FROM: HQ AFCESA/CES
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SUBJECT: **Engineering Technical Letter (ETL) 98-1: Design Criteria for Aggregate Surfaced Helicopter Slide Areas and Heliports**

1. Purpose. This ETL provides geometric and structural criteria for design of aggregate surfaced helicopter slide areas and helipads.

2. Application. This ETL is applicable to all Air Force organizations with pavement design and construction responsibilities.

2.1. Authority: AFJMAN 32-1014, *Pavement Design for Airfields*.

2.2. Effective Date: Immediately. Remains in effect until publication of AFJMAN 32-1013, *Airfield and Heliport Planning and Design Criteria*, and revision of AFJMAN 32-1014.

2.3. Expiration: Five years from date of issue.

2.4. Ultimate Recipients:
- Air Force Base Civil Engineers responsible for design, construction, maintenance and repair of pavements
- Corps of Engineers and Navy offices responsible for design and construction of Air Force pavements.

3. Referenced Publications.

3.1. AFJMAN 32-1019, *Standard Practice for Soil Stabilization.*

3.2. AFR 86-14, *Airfield and Heliport Planning Criteria*.

3.3. ASTM D 4318, *Liquid Limit, Plastic Limit, and Plasticity Index of Soils.*

3.4. Army Waterways Experiment Station Center for Public Works CRD-D-653, *Standard Test Method for Determination of Moisture-Density Relations of Soils.*

4. Requirements.

4.1. Geometric Criteria. The following criteria were extracted from a draft of AFJMAN 32-1013, currently under revision. Dimensional criteria for slide areas are shown in Table 1. Dimensional criteria for helipads are contained in Table 2. Shoulder dimensions are in Table 3, overrun dimensions are in Table 4, clear zone and accident prevention zone dimensions in Table 5, and imaginary surface criteria in Table 6. Dimensional criteria are illustrated in Figures 1 and 2.

4.1.1. Lateral clearances and imaginary surfaces provided within this ETL are for visual flight rule (VFR) only. If the facility must be used during instrument meteorological conditions (IMC), refer to AFR 86-14 for IMC clearances and surfaces pending publication of AFJMAN 32-1013.

4.2 Structural Criteria. Airfield structural design criteria are contained in AFJMAN 32-1014.

4.2.1. Thickness (Non-Frost Areas). The design thickness of aggregate surfaced airfields is similar to flexible pavement airfields as described in AFJMAN 32-1014. Factors which determine thickness are the California Bearing Ratio (CBR) of the subgrade, helicopter weight, and passes. The minimum required thickness is 6 inches. Use Figure 3 for design of aggregate surface thickness for helicopters. Enter Figure 3 with the subgrade CBR (see AFJMAN 32-1014 for selection of subgrade CBR) to determine the thickness required for a given load and pass level. The thickness determined from the figure may be constructed of surface course material for the total depth over the natural subgrade; or in a layered system consisting of select material, subbase, and surface course over compacted subgrade for the same total depth. Check the layered section to ensure sufficient material protects the underlying layer, based upon the CBR of the underlying layer. The top six inches must meet the gradation requirements of Table 7.

Table 1. Helicopter Slide Areas

Item No.	Item Description	Requirement	Remarks
1	Basic Length	490 m [1,600 ft]	490 meters [1,600 feet] is basic length up to 1,220 meters [4,000 feet] in elevation above Mean Sea Level (MSL). Increase length to 610 meters [2,000 feet] when more than 1,220 meters [4,000 feet] in elevation above MSL

Table 1. Helicopter Slide Areas (Continued)

Item No.	Item Description	Requirement	Remarks
2	Width	23 m [75 ft]	
3	Longitudinal Grade	1.0% maximum	Maximum longitudinal grade change is 0.167% per 30 linear meters [100 linear feet] of runway.
4	Transverse Grade	1.0% minimum 1.5% maximum	From centerline of slide area May be crowned or uncrowned
5	Lateral Clearance Zone	45.72 m [150 ft]	Measured perpendicularly from centerline. This area is to be clear of fixed and mobile obstacles. (1) Fixed obstacles include manmade or natural features constituting possible hazards to moving aircraft. Navigational aids and meteorological equipment are possible exceptions. (2) Mobile obstacles include parked aircraft, parked and moving vehicles, railroad cars and similar equipment. (3) Taxiing aircraft are exempt from this restriction. However, parallel taxiways (exclusive of shoulder width) must be located in excess of the lateral clearance distance.
6	Grades Within the Primary Surface Area in Any Direction	5.0% maximum	Exclusive of slide area width and shoulders. A minimum of 2.0 percent before channelization.
7	Distance Between Centerlines of Slide Area or Helipad and Fixed-Wing Runways	213.36 m [700 ft] minimum	Simultaneous VFR operations for Class A runway Minimum distance does not consider wake turbulence.
		304.80 m [1,000 ft] minimum	Simultaneous VFR operations for Class B runway Non-simultaneous operations Distance may be reduced to 60.96 meters [200 feet]; however, waiver must be based on wake-turbulence and jet blast. In locating the helipad or slide area, consider-ation must be given to hold position marking. Rotary-wing aircraft must be located on the side of the hold position markings (away from the runway) during runway operations.

Table 1. Helicopter Slide Areas (Continued)

Item No.	Item Description	Requirement	Remarks
7		213.36 m [700 ft] minimum	Non-simultaneous operations Distance may be reduced to 60.96 meters [200 feet]; however, waiver must be based on wake-turbulence and jet blast. In locating the helipad or slide area, consideration must be given to hold position marking. Rotary-wing aircraft must be located on the side of the hold position markings away from the runway during runway operations.
8	Distance Between Centerlines of Slide Area and Helipad or Any Combination Thereof	213.36 m [700 ft] minimum	Visual flight rules (VFR) without intervening parallel taxiway between centerlines

Table 2. Helipads

Item No.	Item Description	Requirement	Remarks
1	Size	30 m [100 ft] x 30 m [100 ft]	
2	Grade	1.0% minimum 1.5% maximum	Grade pad in one direction.
3	Size of Primary Surface	91.44 m [300 ft] x 91.44 m [300 ft]	Standard VFR Center primary surface on center of helipad.
4	Grades Within the Primary Surface Area in Any Direction	2.0% minimum prior to channelization*; maximum 5.0%	Exclusive of pavement and shoulders
5	Distance Between Centerline of Helipad and Fixed or Rotary Wing Runways		See Table 1, Item 8.

*Bed of channel may be flat.

Table 3. Shoulders

Item No.	Item Description	Requirement	Remarks
1	Width of Shoulders	7.5 m [25 ft]	
2	Longitudinal Grade	Variable	Conform to the longitudinal grade of the abutting semi-prepared surface
3	Transverse Grade	2.0% minimum 4.0% maximum	Slope downward from edge of operating surface
4	Grade (adjacent to shoulder)	5% slope first 3 m [10 ft]	Slope downward from edge of shoulder. Primary surface criteria apply beyond 3 meters [10 feet]. See Table 1, Item 6, and Table 2, Item 4.

Table 4. Overruns for Slide Areas

Item No.	Item Description	Requirement	Remarks
1	Total Length	23 m [75 ft]	
2	Width	38 m [125 ft]	Width of slide area plus shoulders
3	Longitudinal Centerline Grade	1.0% maximum	Changes in longitudinal grade in overrun or between overrun and runway should not exceed 0.167% per 30 linear meters [100 linear feet].
4	Transverse Grade	2.0% minimum 3.0% maximum	Warp to meet slide area and shoulder grades.

Table 5. Clear Zone and Accident Potential Zone (APZ)

Item No.	Item Description	Requirement	Remarks
1	Clear Zone Length	121.92 m [400 ft]	Clear zone begins at the end of the primary surface.
2	Clear Zone Width	91.44 m [300 ft]	Same width as primary surface. Center on extended slide area or helipad centerline.

Table 5. Clear Zone and Accident Potential Zone (APZ) (Continued)

Item No.	Item Description	Requirement	Remarks
3	Grades in Clear Zone in Any Direction	2.0% minimum 5.0% maximum	Clear zone only Area to be free of obstructions. Rough grade and turf when required.
4	APZ I Length	243.84 m [800 ft]	
5	APZ I Width	91.44 m [300 ft]	

Note: The clear zone area for slide areas and pads corresponds to the clear zone land use criteria for fixed-wing airfields as defined in DoD AICUZ standards. The remainder of the approach-departure zone corresponds to APZ I land use criteria similarly defined. APZ II criteria is not applicable for rotary-wing aircraft.

Table 6. Imaginary Surfaces

Item No.	Item Description	Legend in Figures	Slide Area	Helipad	Remarks
1	Primary Surface Width	A	91.44 m [300 ft]	91.44 m [300 ft]	Centered on the Ground Point Intercept (GPI) or centerline
2	Primary Surface Length	A	Runway length plus 22.86 m [75 ft] at each end	91.44 m [300 ft] centered on pad	
3	Primary Surface Elevation	A			The elevation of any point on the primary surface is the same as the elevation of the nearest point on the runway centerline or at the established elevation of the landing surface.
4	Clear Zone	B	See Table 5	See Table 5	
5	Approach-Departure Clearance Surface -- Inner Edge	C	22.86 m [75 ft] from end of slide area	45.72 m [150 ft] from GPI	Begins at the same elevation as the established elevation of the slide area or helipad

Table 6. Imaginary Surfaces (Continued)

Item No.	Item Description	Legend in Figures	Slide Area	Helipad	Remarks
6	Approach-Departure Clearance Surface -- Length	C	365.76 m [1,200 ft]	365.76 m [1,200 ft]	If the facility is collocated on a fixed-wing airfield, this surface terminates where it intersects with the inner horizontal surface at 45.72 meters [150 feet] above the established airfield elevation. This may change the length of the surface slightly.
7	Approach-Departure Clearance Surface -- Slope	C	8:1	8:1	Slope ratio is horizontal to vertical. 8:1 is 8 meters [feet] horizontal to 1 meter [foot] vertical.
8	Approach-Departure Clearance Surface -- Width at Inner Edge	C	91.44 m [300 ft]	91.44 m [300 ft]	Centered on the extended centerline, and the same width as the primary surface
9	Approach-Departure Clearance Surface -- Width at Outer Edge	C	182.88 m [600 ft]	182.88 m [600 ft]	Centered on the extended centerline. If the facility is collocated on a fixed-wing airfield, and the approach-departure zone ends within the limits of the inner horizontal surface, this surface length will be affected by any difference in elevation between the helipad or slide area and the established airfield elevation. In these cases, the width of the outer edge is 182.88 meters [600 feet] wide at 365.76 meters [1,200 feet] from the point of beginning. The surface continues at this width until it intersects with the fixed-wing airfield's inner horizontal surface or until the minimum enroute altitude is reached.

Table 6. Imaginary Surfaces (Continued)

Item No.	Item Description	Legend in Figures	Slide Area	Helipad	Remarks
10	Approach-Departure Clearance Surface -- Elevation at Outer Edge	C	45.72 m [150 ft]	45.72 m [150 ft]	Above the established elevation of the landing surface
11	Approach-Departure Zone -- Length	D	365.76 m [1,200 ft]	365.76 m [1,200 ft]	Measured horizontally from the end of the primary surface and the same length as the approach-departure clearance surface length
12	Transitional Surface -- Elevation	H	45.72 m [150 ft]	45.72 m 150 ft]	Slide areas and helipads: The transitional surface begins at the lateral edges of the primary surface and the approach-departure clearance surface, and continues outward and upward on a 2:1 slope.
13	Horizontal Surface	G	Not required	Not required	

Table 7. Gradation for Aggregate Surface Courses (Percent Passing)

Sieve Designation	No. 1	No. 2	No. 3	No. 4
25. 0 mm (1")	100	100	100	100
9.5 mm (3/8")	50-85	60-100		
No. 4	35-65	50-85	55-100	70-100
No. 10	25-50	40-70	40-100	55-100
No. 40	15-30	24-45	20-50	30-70
No. 200	8-15	8-15	8-15	8-15

Note: The percent by weight finer than 0.02 millimeters (0.04 inches) shall not exceed 3 percent.

Figure 1. Helicopter Slide Areas (VFR Only)

Figure 2. Helipads (VFR Only)

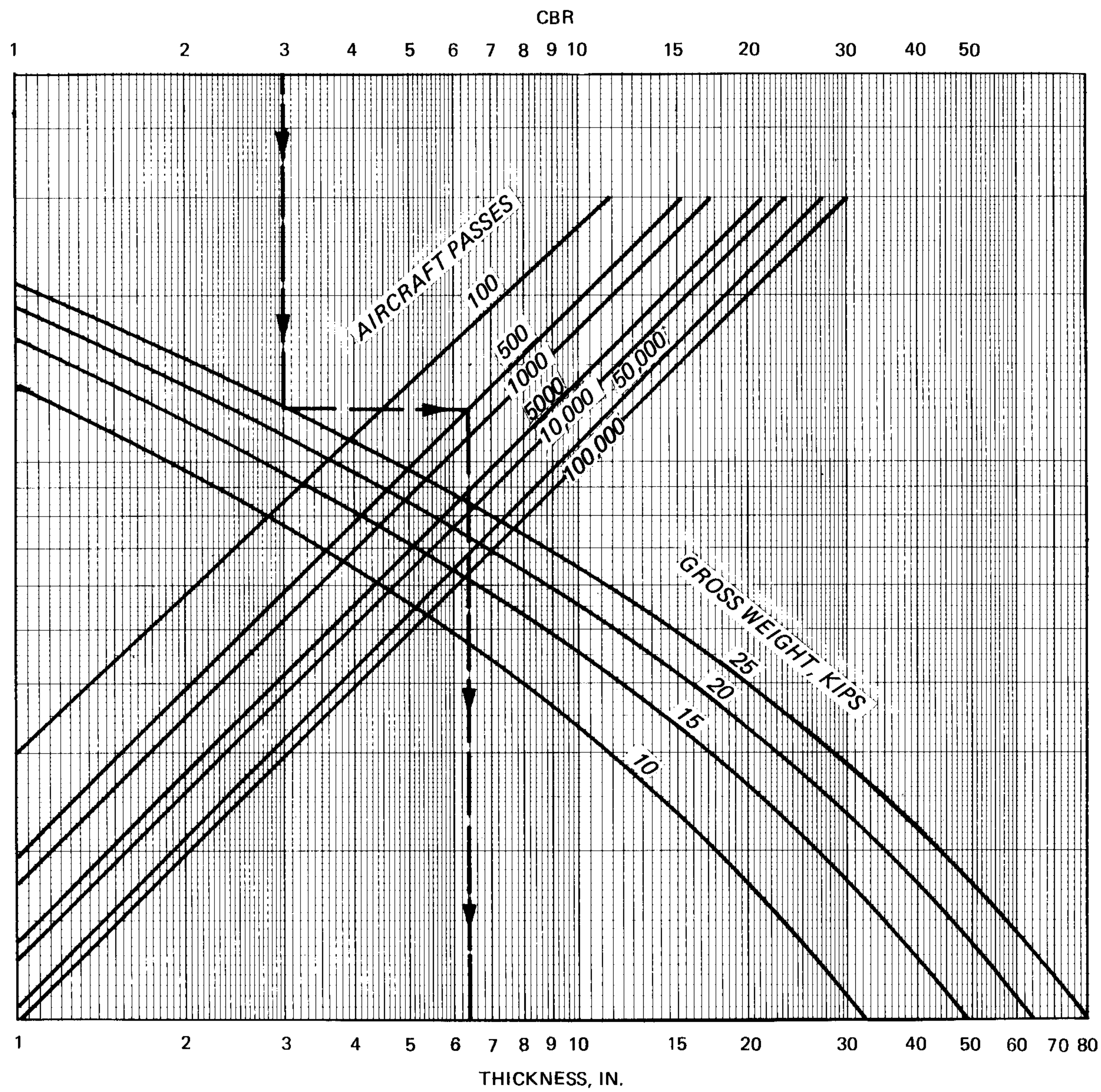

Figure 3. Aggregate Surfaced Design Curves for Helicopters

4.2.2. Select Materials and Subbases. Select design CBR values materials and subbases in accordance with AFJMAN 32-1014, except as modified in Table 8.

Table 8. Maximum Permissible Values for CBR and Gradation Requirements

Material	Maximum CBR	Maximum Size	Maximum % Passing #10	Maximum % Passing #200	Maximum Liquid Limit*	Maximum Plasticity Index*
Subbase	50	51 mm (2 ")	50	15	25	5
Subbase	40	51 mm (2 ")	80	15	25	5
Subbase	30	51 mm (2 ")	100	15	25	5
Select Material	20	76 mm (3")	-	-	35	12

* ASTM D 4318.

4.2.3. Thickness (Frost Areas). In areas where frost effects impact pavement design, there are additional considerations concerning thicknesses and required layers in the pavement structure. For frost design, soils are divided into eight groups as shown in Table 9. Only the non-frost-susceptible (NFS) group is suitable for base course. NFS, S1, or S2 soils may be used for subbase course, and any of the eight groups may be found as subgrade soils. Soils are listed in approximate order of decreasing bearing capability during periods of thaw.

Table 9. Frost Design Soil Classification

Frost Group	Type Soil	Percentage Finer Than 0.02 mm (0.04") by Weight	Unified Soil Classification Soil Types
NFS*	(a) Gravels Crushed stone Crushed rock	0-1.5	GW, GP
	(b) Sands	0-3	SW, SP
PFS**	(a) Gravels Crushed stone Crushed rock	1.5-3	GW, GP
	(b) Sands	3-10	SW, SP
S1	Gravelly soils	3-6	GW, GP, GW-GM, GP-GM
S2	Sandy soils	3-6	SW, SP, SW-SM, SP-SM
F1	Gravelly soils	6-10	GM, GW-GM, GP-GM
F2	(a) Gravelly soils	10-20	GM, GW-GM, GP-GM
	(b) Sands	6-15	SM, SW-SM, SP-SM

Table 9. Frost Design Soil Classification (Continued)

Frost Group	Type Soil	Percentage Finer Than 0.02 mm (0.04") by Weight	Unified Soil Classification Soil Types***
F3	(a) Gravelly soils	over 20	GM, GC
	(b) Sands, except very fine silty sands	over 15	SM, SC
	(c) Clays, PI 12	---	CL, CH
F4	(a) All silts	---	ML, MH
	(b) Very fine silty sands	over 15	SM
	(c) Clays, PI 12	---	CL, CL-ML
	(d) Varved clays and other fine grained banded sediments	---	CL, ML, SM and CH

*Nonfrost-susceptible
**Possible frost-susceptible, but requires laboratory test to determine frost design soil classification
***Defined in AFM 89-3, *Materials Testing*

4.2.3.1. Required Thickness. Where there are frost-susceptible subgrades, determine section thickness according to the reduced subgrade strength method. The reduced subgrade strength method uses the frost area soil support indexes (FASSI) in Table 10. Use FASSI like CBR values. The term CBR is not applied, because FASSI are weighted average values for an annual cycle and their values cannot be determined by CBR tests. Enter Figure 3 with the soil support indexes (vice CBR values) to determine the required section thickness.

Table 10. Frost Area Soil Support Indices (FASSI) of Subgrade Soils

Frost Group	FASSI
F1 and S1	9.0
F2 and S2	6.5
F3 and F4	3.5

4.2.3.2. Pavement Section Layers. When frost is a consideration, recommend the pavement section consist of layers that will ensure the stability of the system, particularly during thaw periods. The layered system may consist of a 152-millimeter- (6-inch-) thick minimum wearing surface of fine crushed stone, a coarse-graded base course, and/or a well-graded subbase of sand or gravely sand. To ensure the stability of the wearing surface, the width of the base course and subbase should exceed the final desired surface width by a minimum of 0.35 meters (1 foot) on each side.

4.2.3.3. Wearing Surface. The wearing surface contains fines (material passing the #200 sieve) to provide stability in the aggregate surface. The presence of fines improves the layer's compaction characteristics and helps to provide a relatively smooth surface.

4.2.3.4. Base Course. The coarse-graded base course is important in providing drainage of the granular fill. Base course should be non-frost-susceptible to retain strength during spring thaw periods.

4.2.3.5. Subbase. A well-graded subbase provides additional bearing capacity over the frost-susceptible subgrade. It also provides a filter layer between the coarse-graded base course and the subgrade to prevent migration of the subgrade into the voids in the coarser material during periods of reduced subgrade strength. Therefore, the material must meet standard filter criteria. The subbase must be either non-frost-susceptible or of low frost susceptibility (S1 or S2). The filter layer may or may not be necessary depending upon the type of subgrade material. If the subgrade consists principally of gravel or sand, the filter layer may not be necessary, and may be replaced by additional base course if the gradation of the base course meets filter criteria. For finer grained soils, the filter layer will be necessary. If using a geotextile, the sand subbase/filter layer may be omitted, as the fabric will be placed directly on the subgrade and acts as a filter.

4.2.3.6. Compaction. The subgrade should be compacted to provide uniformity of conditions and a working platform for placement and compaction of subbase. Compaction will not change a subgrade's frost-area soil support index. However, because frost weakens the subgrade, compacted subgrade in frost areas will not be considered part of the layered system of the airfield, which should be comprised of only the wearing, base, and subbase courses.

4.2.3.7. Base Course and Filter Layer. Relative thicknesses of the base course and filter layer vary, and should be based on the required cover and economic considerations.

4.2.3.8. Alternate Design. The reduced subgrade strength design provides a soil thickness above a frost-susceptible subgrade which minimizes frost heave. For a more economical design, a frost-susceptible select material or subbase may be used as a part of the total thickness above the frost-susceptible subgrade. However, thickness above the select material or subbase must be determined by using the FASSI of the select or subbase material. Frost-susceptible soils used as select materials or subbases must meet current specifications; the restriction on the allowable percent finer than 0.02 mm is waived.

4.2.4. Surface Course. Materials requirements for construction of aggregate surfaced airfields depend upon whether frost is a factor in the design.

4.2.4.1. Nonfrost Areas. Material used for gravel surfaced roads and airfields should be sufficiently cohesive to resist abrasive action. It should have a liquid limit no greater than 35 and a plasticity index between 4 and 9. It also should be graded for maximum density and minimum volume of voids to enhance optimum moisture retention while resisting excessive water intrusion. Gradation should consist of an optimal combination of coarse and fine aggregates to ensure minimum void ratios and maximum density. This material will exhibit cohesive strength as well as intergranular shear strength. Recommended gradations are shown in Table 11. If the fines fraction of the material does not meet plasticity characteristics, the material may be modified by adding chemicals. Chloride products can, in some cases, enhance moisture retention, and lime can be used to reduce excessive plasticity.

Table 11. Gradation for Aggregate Surface Courses (Percent Passing)

Sieve Designation	No. 1	No. 2	No. 3	No. 4
25 mm (1 inch)	100	100	100	100
9.5 mm (3/8 inch)	50-85	60-100	—	—
No. 4	35-65	50-85	55-100	70-100
No. 10	25-50	40-70	40-100	55-100
No. 40	15-30	24-45	20-50	30-70
No. 200	8-15	8-15	8-15	8-15

Note: The percent by weight finer than 0.02 mm shall not exceed 3 percent.

4.2.4.2. Frost Areas. Where frost is a consideration, a layered system should be used. The percentage of fines should be restricted in all the layers to facilitate drainage and reduce the loss of stability and strength during thaw periods. Use gradation numbers 3 and 4 shown in Table 11 with caution, since they may be unstable in a freeze-thaw environment.

4.2.5. Compaction. Compaction requirements for the subgrade and granular layers are expressed as a percent of maximum CE 55 density as determined by using CRD-C-653, *Standard Test Method for Determination of Moisture-Density Relations of Soils*. For granular layers, compact the material to 100 percent of maximum CE 55 density. Select materials and subgrades in fills must have densities equal to or greater than the values shown in Table 12, except that fills will be placed at no less than 95 percent compaction for cohesionless soils (PI - 5; LL 25) or 90 percent compaction for cohesive soils (PI > 5; LL > 25). Subgrades in cuts must have densities equal to or greater than the values shown in Table 12. Subgrades occurring in cut sections will be either compacted from the surface to meet the densities shown in Table 12, removed and replaced before applying the requirements for fills, or covered with sufficient material so that the uncompacted subgrade will be at a depth where the in-place densities are satisfactory. Depths in Table 12 are measured from the surface of the aggregate, and not the surface of the subgrade.

Table 12. Compaction Requirements for Helicopter Pads and Slide Areas

	Cohesive Soils					Cohesionless Soils			
Percent	100	95	90	85	80	100	95	90	85
Depth Below Pavement Surface [millimeters (inches)]	102 (4)	150 (6)	203 (8)	254 (10)	305 (12)	150 (6)	254 (10)	325 (13)	406 (16)

4.3. Drainage. Drainage is a critical factor in aggregate surface airfield design, construction, and maintenance. It should be considered prior to construction; and, when necessary, serve as a basis for site selection.

4.3.1. Provide adequate surface drainage to minimize moisture damage. Quick removal of surface water reduces absorption and ensures more consistent strength and reduced maintenance. Drainage must not result in damage to the aggregate surfaced airfield through erosion of fines or erosion of the entire surface layer. Ensure changes to the drainage regime can be accommodated by the surrounding topography without damage to the environment, or the newly constructed slide area or pad.

4.3.2. The surface geometry of an airfield should be designed so that drainage is provided at all points. Depending upon the surrounding terrain, surface drainage can be achieved by a continual cross slope, or by a series of two or more interconnecting cross slopes. The entire area should consist of one or more cross slopes having a gradient that meets the requirements of Tables 1 and 2.

4.3.3. Provide adequate drainage outside the airfield area to accommodate maximum flow. Use culverts sparingly, and only in areas where adequate cover of granular fill is provided over the culvert. Evaluate drainage for adjacent areas to determine if rerouting is needed to prevent water from other areas flowing across the airfield.

4.4. Maintenance. The two primary causes of deterioration of aggregate surfaced areas requiring frequent maintenance are the environment and traffic. Rain or water flow will wash fines from the aggregate surface; traffic action causes erosion of surface materials. Maintenance should be performed at least every six months, and more frequently if required. Frequency of maintenance will be high for the first few years of use, but will decrease over time to a constant value. Most of the maintenance will consist of grading to remove ruts and potholes and replacing fines. Occasionally, the surface layer may have to be scarified, additional aggregate added to restore original thickness, and the wearing surface recompacted to the specified density.

4.5. Dust Control. A dust palliative prevents soil particles from becoming airborne as a result of wind or traffic. Dust palliatives used on traffic areas must withstand abrasion. An important factor limiting use of dust palliatives in traffic areas is the extent of surface rutting or abrasion that will occur under traffic. Some palliatives will tolerate deformations better than others, but ruts in excess of 13 millimeters (½ inch) will usually destroy any thin layer or shallow-depth penetration dust palliative treatment. A wide selection of materials for dust control is available. Several materials have been recommended for use and are discussed in AFJMAN 32-1019.

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