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by

Karsten Matthew Koch

1999

# An Examination of the Requirements for Fill Materials Included in Guide Specifications

by

# Karsten Matthew Koch, B. S. Civil Engineering ${{\parallel}\!\!\!/}{{\parallel}\!\!\!\!/}$

#### Report

Presented to the Faculty of the Graduate School of

The University of Texas at Austin

in Partial Fulfillment

of the Requirements

for the Degree of

#### **Master of Science in Engineering**

The University of Texas at Austin August 1999

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# An Examination of the Requirements for Fill Materials Included in Guide Specifications

#### Acknowledgements

I would like to thank Dr. Stephen Wright for his assistance in helping me to define a precise scope for this project and for keeping me focused on it throughout my research and writing. I would also like to thank Dr. Alan Rauch for his useful commentary in the preparation of the final draft of this report.

August 13, 1999

#### Abstract

# An Examination of the Requirements for Fill Materials Included in Guide Specifications

Karsten Matthew Koch, M.S.E. The University of Texas at Austin, 1999

Supervisor: Stephen Wright

Guide specifications for fill materials are used in the preparation of the earthwork sections of specifications for individual projects. This report discusses the agencies that produce guide specifications for fill materials and the specific material characteristics that these specifications stipulate. A database of requirements for fill materials taken from 27 sources was compiled for this report. Data from this database were sorted and plotted and conclusions were drawn regarding the material characteristics stipulated by this set of specifications. Recommendations for writing guide specification are presented.



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#### **Chapter 1: Introduction**

Construction of retaining walls, embankments for roadways, earth dams, and utility trenches are just a few examples of projects where earth needs to be placed and compacted as fill. It is usually the job of the geotechnical engineer who performs the design to determine what kind of soil is suitable for the task. While each design deserves individual attention, "guide specifications" exist that can guide the engineer in the selection of a suitable fill material.

Guide specifications are also called "master specifications" or "standard specifications". These are templates that are used to create specific contract specifications. Contract specifications are the actual documents that a contractor and an owner agree upon for the performance of work for a specific project. While contract specifications are by nature precise and specific documents that are tailored to a specific project, guide specifications, which may be used for a multitude of projects, usually make more generalized recommendations.

The primary goal of the study described in this report is to determine what similarities and differences there are in various guide specifications for fill materials. Since the focus of this report is on fill materials, all references to guide specifications are references specifically to guide specifications for fill materials unless otherwise noted. Chapter 2 presents the agencies that use guide specifications and explains how their guide specifications can be obtained. Chapter 3 presents a database containing requirements for fill materials that was created during this study from a diverse collection of guide specifications.

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Chapter 3 also explains how the database works and why the database design was chosen. Chapter 4 presents results of an examination and summary of the data in the database as well as any trends or lack of trends in the data. Chapter 5 contains the summary and conclusions for this study.

#### **Chapter 2: Obtaining Guide Specifications for Fill Materials**

This chapter describes some of the various agencies that maintain guide specifications and presents specific examples from each agency. Methods for obtaining copies of the guide specifications are presented. The guide specifications that are used in this study come from 5 major sources: federal, state, and municipal agencies, manufacturers, and textbooks. The specifications also exist in two main forms of media: electronic and printed.

#### **ELECTRONIC VERSIONS**

Electronic copies of guide specifications are distributed in four basic forms: Internet sites, floppy diskettes, compact discs (CD's), and digital video disks (DVD's).

#### Internet Sites

The Internet is the easiest and fastest way to obtain copies of guide specifications. The most important thing to know is where to look. Known Internet sites with guide specifications and recommended strategies for searching for additional specifications on the Internet are presented below.

#### Federal Level

At the federal level, Internet sites of U.S. government agencies provide a good place to look for guide specifications. Both military and civilian branches of the government use guide specifications and several post full versions of their

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specifications on the Internet. Six government agencies and the corresponding links that lead directly to their guide specifications are listed in Table 2.1.

Table 2.1 - Federal Level Links to Guide Specifications for Fill Materials

Agency	Link
United States Army (Corps of	www.hnd.usace.army.mil/
Engineers)	techinfo
United States Navy (Naval Facilities	www.nfgs.navy.mil
Engineering Command)	
National Aeronautics and Space	www-de.ksc.nasa.gov/
Administration	specsintact/masters.htm
Federal Aviation Administration	www.faa.gov/
	arp/5370-10a.htm
Department of Veterans Affairs	www.va.gov/
	facmgt/standard/spec_idx.htm
Los Alamos National Laboratory	pelagius.lanl.gov:8080/
	f/standards/f9stds/conspec/htmls/
	stdspec.html

#### State Level

At the state level, the Internet sites of many state departments of transportation (DOTs) provide a good source for guide specifications. Two state agencies and the corresponding links to their guide specifications are listed in Table 2.2. Table 2.2 also provides a link to aid in the search for additional guide specifications at the state level.






Agency	Link
Oregon DOT	www.odot.state.or.us/
	techserv/roadway/specs/96book.htm
Florida DOT	www.dot.state.fl.us/
	specificationsoffice/StandPage.htm
Homepages of DOTs for 47 US States	www.library.nwu.edu/
	transportation/statedot.html

Table 2.2 - State Level Links to Guide Specifications for Fill Materials

# Municipal Level

Some cities and towns publish guide specifications on the Internet in the public works section of their Internet site. Two cities and the corresponding links to their guide specifications are listed in Table 2.3. Table 2.3 also provides two links to aid in the search for additional guide specifications at the municipal level.

Table 2.3 - Municipal Level Links to Guide Specifications for Fill Materials

Agency	Link
City of Lake Oswego, OR	www.ci.oswego.or.us/
	engineer/spec.htm
City of Houston, TX	www.ci.houston.tx.us/
	departme/works/ecre/e&cdocs
Homepages of the 50 Largest Cities in	www.wplwloo.lib.ia.us/
the United States	50cities.html
Homepages of Cities throughout the	www.officialcitysites.com
World	

# Manufacturer Level

Manufacturers of geotechnical-related products often develop guide specifications describing the kind of fill materials that they have approved for use with their products. Two manufacturers and the corresponding links to their the second se



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guide specifications are listed in Table 2.4. Table 2.4 also provides a link to aid in the search for additional guide specifications at the manufacturer level.

Company	Link	
Geostone Segmental Retaining Walls	www.geostone.com/	
	tech.asp	
Keystone Retaining Wall Systems, Inc.	www.keystonewalls.com	
Mesa Retaining Wall Systems by	www.tensarcorp.com/	
Tensar Earth Technologies, Inc.	download/dg_mesa.pdf	
The Internet Directory for Specified	www.4specs.com	
Construction Products <sup>™</sup>		

Table 2.4 - Manufacturer Level Links

## Searching the Internet Further

Three search schemes were used in this study to locate guide specifications. The first scheme consisted of locating and using "directories". Directories are on-line listings that are manually compiled by people. The second search scheme used a "search engine". A search engine is different from a directory in that it does not depend on people to compile the listings, but instead searches the Internet itself to find new Internet sites not already in the database. The third search scheme used a special type of search engine called a "metacrawler". A metacrawler is actually a search engine that uses several other search engines to perform the actual search. It works by sending a search request to other search engines in parallel and then returns the listings from the other search engines.

In a search for guide specifications, there are many directories, search engines, and metacrawlers available for use by the three search schemes presented above. Depending on the search phrase used, some return useful listings and

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some return listings that are not useful. In this study, no conclusion was reached concerning which directory, search engine, or metacrawler is the best to use for searching for guide specifications. All of the major directories, search engines, and metacrawlers seemed to work equally well for such a search.

The first step in searching for guide specifications on the Internet is simply to pick a specific directory, search engine, or metacrawler and examine the results to see if they are useful. If little or nothing of value is returned, another should be tried. A helpful site for deciding which directory, search engine, or metacrawler to use is [searchenginewatch.com]. This site lists and reviews almost every directory, search engine, and metacrawler on the Internet.

Once a directory, search engine, or metacrawler is chosen, one or more words to use in the search must be chosen. The following phrases seemed to work well for the searches performed for this study: "specifications", "guide specifications", "standard specifications", "master specifications", "construction specifications", "contract specifications", and "earthwork specifications".

#### **Project Internet Site**

As a part of this study, an Internet site was created. The site contains the complete database for fill materials presented later in this report and all of the guide specification links presented above. The address of the site is [www.ce.utexas.edu/stu/kochkm/home.htm].

#### Diskettes, CD-ROMs, and DVDs

An agency with a need for frequent and widespread use of its guide specification may publish the guide specification on either a CD-ROM or a DVD.

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One of the best known examples of this is the Construction Criteria Base (CCB) published by the National Institute of Building Sciences (NIBS). It comes either as a set of seven CD-ROMS or as one DVD and contains guide specifications and design standards from 22 federal agencies and more than 110 other agencies. There is also a CCB Internet site at [www.ccb.org] where many of these documents are also available for download by subscribing members. Non-subscribing members can download a maximum of five of these documents which makes this a useful visit in a search for guide specifications.

# **PRINTED COPIES**

Before the advent of the Internet, guide specifications were typically published by agencies as books or in three-ring binders. Even with the proliferation of electronic versions now available, many guide specifications are still published on paper.

# States DOTs

Most, if not all, state DOTs publish their guide specifications every year in the form of a hard cover or soft cover book. The most recent versions typically cost less than \$50. Depending on the intended use, individual copies may sometimes be obtained free of charge. Phone numbers and current prices can be found on the state DOT Internet sites.

### Engineering Textbooks, Handbooks, and Manuals

While not guide specifications themselves, geotechnical engineering and construction textbooks, handbooks, and manuals can provide guidance on how to specify requirements for fill materials in guide specifications, and what those

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requirements might be for common cases. Two textbooks that offer guidance for specifying fill requirements are the Construction Guide for Soils and Foundations, 2<sup>nd</sup> Edition<sup>1</sup> and Design of Earth Retaining Structures, Spring 1999 Edition.<sup>2</sup> One example of a handbook that offers fill specification guidance is the Standard Handbook for Civil Engineers, 4th Edition.<sup>3</sup> Finally, engineering and design manuals published by government agencies can also assist in determining requirements for fill materials. Two examples of such manuals are the Army Corps of Engineers Engineer Manuals [www.hnd.usace.army.mil/techinfo] and the United States Bureau of Reclamation Earth Manual [www.usbr.gov/tcg/earth/index.html]. These manuals can also be found on the Internet at the addresses given above.

<sup>1</sup> Ahlvin, Richard G., ed. and Smoots, Vernon Allen, ed. Construction Guide for Soils and Foundations, 2nd ed. New York: John Wiley & Sons, 1988.

<sup>2</sup> Olson, R. E. Design of Earth Retaining Structures: CE 387R, Spring 1999. Austin, Texas: The University of Texas at Austin Co-op, 1999.

<sup>3</sup> Merritt, Frederick S., ed., Loftin, M. Kent, ed., and Ricketts, Jonathan T., ed. Standard Handbook for Civil Engineers, 4th ed. New York: McGraw-Hill, 1996.

# Chapter 3: A Database of Guide Specification Requirements for Fill Materials

On a conceptual level, the creation of a database for this study can be divided into two parts: defining the scope of the database and addressing issues of extracting, organizing, and compiling the data. These two parts are addressed next.

#### **DEFINING THE SCOPE**

Two major decisions needed to be made at the outset of this study regarding the scope. First, the breadth of usage for different fill materials needed to be established. Second, the specific sections of guide specifications for fill materials that needed to be examined had to be determined.

After some deliberation, it was decided that the scope would be restricted primarily to fill materials used for embankments, retaining walls, bedding, and trenches. General fill and structural fill were also examined. Fill materials that involve chemical treatment of the fill, such as lime or cement stabilization, are excluded, except in a few specific instances where chemical treatment alters the allowable values for the types of fill requirements examined in this study. For example, the Louisiana DOT allows a higher plasticity index for embankment fills that are treated with lime. Base courses for roads and highways are also not considered in this study, nor are rip-rap, top soil, and working platforms.

After further deliberation, it was decided to focus on only those sections of the specifications that covered the characteristics of the fill materials. Sections

that specify procedures such as ground preparation before placement of the fill, compaction of the fill after placement, and testing of the fill before and after placement are not addressed in this study.

## ISSUES OF EXTRACTING, ORGANIZING, AND COMPILING DATA

There are several challenges that must be dealt with when summarizing the content of a guide specification, comparing this summarized content with that from other guide specifications, and even when simply reading a guide specification. One obvious and inherent drawback of reducing the complete text of a guide specification into a database of values and brief descriptions is that some information is lost in the process. This challenge is dealt with in part by sufficiently narrowing the scope of this study as addressed above and also by carefully selecting what information is most critical.

Another challenge of creating a single database of fill material requirements from diverse sources is standardization of the language. Of particular interest in this regard are the terms used for describing the intended purposes of the fill materials being considered. A balance had to be found between preserving the specific language of a guide specification and entering data into the database in a usable and comparable form. For instance, the following terms found in the guide specifications of this study have meanings that overlap in some ways and connote differences in others:

- 1. "fill for buildings" and "fill for structures"
- 2. "fill for utilities" and "fill for trenches"

- 3. "base fill" and "bedding fill"
- 4. "select fill" and "controlled fill"

In this study, every effort was made to consistently use the same terminology in creating the database.

Some gradation requirements for fill materials found in guide specifications are very lengthy and highly detailed, especially for granular fill materials. In these cases, such as when several alternative gradations are specified or a gradation matrix of all possible gradation alternatives is presented, the most commonly used gradation requirements were entered into the database.

Some guide specifications require that a numerical value be specified in the contract specification for a particular fill material characteristic, but do not specify what value to use or even recommend one. Instances such as these are treated the same way as those in which the guide specifications say nothing at all about the value.

Sometimes one section of a guide specification will not give a fill material requirement because the requirement is given in more general terms in another section of the guide specification. If no cross-reference is provided, then determining whether or not the fill material requirement is specified elsewhere becomes a daunting task. In these instances, if the more general requirement could be found, then it was applied to the particular purpose being considered. If a more general requirement was not found, then it was assumed that the specification says nothing in this regard.

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#### **CHOOSING A SOFTWARE APPLICATION**

The first tangible step in the creation of the computer database was to choose an appropriate software application. Three software applications were examined for this purpose: Microsoft Word, Microsoft Excel, and Microsoft Access.

# Microsoft Word and Excel

The initial database created for this study consisted of a relatively simple table in Microsoft Word. This approach was chosen initially because it could easily accommodate paragraph size text descriptions as necessary, which made it easier to preserve more of the language of the guide specification. This approach, however, had two flaws that prevented it from clearly showing trends in the data.

The first flaw was the result of the specific design used for the table – it did not draw the appropriate distinction between uses and types of fill materials. This is a critical distinction that had to made before useful conclusions could be drawn from the data. While this flaw could have been corrected, the second flaw was more fundamental and could not be solved without a change in software application.

The second flaw of the table in Microsoft Word was its rigidity, that is, it did not allow for efficient entry and storage of data and it did not allow the data to be sorted and rearranged with the level of flexibility needed. The possibility of using Microsoft Excel instead of Word was considered, but Excel did not add enough flexibility to the database and was therefore not used. However, Excel was utilized in this study for creating charts and graphs.

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# **Microsoft Access**

It was finally decided that a relational database such as Microsoft Access would be the best choice of software application for this study. The power of a relational database comes from the fact that it stores data in separate smaller tables instead of in one large table. This agency structure allows the data to be combined and compared with much greater flexibility than could be done with either Microsoft Word or Excel. A relational database also allows for more efficient data entry since any data that are repeated in multiple records has to be entered only once. Finally, Access encourages uniformity of data entry, which further enhances the comparability of the data. In contrast, records in Word may have individualities of format or language that prevent easy comparison. The next section explains these concepts in greater detail using specific examples from this study.

# **DESIGN OF THE DATABASE**

Fill materials requirements were entered, stored, and examined using tables, queries, forms, and reports from Access and the plotting capability of Excel.

# Tables

Tables are the fundamental building blocks of any relational database. Tables are composed of fields and records where raw data are stored in small groups. Records are stored in the rows of the table and field values are stored in the columns of the table. The fill materials database in this study is composed of the seven tables described below.

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# Agency

The Agencies table shown in Figure 3.1 has one field called "Agency" with a unique agency name in each row. Each name is entered into the table manually.

## Purposes

The Purposes table shown in Figure 3.2 has one field called "Purpose" with a unique fill material purpose in each row. Each purpose is entered into the table manually.

## Satisfactory Soil

The Satisfactory Soils table shown in Figure 3.3 has three fields called "satisfactory soil ID", "satisfactory soil", and "agency". In each row there is a unique alphanumeric ID, a unique satisfactory soil description, and the name of the agency that authored the description. The alphanumeric ID's were created solely for the purpose of this database. They consist of an abbreviation of the agency's name, a number, and an abbreviation of the fill material requirement category. For example, if three different descriptions of satisfactory soil are used by NASA, then the three associated ID's that would be used in this database would be nasa1s, nasa2s, and nasa3s. The creation of unique ID's is an important step in building a relational database as demonstrated later in this report.

For each record in the Satisfactory Soils table, data are entered manually into the description and ID fields. The agency name can selected from a drop down menu if the name has already been entered into the Agencies table.

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	Agency			
	AASHTO 1984			
	Army COE 1997			
	CGSF 1988			
	DERS 1999			
	FAA 1991			
	FL DOT 1999			
	Geostone			
	Houston 1997			
_	IL DOT 1997			
_	Keystone 1994			
-	LA DUI 1992			
	Lake Uswego 1999			
	LANL 1997			
	Novy 1998			
-	NM DOT 1994			
	OR DOT 1996			
	Scotland DOT 1976			
1	SHCE 1996			
	Tensar 1997			
	TX DOT 1993			
	USBR 1999			
	UT DOT 1994			
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	WI DOT 1996			
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Figure 3.1 - Agencies table



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Purpose			
Bedding (For Foundations)			
Bedding (For Sidewalks And Curbing)			
Bedding (For Slope Protection)			
Bedding (General)			
Blankets (For Stone Protection)			
Blankets (Plastic Soil)			
Capillary Water Barrier (Under Concrete Slabs)			
Cellular Cofferdams			
Culverts			
Drains (Subsurface)			
Embankments (Dam, Impervious Soil)			
Embankments (Dam, Pervious Soil)			
Embankments (General)			
Embankments (General, Pervious Soil)			
Embankments (Granular)			
Embankments (Nonplastic Soil)			
Embankments (Soil Above 8 ft Depth)			
Embankments (Soil Below 8 ft Depth)			
Embankments (W/in 1000 ft Of Bridge End)			
Filters (Blanket)			
Filters (For Dam Embankments)			
Filters (For Rip-Rap)			
Foundations (Bridge)			
Foundations (General)	2		
General Fill	·		
Record: 1 + + + of 48			
Datasheet '	11.		

Figure 3.2 - Purposes table



R Microsoft Access	- [Satisfactory Soils : Ta	ble]	
⊏ <u>Eile E</u> dit <u>Y</u> lew	<u>I</u> nsert F <u>o</u> rmat <u>R</u> ecords <u>I</u>	ools <u>W</u> indow <u>H</u> elp	-8
			×
Satisfactory So	II ID Satisfactory Soil	Agency	
aashto1s	Cinders, sand, slag, gravel, or crushed stone.	AASHTO 1984	
aashto2s	Porous, free- draining material consisting of	AASHTO 1984	
aashto3s	Hard, durable particles or fragments of	AASHTO 1984	
aashto4s	Hard, durable, clean sand, gravel, crushed	AASHTO 1984	
aashto5s	Gravel, crushed gravel, crushed stone, crushed air-	AASHTO 1984	8 ) 
army1s	GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-	Army COE 1997	
army2s	Washed sand.	Army COE 1997	
army3s	Clean, crushed, nonporous rock, crushed gravel, or	Army COE 1997	
army4s	Well-graded sand, gravel, crushed gravel, crushed	Army COE 1997	
army5s	Clays, silty clays, or clayey silts. Silts and clays	Army COE 1997	Ŧ
Record: 14	1 > >1 >* of 64		
Datasheet View			11.

Figure 3.3 - Satisfactory soils table



# Unsatisfactory Soil

The Unsatisfactory Soils table shown in Figure 3.4 is identical to the Satisfactory Soil table except that it contains a list of unique unsatisfactory soil descriptions.

# Gradation

The Gradations table shown in Figure 3.5 is identical to the Satisfactory soils table except that it contains a list of unique soil gradations.

# Other Requirements

The Other Requirements table shown in Figure 3.6 is identical to the Satisfactory Soils table except that it contains a list of unique soil requirements not included in any of the previous tables.

# Main Table

The Main Table is the backbone of the database. It is where the information from all of the previously mentioned tables is merged into one larger table. As seen in Figure 3.7, it is composed of nine fields. Each row of the Main Table contains a unique combination of agency and purpose along with the corresponding material requirements. Each row also contains the IDs of the corresponding satisfactory soil description, unsatisfactory soil description, gradation, and other requirements. In addition to the six fields already mentioned, each row in the Main Table has fields for maximum particle size, maximum liquid limit, and maximum plasticity index that are called "particle size", "liquid limit", and "plasticity index", respectively. In each row, information in the first six fields

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🔍 Microsoft Access - [Unsatisfactory Soils : Table]				
Eile Edit View Insert F	ormat <u>R</u> ecords <u>T</u> ools <u>W</u> in	dow Help _ B ×		
Unsatisfactory Soil ID	Unsatisfactory Soil	Agency 🔺		
▶ þashto1u	Soil that cannot be properly compacted, sod, and vegetable	AASHTO 1984		
aashto2u	Organic material, clay balls, or other deleterious	AASHTO 1984		
army1u	Materials containing man-made fills, trash, refuse, backfills from	Army COE 1997		
army2u	OL, OH, and PT. Materials containing man-made fills, trash,	Army COE 1997		
armyЗu	ML, MH, and CH for critical structures.	Army COE 1997		
army4u	Materials containing brush, roots, sod or other perishable	Army COE 1997		
army5u	Material containing thin, flat and elongated particles	Army COE 1997		
dsgn1u	Material containing organic matter.	DERS 1999		
faa1u	Frozen material or material containing vegetable or organic	FAA 1991		
	Material containing			
Datasheet View				

Figure 3.4 - Unsatisfactory soils table



2	Microsoft Acces	s - [Gradation : Table]	_ [ ]	×
	III <u>File E</u> dit <u>V</u> iew	Insert Format <u>R</u> ecords <u>I</u> ools <u>W</u> indow <u>H</u> elp	_ 18	×
	Gradation ID	Gradation	Agency	-
	aashto1	Uniformly graded.	AASHTO 1984	
	aashto2g	3 in 100% no. 4 20-50% no. 200 0-10%	AASHTO 1984	
	aashto3g	Course Aggregate (AASHTO M 43, size No. 89): mm % 12.5 100 9.5 90-100	AASHTO 1984	
	aashto4g	AASHTO M 43, size No. 357: mm % 63 100 50 95-100	AASHTO 1984	
	aashto5g	AASHTO M 43, size No. 467: mm % 50 100 37.5 95-100	AASHTO 1984	
	army1g	0.075 mm less than 5% 0.020 mm not more than 2%	Army COE 1997	
	army2g	4.75 mm no more than 2%	Army COE	-
R	ecord: II I	1 ▶ ▶I ▶* of 50		
C	Patasheet View			11.

Figure 3.5 - Gradations table

\_\_\_\_\_

Microsoft Access - [Other R	equirements : Table]	_ 🗆 ×		
	nat <u>R</u> ecords <u>T</u> ools <u>W</u> indow <u>H</u> elp	<u>_ [5] ×</u>		
Other Requirements ID	Other Requirements	Agency 🔺		
▶ dsgn1o	Angle of internal friction not less than 34 degrees.	DERS 1999		
filo	Los Angeles Abrasion: maximum loss 45%. Soundness (Sodium Sulfate):	FL DOT 1999		
fl2o	Organic material: not more than 2% by weight. pH from 6 to 10.	FL DOT 1999		
il1o	Bearing Ratio not less than 80 (for embankment fill only except when crushed gravel, crushed stone, or	IL DOT 1997		
la1o	Organic content less than 5%. Silt content of 60% or less.	LA DOT 1992		
la2o	Organic content of 2% or less. Silt content of 60% or less.	LA DOT 1992		
la3o	Organic content of 4% or less.	LA DOT 1992		
la40	pH from 5.5 to 8.5.	LA DOT 1992		
navy1o	Coefficient of permeability shall be a minimum of 0.01-1 mm/sec (0.002-0.2 ft/min).	Navy 1998		
none	Not specified.			
tensar1o	pH from 5 to 9 (waived when high density polyethylene or polypropylene geogrid is used).	Tensar 1997 👻		
Record: II I	Record: 1 + + + + of 15			
Datasheet View				

Figure 3.6 - Other requirements table


Microsol	t Access	- (Main Table : Table						
ad File Ec	lit <u>View</u>	Insert Format Records	Icools Window Help					× BI=
Agency	Purpo	se Satisfactory Soll	ID Unsatisfactory Soll IC	Particle Size Gr	radation	Liquid Limit	Plasticity Index	Other Regulrements ID +
ASF -	Embai	none	aashto1u	Not specified. no	ne	Not specified.	Not specified.	none
AASH	Beddir	aashto1s	none	1/2 inch. no	ne	Not specified.	Not specified.	none
AASH	Beddir	aashto2s	none	1 1/2 inches. aa	ishto1	Not specified.	Not specified.	none
AASH	Filters	aashto3s	none	3 inches. aa	ishto2	Not specified.	Not specified.	none
AASH	Trench	aashto4s	aashto2u	1/2 inch (Cour aa	Ishto3	Not specified.	Not specified.	none
AASH	Drains	aashto4s	aashto2u	1/2 inch (Cour aa	ishto3	Not specified.	Not specified.	none
AASH	Blank	aashto5s	none	2 1/2 inches. aa	Ishto4	Not specified.	Not specified.	none
AASH	Filters	aashto5s	none	2 inches. aa	ishto5	Not specified.	Not specified.	none
Army	Gener	army1s	army1u	Half of the allo no	ne	Not specified.	Not specified.	none
Army	Struct	army1s	army2u	3 inches. no	ane	Not specified.	Not specified.	none
Army	Struct	army2s	army3u	Not specified. an	my1g	Not specified.	Not specified.	none
Army	Capills	army3s	none	1 1/2 inches. an	my2g	Not specified.	Not specified.	none
Army	Trenct	armyts	army1u	3 inches. no	ane	Not specified.	Not specified.	none
Army	Trenct	army4s	none	3 inches or 1 i an	my3g	Not specified.	Not specified.	none
Army	Embai	army5s	army4u	Not specified. no	ane	Not specified.	Not specified.	none
Army	Embai	army6s	army4u	Not specified. no	ane	Not specified.	Not specified.	none
Army	Filters	army7s	army5u	Not specified. an	my4g	Not specified.	Not specified.	none
CGSF	Gener	guide1s	guide1 u	Not specified. gu	uide1g	Not specified.	Not specified.	none
DERS	Retain	none	dsgn1u	4-6 inches. ds	ign1g	Not specified.	9	dsgn1o
DERS	Cellula			Not specified.		Not specified.	Not specified.	×
FAA .	Embai	none	faalu	4 inches (with no	ane	Not specified.	Not specified.	none
FLDC	Embai	none	filu	3.5 inches (0- fl1	5	Not specified.	Not specified.	none
FLDC	Trench	fils	fl2u	3/4 inch. ft2	6	Not specified.	Not specified.	f10
FL DC	Geosy	fl2s	fl3u	3 1/2 inches. fl3	6	15	9	fi2o
Geost	Retain	geost1s	none	1 1/2 inches (i no	ne	Not specified.	Not specified.	none
Houst	Embai	none	houst1u	3 inches, no	one	45.	12 to 20 (do not u	none
Record: 14	-	JO *4 14 4 1	109					Andrews and
Datasheet (	iew							

Figure 3.7 - Main table

contraction of the second

mentioned above can be entered into the fields with the use of drop down menus (assuming the data have already been manually entered into the corresponding tables). In each of the latter three fields, the information is entered manually. The information in these latter three fields varied too widely in this study to warrant the creation of separate tables for these data.

#### Queries

Queries bring together information from different individual tables into a single table in a meaningful way. Although this may sound very similar to what the Main Table does, the difference is in what information is displayed. Queries match two or more records from different tables that have similar data in one of their fields and then display those two records as one new record with only the desired information shown. For example, in the Main Table there may be several records with gradation IDs that exactly match the gradation ID of a record in the Gradations table. By finding fields with matching data, a query can identify which records from these two tables are related, take only selected fields from each of these records, and string these selected fields together to create a new temporary record that is displayed in a query table. For example, a query could be used to create a new table that has only agency, purpose, and gradation as the column headings with the corresponding data shown in the rows of the table. The gradation IDs, which are not of interest, would not be displayed.

Figure 3.8 is a graphical representation of the tables and the relationships between tables that are used by queries to identify what records are related in the set of tables. All of the tables in the database are shown in this figure along with

to and the second se



Figure 3.8 - Database relationships diagram



their field names introduced previously in this report. A field name that is shown in bold is called the "primary key" of that table. A primary key is a field that is guaranteed to contain a value that is unique to only one record in the table. For example, say that the value of a primary key field of a given record in one table is found in another record somewhere else in the database. In this example, it can be concluded that the latter record refers only to the former record since no other record has the same primary key value.

Each line in Figure 3.8 connects the common field that is present in both tables. The infinity symbol indicates that multiple records in that table can have identical values for the common field, but the 1 symbol indicates that no two records in that table can share the same value for the common field. In tables that contain a primary key field, the common field is the primary key field and a 1 is displayed next to the bold field name. The relationships shown in Figure 3.8 are examples of what is known as a one-to-many relationship.

The database that was created for this study has four predefined queries. These queries are used to gather information from the database in preparation for producing printed reports. Additional queries with any desired combination of fields can be created as well. The four predefined queries of the database are discussed below.

# ID Query

The ID Query shown in Figure 3.9 looks very much like the Main Table except that both the descriptions and the IDs for the descriptions are displayed.

# states and provide the

the state of the local data and the state of the state of

Agency Purposal S Navy Found n Navy Slabs n Navy Retain Navy Trenct n Navy Struct n	Satisfactory Sol	It ID Unsatisfactory So						
Navy Drains n Navy Found n Navy Slabs n Navy Retain n Navy Trenct n Navy Struct n	avy3s		il ID Particle Size	a Gradation	Liquid Limit, Plasticity Index	Other Requirements	ID Gradation Other Requires	ments Satisfactory Soli Unsatis
Navy Found n Navy Slabs n Navy Retain n Navy Trenct n Navy Struct n	made	none	A size that w	il navy2g	Not specified. Not specified	none	a Perforate Not specified.	Clean sand, stone Not spe
Navy Slabs n Navy Retain n Navy Trenct n Navy Struct n	Steland	none	2 1/2 inches.	navy3g	35 12	navy10	2 1/2 in Coefficient of per	imeab GW, GP, SW, or : Not spe
Navy Retain n Navy Trenct n Navy Struct n	styver	none	2 1/2 inches	BEKneu	35 12	navyto	2 1/2 in Coefficient of per	imeab GW, GP, SW, or : Not spe
Navy Trenct n Navv Struct n	tavy4s	none	2 1/2 inches.	05 Man	35 12	navy10	2 1/2 in Coefficient of per	imeab GW, GP, SW, or : Not spe
Naw Struct n	lavy4s	BUON	2 1/2 inches	navy3g	35 12	nawy10	2 1/2 in Coefficient of per	imeab GW, GP, SW, or : Not spe-
fam.	anyos	navy2u	3 inches	navy4g	Not specified Not specified	none	Shall conts Not specified	GP, GM, GC, SP, Soft, sp
Navy Trenct n	avy6s	new/3u	3 inches	none	Not specified Not specified	none	Not specifie Not specified	GM, SM, or SC PT, OH,
Nawy Trenct n	any7s	none	2 inches.	navy5g	Not specified. Not specified	none	50 mm Not specified.	Clean crushed roc Not spe
Navy Gener n	ames	navy4u	Half of the all.	o navy6g	35 12	none	0 075 mm Not specified	GW, GP, GM, GC Material
Navy Beddir n	avy9s	none	2 inches	navy7g	Not specified. 6 (for matenal pa	none	Class I: Si; Not specified.	Sand, gravel, or cr Not spe
Army Gener a	amy1s	amy1u	Half of the all.	o none	Not specified Not specified	none	Not specifie Not specified.	GW, GP, GM, GP Material
Army Struct a	amy1s	amy2u	3 inches.	none	Not specified Not specified	none	Not specifie Not specified	GW, GP, GM, GP OL, OH,
WVE Gener w	w2s	new	2 inches	P119	Not specified Not specified	wv20	50 mm Crushed stone I	Perce Crushed stone: pa Crushed
WVE Gener w	sew	ww2u	3 inches.	none	Not specified. Not specified	none	Not specifie Not specified.	Random material ( Material
WV C Trenct w	wds	none	3 inches	none	Not specified Not specified	none	Not specifie Not specified.	Random material ( Not spe
WV C Drains w	w3s	none	Not specified	none	Not specified Not specified	none	Not specifie Not specified.	Random material ( Not spe-
Tenss Retain to	ensar1s	none	2 inches	tensaric	Not specified Not specified	tensarlo	2 inch pH from 5 to 9 (v	waived Granular soil Rec Not spe-
Geost Retain g	reost1s	none	1 1/2 inches.	(1 none	Not specified Not specified.	none	Not specifie Not specified.	On-site dewatered Not spe
FL DC Embai n	none	ftu	3.5 inches (0	- filg	Not specified Not specified	none	A gradation Not specified	Not specified Material
FL DC Trenct 1	11s	ŋŊ	3/4 inch.	629	Not specified. Not specified	610	19 mm Los Angeles Abi	irasion Naturally occurring Material
FLD( Geosy ft	Ds	13u	3 1/2 inches	fgg	15 6	fi2o	90 mm Organic material	if not t Free draining mate Soil cen
OR D Struct o	orts	none	3 inches.	or1g	Not specified 6 (for matenal pa	none	75 mm ' Not specified.	Granular matenal + Not spe
OR D Struct o	or2s	none	2 inches	or2g	Not specified 6 (for matenal pa	none	50 mm Not specified.	Granular material e Not spe
USBF Embai n	one	usbr1u	5 inches.	none	Not specified. Not specified.	none	Not specifie Not specified.	Not specified PT, OL,
AASH Embai n	none	aashto1u	Not specified	none	Not specified Not specified	none	Not specifie Not specified	Not specified Soil that
AASH Beddir a	ashto1s	none	1/2 inch.	none	Not specified. Not specified	none	Not specifie Not specified.	Cinders, sand, sla Not spe
AASH Beddir a	ashto2s	none	1 1/2 inches	aashto1	Not specified Not specified	none	Uniformly c Not specified	Porous, free-draini Not spe
AASH Filters a	ashto3s	none	3 inches.	aashto2	Not specified Not specified	none	3 in Not specified.	Hard, durable parts Not spe
tord: 14   c	1 + 11 + 1	1 100 4						

Figure 3.9 - ID query



This query is used to compile a list of records that contain all of the information in the entire database.

# Description Query

The Description Query shown in Figure 3.10 also looks like the Main Table except that it displays descriptions instead of IDs. This query is used to compile a list of records that contain all of the information in the entire database except the IDs.

## Particle Size Query

The Particle Size Query shown in Figure 3.11 is used to display records that show agency, purpose, and maximum particle size only.

## Atterberg Limits Query

The Atterberg Limits Query shown in Figure 3.12 is used to display records that show agency, purpose, liquid limit, and plasticity index only.

### Forms

Both tables and the results of queries can be transformed into forms to aid with data entry and display. A form can be thought of as a table with only one row displayed at a time. Since a form displays only one record at a time, the fields can be rearranged and resized on the screen in a way that best shows the data that they contain. The database that was created for this study has six predefined forms. Additional forms with any desired combination of fields can be created as well. The six predefined forms of the database are introduced next.

×	×	4									M. A				×								•		h
-	-18	quirements	fied.	t of permeab	t of permeab	t of permeab	t of permeab	fied.	fied.	fied.	fied.	fied.	fied.	fied.	stone: Percei	fied.	fied.	fied.	to 9 (waived	fied.	fied.	les Abrasion	naterial: nnt r	and the second se	
		Other Re	: Not speci	Coefficien	Coefficien	Coefficien	Coefficien	Not speci	Not speci	Not speci	Not speci	Not speci	Not speci	Not speci	Crushed s	Not speci	Not speci	Not speci	pH from 5	Not speci	· Not speci	Los Ange	Ornanic n	in commune print	
		Gradation	a. Perforate	2 1/2 in	2 1/2 in	2 1/2 in	2 1/2 in	Shall conte	Not specifi	50 mm	0.075 mm	Class I: Si:	Not specifi	Not specifi	50 mm	Not specifi	Not specifi	Not specifi	2 inch	Not specifi	A gradatior	19 mm	mm []6	and a subscription of the	
		satisfactory Soil	specified.	specified.	specified.	specified.	specified.	t, spongy, highly	OH, or OL. Mate	specified	terial containing d	specified.	terials containing	, OH, and PT. Mar	shed stone: partic	terial containing fr	specified.	specified.	specified.	specified.	terial containing n	terial containing u	I cament or lime s	<ul> <li>A (1)</li> <li>A (1)</li> </ul>	-
		actory Soil Un:	sand, stone, Not	P, SW, or S Not	M, GC, SP, Sof	M, or SC. PT.	crushed rock Not	sP, GM, GC, Mai	gravel, or cru Not	sP, GM, GP- Mai	SP, GM, GP- OL	ed stone: par Cru	m material (¿ Ma	m material (¿ Not	m material (¿ Not	ar soil. Recy Not	e dewatered, Not	ecified. Mai	lly occurring Mai	raining mate Soi					
		ex Satisf	Clean :	GW, G	GW, G	GW, G	GW, G	GP, GI	GM, S	Clean	GW, G	oa Sand,	GW, G	GW, G	Crushe	Rando	Rando	Rando	Granul	On-site	Not sp	Natura	Free d	And a second	
iyl	dow thelp	Plasticity Inde	Not specified.	12	12	12	12	Not specified.	Not specified.	Not specified.	12	6 (for material p	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	œ		
ry : Select Que	rds Iools Win	Liquid Limit	lot specified.	5	5	5	5	vot specified.	Vot specified.	vot specified.	5	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	Vot specified.	5	of 108	
escription Que	t Format Beco	article Size	size that wil h	1/2 inches. 3	1/2 inches. 3	1/2 inches. 3	1/2 inches. 3	inches. h	inches. h	inches.	alf of the allo 3	inches.	alf of the allo h	inches. h	inches.	inches. h	inches.	lot specified. h	inches.	1/2 inches (i h	.5 inches (0- 1	/4 inch. 1	1D inches	1 - 1 1 1 +	
iccess - [D	Yiew Inser	<sup>o</sup> urpose P	Drains A	Found 2	Slabs 2	Retain 2	French 2	Struct 3	French 3	French 2	Gener H	<b>Beddir</b> 2	Gener H	Struct 3	Gener 2	Gener 3	French 3	Drains N	Retain 2	Retain 1	Embai 3.	French 3.	Gensv 3	-	2
Microsoft A	C Ele Edit	Agency F	Navy ~ [	Navy F	Navy S	Navy F	Navy 1	Navy S	Navy 7	Navy 1	Navy (	Navy E	Army (	Army S	WVC (	WVC (	WVC 1	WCC	Tense F	Geost	FLDC	FLDC	FI DC	scord; 14	atasheet Viev
5			*																					ď.	0

Figure 3.10 - Description query

Nicrosoft Access - [Park	ticle Size Query :	Select Query]	>
Eile Edit View Insert	Format Records	Tools Window Help	2
Filters (For Din Don)		Binchas	-
	1984	J inches.	-
Trenches	AASHTO	1/2 inch (Course Aggregate).	3
(Permeable Soil)	1984	3/8 inch (Fine Aggregate).	
Drains (Subsurface)	AASHTO	1/2 inch (Course Aggregate).	
	1984	3/8 inch (Fine Aggregate).	
- Blankets (For	AASHTO	2 1/2 inches.	
Stone Protection)	1984		
Filters (Blanket)	AASHTO	2 inches.	
-	1004		
Bedding (For	AASHTO	1/2 inch.	
Sidewalks And Curbing)	1984		
Bedding (For Slope	AASHTO	1 1/2 inches.	
Protection)	1984		
- General Fill	Army COE	Half of the allowable lift	
	1997	tnickness. 8 inches (for grading). 3 inches (for pavements and	
Capillary Water	Army COE	1 1/2 inches.	
	1007	8	-
Datasheet View			

Figure 3.11 - Particle size query



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2	Microsoft Access	- [Atterberg Query	: Select Query]	_ 🗆 ×
		. 🤊 % 🖻 🖻	1 0 8 8	₹↓ Z↓ / / 2
	Eile Edit Yiew	Insert Format Reco	ords <u>T</u> ools <u>W</u> indow	
	Agency	Purpose	Liquid Limit	Plasticity Index 🔺
•	LA DOT 1992	Bedding (General)	Not specified.	Nonplastic (for sand, stone, and recycled portland cement concrete passing the
	Navy 1998	Bedding (General)	Not specified.	6 (for material passing the 0.075 mm sieve).
	LA DOT 1992	Blankets (Plastic Soil)	Not specified.	12 to 35.
	WI DOT 1996	Drains (Subsurface)	25	6
	UT DOT 1994	Embankments (General)	Not specified.	Nonplastic.
	Houston 1997	Embankments (General)	45.	12 to 20 (do not use a blend cohesive and granular soils to achieve this value).
	IL DOT 1997	Embankments (Granular)	Not specified.	6 (for gravel). 4 (for crushed gravel, stone, and slag but waived if [%passing
	TX DOT 1993	Embankments (Granular)	45	15
Re	ecord: 14 4	1	of 31	
D	atasheet View			

Figure 3.12 - Atterberg query



#### **ID** Form

The ID Form shown in Figure 3.13 is based directly on the ID Query. The ID Form contains the same fields and records as the ID Query. This form is used in conjunction with the Agencies table, Purposes table, and editor forms, which are explained below, to enter new records into the database. Following is an example of how a new record is entered into the database.

First, the name of the agency is entered into the Agencies table, unless it has been previously entered. Next, the purpose of the fill material as specified by the agency is entered into the Purposes table. Following this, qualitative descriptions of satisfactory soil and unsatisfactory soil are entered into the appropriate editor forms and new IDs are assigned to each description. Gradation data and other requirements data are entered in a similar fashion. After all of these data have been entered as described, they become available for selection via drop down menus in the ID Form. The only data that are directly entered manually into the ID Form is the maximum particle size, maximum liquid limit, and maximum plasticity index.

## **Description** Form

The Description Form shown in 3.14 is identical to the ID Form except that the ID fields are not displayed. Since the ID fields are not displayed, drop down menus are not available for selecting different descriptions for satisfactory soil and other similar fields. Hence, this form is used only for viewing records when IDs are not important to the user and the user.

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Agenc	y AASHTO 19	984		and and an and a star	· ap	and the
Purpo	se Bedding (Fo	or Sidewalks And Curb	ing)	-2(	Update Reco	rds /
Satisfa	ctory Soil ID	aashto1s	-1	Plasticity Inde	x	
Satisfa	ctory Soil	(1)。 [1] [1] [1] [1] [1] [1] [1] [1] [1] [1]	Strike Scitte	Not specified.	and a second	adam-interaction
Cinders	s, sand, slag, gra	vel, or crushed stone.				
				Liguid Limit		
				Not specified.		5
Unsati	sfactory Soil ID	none	•	Particle Size	T Post of the case	
Unsati	sfactory Soil			1/2 inch.		1.07 85 10.10
INOL SHE	undu.			Gradation ID	none	-
				Gradation		1 de la
				Not specified.	the second section and interval the second	and the station of
Other	Requirements	ID none	•			
Other	Requirements					
Not spe	ecified.					
						1

Figure 3.13 - ID form





Figure 3.14 - Description form



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### Satisfactory Soil Editor

The Satisfactory Soil Editor form shown in Figure 3.15 is used to enter new descriptions of satisfactory soils. First, an alphanumeric ID is manually entered into the "Satisfactory Soil ID" field. This ID, as described previously in this report, is based on the name of the agency and a sequential number, which depends on how many previous descriptions of satisfactory soils have already been entered into the database for the agency. Second, a qualitative description of a satisfactory soil is manually entered into the field "Satisfactory Soil".

#### Unsatisfactory Soil Editor

The Unsatisfactory Soil Editor form shown in Figure 3.16 is identical to the Satisfactory Soil Editor form except that it is used to enter qualitative descriptions for unsatisfactory soils.

## **Gradation Editor**

The Gradation Editor form shown in Figure 3.17 is identical to the Satisfactory Soil Editor form except that it is used to enter gradations in the form of sieve sizes and percent passing.

#### **Other Requirements Editor**

The Other Requirements Editor form shown in Figure 3.18 is identical to the Satisfactory Soil Editor form, except that it is used to enter other fill material requirements not covered elsewhere in the database. For example, a guide specification may stipulate pH or percentage of organic content. \_\_\_\_

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2	Micros	soft A	ccess	: - [Sal	isfactor	y Soil]				- 🗆 ×
	Eile	Edit	View	Insert	Format	Records	Tools	Window	Help	 - 🗗 ×
	Satisf	factor	y Soil	ID aas	hto1s					
	Satist	factor	y Soil	Cine	ders, san	d, slag, gra	avel, or	crushed s	stone.	
				-						
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				3 43 43						
										- 8
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Figure 3.15 - Satisfactory soil editor form



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4	Micro:	soft A	Acces View	s - In	<b>(Un</b> s sert	satisfac F <u>o</u> rmat	t <mark>ory Soil]</mark> <u>R</u> ecords	Tools	<u>W</u> indow	Help		_ D ×
•	Unsa Unsa	tisfac	tory :	Soil	aasi Soil veg mate	hto1u that cann etable ma erials (w	not be prop atter. Rock there piling	berly co s, broke , will be	mpacted, en concret driven).	sod, and	d her solid	
Re	cord:	14   <			1	T <u>(                                    </u>	•••••••••••••••••••••••••••••••••••••	45				

Figure 3.16 - Unsatisfactory soil editor form



Gradation ID	navy2g	
Gradation	<ul> <li>a. Perforated or slotted wall pipe: Type I.</li> <li>b. Open joint pipe: Type I and Type II (i.e. two soils used as a combination).</li> <li>c. Blind or french drains: Type II.</li> <li>c. Any pipe used with filter fabric: Type I. or Type II.</li> </ul>	
	Type I Type II 37.5 mm 100 25.0 mm 90-100 9.5 mm 100 25-60 4.75 mm 95-100 5-40 2.36 mm 0-20 1.18 mm 45-80 0.300 mm 10-30 0.150 mm 0-10	

Figure 3.17 - Gradation editor form



1	Other	Requ	Jirem	en þsg	n1o					
l	Other	Requ	lirem		le of inte	rnal frictio	n not les	s than 34	degrees.	
1										
				A set from						
				1						
1										
										_
										_

Figure 3.18 - Other requirements editor form



#### Reports

Both tables and queries can be transformed into reports. A report is simply a way of visually organizing the data found in the corresponding table or query into an arrangement that is easier to read and understand. The complete set of reports that was generated for the database is discussed in greater detail in Chapter 4. The reports generated by the database are one of the two ways used in this study to examine the data and identify the presence or absence of patterns and trends.

#### Plots

The data in the database were also used to create a number of plots with Microsoft Excel. The plotting capability of Microsoft Access cannot be used directly because database fields that hold numerical data (like particle size and Atterberg limits) were formatted as general text rather than number fields. This decision was made because the data for some of the fields were best represented with a text description rather than a single number. This is one area of potential improvement for this database. Ideally, all numbers in the database should be stored in numerical fields so that Access can generate the plots directly.

To generate a plot, data were first exported to an Excel spreadsheet as a table. Once in the spreadsheet, the textual data were "trimmed" away from the numerical values leaving a table of numbers with row and column headings as appropriate. The table of numerical values was then transformed into a graph
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using the plotting ("charting") capabilities of Excel. The complete set of plots generated for this study is discussed in greater detail in Chapter 4.

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### Chapter 4: Trends in Current Practice and Further Recommendations

Once the database was created, it was used to examine possible patterns and trends in the requirements of various agencies. The results of this examination are presented in this chapter. The examination of fill requirements is presented as follows. First, a broad overview of all the data is presented. Next, maximum particle size requirements and Atterberg limit requirements stipulated for fill materials are examined. Descriptions for what are considered satisfactory and unsatisfactory fill materials are then presented. Following this, the specific gradation requirements for fill materials are introduced along with any other requirements for fill materials not already covered. Finally, recommendations for writing future guide specifications are made based on these evaluations.

#### FILL REQUIREMENTS: ALL REQUIREMENTS

Appendix A presents a tabular listing of all of the fill material requirements that were collected in this study. The table is sorted first by the purpose of the fill material and then by the name of the agency that authored the guide specification.

#### FILL REQUIREMENTS: MAXIMUM PARTICLE SIZE

All of the maximum particle size requirements stipulated for fill materials in the database are plotted in Figure 4.1. The data in this figure are sorted according to the smallest maximum particle size specified by an agency for fill materials regardless of use. Each location along the horizontal axis corresponds

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Figure 4.1 - Maximum particle size sorted by agency and purpose

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to a specific purpose for the fill material and the agency issuing the guide specification. When an agency specifies more than one value for the purpose in question, the additional values are shown above the smallest size specified. Figure 4.2 shows the same data to an expanded scale that excludes sizes that are 12 inches or greater in order to provide more detail at the lower end of the scale of particle sizes. Nearly all of the maximum particle sizes specified are four inches or less. Three inches appears to be one of the most commonly specified maximum sizes.

Figures 4.3 and 4.4 show the same data presented in the previous two figures sorted by purpose of fill material; Figure 4.3 shows all maximum sizes, Figure 4.4 shows only maximum sizes less than 12 inches. The maximum particle sizes specified for fill materials to be used in embankments have both the greatest absolute range of values and greatest number of different values specified. A total of 11 different sizes ranging from 1 inch to 10 feet are specified for general embankments alone. Figures 4.5 and 4.6 show the same data as the previous four figures but grouped and sorted by the general category of purpose of fill material. When all types of embankments are considered, a total of 13 different maximum particle sizes were observed in the 27 guide specifications studied.

After embankments, the applications with the next greatest number of different values specified for maximum particle size are fill materials for retaining walls and fill materials for trenches. Seven values of maximum particle size (from less than one inch to six inches) are specified for fill materials for retaining



Figure 4.2 - Maximum particle size < 12 in sorted by agency and purpose





Figure 4.3 - Maximum particle size sorted by purpose





Figure 4.4 - Maximum particle size < 12 in sorted by purpose





Figure 4.5 - Maximum particle size sorted by major purpose





Figure 4.6 - Maximum particle size < 12 in sorted by major purpose



walls, and eight values (from less than one inch to six inches) are specified for trenches.

Figures 4.7 and 4.8 show the range of maximum particle size values stipulated by each agency. The prominence of the three inch maximum particle size can be seen here as well. It is the most commonly specified particle size among the agencies and purposes studied. Of the 27 guide specifications studied, only three did not specify a maximum particle size for any purpose. Of the 24 that did specify maximum particle size values, 14 specified three inches for at least one class of fill material.

Appendix B presents a tabular listing of all of the values of maximum particle size. This table also includes any supplemental comments that the guide specifications contain regarding the maximum particle size specified.

#### FILL REQUIREMENTS: LIQUID LIMIT AND PLASTICITY INDEX

Maximum values for liquid limit and plasticity index given by the 27 guide specifications studied are both presented in Figures 4.9, 4.10, and 4.11. The values are sorted differently in each of the three figures. Multiple values in the same vertical column in the plots indicate that more than one value for the liquid limit or plasticity index was specified in that instance depending on the purpose of the fill material.

From these plots, it can be seen that nearly all of the maximum plasticity indices specified are 20 or less. Twelve of the 27 guide specifications specify plasticity index for at least one case. Of those twelve guide specifications, only two specify values greater than 20. In Figure 4.10, seven different values for

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Figure 4.7 - Maximum particle size sorted by agency





Figure 4.8 - Maximum particle size < 12 in sorted by agency





Figure 4.9 - Atterberg limits sorted by purpose and agency





Figure 4.10 - Atterberg limits sorted by major purpose





Figure 4.11 - Atterberg limits sorted by agency



plasticity index, the most of any category in this figure, are given for embankments. In Figure 4.11, five different values for plasticity index, the most of any category in this figure, are given by the Louisiana DOT.

Maximum liquid limit values range from 15 to 45 with one outlying value at 90. The most commonly specified value for liquid limit appears to be 35.

Appendix C presents a tabular listing of all of the values of maximum liquid limit and maximum plasticity index. This table also includes any supplemental comments that the guide specifications contain regarding the Atterberg limits specified.

#### FILL REQUIREMENTS: DESCRIPTION OF SATISFACTORY SOIL

Table 4.1 is a summary of all the different terms that were encountered in the qualitative descriptions of satisfactory fill materials in the guide specifications. This list contains the basic nouns and adjectives used to describe satisfactory fill materials. Sand and gravel were among the most common terms encountered.

Appendix D lists the full qualitative descriptions of satisfactory fill materials contained in the various guide specifications. The table is arranged in alphabetical order by agency name.

#### FILL REQUIREMENTS: DESCRIPTION OF UNSATISFACTORY SOIL

Table 4.2 is a summary of all the different terms that were encountered in the qualitative descriptions of unsatisfactory fill materials in the guide specifications. This list contains the basic nouns and adjectives used to describe

Material from, containing, or characterized as:				
Materia	in from, containing, or character	lizeu as.		
aggregate (crushed)	angular	blow (fine desert)		
broken	caliche	СН		
chats	cinders	cinders (volcanic)		
CL	clam shell	clay		
clay (expanded)	clay (sandy)	clay (silty)		
clean	CL-ML	cohesionless		
compactible	concrete (crushed)	concrete (lean)		
concrete (recycled)	concrete sand	concrete sand (crushed)		
coral	crushed	dewatered		
durable	earth	fragmented		
free draining	GC	GM		
GM-GC	GP	GP-GC		
GP-GM	graded	granular		
granulated	gravel	gravel (crushed)		
gravel (natural)	gravel (pit run)	gravel (screened)		
gravel (uncrushed)	gravel-sand mixture	GW		
GW-GM	hard	impermeable		
imported	inert	loam		
MH	minerals (broken, fragmented)	ML		
native excavated	naturally occurring	noncohesive		
nonporous	novaculite	porous		
random	reef shell	rock		
rock (crushed)	rock (natural)	rock (round)		
rock (uncrushed)	rock fill	round		
sand	sand (coarse)	sand (construction/demo debris)		
sand (fine beach)	sand (natural)	sandstone (crushed)		
SC	screened	shale		
shale (hard)	shale (soft)	shell		
shell (crushed)	silt	silt (clayey)		
site excavated	slag	slag (air cooled blast-furnace)		
slag (crushed)	slag (wet bottom boiler)	slag sand		
slag sand (granulated)	SM	soil		
soil (natural)	soil (site excavated)	SP		
SP-SC	SP-SM	stone		
stone (angular)	stone (crushed)	stone sand		
stone screenings	stream deposited	strong		
SW	SW-SC	SW-SM		
tough	uniformly graded	washed		
well graded	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,			

## Table 4.1 - Satisfactory Fill Material Basic Terms

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Material from, containing, or characterized as:				
adherent coatings	aggregates	alkali		
backfills (from previous	backfills (uncompacted)	bogs		
construction)				
broken concrete	brush	CH		
chemical contamination	clay balls	clay clods		
clay lumps	CL-ML	clods		
compacted (cannot be)	construction debris	contamination		
damaging to pipe	debris	decaying		
decomposing	deleterious	diatomaceous		
dirt	extraneous	fills (man-made)		
foreign	foundation (not usable for)	friable		
frozen	humus	hydrocarbons		
ice	inorganic	lenses (soil)		
limbs	lime stabilized backfill	logs		
lumps	marshes	masonry debris		
MH	micaceous	ML		
moisture (excessive)	muck	objectionable		
ОН	OL	organic		
peat	perishable	plastic clays (highly)		
PT	reef shell (fragmented)	refuse		
rock	rock (unsound)	roots		
rubbish	salt	scrap		
settlement (will cause unacceptable)	silt	slag		
sod	soft	soil cement		
solids	soluble	spongy		
spontaneously combustible	sticks	stone (crushed)		
stones	strength (insufficient)	stumps		
sulphate (soluble)	swamps	thin, flat and elongated		
		particles		
topsoil	trash	undesirable		
unsound	unstable	vegetation		
waste	wastes (man-made)	water saturated		
weeds	wood			

# Table 4.2 - Unsatisfactory Fill Material Basic Terms
unsatisfactory fill materials. Frozen material and organic material were among the most common terms encountered.

Appendix E lists the full qualitative descriptions of unsatisfactory fill materials contained in the various guide specifications. The table is arranged in alphabetical order by agency name.

#### FILL REQUIREMENTS: GRADATION

All of the gradation requirements found in the guide specifications for fill materials are presented in Appendix F. Some guide specifications specify detailed gradations and some specify only requirements for percentages passing for one or two sieve sizes. For example, the gradation requirement specified by the Florida DOT for fill material to be used with geosynthetic reinforcement lists percentage passing requirements for six different sieve sizes (90 mm, 19 mm, 4.75 mm, 0.425 mm, 0.150 mm, 0.075 mm). On the other hand, the gradation requirement specified by the City of Lake Oswego for fill material to be used in trenches lists the percentage passing requirement for only one sieve size (no. 200). Other guide specifications did not give numerical requirements but only qualitative descriptions of satisfactory gradations. For example, the gradation requirement specified by the Texas DOT for fill material to be used around bridge foundations states only that it must be "a gradation that permits thorough compaction."

#### FILL REQUIREMENTS: OTHER REQUIREMENTS

Appendix G presents any additional requirements that were specified for the fill materials in the guide specifications examined. The pH and organic

content are two of the additional requirements most commonly specified. Three guide specifications (Florida DOT, Louisiana DOT, and Tensar) require a pH in the approximate range from 5 to 10. Three guide specifications (Florida DOT, Louisiana DOT, and West Virginia DOT) also have requirements on the maximum percentage of organic content with values ranging from 2 percent to 7.5 percent.

#### WRITING GUIDE SPECIFICATIONS FOR FILL MATERIALS

Writing a guide specification can be divided into two stages: researching and writing. In this section, suggestions for researching and writing guide specifications are presented.

#### Where to Begin the Research

The first step in writing a guide specification for fill materials is to determine the way in which the fill materials are to be used. Once the purpose of the fill has been identified, specifications that have been written for similar purposes can be examined to understand how materials have been specified for this purpose previously. A database such as the one created in this study is an ideal tool for use at this stage. This review of current specifications might then be further narrowed to the specific region of the country where the work will take place. Guide specifications written by agencies for a particular region could prove to be invaluable resources for the specifications writer.

### Specific Recommendations for Writing

In specifying requirements for fill materials, guide specifications typically take on one of four levels of specificity: 1) The guide specification does not

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and provide the later

stipulate any requirement; 2) The guide specification states that a value must be specified for a particular fill material characteristic but gives no guidance for specifying the value; 3) The guide specification recommends a value for a particular fill material characteristic or property, but states that the value may be modified according to the specific conditions of the project; 4) The guide specification stipulates a specific value for a particular material characteristic and allows no possibility of modification. This last category may be somewhat more flexible than indicated because any requirement in a guide specification can usually be modified, with the proper analysis and approval, in the contract specification to fit the needs of the project. When beginning to write, one of the first questions that must be answered is which of the above four approaches best meets the needs of the situation being addressed.

The first approach listed above is the least desirable of the four. One should avoid saying nothing about fill material requirements. More specifically, either a value should be recommended or it should be stated clearly that the value is to be determined according to the specific needs of the project. Neglecting to provide any requirements gives the reader no guidance.

Another important consideration in writing a guide specification for fill materials is to clearly specify minimum and maximum values for fill material characteristics and not just provide examples of fill materials with acceptable characteristics. For example, suppose that an embankment that is frequently constructed by a state DOT requires a fill material with a maximum particle size

of 3 inches. Following are two possible ways to write a guide specification for this material.

Method #1 (correct): "Fill material with a maximum particle size of 3 inches shall be used to constructed the embankment." Method #2 (ambiguous): "Soil types A and B are acceptable fill materials

for use in constructing the embankment."

The first method is the correct way, but the second method is ambiguous.

In the example above, the guide specification describes two fictitious soil types, A and B, in a separate section. This is not an uncommon arrangement since these same soil types may be referred to frequently in other sections of the guide specification. Soil type A has a maximum particle size of 2 inches and soil type B has a maximum particle size of 2 ½ inches. The most reasonable interpretation of a guide specification that is written using method #2 is that 2 ½ inches is the maximum permissible particle size for the fill material to be used in the embankment. Thus, a guide specification that is written using method #2 may add unnecessarily cost to the project due to the fact that it presents requirements that are interpreted to be more stringent than necessary for the fill material. More stringent fill material requirements may translate into more expensive fill material.

## **Chapter 5: Summary and Conclusion**

Guide specifications for fill materials are used in the preparation of the earthwork sections of specifications for individual projects. Electronic versions of guide specifications are distributed by federal agencies, state agencies, municipal agencies, and manufacturers via the Internet, by diskettes, compact disks, and digital video disks. Printed versions of guide specifications are also available. Recommendations for preparing guide specifications can also be found in engineering textbooks, handbooks, and manuals.

A database of requirements for fill materials as specified by a number of existing guide specifications was created for this study in Microsoft Access using information from 27 different sources. A database like this is a useful tool for the preparation of guide specifications for fill materials. Issues of defining the scope, choosing a software application, and entering the data were examined. Individual tables of data, queries, forms, reports, and plots were created from this database and are presented in this report. These were examined to determine the conclusions of this study. Finally, recommendations for writing guide specifications were presented based on the guide specifications examined in this study.

Maximum particle sizes stipulated in the guide specifications were found to range from 3/8 inch to 10 feet with 3 inches being the most common maximum size observed. Maximum liquid limit ranged from 15 to 90 with 35 being the most common value observed. Maximum plasticity index ranged from 4 to 65

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with 6 being the most common value observed. Descriptions of what constituted satisfactory soil varied widely with sand and gravel being the most common characteristics cited. Descriptions of unsatisfactory soil also varied widely with frozen material and organic material being cited most often as unsatisfactory materials. Twenty of the 27 sources included in the database specify either a qualitative or quantitative requirement for fill materials based on grain size distribution. Eight of the 27 sources also specify additional requirements for fill materials with pH and organic content being the items most commonly stipulated as additional requirements.

This study has introduced the most commonly specified characteristics of fill materials. Specific examples of the numerical values and textual descriptions used by a number of agencies have also been presented. Conclusions drawn from these examples have been presented above and should be useful for writing both guide specifications and specifications unique to individual projects.

Appendix A: All Fill Material Requirements Grouped by Purpose



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hrpese	Agency	Satisfactory Sol	<b>Unsatisfactory Soll</b>	Max Particle Size	Gradation Max	Liquid Limit	Max Plasticity Index	Other Requirement
Bedding (For Sidewalks And Curbing)	AASHTO 1984	Cinders, sand, slag, gravel, or crushed stone.	Not specified.	1/2 inch.	Not specified.	Not specified.	Not specified.	Not specified.
Bedding (For Slope Protection)	AASHTO 1984	Porous, free-draining material consisting of sand, gravel, cinders, slag, or crushed store.	Not specified.	1 1/2 inches.	Uniformity graded.	Not specified.	Not specified.	Not specified.
Bedding (General)	IL DOT 1997	Sand, stone sand, stone screenings, chats, wet button holier stag, sing and, granulated stag sand, crushed concrete sand, or construction and demolition debris sand.	Material containing an excess of soft and unsound periodes and other objectionable matter.	38 inch.	FA1 FA2 9.5mm 100 4.57mm 97a3 97a3 11.81mm 65420 65a20 0.300mm 1641 2541 0.300mm 545 545 0.0150mm 242 242	Not specified.	Not specified.	Not specified.
	LA DOT 1992	Stone, recycled portland cement concrete, expanded day, shell, gravel, crushed slag, or sand.	Not specified.	Not specified.	Extensive gradation requirements that are too lengthy and detailed to include in this database.	Not specified.	Nonplastic (for sand, stone, and recycled portland coment concrete passing the no. 40 sieve).	Not specified.
	Lake Oswego 1999	Imported crushed rock.	Material containing dirt, clay balls, and organic material.	1 inch.	Less than 8% passing the No. 200 sieve.	Not specified.	Not specified.	Not specified.

Tress	ADBIDCY	Satisfactory Sol	Uncattsfactory Sol	Max Particle 500	Cradation Ma	X LIQUIN LINE	Wax Fasuery weak	
ladding (Caneral)	Navy 1998	Sand, gravel, or crushed rexist concerts of truth mode particles. ASTM D2321 Mannias: Class 1: Angular store (including data store including stores and activated shells where available). Class 1: Coarse sands and gravels including gravels areas prevels parter areas prevels parter areas prevelsed on the preventing preventing gravels areas preventing gravels areas preventing gravels areas preventing gravels areas preventing gravels areas preventing areas preventing gravels areas preventing gravels areas preventing areas preventing gravels areas preventing areas p	Vus specified.	2 inches.	Class 1 Sizes from 0.25 in 1.5 in Class 11: Max size of 1.5 in.	Not specified.	passing the 0.075 mm sieve).	Nut specified.
Blankets (For Stone Protection)	AASHTO 1984	Gravel, crushed gravel, crushed sine, crushed air- coubled last-furnear slag, or crushed concrete.	Not specified.	2 1/2 inches	AASHTO M 43, size No. 357; mm % 33 100 59 35-100 25 35-10 25 35-70 125 10-30 475 0.5	Not specified.	Not specified.	Not specified.
Blankets (Plastic Soil)	LA DOT 1992	Not specified.	Large or frozen lumps, stones, roots, wood, and other foreign matter.	Not specified.	Not specified.	Not specified.	12 to 35.	pH from 5.5 to 8
Capillary Water Barrier (Under Concrete Slabs)	Army COE 1997	Clean, crushed, nonporous rock, crushed gravel, or uncrushed gravel.	Not specified.	1 1/2 inches.	4.75 mm no more than 2%	Not specified.	Not specified.	Not specified.



Purness	Americy	Satisfactory Sel	Unsatisfactory Sel	Max Particle Size	Gradation Max	Linet Lint	Max Plasticity Index	VICINET REQUIPTIONDERLS
Capillary Water Barrier (Under Concrete Slabs)	Navy 1998	Clean crushed store. crushed gravel. or uncrushed gravel. Clean concrete sand for capillary water barrier underlary or for capillary water barrier not under statis).	Not specified.	Not specified.	Underlay, 3% possing 0.075 mm siere.	Not specified.	Not specified.	voi specimen.
Culverts	TX DOT 1993	Stone or lean concrete (only if backfilling an excavation in hard material resistant to erosion).	Not specified.	4 inches.	A gradation that permits thorough compaction.	Not specified.	Not specified.	Not specified.
	WI DOT 1996	Sand, a muxture of sand with gravel, routshof gravel, cutshed stone, or other broken or fragmented mineral material.	Material containing frozen lumps, wood, logs, stumps, brush, or other extraneous or perishable material.	3 inches.	75 mm 100% 4,75 mm not less than 25% Of all malerial passing 4,75 mm sieve 0,075 mm not more than 15%	Not specified.	Not specified.	Not specified.



AASHTO frace) 1984	Hard, durable, clean sand, gravel, crushed stone, or crushed slag.	Organic material, clay balls, or other deleterious substances.	1/2 inch (Course Aggregate). 3/8 inch (Fine Aggregate).	Course Aggregate (AASHTO M 43, size No. 89): mm %	Not specified.	Not specified.	Not specified.
				12.5 100 4.75 20-55 2.36 5.30 1.18 0-10 0.300 0-5			
				Fine Aggregate (AASHTO M 6):			
				mm % 9.5 100 4.75 05.100			
				1.18 45-80 0.300 10-30 0.150 2-10			
IL DOT 13	17 Fine Aggregates: Sand, store sead, store screenings, chas, well bottom bales stog, stag screenings, chas, well bottom bales stag, sand, crushed concrete sand, or debris sand. Curres Aggregel, pir tun gravel, crushed store, crushed stag concrete, crushed stag. crushed stand.	Nut specified	3 inches (for coarse aggregates) 38 inch (for fine aggregates).	Course Aggregates: Course Aggregates: 75 mm 100 25 mm 96+5 118 mm 55+25 118 mm 55+25 118 mm 22+2 118 mm 22+2 118 mm 22+2 118 mm 22+2 118 mm 16+20 118 mm 16+20	Not specified.	Not specified.	Not specified.
				0.150 mm 5±5 5±5 0.075 mm 2±2 2±2			



Drains	AUGHUCY	Satisfactory Sol	MISSIDETACTORY Sol	Max Paruce Sus	Gradation Max.		Max Plasticity Index	Other Requirements
(Subsurface)	Lake Oswego 1999	Washed round rock.	Not specified.	Not specified.	Graded from 1.5 inches to 3/4 inches.	Not specified.	Not specified.	Not specified.
	NASA 1997	Uniformly graded mixture of natural or crushed gravel, crushed stone, and natural sand.	Not specified.	3/8 inch.	9.5 mm 100% 0.150 mm 2-10%	Not specified.	Not specified.	Not specified.
	Navy 1998	Clean sand, stone, or gravel fill.	Not specified	A size that will prevent the entrance of any of the porous material into the drain.	<ul> <li>a. Perforated or slotted well pipe: Type I Open joint pipe: Type I and Type II (i.e. two soils used as a combination).</li> <li>c. Siny pipe used with filler fabric: Type I, or Type II.</li> </ul>	Not specified.	Not specified.	Not specified.
					Type I 37.5 mm - 100 35.0 mm - 90.00 9.5 mm 100 25-40 4.7 mm 95:100 5-40 2.36 mm - 0.20 1.18 mm 45:80 - 0.300 mm 10-30 - 0.150 mm 0-10 -			



Max Plasticity Index Other Requi	6 Not specifie	Not specified Not specifie	Not specified . Not specifie	Not specified. Not specifier
Liquid Linit	52	Not specified.	Not specified.	Not specified.
Gradation Max	150 mm 100% list 155 mm ock less than 25% 4.75 mm ock less than 25% Crimaterial passing 4.75 mm slove: Gada I: 4.75 mm 100% 0.425 mm not reve than 15% 0.150 mm not more than 15% 0.025 mm - 0.425 mm 100% Cada 2: 0.150 mm not more than 15% 0.150 mm not more than 120% 0.150 mm not more than 120%	Not specified.	Not specified.	Not specified.
MAX FAFLEDB & LO	6 incheas. 1 inch (ico pipe beeding).	Not specified.	Not specified.	Not specified.
MISSING STREET, SHI	Material containing fozen lumps, wock, logs, stumps, umps, or berishable material.	Not specified.	Materials containing brush, roots, soot or other perishable materials.	Materials containing brush, rools, sod or other perishable materials.
SALISIZELINY SHI	Sand, a mitture of sand with gravel, curbled gravel, unshed some, or dhear broken or fragmented mineral material.	Random material (a mixture of any or all of soil, granular material, or soft shale).	Clays, silty clays, or clayery sits, Sitts and clays containing and may be containing and may be uncompacting with a table importancing with a data tamping or tubber-tired roller.	Clean, free draining sand or sand and gravel free from any objectionable coating.
Agency	M DOT 1996	WV DOT 1994	Army COE 1997	Army COE 1997
Tryess	Subsurface) Subsurface)		Embankments (Dam, Impervious Soil)	Embankments (Dam, Pervious Soil)

Purpase	Agency	Satisfactory Sel	Unsatisfactory Sol	Max Particle Size	Gradation	Max Liquid Linit	Max Plasticity Index	Other Requirements
Embankments (General)	AASHTO 1984	Not specified.	Soil that cannot be properly compacted, sod, and vegetable ander. Rocks, borken concrette, or other solid materials (where pling will be driven).	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.
	FAA 1991	Not specified.	Frozen material or material containing vegetable or organic matter, such as muck, peat, organic sitl, or sod.	4 inches (within top 6 inches of embankment).	Not specified.	Not specified.	Not specified.	Not specified.
	FL DOT 1999	Not specified.	Material containing muck, sturnes, roots, brush, vegetable matter, mubish, or offer material tat does not compact find a stuttable and enduing reached.	3.5 inches (0-12 inches depth or whthin 3 feet of whthin 3 feet of 6 inches (12-24 inches depth), inches or compacte thickness of layer thickness of layer (below 24 inches depth),	A gradation that minimizes voids between particles.	Not specified.	Not specified.	Not specified
	Houston 1997	Not specified.	Material containing lumps (greater than 6 inchres), organic material, chemical wastle or other contamination, and debris.	3 inches.	Not specified.	45.	12 to 20 (do not use a blend cohssive and granular soils to achieve this value).	Not specified.



1)050	Agency	SALISIACIUTY SOL	Unsatustactory sol	M2X Farucie 828	6703090	Max Liquin Link	MAX PASUCILY BREAK	CURY KOULTWIND
eneral) eneral)	IL DOT 1997	Earth, store, or granel.	Sou, frame material, or any material which by docay or otherwise, might cause settlement	A increase while loop (12) increase of fill or top 3) increase of fill outer parement, surfaces course, or under parement, with test than 2 sett and the set than 2 sett press dest range press of the set press of the set press of the set press of the set press o	Not specified.	Not	Not specified.	NM specified
	Lake Oswego 1999	Native excavaled material.	Material containing weeds, refuse, sticks, or other organic material which in the Engineer's opinion would compromise the integrity of the compacted trench.	1 inch.	3 inch more than 90% 1 inch more than 50% no. 200 not more than 20	Not specified.	Not specified.	Not specified.
	MD DOT 1993	Not specified.	Frozen material.	24 inches.	Not specified.	Not specified.	Not specified.	Not specified.
	NASA 1997	Not specified.	Not specified.	3 inches.	Not specified.	Not specified.	Not specified.	Not specified.



Ljess	AGency	SAUSINCULTY ME	Unsatisfactory son	MAX PAPIDON 3420	12121200	Max Lepter Level	Max Plasticity Index	UTINE KOQUE TOTICU
nbankments ieneral)	NM DOT 1994	Not specified.	Frozen material. Material containing nox, bioken concrete, or organing, materials (Mene paing, utifiles, or structures are to be built).	36 inches. 10 feet or 1/2 of the embankment height (near the toe of the stope).	Not specified.	Not specified.	Not specified.	Not specified.
	SHCE 1996	Not specified.	Material containing organic matter.	3 inches (within 18 inches of foundations, slabs, or ground surface).	Not specified.	Not specified.	Not specified.	Not specified.
	TX DOT 1993	Rock, Ioam, clay, or other materials.	Material containing organic or otherwise deteterious matter or unacceptable lumps of earth.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.
	USBR 1999	Not specified.	PT. OL. OH Material Children prost. stumps. limits. vegetation. organic matter. i.c. construction debris. scrap materials. refuse. man-made wastes, or chemical or hydrocarbon contamination.	5 inches.	Not specified.	Not specified.	Not specified.	Not specified.
	UT DOT 1994	Granular material.	Not specified.	2-3 inches.	Not specified.	Not specified.	Nonplastic.	Not specified.

ULTRI KOQUIT WINKILLS	Not specified	Organic content shall be less than 7.5% by weight.
Max Plasticity Index	Not specified.	Not specified.
Max Liquid Limit	Not	Not specified.
Gradation	Not specified.	Not specified.
Max Particle Size	A actae that would A actae that would scampacing, and finishing the subgrade (within 8 surgace). Thorkes or a surgace) andres or a size significantly affect diving of thes boring of holes of holes of holes of holes of holes of holes bored).	Not specified.
Unsatisfactory Sol	Material containing frozen lumps, and logs immes, uns, and other extaneous or perishable material.	Materials which cannot be satisfactority placed and compacted to a stable and durable continor. Sol, tarsh, organic substances beyond particitations consessive motions. Soli onthaining threen: soli onthaining rock, driven: soli containing rock.
Satisfactory Sol	Not specified.	Random material (a mixture provident or soft soft, granular material, or soft sheb), hands sheb, or nock, Preference given to granular softs.
Agency	MI DOT 1996	1994 DOT
Pirnese	(General) (General)	



Purpose	Agency	Satisfactory Sol	Unsatisfactory Sol	Max Particle \$128	Gradation	Max Liquid Limit	Max Plasticity Index	Other Requirements
Embankments (General, Perviour Soli)	IL DOT 1997	Fine Appropriates Sand, screenings, chats, wel bottom bolier slag, sand, screenings, chats, wel bottom bolier slag, sand, crutshed chorchet sand, cor construction and demolition debts sand. Course grand, frun grand, crutshed stone, crutshed slag, crutshed slag, chats, crutshed slag, chats, crutshed slag, concrete crutshed slag.	Not specified	a) purbes (for coarse 3) groupsdach. 308 inch (for fine aggregates). aggregates).	Course Aggregates: 75 mm 00 75 mm 00 8545 418 mm 5545 118 mm 55425 0075 mm 22 60075 mm 22 616 mm 104 0075 mm 22 457 mm 1242 118 mm 1242 000 000 mm 518 2240 0075 mm 222 232	Not	Not specified.	Not speafied.
(Granular)	IL DOT 1997	Pit nn gravel, gravel, crushed gravel, novæzulle. crushed store, crushed slag, or concrete, crushed slag, or crushed sandstore.	Not specified	1 inch (for gradation CA 6). 1 112 inches (for gradation CA 10).	CA6 CA10 37.5 mm 100 - 25 mm 100 - 31.6 mm 100 15 mm - 54.5 80.4 5 4.7 5 mm 24.15 30.4 15 4.13 mm 24.15 30.4 15 0.075 mm 84.4 34.4	specified.	6 (for grave), 4 (for crushed grave), 8 shore, and siap but waived if (spassing 0.075 siere) / 9 spassing 0.425 sieve] is 0.60 or fess)	Bearing Ratio not less than 80 (for less than 80 (for except when cushed greed, not subsed greed, not subsed stag used), not monthess 5 Cycle: monthess 5 Cycle: Monthess 25%, Lick Migles Abrasion: maximum
	TX DOT 1993	Granular material.	Material containing organic or otherwise deleterious matter or unacceptable lumps of earth.	Not specified.	Not specified.	45	15	Bar Linear Shrinkage not greater than 2.


Entrementer         LA DOT         Send         Note         No. 200         Specified.         North           (Norplassic Sol)         192         sakit         Option transition and the constraint and co	Princes	Agency	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	Gradation	Max Liquid Limit	Max Plasticity Index	Other Requirements
Abore 6 th (Soli Mone 6 th Deph)         LADOT         Mot specified         Not specified         Not specified         Not specified         <	Embankments (Nonplastic Soil)	LA DOT 1992	Sand, dam shell, or reef shell.	Water saturated sols, organizater, material not usable for foundation material, or material which will dest or produce will dest or produce subsistence in the soil such saturmar, rock, togs, or fragmented red shell.	Not specified.	Sand No. 4 75% No. 200 15% Shell No. 200 15%	Not specified.	Nonplastic.	Organic content of 4% or less.
Filter filter         LA DOT         Not specified.         Not specified. </td <td>Embankments (Soil Above 8 ft Depth)</td> <td>LA DOT 1992</td> <td>Not specified.</td> <td>Not specified.</td> <td>Not specified.</td> <td>Not specified.</td> <td>Not specified.</td> <td>20 (20 to 35 if treated with at least 6% lime).</td> <td>Organic content less than 5%. Sitt content of 60% or less.</td>	Embankments (Soil Above 8 ft Depth)	LA DOT 1992	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	20 (20 to 35 if treated with at least 6% lime).	Organic content less than 5%. Sitt content of 60% or less.
Entrantments         LA DOT         Nut specified.         Nut specified. <td>Embankments (Soil Below 8 ft Depth)</td> <td>LA DOT 1992</td> <td>Not specified.</td> <td>Not specified.</td> <td>Not specified.</td> <td>Not specified.</td> <td>Not specified.</td> <td>35 (35 to 45 if treated with at least 10% lime).</td> <td>Organic content less than 5%. Silt content of 60% or less.</td>	Embankments (Soil Below 8 ft Depth)	LA DOT 1992	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	35 (35 to 45 if treated with at least 10% lime).	Organic content less than 5%. Silt content of 60% or less.
Filters (Blanket) AASHTO Gravel, russhed gravel, Not specified 2 inches. AASHTO M.43, size No. 457: Not Not specified. 1984 cutshed bistory.cutshed air- cooled bistory.cutshed air- cutshed concrete. 313, or 19 35:70 19 35:70 15 05:00	Embankments (Wiin 1000 ft Of Bridge End)	LA DOT 1992	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	10 to 20.	Organic content less than 5%. Sit content of 60% or less.
	Fitters (Blanket)	AASHTO 1984	Gravel, crushed gravel, crushed store, crushed air- cooled blast-furmee stag, or crushed concrete.	Nut specified.	2 inches.	AASHTO M 43, size No. 467 mm % 50 100 37.5 95-100 37.5 95-100 9.5 10-30 4.75 0-5	Not specified.	Not specified.	Not specified.

Purpase	Agency	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	Gradation Ma	X Liquidi Limit	Max Plasticity Index	Other Requirements
Fitters (For Dam Embankments)	Army COE 1997	Tough, durable particles of sand, gravel, or crushed stone.	Material containing thin, flat and elonged panticles and/or soft, finable panticles in objectionable quantities or material containing brush, perishable materials.	Not specified.	Grading curves shall not exhibit adout change or is stope denoing sid grading, scaping or is real a size, so other irregularties which would be definiential to the proper functioning of the filter.	P specified.	Not specified.	Not specified.
Filters (For Rip- Rap)	AASHTO 1984	Hard, durable particles or fragments of crushed stone or natural gravel.	Not specified.	3 inches.	3 in 100% no. 4 20-50% no. 200 0-10%	Not specified.	Not specified.	Not specified.
Foundations (Bridge)	TX DOT 1993	Stone or lean concrete (only if backfiling an excavation in had material resistant to erosion).	Not specified.	4 inches.	A gradation that permits thorough compaction.	Not specified.	Not specified.	Not specified.
	WI DOT 1996	Sand, a mixture of sand with gravel, consibled gravel, conside store, or other consideration mineral material.	Material containing frozen Imps, wood, logs, stumps, brush, or ofthe extraneous or perishable material.	3 inches.	75 mm 100% 4.75 mm not leas than 25% Of all material passing 4.75 mm siev 0.075 mm not more than 15%	Not specified.	Not specified.	Not specified.



TUTOSE	Agency	Satisfactory Sol	Unsatisfactory Sel	Max Particle Size	Gradation	(RM)	X Liquid Lint	<b>Max Plasticity Index</b>	Other Requirements
(General) (General)	Houston 1997	GW and SW. Well-graded graded sards, gradel and mixtures, crusted well- graded rock, little or no fines.	ML. CL-ML. MH. PT. OH. and OL. Maerials strat according targe clots: acgroupdates, debreis: protocapates, debreis: hydrocapates or any inder deleterious materials. Materials and accordinationals. Materials and accordinationals according to the required deresty due to effer gradiation, plastely, or molsture content.	4 inches.	D60/D10 no 200	greater than 5% not greater than 5%	Not specified.	Nonplastic.	Net specified.
	LA DOT 1992	Not specified.	Large or frozen lumps, stones, roots, wood, and other foreign matter.	Not specified.	Not specifie	8	Not specified.	Not specified.	Not specified.
	Navy 1998	GW, GP, SW, of SP.	Not specified.	2 1/2 inches.	2 1/2 in No. 4 No. 10 No. 200 No. 200	00% 40.85% 20.80% 5-35% (10% for crib wall) 5-35% (10% for crib wall)	55	12	Coefficient of permeability shall be a minimum of 0.01-1 mmr/sec (0.002-0.2 ft/min).
General Fill	Army COE 1997	GW, GP, GM, GP-GM, GW- GM, GC, PC-GC, GM-GC, SW, SP, SM, SWSM, SC, SW-SC, SP-SM, SP-SC, GL, ML, CL-ML, CH, or MH.	Materials containing mar- made fills, trash, retues, bachfills from previous construction, rods, organic marker, frozen materials, or contaminated materials.	Haff of the allowable lift thickness. 8 inches (for grading). 3 inches (for pavements and railroads).	Not specifi	8	Not specified.	Not specified.	Not specified.



Purpese	Agency	Satisfactory Sol	Unsattsfactory Sol	Max Particle Size	Gradiation Mi	ax Liquid Limit	Max Plasticity Inde	x Other Require
General Fill	CGSF 1988	Predominantly sand or sand and gravel.	Material containing clods, wood, or masonry debris, or other deleterious material.	Not specified.	Not more than 20% passing the No. 200 sieve.	Not specified.	Not specified.	Not specified.
	LA DOT 1992	Not specified.	Not specified.	Not specified.	Not specified .	Not specified.	20	Organic cont than 5%. Silt of 60% or les
	LANL 1997	Granular soil.	Material containing organic material or other deleterious materials.	Not specified.	Not specified.	Not specified.	Nonplastic.	Not specified
	NASA 1997	AASHTO M 145 Classification Groups A-1 (well graded mitute of store harmens or gravel, correeby plastic an tonplastic or feeby plastic soil thinker, volcare codes whon stol binde), A-2, and A-2 (grave to coarse sand cordaning stif, fine sand cordaning stif, fine sand cordaning the fine	AASHTO M 145 AASHTO M 145 and A-2 (A-24 ang A-26 and A-2 (A-24 and A-25 sols containing plastic clary). A (nonplastic or moderately plastic sithy soli: frite sith sol). A-5 diadoma-coust A micascoust A solis, A-6 micascoust A solis, frite clary soli), and A-7 soli).	2 inches.	Not specified	Not specified.	Not specified.	Not specified
		siny, and A-3 (me beach sand and fine desert blow sand without silly or clay fines; stream deposited micure of poorly graded fine sand, coarse sand, and gravel).	(allatomaceous or micaceous A-6 soils), peat and other highly organic soil. Materials containing clay decis debits, areate, frozen materials, or other deletenous matter.					



Purpese	Agency	Satisfactory Sol	Unsatistactory Sol	MAX FAFLICES SUL	USU ENC.PI	MAX LINKING LINKI	Max Frasticity mean	Uther Kequireme
General Fill	Navy 1998	GW, GP, GM, GC, SW, SP, SM, or SC.	Material containing debris, roots, wood, scrap material, vegetation, retuse, soft unsound particles, frozen, deterious, or objectionable materials.	Haif of the allowable lift thickness.	0.075 mm 25%	8	12	Not specified.
	Scotland DOT 1976	Not specified.	Material from swamps, masterial and bogs, pest, logs, stumps, and perishable material susceptible to spontaneous combustion, frozen material	Not specified.	Not specified.	8	ន	Not specified.
	VA 1996	Not specified.	Topsol, frozen materials, construction materials, materials, subject to desomposition, clobs of desomposition, clobs of desy organic material, including sits, who materials, including sits, too well to be stable.	3 inches.	Not specified.	Not specified.	Not specified.	Not specified.
	WV DOT 1994	Random material (a mixture of any or all of soil, granular material, or soft shale).	Material containing frozen lumps, wood, or other extraneous material.	3 inches.	Not specified.	Not specified.	Not specified.	Not specified.
General Fill (Against Waterproofed Surfaces)	NASA 1997	Natural sand.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.



General Fill Scotland Granular mate (Below Water DOT 1976 Granular mate Table) General Fill LA DOT Natural sol. (Select, Controlled) 1992 Matural sol. 1994 ecks.hard.h	erial.					And Laplace Land	MAA I MOUNTLY MINUT	ULUBIT ABUM THINKILLS
General Fill LA DOT Natural soil. (Select. Controlled) 1992 Matural soil. WV DOT Crushed ston 1994 rock. DM ca		Not specified.	15 3/4 inches.	10 mm 5 mm 0.6 mm 0.075 mm	up to 100% not more than 85% not more than 45% not more than 5%	Not specified.	Not specified.	Not specified.
WV DOT Crushed ston 1994 clean, hard, it rock, OR Gra		Not specified.	Not specified.	Not specifie	x	35	15	Organic content of 2% or less. Sitt content of 60% or less.
hard, durated Browgipy of Stack, OF S Brack, Armase Resonaby density and q	e: particles of wei: particles of wei: particles of rock, ana and well sag: air cooled slag: slag: uality.	Cushed store: particles with adherent caratings. Slags slag containing dit or other objectionable matter.	2 increas.	50 mm 1.18 mm mm	00%	Not specified.	Not specified.	Crushed store: Percentage wear not to exceed 9. Warmond to exceed 12. To exceed 13. To
Geosynthetic F.L.DOT Free draining Reinforcement (199 (General)	material.	Soil carnett or linne stabilized backfill.	3 1/2 inches.	90 mm 19 mm 4.75 mm 0.425 mm 0.150 mm 0.075 mm	100% 70 to 100% 30 to 100% 5 to 65% 0 to 15%	ŧ	G	Organic material: not more than 2% by weight. pH from 6 to 10.



Purpase	Agency	Satisfactory Soll	Unsatisfactory Sol	Max Particle Size	Gradation		Max Liquid Limit	Max Plasticity Index	Other Requirements
Geotextile Fabric Covering	IL DOT 1997	Pit nn graek, graek, crushed graek (noreaufie, crushed stork: crushed lag, or concrete, crushed lag, or crushed sardstore.	Mot specified.	1 Inch (br. gradation A b) 112 Inches (for gradation CA 10).	37.5 mm 25 mm 19 mm 12.5 mm 1.18 mm 1.18 mm 0.075 mm	A 6 C 4 10 95±5 10 95±5 10 75±15 80±15 42±13 50±15 42±13 50±15 22±15 30±15 8±4 9±4	Not specified.	6 (for gravel) store, and gravel, store, and sag but weved if 1%2assing 0.075 sievel / 196passing 0.425 sievel is 0.60 or less)	Bearing Ratio not embaning Ratio not embanitrmer fill only gravel, crushed store, or
Pipe Arches and Structural Plate Pipes	WI DOT 1996	Sand, a mixture of sand with gravel, crushed gravel, crushed sknee, or other broken or fragmented mineral material.	Material containing frozen lumps, wock, Jogs, stumps, buush, or other extraneous or persitable material.	3 inches.	75 mm 4.75 mm Of all materi 0.075 mm	100% not less than 25% tal passing 4.75 mm t not more than 15%	Not specified. sieve:	Not specified	Not specified.
Cetaining Walls (Crib Type)	Navy 1998	GW, GP, SW, of SP.	Not specified.	2 1/2 inches.	2 1/2 in 1 No. 4 4 No. 10 2 No. 200 5	00% D-85% D-80% D-60% E-35% (10% for crib w	al) 35	12	Coefficient of permeability shall be a minimum of 0.01-1 mm/sec (0.002-0.2 ft/min).
Retaining Walls (General)	LA DOT 1992	Not specified.	Large or frozen lumps, stones, roots, wood, and other foreign matter.	Not specified.	Not specifie	÷	Not specified.	Not specified.	Not specified.



Purpese	Agency	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	Gradation M	ax Liquid Limit	Max Plasticity Index	( Other Requirements
Retaining Walls (General)	1X DOT 1993	Stone or learn concrete (only if backfilling an excavation in hard material resistant to erosion).	Not specified.	4 inches.	A gradation that permits thorough compaction.	Not specified.	Not specified.	Not specified.
	WI DOT 1996	Sand, a mixture of sand with gravel, crushed gravel, crushed stone, or other broken or fragmented mineral material.	Material containing frozen lumps, word logs, stumps, brush, or other extraneous or penshable material.	3 inches.	75 mm 100% 4.75 mm not less than 25% Of all material passing 4.75 mm sie 0.075 mm not more than 15%	Not specified. ve:	Not specified.	Not specified.
Retaining Walls (MSE Type)	DERS 1999	Not specified.	Material containing organic matter.	4.6 inches. 3.4 inch (where geoffabrios or metals coated with PVC or epoxy are used).	6 inch 100% 3 inch 1075% co. 200 -25% 4 inch 100% no. 40 0-60% no. 200 0-15%	Not specified.	œ	Angle of internal finction not less than 34 degrees
	Geostone	On-site dewatered, compatible selected fill and crushed stone.	Not specified	<ol> <li>112 inches (unless field tests have been performed to been performed to been performed be available the geosynthetic due to installation damage).</li> </ol>	Not specified.	Not specified.	Not specified.	Not specified.



Purpose	Agency	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	<b>Cradation</b>	-	tax Linnid Limit	Max Plasticity Index	Other Readments
Retaining Walls (MSE Type)	Keystone 1994	Site excavated solis.	Material containing debris. Highly plastic clays or organic soils.	3/4 inch (unless field tests evaluate potential strength reductions to the geogrid design due to damage during construction).	2 inch 3/4 inch No. 4 No. 200	100-75% 100-25% 0-60% 0-35%	4	9	Not specified.
	Tensar 1997	Granular soil. Recycled concrete if high density polypthytene or polypthytene geograf is used.	Not specified.	2 inches.	2 inch 3/4 inch no 40 no 200	100-75% 100-75% 100-20% 0-50% 0-35%	Not specified.	Not specified.	pH from 5 to 9 (waived when high density polyethylene or polypropylene geogrid is used).
	TX DOT 1993	Not specified.	Material containing organic or otherwise deletarious matter.	34 inch (for more able or epoxy rosted reinforcement). and ables (for gradation B). gradation B).	Gradation 3 inches No. 40 No. 200 6 inches 3 inches 3 inches No. 200	A: 100% 0-60% 0-15% 0-15% 75-100% 0-15% 0-15%	Not specified.	6 (for gradation B).	Angle of internal friction not less han 34 degrees at 95% of Da densky (only for Alternative Type B).
Retaining Walls (Spread Footing Type)	TX DOT 1993	Rock, Ibam, clay, or other materials.	Material containing organic or otherwise deletenous matter or unacceptable lumps of earth.	Not specified.	Not specif	2	Not specified.	Not specified.	Not specified.
Slabs	NASA 1997	Washed, uniformly graded mixture of crushed stone or crushed or uncrushed gravel	Not specified.	1 1/2 inches.	37.5 mm 4.75 mm	100% not more than 5%	Not specified.	Not specified.	Not specified.

	Aguicy	Satisfactory Sol	Unsatisfactory Sel	Max Particle Size	Cratation I	Max Liquid Limit	Max Plasticity Index	Other Requirements
Slabs	Navy 1998	GW, GP, SW, or SP.	Not specified.	2 1/2 inches.	2 112 in 100% No. 4 4035% No. 10 20-80% No. 40 10-60% No. 200 5-35%(10% for crib wa	35	12	Coefficient of permeability shall be a minimum of 0.01-1 mm/sec (0.002-0.2 ff/min).
	VA 1996	Crushed stone or gravel.	Not specified.	1 inch.	Graded from 25 mm (1 inch) to No	.4. Not specified.	Not specified.	Not specified.
Structures (Against Sides Above Drains)	Keystone 1994	Clean crushed stone or crushed gravel.	Material containing debris. Highly plastic clays or organic soils.	Not specified.	Not specified.	Not specified.	Not specified.	Not specified.
	NASA 1997	Uniformly graded mixture of natural or crushed gravel, crushed stone, and natural sand.	Not specified.	3/8 inch.	9.5 mm 100% 0.150 mm 2-10%	Not specified.	Not specified.	Not specified.
Structures (Against Sides)	Navy 1998	GP, GM, GC, SP, or SM.	Soft, spongy, highly plastic, or otherwise unstable material.	3 inches.	Shall contain sufficient fines to ens proper compaction.	ure Not specified.	Not specified.	Not specified.
	OR DOT 1996	Granular material composed of crushed and/or uncrushed rock.	Not specified.	3 inches.	75 mm 100% 9.5 mm 0.00% 425 mm 0.40% 150 mm 0.10% 75 mm 0.6%	Not specified.	6 (for material passing 0.425 mm sieve).	Not specified.

Prose of	Agency	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	Gradation	Max	Liquid Limit	Max Plasticity Index	Other Requirements
Structures (Against Sides)	Scotland DOT 1976	Well graded crushed or uncrushed gradel, stone, rock fill, crushed concrete or stag or natural sand or a combination of any of these.	Soluble sulphate content < 2.5 g/L.	0.015 cubic meters.	125 mm 75 mm 0.075 mm	not less than 95% at least 90% not more than 10%	Not specified.	Not specified.	Not specified.
Structures (General)	Amy COE 1997	GW, GP, GM, GP-GM, GW, GM, GS, GP-GS, GM-GS, SW, SP, SM, SN, SN, SN, SN, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML, CH, or MH,	OL, OH, and PT. Materials containing, max-made fills, trash, reluts, maxafills from previous construction, rods, organic matter, troxen materials, or contaminated materials.	3 inches.	Not specified		Not specified.	Not specified.	Not specified.
	Lake Oswego 1999	Imported crushed rock.	Not specified.	2 inches.	Well graded no more that the No. 200	from course to fine with 18% by weight passing sieve.	Not specified.	Not specified.	Not specified.
	Navy 1998	GP, GM, GC, SP, SM, or SC.	PT, OH, or OL, Material most, word, scrap most, word, scrap most, word, scrap material, veglable material frivan material, or material having machinetar scraph or abality to carry memode basis whore accessive basis whore accessive basis whore accessive basis whore accessive basis who accessive basis who accessive basis who accessive basis who accessive basis who accessive basis accessin accessive basis accessin accessive basis accessive bacce	3 inches.	Not specifica		Not specified.	Not specified.	Not specified.



Structures         NMOI         Structure streamed stame, claime, or administrate frant or applicities         Terms of a structure structure static administration of a structure structure static administration of a structure	Purpese	Aponcy	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	Gradation	Ŧ	x Liquid Limit	Max Plasticity Index	Other Requirements
OR D01         Granutar material consisting 1986         Mot specified d crustelet durable root.         Not specified 135.mm         Storm         Not specified 135.mm         Not specified sereity         Not specified sereity <t< td=""><td>Structures (General)</td><td>NM DOT 1994</td><td>Stone, crushed stone, crushed or screened gravel, caliche, or sand.</td><td>Material free from organic matter, sitt, clay balls, frozen matter, or other deleterious matter</td><td>2 inches.</td><td>No. 200 25</td><td>*</td><td>Not specified.</td><td>6 (for material passing No. 200 sieve).</td><td>Not specified.</td></t<>	Structures (General)	NM DOT 1994	Stone, crushed stone, crushed or screened gravel, caliche, or sand.	Material free from organic matter, sitt, clay balls, frozen matter, or other deleterious matter	2 inches.	No. 200 25	*	Not specified.	6 (for material passing No. 200 sieve).	Not specified.
TXODT         Cohesionless materials, such as sand, such as sand, su		OR DOT 1996	Granular material consisting of crushed, durable rock.	Not specified.	2 inches.	50 mm 10 12.5 mm 50 4.75 mm 35 425 mm 15 150 mm 0 -	9% - 80% - 35% 15%	Not specified.	6 (for material passing 0.425 mm sieve).	Not specified.
Stuctures (Nor- Amy COE Washed sand, M., Mil and Ch for critical Not specified, 0.075 mm less than 5%, Not Mod Specified. Not specified Succeptible 1997 (S. M. Scholl Scholl, Scholl Scholl, Scholl Scholl, Scholl		TX DOT 1993	Cohesionless materials, such as sand.	Material containing wood, other extraneous material, frozen lumps, or large lumps that would not break down readily under compaction.	A size that would interfere with compaction.	Not specified.		Not specified.	Not specified.	Not specified.
Trenches (General) Amy COE GW, GP, GM GP-GM, GW. Materials containing man- 3 inches. Not specified. Not specified. Not specified GM GC, GP-GC, GN+GC, made fills, trash, relises, sinches and fills, trash, relises, sinches and sinches a	Structures (Non- Frost Susceptible Soil)	Army COE 1997	Washed sand.	ML, MH, and CH for critical structures.	Not specified.	0.075 mm le 0.020 mm nx	ss than 5% of more than 2%	Not specified.	Not specified.	Not specified.
	Trenches (General)	Army COE 1997	GW, GP, GM, GP-GM, GW. GM, GP, GP, GP, GP, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, SU, ML, CL-ML, CH, or MH.	Materials containing man- made fils, trash, retuse, backfils from previous construction, roots, organic matter, frozen materials, or contaminated materials.	3 inches.	Not specified.		Not specified.	Not specified.	Not specified.



L'pass	Aponcy	Satisfactory Sel	Unsatisfactory Sell	Max Particle Size	Gradation	R.	x Liquid Limit	<b>Max Plasticity Index</b>	Other Required
(General)	1999 1999	Naturahy occurring materials such as pravid, or reaching provide natural rock, aggs, supanded clays and stags, supanded clays and aggreght and clarer aggreght and clarer aggreght inert materials with similar characteristics, having hard, strong, durable particles.	Material containing unreasonable amounts of the jumps, soft and frable particles, sait, atlasi, organic matter, adherent coartings, and other substances nd defined which may possess undesirable characteristics.	34 inch.	19 mm 12.5 mm 9.5 mm 2.36 mm 2.36 mm	100% 90-100% 40-70% 0-15% 0-5%	Not specified.	Not specified	Los Angeles Abrasion: maxin los Astoris Soundness (30 Sulfate): maxim loss 12% Fial or elongate pieces: maxim 10%.
	IL DOT 1997	Sand, stone sand, stone screening, chas, wet beform bolier stag, stag sand, granulated stag sand, crushed concrete sand, or construction and demolition debris sand.	Material containing an excess and and unsound protices and other objectionable matter.	Not specified.	4.75 mm 0.150 mm 0.075 mm	FA 6 92±8 20±20 6±6	Not specified.	Not specified.	Not specified.
	Lake Oswego 1999	Imported crushed rock.	Material containing dirt, clay balls, and organic material.	1 inch.	Less than sieve.	8% passing the No. 200	Not specified.	Not specified.	Not specified.
	NASA 1997	Sandy clay, sand, gravel, soft shale.	Not specified.	Not specified.	Not specifi	jec.	Not specified.	Not specified.	Not specified.



Purpess	Apency	Satisfactory Sol	Unsatisfactory Sol	Max Particle Size	Gradation	Max Liquid Limit	Max Plasticity Index	Other Requirements
Trenches (General)	Navy 1998	GM, SM, or SC.	PT, OH, or OL, Material containing obtoin: retures, containing obtoin: retures, material, swegtable matter, material, or material, or material haning sus/fiferian teres of adds without excessive consolidation or tisss of addition or tisss of addition or tisss of addition or tisss of addition or tiss of addition or tiss, or other material withol could damage the particles, soluble proto or cause the backfill not to compact.	3 inches.	Not specified.	Not specified.	Not specified.	Not specified.
	WV DOT	Random material (a mixture of anv or all of soil oranular	Not specified.	3 inches.	Not specified.	Not specified.	Not specified.	Not specified.

specified.
Not
Not specified
Not specified.
Not specified.
3 inches.
Not specified.
Random material (a mixture of any or all of soil, granular material, or soft shale) or crushed aggregate.
WV DOT 1994



Parpese	Agency	Satisfactory Sel	Unsatisfactory Sol	Max Particle Size	Gradation Max	c Liquid Limit	<b>Max Plasticity Index</b>	Other Requirements
Trenches (Permeable Soil)	AASHTO 1984	Hand, undek, cean sand, grand, crutshed stone, or grutshed stag.	Organic material. Clay balls, substances. substances.	1/2 inch (Course Aggregate) Aggregate). Aggregate).	Course Aggregate (AASHTO M.43, area No. 89): 12.5 90-100 9.5 90-100 1.18 0.10 0.300 0.5 0.300 0.5 Fine Aggregate (AASHTO M.6):	Not specified.	Not specified.	Not specified
					mm % 9.5 100 9.4 75 95-100 1.18 95-100 0.300 10-30 0.150 2-10			
	L DOT 1987	Fire Aggregates: Sand, slore each store store each store bottom bolier stag, stag sand, grantieler dags sand, cutshed concrete sand, or construction and dent Aggregate, plut nu gravel, and store cutshed store cutshed store cutshed date, cutshed store cutshed concrete. Cutshed store cutshed store cutshed store.	Not specified	3 inches (for coarse aggregates) 338 mch (for fine aggregates).	Course Aggregates: 75 mm 100 75 mm 100 25 mm 95-5 25 mm 95-5 118 mm 55-25 118 mm 55-25 0030 mm 10-100 0075 mm 22-2 5-50 55-50 110 mm 10-2 110 mm 10-2	Not specified.	Not specified.	Not specified

Trenches (Sanitary/Storm Sever Bedding)	Appency VA 1996	Satisfraction y Sual Crushed stone or gravel.	Insatisfactury Sal	Max Particle Size 1/2 inch.	Graded fr. 4.	Ma Ma 13 mm (1/2 inch) to No.	x Liquidi Limit Not specified.	Max Plasticit	ty Index
Trenches (Select Soil)	Army COE 1997	Well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, bugh and durable particles.	Not specified.	3 inches or 1 inch per foot of pipe diameter.	25 mm 0.075 mm	not less than 95% not more than 10%	Not specified.		Vol specified.
	WI DOT 1996	Sand, a mixture of sand with gravel, crushed gravel, crushed stone, or other broken or fragmented mineral material.	Not specified.	6 inches. 1 inch (for pipe bedding).	150 mm 75 mm 4.75 mm Of materia	100% not less than 85% not less than 25% I passing 4.75 mm sieve:	25	9	
					Grade 1: 4.75 mm 0.425 mm 0.150 mm 0.075 mm	100% not more than 75% not more than 15% not more than 8%			
					Grade 2: 4.75 mm 0.425 mm 0.150 mm 0.075 mm	100% - not more than 30% not more than 15%			
Trenches (Sewage Absorption)	Navy 1998	Clean crushed rock or gravel.	Not specified.	2 inches.	50 mm 12.5 mm	100% 0%	Not specified.	Not	specified.



Purpess	Agency	Satisfactory Soil	<b>Unsatisfactory Sol</b>	Max Particle Size	Gradation	Max	Liquidi Limit	Max Plasticity Index	Other Requirements
Trenches (Stabilization Of)	Lake Oswego 1999	Imported crushed rock or gravel or clean pit run gravel.	Not specified.	3 inches.	Well grade no more th the No. 201	d from course to fine with an 8% by weight passing 3 sieve.	Not specified.	Not specified.	Not specified.
Trenches (Under Paved Areas)	Navy 1998	GW, GP, SW, or SP.	Not specified .	2 1/2 inches.	2 1/2 in No. 4 No. 200 No. 200	100% 40.85% 20.80% 5.35% (10% for crib wail)	×	12	Coefficient of permeability shall be a minimum of 0.01-1 arm/sec (0.002-0.2 ft/min).
	TX DOT 1993	Not specified.	Not specified.	Not specified.	Less than	20% passing 3 inch sieve.	Not specified.	Not specified.	Not specified.

Appendix B: Maximum Particle Size Grouped by Purpose


# Maximum Particle Size Grouped by Purpose

Purpose	Agency	Maximum Particle Size
Bedding (For Sidewalks And Curbing)	AASHTO 1984	1/2 inch.
Bedding (For Slope Protection)	AASHTO 1984	1 1/2 inches.
Bedding (General)	IL DOT 1997	3/8 inch.
	Lake Oswego 1999	1 inch.
	Navy 1998	2 inches.
Blankets (For Stone Protection)	AASHTO 1984	2 1/2 inches.
Capillary Water Barrier (Under Concrete Slabs)	Army COE 1997	1 1/2 inches.
Culverts	TX DOT 1993	4 inches.
	WI DOT 1996	3 inches.
Drains (Subsurface)	AASHTO 1984	1/2 inch (Course Aggregate). 3/8 inch (Fine Aggregate).
	IL DOT 1997	3 inches (for coarse aggregates). 3/8 inch (for fine aggregates).
	NASA 1997	3/8 inch.

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Purpose	Agency	Maximum Particle Size
Drains (Subsurface)	Navy 1998	A size that will prevent the entrance of any of the porous material into the drain.
	WI DOT 1996	6 inches. 1 inch (for pipe bedding).
Embankments (General)	FAA 1991	4 inches (within top 6 inches of embankment).
	FL DOT 1999	<ul> <li>3.5 inches (0-12 inches depth or within 3 feet of bridge piling).</li> <li>6 inches (12-24 inches depth).</li> <li>12 inches or compacted thickness of layer (below 24 inches depth).</li> </ul>
	Houston 1997	3 inches.
	IL DOT 1997	4 inches (within top 12 inches of fill or top 3 inches of fill under pavement, surface course, or base course). Concrete and rocks with less than 2 sqft on any face may be placed in fill in layers less than 12 inches thick if well embedded and surrounded by enough smaller particles to give the required density.
	Lake Oswego 1999	1 inch.
	MD DOT 1993	24 inches.
	NASA 1997	3 inches.
	NM DOT 1994	36 inches. 10 feet or 1/2 of the embankment height (near the toe of the slope).
	SHCE 1996	3 inches (within 18 inches of foundations, slabs, or ground surface).

Purpose	Agency	Maximum Particle Size
Embankments (General)	USBR 1999	5 inches.
	UT DOT 1994	2-3 inches.
	WI DOT 1996	A size that would significantly affect scarifying, compacting, and finishing the subgrade (within 8 inches of the surface). 3 inches or a size that would significantly affect driving of piles or boring of holes (where piles driven or holes bored).
Embankments (General, Pervious Soil)	IL DOT 1997	3 inches (for coarse aggregates). 3/8 inch (for fine aggregates).
Embankments (Granular)	IL DOT 1997	1 inch (for gradation CA 6). 1 1/2 inches (for gradation CA 10).
Filters (Blanket)	AASHTO 1984	2 inches.
Filters (For Rip-Rap)	AASHTO 1984	3 inches.
Foundations (Bridge)	TX DOT 1993	4 inches.
	WI DOT 1996	3 inches.
Foundations (General)	Houston 1997	4 inches.
	Navy 1998	2 1/2 inches.
General Fill	Army COE 1997	Half of the allowable lift thickness. 8 inches (for grading). 3 inches (for pavements and railroads).

Purpose	Agency	Maximum Particle Size
General Fill	NASA 1997	2 inches.
	Navy 1998	Half of the allowable lift thickness.
	VA 1996	3 inches.
	WV DOT 1994	3 inches.
General Fill (Below Water Table)	Scotland DOT 1976	15 3/4 inches.
General Fill (Select, Controlled)	WV DOT 1994	2 inches.
Geosynthetic Reinforcement (General)	FL DOT 1999	3 1/2 inches.
Geotextile Fabric Covering	IL DOT 1997	1 inch (for gradation CA 6). 1 1/2 inches (for gradation CA 10).
Pipe Arches and Structural Plate Pipes	WI DOT 1996	3 inches.
Retaining Walls (Crib Type)	Navy 1998	2 1/2 inches.
Retaining Walls (General)	TX DOT 1993	4 inches.
	WI DOT 1996	3 inches.
Retaining Walls (MSE Type)	DERS 1999	4-6 inches. 3/4 inch (where geofabrics or metals coated with PVC or epoxy are used).

Purpose	Agency	Maximum Particle Size
Retaining Walls (MSE Type)	Geostone	1 1/2 inches (unless field tests have been performed to elevate potential strength reduction in the geosynthetic due to installation damage).
	Keystone 1994	3/4 inch (unless field tests evaluate potential strength reductions to the geogrid design due to damage during construction).
	Tensar 1997	2 inches.
	TX DOT 1993	3/4 inch (for nonmetallic or epoxy coated reinforcement). 3 inches (for gradation A). 6 inches (for gradation B).
Slabs	NASA 1997	1 1/2 inches.
	Navy 1998	2 1/2 inches.
	VA 1996	1 inch.
Structures (Against Sides Above Drains)	NASA 1997	3/8 inch.
Structures (Against Sides)	Navy 1998	3 inches.
	OR DOT 1996	3 inches.
	Scotland DOT 1976	0.015 cubic meters.
Structures (General)	Army COE 1997	3 inches.
	Lake Oswego 1999	2 inches.

Purpose	Agency	Maximum Particle Size
Structures (General)	Navy 1998	3 inches.
	NM DOT 1994	2 inches.
	OR DOT 1996	2 inches.
	TX DOT 1993	A size that would interfere with compaction.
Trenches (General)	Army COE 1997	3 inches.
	FL DOT 1999	3/4 inch.
	Lake Oswego 1999	1 inch.
	Navy 1998	3 inches.
	WV DOT 1994	3 inches.
Trenches (Permeable Soil)	AASHTO 1984	1/2 inch (Course Aggregate). 3/8 inch (Fine Aggregate).
	IL DOT 1997	3 inches (for coarse aggregates). 3/8 inch (for fine aggregates).
Trenches (Sanitary/Storm Sewer Bedding)	VA 1996	1/2 inch.
Trenches (Select Soil)	Army COE 1997	3 inches or 1 inch per foot of pipe diameter.
	WI DOT 1996	6 inches. 1 inch (for pipe bedding).

Purpose	Agency	Maximum Particle Size	
Trenches (Sewage Absorption)	Navy 1998	2 inches.	
Trenches (Stabilization Of)	Lake Oswego 1999	3 inches.	
Trenches (Under Paved	Navy 1998	2 1/2 inches.	

### **Appendix C: Atterberg Limits Grouped by Purpose**

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# Atterberg Limits Grouped by Purpose

Purpose	Agency	Max Liquid Limit	Max Plasticity Index
Bedding (General)	LA DOT 1992	Not specified.	Nonplastic (for sand, stone, and recycled portland cement concrete passing the no. 40 sieve).
	Navy 1998	Not specified.	6 (for material passing the 0.075 mm sieve).
Blankets (Plastic Soil)	LA DOT 1992	Not specified.	12 to 35.
Drains (Subsurface)	WI DOT 1996	25	6
Embankments (General)	Houston 1997	45.	12 to 20 (do not use a blend cohesive and granular soils to achieve this value).
	UT DOT 1994	Not specified.	Nonplastic.
Embankments (Granular)	IL DOT 1997	Not specified.	6 (for gravel). 4 (for crushed gravel, stone, and slag but waived if [%passing 0.075 sieve] / [%passing 0.425 sieve] is 0.60 or less).
	TX DOT 1993	45	15
Embankments (Nonplastic Soil)	LA DOT 1992	Not specified.	Nonplastic.
Embankments (Soil Above 8 ft Depth)	LA DOT 1992	Not specified.	20 (20 to 35 if treated with at least 6% lime).

Purpose	Agency	Max Liquid Limit	Max Plasticity Index
Embankments (Soil Below 8 ft Depth)	LA DOT 1992	Not specified.	35 (35 to 45 if treated with at least 10% lime).
Embankments (W/in 1000 ft Of Bridge End)	LA DOT 1992	Not specified.	10 to 20.
Foundations (General)	Houston 1997	Not specified.	Nonplastic.
	Navy 1998	35	12
General Fill	LA DOT 1992	Not specified.	20
	LANL 1997	Not specified.	Nonplastic.
	Navy 1998	35	12
	Scotland DOT 1976	90	65
General Fill (Select, Controlled)	LA DOT 1992	35	15
Geosynthetic Reinforcement (General)	FL DOT 1999	15	6
Geotextile Fabric Covering	IL DOT 1997	Not specified.	6 (for gravel). 4 (for crushed gravel, stone, and slag but waived if [%passing 0.075 sieve] / [%passing 0.425 sieve] is 0.60 or less).
Retaining Walls (Crib Type)	Navy 1998	35	12

Purpose	Agency	Max Liquid Limit	Max Plasticity Index
Retaining Walls (MSE Type)	DERS 1999	Not specified.	6
	Keystone 1994	40	10
	TX DOT 1993	Not specified.	6 (for gradation B).
Slabs	Navy 1998	35	12
Structures (Against Sides)	OR DOT 1996	Not specified.	6 (for material passing 0.425 mm sieve).
Structures (General)	NM DOT 1994	Not specified.	6 (for material passing No. 200 sieve).
	OR DOT 1996	Not specified.	6 (for material passing 0.425 mm sieve).
Trenches (Select Soil)	WI DOT 1996	25	6
Trenches (Under Paved	Navy 1998	35	12

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## Appendix D: Satisfactory Soils Grouped by Agency

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## Satisfactory Soils Grouped by Agency

Agency	Satisfactory Soil Description			
	Not specified.			
AASHTO 1984	Gravel, crushed gravel, crushed stone, crushed air-cooled blast-fumace slag, or crushed concrete.			
	Porous, free-draining material consisting of sand, gravel, cinders, slag, or crushed stone.			
	Cinders, sand, slag, gravel, or crushed stone.			
	Hard, durable particles or fragments of crushed stone or natural gravel.			
	Hard, durable, clean sand, gravel, crushed stone, or crushed slag.			
Army COE 1997	Tough, durable particles of sand, gravel, or crushed stone.			
	Clean, free draining sand or sand and gravel free from any objectionable coating.			
	Clays, silty clays, or clayey silts. Silts and clays containing sand may be used if sufficiently impermeable and suitable for compacting with a tamping or rubber-tired roller.			
	Well-graded sand, gravel, crushed gravel, crushed stone or crushed slag composed of hard, tough and durable particles.			
	Clean, crushed, nonporous rock, crushed gravel, or uncrushed gravel.			
	Washed sand.			
	GW, GP, GM, GP-GM, GW-GM, GC, GP-GC, GM-GC, SW, SP, SM, SW-SM, SC, SW-SC, SP-SM, SP-SC, CL, ML, CL-ML, CH, or MH.			

Agency	Satisfactory Soil Description			
CGSF 1988	Predominantly sand or sand and gravel.			
FL DOT 1999	Naturally occurring materials such as gravel, or resulting from the crushing of parent rock, to include natural rock, slags, expanded clays and shales (lightweight aggregates) and other approved inert materials with similar characteristics, having hard, strong, durable particles.			
	Free draining material.			
Geostone	On-site dewatered, compatible selected fill and crushed stone.			
Houston 1997	GW and SW. Well-graded gravels and sands, gravel-sand mixtures, crushed well-graded rock, little or no fines.			
IL DOT 1997	Sand, stone sand, stone screenings, chats, wet bottom boiler slag, slag sand, granulated slag sand, crushed concrete sand, or construction and demolition debris sand.			
	Fine Aggregates: Sand, stone sand, stone screenings, chats, wet bottom boiler slag, slag sand, granulated slag sand, crushed concrete sand, or construction and demolition debris sand. Course Aggregates: Gravel, crushed gravel, pit run gravel, crushed stone, crushed concrete, crushed slag, chats, crushed sandstone, or wet bottom boiler slag.			
	Pit run gravel, gravel, crushed gravel, novaculite, crushed stone, crushed concrete, crushed slag, or crushed sandstone.			
	Earth, stone, or gravel.			
Keystone 1994	Site excavated soils.			
	Clean crushed stone or crushed gravel.			
LA DOT 1992	Sand, clam shell, or reef shell.			
	Natural soil.			

Agency	Satisfactory Soil Description	
LA DOT 1992	Stone, recycled portland cement concrete, expanded clay, shell, gravel, crushed slag, or sand.	
Lake Oswego 1999	Washed round rock.	
	Native excavated material.	
	Imported crushed rock or gravel or clean pit run gravel.	
	Imported crushed rock.	
	Imported crushed rock.	
LANL 1997	Granular soil.	
NASA 1997	Washed, uniformly graded mixture of crushed stone or crushed or uncrushed gravel.	
	AASHTO M 145 Classification Groups A-1 (well graded mixture of stone fragments or gravel, coarse sand, fine sand and a nonplastic or feebly plastic soil binder, volcanic cinders without soil binder), A-2-4 and A-2-5 (gravel or coarse sand containing silt; fine sand containing nonplastic silt), and A-3 (fine beach sand and fine desert blow sand without silty or clay fines; stream deposited mixture of poorly graded fine sand, coarse sand, and gravel).	
	Natural sand.	
	Uniformly graded mixture of natural or crushed gravel, crushed stone, and natural sand.	
	Sandy clay, sand, gravel, soft shale.	
Navy 1998	GW, GP, SW, or SP.	
	Clean sand, stone, or gravel fill.	

Agency	Satisfactory Soil Description			
Navy 1998	Clean crushed stone, crushed gravel, or uncrushed gravel. Clean concrete sand (for capillary water barrier underlay or for capillary water barrier not under slabs).			
	GP, GM, GC, SP, SM, or SC.			
	Sand, gravel, or crushed rock composed of tough, durable particles. ASTM D2321 Materials: Class I: Angular stone (including coral, slag, cinders, crushed stone, and crushed shells where available). Class II: Coarse sands and gravels including graded sands and gravels containing small percentages of fines, generally granular and noncohesive, wet or dry (this includes GW, GP, SW, and SP).			
	GW, GP, GM, GC, SW, SP, SM, or SC.			
	Clean crushed rock or gravel.			
	GM, SM, or SC.			
	GP, GM, GC, SP, or SM.			
NM DOT 1994	Stone, crushed stone, crushed or screened gravel, caliche, or sand.			
OR DOT 1996	Granular material consisting of crushed, durable rock.			
	Granular material composed of crushed and/or uncrushed rock.			
Scotland DOT 1976	Well graded crushed or uncrushed gravel, stone, rock fill, crushed concrete or slag or natural sand or a combination of any of these.			
	Granular material.			
Tensar 1997	Granular soil. Recycled concrete if high density polyethylene or polypropylene geogrid is used.			
TX DOT 1993	Cohesionless materials, such as sand.			

Agency	Satisfactory Soil Description		
TX DOT 1993	Stone or lean concrete (only if backfilling an excavation in hard material resistant to erosion). Rock, loam, clay, or other materials.		
	Granular material.		
UT DOT 1994	Granular material.		
VA 1996	Crushed stone or gravel.		
WI DOT 1996	Sand, a mixture of sand with gravel, crushed gravel, crushed stone, or other broken or fragmented mineral material.		
WV DOT 1994	Random material (a mixture of any or all of soil, granular material, or soft shale), hard shale, or rock. Preference given to granular soils.		
	Crushed stone: particles of clean, hard, tough, durable rock, OR Gravel: particles of hard, durable rock, thoroughly clean and well graded, OR Slag: air cooled blast-furnace slag, reasonably uniform in density and quality.		
	Random material (a mixture of any or all of soil, granular material, or soft shale).		
	Random material (a mixture of any or all of soil, granular material, or soft shale) or crushed aggregate.		

### Appendix E: Unsatisfactory Soils Grouped by Agency
# Unsatisfactory Soils Grouped by Agency

Agency	Unsatisfactory Soil Description Not specified.		
AASHTO 1984	Soil that cannot be properly compacted, sod, and vegetable matter. Rocks, broken concrete, or other solid materials (where piling will be driven).		
	Organic material, clay balls, or other deleterious substances.		
Army COE 1997	OL, OH, and PT. Materials containing man-made fills, trash, refuse, backfills from previous construction, roots, organic matter, frozen materials, or contaminated materials.		
	ML, MH, and CH for critical structures.		
	Materials containing man-made fills, trash, refuse, backfills from previous construction, roots, organic matter, frozen materials, or contaminated materials.		
	Materials containing brush, roots, sod or other perishable materials.		
	Material containing thin, flat and elongated particles and/or soft, friable particles in objectionable quantities or material containing brush, roots, sod or other perishable materials.		
CGSF 1988	Material containing clods, wood, or masonry debris, or other deleterious material.		
DERS 1999	Material containing organic matter.		
FAA 1991	Frozen material or material containing vegetable or organic matter, such as muck, peat, organic silt, or sod.		
FL DOT 1999	Soil cement or lime stabilized backfill.		

Agency Unsatisfactory Soil Description				
FL DOT 1999	Material containing unreasonable amounts of clay lumps, soft and friable particles, salt, alkali, organic matter, adherent coatings, and other substances not defined which may possess undesirable characteristics.			
	Material containing muck, stumps, roots, brush, vegetable matter, rubbish, or other material that does not compact into a suitable and enduring roadbed.			
Houston 1997	ML, CL-ML, MH, PT, OH, and OL. Materials that contain large clods, aggregates, debris, vegetation, waste or any other deleterious materials, hydrocarbons or other chemical contaminants. Materials that cannot be compacted to the required density due to either gradation, plasticity, or moisture content.			
	Material containing lumps (greater than 6 inches), organic material, chemical waste or other contamination, and debris.			
IL DOT 1997	Material containing an excess of soft and unsound particles and other objectionable matter.			
	Sod, frozen material, or any material which by decay or otherwise, might cause settlement			
Keystone 1994	Material containing debris. Highly plastic clays or organic soils.			
	Highly plastic clays or organic soils.			
LA DOT 1992	Large or frozen lumps, stones, roots, wood, and other foreign matter.			
	Water saturated soils, organic matter, material not usable for foundation material, or material which will decay or produce subsistence in the soil such as stumps, roots, logs, or humus. Large amounts of fragmented reef shell.			
Lake Oswego 1999	Material containing dirt, clay balls, and organic material.			
	Material containing weeds, refuse, sticks, or other organic material which in the Engineer's opinion would compromise the integrity of the compacted trench.			



Agency	Unsatisfactory Soll Description Material containing organic material or other deleterious materials. Frozen material.		
LANL 1997			
MD DOT 1993			
NASA 1997	AASHTO M 145 Classification Groups A-2-6 and A-2-7(A-2-4 and A-2-5 soils containing plastic clay), A-4 (nonplastic or moderately plastic silty soil; fine silty soil, A-5 (diatomaceous or micaceous A-4 soils), A-6 (plastic clay soil; fine clayey soil), and A-7 (diatomaceous or micaceous A-6 soils), peat and other highly organic soil. Materials containing clay clods, debris, waste, frozen materials, or other deleterious matter.		
Navy 1998	PT, OH, or OL. Material containing debris, refuse, roots, wood, scrap materials, vegetable matter, frozen material, or material having insufficient strength or stability to carry intended loads without excessive consolidation or loss of stability. Man-made fills, uncompacted backfills from previous construction, unsound rock or soil lenses, or other deleterious or objectionable material.		
	PT, OH, or OL. Material containing debris, refuse, roots, wood, scrap materials, vegetable matter, frozen material, or material having insufficient strength or stability to carry intended loads without excessive consolidation or loss of stability. Large rocks, soft unsound particles, soluble particles, or other material which could damage the pipe or cause the backfill not to compact.		
	Material containing debris, roots, wood, scrap material, vegetation, refuse, soft unsound particles, frozen, deleterious, or objectionable materials.		
	Soft, spongy, highly plastic, or otherwise unstable material.		
NM DOT 1994	Material free from organic matter, silt, clay balls, frozen matter, or other deleterious matter.		
	Frozen material. Material containing rock, broken concrete, or other solid materials (where piling, utilities, or structures are to be built).		
Scotland DOT 1976	Soluble sulphate content < 2.5 g/L.		

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Agency Unsatisfactory Soil Description		
Scotland DOT 1976	Material from swamps, marshes, and bogs; peat, logs, stumps, and perishable materials; material susceptible to spontaneous combustion; frozen material.	
SHCE 1996	Material containing organic matter.	
TX DOT 1993	Material containing wood, other extraneous material, frozen lumps, or large lumps that would not break down readily under compaction.	
	Material containing organic or otherwise deleterious matter.	
	Material containing organic or otherwise deleterious matter or unacceptable lumps of earth.	
USBR 1999	PT, OL, OH. Material containing roots, stumps, limbs, vegetation, organic matter, ice, construction debris, scrap materials, refuse, man- made wastes, or chemical or hydrocarbon contamination.	
VA 1996	Topsoil, frozen materials, construction materials, materials subject to decomposition, clods of clay, organic material, including silts, which are unstable, and inorganic materials, including silts, too wet to be stable.	
WI DOT 1996	Material containing frozen lumps, wood, logs, stumps, brush, or other extraneous or perishable material.	
WV DOT 1994	Materials which cannot be satisfactorily placed and compacted to a stable and durable condition. Sod, trash, organic substances beyond the allowed percentage, or muck. Soil that contains excessive moisture. Soil containing stumps and spongy or frozen soil. When piles driven: soil containing rock.	
	Material containing frozen lumps, wood, or other extraneous material.	
	Crushed stone: particles with adherent coatings.	

Appendix F: Gradations Grouped by Agency





# Gradations Grouped by Agency

Agency	Gradation		
	Not specified.		
AASHTO 1984	Course Aggregate (AASHTO M 43, size No. 89):		
	mm %		
	12.5 100		
	9.5 90-100		
	4.75 20-55		
	2.36 5-30		
	1.18 0-10		
	0.300 0-5		
	Fine Aggregate (AASHTO M 6):		
	mm %		
	9.5 100		
	4.75 95-100		
	1 18 45-80		
	0.300 10-30		
	0.150 2-10		
	Uniformly graded.		
	AASHTO M 43, size No. 467:		
	mm %		
	50 100		
	37.5 95-100		
	19 35-70		
	9.5 10-30		
	4.75 0-5		
	AASHTO M 43, size No. 357:		
	mm %		
	63 100		
	50 95-100		
	25 35-70		
	12.5 10-30		
	4.75 0-5		
	2 := 4009/		
	3 III 100%		
	no. 4 20-50%		
	10. 200 0-10%		



4.75 mm no more than 2%			
Grading curves shall not exhibit abrupt changes in slope denoting skip grading, scalping of certain sizes, or other irregularities which would be detrimental to the proper functioning of the filter.			
0.075 mm less than 5% 0.020 mm not more than 2%			
25 mm not less than 95% 0.075 mm not more than 10%			
Not more than 20% passing the No. 200 sieve.			
6 inch 100% 3 inch 10-75% no. 200 0-25%			
4 inch 100% no. 40 0-60% no. 200 0-15%			
19 mm         100%           12.5 mm         90-100%           9.5 mm         40-70%           4.75 mm         0-15%           2.36 mm         0-5%			
90 mm         100%           19 mm         70 to 100%           4.75 mm         30 to 100%           0.425 mm         15 to 100%           0.150 mm         50 65%           0.075 mm         0 to 15%			
A gradation that minimizes voids between particles.			
D60/D10 greater than 4% no 200 not greater than 5%			



Agency	Gradation			
IL DOT 1997	FA 6 4.75 mm 92±8 0.150 mm 20±20 0.075 mm 6±6			
	CA 6 CA 10 37.5 mm 100 25 mm 95±5 100 19 mm 95±5 12.5 mm 75±15 80±15 4.75 mm 43±13 50±10 1.18 mm 25±15 30±15 0.075 mm 8±4 9±4			
	Course Aggregates: CA 18 75 mm 100 25 mm 95±5 4.75 mm 75±25 1.18 mm 55±25 0.300 mm 10±10 0.25 mm 0.20			
	Fine Aggregates:         FA 1         FA 2           9.5 mm         100         100           4.57 mm         97±3         97±3           1.18 mm         65±20         65±20           0.300 mm         16±13         20±10           0.150 mm         5±5         5±5			
	FA 1         FA 2           9.5 mm         100         100           4.57 mm         97±3         97±3           1.18 mm         65±20         65±20           0.300 mm         16±13         20±10           0.150 mm         5±5         5±5           0.075 mm         2±2         2±2			
Keystone 1994	2 inch 100-75% 3/4 inch 100-75% No. 4 100-20% No. 40 0-60% No. 200 0-35%			
LA DOT 1992	Extensive gradation requirements that are too lengthy and detailed to include in this database.			



Agency	Gradation		
LA DOT 1992	Sand No. 4 75% No. 200 15%		
	Shell No. 200 15%		
Lake Oswego 1999	Well graded from course to fine with no more than 8% by weight passing the No. 200 sieve.		
	Graded from 1.5 inches to 3/4 inches.		
	Less than 8% passing the No. 200 sieve.		
	3 inch more than 90% 1 inch more than 50% no. 200 not more than 20%		
NASA 1997	9.5 mm 100% 0.150 mm 2-10%		
	37.5 mm 100% 4.75 mm not more than 5%		
Navy 1998	Shall contain sufficient fines to ensure proper compaction.		
	Underlay: 3% passing 0.075 mm sieve.		
	Class I: Sizes from 0.25 to 1.5 in. Class II: Max size of 1.5 in.		
	0.075 mm 25%		
	50 mm 100% 12.5 mm 0%		
	50 mm 100% 12.5 mm 0%		



Agency	Gradation
Navy 1998	2 1/2 in 100% No. 4 40-85% No. 10 20-80% No. 40 10-60% No. 200 5-35% (10% for crib wall)
	<ul> <li>a. Perforated or slotted wall pipe: Type I.</li> <li>b. Open joint pipe: Type I and Type II (i.e. two soils used as a combination).</li> <li>c. Blind or french drains: Type II.</li> <li>c. Any pipe used with filter fabric: Type I, or Type II.</li> </ul>
	Type I Type II 37.5 mm – 100 25.0 mm – 90-100 9.5 mm 100 25-60 4.75 mm 95-100 5-40
	2.36 mm 0-20 1.18 mm 45-80 0.300 mm 10-30 0.150 mm 0-10
NM DOT 1994	No. 200 25%
OR DOT 1996	75 mm 100% 9.5 mm 0 - 80% 425 mm 0 - 40% 150 mm 0 - 10% 75 mm 0 - 6%
	50 mm 100% 12.5 mm 50 - 80% 4.75 mm 35 - 70% 425 mm 15 - 35%
	150 mm 0 - 15%
Scotland DOT 1976	10 mm up to 100% 5 mm not more than 85% 0.6 mm not more than 45% 0.075 mm not more than 5%
	125 mm not less than 95% 75 mm at least 90% 0.075 mm not more than 10%



Agency	Gradation
Tensar 1997	2 inch 100-75% 3/4 inch 100-75% no 4 100-20% no 40 0-60% no 200 0-35%
TX DOT 1993	Less than 20% passing 3 inch sieve.
	Gradation A:         3 inches       100%         No. 40       0-60%         No. 200       0-15%         Gradation B:       6         6 inches       100%         3 inches       75-100%         No. 200       0-15%         15-25% (Alternative)
	A gradation that permits thorough compaction.
VA 1996	Graded from 25 mm (1 inch) to No. 4.
	Graded from 13 mm (1/2 inch) to No. 4.
WI DOT 1996	75 mm 100% 4.75 mm not less than 25%
	Of all material passing 4.75 mm sieve:
	0.075 mm not more than 15%



.

### Agency

WI DOT 1996

### Gradation

 Grade 2:

 4.75 mm

 100%

 75 mm

 75 mm

 100%

 4.75 mm

 100%

 0 f material passing 4.75 mm sieve:

 Grade 1:

 4.75 mm

 0.425 mm

 0.425 mm

 0.150 mm

 0.75 mm

 0.075 mm

0.425 mm -0.150 mm not more than 30% 0.075 mm not more than 15%

WV DOT 1994

50 mm 100% 1.18 mm 0-5%



## Appendix G: Other Requirements Grouped by Agency

# Other Requirements Grouped by Agency

Agency	Other Requirements
	Not specified.
DERS 1999	Angle of internal friction not less than 34 degrees.
FL DOT 1999	Organic material: not more than 2% by weight. pH from 6 to 10.
	Los Angeles Abrasion: maximum loss 45%. Soundness (Sodium Sulfate): maximum loss 12%. Flat or elongated pieces: maximum 10%.
IL DOT 1997	Bearing Ratio not less than 80 (for embankment fill only except when crushed gravel, crushed stone, or crushed slag used). Na2SO4 Soundness 5 Cycle: maximum loss 25%. Los Angeles Abrasion: maximum loss 45%.
LA DOT 1992	pH from 5.5 to 8.5.
	Organic content of 4% or less.
	Organic content of 2% or less. Silt content of 60% or less.
	Organic content less than 5%. Silt content of 60% or less.
Navy 1998	Coefficient of permeability shall be a minimum of 0.01-1 mm/sec (0.002-0.2 fl/min).
Tensar 1997	pH from 5 to 9 (waived when high density polyethylene or polypropylene geogrid is used).
TX DOT 1993	Angle of internal friction not less than 34 degrees at 95% of Da density (only for Alternative Type B).

Agency	Other Requirements
TX DOT 1993	Bar Linear Shrinkage not greater than 2.
WV DOT 1994	Crushed stone: Percentage wear not to exceed 40. Soundness loss not to exceed 12. Percent by weight maximums: thin or elongated pieces 5%, shale 1%, coal and other lightweight deleterious material 1.5%, friable particles 0.25%.
	Organic content shall be less than 7.5% by weight.

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Vita

Karsten Matthew Koch was born in Boynton Beach, Florida on October 3, 1973, the son of Lillian Koch and Jonathan Lepisto. After completing his work at Saint Andrew's School, Boca Raton, Florida, in 1991, he entered Carnegie Mellon University in Pittsburgh, Pennsylvania. He received the degree of Bachelor of Science from Carnegie Mellon University in May, 1995. In June, 1995, he entered Navy Officer Candidate School in Pensacola, Florida and was commissioned as an Ensign in the Civil Engineer Corps on September 22, 1995. During the following years he worked as an Assistant Resident Officer in Charge of Construction in San Diego, California. In August, 1998, he entered The Graduate School at the University of Texas.

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