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## Standard Specification for

# Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes

AASHTO Designation: M 145-91 (2004)



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## 1. SCOPE

- 1.1. This recommended practice describes a procedure for classifying soils into seven groups based on laboratory determination of particle-size distribution, liquid limit, and plasticity index. Evaluation of soils within each group is made by means of a “group index,” which is a value calculated from an empirical formula. The group classification, including group index should be useful in determining the relative quality of the soil material for use in earthwork structures, particularly embankments, subgrades, subbases, and bases. However, for the detailed design of important structures additional data concerning strength or performance characteristics of the soil under field conditions will usually be required.
- 1.2. The values stated in SI units are to be regarded as the standard.

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## 2. REFERENCED DOCUMENTS

- 2.1. *AASHTO Standards:*
- T 11, Materials Finer Than 75- $\mu\text{m}$  (No. 200) Sieve in Mineral Aggregates by Washing
  - T 27, Sieve Analysis of Fine and Coarse Aggregates
  - T 87, Dry Preparation of Disturbed Soil and Soil Aggregate Samples for Test
  - T 88, Particle Size Analysis of Soils
  - T 89, Determining the Liquid Limit of Soils
  - T 90, Determining the Plastic Limit and Plasticity Index of Soils
  - T 146, Wet Preparation of Disturbed Soil Samples for Test
- 2.2. *ASTM Standard:*
- D 1140, Amount of Material in Soils Finer Than the No. 200 (75- $\mu\text{m}$ ) Sieve
- Note 1**—Either T 88, or T 11 and T 27, or ASTM D 1140 will be used to determine the particle size distribution of soils or soil-aggregate mixtures as a basis for classification.

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## 3. CLASSIFICATION

- 3.1. The classification is made by using the test limits and group index values shown in Table 1. If a more detailed classification is desired, a further subdivision of the groups shown in Table 1 may be made. An example of the classification with such subgroups as shown in Table 1 may be made. An example of the classification with such subgroups is shown in Table 2. The liquid limit and plasticity index ranges for the A-4, A-5, A-6, and A-7 soil groups are shown graphically in Figure 2.

**Table 1—Classification of Soils and Soil-Aggregate Mixtures**

General Classification	Granular Materials (35 Percent or Less Passing 75 µm)			Silt-Clay Materials (More Than 35 Percent Passing 75 µm)			
	A-1	A-3 <sup>a</sup>	A-2	A-4	A-5	A-6	A-7
Sieve analysis, percent passing: 2.00 mm (No. 10)	—	—	—	—	—	—	—
0.425 mm (No. 40)	50 max	51 min	—	—	—	—	—
75 µm (No. 200)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)							
Liquid limit	—	NP	<sup>b</sup>	40 max	41 min	40 max	41 min
Plasticity index	6 max	—	—	10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to Good			Fair to Poor			

<sup>a</sup> The placing of A-3 before A-2 is necessary in the "left to right elimination process" and does not indicate superiority of A-3 over A-2.

<sup>b</sup> See Table 2 for values.

**Table 2—Classification of Soils and Soil-Aggregate Mixtures**

General Classification	Granular Materials (35 Percent or Less Passing 75 µm)					Silt-Clay Materials (More Than 35 Percent Passing 75 µm)					
	A-1		A-3	A-2		A-4	A-5	A-6	A-7		
Group Classification	A-1-a	A-1-b	A-3	A-2-4	A-2-5	A-2-6	A-2-7	A-4	A-5	A-6	A-7
Sieve analysis, percent passing: 2.00 mm (No. 10)	50 max	—	—	—	—	—	—	—	—	—	—
0.425 mm (No. 40)	30 max	50 max	51 min	—	—	—	—	—	—	—	—
75 µm (No. 200)	15 max	25 max	10 max	35 max	35 max	35 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing 0.425 mm (No. 40)											
Liquid limit	—	—	—	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max	—	NP	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min <sup>v</sup>
Usual types of significant constituent materials	Stone fragments, gravel and sand		Fine sand	Silty or clayey gravel and sand		Silty or clayey gravel and sand		Silty soils	Clayey soils		
General rating as subgrade	Excellent to Good					Fair to Poor			Fair to Poor		

<sup>v</sup> Plasticity index of A-7-5 subgroup is equal to or less than LL minus 30. Plasticity index of A-7-6 subgroup is greater than LL minus 30. (See Figure 2.)

- 3.2. *Classification Procedure*—With required test data available, proceed from left to right in Table 1 or Table 2 and the correct group will be found by process of elimination. The first group from the left into which the test data will fit is the correct classification. All limiting test values are shown as whole numbers. If fractional numbers appear on test reports, convert to nearest whole number for purposes of classification. Group index values should always be shown in parentheses after group symbol as: A-2-6(3), A-4(5), A-6(12), A-7-5(17), etc.

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## 4. DEFINITIONS OF GRAVEL, SAND, AND SILT-CLAY

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- 4.1. The terms “gravel,” “coarse sand,” and “silt-clay,” as determinable from the minimum test data required in this classification arrangement and as used in subsequent word descriptions, are defined as follows:
- 4.1.1. *gravel*—material passing sieve with 75-mm (3-in.) square openings and retained on the 2.00-mm (No. 10) sieve.
- 4.1.2. *coarse sand*—material passing the 2.00-mm (No. 10) sieve and retained on the 0.425-mm (No. 40) sieve.
- 4.1.3. *fine sand*—material passing the 0.425-mm (No. 40) sieve and retained on the 75- $\mu$ m (No. 200) sieve.
- 4.1.4. *silt clay (combined silt and clay)*—material passing the 75- $\mu$ m (No. 200) sieve.
- 4.1.5. Boulders and Cobbles (retained on 75-mm (3-in.) sieve) should be excluded from the portion of the sample to which the classification is applied, but the percentage of such material, if any, in the sample should be recorded.
- 4.1.6. The term “silty” is applied to fine material having plasticity index of 10 or less and the term “clayey” is applied to fine material having plasticity index of 11 or greater.

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## 5. DESCRIPTION OF CLASSIFICATION GROUPS

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- 5.1. *Granular Materials*—Containing 35 percent or less passing 75- $\mu$ m (No. 200) sieve, Note 2.
- 5.1.1. *Group A-1*—The typical material of this group is a well-graded mixture of stone fragments or gravel, coarse sand, fine sand, and a nonplastic or feebly plastic soil binder. However, this group also includes stone fragments, gravel, coarse sand, volcanic cinders, etc. without soil binder.
- 5.1.1.1. *Subgroup A-1-a* includes those materials consisting predominantly of stone fragments or gravel, either with or without a well-graded binder of fine material.
- 5.1.1.2. *Subgroup A-1-b* includes those materials consisting predominantly of coarse sand either with or without a well-graded soil binder.
- 5.1.2. *Group A-3*—The typical material of this group is fine beach sand or fine desert blow sand without silty or clay fines or with a very small amount of nonplastic silt. The group includes also stream-deposited mixtures of poorly graded fine sand and limited amounts of coarse sand and gravel.

5.1.3. *Group A-2*—This group includes a wide variety of “granular” materials which are borderline between the materials falling in Groups A-1 and A-3 and silt-clay materials of Groups A-4, A-5, A-6, and A-7. It includes all materials containing 35 percent or less passing the 75- $\mu\text{m}$  (No. 200) sieve which cannot be classified as A-1 or A-3, due to fines content or plasticity or both, in excess of the limitations for those groups.

5.1.3.1. Subgroups A-2-4 and A-2-5 include various granular materials containing 35 percent or less passing the 75- $\mu\text{m}$  (No. 200) sieve and with a minus 0.425-mm (No. 40) portion having the characteristics of the A-4 and A-5 groups. These groups include such materials as gravel and coarse sand with silt contents or plasticity indexes in excess of the limitations of Group A-1, and fine sand with nonplastic silt content in excess of the limitations of Group A-3.

5.1.3.2. Subgroups A-2-6 and A-2-7 include materials similar to those described under Subgroups A-2-4 and A-2-5 except that the fine portion contains plastic clay having the characteristics of the A-6 or A-7 group.

**Note 2**—Classification of materials in the various groups applies only to the fraction passing the 75-mm (3-in.) sieve. Therefore, any specifications regarding the use of A-1, A-2, or A-3 materials in construction should state whether boulders retained on the 75-mm (3-in.) sieve are permitted.

5.2. *Silt-Clay Materials*—Containing more than 35 percent passing the 75- $\mu\text{m}$  (No. 200) sieve.

5.2.1. *Group A-4*—The typical material of this group is a nonplastic or moderately plastic silty soil usually having the 75 percent or more passing the 75- $\mu\text{m}$  (No. 200) sieve. The group includes also mixtures of fine silty soil and up to 64 percent of sand and gravel retained on 75- $\mu\text{m}$  (No. 200) sieve.

5.2.2. *Group A-5*—The typical material of this group is similar to that described under Group A-4, except that it is usually of diatomaceous or micaceous character and may be highly elastic as indicated by the high liquid limit.

5.2.3. *Group A-6*—The typical material of this group is a plastic clay soil usually having 75 percent or more passing the 75- $\mu\text{m}$  (No. 200) sieve. The group includes also mixtures of fine clayey soil and up to 64 percent of sand and gravel retained on the 75- $\mu\text{m}$  (No. 200) sieve. Materials of this group usually have high-volume change between wet and dry states.

5.2.4. *Group A-7*—The typical material of this group is similar to that described under Group A-6, except that it has the high liquid limits characteristic of the A-5 group and may be elastic as well as subject to high-volume change.

5.2.4.1. Subgroup A-7-5 includes those materials with moderate plasticity indexes in relation to liquid limit and which may be highly elastic as well as subject to considerable volume change.

5.2.4.2. Subgroup A-7-6 includes those materials with high plasticity indexes in relation to liquid limit and which are subject to extremely high-volume change.

**Note 3**—Highly organic soils (peat or muck) may be classified in an A-8 group. Classification of these materials is based on visual inspection, and is not dependent on percentage passing the 75- $\mu\text{m}$  (No. 200) sieve, liquid limit, or plasticity index. The material is composed primarily of partially decayed organic matter, generally has a fibrous texture, dark brown or black color, and an odor of decay.

These organic materials are unsuitable for use in embankments and subgrades. They are highly compressible and have low strength.

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## 6. GROUP INDEX

6.1. The group index is calculated from the following formula:

$$\text{Group index} = (F - 35) [0.2 + 0.005 (LL - 40)] + 0.01 (F - 15) (PI - 10)$$

where:

$F$  = percentage passing 75- $\mu\text{m}$  (No. 200) sieve, expressed as a whole number. This percentage is based only on the material passing the 75-mm (3-in.) sieve.

$LL$  = liquid limit, and

$PI$  = plasticity index.

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6.1.1. When the calculated group index is negative, the group index shall be reported as zero.

6.1.2. The group index should be reported to the nearest whole number.

6.2. Figure 1 may be used in estimating the group index, by determining the partial group index due to liquid limit and that due to plasticity index, then obtaining the total of the two partial group indexes.

6.3. When calculating the group index of A-2-6 and A-2-7 subgroups, only the PI portion of the formula (or of Figure 1) shall be used.

6.4. The following are examples of calculations of the group index:

6.4.1. Assume that an A-6 material has 55 percent passing the 75- $\mu\text{m}$  (No. 200) sieve, liquid limit of 40, and plasticity index of 25. Then,

$$\text{Group index} = (55 - 35) [0.2 + 0.005 (40 - 40)] + 0.01 (55 - 15) (25 - 10) = 4.0 + 6.0 = 10$$

6.4.2. Assume that an A-7 material has 80 percent passing the 75- $\mu\text{m}$  (No. 200) sieve, liquid limit of 90, and plasticity index of 50. Then,

$$\text{Group index} = (80 - 35) [0.2 + 0.005 (90 - 40)] + 0.01 (80 - 15) (50 - 10) = 20.3 + 26.0, \text{ or } 46.3$$

6.4.3. Assume that an A-4 material has 60 percent passing the 75- $\mu\text{m}$  (No. 200) sieve, liquid limit of 25, and plasticity index of 1. Then,

$$\text{Group index} = (60 - 35) [0.2 + 0.005 (25 - 40)] + 0.01 (60 - 15) (1 - 10) = 25 \times (0.2 - 0.075) + 0.01 (45) (-9) = 3.1 - 4.1 = -1.0$$

Report as zero.

6.4.4. Assume that an A-2-7 material has 30 percent passing the 75- $\mu\text{m}$  (No. 200) sieve, liquid limit of 50, and plasticity index of 30. Then,

$$\text{Group index} = 0.01 (30 - 15) (30 - 10) = 3.0 \text{ or } 3 \text{ (Note that only the PI portion of formula was used.)}$$

Group Index (GI) =  $(F-35)[0.2 + 0.005(LL-40)] + 0.01(F-15)(PI-10)$   
 where F = Percent Passing 0.075-mm sieve, LL = Liquid Limit,  
 and PI = Plasticity Index.

When working with A-2-6 and A-2-7 Subgroups, the Partial Group Index (PGI)  
 is determined from the PI only.

When the combined Partial Group Indices are negative, the Group Index  
 should be reported as zero.

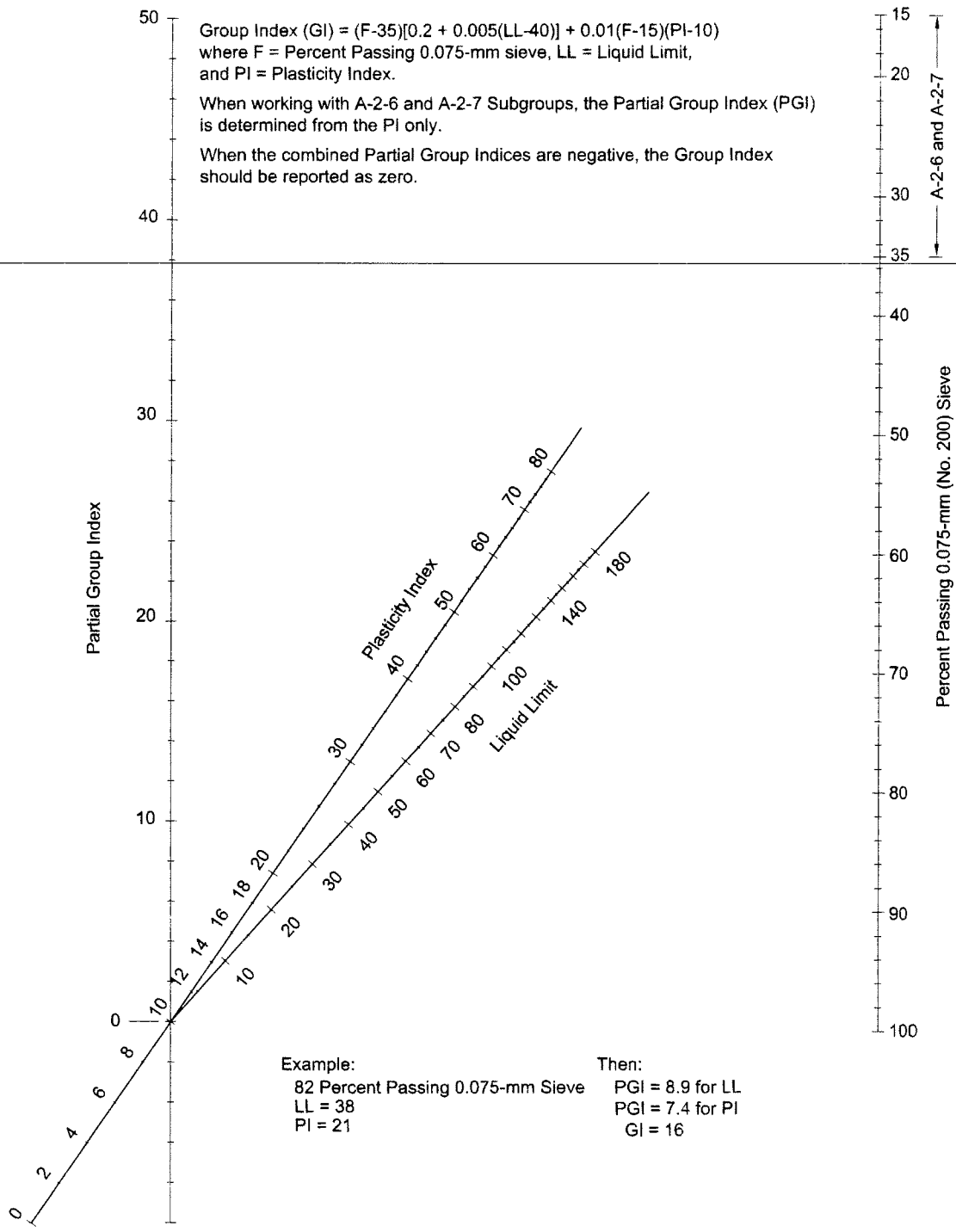
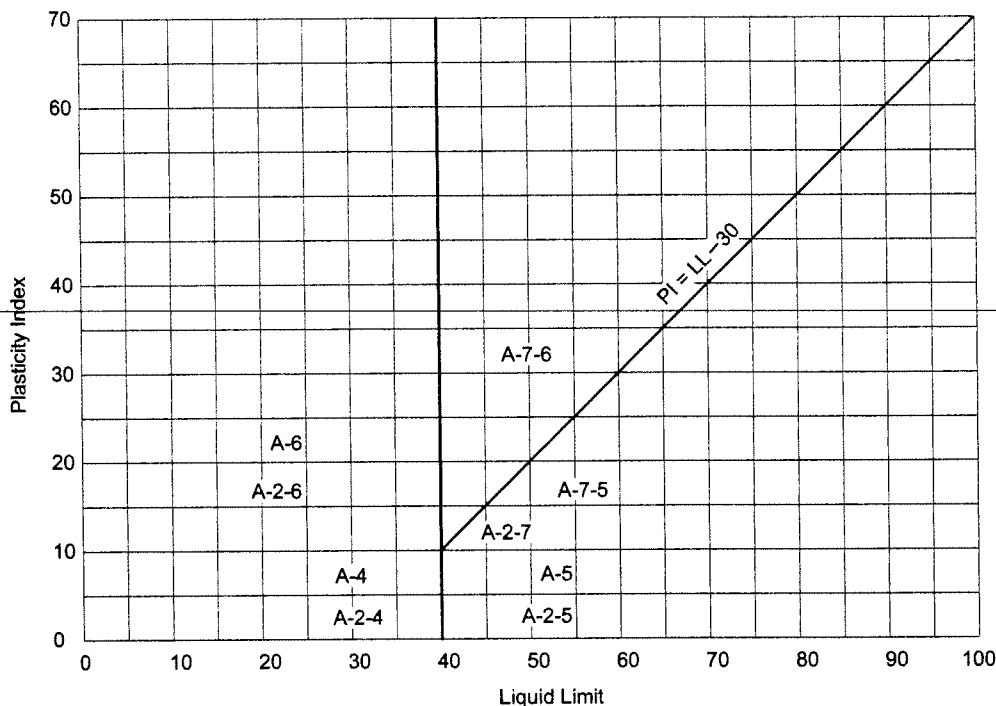


Figure 1—Group Index Chart



Note: A-2 Soils contain less than 35 percent finer than the 75- $\mu$ m (No. 200) sieve.

**Figure 2**—Liquid Limit and Plasticity Index Ranges for Silt-Clay Materials

## 7. BASIS FOR GROUP INDEX FORMULA

- 7.1. The empirical group index formula devised for approximately within-group evaluation of the “clayey granular materials” and the “silt-clay materials” is based on the following assumptions:
- 7.1.1. Materials falling within Groups A-1-a, A-1-b, A-2-4, A-2-5, and A-3 are satisfactory as subgrade when properly drained and compacted under moderate thickness pavement (base and/or surface course) of a type suitable for the traffic to be carried, or can be made satisfactory by additions of small amounts of natural or artificial binders.
- 7.1.2. Materials falling within the “clayey granular” Groups A-2-6 and A-2-7 and the “silt-clay” Groups A-4, A-5, A-6, and A-7 will range in quality as subgrade from the approximate equivalent of the good A-2-4 and A-2-5 subgrades to fair and poor subgrades requiring a layer of subbase material or an increased thickness of base course over that required under Section 7.1.1 in order to furnish adequate support for traffic loads.
- 7.1.3. The assumed critical minimum percentage passing the 75- $\mu$ m (No. 200) sieve is 35 neglecting plasticity, and 15 as affected by plasticity indexes greater than 10.
- 7.1.4. Liquid limits of 40 and above are assumed to be critical.
- 7.1.5. Plasticity indexes of 10 and above are assumed to be critical.
- 7.1.6. For soils that are non-plastic and when the liquid limit cannot be determined, the group index shall be considered zero.

- 7.2. There is no upper limit of group index value obtained by use of the formula. The adopted critical values of percentage passing the 75- $\mu$ m (No. 200) sieve, liquid limit and plasticity index, are based on an evaluation of subgrade, subbase and base course materials by several highway organizations that use the tests involved in this classification system.
- 7.3. Under average conditions of good drainage and thorough compaction, the supporting value of a material as subgrade may be assumed as an inverse ratio to its group index; that is, a group index of zero indicates a "good" subgrade material and a group index of 20 or greater indicates a "very poor" subgrade material.
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