Geotechnical Manual
Chapter 3   Wisconsin Soil Development and Distribution
Section 3   Soil Classification Systems

Wisconsin Department of Transportation

There are a number of systems and methods used to classify soils. The most common of these systems are the American Association of State Highway and Transportation Officials (AASHTO) soil classification system, the Unified Soil Classification System (USCS), and the United States Department of Agriculture (USDA) soil classification system. This manual will not provide details of these classification systems, but the reader can find this information in various geotechnical references. Each of the referenced classification systems was developed to fill a specific need and purpose. As a result, each has some strengths and some limitations.

The common feature of these systems is the use of particle size distribution to differentiate the various groupings of each particular system. However, both the AASHTO and the Unified systems also use plasticity to further refine classification. As a result, each system has a distinct method and nomenclature to identify and classify soils. For instance, a soil with 85% sand, 15% silt, and Plasticity Index of 4 would be classified as an A-2-4 in the AASHTO system, an SM in the Unified system, and a Loamy Sand in the USDA system. Summaries of each system, showing a methodology to determine a particular soil description/classification can be found below. The reader is urged to refer to one of these texts to gain a clear understanding of the classification process. A specific discussion of application goes beyond the scope of this manual, but can be found in any text on geotechnical engineering.

The proper soil classification system for an organization depends on application, practice, and experience. WisDOT has used the AASHTO system on its projects for many years and has a familiarity and history with that system. Therefore, the AASHTO soil classification system should continue to be the primary method to describe soils for WisDOT projects. The Unified classifications may also be used as a secondary method. The USDA system should be limited to general field classification.

3-3.1 AASHTO Classification System

The AASHTO system was developed specifically for highway construction and is still widely used for that purpose. With practice and experience, a reasonably accurate field classification can be determined. However, it is necessary to run sieve analyses and plasticity determinations to precisely classify a soil with this method. Figure 1 presents the basic AASHTO soil classification system.

Figure 1 – AASHTO Soil Classification System

General Classification	Granular Materials (35 percent or less of total sample passing No. 200 (75 μm))								Silt-Clay Materials (More than 35 percent of total sample passing No. 200 (75 μm))						
Group Classification	A-1		A-3 [1]		A-2				A-4		A-5	A-6		A-7	
	A-1-a	A-1-b	A-3	A-3a	A-2-4	A-2-5	A-2-6	A-2-7	A-4a	A-4b		A-6a	A-6b	A-7-5	A-7-6
Sieve analysis, percent passing:					*					**	*				*
No. 10 (2 mm)	50 max														
No. 40 (425 μm)	30 max	50 max	51 min	[2]					[3]	[4]					
No. 200 (75 μm)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	35 max	36 min	50 min	36 min	36 min		36 min	
Characteristics of fraction passing No. 40															
Liquid limit	—	—	Non-Plastic	—	40 max	41 min	40 max	41 min	40 max		41 min	40 max		41 min	
Plasticity index	6 max	6 max		6 max	10 max	10 max	11 min	11 min	10 max		10 max	11 – 15	16 min	≤LL-30	>LL-30
Group Index	0				4 max				8 max		12 max	10 max	16 max	20 max	
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Sand	Silty or clayey gravel and sand				Silty soils			Clayey soils			
General rating as subgrade	Excellent to good								Good to fair						

Notes

With the test data available, the classification of a soil is found by proceeding from left to right on the chart. The first classification that the test data fits is the correct classification.

* A-2-5 is not allowed under 703.16.B. A-5 and A-7-5 is not allowed under 703.16.A. See "Natural Soil and Natural Granular Soils" (203.02.H) in this manual

** A-4b is not allowed in the top 3 feet (1.0 m) of the embankment under 203.03.A.

[1] The placing of A-3 before A-2 is necessary in the "left to right" process, and does not indicate superiority of A-3 over A-2.

[2] A-3a must contain a minimum 50 percent combined coarse and find sand sizes (passing No. 10 but retained on No. 200, between 2 mm and 75 μm).

[3] A-4a must contain less than 50 percent silt size material (between 75 μm and 5 μm).

[4] A-4b must contain 50 percent or more silt size material (between 75 μm and 5 μm).

3-3.2 Unified Classification System

The Unified (USCS) system was developed later, and as the name suggests, it was intended to be a more all-encompassing system for geotechnical engineering. It is the most detailed system but it requires laboratory analysis for application. While the system does have limitations for uses as a field classification method, it is widely used for many geotechnical applications. Figure 2 presents the basic Unified soil classification system.

Figure 2 – Unified Soil Classification System

Major Divisions				Group Symbol	Typical Names
Course-Grained Soils More than 50% retained on the 0.075 mm (No. 200) sieve	Gravels 50% or more of course fraction retained on the 4.75 mm (No. 4) sieve	Clean Gravels		GW	Well-graded gravels and gravel-sand mixtures, little or no fines
				GP	Poorly graded gravels and gravel-sand mixtures, little or no fines
		Gravels with Fines		GM	Silty gravels, gravel-sand-silt mixtures
				GC	Clayey gravels, gravel-sand-clay mixtures
	Sands 50% or more of course fraction passes the 4.75 (No. 4) sieve	Clean Sands		SW	Well-graded sands and gravelly sands, little or no fines
				SP	Poorly graded sands and gravelly sands, little or no fines
		Sands with Fines		SM	Silty sands, sand-silt mixtures
				SC	Clayey sands, sand-clay mixtures
Fine-Grained Soils More than 50% passes the 0.075 mm (No. 200) sieve	Silts and Clays Liquid Limit 50% or less			ML	Inorganic silts, very fine sands, rock four, silty or clayey fine sands
				CL	Inorganic clays of low to medium plasticity, gravelly/sandy/silty/lean clays
				OL	Organic silts and organic silty clays of low plasticity
	Silts and Clays Liquid Limit greater than 50%			MH	Inorganic silts, micaceous or diatomaceous fine sands or silts, elastic silts
				CH	Inorganic clays or high plasticity, fat clays
				OH	Organic clays of medium to high plasticity
Highly Organic Soils				PT	Peat, muck, and other highly organic soils

Prefix: G = Gravel, S = Sand, M = Silt, C = Clay, O = Organic
Suffix: W = Well Graded, P = Poorly Graded, M = Silty, L = Clay, LL < 50%, H = Clay, LL > 50%

3-3.3 USDA Classification System

The USDA system was developed for agricultural purposes. It has some engineering application in that it provides a relatively easy method for general field classification of soils. However, "loamy", while descriptive, is not an engineering term and should be avoided when discussing the engineering properties of a soil. Figure 3 presents the basic USDA soil classification system.
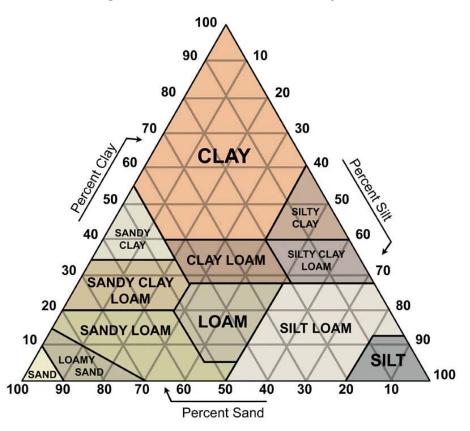
Figure 3 – USDA Soil Classification System