Green Stormwater: Low Impact Design - Managing Stormwater Through Infiltration

An Online Continuing Education Course for Engineers

Course Number: C-3033

Credit: 3 Hours / 3 PDH / 3 CPD

Low Impact Development - Managing Stormwater Through Infiltration

Low impact development (LID) is an innovative approach to land planning and design that seeks to manage the stormwater from a project at the site rather than simply conveying it downstream of the project. The goal of LID is to manage stormwater in such a way that the runoff from a project after development is comparable to the quantity and quality of runoff before the land was developed. The use of LID practices for stormwater management is becoming more prevalent in most areas and types of projects, including building sites, commercial developments, residential subdivisions, and street projects. In some cases, more stringent regulations require the use or consideration of low-impact stormwater practices, while in other cases, it is necessary to incorporate LID design techniques to obtain Leadership in Energy and Environmental Design (LEED) certification for a project. The proposed benefits of LID stormwater systems are very attractive, including improved water quality, increased groundwater recharge, and reduced stormwater volumes which reduce downstream channel erosion/flooding. Infiltration-based stormwater systems have been shown to attain these benefits while also reducing overall stormwater costs. Common LID systems using infiltration are infiltration basins, infiltration trenches, bioretention areas, and porous pavement/recharge systems. These LID practices can be cost-effective when sited and designed correctly.

This course begins with a discussion of site feasibility, including guidelines for preliminary determination of soils suitable for infiltration and testing methods to determine actual rates. Next, the design guidelines, uses, costs, and construction and maintenance issues are presented for each system. In the field performance for each system is evaluated to reveal possible problems and useful criteria to incorporate in design/construction.

With this information, the engineer can effectively evaluate if these LID systems are suitable for use in a specific project, which system to use, and important construction and maintenance practices to incorporate to ensure successful implementation.

Site Feasibility

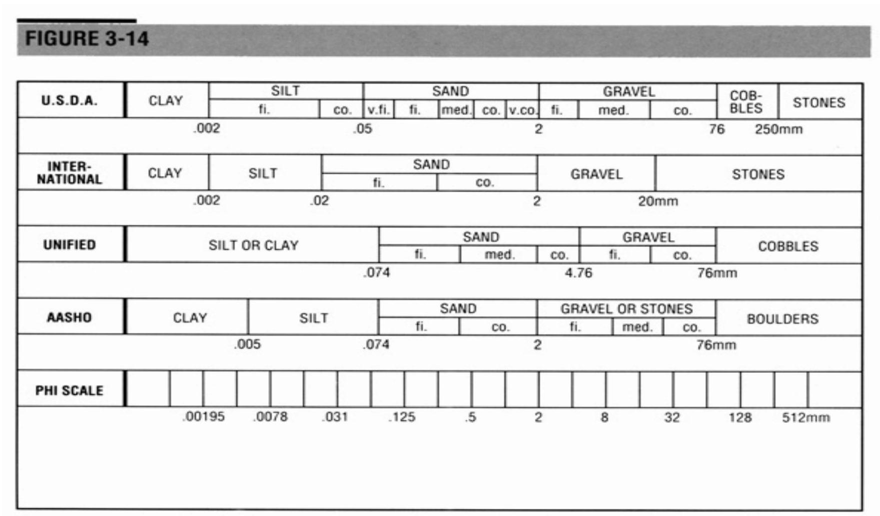
There are several factors to determine whether infiltration measures are viable for a particular site. Some factors of site feasibility for LID stormwater measures are soil type, water table and bedrock depths, site slope, and proximity to other structures/systems. Also to be considered is the planned usage for a particular site.

Soil

One of the major factors affecting feasibility for infiltration is the nature of the soils on the site. For purposes of stormwater management, the capacity of the soil to absorb, or infiltrate, water is of primary concern. Many factors affect a soils infiltration rate. Soil features that may be useful in determining preliminary feasibility for infiltration are gradation/texture and classification/group. Soil studies from Natural Resources

Conservation Service (NRCS) and local geologic surveys can provide this information to be used for concept and preliminary design. By using these preliminary indicators, the engineer can look for infiltration possibilities early in the project.

Soil texture is categorized by the proportion of sand, clay, silt, and gravel sized particles. The general particle sizes are shown in Figure 1 below.



Relationships among particle size classes of 5 different systems.

Figure 1 – Soil Particle Sizes (Reprinted from USDA Soil Survey Manual, 1993)

Clay and silt particles are commonly referred to as “fines”. Clay particles have surface charges which attract ions and water and can bind particles together (Ferguson, 2005). Silt particles are often surrounded by a thin layer of clay. Therefore, soils with higher amounts of clay and silt hold more water, rather than infiltrating the water through the soil. Sand and gravel are larger and normally act as separate particles (Ferguson, 2005), allowing water to flow through easily. Figure 2 shows the United States Department of Agriculture (USDA) texture classes. This figure provides approximate percentages of particle sizes for a given classification. The better draining soils will have lower percentages of clay and silt and higher percentages of sand.

FIGURE 3-16

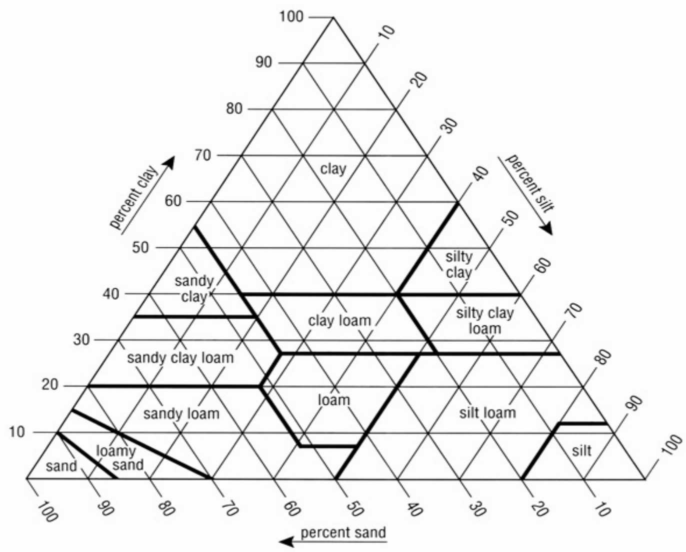


Chart showing the percentages of clay, silt, and sand in the basic textural classes.

Figure 2 – USDA Texture Classes (Reprinted from USDA Soil Survey Manual, 1993)

Soil classification and hydrologic soil grouping can also provide preliminary guidance on the infiltration capacity of site soils. Categories from the Unified Soil Classification system are shown in Table 1.

MAJOR DIVISIONS			GROUP SYMBOL	GROUP NAME
COARSE GRAINED SOILS MORE THAN 50% RETAINED ON NO.200 SIEVE	GRAVEL MORE THAN 50% OF COARSE FRACTION RETAINED ON NO.4 SIEVE	CLEAN GRAVEL	GW	WELL-GRADED GRAVEL, FINE TO COARSE GRAVEL
			GP	POORLY-GRADED GRAVEL
		GRAVEL WITH FINES	GM	SILTY GRAVEL
			GC	CLAYEY GRAVEL
	SAND MORE THAN 50% OF COARSE FRACTION PASSES NO.4 SIEVE	CLEAN SAND	SW	WELL-GRADED SAND, FINE TO COARSE SAND
			SP	POORLY-GRADED SAND
		SAND WITH FINES	SM	SILTY SAND
			SC	CLAYEY SAND
FINE GRAINED SOILS MORE THAN 50% PASSES NO.200 SIEVE	SILT AND CLAY LIQUID LIMIT LESS THAN 50	INORGANIC	ML	SILT
			CL	CLAY
		ORGANIC	OL	ORGANIC SILT, ORGANIC CLAY
	SILT AND CLAY LIQUID LIMIT 50 OR MORE	INORGANIC	MH	SILT OF HIGH PLASTICITY, ELASTIC SILT
			CH	CLAY OF HIGH PLASTICITY, FAT CLAY
		ORGANIC	OH	ORGANIC CLAY, ORGANIC SILT
HIGHLY ORGANIC SOILS			PT	PEAT

Table 1 - Unified Soil Classification System (from American Society for Testing and Materials, 1985)

Soils in the upper portion of the table have less fines and have relatively good drainage. The percentage of fines in the soil increases as you move down through the table; soils with a large percentage of fines will have slower drainage. Make sure to look at the most limiting soil layer. If there is a well-drained layer at the surface, but a deep clay layer just beneath, infiltration is based on the clay layer.

Hydrologic soil classification is an excellent beginning point for estimating infiltration possibilities on a site. Soils in the United States are grouped into four classifications, groups A, B, C, and D. The classifications were established in 1955 by G.W. Musgrave based on the minimum infiltration capacity (Woodward, et. al) determined from laboratory tests and soil texture. Table 2 shows the infiltration rates and textures for the different groups.

Soil Group	Infiltration Rate (in/hr)	Soil Texture
A	> 0.30	Sand, loamy sand or sandy loam
B	0.15 - 0.30	Silt loam or loam
C	0.05 - 0.15	Sandy clay loam
D	0 [illegible]	[illegible] ilty clay loam, sandy [illegible] lty clay or clay

Table 2. [illegible]

According to Chapte [illegible] determination of soil group is based on the [illegible] ate for a bare ground surface. That rate [illegible] ate that is typically experienced in that a [illegible] within a small area; therefore the rates g [illegible] guide only. Other published infiltration ra [illegible]

Texture Class	[illegible]	[illegible] ydraulic [illegible] y (in/hr)
Sand	[illegible]	8.268
Loamy Sand	A	2.406
Sandy Loam	B	1.020
Loam	B	0.520
Silt Loam	C	0.268
Sandy Clay Loam	C	0.169
Clay Loam	D	0.091