UFC 3-201-01
1 June 2013

UNIFIED FACILITIES CRITERIA (UFC)

CIVIL ENGINEERING

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CIVIL ENGINEERING

U.S. ARMY CORPS OF ENGINEERS

NAVAL FACILITIES ENGINEERING COMMAND (Preparing Activity)

AIR FORCE CIVIL ENGINEER SUPPORT AGENCY

Record of Changes (changes are indicated by **1**\ ... /**1**/)

Change No.	**Date**	**Location**

This UFC supersedes UFC 3-200-10N (Final Draft), dated July 2006, UFC 3-210-01A, dated January 2004, UFC 3-210-02, dated January 2004, UFC 3-210-03A, dated January 2004, UFC 3-210-06A, dated January 2006, UFC 3-230-17-FA, dated January 2004 and UFC 3-250-18FA, dated January 2006.

FOREWORD

The Unified Facilities Criteria (UFC) system is prescribed by MIL-STD 3007 and provides planning, design, construction, sustainment, restoration, and modernization criteria, and applies to the Military Departments, the Defense Agencies, and the DoD Field Activities in accordance with USD (AT&L) Memorandum dated 29 May 2002. UFC will be used for all DoD projects and work for other customers where appropriate. All construction outside of the United States is also governed by Status of Forces Agreements (SOFA), Host Nation Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA.) Therefore, the acquisition team must ensure compliance with the most stringent of the UFC, the SOFA, the HNFA, and the BIA, as applicable.

UFC are living documents and will be periodically reviewed, updated, and made available to users as part of the Services' responsibility for providing technical criteria for military construction. Headquarters, U.S. Army Corps of Engineers (HQUSACE), Naval Facilities Engineering Command (NAVFAC), and Air Force Civil Engineer Center (AFCEC) are responsible for administration of the UFC system. Defense agencies should contact the preparing service for document interpretation and improvements. Technical content of UFC is the responsibility of the cognizant DoD working group. Recommended changes with supporting rationale should be sent to the respective service proponent office by the following electronic form: Criteria Change Request. The form is also accessible from the Internet sites listed below.

UFC are effective upon issuance and are distributed only in electronic media from the following source:

- Whole Building Design Guide web site http://dod.wbdg.org/.

Hard copies of UFC printed from electronic media should be checked against the current electronic version prior to use to ensure that they are current.

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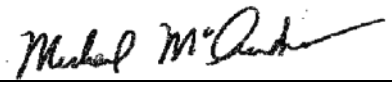

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UNIFIED FACILITIES CRITERIA (UFC)
NEW REVISION SUMMARY SHEET

Document: UFC 3-201-01, *Civil Engineering*

Superseding: UFC 3-200-10N, UFC 3-210-01A, UFC 3-210-02, UFC 3-210-03A, UFC 3-210-06A, UFC 3-230-17FA, and UFC 3-250-18FA.

Description: This new UFC 3-201-01 consolidates into one Tri-Service document the civil engineering criteria applicable to site development, grading, storm drainage and pavements that were formerly in the superseded documents. This UFC – through succinct reference to industry and government standards, codes and references – makes possible the replacement and/or consolidation of numerous criteria documents.

The complete list of civil engineering documents referenced in this UFC can be found in Appendices A and B.

Reasons for Document:

- The new UFC updates the guidance and requirements for site development, grading, storm drainage and pavements contained in several existing civil engineering documents and efficiently consolidates them into a single UFC.

- The superseded UFC documents included requirements that were not consistent with industry standards or utilized different industry standards.

Impact:

This unification effort will result in the more effective use of DoD funds, in the following ways:

- By significantly improving the design process for DoD projects and facilities, through a more efficient application of facilities criteria and enabling more efficient maintenance of facilities criteria.

- The consolidation of the UFC 3-201-01 will positively impact the project costs incurred, as a result of the following direct benefits:

  - Reduction in the number of civil references used for military construction provides more clear and efficient guidance for the design and construction of DoD facilities.

  - Reduction in ambiguity and the need for interpretation reduces the potential for design and construction conflicts.

  - The reduction in the number of documents and the use of industry standards improves the ease of updating and revising this reference document as better information becomes available.

Non Unification Issues:

- For design of drainage systems for apron pavements, use a minimum 2 year storm frequency for Army and Air Force projects and use a minimum 5 year storm frequency for Navy projects.

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CHAPTER 1 INTRODUCTION

1-1 PURPOSE AND SCOPE.

This UFC provides civil engineering requirements for all new and renovated government-owned facilities for the Department of Defense (DoD). Where other criteria, statutory or regulatory requirements are referenced in the contract, the more stringent requirement must be met.

1-2 APPLICABILITY.

This UFC applies to all service elements and contractors involved in the planning, design and construction of DoD facilities worldwide. It is applicable to all methods of project delivery and levels of construction, but is not applicable to public-private ventures (PPV). All design and construction outside of the United States and United States territories is governed by international agreements, such as the Status of Forces Agreements (SOFA), Host Nation-Funded Construction Agreements (HNFA), and in some instances, Bilateral Infrastructure Agreements (BIA), and country-specific Final Environmental Governing Standards (FGS) or the DoD Overseas Environmental Baseline Guidance Document (OEBGD), DoD 4715.05-G. The OEBGD applies when there are no FGS in place. Therefore, in foreign countries this UFC will be used for DoD projects to the extent that it is allowed by and does not conflict with the applicable international agreements and the applicable FGS or OEBGD.

This UFC assumes that appropriate National Environmental Policy Act (NEPA) action has been accomplished prior to committing resources to any proposed activity.

1-3 OTHER CRITERIA.

1-3.1 General Building Requirements.

UFC 1-200-01, “General Building Requirements”, provides applicability of model building codes and government unique criteria for typical design disciplines and building systems, as well as for accessibility, antiterrorism, security, high performance, sustainability, and safety. Use this UFC in addition to UFC 1-200-01 and the UFCs and government criteria referenced therein.

1-3.2 Low Impact Development (LID).

Use UFC 3-210-10 for LID criteria. UFC 3-210-10 was developed to meet the requirements of Section 438 of the Energy Independence and Security Act (EISA).

1-3.3 Antiterrorism and Security.

UFC 4-020-01 supports the planning of DoD facilities that include requirements for security and antiterrorism. Use UFC 4-020-01 in conjunction with UFC 4-010-01 to establish the security and antiterrorism design criteria that will be the basis for DoD facility designs. All DoD facilities must also comply with Geographic Combatant Commander antiterrorism construction standards for antiterrorism requirements.

1-4 REFERENCES.

Appendix A contains the list of references used in this document. The publications, standards, and technical data referenced herein form a part of these criteria to the extent referenced.

1-5 BEST PRACTICES.

Appendix B identifies background information and practices for accomplishing certain civil design and engineering services. The Designer of Record (DoR) is expected to review and interpret this guidance as it conforms to criteria and contract requirements, and apply the information according to the needs of the project. If a Best Practices document has guidelines or requirements that differ from the UFC or the Unified Facilities Guide Specifications (UFGS), the UFC and the UFGS must prevail. If a Best Practices document has guidelines or requirements that are not discussed in the UFC or UFGS, the DoR must submit a list of the guidelines or requirements being used for the project with sufficient documentation to the Government Project Manager for review and approval prior to completing design.

CHAPTER 2 SITE DEVELOPMENT

2-1 PRELIMINARY SITE ANALYSIS.

Use UFC 2-100-01 to develop a preliminary approach appropriate to the site and adjacent facilities and integrates sustainable strategies, utilizing a holistic design approach. Conduct a preliminary site visit and obtain photographs of the site. Research and obtain Installation's master plan, utility maps and as-built record drawings for information related to topography, utility and storm drainage availability, including design approaches used in the project vicinity. Evaluate the potential for abandoned or unmapped utilities. Research and review available subsurface investigation data and reports in order to evaluate subsurface conditions. Identify flood hazard areas in accordance with the IBC Section 1612, Flood Loads. Research and obtain explosive safety requirements. Consult with the Government Project Manager to establish contact with the Installation's Environmental personnel to determine if the site has environmental concerns, such as radon, pesticides, or known contamination. If required, provide radon mitigation system design in accordance with UFC 3-101-01. Evaluate the need for additional analysis based on project requirements and site conditions.

Conduct detailed consultations with the Government in order to clearly define requirements and preferences.

2-2 EXISTING CONDITIONS.

2-2.1 Geotechnical Site Investigation.

Obtain soil exploration, testing and evaluation from a professional geotechnical engineer. Determine the extent of exploration and testing based on recommendations with the geotechnical engineer, structural engineer (for foundations), civil engineer (for LID, pavements, wells, septic systems, etc.), local stormwater permitting agency (for detention ponds), and Government reviewers. Soils investigation (sampling, testing and evaluation) must be in accordance with UFC 3-220-01, UFC 3-250-01, and UFC 3-260-02.

Indicate the results of the subsurface investigation, including boring locations, boring logs, groundwater observations, a summary of laboratory test results, and any details required to convey requirements for site preparation on the contract documents.

2-2.2 Surveying.

Unless provided by Government personnel, a licensed or certified professional must seal all surveys in accordance with the applicable requirements of the local regulatory agency or overseas equivalent having jurisdiction over the installation. Where overseas equivalent requirements do not include an accuracy standard, provide surveys at a minimum third order in accordance with the Federal Geodetic Control Committee's *Standards and Specifications for Geodetic Control Networks*.

Consult with the Government Project Manager to establish contact with the Installation's real estate personnel prior to entering property not owned by the Government. Notify and obtain authorization from all public and private landowners for a right of entry and trespass, over, across and through all lands necessary to perform required field survey work. Coordinate with the Installation's Security section for approval to enter controlled or restricted areas (e.g. airfield, ranges, munition storage, etc.). Consult with Government Project Manager to establish contact with the Installation's Environmental personnel before entering the area with regards to any restrictions concerning vegetation cutting/clearing, natural resources, endangered species, etc.

2-2.2.1 Topographic Surveys.

Provide a topographic survey of the project site in accordance with each service's requirements as well as the requirements of the state or Host nation equivalent in which the site is located. If state or Host nation equivalent requirements are not available, use the National Society of Professional Surveyors (NSPS) *Model Standards for Topographic Surveys.*

2-3 DESIGN APPROVALS AND PERMITS.

The DoR must identify, assist and provide, as applicable, all permits, approvals and fees required for the design and construction of the proposed project from federal, state and local regulatory authorities or overseas equivalent. The Civil Engineering DoR must be a Professional Civil Engineer experienced and licensed; licensure in the state where the project is located may be required to obtain permits and approvals. Seek out the project NEPA documentation, as applicable, for project specific requirements. In CONUS locations the Government will review for acceptability site improvement plans. In OCONUS locations with Host nation agreements, follow design approval procedure as directed in project scope and by the Government Project Manager. In OCONUS locations without Host nation agreements, the Government will review and approve site improvement plans.

Consult with the Government Project Manager to determine the appropriate signatories for permit applications.

2-4 CLEARING AND DEMOLITION.

Identify the following in the construction documents: limits of disturbance; limits of demolition; limits of clearing and grubbing; isolated trees and shrubs to remain or to be removed. Describe size, density and type of trees to be cleared and grubbed, items to be salvaged or relocated, staging area, temporary storage area and location. Coordinate with the Installation concerning clearing options to remove merchantable timber from the project site.

During site demolition and preparation, remove existing and abandoned utilities under or within 10 feet (3.05 m) of the proposed buildings and facilities foundations; reroute existing utilities to remain.

2-5 SITE DEVELOPMENT.

Base location and orientation of DOD facilities on an analysis of activities to be accommodated and on specific requirements for each project, to include all functional, technical and economic factors. Use UFC 3-101-01 for building function, size and orientation criteria

Incorporate the following into site design, as applicable:

a. Land Use (existing and future)

b. Circulation (vehicle and pedestrian)

c. Orientation and Location to integrate green space. Provide adequate grading and drainage while preserving natural topographic features to minimize cut and fill, impact on existing drainage patterns and tree removal.

d. Operational and natural constraints

1. Maintain mandated buffers:

(a) Airfield and helipad clearances.

(b) Explosives safety clearances.

(c) Noise abatement.

(d) Antiterrorism/physical security clearances.

(e) Storage and handling hazardous material clearances.

(f) Separation of incompatible land use or functions.

(g) Building setbacks (if established).

(h) Fire separation zones per building and fire codes.

2. Eliminate or minimize construction activities requiring permits, for areas such as archaeological sites, wetlands, utilities, and stormwater management.

3. Minimize site or utility maintenance and operating costs.

4. Accommodate site constructability and security requirements.

5. Minimize distance to existing utility connections.

2-5.1 Flood Hazard Areas.

Project sites located in flood hazard areas must be designed in accordance with IBC 1612. Ensure proper correlation between vertical datums.

2-5.2 Vehicle Circulation.

For design of streets and parking for DoD facilities, the DoR must address unique aspects of military facilities. For example, roads on military installations are typically designed for lower speeds while addressing movement of specialized military vehicles.

Provide vehicle circulation and parking systems in accordance with Military Surface Deployment and Distribution Command, Transportation Engineering Agency's (SDDCTEA's) Pamphlet 55-17 *Better Military Traffic Engineering,* American Association of State Highway and Transportation Officials' (AASHTO's) *A Policy on Geometric Design of Highways and Streets;* and AASHTO's *Roadside Design Guide*. Design streets and parking areas (i.e., site entrances and exits, service drives, parking lots and other areas with special requirements (e.g., drive up drop off areas or loading docks)) to accommodate the largest vehicle that will use the facility. The design must also address the turning and reverse movements for the vehicles using the facility. Streets, parking areas and structures must conform to current antiterrorism and handicap accessibility requirements. Use Best Practices document, AASHTO's *Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400)* as applicable.

2-5.2.1 Traffic Studies.

Provide traffic studies and analysis in accordance with SDDCTEA's Pamphlet 55-17 which references SDDCTEA's Pamphlet 55-8, *Traffic Engineering Study Reference*.

2-5.2.2 Design Vehicles.

Design vehicle types include:

a. Passenger car, truck, light-delivery truck, bus, and truck combinations are as defined by AASHTO (e.g., moving vans, refuse trucks and school buses, snow-clearing trucks)
b. Emergency vehicles
c. Specialized military vehicles, such as tracked vehicles

Obtain design information for emergency vehicles and specialized military vehicles from the Government's Project Manager.

2-5.2.3 Design Traffic.

Use the Transportation Research Board's (TRB's) *Highway Capacity Manual* to evaluate average daily traffic (ADT) and peak hourly traffic, as applicable. Adjust for vehicles other than passenger cars. In addition to the vehicles indicated in the *Highway Capacity Manual* (e.g., trucks, RV's and buses), add specialized military vehicles as a vehicle type and determine the nearest equivalent AASHTO vehicle type.

2-5.2.4 Streets and Roadways.

Single-lane streets may be provided for fire lanes and approach drives to buildings within built-up areas. Access roads to unmanned facilities may also be single-lane roads. Where shoulders are not sufficiently stable to permit all-weather use and the

distance between intersections is greater than ½-mile (805 m), turnouts must be provided at 1/4-mile (402 m) intervals along single lane roads for use by occasional passing or meeting vehicles.

2-5.2.4.1 Fire Lane and Emergency Vehicle Access.

Fire lanes and emergency vehicle access must comply with UFC 3-600-01.

2-5.2.5 Parking Areas.

Parking areas include on-street parking, off-street parking lots, and parking structures. Conform to existing topography to the greatest extent possible. Refer to scope of work for total parking requirement of number of spaces. If the number of parking spaces is not identified in the project scope of work, utilize Table B-1 in Appendix B to calculate parking requirements. Provide parking spaces primarily by off-street parking areas or structures. Design parking areas in accordance with SDDCTEA Pamphlet 55-17 *Better Military Traffic Engineering, Chapter 17.*

The design must allow for all types of traffic that may be associated with the facility, including deliveries, emergencies and garbage pick-up. However, the design must discourage through traffic.

2-5.2.5.1 On-Street Parking.

The use of on-street parking is discouraged. On-street parking will not be allowed within 20 feet (6.10 m) of an intersection. The minimum length for the first and last stall is 18 feet (5.49 m). The minimum length for each interior stall is 22 feet (6.71 m).

Exception to SDDCTEA Pamphlet 55-17: The minimum width for all stalls is 8 feet (2.44 m).

2-5.2.5.2 Off-Street Parking.

Typically 90 degree parking is preferred for off-street parking for ease of traffic flow. If 90 degree parking is not used, the designer must be able to justify by showing that the minimum functional and technical requirements are met while providing an economic benefit to the Government. Provide minimum 9 feet (2.74 m) wide and 18.5 feet (5.64 m) long parking spaces for 90 degree parking.

Exception to SDDCTEA Pamphlet 55-17: In areas of limited space, provide a minimum buffer strip of 8 feet (2.44 m).

2-5.2.5.3 Motorcycle Parking.

Motorcycle parking surfaces are typically designed as rigid pavements to prevent kickstands from penetrating bituminous pavement in warm weather. Motorcycle parking stalls will be a minimum of 9 feet (2.74 m) long and 4.5 feet (1.37 m) wide.

2-5.2.5.4 Petroleum, Oil and Lubrication (POL) Parking Areas.

Use UFC 3-460-01 for POL criteria.

2-5.3 Bridges and Underpasses.

Where applicable, comply with AASHTO's *A Policy on Geometric Design of Highways and Streets* and AASHTO's *Standard Specifications for Highway Bridges*. Use Best Practices document, U.S. Department of Agriculture's (USDA's) *Low-Water Crossings: Geomorphic, Biological, and Engineering Design Considerations* as applicable.

For railroad bridges comply also with UFC 4-860-01FA and use Best Practices document, the American Railway Engineering and Maintenance-of-Way Association (AREMA) publication *Manual for Railway Engineering* as well as the design manual of the relevant railroad company.

2-5.4 Special Circulation Areas.

Circulation areas for other than normal passenger car traffic have special requirements to maintain traffic safety. These areas require additional space to accommodate unusual traffic patterns and greater turning radii for maneuverability. Special circulation areas include areas such as drop off areas, delivery and service zones, dumpsters, drive-in facilities, emergency vehicle access, and entry control facilities.

2-5.4.1 Entry Control Facilities.

Use UFC 4-022-01 and SDDCTEA Pamphlet 55-15, *Traffic and Safety Engineering for Better Entry Control Facilities* for entry control facility criteria.

2-6 SITE APPURTENANCES.

Provide site appurtenances in accordance with State or local standards where project is located.

2-6.1 Pedestrian Circulation.

Provide a network of sidewalks, separated from, but connected to vehicular circulation systems, to allow for pedestrian circulation between various new and existing elements of the project. Interface new pedestrian circulation systems with existing pedestrian circulation systems. Provide crosswalks for pedestrian safety as indicated in SDDCTEA's Pamphlet 55-17, Chapter 8. Consult the Government Project Manager for any special walk requirements for such facilities as barracks, where extra wide walks may be required for marching purposes and/or muster formation. The minimum width for walks is 4 feet (1.22 m). Use Best Practices document, AASHTO's *Guide for the Planning, Design and Operation of Pedestrian Facilities* for additional design guidance.

Sidewalks may consist of portland cement concrete (PCC), bituminous concrete (asphalt), solid pavers, permeable pavers, or pervious concrete. The minimum thickness of PCC concrete sidewalks is 4 inches (100 mm). Provide bituminous sidewalks with a minimum 4 inches (102 mm) thick base and a 1 inch (25 mm) thick bituminous surfacing.

2-6.2 Curb/Curb and Gutter.

Use concrete curb and gutter when overland flow cannot be achieved; to extend curb/curb and gutter from an adjacent facility; or to confine traffic. Asphalt-type curbs are only allowed in remote areas where approved by the Installation.

2-6.3 Wheelstops.

Provide 6 feet (1.83 m) long wheelstops anchored to the pavement at parking spaces adjacent to sidewalks, buildings, stormwater management facilities, areas of extreme slope, and other areas without curb where a vehicle would likely cause property damage. Locate the front face of the wheelstop 30 inches (762 mm) from the edge of the pavement or sidewalk.

Where snow removal equipment is used, wheelstops may not be allowed by the Installation; coordinate with Government Project Manager.

2-6.4 Bollards.

2-6.4.1 Bollards around Structures.

Provide bollards around any structures subject to damage from vehicular traffic by incidental contact; such bollards must be at minimum 4 feet (1.22 m) high. For steel bollards, provide minimum 4 inch (100 mm) diameter filled with concrete and painted. Bollards on aircraft aprons protecting fire hydrants may not exceed 30 inches (762 mm) aboveground and 24 inches (610 mm) above load bearing paving.

2-6.4.2 Bollards for Security.

For vehicular barrier and crash rated applications, use UFC 4-022-02.

2-6.5 Signage and Markings.

Provide signs and associated pavement markings to facilitate proper utilization of the project site. Provide new traffic control devices (i.e. signs, markings, etc.) in accordance with SDDCTEA's Pamphlet 55-17 *Better Military Traffic Engineering* and Pamphlet 55-14, *Traffic Engineering for Better Signs and Markings.* Also use Federal Highway Administration's (FHWA's) *Manual on Uniform Traffic Control Devices* (MUTCD) and *Standard Highway Signs and Markings* (SHSM).

Provide non-reflectorized pavement markings for paved parking areas, reflectorized pavement markings for paved roads and streets, and fire access markings in accordance with State DOT or local governing authority's requirements.

2-6.6 Trash Dumpster Enclosures.

Where dumpster pads are required in a project, provide a dumpster pad with an enclosure conforming to the Installation Appearance Plan. For airfield projects locate dumpsters in locations approved by Airfield Operations (AIROPS) to avoid a Bird/Animal

Aircraft Strike Hazard (BASH) issue. Provide a concrete pavement pad to support and accommodate the dumpster(s) and front wheels of the service truck.

2-7 UTILITIES.

Use UFC 3-301-01 for frost penetration criteria to determine cover over underground utilities. Locate utilities to minimize connection costs. New underground utilities must be at least 10 feet (3.05 m) from proposed structures, except for building connections. Minimize underground utilities located beneath pavements, except where crossings are required. Locate required crossings to minimize traffic interference with future maintenance.

Obstructions including signs and poles for overhead utilities must be located outside the limits of usable shoulder on roads designed without barrier curbs. Where practicable, roads designed with barrier curbs must have the desirable lateral clearances to obstructions as indicated in AASHTO's, *A Policy on Geometric Design of Highways and Streets* except that fire hydrant clearances must be in accordance with UFC 3-600-01.

2-7.1 Water Distribution Systems.

Use UFC 3-230-01 for water distribution system criteria. Use UFC 3-230-03 to establish water demand.

2-7.2 Wastewater Collection Systems.

Use UFC 3-240-01 for wastewater collection system criteria. Use UFC 3-240-02 to establish wastewater flows.

2-7.3 Storm Drainage Systems.

Refer to Chapter 3 of this UFC.

2-8 LIGHTING.

Use UFC 3-530-01 for lighting criteria.

2-9 LANDSCAPE.

Use UFC 3-201-02 for landscape criteria. Coordinate building location and orientation, vehicular and pedestrian circulation, parking, lighting, and utilities.

CHAPTER 3 STORM DRAINAGE SYSTEMS

3-1 DESIGN CRITERIA.

Design surface drainage, underground drainage systems, stormwater management facilities, and erosion and sediment control in accordance with the applicable requirements of the local regulatory agency with jurisdiction over the Installation; UFC 3-210-10; applicable LEED credits; and the criteria noted in this UFC; whichever is more stringent. Submit calculations to the Government Civil Engineer to document the criteria that governs. For additional design guidance, consult Best Practices documents, as indicated in Appendix B and manufacturer's data.

The design of the storm drainage system and stormwater management must address the following:

a. The stormwater management plan must comply with federal, state, and local regulatory requirements including regional or site-specific stormwater management agreements.

b. The temporary and permanent erosion and sediment control practices must be provided in accordance with local regulatory requirements during both the construction and operational phases of the project.

c. The grading must complement the features and functions of the natural drainage system and the existing contours. Also consider the high and seasonal groundwater table elevations in the siting and sizing of stormwater management facilities.

d. Utilize overland flow and natural site features where stormwater drainage will not impact site function. Drainage systems must prevent erosion of existing soils, ponding, and convey flow to a suitable outfall location. Use pump stations and transmission mains only with explicit authorization by the Government.

e. Culverts, ditches, and other drainage structures constructed along or tributary to fish streams must be designed to minimize adverse environmental effects.

3-1.1 Design Methods.

Time of concentration must be calculated using the TR-55 method or as approved by the Government Civil Engineer. UFC 3-210-10 recommends the TR-55 Curve Number method. The Rational Method may also be used for drainage areas smaller than 200 acres. Regional IDF curves are available in most state or local regulatory agency drainage manuals or from NOAA. If the IDF curves are not available, particularly in OCONUS locations, the DOR needs to develop them on a project-by-project basis with approval from the Government Civil Engineer.

3-1.2 Design Storm Frequency and Spread.

For design of the drainage system, use a minimum 10-year storm frequency, the facility type minimum, or the minimum required by the local governing authority, whichever is more stringent. Maximum spread for DoD roads is ½ driving lane using a minimum 5-year storm frequency.

3-2 ROOF DRAINAGE.

Where roof drainage is discharged to grade, provide splash blocks/paved channels to direct the flow away from the structure. Eliminate safety hazards from ice, ponding, flooding, etc., in pedestrian and vehicular traffic areas.

Where underground collection of roof drainage is used, provide an air break between the downspouts and underground piping. Size underground piping in accordance with the latest edition of the International Plumbing Code (IPC) or minimum 6 inches (150 mm) interior diameter, whichever is greater. No more than three downspouts shall be collected in a single outlet before connecting to a storm drainage structure, and the length of pipe from the most distant downspout to a drainage structure shall not exceed 150 feet (45.7 m). Provide a cleanout for each downspout connection and the collection header; distances between cleanouts must not be greater than 100 feet; provide cleanouts at changes in direction.

3-3 SURFACE STORM DRAINAGE.

3-3.1 Grading.

Use UFC 1-200-01 and the criteria in this UFC to determine the appropriate requirements for site grading and accessibility. UFC 1-200-01 implements grading requirements from the IBC and provides supplements to IBC criteria. Ensure that the grading and associated stormwater runoff do not adversely affect surrounding sites. Acceptable ranges of transverse and longitudinal slopes are indicated in Table 3-1. Grading criteria is also indicated in AASHTO's *A Policy on Geometric Design of Highways and Streets*.

Table 3.1: Grading

Item No.	Item Description	Requirement	Best Practices
1	Longitudinal grades of roadways	Min. 0.3%	Min. 0.5%
2	Transverse grades of roadways	Min. 2.0%	
3	Concrete pavement in parking areas	Min. 1.0%	Min. 1.5% Max. 5.0%
4	Curb & Gutter Valley Gutter	Min. 0.3%	Min. 0.5%
5	Bituminous pavement in parking areas	Min. 1.5%	Min. 2.0% Max. 5.0%
6	Permeable Pavements in parking areas*	Min. 1.0%	Max. 5.0%
7	Walks, Transverse	Max. 2.0%	
8	Walks, longitudinal		Max. 5.0%
9	Concrete Landings	Max. 2.0%	
10	Paved Concrete Ditches, longitudinal	Min. 0.3%	
11	Unpaved Ditches, longitudinal*	Min. 0.5%	
12	Pervious Surfaces (Grass/Turf/Landscape)*	Min 2.0%	

* Regulatory agency's stormwater management criteria may govern for items used as stormwater management features.

3-3.2 Erosion and Sediment Control.

Design erosion and sediment controls that minimize the discharge of pollutants from earth disturbing activities in conformance with the applicable requirements of the regulatory agency with jurisdiction over the Installation regarding erosion and sediment control. Where requirements do not exist, provide an erosion and sediment control plan in accordance with the requirements of Environmental Protection Agency's (EPA's) 2003 Construction General Permit (which is also the referenced standard for LEED Sustainable Site Prerequisite 1).

3-4 UNDERGROUND GRAVITY STORM DRAINAGE SYSTEM.

For drainage system design comply with the documents referenced in the paragraph entitled, "Design Criteria" in Chapter 3, or the following criteria, whichever is more stringent.

a. Provide straight alignments for piping between storm drainage structures. Use of curvilinear alignment is not allowed for pipes with a diameter of 48

inches (1200 mm) or less. For pipes with a diameter greater than 48 inches (1200 mm) use of curvilinear alignment may be allowed with explicit authorization by the Government. Deflection at structures must not be less than 90 degrees for main line flows and not less than 60 degrees for contributory flows, as measured from the centerline of the mainline discharge.

b. Storm drainage piping must not pass under buildings and must be a parallel distance of at least 10 feet (3.05 m) from building foundations.

c. Avoid conflicts with other utilities.

d. Conflict structures will not be allowed without Government approval.

e. Comply with state or applicable regulatory agency's requirements for separation distances between utilities and other public health and safety issues.

f. Provide a structure at collection and inlet points, at changes in horizontal or vertical alignment, at pipe junctions and with minimum spacing of a pipe run according to Table 3-2. Provide a discharge structure wherever flow changes from piped to open channel flow.

Table 3.2: Storm Structure Spacing Criteria

Pipe Diameter		**Maximum Spacing**	
inches	mm	feet	meters
12 – 24	300 - 600	300	91.44
27 - 36	675 - 900	400	121.92
42 - 54	1050 - 1350	500	152.4
60 and up	1500 and up	1000	304.8

g. In the design of culverts and storm drains, consider headwater and tailwater and their effects on hydraulic grade line and capacity. The following upstream controls may limit the headwater elevation:

1. Not higher than an elevation that is 18 inches (450 mm) below the outer edge of the shoulder at its lowest point in the grade.
2. Upstream property damage.
3. Elevations established to delineate National Flood Insurance Program or other floodplain zoning.
4. HW/D is at least 1.0 and not to exceed 1.5 or the local requirement where HW is the headwater depth from the culvert inlet invert and D is the height of the barrel.

5. Low point in the road grade which is not necessarily at the culvert location.
6. Elevation of terrain and ditches that will permit flow to divert around the culvert.

The tailwater elevation in the storm drain outfall must be either the average of the critical depth and the height of the storm drain conduit, $(d_c + D)/2$, or the mean high tide if tidal conditions are present, whichever is greater. Storm drains must be designed for open channel flow. The hydraulic grade line for the storm sewer system must not exceed the pipe crown elevation unless the outfall is submerged. If the controlling tailwater elevation is above the crown elevation of the outfall, the hydraulic grade line for the storm sewer system must not exceed one foot (300 mm) above the crown, or one foot (300 mm) below the structure rim or gutter flow line at inlets, whichever is the lower elevation at each structure.

At structures, consider setting the inlet pipe crown elevation equal to or greater than the outlet pipe crown elevation to minimize the hydraulic turbulence at the junction. Consider setting the invert elevation of the outflow pipe at least 0.1 feet (30 mm) lower than the lowest inflow pipe invert elevation to accommodate the hydraulic losses through the structure.

h. The downstream pipe configuration, slope and size must have capacity for the upstream hydraulic peak flow. The pipe size must not decrease downstream in the direction of flow.

i. Locate drainage structures out of paved areas wherever possible. Adjust structure locations to avoid primary wheel tracks when structures must be located in roadways.

j. During design evaluate the potential for infiltration of fine soils into drainage pipe joints and if it is a known maintenance issue at the Installation, specify watertight joints to mitigate the possibility.

3-4.1 Minimum Pipe Size.

Use a minimum inside diameter of 12 inches (300 mm) for storm drainage piping (not including roof drainage piping) for runs 50 feet (15.2 m) or less and where the existing downstream pipe is a 12-inch (300 mm) inside diameter with sufficient capacity; otherwise, use a minimum inside diameter of 15 inches (375 mm).

3-4.2 Minimum and Maximum Cover.

Provide minimum cover for all pipes sufficient to support imposed dead and live loads for the pipe materials used, 24 inches (600 mm), ½ of the pipe diameter, or greater than frost penetration according to UFC 3-301-01, whichever is greater. For pipe in non-paved areas, account for loads from expected maintenance equipment. Increase depth of cover, pipe material strength, or bedding requirements to accommodate the imposed loads during and after construction. For pipe under rigid pavement minimum cover may

be reduced to 12 inches (300 mm) from the top of pipe to the finished grade and to 6 inches (150 mm) from the top of the pipe to the bottom of concrete pavement if:

a. Reinforced concrete pipe (ASTM C76, Class V) is used.

b. Design assumptions and calculations are approved by the Government Civil Engineer.

Determine maximum cover for all individual pipe and culvert installations underlying roads, streets, and open storage areas subject to H-20 live loads. See Chapter 9 of the FAA document AC 150/5320-5C for additional design guidance on minimum and maximum cover.

3-4.3 Design Velocity.

Provide a minimum full flow velocity as indicated in Table 3.3. Determine full flow velocity using the Manning equation under no surcharge at peak flow conditions. Consider a minimum slope of 0.2 percent for constructability.

Table 3.3: Design Velocity

Item Description	Requirement	Best Practices
Full Flow Velocity	Min. 2 ft/sec (0.61 m/sec)	Min. 3 ft/sec (0.914 m/sec)

3-4.4 Manning's Roughness Coefficient.

Use Manning's roughness coefficient, "n" of 0.013 for smooth concrete pipe. For other drainage materials see state or local regulatory agency's requirement.

3-4.5 Material Selection.

Provide storm drain system materials in conformance with the UFGS to meet specific site conditions and soil characteristics. Consider thermal expansion of pipe material based on pipe location and temperatures of stormwater.

3-4.6 Culverts and Outfalls.

Culverts and outfalls must have headwalls, endwalls, wingwalls, flared or mitered end sections at free outlets. In areas of seasonal freezing, the structure must also be designed to preclude detrimental heave or lateral displacement caused by frost action. The most satisfactory method of preventing such damage is to restrict frost penetration beneath and behind the wall to non-frost-susceptible materials. Positive drainage behind the wall is also essential. Outlets and endwalls must be protected against undermining, bottom scour, damaging lateral erosion, and degradation of the downstream channel.

3-4.7 Storm Structures.

Storm structures for roads and site drainage must be in accordance with the UFGS, State Department of Transportation's (DOT) Standards and Specifications where the project is located or the requirements of the applicable local regulatory agency that governs stormwater management, whichever is more stringent. Structures must provide access for maintenance. Internal dimensions must not be less than 2 feet (600 mm) in any one direction. Ensure that catch basins, curb inlets, and manholes are of adequate size to accommodate inlet and outlet pipes.

Provide structures of cast-in-place or precast concrete. Masonry structures are allowed for shallow installations less than 5 feet (1.52 m) in depth. Design structure frames, covers and grates to withstand traffic loadings and meet any additional requirements set forth in the using agency criteria for the particular application. Select grate type based on such factors as hydraulic efficiency, debris handling characteristics, pedestrian and bicycle safety, and loading conditions. Grates in traffic areas must be able to withstand traffic loads. DoD projects require fixed ladders on all structures over 12 feet (3.66 m) in depth.

3-5 STORMWATER MANAGEMENT FACILITIES.

Design stormwater management facilities in accordance with the criteria referenced in the paragraph entitled, "Design Criteria" in Chapter 3. The selected approach must conform to any stormwater management agreements.

3-6 STORMWATER PUMP STATIONS.

Use of stormwater pump stations is not allowed except with explicit authorization by the Government. Design stormwater pump stations in accordance with the criteria referenced in the paragraph entitled, "Design Criteria" in Chapter 3.

3-6.1 Upgrades to Existing Pump Stations.

Existing pump stations may be upgraded where a complete hydraulic analysis shows that the pump station can operate at the proposed capacity in conformance with the jurisdictional requirements for a new pump station of equal capacity. Include effects on the existing force main to its point of discharge in the hydraulic analysis, and if networked, the effects on all other pump stations connected to the system. This analysis is required whenever additional flow is added to a pump station, even if physical changes to the station are not proposed.

3-7 SAFETY AND STORM DRAINAGE SYSTEM COMPONENTS.

Provide protective measures for stormwater management facilities, such as detention/retention ponds, in residential housing areas and other areas frequented by children in accordance with the applicable requirements of the locality, State or Host Nation equivalent. Protective measures include, but are not limited to, appropriate site selection for the storm water management facility and/or providing a fenced enclosure

surrounding the facility. When provided, fence must be at a minimum 4 feet (1.22 m) high with locking access gates.

3-8 SECURITY AND STORM DRAINAGE SYSTEM COMPONENTS.

Provide security barriers at all locations where security fences must cross drainage ditches or swales to ensure that intruders are prevented from passing under the fence. Pipes larger than 10 inches (250 mm) in diameter that cross under security fences require protective measures. Designs must comply with the physical security criteria referenced in the earlier paragraph entitled “Antiterrorism and Security” in Chapter 1.

3-9 AIRFIELD DRAINAGE

3-9.1 Design Storm Frequency and Spread.

For design of drainage systems for DoD airfields and heliports, use the minimum required by the local governing authority for DoD airfield and heliports or the minimum required as follows, whichever is more stringent:

a. Runways and Taxiway Pavements – 2 year storm frequency.

b. Apron Pavements - for Army and Air Force projects, 2 year storm frequency; for Navy and Marine Corps projects, 5 year storm frequency.

Ponding is not allowed on taxiway and runway pavements including paved shoulders. Ponding around apron inlets must not exceed 4 inches (100 mm). Center 50 percent of runways; center 50 percent of taxiways serving these runways; and helipad surfaces along the centerline must be free from ponding resulting from storms of a 10-year frequency.

3-9.2 Surface Storm Drainage for Airfields

3-9.2.1 Grading.

Use UFC 3-260-01 for grading criteria for airfields.

3-9.2.2 Curbs and Gutters

Curbs and gutters are not permitted to interrupt surface runoff along a taxiway or runway. The runoff must be allowed unimpeded travel transversely off the runway and then directed to the area inlets. Inlets spaced throughout the paved apron construction must be placed at proper intervals and in well-drained depressed locations.

3-9.2.3 Open Channels

Open channels or natural water courses are permitted only at the periphery of an airfield or heliport facility and must be well removed from the landing strips and traffic areas.

3-9.3 Underground Gravity Storm Drainage System for Airfields

Avoid drainage patterns consisting of closely spaced interior inlets in pavements with intervening ridges for airfields. Such grading may cause taxiing problems, including bumping or scraping of wing tanks. Crowned sections are the standard cross sections for roadways, runways, taxiways, and safety areas. Crowned sections generally slope each way from the center line of the runway on a transverse grade to the pavement.

If there is a long, gradually sloping swale between a runway and its parallel taxiway (in which the longitudinal grade, for instance, is all in one direction), additional inlets should be placed at regular intervals down this swale. Should this be required, ridges may be provided to protect the area around the inlet, prevent bypassing, and facilitate the entry of the water into the structure. If the ridge area is within the runway safety area, the grades and grade changes will need to conform to the limitations established for runway safety areas in other pertinent publications.

Watertight joints are recommended under airfield pavements.

3-9.3.1 Minimum and Maximum Cover

Use cover tables included in Chapter 9 of FAA document AC 150/5320-5C provided project specific loads and conditions do not deviate from those indicated.

3-9.3.2 Material Selection for Airfields

The use of plastic pipe is not approved for use under any type of airfield pavement except for subsurface water collection and disposal.

3-9.3.3 Storm Structures for Airfields

Design structure frames, covers and grates to withstand airfield traffic loadings and meet any additional requirements set forth in the using agency criteria. Isolate airfield structures from the pavement section. Provide structures of cast-in-place or precast concrete; do not use masonry structures in airfield construction.

Use ductile iron or steel grates and covers. Inlet grating and frames must be designed to withstand maximum aircraft wheel loads, considering the gear configuration, of the largest aircraft using or expected to use the facility. Commercially manufactured grates and frames have been designed specifically for airport loadings. Provide hold-down devices to prevent grate displacement by aircraft traffic. If manufactured grates are used, the vendor must certify the design load capacity.

For structures that will be required to support both in-line and directional traffic lanes such as diagonal taxiways or apron taxi routes, do not consider load transfer at expansion joints in the design process; however, if specific knowledge about the long-term load transfer characteristics of a particular feature supports the use of load transfer in the design of a particular drainage structure, then an exception can be allowed and load transfer considered.

3-9.4 Safety

Avoid attracting wildlife to the facility; avoid a Bird/Animal Aircraft Strike Hazard (BASH) issue.

CHAPTER 4 PAVEMENTS

4-1 SURFACED AND UNSURFACED ROADWAYS AND SITE PAVEMENTS.

Provide geometric design of vehicular roads and streets in accordance with Chapter 2 of this UFC. Unless specified otherwise in project specific requirements, design pavement based upon anticipated vehicles and loadings for a 25 year life; however, sections shall not be less than the minimums indicated below. Use pavement design criteria and procedures recognized by the Department of Transportation (DOT) in the state in which the project is located or UFC 3-250-01 for roads and parking areas not trafficked by any special military vehicles. When state design criteria and procedures are used, the entire pavement section must conform in every detail to the applicable state criteria and materials must conform to the DOT material specifications.

The use of UFC 3-250-01 is mandatory for design of roads and parking areas trafficked by special military vehicles and in OCONUS locations. Special military vehicles include, but are not limited to: cranes, aircraft tow tractors, forklifts, container handling vehicles, tracked vehicles, heavy military cargo trucks (greater than 10,000 pounds (4535 kg) (, i.e. HEMTT), heavy equipment transport systems (HET), palletized load systems (i.e. M1074, M1075, etc), mine resistant ambush protected vehicles (MRAP), and Stryker vehicles.

4-1.1 Frost Conditions

The design must address seasonal frost conditions per State DOT. For overseas locations or locations where the State DOT does not address seasonal frost conditions use UFC 3-250-01.

4-1.2 Recycled Materials

Limit recycled materials to limits in applicable UFGS sections. Recycled concrete affected by Alkali-Silica Reaction (ASR) and recycled asphalt may not be used as subbase or base course materials.

4-1.3 Flexible Pavements.

4-1.3.1 Base and Subbase Courses

Provide a minimum thickness of granular base of 4 inches (100 mm). Provide a thicker aggregate base or subbase(s) if required to protect weak subgrade soils or to reduce frost penetration into the subgrade.

4-1.4 Rigid Pavements.

The minimum flexural strength for portland cement concrete pavements at 28 days is 650 psi (4.48 MPa). No reduction in thickness will be allowed for increased flexural strength. The minimum compressive strength for portland cement concrete sidewalks, curbs and gutters is 3500 psi (25 MPa). Provide air entrainment in all exterior concrete

pavements in areas subject to freezing temperatures. Use plain (non-reinforced) concrete for rigid pavements for roads, streets and open storage areas at military installations; use reinforced concrete for odd-shaped slabs or mismatched joints. An odd-shaped slab has a length to width ratio greater than 1.25. Clearly indicate on the drawings the specific individual slabs requiring reinforcement.

During design evaluate the potential for ASR and specify requirements for aggregates and cementitious materials to mitigate the possibility of ASR occurring in the concrete job mix formula for the project.

4-1.4.1 Concrete Pavement.

4-1.4.1.1 Plain Concrete.

The minimum thickness of plain concrete for any military road, street, or open storage area is 6 inches (150 mm).

4-1.4.2 Joints.

Provide joints in a manner to form a regular rectangular pattern and to prevent random or uncontrolled cracking. Do not allow the use of insertable forms for contraction joints. The use of keyed joints are discouraged, but may be used subject to evaluation of subgrade strength, loadings, pavement thickness, and details in UFC 3-250-01 and UFC 3-250-04. Dowels and tie-bars shall not be placed closer than 0.6 times the dowel or tie-bar length from the planned joint line.

4-1.5 Permeable Pavements.

Permeable pavements (such as permeable interlocking concrete pavers or pervious portland cement concrete) may be used on site pavements, such as parking lots, provided there is documented evidence of successful past performance for similar applications. Provide signage to indicate salting and sanding is not allowed for pervious portland cement concrete. Permeable pavements may not be used in areas where there is the potential to contaminate existing soils, such as fuel areas, industrial storage, marinas, vehicle maintenance or service areas. Porous asphalt pavement is not allowed. Compacted gravel is not considered permeable pavement.

Use Best Practices documents, *Permeable Interlocking Concrete Pavements Manual - Design, Specification, Construction, Maintenance,* from the Interlocking Concrete Pavement Institute (ICPI) and ACI 522R, *Report on Pervious Concrete*, for additional design guidance.

4-1.6 Aggregate Pavements.

Minimum thickness for aggregate surfaced roads is 8 inches (200 mm).

4-2 AIRFIELD PAVEMENTS AND MARKINGS.

Use UFC 3-260-01 and UFC 3-260-02. Key joints for rigid pavements are not allowed for airfields.

APPENDIX A REFERENCES

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

http://www.transportation.org

A Policy on Geometric Design of Highways and Streets

Roadside Design Guide

Standard Specifications for Highway Bridges

AMERICAN CONCRETE INSTITUTE

http://www.concrete.org

ACI 522R, Report on Pervious Concrete

DEPARTMENT OF THE ARMY

http://www.tea.army.mil

SDDCTEA Pamphlet 55-8, Traffic Engineering Study Reference

SDDCTEA Pamphlet 55-14, Traffic Engineering for Better Signs and Markings

SDDCTEA Pamphlet 55-15, Traffic and Safety Engineering for Better Entry Control Facilities

SDCCTEA Pamphlet 55-17, Better Military Traffic Engineering

DEPARTMENT OF DEFENSE

http://www.wbdg.org/ccb/browse_cat.php?o=29&c=76

DoD 4715.5-G, Overseas Environmental Baseline Guidance Document

DEPARTMENT OF DEFENSE, UNIFIED FACILITIES CRITERIA PROGRAM

http://www.wbdg.org/

Consult active UFCs for all aspects of design, including but not limited to:

UFC 1-200-01, General Building Requirements

UFC 2-100-01, Installation Master Planning

UFC 3-101-01, Architecture

UFC 3-201-02, Landscape Architecture

UFC 3-210-10, Low Impact Development

UFC 3-220-01, Geotechnical Engineering

UFC 3-230-01, Water Storage, Distribution, and Transmission

UFC 3-230-03, Water Treatment

UFC 3-240-01, Wastewater Collection

UFC 3-240-02, Domestic Wastewater Treatment

UFC 3-250-01, Pavement Design for Roads, Streets, Walks, and Open Storage Areas, target publication date DECEMBER 2013. Use UFC 3-250-01FA, Pavement Design for Roads, Streets, Walks, and Open Storage Areas, and 3-230-06A, Subsurface Drainage, as interim criteria until publication of UFC 3-250-01.

UFC 3-250-04, Standard Practice for Concrete Pavements

UFC 3-260-01, Airfield and Heliport Planning and Design

UFC 3-260-02, Pavement Design for Airfields

UFC 3-301-01, Structural Engineering

UFC 3-460-01, Design: Petroleum Fuel Facilities

UFC 3-530-01, Design: Interior and Exterior Lighting and Controls

UFC 3-600-01, Fire Protection Engineering for Facilities

UFC 4-010-01, DoD Minimum Antiterrorism Standards for Buildings

UFC 4-020-01, DoD Security Engineering: Facilities Planning Manual

UFC 4-022-01, Security Engineering: Entry Control Facilities/Access Control Points

UFC 4-022-02, Selection and Application of Vehicle Barriers

UFC 4-510-01, Design: Medical Military Facilities

UFC 4-860-01FA, Railroad Design and Rehabilitation

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION (FAA)

AC 150/5320-5C, Surface Drainage Design[1], http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5320-5

DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION (FHWA)

Manual on Uniform Traffic Control Devices, (MUTCD) and supplement, Standard Highway Signs and Markings (SHSM), http://mutcd.fhwa.dot.gov/

FEDERAL GEODETIC CONTROL COMMITTEE (FGCC)

Standards and Specifications for Geodetic Control Networks, http://www.ngs.noaa.gov/FGCS/tech_pub/1984-stds-specs-geodetic-control-networks.htm

INTERNATIONAL CODE COUNCIL (ICC)

http://www.iccsafe.org

International Building Code (IBC)

International Plumbing Code (IPC)

NATIONAL SOCIETY OF PROFESSIONAL SURVEYORS (NSPS)

http://www.nspsmo.org

Model Standards for Topographic Surveys

NATIONAL RESEARCH COUNCIL, TRANSPORTATION RESEARCH BOARD (TRB)

http://www.trb.org

Highway Capacity Manual

[1] For Section 3-9: criteria for Airfield Drainage

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APPENDIX B BEST PRACTICES

This appendix identifies background information and practices for accomplishing certain civil design and engineering services. The Designer of Record (DoR) is expected to review and interpret this guidance and apply the information according to the needs of the project. If a Best Practices document has guidelines or requirements that differ from the UFGS or UFC, the UFGS and the UFC must prevail. If a Best Practices document has guidelines or requirements that are not discussed in the UFGS or UFC, the DoR must submit a list of the guidelines or requirements being used for the project with sufficient documentation to the Government Civil Engineer for review and approval prior to completing design.

B-1 WHOLE BUILDING DESIGN GUIDE.

The Whole Building Design Guide (www.wbdg.org) provides additional information and discussion on practice and facility design, including a holistic approach to integrated design of facilities.

The WBDG provides access to Construction Criteria Base (CCB) criteria, standards and codes for the DoD Military Departments, National Aeronautics and Space Administration (NASA), and others. These include, UFC, UFGS, Performance Technical Specifications (PTS), design manuals, and specifications. For approved Government employees, it also provides access to non-government standards.

B-2 BEST PRACTICES CIVIL ENGINEERING RELATED GUIDANCE.

B-2.1 Building Location and Orientation.

Consider the following in regards to spacing between buildings:

a. Functional relationships.
b. Operational efficiency.
c. Future expansion.
d. Open space – passive and active.

A building's relationships to its support facilities and to other primary facilities influence its location. Proximity to access roads, existing utility lines, and other compatible functions (especially if they share facilities or have interdependent activities) also influence location. When a building is a shared facility, it should be centrally located and within a reasonable distance from all participating users. Buildings which depend upon a shared facility should orient either the front building face or a doorway area towards the shared facility.

B-2.2 Street and Parking Area Design.

Consider bicycle lanes and pedestrian corridors to reduce vehicle traffic.

B-2.2.1 Access and Service Drives.

Consider the following in locating access drives:

a. Spacing.
b. Corner Clearances.
c. Sight Distances.
d. Left Turns.
e. Entrances.
f. Grading and Drainage.
g. Traffic Controls.

When a safe sight distance cannot be met, consider the following alternatives:

a. Removal of sight obstructions.
b. Relocation of the access drive to a more favorable location along the access road.
c. Prohibition of critical movements at the access drive.
d. Relocation of the access drive to another access road.

B-2.2.2 Parking Areas.

Refer to scope of work or planning document for total parking space requirement. If the number of parking spaces is not identified, use parking space guidelines in Table B-1. Where slopes are steep provide more than one level of parking.

Table B-1: Parking Space Guidelines for Non-Organizational Vehicles

Facility	Number of Parking Spaces
Administration, Headquarters, and Office Buildings	60 percent of assigned personnel
Bakeries	75 percent of civilian employees, largest shift
Bank and Credit Union, when not included in a Community Shopping Center	2 percent of authorized customers served
Cafeteria, Civilian, when not included in a Community Shopping Center	15 percent of seating capacity
Central Food Preparation Facilities	38 percent of military and civilian food service operating personnel, largest shift
Chapels	30 percent of seating capacity
Child Development Centers	10 percent of children, 80 percent of staff
Commissary Stores, Food Sales, when not included in a Community Shopping Center	Contact DeCA for parking requirements
Community Shopping Center, including such elements as Main Exchange, Miscellaneous Shops, Restaurant,	4 percent of authorized customers served

Facility	Number of Parking Spaces
Commissary Stores, Food Sales, Bank, Theater, Post Office	
Dormitories	70% of design capacity
Enlisted Personnel Dining Facilities	38 percent of military and civilian food service operating personnel, largest shift, plus 8 percent of enlisted personnel (patron parking) to be served during a meal period
Exchanges, Main, when not included in a Community Shopping Center	25 percent of authorized customers served
Family Housing	2.5 spaces per living unit
Field House, combined with Football and Baseball Facilities	1 percent of military strength
Fire Stations	100% of positions per shift
Guard Houses, Brigs, Military Police Stations	30 percent of guard and staff strength
Fitness Center	Total parking shall not exceed 1 percent of military strength served
Laundries and Dry Cleaning Plants	38 percent of civilian employees, largest shift
Libraries Central Branch	 1 space for each 500 ft^2 (46.5 m^2) gross area of floor area 8 spaces
Maintenance Shops	40 percent of assigned personnel, largest shift
Medical Facilities	See UFC 4-510-01
Officers' Quarters	100% of living suites
Schools, Dependent Without Auditorium With Auditorium	 2 spaces per classroom 2 spaces per classroom, plus 15 percent of auditorium seats
Security Offices (at gates) for military installations of: 100 to 2,000 population 2,001 to 4,000 population 4,001 to 6,000 population 6,001 to 10,000 population 10,001 and over	 5 spaces 10 spaces 15 spaces 20 spaces To be based on a special study
Service Clubs	2 percent of enlisted personnel or officer

Facility	Number of Parking Spaces
	strength served
Swimming Pools	20 percent of design capacity of the swimming pool
Temporary Lodging Facilities	90 percent of bedrooms
Theaters, when not included in a Community Shopping Center	25 percent of seating capacity
Warehouses	1 space for each 500 ft^2 [46.5 m^2] gross area of office area, plus one space for 4 persons assigned to storage activities

B-2.2.3 Off-Street Parking.

a. Layout. Consider the following in the parking lot design:

1. Maintain two-way movement.
2. Avoid dead end parking lots.
3. Provide traffic breaks in aisles longer than 350 feet (107 m).
4. Provide curbs or painted lines at the ends of stalls to control placement of vehicles.
5. Provide adequate walkway width to allow comfortable pedestrian movement in areas of bumper overhang.
6. Consider the requirements for snow removal.

b. Islands and Medians. Locate islands at the ends of parking stalls and at the intersections of parking aisles. The islands establish turning radii for vehicular movement and protect end stalls. Consider the 52 inches (1.3 m) motorist eye level viewing height when providing shrubs and small trees.

B-2.2.4 Motorcycle Parking.

Design considerations for motorcycle parking include:

a. Locate parking close to building entrances.
b. Locate parking in parking lot corners.
c. Provide signage and pavement markings.

B-2.2.5 Buffers

Provide a 20 feet (6.10 m) wide buffer strip to separate parking areas from adjacent streets.

B-2.2.6 Drop Off Areas.

Design considerations for drop-off areas include adequate width and length to accommodate the safe movement of vehicles in and out of the flow of traffic.

B-2.2.7 Delivery and Service Zones.

Delivery and service trucks need to access service doors in buildings. Delivery may require dock facilities, which need to accommodate the necessary maneuvering into and out of the dock. Design considerations for delivery zones include:

a. Separate service access drives from parking circulation because these functions are incompatible. Service access that is required through a parking area goes straight to and straight out of the service area.

b. On a dead-end service drive, provide the necessary turning movements.

c. Provide for visual screening with walls, fences or plant material.

B-2.2.8 Dumpsters.

The design of garbage and trash removal areas is controlled by the size and location of the dumpster and is coordinated with the local management company. Design considerations for dumpster pads include:

a. Maintain a forward movement for dumpster trucks through the site. Design for dumpster trucks to approach the pad in a straightforward manner, align with the dumpster, reverse away from the pad and exit forward from the site.

b. Screen the pad with fences, walls or plant material.

B-2.2.9 Facilities with Drive Thru Lane(s).

Facilities with drive thru lane(s), such as banks, pharmacies, and fast–food restaurants, require careful and clear establishment of traffic patterns and a continuous traffic flow. The standard configuration for a single – or double-service position facility does not lend itself to a two–lane approach and departure design. It usually relies on some form of loop system. Average stacking distance is recommended as 180 feet (55 m). Stacking space is determined by subtracting the number served (serving time averages 2-3 minutes per customer) from the expected arrivals per 15-minute period (4-14 minutes is the average) and multiplying the difference times 20 feet (6.10 m). Recommended parking for facilities with drive thru lane(s) is 17.5 spaces per 1,000 sq. feet (93.0 square meters) of building area. Design considerations for facilities with drive thru lane(s) include:

a. Maintain traffic lanes into and out of the drive thru windows while working with other on-site vehicular traffic flow including parking.
b. Minimize interference with pedestrian traffic flow.
c. Provide the recommended average stacking distance in the drive-thru lanes.
d. Provide the recommended average stacking distance on-site to prevent traffic safety conflicts with access roads.

e. Use curb and planting islands for vehicle control.
f. Provide adequate pavement markings.

B-2.3 Airfield Pavements.

For additional guidance on design and construction of airfield pavements see Innovative Pavement Research Foundation (IPRF) IPRF-01-G-002-1 (ACPA JP007P), *Best Practices for Airport Portland Cement Concrete Pavement Construction (Rigid Airport Pavement).*

B-3 BEST PRACTICE REFERENCES.

AMERICAN ASSOCIATION OF STATE HIGHWAY AND TRANSPORTATION OFFICIALS (AASHTO)

http://www.transportation.org

Guide for the Planning, Design and Operation of Pedestrian Facilities

Guidelines for Geometric Design of Very Low-Volume Local Roads (ADT ≤ 400)

Highway Drainage Guidelines

AMERICAN CONCRETE PIPE ASSOCIATION

http://www.concrete-pipe.org

Concrete Pipe Design Manual

AMERICAN IRON AND STEEL INSTITUTE (AISI)

http://www.steel.org

Modern Sewer Design

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE-OF-WAY ASSOCIATION (AREMA)

http://www.arema.org

Manual for Railway Engineering

AMERICAN WATER WORKS ASSOCIATION (AWWA)

http://www.awwa.org

AWWA M23, PVC Pipe – Design and Installation

AWWA M41, Ductile-Iron Pipe and Fittings

DEPARTMENT OF AGRICULTURE

Low-Water Crossings: Geomorphic, Biological, and Engineering Design Considerations, http://www.fs.fed.us/t-d//php/library_card.php?p_num=0625%201808P

DEPARTMENT OF THE AIR FORCE

Through WBDG, consult active Air Force publications, including manuals and engineering technical letters.

DEPARTMENT OF THE ARMY

Through WBDG, consult active Army publications, including engineering manuals, and engineer technical letters.

DEPARTMENT OF TRANSPORTATION, FEDERAL AVIATION ADMINISTRATION (FAA)

AC 150/5320-5C, Surface Drainage Design[2], http://www.faa.gov/airports/resources/advisory_circulars/index.cfm/go/document.current/documentNumber/150_5320-5

DEPARTMENT OF TRANSPORTATION, FEDERAL HIGHWAY ADMINISTRATION (FHWA)

Hydraulic Design of Highway Culverts (HDS-5) (FHWA-NHI-01-020), http://www.fhwa.dot.gov/resourcecenter/teams/geotech/geo_042006_3.cfm

Urban Drainage Design Manual (HEC-22) (FHWA-NHI-01-021), http://www.fhwa.dot.gov/engineering/hydraulics/pubs/10009/page00.cfm

INNOVATIVE PAVEMENT RESEARCH FOUNDATION (IPRF)

http://www.iprf.org

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http://www.icpi.org

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NATIONAL RESEARCH COUNCIL, TRANSPORTATION RESEARCH BOARD (TRB)

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http://www.uni-bell.org

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http://www.wef.org

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