LIST OF FIGURES

		Page
Figure 1-1.	*Crystal forms*	1-2
Figure 1-2.	*Cleavage*	1-2
Figure 1-3.	*Fractures*	1-3
Figure 1-4.	*The rock cycle*	1-7
Figure 1-5.	*Intrusive and extrusive rock bodies*	1-7
Figure 1-6.	*Cross section of igneous rock*	1-8
Figure 1-7.	*Bedding planes*	1-9
Figure 1-8.	*Contact metamorphism zone*	1-9
Figure 1-9.	*Metamorphic foliation*	1-10
Figure 1-10.	*Jointing in igneous rocks*	1-12
Figure 1-11.	*Cross bedding in sandstone*	1-14
Figure 1-12.	*Metamorphism of existing rocks*	1-18
Figure 1-13.	*Crushed shape*	1-22
Figure 2-1.	*The major plates of the earth's crust*	2-2
Figure 2-2.	*Major features of the plate tectonic theory*	2-3
Figure 2-3.	*Location of rock outcrops*	2-3
Figure 2-4.	*Folding of sedimentary rock layers*	2-4
Figure 2-5.	*Common types of folds*	2-5
Figure 2-6.	*Topographic expression of plunging* folds	2-5
Figure 2-7.	*Fold symmetry*	2-6
Figure 2-8.	*Faulting*	2-7
Figure 2-9.	*Fault zone*	2-7
Figure 2-10.	*Thrust fault with drag folds*	2-8
Figure 2-11.	*Fault terminology*	2-8
Figure 2-12.	*Types of faults*	2-9
Figure 2-13.	*Graben and horst faulting*	2-9

		Page
Figure 2-14.	*Jointing in sedimentary and igneous rock*	2-10
Figure 2-15.	*Strike*	2-11
Figure 2-16.	*Dip*	2-11
Figure 2-17.	*Measuring strike and dip with a Brunton compass*	2-12
Figure 2-18.	*Strike and dip symbols*	2-12
Figure 2-19.	*Strike and dip symbols of sedimentary rocks*	2-13
Figure 2-20.	*Symbolic patterns for rock types*	2-17
Figure 2-21.	*Geologic map symbols*	2-18
Figure 2-22.	*Placement of strike and dip symbols on a geologic map*	2-19
Figure 2-23.	*Geologic map and cross section*	2-19
Figure 2-24.	*Outcrop patterns of horizontal strata*	2-20
Figure 2-25.	*Outcrop patterns of inclined strata*	2-20
Figure 2-26.	*Outcrop patterns of an eroded dome*	2-20
Figure 2-27.	*Outcrop patterns of an eroded basin*	2-20
Figure 2-28.	*Outcrop patterns of plunging folds*	2-21
Figure 2-29.	*Outcrop patterns produced by faulting*	2-21
Figure 2-30.	*Outcrop patterns of intrusive rocks*	2-21
Figure 2-31.	*Outcrop patterns of surficial deposits*	2-21
Figure 2-32.	*Ripping in the direction of dip*	2-24
Figure 2-33.	*Rock drills*	2-24
Figure 2-34.	*Rock slide on inclined bedding plane*	2-25
Figure 2-35.	*Rules of thumb for inclined sedimentary rock cuts*	2-25
Figure 2-36.	*Road cut alignment*	2-27
Figure 2-37.	*Quarry in the direction of strike*	2-28
Figure 3-1.	*Typical drainage patterns*	3-3
Figure 3-2.	*Topographic expression of a braided stream*	3-4
Figure 3-3.	*Stream evolution and valley development*	3-5

		Page
Figure 3-4.	*A youthful stream valley*	3-7
Figure 3-5.	*A mature stream valley*	3-8
Figure 3-6.	*An old age stream valley*	3-9
Figure 3-7.	*Meander erosion and deposition*	3-10
Figure 3-8.	*Point bar deposits designated by gravel symbols*	3-11
Figure 3-9.	*Channel bar deposits, oxbow lakes, and backswamp / floodplain deposits*	3-12
Figure 3-10.	*Meander development and cutoff*	3-13
Figure 3-11.	*Oxbow lake deposits, natural levees, and backswamp deposits*	3-13
Figure 3-12.	*Alluvial terraces*	3-14
Figure 3-13.	*Topographic expression of alluvial terraces*	3-15
Figure 3-14.	*Growth of a simple delta*	3-16
Figure 3-15.	*Arcuate, bird's-foot, and elongate deltas*	3-16
Figure 3-16.	*Alluvial fan and coalescing alluvial fans*	3-17
Figure 3-17.	*Cedar Creek alluvial fan*	3-19
Figure 3-18.	*Coalescing alluvial fans*	3-20
Figure 3-19.	*Major floodplain features*	3-21
Figure 3-20.	*World distribution of fluvial landforms*	3-22
Figure 3-21.	*Ice sheets of North America and Europe*	3-23
Figure 3-22.	*Continental glaciation*	3-24
Figure 3-23.	*Alpine glaciation*	3-25
Figure 3-24.	*Moraine topographic expression with kettle lakes, swamps, and eskers*	3-26
Figure 3-25.	*Valley deposits from melting ice*	3-27
Figure 3-26.	*Idealized cross section of a drumlin*	3-28
Figure 3-27.	*Topographic expression of a drumlin field*	3-29
Figure 3-28.	*Distribution of major groups of glacial landforms across the United States*	3-30
Figure 3-29.	*World distribution of glacial landforms*	3-31

		Page
Figure 3-30.	*Three stages illustrating the development of desert armor*	3-32
Figure 3-31.	*Cutting of a ventifact*	3-33
Figure 3-32.	*Eolian features*	3-33
Figure 3-33.	*Sand dune types*	3-34
Figure 3-34.	*Loess landforms*	3-35
Figure 3-35.	*Topographic expression of sand dunes and desert pavement*	3-36
Figure 3-36.	*Worldwide distribution of eolian landforms*	3-37
Figure 4-1.	*Residual soil forming from the in-place weathering of igneous rock*	4-4
Figure 4-2.	*Soil profile showing characteristic soil horizons*	4-5
Figure 4-3.	*Dry sieve analysis*	4-6
Figure 4-4.	*Data sheet, example of dry sieve analysis*	4-8
Figure 4-5.	*Grain-size distribution curve from sieve analysis*	4-9
Figure 4-6.	*Well-graded soil*	4-10
Figure 4-7.	*Uniformly graded soil*	4-10
Figure 4-8.	*Gap-graded soil*	4-10
Figure 4-9.	*Typical grain-size distribution curves for well-graded and poorly graded soils*	4-11
Figure 4-10.	*Bulky grains*	4-11
Figure 4-11.	*Volume-weight relationships of a soil mass*	4-12
Figure 4-12.	*Layer of adsorbed water surrounding a soil particle*	4-15
Figure 4-13.	*Capillary rise of water in small tubes*	4-16
Figure 4-14.	*U-shaped compaction curve*	4-18
Figure 4-15.	*Liquid limit test*	4-18
Figure 5-1.	*Sample plasticity chart*	5-3
Figure 5-2.	*Graphical summary of grain-size distribution*	5-20
Figure 5-3.	*Breaking or dry strength test*	5-22
Figure 5-4.	*Roll or thread test*	5-22

		Page
Figure 5-5.	*Ribbon test (highly plastic clay)*	5-23
Figure 5-6.	*Wet shaking test*	5-24
Figure 5-7.	*Suggested procedure for hasty field identification*	5-26
Figure 5-7.	*Suggested procedure for hasty field identification (continued)*	5-27
Figure 5-7.	*Suggested procedure for hasty field identification (continued)*	5-28
Figure 5-8.	*Group index formula and charts, Revised Public Roads System*	5-31
Figure 5-9.	*Relationship between LL and PI silt-clay groups, Revised Public Roads System*	5-32
Figure 5-10.	*US Department of Agriculture textural classification chart*	5-33
Figure 6-1.	*Laboratory shear tests*	6-3
Figure 6-2.	*Correlation of CBR and AI*	6-7
Figure 6-3.	*Typical failure surfaces beneath shallow foundations*	6-7
Figure 6-4.	*Bearing piles*	6-8
Figure 6-5.	*Principal types of retaining walls*	6-10
Figure 6-6.	*Common types of retaining-wall drainage*	6-12
Figure 6-7.	*Eliminating frost action behind retaining walls*	6-13
Figure 6-8.	*Typical timber crib retaining wall*	6-14
Figure 6-9.	*Other timber retaining walls*	6-15
Figure 6-10.	*Typical gabion*	6-15
Figure 6-11.	*Bracing a narrow shallow excavation*	6-16
Figure 6-12.	*Bracing a wide shallow excavation*	6-17
Figure 7-1.	*Capillary rise of moisture*	7-2
Figure 7-2.	*Base drains in an airfield pavement*	7-5
Figure 7-3.	*Typical subgrade drainage installation*	7-6
Figure 7-4.	*Mechanical analysis curves for filter material*	7-8
Figure 7-5.	*Determination of freezing index*	7-9
Figure 7-6.	*Formation of ice crystals on frost line*	7-10
Figure 7-7.	*Sources of water that feed growing ice lenses*	7-15

		Page
Figure 8-1.	*Typical moisture-density relationship*	8-3
Figure 8-2.	*Moisture-density relationships of seven soils*	8-5
Figure 8-3.	*Moisture-density relationships of two soils*	8-7
Figure 8-4.	*Density, compaction, and moisture content*	8-8
Figure 8-5.	*Density and moisture determination by CBR design method*	8-10
Figure 8-6.	*Self-propelled, pneumatic-tired roller*	8-18
Figure 8-7.	*Compaction by a sheepsfoot roller*	8-19
Figure 8-8.	*Two-axle, tandem steel-wheeled roller*	8-20
Figure 8-9.	*Self-propelled, smooth-drum vibratory roller*	8-20
Figure 8-10.	*Use of test strip data to determine compactor efficiency*	8-21
Figure 9-1.	*Graphical method of proportioning two soils to meet gradation requirements*	9-7
Figure 9-2.	*Arithmetical method of proportioning soils to meet gradation requirements*	9-7
Figure 9-3.	*Graphical method of estimating plasticity characteristics of a combination of two soils*	9-9
Figure 9-4.	*Gradation triangle for use in selecting a stabilizing additive*	9-12
Figure 9-5.	*Group index for determining average cement requirements*	9-17
Figure 9-6.	*Alternate method of determining initial design lime content*	9-20
Figure 9-7.	*Classification of aggregates*	9-25
Figure 9-8.	*Approximate effective range of cationic and anionic emulsion of various types of asphalt*	9-25
Figure 9-9.	*Determination of asphalt grade for expedient construction*	9-26
Figure 9-10.	*Selection of asphalt cement content*	9-26
Figure 9-11.	*Typical sections for single-layer and multilayer design*	9-27
Figure 9-12.	*Design curve for Class A and Class B single-layer roads using stabilized soils*	9-31
Figure 9-13.	*Design curve for Class C single-layer roads using stabilized soils*	9-31
Figure 9-14.	*Design curve for Class D single-layer roads using stabilized soils*	9-31
Figure 9-15.	*Design curve for Class E single-layer roads using stabilized soils*	9-32

		Page
Figure 9-16.	*Design curve for Class A and Class B multilayer roads using stabilized soils*	9-33
Figure 9-17.	*Design curve for Class C multilayer roads using stabilized soils*	9-33
Figure 9-18.	*Design curve for Class D multilayer roads using stabilized soils*	9-34
Figure 9-19.	*Design curve for Class E multilayer roads using stabilized soils*	9-34
Figure 9-20.	*Equivalency factors for soils stabilized with cement, lime, or cement and lime mixed with fly ash*	9-36
Figure 9-21.	*Design curves for single-layer airfields using stabilized soils in close battle areas*	9-38
Figure 9-22.	*Design curves for single-layer airfields using stabilized soils in rear areas*	9-39
Figure 9-23.	*Design curves for single-layer airfields using stabilized soils in rear area 6,000'*	9-40
Figure 9-24.	*Design curves for single-layer airfields using stabilized soils in tactical rear area*	9-40
Figure 9-25.	*Design curves for single-layer airfields using stabilized soils in tactical COMMZ areas*	9-41
Figure 9-26.	*Design curves for single-layer airfields using stabilized soils in liaison COMMZ airfields*	9-42
Figure 9-27.	*Design curves for single-layer airfields using stabilized soils in COMMZ*	9-43
Figure 9-28.	*Design curves for single-layer airfields using stabilized soils in semipermanent COMMZ airfields*	9-44
Figure 9-29.	*Thickness design procedure for subgrades that increase in strength with depth*	9-53
Figure 9-30.	*Thickness design procedure for subgrades that decrease in strength with depth*	9-54
Figure 9-31.	*Polypropylene membrane layout for tangential sections*	9-64
Figure 9-32.	*Polypropylene membrane layout for curved sections*	9-64
Figure 9-33.	*Dust control effort required for heliports*	9-73
Figure 9-34.	*Cross section of dune showing initial and subsequent fences*	9-75
Figure 9-35.	*Three fences installed to control dune formation*	9-75
Figure 9-36.	*Three types of solid fencing or paneling for control of dune formation*	9-76

Page

Figure 9-37. *Schematic of dune destruction or stabilization by selective treatment* 9-77

Figure 10-1. *Slope of bedding planes* 10-2

Figure 10-2. *Normal force* 10-4

Figure 10-3. *Downslope or driving force* 10-5

Figure 10-4. *Frictional resistance to sliding* 10-6

Figure 10-5. *Frictional resistance to sliding with uplift force of groundwater* 10-9

Figure 10-6. *Fricitonal resistance to sliding with and without groundwater* 10-9

Figure 10-7. *Debris avalanche* 10-11

Figure 10-8. *Backward roation of a slump block* 10-12

Figure 10-9. *Jackstrawed trees* 10-12

Figure 10-10. *Structural features of a slump* 10-13

Figure 10-11. *Road construction across short slopes* 10-13

Figure 10-12. *Increasing slope stability with surface drainage* 10-14

Figure 10-13. *Using rock riprap to provide support for road cuts or fills* 10-15

Figure 10-14. *Installing interceptor drains along an existing road* 10-15

Figure 10-15. *Building a road on a blanket* 10-16

Figure 10-16. *Block diagram of a Type I site* 10-17

Figure 10-17. *Topographic map of Type I site* 10-18

Figure 10-18. *Pistol-butted trees* 10-19

Figure 10-19. *Tipped trees* 10-19

Figure 10-20. *Tension cracks* 10-19

Figure 10-21. *Safe disposal site* 10-20

Figure 11-1. *Comparison of aggregate depth requirements with and without a geotextile* 11-1

Figure 11-2. *Effect of pumping action on base course* 11-2

Figure 11-3. *Separating a weak subgrade from a granular subbase with a geofabric* 11-2

		Page
Figure 11-4.	*Determining the soil's shear strength by converting CBR value or Cone Index*	11-3
Figure 11-5.	*Thickness design curve for single-wheel load on gravel surfaced pavements*	11-7
Figure 11-6.	*Thickness design curve for dual-wheel load on gravel surfaced pavements*	11-7
Figure 11-7.	*Thickness design curve for tandem-wheel load on gravel-surfaced pavements*	11-8
Figure 11-8.	*Construction sequence using geotextiles*	11-11
Figure 11-9.	*Constructing an earth retaining wall using geofabrics*	11-13
Figure 11-10.	*Sand grid*	11-14
Figure 12-1.	*Maximum depth to permafrost below a road after 5 years in a subarctic region*	12-8
Figure 12-2.	*Thickness of base required to prevent thawing of subgrade*	12-9
Figure 12-3.	*Distribution of mean air thawing indexes (^{o})—North America*	12-10
Figure 12-4.	*Distribution of mean air thawing indexes (^{o})—Northern Eurasia*	12-11
Figure 12-5.	*Distribution of mean air thawing index values for pavements in North America (^{o})*	12-12
Figure 12-6.	*Determining the depth of thaw beneath pavements with gravel bases*	12-13
Figure 12-7.	*Determining the depth of freeze beneath pavements with gravel bases*	12-14
Figure 12-8.	*Permafrost degradation under* different *surface treatments*	12-15
Figure A-1.	*CBR design flowchart*	A-2
Figure A-1.	*CBR design flowchart (continued)*	A-3
Figure A-2.	*Grain size distribution of Rio Meta Plain soil*	A-7
Figure A-3.	*Plasticity chart plotted with Rio Meta Plain soil data*	A-8
Figure A-4.	*Density-moisture curve for Rio Meta Plain soil*	A-9
Figure A-5.	*Swelling curve for Rio Meta Plain soil*	A-10
Figure A-6.	*CBR Family of Curves for Rio Meta Plain soil*	A-11
Figure A-7.	*Density-moisture curve for Rio Meta Plain soil with density and moisture ranges plotted*	A-12

Page

Figure A-8. *CBR Family of Curves for Rio Meta Plain soil with density range plotted* A-13

Figure A-9. *Design CBR from Rio Meta Plain soil from CBR Family of Curves* A-14