted.

4–7. Finishing

The surface of all excavations, fills, and sub-grades shall be finished to a smooth and compact surface in accordance with the lines, grades, and cross sections or elevations shown. Ditches shall be finished in a manner that will result in effective drainage. Areas to be turfed shall be finished to smoothness suitable for the application of turfing materials.

4–8. Sub-grade and fill protection

During construction, fills and excavations shall be kept shaped and drained, and the area sealed at the end of each workday. Ditches and drains along sub-grade shall be maintained to drain effectively at all times. The finished sub-grade shall not be disturbed by traffic or other operation and shall be protected and maintained in a satisfactory condition until the base course is placed. The storage or stockpiling of materials on the finished sub-grade will not be permitted. No base course shall be laid until the sub-grade has been checked and approved, and in no case shall base course be placed on a muddy or spongy sub-grade.

4–9. Determination of density

a. Moisture-density relations shall be determined in accordance with ASTM D 1557, Method D, as described in FM 5-530, chapter 2, section IX.

b. In-place density shall be determined in accordance with FM 5-530, chapter 2, section X. When test results indicate that compaction is not as specified, additional rolling, adjustment of the moisture content, use of a heavier roller, or reducing the lift thickness maybe necessary to meet the required compaction. Tests on re-compacted areas shall be performed to determine conformance with specification requirements.

4–10. Testing frequency

a. Fill and back-fill material gradation including borrow materials. One gradation test per 100 dump-truck loads or 500 cubic yards of stockpiled or in-place source material. Gradation of fill and back-fill material shall be determined in accordance with FM 5-530, chapter 2, section III.

b. In-place densities.

(*1*) One test per 5000 square feet, or fraction thereof, of each lift of fill or back-fill areas compacted by other than hand- operated machines.

(*2*) One test per 1000 square feet, or fraction thereof, of each lift of fill or back-fill areas compacted by hand-operated machines.

(*3*) One test per 1000 linear feet per roller lane of each lift of road fill, in accordance with approved compaction test plan.

(*4*) Compaction test plans shall be submitted to the USARSO DCSENG for approval prior to start of fill operations.

c. Moisture contents. In the stockpile, excavation to borrow areas, a minimum of two tests per day per type of material or source of material being placed shall be made during stable weather conditions. During unstable weather, additional tests shall be made as dictated by local conditions and approved by the quality control officer.

d. Optimum moisture and laboratory maximum density. Tests shall be made for each type material or sources of material including borrow material to determine the optimum moisture and laboratory maximum density values. One representative test per 100 dump-truck loads or 500 cubic yards of fill and back-fill, or when any change in material occurs which may affect the optimum moisture content or laboratory maximum density.

4–11. Quality control for excavation, fill, and preparation of sub-grade for roadways, and airfields

a. The TF QC officer shall establish and maintain quality control for operations under this section to assure compliance with project requirements and approved quality control plan. The QC officer will maintain records of his quality control for materials, equipment, construction operations, and required tests in accordance with USARSO Reg. 415-2.

b. QC shall include but is not limited to the following:

(1) Preparatory inspection (to be conducted prior to commencing work).

(a) Review approved plans and specifications, including compaction test plans and work checklists.

(b) Check to see that borrow sites are approved, if applicable. Review classification, gradation, and moisture-density test results.

(c) Discuss the plan of action for excavation, sub-grade preparation, shoulder and fill construction with the project OIC.

(d) See that all construction equipment is approved and is in satisfactory working condition.

(e) Discuss testing requirements with the soils laboratory staff and check if required equipment is on hand and recently calibrated.

(2) Initial inspection (to be conducted after a representative sample of the work is completed).

(a) Check excavation for proper lines, grades, and elevations.

(b) Ensure all unsatisfactory excavation material is removed to designated waste or spoil area.

(c) Check to see that satisfactory excavated materials are utilized or stored properly.

(d) Check preparation, construction, and compaction of fill areas, including embankment side slopes.

(e) Check construction of sub-grade for proper line, grade, cross section, and compaction.

(f) Check shoulder construction for proper compaction, alignment, grade, and shape.

(g Check all ditching for effective drainage.

(h) Check to see the sub-grade, fills, and excavated areas are protected during construction.

(i) See that all required tests are performed and conforming to requirements.

(3) Follow-up inspection (to be conducted daily to assure compliance with results of initial inspection).

(a) Check items mentioned in preparatory and initial inspection.

(b) Ensure correction of damage, defects, or deficiencies.

(4) The above inspections and all required tests, as well as result of any corrective actions taken, shall be documented in appropriate forms. Reports, forms, and completed checklists shall be filed with the daily quality control reports.

Chapter 5
Crushed-Aggregate Base Course

5–1. Aggregates

Aggregates shall consist of clean, sound, durable particles of crushed stone, crushed gravel, and screenings. The aggregates shall be free of silt and clay, vegetable matter, and other objectionable materials or coatings. The portion retained on the No. 4 sieve shall be known as coarse aggregate; that passing the No. 4 sieve shall be known as fine aggregate.

a. Coarse aggregate shall be angular particles of uniform density. The coarse aggregate shall have a loss not greater than 18 percent weighted average at 5 cycles when tested for soundness in magnesium sulfate in accordance with ASTM C 88. The coarse aggregate shall have a percentage of wear not to exceed 50 after 500 revolutions as determined by ASTM C 131.

b. Fine aggregate shall be angular particles produced by crushing stone, or gravel that meets the requirements for wear and soundness specified for coarse aggregate.

c. Gradation requirements specified herein shall apply to the completed base course after undergoing mixing, placing, compacting, and other operations. The aggregates shall be graded continuously well within the following limits as shown in Table 5-1.

Table 5–1
Aggregates

Sieve Size	Percentage Passing By Weight
1 1/2 inches	100
1 inch	60-100
1/2 inch	30-65
No. 4	20-50
No. 10	15-40
No. 40	5-25
No. 200	0-10

d. Liquid limit and plasticity index requirements stated herein shall apply to any aggregate that is blended to meet the required gradation and also the aggregate in the completed base course. The portion of the aggregate passing the No. 40 sieve shall be either non-plastic or have a liquid limit not greater than 25 and a plasticity index not greater than 5.

(1) The liquid limit (LL) is the greatest water content in which a material may contain and still remain plastic.
(2) The plastic limit (PL) is the lowest water content, which a material may contain for plastic behavior.
(3) The plasticity index (PI) = (LL) - (PL).

5–2. Stockpiling of materials

Prior to stockpiling of material, the storage site shall be cleared, drained, and leveled. Coarse and fine aggregates shall be stockpiled separately.

5–3. Preparation of sub-grade

Prior to constructing crushed aggregate base course, the previously constructed sub-grade shall be inspected and cleaned of all foreign substances. The sub-grade for the base course shall conform to appendix C, Excavation, Fill, and Preparation of Sub-grade for Roadways. Ruts and soft yielding spots shall be corrected to line and grade.

5–4. Placing

The material shall be placed on the prepared sub-base in layers of uniform thickness. When a compacted layer 6 inches or less in thickness is required, the material shall be placed in a single layer. When a compacted layer in excess of 6 inches is required, the material shall be placed in layers of equal thickness. No layer shall exceed 6 inches or be less than 3 inches when compacted. The moisture content of the material shall be maintained during the placing period at 2 percent plus or minus of the optimum moisture content (OMC) of the material. The OMC is the moisture content corresponding to the maximum dry density obtained by the test procedure in ASTM D 1557, Method D, or FM 5-530, as shown on DD Form 1211 (Soil Compaction test Graph) of the soil.

5–5. Compaction
The degree of compaction shall be 100 percent of the maximum density obtained by test procedure MIL-STD-621, Method 100, CE 55.

Table 5–2
Test frequency (in accordance with TM 5-530).

Test	Frequency
Wear Test, Soundness Test	1 test each per aggregate source
Gradation, Liquid Limit, Plasticity Index	1 initially and every 2000 tons thereafter
In-Place Density	1 test per layer per 1000 linear feet per roller lane in accordance with compaction test plan approved by the DCSENG
Moisture-Density Relationship	1 test initially and every 100 dump-truck loads of base

5–6. Quality control for crushed-aggregate base course application
a. The TF QC officer shall establish and maintain quality control for operations under this section to assure compliance with project requirements and the approved quality control plan. The QC officer will maintain records of his quality control for materials, equipment, construction operations, and required tests.
b. QC shall include but is not limited to the following:
(1) Preparatory Inspection (to be conducted prior to commencing work).
(a) Review approved plans and specifications, including compaction test plans and work checklists.
(b) Check for proper stockpiling of materials.
(c) Verify that required materials are available and check all materials against approved tests and samples.
(d) Check equipment to be used and see that it is available and in satisfactory working condition (construction and testing equipment).
(e) Discuss the preparation, placing, compaction, and testing procedures for base course with the project OIC.
(2) Initial Inspection (to be conducted after a representative sample of the work is completed).
(a) Check for proper cleaning and preparation of sub-grade.
(b) Ensure that lines and grades are maintained and in compliance with approved plans and specifications.
(c) See that placing and compacting procedures conform to requirements and that they produce a base course that has proper density, smoothness and thickness.
(d) Ensure that all required tests are performed and conform to requirements, and that non-conforming base course is removed and replaced, or reworked and re-tested as necessary.
(3) Follow-up inspection (to be conducted daily to assure compliance with results of initial inspection).
(a) Check all items mentioned in preparatory and initial inspections.
(b) Ensure correction of any damage, defects, or deficiencies.
c. The above inspections and all required tests, as well as result of any corrective actions taken, shall be documented in appropriate forms. Reports, forms, and completed checklists shall be filed with the daily quality control reports.

Chapter 6
Reinforced Concrete Pipe Culverts

6–1. Delivery, storage and handling
Materials delivered to the site shall be inspected for damage, unloaded and stored with minimum of handling. Insides of pipes and fittings shall be kept free of dirt and debris.

6–2. Culvert pipes
Reinforced concrete pipe for culverts shall conform to the requirements of ASTM C 76.

6–3. Headwalls
Headwalls at inlets and outlets of culverts shall be as shown in the drawings. Wing-walls shall be provided for culverts with tail-water velocities greater than 5 feet per second.

6–4. Concrete
The 28-day strength of concrete for headwalls shall be 3000 psi, as specified in Chapter 8, “Concrete”.

6–5. Mortar
Mortar for pipe joints shall be Type M mortar in accordance with FM 5-742, chapter 7. The maximum placement time shall be 2 1/2 hours after the ingredients are mixed with water. All joints shall be wiped clean and finished smooth.

6–6. Trenching
Width of trenches shall be at least twice the outside diameter of the pipe. Use 1/2 outside diameter spacing between multiple culverts. Trench banks more than 5 feet high shall be shored or laid back to a stable slope of not less than 3/4 horizontal to 1 vertical, unless solid rock is encountered. Excavations over 4 feet deep shall be provided with ladders or ramps to require no more than 25 feet of lateral travel. Excavated material shall be stored and retained at least 2 feet away from the edge of the excavation to prevent excessive loading on the face of the excavation. Diversion ditches, dikes, or other means shall be used to prevent surface water entering the trench. Rock in either ledge or boulder formation shall be replaced with suitable materials to provide an 8-inch minimum compacted earth cushion for the pipe culvert. Wet or otherwise unstable soil encountered shall be replaced with compacted suitable material.

6–7. Bedding
Use sand bedding, 6-inch thick minimum throughout the entire length of the pipe, when the culvert is installed on rock material. The sand bedding can be compacted by mechanical tampers or hydra-compacted, provided both ends of the trench are adequately blocked to prevent rapid loss of water and sand. On stable, well compacted soil (satisfactory back-fill or in-place material), no extra bedding material will be required. The soil shall be shaped to bed the pipe a minimum depth of 1/10 the pipe diameter.

6–8. Placing pipe
Carefully examine each pipe before being laid. Defective or damaged pipe shall not be used. The first pipe shall be laid with bell or groove ends placed upstream. All pipes shall be laid true to the designated line and grade.

6–9. Back filling in trenches
Select material from excavation or borrow shall be placed along both sides of the pipe on 6-inch layers. The back-fill shall be brought up evenly on both sides and for the full length of the pipe. Ensure compaction under the haunches of the pipe. Use mechanical tampers or rammers. This method of filling and compacting shall continue until the fill is at least 12 inches above the top of the pipe. Back-fill the remainder of the trench and compact by spreading and rolling or by mechanical rammers or tampers in 6-inch layers.

6–10. Back filling in fill sections
Back-fill material, placement, and compaction procedures shall be as specified above. Prior to commencing normal filling and compaction operations with the use of heavy equipment, the width of the fill at 12 inches above the top of the pipe shall extend a distance of not less than 5 times the outside pipe diameter or 12 feet, whichever is less. The remainder of the fill shall be placed and compacted in 6-inch layers.

6–11. Compaction
Back-fill over and around pipes shall be compacted at 2 percent plus or minus of the OMC and not less than 90 percent of maximum density for cohesive soils and 95 percent for cohesionless material. The OMC is the moisture content corresponding to the maximum dry density as obtained by the test procedure presented in ASTM D 1557, Method D, or FM 5-530, and as shown on the DD Form 1211 (Soil Compaction Test Graph) of the soil.

6–12. Cohesionless and cohesive materials
Cohesionless materials include materials classified in MIL-STD-619B as GW, GP, SW, and SP. Cohesive materials include materials classified as GC, SC, ML, CL, MH, and CH. Materials classified as GM and SM will be identified as cohesionless only when fines are non-plastic.

6–13. Testing frequency
One test per day for each culvert trench for in-place density and moisture content, in accordance with FM 5-530, using either the sand cone or nuclear densitometer. Calibration checks of both density and moisture gages shall be made at the beginning of a job and on each type of material encountered.

6–14. QC for reinforced concrete pipe culverts

a. The TF QC officer shall establish and maintain quality control for operations under this section to assure compliance with project requirements and the approved quality control plan. The QC officer will maintain records of his quality control for material, equipment, construction operations, and required tests.

b. Quality control shall include but is not limited to the following:

(1) Preparatory inspection (to be conducted prior to commencing work).

(a) Review approved plans and specifications.

(b) Check pipe for conformance to material specifications, proper storage and handling.

(c) Discuss and review with the project OIC, the pipe installation procedures and checklists for the following:

- Excavation, trenching and bedding.
- Placing of pipe and joint preparation.
- Back filling.

(d) Required equipment for above procedures.

(e) Check mix design for concrete headwalls.

(2) Initial Inspection (to be conducted after representative sample of the work is completed).

(a) Check for proper width, depth, grade and bedding of trench for pipe.

(b) Check testing for proper number and satisfactory results.

(c) Check proper alignment and jointing of pipes before starting back-fill operations.

(d) Check back filling for proper layer thickness, compaction and density.

(3) Follow-up Inspection (to be conducted daily to assure compliance with results of initial inspection).

(a) Check items mentioned in the preparatory and initial inspections.

(b) Ensure correction of any damage, defects, or deficiencies.

c. The above inspections and all required tests, as well as results of any corrective actions taken shall be documented in appropriate forms. Reports, forms, and completed checklists shall be filed with the daily quality control reports.

Chapter 7
Erosion Control

7–1. General

Erosion must be controlled to maintain an effective and clear drainage system with minimum maintenance and reduce hazardous dust conditions. Erosion may occur at any point where the force of moving water exceeds the cohesive strength of the material with which the water is in contact. Proper design of side slopes in cut and fill sections will reduce the need for extensive erosion control measures. Most methods of additional erosion control are based on dissipating the water energy or providing an erosion resistant surface or some combination of these techniques.

7–2. Benches

Bench cuts to reduce excessive heights of side-hill slopes shall be 3 meters wide minimum, sloped back 10 percent toward the hill, and shall be vertically spaced at not more than 5-meter height intervals, unless otherwise approved by the Host Nation authorized representative.

7–3. Ditches

The various types of ditches, shall be constructed as follows:

a. Side ditches along the side of the road shall be 24 inches deep, minimum and 4 feet away from the edge of the shoulder unless otherwise shown on the drawings. A V-shaped ditch shall be used for flows less than 60 cubic feet per second; trapezoidal shape for flows exceeding 60 cubic feet per second.

b. A diversion ditch can be used in conjunction with interceptor and side ditches to divert any existing stream channel around a project.

c. Interceptor ditches shall be provided above bench cuts and side cuts as shown on the drawings. Provide 18-inch V-ditch with berm on one side along the bench or side cut to prevent overflow and erosion of the downhill slopes.

7–4. Check dams

Check dams are installed in steep ditches to reduce the water velocity and prevent excessive erosion.

a. Ditches with slopes greater than 2 percent shall be provided with 3-foot high check dams, and spaced as shown in Table 7-1.

b. Construction of check dams with weir notches shall be in accordance with chapter 6, FM 5-335. Eight-inch minimum logs shall be used with the sides and bottom anchored into at least 2 feet of compacted material. Two-foot long weirs shall be notched at the top of the check dam for ditch flows under 35 cubic feet per second. See FM 5-335, Table 6-5, for lengths of weir notches for flows greater than 35 cubic feet per second.

Table 7–1
Check dam spacing

Ditch Slope	Check Dam Spacing
3 percent	300 feet
4 percent	150 feet
5 percent	100 feet
6 percent	75 feet
7 percent	60 feet
8 percent	50 feet

7–5. Riprap aprons

Riprap apron protection shall be provided at all headwall outlets, in front of check dams, and at bottoms of chutes.

a. Apron sizes shall be as follows:

(1) Headwall (w/out wing-wall): L=12 ft, W=Head-wall length

(2) Head-wall (with wing-wall): L=7 ft, W=Wing-wall apron

(3) Check Dam: L=4 ft, W=Ditch width

(4) Chute: L=8 ft, W=6 ft

b. Bedding material for aprons shall be 6-inch minimum sand crushed rock or gravel. The sub-grade shall be compacted prior to placement of bedding material.

c. Riprap stone shall be durable field or quarry stone of approved quality, free from seams or cracks, and approximately rectangular. Hand-placed riprap shall weigh between 50 to 100 pounds each, and at least 60 percent weighing 100 pounds. For grouted riprap, stones shall be laid with open joints to facilitate grouting. Place the longer dimension of the stone perpendicular to the water flow. Double the layer of riprap at the downstream end at least 1/5 of the required apron length.

d. Grout shall not be placed when the temperature is above 85 degrees Fahrenheit. Prior to grouting, all surfaces of riprap shall be wetted. The grout shall be worked into place between the stones with suitable spades, trowels, or vibrating equipment. No workman or any load shall be permitted on the grouted surface for at least 24 hours. Wet cure the grouted rip-rap for 7 days minimum.

7–6. Gabions

Gabions may be used in lieu of stone riprap if riprap material is not readily available. Stones for filling gabions shall be small, just slightly larger than the mesh size and shall be clean, hard and durable. Use rounded stones if available, to reduce damage to the (PVC) or galvanized coating of the wire during filling.

7–7. Ditch relief culverts

a. Side-hill ditches with slopes greater than 5 percent shall be provided with 12-inch concrete relief culverts in accordance with FM 5-335, chapter 7, spaced as shown in Table 7-2 below:

Table 7-2
Concrete relief culvert spacing

Ditch Slope	Relief Culvert Spacing
5 percent	500 feet
6 percent	430 feet
7 percent	370 feet
8 percent	300 feet

b. Cover of relief culverts shall be 12 inches minimum from the top of the pipe.

c. A riprap chute shall be provided at the outlet of the relief culvert to prevent erosion of the road embankment.

7–8. QC for erosion control

a. The TF QC officer shall establish and maintain quality control for operations under this section to assure compliance with project requirements and the approved quality control plan. The QC officer will maintain quality control records for materials, equipment, construction operations, and required tests.

b. Quality control shall include but is not limited to the following:

(1) Preparatory inspection (to be conducted prior to commencing work).

(a) Review approved plans and specifications, including work checklists.

(b) Discuss the plan of action for construction of the various erosion control work with the project OIC.

(c) Check that all construction adjacent to or incorporating the work has been satisfactorily completed.

(d) See that all materials and construction equipment are approved.

(2) Initial inspection (to be conducted daily to assure compliance with results of initial inspection).

(a) Check items mentioned in preparatory and initial inspections.

(b) Ensure correction of any damage, defects, or deficiencies.

c. The above inspections as well as results of any corrective actions taken, shall be documented in appropriate forms. Forms and completed checklists shall be filed with the daily quality control reports.

Chapter 8
Concrete

8–1. Submittals

a. Shop drawings for all reinforced concrete work shall be submitted to the USARSO DCSENG for approval prior to start of work. Drawings shall show details of formwork, reinforcement size and grades of steel, bending and splicing details.

b. Concrete mix design in accordance with FM 5-742 shall be submitted to the USARSO DCSENG for approval prior to batching operations. Mix design submittal shall include laboratory test results on aggregate gradation, fineness, modulus, soundness, impurities, specific gravity, type of cement, and any admixtures proposed.

8–2. Storage of materials

Upon delivery, cement shall be immediately stored in weathertight and moisture-free enclosures. Separate aggregate stockpiles for coarse and fine aggregates shall be used to avoid excessive segregation and contamination. Reinforcing bars and accessories shall be stored above the ground on platforms, skids, or other approved supports.

8–3. Materials

a. Aggregates shall be clean, hard, and durable, free from chemicals or coatings of clay, dirt, silt, or other organic matter that affect the bond of the cement paste.

b. Coarse aggregate nominal size shall be 1-inch and conform to the gradation as shown in Table 8–1:

Table 8–1
Coarse aggregate nominal size

Sieve Size	% Passing by Weight
1 1/2 inches	100
1 inch	95-100
1/2 inch	25-100
No. 4	0-10

c. Fine aggregate shall have a fineness modulus of not less than 2.40 nor more than 2.90, and shall conform to the gradation as shown in Table 8-2:

Table 8-2
Fine aggregate graduation

Sieve Size	% Passing by Weight
No. 4	100
No. 8	80-90
No. 16	60-80
No. 30	30-60
No. 50	12-30
No. 100	0-10
No. 200	0-5

d. Portland cement shall conform to ASTM C 150.

e. Reinforcement shall be deformed steel bars conforming to ASTM A 615, grade 40.

f. Water shall be potable, except that non-potable water may be used if it produces mortar cubes having 7 and 28-day strengths equaling at least 90 percent of the strength of similar specimens made with local potable water.

8–4. Concrete strength

Concrete for all work shall have a compressive strength of no less than 3000 psi at 28 days.

8–5. Concrete forms

Forms shall be designed and constructed in accordance with FM 5-742 to have sufficient strength to withstand the pressure resulting from placement and vibration of the concrete and have sufficient rigidity to maintain specified tolerances. Forms shall be fabricated with facing materials that produce the specified tolerance and surface requirements. Form ties, embedded in the concrete shall terminate not less than 2 inches from the surface of the concrete and be constructed so that the ends can be removed without damaging the concrete. The forms shall be coated with form oil to facilitate form removal. Forms shall be mortar tight, properly aligned, and adequately supported. Where forms for continuous surfaces are placed in successive units, care shall be taken to fit the forms over the completed surface so as to obtain accurate alignment of the surface and to prevent leakage of the mortar. Forms shall not be removed before expiration of the minimum required 24-hour period to allow all necessary concrete repairs to be completed within that 24 hours.

8–6. Reinforcement

Reinforcement shall be fabricated to the shapes and dimensions shown and placed where indicated on the drawings. Detailing and placement shall conform to FM 5-742, chapter 6, section III. At the time of concrete placement, all steel shall be free from loose, flaky rust, scale, mud, oil, grease, or any other coating that might reduce the bond with the concrete. Spacing between adjacent bars and the distance between layers shall not vary more than one bar diameter or more than 1 inch. The minimum concrete cover of steel reinforcement and allowable tolerance shall be as shown in Table 8-3.

Table 8–3
Minimum cover and allowable tolerance

Minimum Cover	Variation
3"	+3/8"
2"	+1/4"
1"	+1/8"

8–7. Preparation for placing concrete

a. General. Remove water from the excavation. Any flow of water shall be diverted through side drains. Hardened concrete, debris, and foreign material shall be removed from forms. Inspect reinforcement and embedded items, and tighten forms as required.

b. Concrete on earth foundations. Care shall be taken not to disturb the prepared foundation. Surfaces shall be clean and free from mud and water.

c. Bonding to hardened concrete. Surfaces of horizontal construction joints shall be roughened and moistened. Remove all traces of soft mortar of laterite (red tropical soil, varying in hardness from indurated crusts to soft red earth) or pools of water.

8–8. Batching, mixing and transporting concrete

Concrete shall be batched, mixed, and transported in accordance with FM 5-742, chapter 5.

8–9. Placing concrete

a. General. Concrete shall be deposited as close as possible to its final position in the forms, and there shall be no vertical drop greater than 5 feet except where suitable equipment like an “elephant trunk” is provided. Pouring rate shall be regulated to result in consolidated horizontal layers not more than 12 inches thick.

b. Consolidation. Immediately after placement, internal vibrators shall consolidate each layer of concrete. A spare vibrator shall be on hand at all times during concrete placements. Vibrators shall be rated not less than 8000 vibrations per minute frequency. Insert vibrators vertically at uniform spacing over the area of placement. The vibrator shall penetrate rapidly to the bottom of the layer and at least 6 inches into the preceding layer, if there is such. It shall be held stationary until the concrete is consolidated and then withdrawn slowly. Vibrators shall not be used to transport concrete within the forms. Slabs 4 inches and less in thickness shall not be consolidated by internal vibration.

c. Time interval between mixing and placing. Mixed concrete that is transported in truck mixers or agitators shall be discharged within 1-1/2 hours after introduction of the cement to the aggregates, except that when the concrete temperature exceeds 85 degrees F, this time shall be reduced to 45 minutes.

d. Weather requirements. The temperature of the concrete as placed shall not exceed 90 degrees F, except where an approved retarder is used. The mixing water and/or aggregates shall be cooled, if necessary, to maintain a satisfactory placing temperature.

8–10. Treatment of formed surface

Within 24 hours after forms are removed, surface defects shall be remedied as specified herein. For permanently exposed surfaces, fins shall be removed and holes left by removal of tie rods shall be reamed and filled solid with a stiff portland-cement-sand mortar mix. Holes left after the removal of form ties shall be cleaned and filled with concrete patching mortar. For all surfaces, honeycomb and other defective areas, including holes left by removal of tie rods, shall be cut back to sound concrete to a depth of not less than 1 inch. The edges of the cut shall be perpendicular to the surface of the concrete. The prepared area shall be dampened and brush-coated with neat cement grout. The repair shall then be made using a stiff mortar, preshrunk by allowing the mixed mortar to stand for 45 minutes and then re-mixed, thoroughly tamped into place. Moist cure repaired areas for 72 hours. Patches shall be finished flush with adjacent surfaces.

8–11. Curing and protection

a. General. Immediately after placement, concrete shall be protected from premature drying, rapid temperature change, mechanical injury and injury from rain and flowing water. All materials and equipment needed for adequate curing and protection shall be readily available at the site prior to placing concrete. Curing shall start as soon as free water has disappeared from concrete surfaces after finishing. Curing for not less than 7 days shall be accomplished by any of the following methods or combination thereof, as approved.

b. Moist curing. Concrete to be moist-cured shall be maintained continuously wet for the entire curing period. When wooden forms are left in place during curing, they shall be kept wet at all times. Horizontal surfaces shall be cured by ponding, by covering with a 2-inch minimum thick continuously saturated sand, or by covering with waterproof paper, polyethylene sheet, polyethylene- coated burlap or saturated burlap.

c. Membrane curing. Approved membrane-forming curing compound shall be applied either by hand brushing or in a one-coat continuous operation by mechanical spraying equipment at a uniform coverage rate recommended by the manufacturer. Concrete surfaces shall be re-sprayed, which have been subjected to rainfall within 3 hours after curing compound has been applied,. Surfaces coated with curing compound shall be kept free of foot and vehicular traffic, and from other sources of abrasion and contamination during the curing period.

8–12. Testing frequency

Test procedures will be in accordance with FM 5-530 as shown in Table 8-4.

Table 8–4
Testing frequency

Material	Test	Testing Frequency
Coarse and Fine Aggregates	Gradation	1 test every week or with each new source.
	Deleterious	1 test initially and with each new source or when appearance makes the material suspect.
	Abrasion	1 test initially and monthly thereafter or with each new source.
	Moisture, Specific Gravity & Absorption	1 test initially and monthly thereafter or with each new source.
Concrete	Slump	1 test every truck load.
	Ambient & Concrete Temperatures	Conduct with slump test.
	Compressive Strength	Take 1 set of 3 cylinders per day. Test 1 cylinder at 7 days; 2 at 28 days.

8–13. QC for concrete

a. The TF QC officer shall establish and maintain quality control for operations under this section to assure compliance with project requirements and the approved quality control plan. The QC officer will maintain QC records for all materials, equipment, construction operations, and required tests.

b. QC for concrete shall include but is not limited to the following:

(1) Preparatory inspection (to be conducted prior to commencing work).

(a) Review approved plans and specifications, including work checklists.

(b) Ensure shop drawings and mix designs are already approved before the work begins.

(c) Check material as received to assure it conforms to requirements.

(d) Check for proper storage and protection of materials.

(e) Discuss the mixing, preparation, and placing procedures, including all required materials and equipment with the project OIC.

(2) Initial inspection (to be conducted after a representative sample of the work is completed).

(a) Check form work for proper shape, elevations, dimensions, grade, ties, chamfering, coating, and cleanliness.

(b) Check sizes, spacing, splices, anchoring, and cleanliness of reinforcing steel.

(c) Check concrete placement. Assure that proper strength is being used in locations specified. Obtain samples for slump and compressive strength tests. Check time intervals of truck mixers, ambient and concrete temperatures, and proper use of vibrators.

(d) Check finishing and curing for compliance and assure sufficient protection of fresh concrete.

(3) Follow-up inspection (to be conducted daily to assure compliance with results of initial inspection).

(a) Check items mentioned in preparatory and initial inspections.

(b) Ensure correction of any damage, defects or deficiencies.

c. The above inspections and all required testing, as well as results of any corrective actions taken, shall be documented in appropriate forms. Reports, forms, and completed checklists shall be filed with the daily QC reports.

Chapter 9
Quality Control

9–1. Inspection of construction
The QC program will perform sufficient inspections and tests of all items of work to ensure conformance to applicable specifications and drawings with respect to the required materials, workmanship, construction, finish, and functional performance. The QC Program shall specifically include the surveillance and tests required in the technical project specifications.

9–2. Phases of inspection
The TF QC inspection plan is the means by which the TF assures itself that its construction complies with the requirements of project plans and specifications. The plan shall be adequate to cover all construction operations, including both on site and off site fabrication and will be keyed to the proposed construction sequence. The plan shall include as a minimum at least 4 types of inspections for all definable features of work, as follows:

a. Preparatory Inspection. This shall be performed prior to beginning work on any definable feature of work. It shall include a review of approved plans, specifications, and project requirements; a check to assure that all required materials and/or equipment have been tested, submitted and approved; a check to assure that provisions have been made to provide required control testing; examination of the work area to ascertain that all preliminary work has been completed; and a physical examination to see that all required materials, manpower and equipment are on hand. Names and rank/grade of all attendees in Preparatory Inspections shall be recorded in the daily reports.

b. Initial Inspection. This shall be performed as soon as a representative portion of the particular feature of the work has been accomplished and shall include examination of the quality of workmanship and shall include a review of control testing for compliance with project requirements, use of defective or damaged materials, omissions, and dimensional requirements. Names and rank/grade of all attendees in Initial Inspections shall be recorded in the daily reports.

c. Follow-up Inspections. These shall be performed daily to assure continuing compliance with project requirements, including control testing, until completion of the particular feature of work. Such inspections shall be made a matter of record in the TF's QC documentation as required by paragraph 3 below. Names and rank/grade of all attendees in follow-up inspections shall be recorded in the daily reports.

d. Completion Inspection. At the completion of all work or any increment thereof, the TF QC officer shall conduct a final inspection of the work and develop a "punch list" of items that do not conform to the approved plans and specifications. Such a list shall be included in the TF's QC documentation, as required by paragraph 4 below, and shall include the estimated date by which the deficiencies will be corrected. Names and rank/grade of all attendees in completion inspections will be recorded in the daily reports.

9–3. QC documentation
The TF's QC officer shall maintain current records on appropriate forms of all inspections and tests performed and submit on a daily basis within 24 hours after completion of the day's work. These records shall include factual evidence that the required inspections or tests have been performed, including type and number of inspections or tests involved; results of inspections or tests; nature of defects, causes for rejection, etc.; proposed remedial action; and corrective actions taken. The TF shall not build upon or conceal any feature of the work containing defects not corrected. The QC officer shall document inspections and tests specified in each section of the technical specifications.

9–4. QC organization
The TF's QC system shall be implemented by the establishment of a separate QC organization consisting, as a minimum, of the following recommended staffing and specialties:

a. One QC officer whose sole responsibility is to ensure compliance with the project plans and specifications. This officer will be physically on the project site during performance of all work and will be in charge of the QC organization, and report directly to the TF commander.

b. Adequate number of laboratory technicians (51G MOS) to perform all laboratory and field tests specified.

c. Adequate number of construction inspectors to perform daily inspections as specified above.

d. Adequate number of draftspersons to update drawings for design or field changes and as-built conditions.

e. Adequate number of survey crews responsible for construction survey and staking.

9–5. QC plan
In accordance with USARSO Exercise OPORD milestones, the TF shall prepare and submit the QC plan to the USARSO DCSENG for review and approval. This plan shall include as a minimum:

a. The QC organization and its methods for documenting QC operations, inspections and testing.
b. Authority and area of responsibilities of QC personnel.
c. Methods of performing quality control inspections and a listing of required inspections.
d. Methods of testing and a list of required tests.

Appendix A
References

Section I
Required Publications

FM 5-335
Drainage (Cited in para F-6.)

FM 5-530
Materials Testing (Cited in paras C-2, C-10, C-11, E-12, E-14, F-9, and G-13.)

FM 5-742
Concrete and Masonry (Cited in paras E-6, G-2, G-6, G-7, and G-9.)

American Society for Testing and Materials (ASTMs) Publication:

Paragraphs:

A 615
(Cited in para G-4.)

C 76
(Cited in para E-3.)

C 88
(Cited in para D-2.)

C 131
(Cited in para D-2.)

C 150
(Cited in para G-4.)

D 1557
(Cited in paras C-2, C-10, D-5, and E-12.)

Military Standards Publications:

MIL-STD-619B
(Cited in paras C-2 and E-13.)

MIL-STD-621
(Cited in para D-6.)

USARSO Publications:

USARSO Reg 415-2
Construction Quality Management Program (Cited in para C-12.)

Section II
Related Publications
A related publication is a source of additional information. The user doesn't have to read it to understand this publication.

FM 5-25
Explosives and Demolitions

FM 5-34
Engineer Field Data

FM 5-35
Engineer's Reference and Logistical Data

FM 5-104
General Engineering

FM 5-233
Construction Surveying

FM 5-333
Construction Management

FM 5-541
Military Soils Engineering

FM 5-551
Carpentry

FM 5-553
General Drafting

FM 5-760
Interior Electrical Systems

FM 20-31
Electric Power Generation in the Field

American Society for Testing and Materials (ASTMs) Publication:

Paragraphs:

A 615-85
Deformed Steel Bars for Concrete Reinforcement

C 76-85a
Reinforced Concrete Culvert

C 88-83
Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate C 117-84 Materials Finer than 75-Microns (No. 200 Sieve) in Mineral Aggregate by Washing.

ASTM Paragraphs continued:

C 131-81
Resistance to Degradation of Small Size Coarse Aggregate by Abrasion and Impact (Los Angeles Machine)

C 136-84a
Sieve Analysis of Fine and Coarse Aggregates

C 150-84
Portland Cement

C 309-81
Liquid Membrane-Forming Compounds for Curing Concrete

D 422-63
Particle-Size Analysis of (R 1972) Soils
D 1556-82
Density of Soil in Place by the Sand-Cone Method

D 1557-78
Moisture-Density Relations of Soils and Soil Aggregate Mixtures Using 10-1b Rammer and 18-inch Drop

D 2922-81
Density of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

D 3017-78
Moisture Content of Soil and Soil-Aggregate in Place by Nuclear Methods (Shallow Depth)

AR 420-40
Historic Preservation

AR 420-74
Natural Resource Management - Land, Forest, Fish, and Wildlife

TM 5-232
Elements of Surveying

TM 5-302
Vol. 1 & 2, Army Facilities Component System-Design

TM 5-303
Army Facilities Component System-Log Data/Bills of Materials

TM 5-304
Army Facilities Component System-User's Guide

TM 5-330
Planning and Design of Roads, Air Bases, and Heliports in the Theater of Operations

TM 5-331
Volumes A - E, Utilization of Engineer Construction Equipment

TM 5-332
Pits and Quarries

TM 5-333
Construction Management

TM 5-337
Paving and Surfacing Operations

TM 5-545
Geology

TM 5-551K
Plumbing and Pipe Fitting

TM 5-765
Electric Power Transmission and Distribution

TM 5-830-3
Dust Control

American Association of State Highway and Transportation Officials (AASHTO) M 170-871
Reinforced Concrete Culvert, Storm Drain, and Sewer Pipe

AASHTO T 191-86
Density of Soil In-Place by the Sand-Cone Method

Other Publications:

EM 385-1-1, Apr 81, Safety And Health Requirements Manual, US Army Corps of Engineers Technical Report M-86/07, May 1986, Construction Manual For Central And South America, By Cerl, Wes, and Etl

Engineer Assessment for Various Projects, Honduras, 6-17 March 1988, By Mobile District, Corps of Engineers

Miscellaneous Paper EL-89-6, June 1989, Dust And Erosion Control Methods For Us Army Construction Projects In Honduras, By Wes

USARSO Standard Drawings for HCA engineer exercise construction

Section III
Prescribed Forms

This section contains no entries.

Section IV
Referenced Forms

DD Form 1211
Soil Compaction Test Graph

DA Form 2028
Recommended Changes to Publications and Blank Forms

Glossary

Section I
Abbreviations

DOD
Department of Defense

MOS
military occupational specialty

OIC
officer in charge

QC
quality control

USSOUTHCOM
United States Southern Command

Section II
Terms

MIL-STD
Unified Soil Classification -619B System for Roads, Airfields, Embankments and Foundations

Section III
Special Abbreviations, Brevity Codes, and Acronyms

This publication uses the following terms, abbreviations, brevity codes, and acronyms not contained in AR 310-50.

Special Terms

Bench
A wide (normally a dozer blade width) terrace-like cut located at several levels of high and steep side-hill slopes, used to intercept, hold, and divert the run-off and its affects, from above the slope.

Berm
A raised lip, usually of earth, placed at edges of a channel to prevent flow into the channel at places not protected against erosion. Berms are normally placed on both sides of a diversion ditch, on the downhill side of an interceptor ditch, and along the embankment edge of roads.

Check Dam
Small dams usually made of logs, installed at intervals across a ditch to decrease the velocity and slope of the water surface.

Chute
An inclined waterway used to pass water from a channel, culvert outlet, or berm pond to a lower channel or waterway.

Culvert
An enclosed waterway used to pass water through a structure consisting of an embankment or fill.

Diversion Ditch
A ditch used to transport water away from roadways or airfields.

Erosion
The wearing away of a surface in open channels by the turbulence and velocity of water.

Gabions
Large galvanized or PVC coated steel wire mesh baskets filled with stones and used in place of sheet piling, masonry construction, rip-rap or cribbing to prevent erosion.

Headwall
A retaining wall, with or without wing-walls, installed at the ends of culverts to support the soil mass and protect against erosion.

Interceptor ditch
A ditch that intercepts runoff and directs the flow to a more desirable location.

Relief Culverts
Pipe culverts installed to reduce the volume of flow in long and steep side ditches.

Rip-rap
Rocks or rubble placed in a ditch bottom and on the sides to prevent soil erosion; also installed at aprons of culverts with high tail-water velocities.

Wing-walls
Retaining walls set at an angle to culvert headwalls to support the fill and direct the flow of water. Wing-walls shall be used where tail-water velocities exceed 5 feet per second.

Special Abbreviations, Brevity Codes, and Acronyms

AOR
area of responsibility

ASTM
American Society for Testing and Materials

BOM
bill of materials

DCSENG
USARSO Deputy Chief of Staff for Engineers

DCSOPS
USARSO Deputy Chief of Staff for Operations

ERC
exercise related construction

CH
fat clay

CL
lean clay

GC
clay gravel

GM
silty gravel

GP
poorly graded gravel

GW
well graded gravel

HCA
humanitarian civic action

LL
liquid limit

MH
inorganic silt/fine clay - high plasticity

ML
inorganic silt/fine sand - low plasticity

OMC
optimum moisture content

PI
plasticity index

PL
plastic limit

PVC
polyvinyl chloride

SC
clay sands

SM
silty sand

SP
poorly graded sand

SW
well graded sand

USARSO
United States Army South