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Soil mechanics

By

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Classification of Soil

Different soils with similar properties may be classified into groups and subgroups according to their engineering behavior.

- Most of the soil classification systems that have been developed for engineering purposes are based on simple index properties such as particle-size distribution and plasticity (i.e., liquid limit and plasticity index).
- There are two major classification systems in extensive use now:
 - a. The AASHTO classification system, and
 - b. The Unified classification system.
 - The AASHTO classification system is used mostly by state and county highway departments.
 - Geotechnical engineers generally prefer the USCS.

Unified Soil Classification System

Soil symbols:

- ❖ **G: Gravel**
- ❖ **S: Sand**
- ❖ **M: Silt**
- ❖ **C: Clay**
- ❖ **O: Organic**
- ❖ **Pt: Peat**

• Liquid limit symbols:

- **H: High LL (LL>50)**
- **L: Low LL (LL<50)**

• Gradation symbols:

- **W: Well-graded**
- **P: Poorly-graded**

According the Unified Soil Classification System (USCS) each soil is given a group symbol and group name.

a- Group symbol is a composed of two capital letters, the first is called the primary letter and refer to the soil type. The second letter called secondary and it gives an idea about soil nature.

Primary letter	Secondary letter
G =gravel	W = well graded
S = Sand	P = poorly graded
M = Silt	C = with clay
C = Clay	M = with silt
O = Organic	H = of high plastic (L.L ≥ 50)
	L = of low plasticity (L.L < 50)

- A typical USCS classification would be:

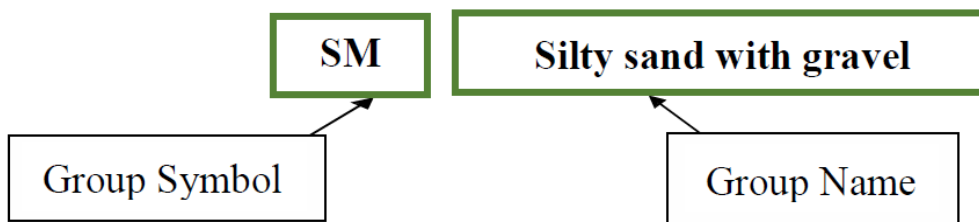


Table 5.2 Unified Soil Classification System

Group symbol	Group name
GW	<15% sand → Well-graded gravel
	≥15% sand → Well-graded gravel with sand
GP	<15% sand → Poorly graded gravel
	≥15% sand → Poorly graded gravel with sand
GW-GM	<15% sand → Well-graded gravel with silt
	≥15% sand → Well-graded gravel with silt and sand
GW-GC	<15% sand → Well-graded gravel with clay (or silty clay)
	≥15% sand → Well-graded gravel with clay and sand (or silty clay and sand)
GP-GM	<15% sand → Poorly graded gravel with silt
	≥15% sand → Poorly graded gravel with silt and sand
GP-GC	<15% sand → Poorly graded gravel with clay (or silty clay)
	≥15% sand → Poorly graded gravel with clay and sand (or silty clay and sand)
GM	<15% sand → Silty gravel
	≥15% sand → Silty gravel with sand
GC	<15% sand → Clayey gravel
	≥15% sand → Clayey gravel with sand
GC-GM	<15% sand → Silty clayey gravel
	≥15% sand → Silty clayey gravel with sand
SW	<15% gravel → Well-graded sand
	≥15% gravel → Well-graded sand with gravel
SP	<15% gravel → Poorly graded sand
	≥15% gravel → Poorly graded sand with gravel
SW-SM	<15% gravel → Well-graded sand with silt
	≥15% gravel → Well-graded sand with silt and gravel
SW-SC	<15% gravel → Well-graded sand with clay (or silty clay)
	≥15% gravel → Well-graded sand with clay and gravel (or silty clay and gravel)
SP-SM	<15% gravel → Poorly graded sand with silt
	≥15% gravel → Poorly graded sand with silt and gravel
SP-SC	<15% gravel → Poorly graded sand with clay (or silty clay)
	≥15% gravel → Poorly graded sand with clay and gravel (or silty clay and gravel)
SM	<15% gravel → Silty sand
	≥15% gravel → Silty sand with gravel
SC	<15% gravel → Clayey sand
	≥15% gravel → Clayey sand with gravel
SC-SM	<15% gravel → Silty clayey sand
	≥15% gravel → Silty clayey sand with gravel

Find C_u and C_c in order to check soil graded (Well or Poor)

For Gravel G

If $C_u > 4$ and $1 < C_c < 3$ then well graded (W)

Otherwise the graded is poor graded (P)

For Sand S

If $C_u > 6$ and $1 < C_c < 3$ then well graded (W)

Otherwise the graded is poor graded (P)

This system classifies soils into two broad categories:

1. Coarse-grained soils that are gravelly and sandy in nature with less than 50% passing through the No. 200 sieve.
2. Fine-grained soils are with 50% or more passing through the No. 200 sieve.

Criteria for assigning group symbols				Group symbol
Coarse-grained soils More than 50% of retained on No. 200 sieve	Gravels More than 50% of coarse fraction retained on No. 4 sieve	Clean Gravels	$C_u \geq 4$ and $1 \leq C_c \leq 3^c$	GW
		Less than 5% fines ^a	$C_u < 4$ and/or $C_c < 1$ or $C_c > 3^c$	GP
	Sands 50% or more of coarse fraction passes No. 4 sieve	Gravels with Fines	$PI < 4$ or plots below "A" line (Figure 5.3)	GM
		More than 12% fines ^{a,d}	$PI > 7$ and plots on or above "A" line (Figure 5.3)	GC
	Sands 50% or more of coarse fraction passes No. 4 sieve	Clean Sands	$C_u \geq 6$ and $1 \leq C_c \leq 3^c$	SW
		Less than 5% fines ^b	$C_u < 6$ and/or $C_c < 1$ or $C_c > 3^c$	SP
Sands with Fines		$PI < 4$ or plots below "A" line (Figure 5.3)	SM	
	More than 12% fines ^{b,d}	$PI > 7$ and plots on or above "A" line (Figure 5.3)	SC	
Fine-grained soils 50% or more passes No. 200 sieve	Silts and clays Liquid limit less than 50	Inorganic	$PI > 7$ and plots on or above "A" line (Figure 5.3) ^e $PI < 4$ or plots below "A" line (Figure 5.3) ^f	CL ML
		Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OL zone	OL
	Silts and clays Liquid limit 50 or more	Inorganic	PI plots on or above "A" line (Figure 5.3) PI plots below "A" line (Figure 5.3)	CH MH
		Organic	$\frac{\text{Liquid limit—oven dried}}{\text{Liquid limit—not dried}} < 0.75$; see Figure 5.3; OH zone	OH
	Highly organic soils	Primarily organic matter, dark in color, and organic odor		Pt

^aGravels with 5 to 12% fine require dual symbols: GW-GM, GW-GC, GP-GM, GP-GC.

^bSands with 5 to 12% fines require dual symbols: SW-SM, SW-SC, SP-SM, SP-SC.

$${}^c C_u = \frac{D_{60}}{D_{10}}; \quad C_c = \frac{(D_{30})^2}{D_{60} \times D_{10}}$$

^dIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol GC-GM or SC-SM.

^eIf $4 \leq PI \leq 7$ and plots in the hatched area in Figure 5.3, use dual symbol CL-ML.