ORDINE DEI GEOLOGI DELLE MARCHE

Manuale 1

RACCOMANDAZIONI PER LA REDAZIONE DELLE INDAGINI E STUDI GEOLOGICO-GEOTECNICI

Rapporto Geologico-Geotecnico

(STANDARD DI QUALITÀ)

Giugno 1997

PREFAZIONE

Il consiglio dell'Ordine dei Geologi delle Marche ha ritenuto di dover elaborare il seguente "manuale" contenente le raccomandazioni per la redazione delle indagini e studi geologici e geotecnici, al fine di fornire uno standard al quale attenersi e fare riferimento.

Siamo certi che molti colleghi già seguono le indicazioni riportate, è tuttavia indispensabile anche per noi geologi, al pari di altre categorie professionali, adottare delle "modalità" di lavoro più appropriate per inquadrare e sviluppare i problemi dal punto di vista sostanziale nei contenuti e formale nella presentazione degli elaborati.

Il termine "rapporto" che sostituisce la dicitura "relazione" ritenuta troppo semplicistica e riduttiva, è certamente più consono e adatto per sintetizzare il carattere progettuale degli elaborati geologici e geotecnici.

Questo fascicolo costituisce un primo esempio promosso nella speranza e nella convinzione che in futuro possano essere intraprese iniziative analoghe in riferimento ai numerosi campi di applicazione della professione del geologo.

Un doveroso e cordiale ringraziamento va ai colleghi Walter Borghi, Enrico Gennari, Andrea Paoletti, Enzo Franchini e Vincenzo Bruno Otera che hanno validamente contribuito alla stesura del testo.

Il Presidente
Dott. Geol. Piergiacomo Beer

IL CONSIGLIO DELL'ORDINE DEI GEOLOGI DELLE MARCHE

Dott. Geol. Piergiacomo Beer
Dott. Geol. Gigliola Alessandroni
Dott. Geol. Walter Borghi
Dott. Geol. Maurizio Consoli
Dott. Geol. Enrico Gennari
Dott. Geol. Mario L. Rainone
Dott. Geol. Romano Romanini
Dott. Geol. Anna Spinaci
Dott. Geol. Luciano Taddei

SOMMARIO

1. Normativa di riferimento

- Leggi, regolamenti, tariffario e normativa per l'esercizio della professione di geologo (Consiglio Nazionale Geologi, 1993)
- Legge 64 del 02.02.74 (Legge Sismica)
- D.M. 24.03.82 (dighe)
- L.R. n° 33 del 03.11.84
- D.M. 12.12.85 (tubazioni)
- D.M. 24.01.86 (costruzioni in zone sismiche)
- D.M. 09.01.87 (progetto. esecuzione e collaudo di edifici in muratura e loro consolid.)
- Circolare Regionale n. 10 del 10.11.87 (istruzioni al D.M. 21.01.81, ...)
- D.M. 11.03.88 e Circolare LL.PP. 24.09.88 n. 30483
- Circolare Regionale n. 4 del 28.08.88 (PPAR)
- Circolare Regionale n. 14 del 16.08.89 (PPAR)
- D.P.G.R. n. 23 del 14.09.89 (Regolamento Edilizio Tipo)
- Circolari Regionali n. 14 e 15 del 28.08.90 (PPAR)
- Legge Regionale n. 34 del 05.08.92 (Legge urbanistica)
- D.M. 16/01/96 (norme per le costruzioni in zona sismica)

2. Rapporto Geologico-Geotecnico (obiettivi)

Per rapporto geologico geotecnico si è voluto intendere la sintesi della presentazione degli elaborati che traggono origine dalle diverse fasi in cui deve articolarsi il lavoro del geologo, dalla impostazione di studi e indagini per la definizione del modello geologico-geotecnico del sito, fino alla formulazione delle indicazioni sui criteri di fattibilità per la realizzazione di un intervento di modificazione o trasformazione del territorio.

OBIETTIVI:

DEFINIZIONE DEL
MODELLO GEOLOGICO-GEOTECNICO
DEL SITO

INDICAZIONI SUI CRITERI DI FATTIBILITA' DELL'OPERA

3. Rapporto Geologico-Geotecnico (metodologia di lavoro)

Lo studio, i rilievi e le indagini geologiche e geotecniche che concorrono alla redazione del rapporto geologico-geotecnico, si sviluppano generalmente secondo uno standard di lavoro che, sulla base delle finalità e delle tipologie degli interventi per cui sono eseguiti, prevede le seguenti fasi:

I^ FASE
FASE CONOSCITIVA

II^ FASE
ESECUZIONE DELLE INDAGINI
DIRETTE E/O INDIRETTE

III^ FASE
ELABORAZIONE E SINTESI
DEI RISULTATI DELLE INDAGINI

IV^ FASE
FATTIBILITA' DELL'INTERVENTO
VALUTAZIONI ANALITICHE E PRESCRIZIONI

TECNICHE E MEZZI DI INDAGINE DI USO CORRENTE		
PROFILO STRATIGRAFICO	INDAGINI DIRETTE Fori di sondaggio pozzetti esplorativi	INDAGINI INDIRETTE (*) - indagini geofisiche - penetrometri statici CPT punta meccanica - penetrometri statici CPT punta elettrica - penetrometri statici CPTU (piezocono) - penetrometri dinamici tipo: DPL-M/DPH/DPSH (**) - prove dilatometriche (DMT)
CARATTERISTICHE FISICO-MECCANICHE	PROVE GEOTECNICHE DI LABORATORIO	PROVE IN SITO - penetrometri statici (CPT, CPTU) - penetrometri dinamici tipo: DPL-M/DPH/DPSH (**) - prove penetrometriche SPT - prove scissometriche (FV) - prove pressiometriche - prove dilatometriche (DMT) - prove di carico su piastra - indagini geofisiche (di superficie e in foro)
PRESSIONI NEUTRALI	Piezometri a tubo aperto (per terreni permeabili)	- piezometri tipo "Casagrande" - celle piezometriche - prove CPTU (per terreni poco permeabili)
PERMEABILITÀ	PROVE GEOTECNICHE DI LABORATORIO - permeametri a carico costante - permeametri a carico variabili - celle triassiali	PROVE IN SITO - immissione in pozzetti superficiali - immiss. in fori di sondaggio (Lugeon, Lefranc...) - permeametri tipo Boutwell, etc. - prove di emungimento

(*) necessitano di sondaggi di taratura.

(**) raccomandabile il solo uso di penetrometri con tubo di rivestimento o con immissione di fango bentonitico lungo l'intercapedine

II^ Fase - esecuzione delle indagini

A) Indagini in sito

Le indagini dirette e/o indirette in sito debbono essere eseguite, secondo standard raccomandati (si veda ad esempio: A.G.I. - A.N.I.S.I.G.) da ditte specializzate operanti nel settore, con l'assistenza tecnica fornita dal geologo della ditta stessa sotto la D.L. del geologo incaricato.

B) Prove di laboratorio

Le prove di laboratorio su terre e rocce debbono essere effettuate presso Laboratori qualificati che operano preferibilmente in regime di "controllo della qualità" secondo metodologie di prova raccomandate (es. CNR-UNI, ASTM, AGI, ISRM).
"I risultati delle prove devono essere accompagnati da chiare indicazioni sulle modalità sperimentali adottate" (Circ. LL.PP. 24/09/88 n. 30483 - vedi punto B.4).

I^ FASE - fase conoscitiva

A) Ricerca Bibliografica

Prevede il reperimento di tutti i dati bibliografici esistenti e disponibili in relazione all'intervento previsto.
Dei dati bibliografici utilizzati ne dovrà essere espressamente citata la fonte di origine.

B) Analisi Geologica Integrata "Geologia - Geomorfologia - Idrogeologia"

L'analisi geologica integrata prevede l'acquisizione di una serie di dati che si esplicano generalmente mediante rilievi di superficie (fondamentali al fine di una corretta programmazione delle indagini dirette e indirette previste successivamente a completamento della I^ fase) finalizzati a valutazioni integrate di carattere geologico, geomorfologico, idrogeologico quali ad esempio:

- rilievi diretti in affioramento
  (giacitura, litologia, giunti <apertura-scabrezza-riempimento....> alterazione, etc);

- analisi geomorfologica
  (esposizione/acclività dei versanti, forme e/o processi, etc...);

- analisi idrogeologica
  (misure piezometriche in pozzi, sorgenti, etc...);

- analisi idrologica e meteorologica
  (reticoli idrografici, precipitazioni, venti, etc...);

- analisi dei fenomeni antropici
  (sbancamenti, riporti, etc.....).

C) Programma delle indagini

La scelta e la programmazione delle indagini dirette e indirette sarà fatta tenendo in considerazione:

- tipologia dell'intervento
  (acquisizione di tutti gli elementi in relazione alle problematiche progettuali dell'opera prevista);

- dati bibliografici disponibili;

- ampiezza e profondità delle indagini stesse
  (limiti dei mezzi e tecniche di indagine);

- litologia e spessori presunti dei materiali costituenti il sottosuolo
  (coperture, sub-strato);

- caratteristiche idrogeologiche presunte del sottosuolo;

- conoscenze acquisite attraverso l'analisi geologica integrata.

III^ Fase - elaborazione e sintesi dei risultati delle indagini

I risultati di tutte le indagini dirette e/o indirette eseguite, vengono elaborati, interpretati, correlati e/o confrontati con i dati bibliografici a disposizione e integrati con quanto emerso dagli studi e rilievi di superficie al fine di definire uno schema < MODELLO GEOLOGICO-GEOTECNICO > del sito interessato dall'intervento.

IV^ Fase - fattibilità dell'intervento, valutazioni analitiche e prescrizioni

Valutate le caratteristiche "geologiche e geotecniche" (modello o schema) del sito, sulla base di un preliminare confronto con il progettista dell'opera, si formulano:

- indicazioni inerenti la fattibilità geologica dell'intervento;
- valutazioni analitiche di orientamento in relazione all'intervento previsto (coeff. di stabilità pendii - scarpate - fronti di scavo, terreni di fondazione, etc...);
- prescrizioni (sistemi di regimazione idrogeologica, opere di protezione, monitoraggio, bonifica e miglioramento dei terreni, etc...).

4. Rapporto Geologico-Geotecnico (presentazione degli elaborati)

I risultati dello studio-rilievi di superficie e delle indagini dirette e/o indirette svolte vengono raccolti in un elaborato progettuale definito

RAPPORTO
GEOLOGICO - GEOTECNICO

composto da

Relazione esplicativa
e
Allegati

Tutti gli elaborati (relazione + allegati) devono recare la data e e contenere riferimenti precisi (ubicazione, riferimenti cartografici, etc...) inerenti l'intervento cui si riferiscono.

4.1) Relazione esplicativa: contenuti

4.1a) Premessa (con indicazioni sulle caratteristiche dell'opera in progetto, sull'ubicazione corografica e planimetrica del sito, sulle finalità delle indagini e sulle modalità di espletamento delle stesse, sulla committenza, sulla normativa di riferimento, e quant'altro ritenuto utile);

4.1b) Inquadramento geologico generale con riferimenti alle caratteristiche idrogeologiche , strutturali e sismiche di un intorno arealmente significativo;

4.1c) Aspetti geomorfologici (forme, processi in atto e/o passati) e di idrologia superficiale;

4.1d) Programma delle indagini (prove in sito e/o laboratorio, sondaggi, rilievi geologici, indagini sismiche, geoelettrica, etc...) con indicazioni sulle modalità di esecuzione delle stesse e sulla ditta prestatrice d'opera;

4.1e) Caratteristiche litostratigrafiche locali (con indicazioni su: litologia, colore, consistenza <per terreni coesivi> addensamento <per terreni incoerenti> stato di fratturazione, alterazione, presenza di noduli carbonatici, ossidazioni, materia organica, etc... dei terreni osservati). (*)

(*) La schematizzazione lito-stratigrafica (modello) del sottosuolo deve essere definita attraverso singole unità stratigrafiche per le quali è possibile definire caratteri pressoché omogenei.

4.1f) Caratteristiche fisico-meccaniche delle singole unità stratigrafiche costituenti il sottosuolo;
(la caratterizzazione geotecnica di tutti i litotipi riscontrati deve essere dimostrata mediante specifiche prove in sito e/o di laboratorio appositamente eseguite e di cui ne devono essere allegati grafici e diagrammi; per le zone geotecnicamente sufficientemente note, la caratterizzazione geotecnica del sottosuolo può essere eseguita in riferimento a prove in sito e/o di laboratorio eseguite per altre indagini, purché si specifichino estesamente le fonti, se ne citi la provenienza e se ne alleghi la documentazione reperita);

Per quanto attiene la classificazione geotecnica dei terreni, si dovrà far riferimento ai sistemi di classificazione generalmente adottati, tra i quali si raccomandano:

- [CLASSIFICAZIONE ASTM D 2487-92] :
  Classification of Soil for Engineering Purposes (Unified Soil Classification System - USCS)
  (generalmente impiegata per terreni a grana grossa e terreni a grana fine).

- [CLASSIFICAZIONE ASTM D 3282-92] :
  Classification of Soil and Soil Aggregate Mixtures for Highway Construction Purposes
  (generalmente impiegata per materiali stradali).

Nelle allegate TAVOLE sono riportati i sistemi di classificazione sopracitati.

Per quanto attiene la classificazione geomeccanica degli ammassi rocciosi si dovrà far riferimento alle principali classificazioni, fra le quali si ricordano, ad esempio:

- [BIENIAWSKI - 1973] classificazione R.M.R.
- [BURTON et Al.- 1974] classificazione Q System
- [ISRM - 1981] classificazione BGD
- [A.G.I. - 1979]

4.1g) Condizioni idrogeologiche locali;

4.1h) Condizioni di stabilità del/i versante/i sia in condizioni statiche che dinamiche;

4.1i) Definizione della fattibilità geologica dell'opera (sulla base degli elementi acquisiti) e valutazioni analitiche di orientamento in riferimento all'intervento previsto (valutazioni sulle tipologie di fondazione, carichi ammissibili, cedimenti, coefficienti di stabilità di versanti, scarpate e fronti di scavo, etc...);

4.2) Allegati

4.2a) Stralcio cartografico di inquadramento generale dell'area (1:25.000; 1:10.000, 1:2.000);

4.2b) Stralcio, in scala adeguata, della documentazione geologico tecnica esistente a corredo dello strumento urbanistico generale (PdF o PRG) e/o dei Piani Urbanistici Attuativi

4.2c) Carta geologica di inquadramento generale in assenza di quanto previsto al punto 4.2b

4.2d) Planimetria quotata (in scala di dettaglio significativo), dell'area interessata dal progetto contenente sufficienti punti quotati , l'ubicazione dei sondaggi e/o delle Prove di Campagna (quotati) con evidenziato l'andamento delle Sezioni geologiche;

4.2e) Carta Geomorfologica di un ambito territoriale morfologicamente significativo dall'area del progetto in essa dovranno essere evidenziati gli elementi geomorfologici (forme e processi) gravitativi ed erosivi sia attivi che inattivi e/o potenzialmente attivi;

4.2f) Stratigrafia dei sondaggi geognostici.
La successione lito-stratigrafica del sottosuolo deve essere schematizzata mediante distinte UNITA' STRATIGRAFICHE identificate attraverso una apposita simbologia (*).
Le tabelle dei sondaggi debbono contenere: la località, il committente, la data, la descrizione dettagliata (colore, consistenza, addensamento, fratturazione, alterazione, etc...) dei vari litotipi caratterizzanti i singoli livelli esistenti nel sottosuolo e la loro profondità di rinvenimento, i valori di resistenza al pocket penetrometer e/o scissometro, la profondità di prelievo dei campioni e il grado di qualità degli stessi, la profondità della falda, le eventuali prove in foro (permeabilità, SPT, etc...) il metodo di perforazione adottato, l'assistenza tecnica alla perforazione (firma del geologo che assiste alla perforazione);
le determinazioni litostratigrafiche mediante prove dirette e/o indirette, devono essere eseguite in numero e fino a profondità significative in funzione del tipo di progetto (raccomandazioni AGI, 77 e Circolare LL.PP n. 30483 del 24.09.88-comma C3);

(*) Nelle tavole allegate sono riportati alcuni esempi di simbologia da utilizzarsi per identificare le unità stratigrafiche. Nello specifico risultano i seguenti:

- Simbologia A.G.I. per terreni e ammassi rocciosi (tratta da: raccomandazioni sulla programmazione ed esecuzione delle indagini geotecniche, Giugno 1977).

- Simbologia per terreni e rocce proposta dal Servizio Geologico per la redazione delle carte (tratta da: Servizio Geologico - guida al rilevamento - quaderno n.5 anno 1995)

4.2g) Grafici e diagrammi delle Prove in sito e/o di laboratorio eseguite, riportanti precisi riferimenti sulla committenza, la località, la data;

4.2h) Sezioni geologiche su base litostratigrafica e di verifica di stabilità del/i versante/i (quando esistenti) in numero sufficiente (almeno una) ed in scala preferibilmente non inferiore a 1:500;

4.2i) Sezioni geologiche su base litostratigrafica a correlazione dei sondaggi e/o delle prove in sito, in scala preferibilmente non inferiore a 1:500 (1:1000 per i piani attuativi);

4.2l) tabelle ed elaborati di calcolo relativi ai risultati della valutazione analitica della stabilità di versanti e/o scarpate (se esistenti);

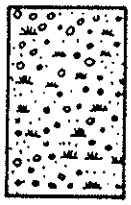
4.2m) eventuali ulteriori elaborati utili ai fini di una chiara comprensione dei risultati.

5. Tavole

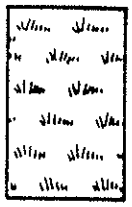
- Simbologia <A.G.I.> per terreni
- Simbologia <A.G.I.> per ammassi rocciosi
- Simbologia <Servizio Geologico> per terreni e rocce

- Sistema di classificazione ASTM D 2487-92
- Sistema di classificazione ASTM D 3282-92

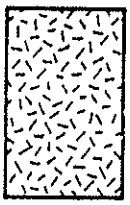
SIMBOLI GRAFICI PER I TERRENI (da A.G.I. 1977)



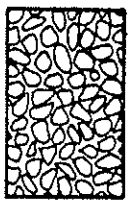
terreno vegetale



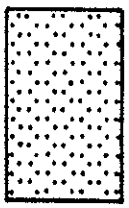
torba



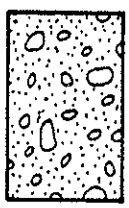
terreno di riporto



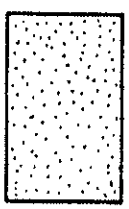
ghiaia



sabbia

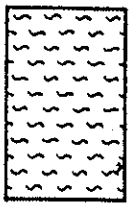


sabbia e ghiaia



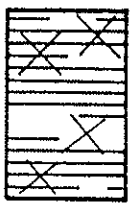
sabbia fine

terreni piroclastici



limo

argilla

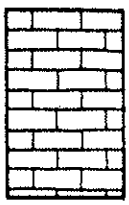


argilla sovraconsolidata fessurata

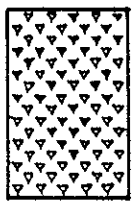
argilliti

argilliti scagliose, argilloscisti

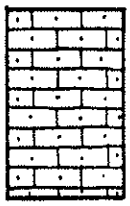
SIMBOLI GRAFICI PER GLI AMMASSI ROCCIOSI (da A.G.I. 1977)



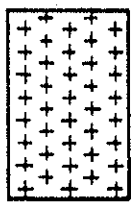
rocce calcaree (calcari, calcari dolomitici, dolomie, etc.)



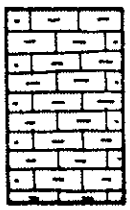
tufi vulcanici



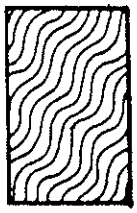
arenarie



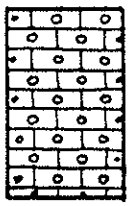
rocce ignee



marne

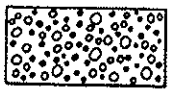


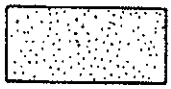
rocce scistose

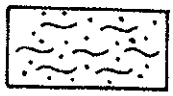


conglomerati

SIMBOLI GRAFICI PER TERRENI E ROCCE
(Da Servizio Geologico - guida al rilevamento, quaderno 5)

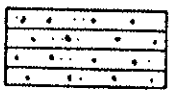

ghiaia

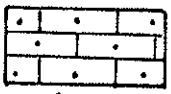

sabbia

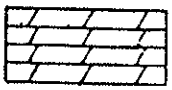

limo


conglomerati


travertini

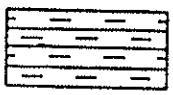

arenarie

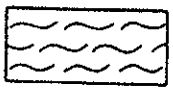

tufi calcarei


dolomie

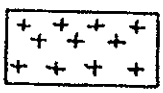

calcari


calcari marnosi

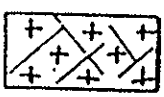

marne


argille


sequenze sedimentarie indifferenziate

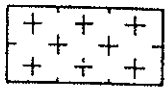

granito a grana medio-fine

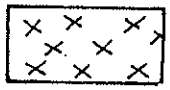

granito a grana grossa

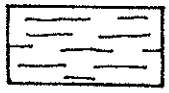

granito cataclastico

SIMBOLI GRAFICI PER TERRENI E ROCCE
(Da Servizio Geologico - guida al rilevamento, quaderno 5)


cataclastite granitica


rocce intrusive


rocce filoniane

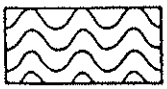

argillificazioni nei graniti


rocce effusive

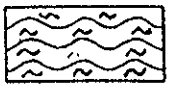

piroclastiti litoidi

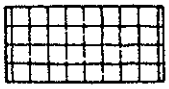

piroclastiti sciolte


rocce a basso grado di metamorfismo


rocce a medio grado di metamorfismo


rocce ad alto grado di metamorfismo


filladi


calcari cristallini


quarziti


ammassi salini (con formula di minerale prevalente)

Designation: D 3282 - 92

Standard Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes[1]

This standard is issued under the fixed designation D 3282; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DoD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This standard describes a procedure for classifying mineral and organomineral soils into seven groups based on laboratory determination of particle-size distribution, liquid limit, and plasticity index. It may be used when a precise engineering classification is required, especially for highway construction purposes. Evaluation of soils within each group is made by means of a *group index*, which is a value calculated from an empirical formula.

NOTE 1—The group classification, including the 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 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 420 Guide for Investigating and Sampling Soil and Rock[2]

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

D 422 Test Method for Particle-Size Analysis of Soils[2]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]

D 1140 Test Method for Amount of Material in Soils Finer Than the No. 200 (75-μm) Sieve[2]

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]

D 1586 Method for Penetration Test and Split-Barrel Sampling of Soils[2]

D 1587 Practice for Thin-Walled Tube Sampling of Soils[2]

D 2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[2]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[2]

3. Terminology

3.1 *Descriptions of Terms Specific to This Standard:*

3.1.1 The following terms are frequently used in this standard. These terms differ slightly from those given in Terminology D 653, but are used here to maintain consistency with common highway usage.

3.1.2 *boulders*—rock fragments, usually rounded by weathering or abrasion, that will be retained on a 3-in. (75-mm) sieve.

3.1.3 *coarse sand*—particles of rock or soil that will pass a No. 10 (2-mm) sieve and be retained on a No. 40 (425-μm) sieve.

3.1.4 *fine sand*—particles of rock or soil that will pass a No. 40 (425-μm) sieve and be retained on a No. 200 (75-μm) sieve.

3.1.5 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 10 (2-mm) sieve.

3.1.6 *silt-clay (combined silt and clay)*—fine soil and rock particles that will pass a No. 200 (75-μm) sieve.

3.1.6.1 *silty*—fine-grained material that has a plasticity index of 10 or less.

3.1.6.2 *clayey*—fine-grained material that has a plasticity index of 11 or more.

4. Significance and Use

4.1 The standard described classifies soils from any geographic location into groups (including group indexes) based on the results of prescribed laboratory tests to determine the particle-size characteristics, liquid limit, and plasticity index.

4.2 The assigning of a group symbol and group index can be used to aid in the evaluation of the significant properties of the soil for highway and airfield purposes.

4.3 The various groupings of this classification system correlate in a general way with the engineering behavior of soils. Also, in a general way, the engineering behavior of a soil varies inversely with its group index. Therefore, this standard provides a useful first step in any field or laboratory investigation for geotechnical engineering purposes.

5. Apparatus

5.1 *Apparatus for Preparation of Samples*—See Practices D 421 or D 2217.

5.2 *Apparatus for Particle-Size Analysis*—See Test Methods D 1140 and D 422.

---

[1] This standard is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved May 15, 1992. Published July 1992. Originally published as D 3282 - 73. Last previous edition D 3282 - 88[ε1].

[2] *Annual Book of ASTM Standards*, Vol 04.08.

5.3 *Apparatus for Liquid Limit and Plastic Limit Tests*—See Test Method D 4318.

6. Sampling

6.1 Conduct field investigations and sampling in accordance with one or more of the following procedures:

6.1.1 Guide D 420,

6.1.2 Practice D 1452,

6.1.3 Method D 1586,

6.1.4 Practice D 1587.

7. Test Sample

7.1 Test samples shall represent that portion of the field sample finer than the 3-in. (75-mm) sieve and shall be obtained as follows:

7.1.1 Air-dry the field sample,

7.1.2 Weigh the field sample,

7.1.3 Separate the field sample into two fractions on a 3-in. (75-mm) sieve,

7.1.4 Weigh the fraction retained on the 3-in. (75-mm) sieve. Compute the percentage of plus 3-in. material in the field sample, and note this percentage as auxiliary information, and

7.1.5 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve and select the test samples.

NOTE 2—If visual examination indicates that no boulder size material is present, omit 7.1.3 and 7.1.4.

7.2 Prepare the test sample in accordance with Practices D 421 or D 2217. Determine the percentage of the sample finer than a No. 10 (2-mm) sieve.

NOTE 3—It is recommended that the method for wet preparation be used for soils containing organic matter or irreversible mineral colloids.

8. Testing Procedure

8.1 Determine the percentage of the test sample finer than a No. 200 (75-μm) sieve in accordance with Test Methods D 1140 or D 422.

NOTE 4—For granular materials the percentage of the sample finer than a No. 40 (425-μm) sieve must also be determined.

8.2 Determine the liquid limit and the plasticity index of a portion of the test sample passing a No. 40 (425-μm) sieve in accordance with Test Method D 4318.

9. Classification Procedure

9.1 Using the test data determined in Section 8, classify the soil into the appropriate group or subgroup, or both, in accordance with Tables 1 or 2. Use Fig. 1 to classify silt-clay materials on the basis of liquid limit and plasticity index values.

NOTE 5—All limiting values are shown as whole numbers. If fractional numbers appear on test reports, convert to the nearest whole numbers for the purpose of classification.

9.1.1 With the required test data available, proceed from left to right in Tables 1 or 2 and the correct classification will be found by the process of elimination. The first group from the left into which the test data will fit is the correct classification.

NOTE 6—Classification of materials in the various groups applies only to the fraction passing the 3-in. (75-mm) sieve. Therefore, any specification regarding the use of A-1, A-2, or A-3 materials in construction should state whether boulders (retained on 3-in. sieve) are permitted.

10. Description of Classification Groups

10.1 *Granular Materials,* containing 35 % or less passing the No. 200 (75-μm) sieve:

10.1.1 *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 a soil binder.

10.1.1.1 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.

10.1.1.2 Subgroup A-1-b includes those materials consisting predominantly of coarse sand, either with or without a well-graded soil binder.

10.1.2 *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 also includes stream-deposited mixtures of poorly graded fine sand and limited amounts of coarse sand and gravel.

10.1.3 *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 the silt-clay materials of Groups A-4, A-5, A-6, and A-7. It includes materials containing 35 % or less passing a No. 200 (75-μm) sieve which cannot be classified in Groups A-1 or A-3, due to the fines content or the plasticity indexes, or both, in excess of the limitations for those groups.

10.1.3.1 Subgroups A-2-4 and A-2-5 include various granular materials containing 35 % or less passing a No. 200 (75-μm) sieve and with a minus No. 40 (425-μm) portion having the characteristics of Groups A-4 and A-5, respectively. 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.

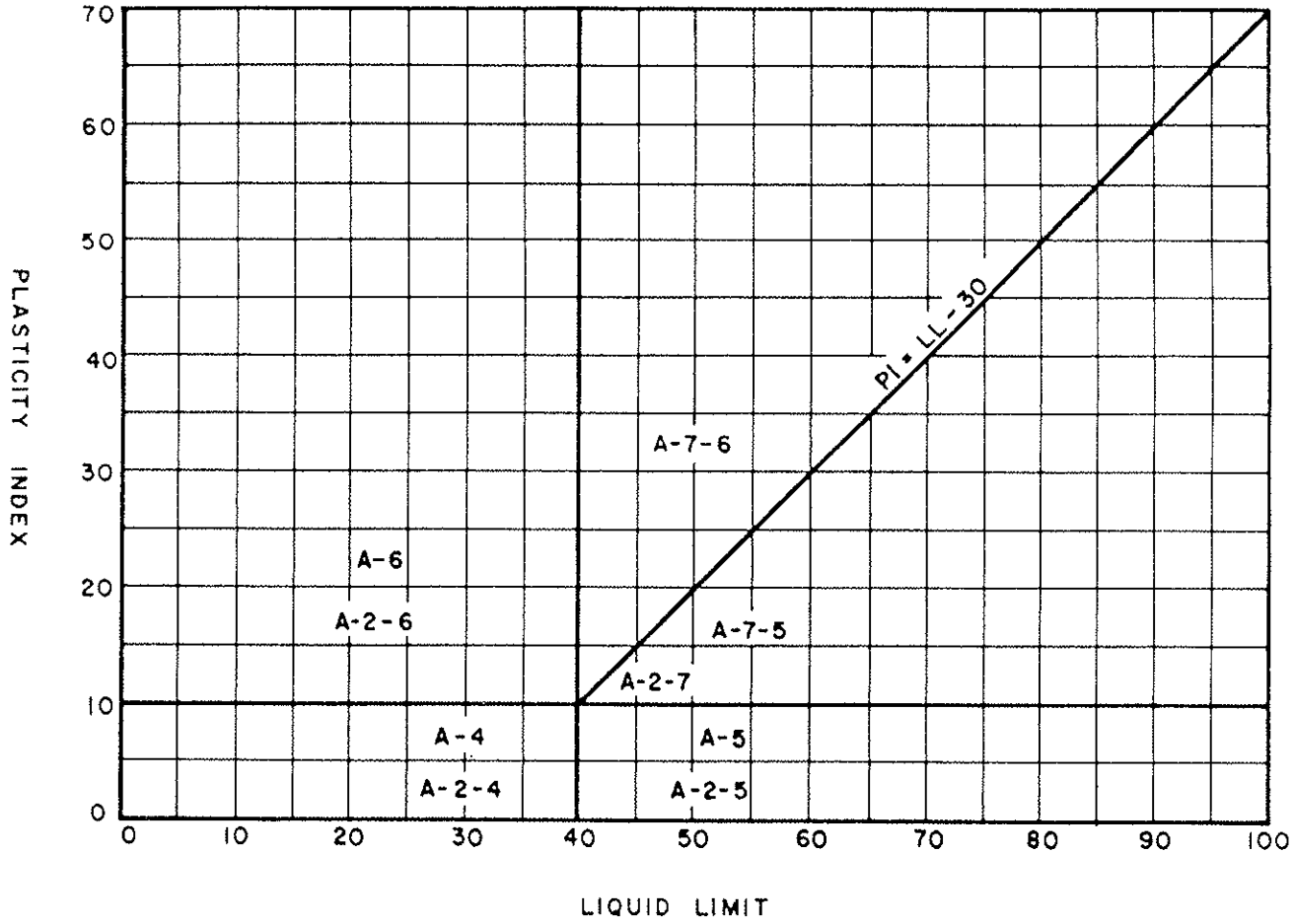
10.1.3.2 Subgroups A-2-6 and A-2-7 include materials similar to those described under Subgroups A-2-4 and A-2-5 except that the fine portion contains plastic clay having the characteristics of the A-6 or A-7 group, respectively.

10.2 *Silt-Clay Materials,* containing more than 35 % passing a No. 200 (75-μm) sieve:

10.2.1 *Group A-4*—The typical material of this group is a nonplastic or moderately plastic silty soil usually having 75 % or more passing a No. 200 (75-μm) sieve. This group also includes mixtures of fine silty soil and up to 64 % sand and gravel retained on a No. 200 sieve.

10.2.2 *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.

10.2.3 *Group A-6*—The typical material of this group is a plastic clay soil usually having 75 % or more passing a No. 200 (75-μm) sieve. This group also includes mixtures of plastic clayey soil and up to 64 % of sand and gravel retained on the No. 200 sieve. Materials of this group usually have a



NOTE—A-2 soils contain less than 35 % finer than 200 sieve.

FIG. 1 Liquid Limit and Plasticity Index Ranges for Silt-Clay Materials

volume change between wet and dry states.

10.2.4 *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 Group A-5 and may be elastic as well as subject to high-volume change.

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

10.2.4.2 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 7—Highly organic soils (peat or muck) may be classified in Group A-8. Classification of these materials is based on visual inspection and is not dependent on the percentage passing the No. 200 (75-μm) sieve, liquid limit, or plasticity index. The material is composed primarily of partially-decayed organic matter, generally has a fibrous texture, a 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.

11. Group Index Computation

11.1 The classifications obtained from Tables 1 or 2 may be modified by the addition of a group-index value. Group-index values should always be shown in parentheses after the group symbol as A-2-6(3), A-4(5), A-6(12), A-7-5(17), etc.

11.1.1 Calculate the group index from the following empirical formula:

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

where:

F = percentage passing No. 200 (75-μm) sieve, expressed as a whole number (this percentage is based only on the material passing the 3-in. (75-mm) sieve),

LL = liquid limit, and

PI = plasticity index.

11.1.2 If the calculated group index is negative, report the group index as zero (0).

11.1.3 If the soil is nonplastic and when the liquid limit cannot be determined, report the group index as zero (0).

11.1.4 Report the group index to the nearest whole number.

11.1.5 The group index value may be estimated using Fig. 2 by determining the partial group index due to the liquid limit and that due to the plasticity index, then obtaining the total of the two partial group indexes.

11.1.6 The group index of soils in the A-2-6 and A-2-7 subgroups shall be calculated using only the *PI* portion of the formula (or Fig. 2).

11.2 The following examples illustrate the calculations for the group index:

TABLE 1 Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35 % or less passing No. 200)			Silt-Clay Materials (More than 35 % passing No. 200)			
Group Classification	A-1	A-3[A]	A-2	A-4	A-5	A-6	A-7
Sieve analysis, % passing:							
No. 10 (2.00 mm)	...	...	...	...	...	...	...
No. 40 (425 μm)	50 max	51 min	...	...	...	...	...
No. 200 (75 μm)	25 max	10 max	35 max	36 min	36 min	36 min	36 min
Characteristics of fraction passing No. 40 (425 μm):							
Liquid limit	...	...	[B]	40 max	41 min	40 max	41 min
Plasticity index	6 max	N.P.	[B]	10 max	10 max	11 min	11 min
General rating as subgrade	Excellent to Good			Fair to Poor			

[A] 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.
[B] See Table 2 for values.
Reprinted with permission of American Association of State Highway and Transportation Officials

TABLE 2 Classification of Soils and Soil-Aggregate Mixtures

General Classification	Granular Materials (35 % or less passing No. 200)							Silt-Clay Materials (More than 35 % passing No. 200)			
Group classification	A-1		A-3	A-2				A-4	A-5	A-6	A-7
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6
Sieve analysis, % passing:											
No. 10 (2.00 mm)	50 max	...	...	...	...	...	...	...	...	...	...
No. 40 (425 μm)	30 max	50 max	51 min	...	...	...	...	...	...	...	...
No. 200 (75 μm)	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 No. 40 (425 μm):											
Liquid limit	...		...	40 max	41 min	40 max	41 min	40 max	41 min	40 max	41 min
Plasticity index	6 max		N.P.	10 max	10 max	11 min	11 min	10 max	10 max	11 min	11 min[A]
Usual types of significant constituent materials	Stone Fragments, Gravel and Sand		Fine Sand	Silty or Clayey Gravel and Sand				Silty Soils		Clayey Soils	
General rating as subgrade	Excellent to Good							Fair to Poor			

[A] 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 Fig. 1).
Reprinted with permission of American Association of State Highway and Transportation Officials.

11.2.1 Assume that an A-6 material has 55 % passing a No. 200 (75-μm) sieve, a liquid limit of 40, and a plasticity index of 25, then:

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

11.2.2 Assume that an A-7 material has 80 % passing a No. 200 (75-μm) sieve, a liquid limit of 90, and a plasticity index of 50, then:

$$\text{Group index} = (80 - 35)[0.2 \pm 0.005(90 - 40)] + [0.01(80 - 15)(50 - 10)] = 20.3 + 26.0 = 46.3 \text{ (report as 46)}$$

11.2.3 Assume that an A-4 material has 60 % passing a No. 200 (75-μm) sieve, a liquid limit of 25, and a plasticity index of 1, then

$$\text{Group index} = (60 - 35)[0.2 + 0.005(25 - 40)] + [0.01(60 - 15)(1 - 10)] = 25 \times (0.2 - 0.075) + 0.01(45)(-9) = 3.1 - 4.1 = -1.0 \text{ (report as 0)}$$

11.2.4 Assume that an A-2-7 material has 30 % passing a No. 200 (75-μm) sieve, a liquid limit of 50, and a plasticity index of 30, then

$$\text{Group index} = 0.01(30 - 15)(30 - 10) = 3.0 \text{ or } 3$$

(note that only the *PI* portion of the formula was used)

12. Discussion of Group Index

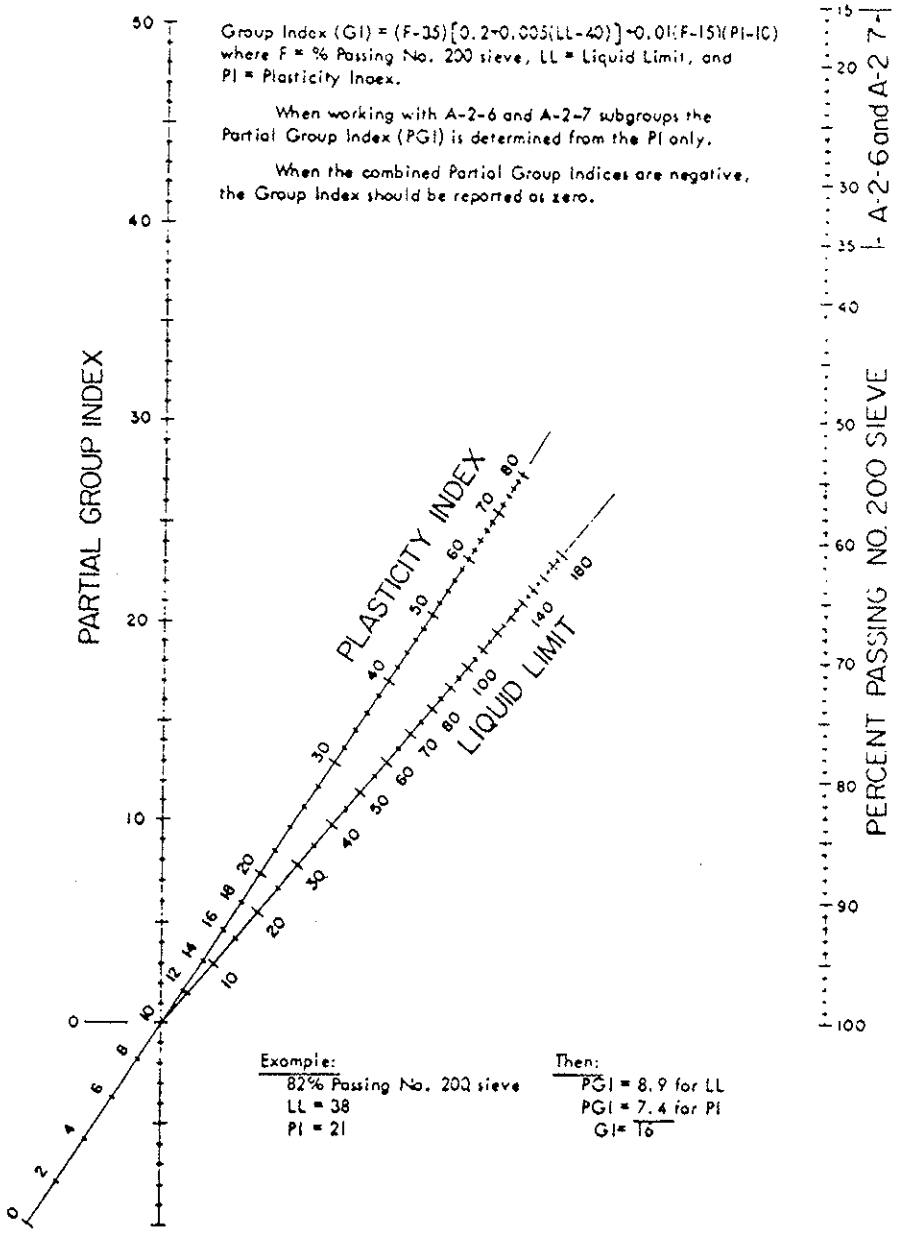
12.1 The empirical group index formula devised for approximate within-group evaluation of the "clayey-granular materials" and the "silt-clay materials" is based on the following assumptions:

NOTE 8—Group index values should only be used to compare soils within the same group and not between groups.

12.1.1 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 of pavement (base or surface course, or both) of a type suitable for traffic to be carried or can be made satisfactory by additions of small amounts of natural or artificial binders.

12.1.2 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 in 12.1.1, in order to furnish adequate support for traffic loads.

12.1.3 A minimum of 35 % passing a No. 200 (75-μm) sieve is assumed to be critical if plasticity is neglected, but the critical minimum is only 15 % when affected by plasticity indexes greater than 10.



Reprinted with permission of American Association of State Highway and Transportation Officials

FIG. 2 Group Index Chart

12.1.4 Liquid limits of 40 and above are assumed to be critical.

12.1.5 Plasticity indexes of 10 and above are assumed to be critical.

12.2 There is no upper limit of group index value obtained by use of the formula: The adopted critical values of percentage passing the No. 200 (75-μm) 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.

12.3 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 0 indicates a "good" subgrade material and a group index of 20 or greater indicates a "very poor" subgrade material.

13. Keywords

13.1 Atterberg limits; classification; clay; gradation; highways; sand gravel; silt; soil classification; soil tests

Designation: D 2487 – 92

Standard Classification of Soils for Engineering Purposes (Unified Soil Classification System)[1]

This standard is issued under the fixed designation D 2487; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense. Consult the DOD Index of Specifications and Standards for the specific year of issue which has been adopted by the Department of Defense.

1. Scope

1.1 This standard describes a system for classifying mineral and organo-mineral soils for engineering purposes based on laboratory determination of particle-size characteristics, liquid limit, and plasticity index and shall be used when precise classification is required.

NOTE 1—Use of this standard will result in a single classification group symbol and group name except when a soil contains 5 to 12 % fines or when the plot of the liquid limit and plasticity index values falls into the crosshatched area of the plasticity chart. In these two cases, a dual symbol is used, for example, GP-GM, CL-ML. When the laboratory test results indicate that the soil is close to another soil classification group, the borderline condition can be indicated with two symbols separated by a slash. The first symbol should be the one based on this standard, for example, CL/CH, GM/SM, SC/CL. Borderline symbols are particularly useful when the liquid limit value of clayey soils is close to 50. These soils can have expansive characteristics and the use of a borderline symbol (CL/CH, CH/CL) will alert the user of the assigned classifications of expansive potential.

1.2 The group symbol portion of this sytem is based on laboratory tests performed on the portion of a soil sample passing the 3-in. (75-mm) sieve (see Specification E 11).

1.3 As a classification system, this standard is limited to naturally occurring soils.

NOTE 2—The group names and symbols used in this test method may be used as a descriptive system applied to such materials as shale, claystone, shells, crushed rock, etc. See Appendix X2.

1.4 This standard is for qualitative application only.

NOTE 3—When quantitative information is required for detailed designs of important structures, this test method must be supplemented by laboratory tests or other quantitative data to determine performance characteristics under expected field conditions.

1.5 This standard is the ASTM version of the Unified Soil Classification System. The basis for the classification scheme is the Airfield Classification System developed by A. Casagrande in the early 1940's.[2] It became known as the Unified Soil Classification System when several U.S. Government Agencies adopted a modified version of the Airfield System in 1952.

1.6 *This standard does not purport to address all of the safety problems, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

C 117 Test Method for Materials Finer Than 75-μm (No. 200) Sieve in Mineral Aggregates by Washing[3]

C 136 Method for Sieve Analysis of Fine and Coarse Aggregates[3]

C 702 Practice for Reducing Field Samples of Aggregate to Testing Size[3]

D 420 Guide for Investigating and Sampling Soil and Rock[4]

D 421 Practice for Dry Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[4]

D 422 Test Method for Particle-Size Analysis of Soils[4]

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[4]

D 1140 Test Method for Amount of Material in Soils Finer than the No. 200 (75-μm) Sieve[4]

D 2216 Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock[4]

D 2217 Practice for Wet Preparation of Soil Samples for Particle-Size Analysis and Determination of Soil Constants[4]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[4]

D 4083 Practice for Description of Frozen Soils (Visual-Manual Procedure)[4]

D 4318 Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils[4]

D 4427 Classification of Peat Samples by Laboratory Testing[4]

E 11 Specification for Wire-Cloth Sieves for Testing Purposes[3]

3. Terminology

3.1 *Definitions*—Except as listed below, all definitions are in accordance with Terminology D 653.

---

[1] This standard is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.07 on Identification and Classification of Soils.

Current edition approved May 15, 1992. Published July 1992. Originally published as D 2487 – 66 T. Last previous edition D 2487 – 90[ε1].

[2] Casagrande, A., "Classification and Identification of Soils," *Transactions*, ASCE, 1948, p. 901.

[3] *Annual Book of ASTM Standards*, Vol 04.02.

[4] *Annual Book of ASTM Standards*, Vol 04.08.

NOTE 4—For particles retained on a 3-in. (75-mm) U.S. standard sieve, the following definitions are suggested:

Cobbles—particles of rock that will pass a 12-in. (300-mm) square opening and be retained on a 3-in. (75-mm) U.S. standard sieve, and

Boulders—particles of rock that will not pass a 12in. (300-mm) square opening

3.1.1 *gravel*—particles of rock that will pass a 3-in. (75-mm) sieve and be retained on a No. 4 (4.75-mm) U.S. standard sieve with the following subdivisions:

Coarse—passes 3-in. (75-mm) sieve and retained on ¾-in. (19-mm) sieve, and

Fine—passes ¾-in. (19-mm) sieve and retained on No. 4 (4.75-mm) sieve.

3.1.2 *sand*—particles of rock that will pass a No. 4 (4.75-mm) sieve and be retained on a No. 200 (75-μm) U.S. standard sieve with the following subdivisions:

Coarse—passes No. 4 (4.75-mm) sieve and retained on No. 10 (2.00-mm) sieve,

Medium—passes No. 10 (2.00-mm) sieve and retained on No. 40 (425-μm) sieve, and

Fine—passes No. 40 (425-μm) sieve and retained on No. 200 (75-μm) sieve.

3.1.3 *clay*—soil passing a No. 200 (75-μm) U.S. standard sieve that can be made to exhibit plasticity (putty-like properties) within a range of water contents and that exhibits considerable strength when air dry. For classification, a clay is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index equal to or greater than 4, and the plot of plasticity index versus liquid limit falls on or above the "A" line.

3.1.4 *silt*—soil passing a No. 200 (75-μm) U.S. standard sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air dry. For classification, a silt is a fine-grained soil, or the fine-grained portion of a soil, with a plasticity index less than 4 or if the plot of plasticity index versus liquid limit falls below the "A" line.

3.1.5 *organic clay*—a clay with sufficient organic content to influence the soil properties. For classification, an organic clay is a soil that would be classified as a clay except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.6 *organic silt*—a silt with sufficient organic content to influence the soil properties. For classification, an organic silt is a soil that would be classified as a silt except that its liquid limit value after oven drying is less than 75 % of its liquid limit value before oven drying.

3.1.7 *peat*—a soil composed of vegetable tissue in various stages of decomposition usually with an organic odor, a dark-brown to black color, a spongy consistency, and a texture ranging from fibrous to amorphous.

3.2 *Descriptions of Terms Specific to This Standard:*

3.2.1 *coefficient of curvature*, Cc—the ratio $(D_{30})^2/(D_{10} \times D_{60})$, where D_{60}, D_{30}, and D_{10} are the particle diameters corresponding to 60, 30, and 10 % finer on the cumulative particle-size distribution curve, respectively.

3.2.2 *coefficient of uniformity*, Cu—the ratio D_{60}/D_{10}, where D_{60} and D_{10} are the particle diameters corresponding to 60 and 10 % finer on the cumulative particle-size distribution curve, respectively.

4. Summary

4.1 As illustrated in Table 1, this classification system identifies three major soil divisions: coarse-grained soils, fine-grained soils, and highly organic soils. These three divisions are further subdivided into a total of 15 basic soil groups.

4.2 Based on the results of visual observations and prescribed laboratory tests, a soil is catalogued according to the basic soil groups, assigned a group symbol(s) and name, and thereby classified. The flow charts, Fig. 1 for fine-grained soils, and Fig. 2 for coarse-grained soils, can be used to assign the appropriate group symbol(s) and name.

5. Significance and Use

5.1 This standard classifies soils from any geographic location into categories representing the results of prescribed laboratory tests to determine the particle-size characteristics, the liquid limit, and the plasticity index.

5.2 The assigning of a group name and symbol(s) along with the descriptive information required in Practice D 2488 can be used to describe a soil to aid in the evaluation of its significant properties for engineering use.

5.3 The various groupings of this classification system have been devised to correlate in a general way with the engineering behavior of soils. This standard provides a useful first step in any field or laboratory investigation for geotechnical engineering purposes.

5.4 This standard may also be used as an aid in training personnel in the use of Practice D 2488.

5.5 This standard may be used in combination with Practice D 4083 when working with frozen soils.

6. Apparatus

6.1 In addition to the apparatus that may be required for obtaining and preparing the samples and conducting the prescribed laboratory tests, a plasticity chart, similar to Fig. 3, and a cumulative particle-size distribution curve, similar to Fig. 4, are required.

NOTE 5—The "U" line shown on Fig. 3 has been empirically determined to be the approximate "upper limit" for natural soils. It is a good check against erroneous data, and any test results that plot above or to the left of it should be verified.

7. Sampling

7.1 Samples shall be obtained and identified in accordance with a method or methods, recommended in Recommended Guide D 420 or by other accepted procedures.

7.2 For accurate identification, the minimum amount of test sample required for this test method will depend on which of the laboratory tests need to be performed. Where only the particle-size analysis of the sample is required, specimens having the following minimum dry weights are required:

Maximum Particle Size, Sieve Opening	Minimum Specimen Size, Dry Weight
4.75 mm (No. 4)	100 g (0.25 lb)
9.5 mm (⅜ in.)	200 g (0.5 lb)
19.0 mm (¾ in.)	1.0 kg (2.2 lb)
38.1 mm (1½ in.)	8.0 kg (18 lb)
75.0 mm (3 in.)	60.0 kg (132 lb)

Whenever possible, the field samples should have weights two to four times larger than shown.

TABLE 1 Soil Classification Chart

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests[A]				Soil Classification	
				Group Symbol	Group Name[B]
COARSE-GRAINED SOILS More than 50 % retained on No. 200 sieve	Gravels More than 50 % of coarse fraction retained on No. 4 sieve	Clean Gravels Less than 5 % fines[C]	$Cu \geq 4$ and $1 \leq Cc \leq 3^E$	GW	Well-graded gravel[F]
			$Cu < 4$ and/or $1 > Cc > 3^E$	GP	Poorly graded gravel[F]
		Gravels with Fines More than 12 % fines[C]	Fines classify as ML or MH	GM	Silty gravel[F,G,H]
			Fines classify as CL or CH	GC	Clayey gravel[F,G,H]
	Sands 50 % or more of coarse fraction passes No. 4 sieve	Clean Sands Less than 5 % fines[D]	$Cu \geq 6$ and $1 \leq Cc \leq 3^E$	SW	Well-graded sand[I]
			$Cu < 6$ and/or $1 > Cc > 3^E$	SP	Poorly graded sand[I]
		Sands with Fines More than 12 % fines[D]	Fines classify as ML or MH	SM	Silty sand[G,H,I]
			Fines classify as CL or CH	SC	Clayey sand[G,H,I]
FINE-GRAINED SOILS 50 % or more passes the No. 200 sieve	Silts and Clays Liquid limit less than 50	inorganic	PI > 7 and plots on or above "A" line[J]	CL	Lean clay[K,L,M]
			PI < 4 or plots below "A" line[J]	ML	Silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OL	Organic clay[K,L,M,N] / Organic silt[K,L,M,O]
	Silts and Clays Liquid limit 50 or more	inorganic	PI plots on or above "A" line	CH	Fat clay[K,L,M]
			PI plots below "A" line	MH	Elastic silt[K,L,M]
		organic	$\frac{\text{Liquid limit - oven dried}}{\text{Liquid limit - not dried}} < 0.75$	OH	Organic clay[K,L,M,P] / Organic silt[K,L,M,Q]
HIGHLY ORGANIC SOILS	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-in. (75-mm) sieve.

[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.

[C] Gravels with 5 to 12 % fines require dual symbols:
GW-GM well-graded gravel with silt
GW-GC well-graded gravel with clay
GP-GM poorly graded gravel with silt
GP-GC poorly graded gravel with clay

[D] Sands with 5 to 12 % fines require dual symbols:
SW-SM well-graded sand with silt
SW-SC well-graded sand with clay
SP-SM poorly graded sand with silt
SP-SC poorly graded sand with clay

[E] $Cu = D_{60}/D_{10}$ $\quad Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$

[F] If soil contains ≥ 15 % sand, add "with sand" to group name.

[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.

[H] If fines are organic, add "with organic fines" to group name.

[I] If soil contains ≥ 15 % gravel, add "with gravel" to group name.

[J] If Atterberg limits plot in hatched area, soil is a CL-ML, silty clay.

[K] If soil contains 15 to 29 % plus No. 200, add "with sand" or "with gravel," whichever is predominant.

[L] If soil contains ≥ 30 % plus No. 200, predominantly sand, add "sandy" to group name.

[M] If soil contains ≥ 30 % plus No. 200, predominantly gravel, add "gravelly" to group name.

[N] PI ≥ 4 and plots on or above "A" line.

[O] PI < 4 or plots below "A" line.

[P] PI plots on or above "A" line.

[Q] PI plots below "A" line.

7.3 When the liquid and plastic limit tests must also be performed, additional material will be required sufficient to provide 150 g to 200 g of soil finer than the No. 40 (425-μm) sieve.

7.4 If the field sample or test specimen is smaller than the minimum recommended amount, the report shall include an appropriate remark.

8. Classification of Peat

8.1 A sample composed primarily of vegetable tissue in various stages of decomposition and has a fibrous to amorphous texture, a dark-brown to black color, and an organic odor should be designated as a highly organic soil and shall be classified as peat, PT, and not subjected to the classification procedures described hereafter.

8.2 If desired, classification of type of peat can be performed in accordance with Classification D 4427.

9. Preparation for Classification

9.1 Before a soil can be classified according to this standard, generally the particle-size distribution of the minus 3-in. (75-mm) material and the plasticity characteristics of the minus No. 40 (425-μm) sieve material must be determined. See 9.8 for the specific required tests.

9.2 The preparation of the soil specimen(s) and the testing for particle-size distribution and liquid limit and plasticity index shall be in accordance with accepted standard procedures. Two procedures for preparation of the soil specimens for testing for soil classification purposes are given in Appendixes X3 and X4. Appendix X3 describes the wet preparation method and is the preferred method for cohesive soils that have never dried out and for organic soils.

9.3 When reporting soil classifications determined by this standard, the preparation and test procedures used shall be reported or referenced.

9.4 Although the test procedure used in determining the particle-size distribution or other considerations may require a hydrometer analysis of the material, a hydrometer analysis is not necessary for soil classification.

9.5 The percentage (by dry weight) of any plus 3-in. (75-mm) material must be determined and reported as auxiliary information.

9.6 The maximum particle size shall be determined (measured or estimated) and reported as auxiliary information.

9.7 When the cumulative particle-size distribution is required, a set of sieves shall be used which include the

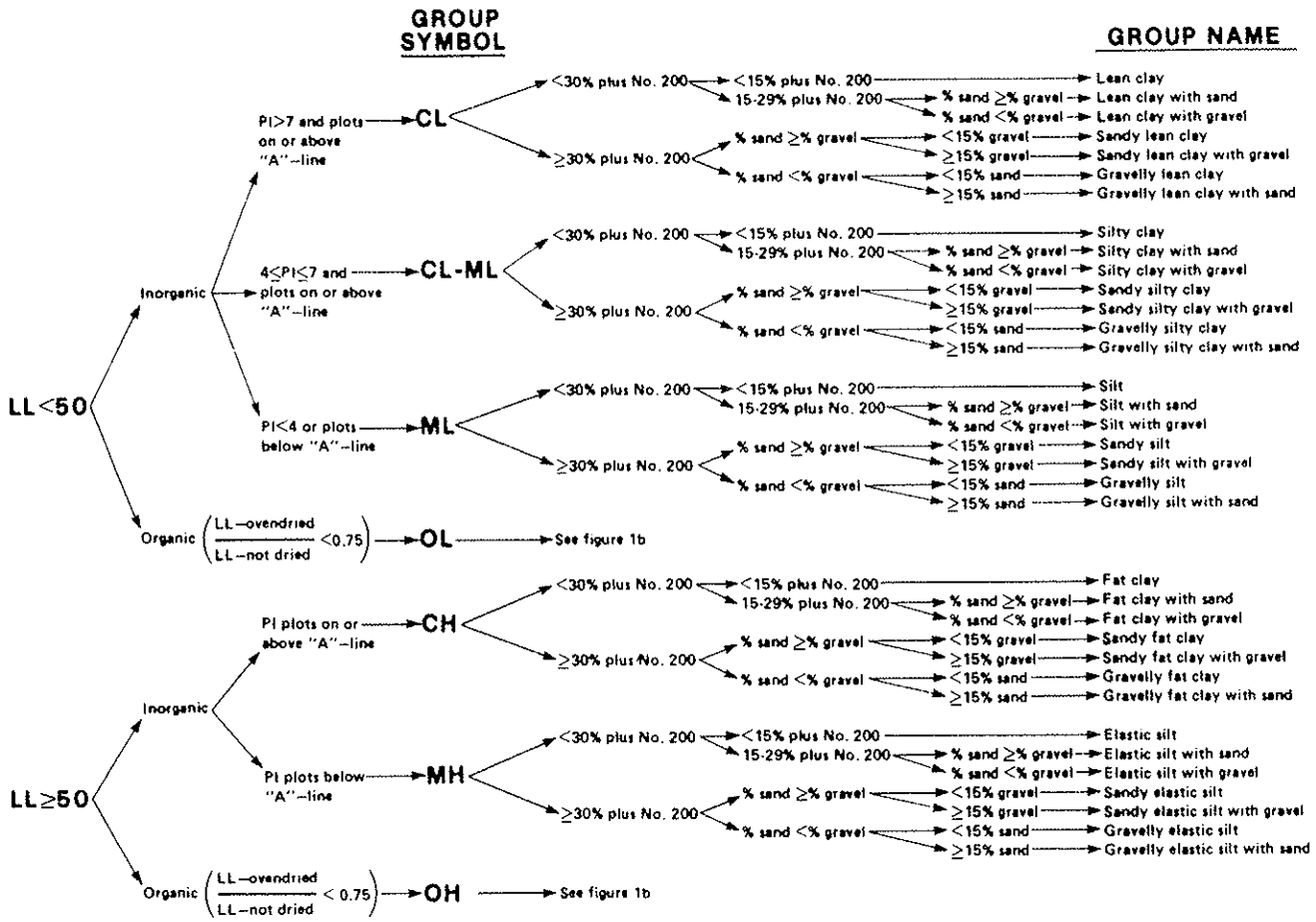


FIG. 1a Flow Chart for Classifying Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

following sizes (with the largest size commensurate with the maximum particle size) with other sieve sizes as needed or required to define the particle-size distribution:

3-in. (75-mm)
¾-in.(19.0-mm)
No. 4 (4.75-mm)
No. 10 (2.00-mm)
No. 40 (425-μm)
No. 200 (75-μm)

9.8 The tests required to be performed in preparation for classification are as follows:

9.8.1 For soils estimated to contain less than 5 % fines, a plot of the cumulative particle-size distribution curve of the fraction coarser than the No. 200 (75-μm) sieve is required. The cumulative particle-size distribution curve may be plotted on a graph similar to that shown in Fig. 4.

9.8.2 For soils estimated to contain 5 to 15 % fines, a cumulative particle-size distribution curve, as described in 9.8.1, is required, and the liquid limit and plasticity index are required.

9.8.2.1 If sufficient material is not available to determine the liquid limit and plasticity index, the fines should be estimated to be either silty or clayey using the procedures described in Practice D 2488 and so noted in the report.

9.8.3 For soils estimated to contain 15 % or more fines, a determination of the percent fines, percent sand, and percent gravel is required, and the liquid limit and plasticity index are required. For soils estimated to contain 90 % fines or more, the percent fines, percent sand, and percent gravel may be estimated using the procedures described in Practice D 2488 and so noted in the report.

10. Preliminary Classification Procedure

10.1 Class the soil as fine-grained if 50 % or more by dry weight of the test specimen passes the No. 200 (75-μm) sieve and follow Section 11.

10.2 Class the soil as coarse-grained if more than 50 % by dry weight of the test specimen is retained on the No. 200 (75-μm) sieve and follow Section 12.

11. Procedure for Classification of Fine-Grained Soils (50 % or more by dry weight passing the No. 200 (75-μm) sieve)

11.1 The soil is an inorganic clay if the position of the plasticity index versus liquid limit plot, Fig. 3, falls on or above the "A" line, the plasticity index is greater than 4, and the presence of organic matter does not influence the liquid limit as determined in 11.3.2.

NOTE 6—The plasticity index and liquid limit are determined on the minus No. 40 (425 μm) sieve material.

11.1.1 Classify the soil as a *lean clay*, CL, if the liquid limit is less than 50. See area identified as CL on Fig. 3.

11.1.2 Classify the soil as a *fat clay*, CH, if the liquid limit

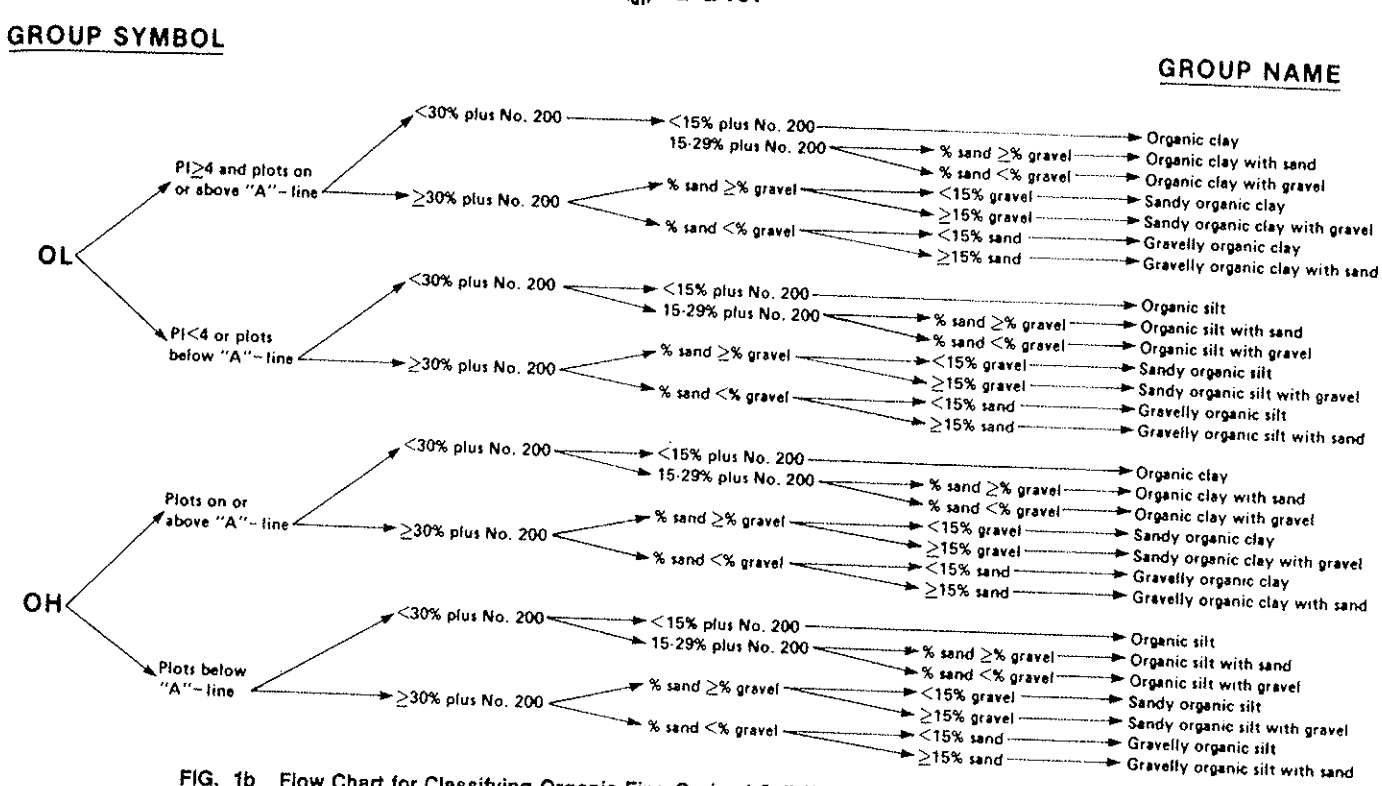


FIG. 1b Flow Chart for Classifying Organic Fine-Grained Soil (50 % or More Passes No. 200 Sieve)

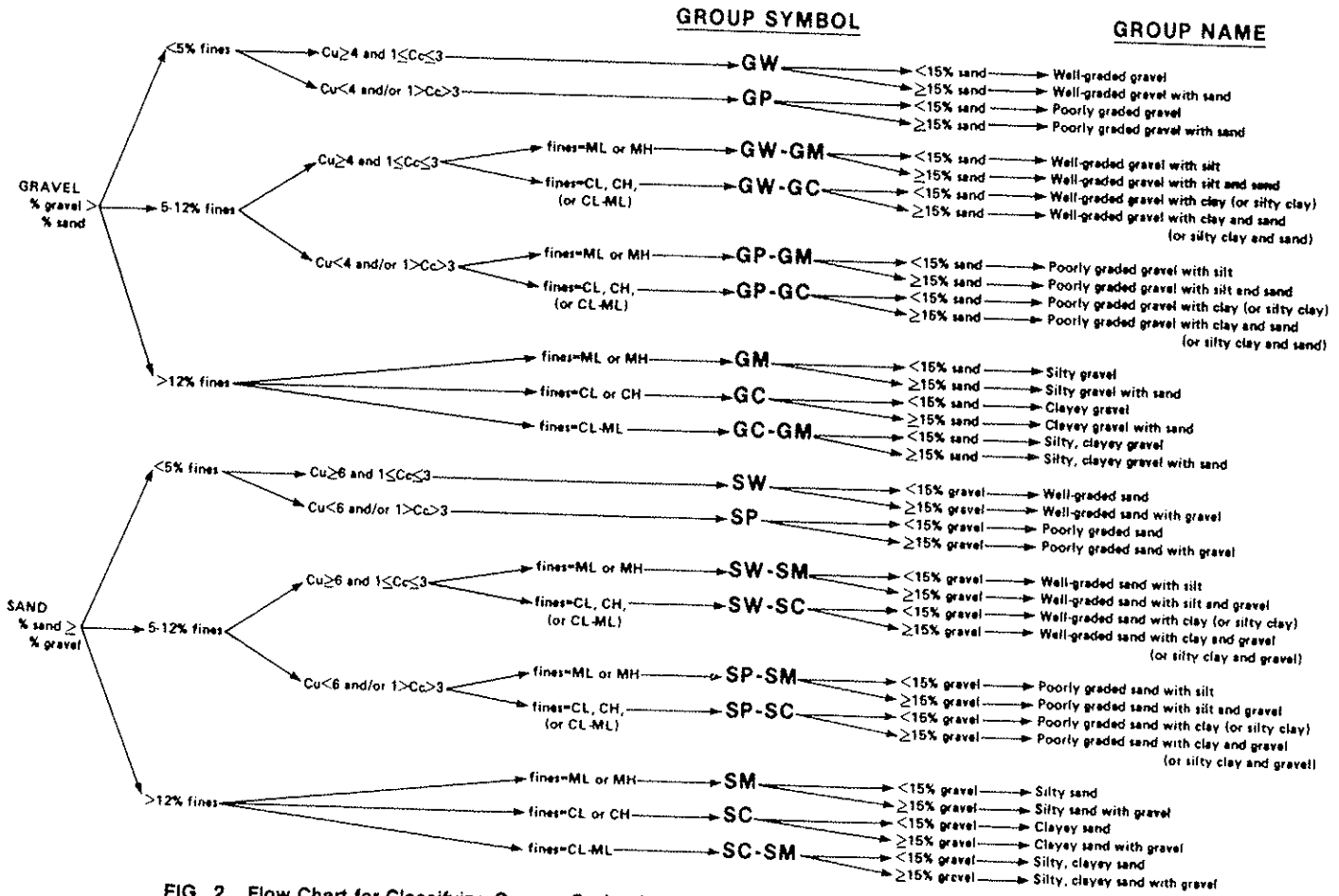


FIG. 2 Flow Chart for Classifying Coarse-Grained Soils (More Than 50 % Retained on No. 200 Sieve)

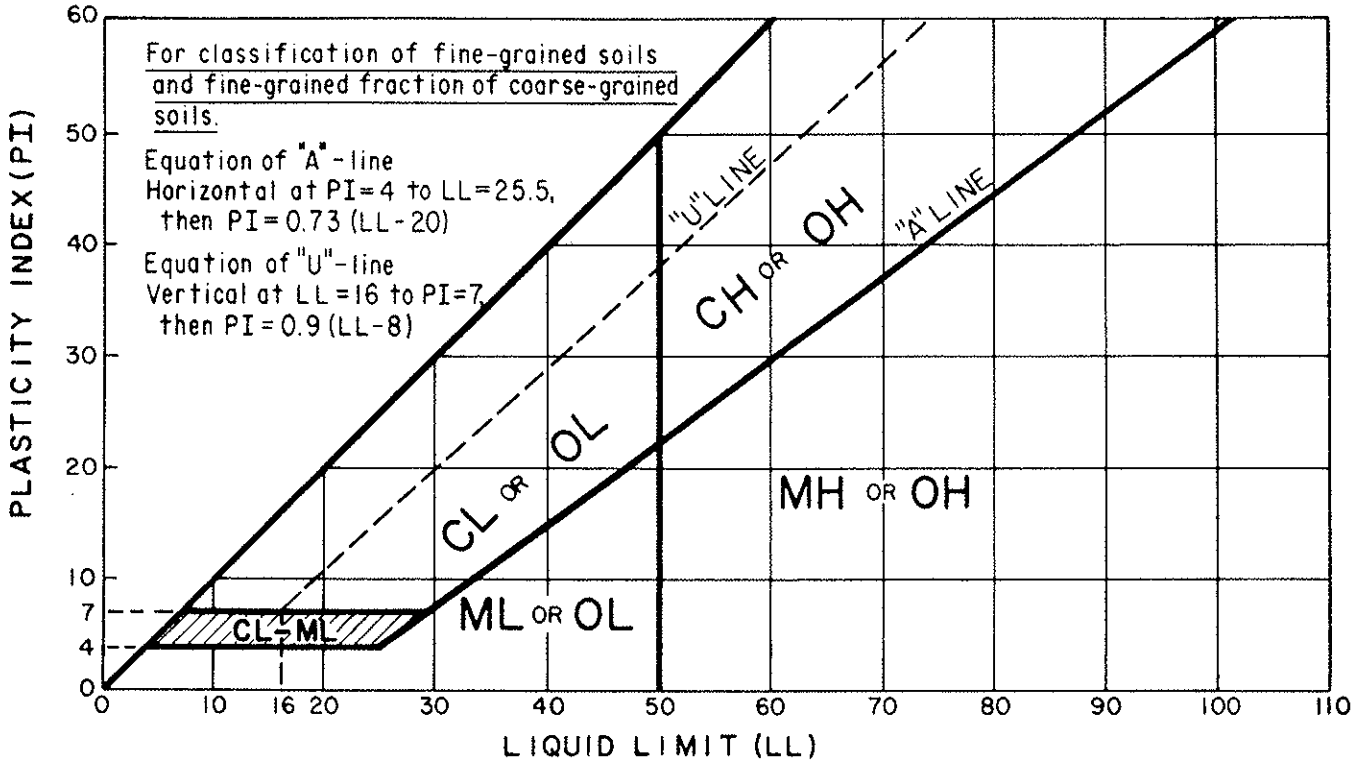


FIG. 3 Plasticity Chart

is 50 or greater. See area identified as CH on Fig. 3.

NOTE 7—In cases where the liquid limit exceeds 110 or the plasticity index exceeds 60, the plasticity chart may be expanded by maintaining the same scale on both axes and extending the "A" line at the indicated slope.

11.1.3 Classify the soil as a *silty clay*, CL-ML, if the position of the plasticity index versus liquid limit plot falls on or above the "A" line and the plasticity index is in the range of 4 to 7. See area identified as CL-ML on Fig. 3.

11.2 The soil is an inorganic silt if the position of the plasticity index versus liquid limit plot, Fig. 3, falls below the "A" line or the plasticity index is less than 4, and presence of organic matter does not influence the liquid limit as determined in 11.3.2.

11.2.1 Classify the soil as a *silt*, ML, if the liquid limit is less than 50. See area identified as ML on Fig. 3.

11.2.2 Classify the soil as an *elastic silt*, MH, if the liquid limit is 50 or greater. See area identified as MH on Fig. 3.

11.3 The soil is an organic silt or clay if organic matter is present in sufficient amounts to influence the liquid limit as determined in 11.3.2.

11.3.1 If the soil has a dark color and an organic odor when moist and warm, a second liquid limit test shall be performed on a test specimen which has been oven dried at 110 ± 5°C to a constant weight, typically over night.

11.3.2 The soil is an organic silt or organic clay if the liquid limit after oven drying is less than 75 % of the liquid limit of the original specimen determined before oven drying (see Procedure B of Practice D 2217).

11.3.3 Classify the soil as an *organic silt* or *organic clay*, OL, if the liquid limit (not oven dried) is less than 50 %. Classify the soil as an *organic silt*, OL, if the plasticity index is less than 4, or the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay*, OL, if the plasticity index is 4 or greater and the position of the plasticity index versus liquid limit plot falls on or above the "A" line. See area identified as OL (or CL-ML) on Fig. 3.

11.3.4 Classify the soil as an *organic clay* or *organic silt*, OH, if the liquid limit (not oven dried) is 50 or greater. Classify the soil as an *organic silt*, OH, if the position of the plasticity index versus liquid limit plot falls below the "A" line. Classify the soil as an *organic clay*, OH, if the position of the plasticity index versus liquid-limit plot falls on or above the "A" line. See area identified as OH on Fig. 3.

11.4 If less than 30 % but 15 % or more of the test specimen is retained on the No. 200 (75-μm) sieve, the words "with sand" or "with gravel" (whichever is predominant) shall be added to the group name. For example, lean clay with sand, CL; silt with gravel, ML. If the percent of sand is equal to the percent of gravel, use "with sand."

11.5 If 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve, the words "sandy" or "gravelly" shall be added to the group name. Add the word "sandy" if 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve and the coarse-grained portion is predominantly sand. Add the word "gravelly" if 30 % or more of the test specimen is retained on the No. 200 (75-μm) sieve and the coarse-grained portion is predominantly gravel. For example, sandy lean clay, CL; gravelly fat clay, CH; sandy silt, ML. If the percent of sand is equal to the percent of gravel, use "sandy."

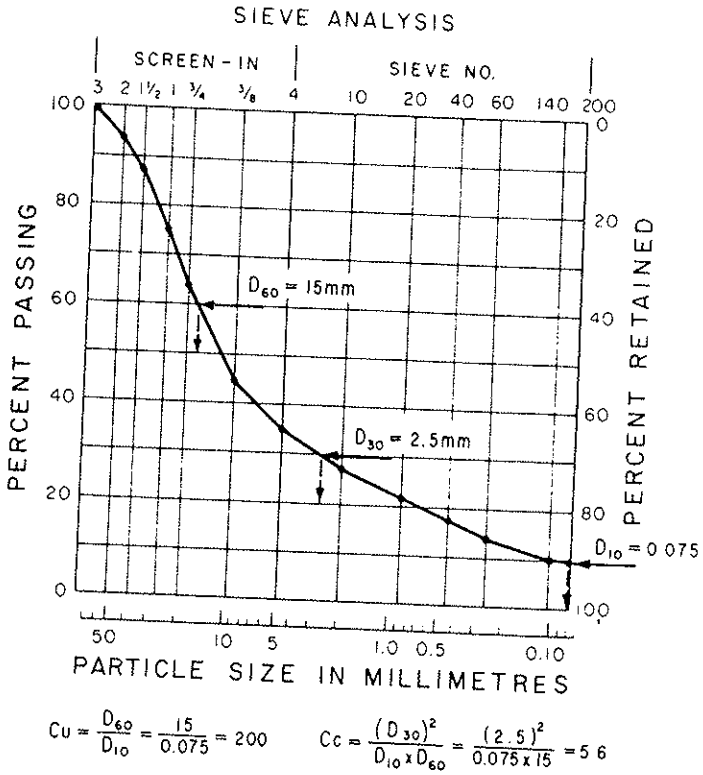


FIG. 4 Cumulative Particle-Size Plot

12. Procedure for Classification of Coarse-Grained Soils (more than 50 % retained on the No. 200 (75-μm) sieve)

12.1 Class the soil as gravel if more than 50 % of the coarse fraction [plus No. 200 (75-μm) sieve] is retained on the No. 4 (4.75-mm) sieve.

12.2 Class the soil as sand if 50 % or more of the coarse fraction [plus No. 200 (75-μm) sieve] passes the No. 4 (4.75-mm) sieve.

12.3 If 12 % or less of the test specimen passes the No. 200 (75-μm) sieve, plot the cumulative particle-size distribution, Fig. 4, and compute the coefficient of uniformity, Cu, and coefficient of curvature, Cc, as given in Eqs 1 and 2.

$$Cu = D_{60}/D_{10} \quad (1)$$

$$Cc = (D_{30})^2/(D_{10} \times D_{60}) \quad (2)$$

where:

D_{10}, D_{30}, and D_{60} = the particle-size diameters corresponding to 10, 30, and 60 %, respectively, passing on the cumulative particle-size distribution curve, Fig. 4.

NOTE 8—It may be necessary to extrapolate the curve to obtain the D_{10} diameter.

12.3.1 If less than 5 % of the test specimen passes the No. 200 (75-μm) sieve, classify the soil as a *well-graded gravel*, GW, or *well-graded sand*, SW, if Cu is greater than 4.0 for gravel or greater than 6.0 for sand, and Cc is at least 1.0 but not more than 3.0.

12.3.2 If less than 5 % of the test specimen passes the No. 200 (75-μm) sieve, classify the soil as *poorly graded gravel*, GP, or *poorly graded sand*, SP, if either the Cu or the Cc criteria for well-graded soils are not satisfied.

12.4 If more than 12 % of the test specimen passes the No. 200 (75-μm) sieve, the soil shall be considered a coarse-grained soil with fines. The fines are determined to be either clayey or silty based on the plasticity index versus liquid limit plot on Fig. 3. (See 9.8.2.1 if insufficient material available for testing). (See NOTE 6)

12.4.1 Classify the soil as a *clayey gravel*, GC, or *clayey sand*, SC, if the fines are clayey, that is, the position of the plasticity index versus liquid limit plot, Fig. 3, falls on or above the "A" line and the plasticity index is greater than 7.

12.4.2 Classify the soil as a *silty gravel*, GM, or *silty sand*, SM, if the fines are silty, that is, the position of the plasticity index versus liquid limit plot, Fig. 3, falls below the "A" line or the plasticity index is less than 4.

12.4.3 If the fines plot as a silty clay, CL-ML, classify the soil as a *silty, clayey gravel*, GC-GM, if it is a gravel or a *silty, clayey sand*, SC-SM, if it is a sand.

12.5 If 5 to 12 % of the test specimen passes the No. 200 (75-μm) sieve, give the soil a dual classification using two group symbols.

12.5.1 The first group symbol shall correspond to that for a gravel or sand having less than 5 % fines (GW, GP, SW, SP), and the second symbol shall correspond to a gravel or sand having more than 12 % fines (GC, GM, SC, SM).

12.5.2 The group name shall correspond to the first group symbol plus "with clay" or "with silt" to indicate the plasticity characteristics of the fines. For example, well-graded gravel with clay, GW-GC; poorly graded sand with silt, SP-SM (See 9.8.2.1 if insufficient material available for testing).

NOTE 9—If the fines plot as a *silty clay*, CL-ML, the second group symbol should be either GC or SC. For example, a poorly graded sand with 10 % fines, a liquid limit of 20, and a plasticity index of 6 would be classified as a poorly graded sand with silty clay, SP-SC.

12.6 If the specimen is predominantly sand or gravel but contains 15 % or more of the other coarse-grained constituent, the words "with gravel" or "with sand" shall be added to the group name. For example, poorly graded gravel with sand, clayey sand with gravel.

12.7 If the field sample contained any cobbles or boulders or both, the words "with cobbles," or "with cobbles and boulders" shall be added to the group name. For example, silty gravel with cobbles, GM.

13. Report

13.1 The report should include the group name, group symbol, and the results of the laboratory tests. The particle-size distribution shall be given in terms of percent of gravel, sand, and fines. The plot of the cumulative particle-size distribution curve shall be reported if used in classifying the soil. Report appropriate descriptive information according to the procedures in Practice D 2488. A local or commercial name or geologic interpretation for the material may be added at the end of the descriptive information if identified as such. The test procedures used shall be referenced.

NOTE 10—*Example: Clayey Gravel with Sand and Cobbles* (GC)—46 % fine to coarse, hard, subrounded gravel; 30 % fine to coarse, hard, subrounded sand; 24 % clayey fines, LL = 38, PI = 19; weak reaction with HCl; original field sample had 4 % hard, subrounded cobbles; maximum dimension 150 mm.

In-Place Conditions—firm, homogeneous, dry, brown,

Geologic Interpretation—alluvial fan.

NOTE 11—Other examples of soil descriptions are given in Appendix X1.

14. Keywords

14.1 Atterberg limits; classification; clay; gradation; gravel; laboratory classification; organic soils; sand; silt; soil classification; soil tests

APPENDIXES

(Nonmandatory Information)

X1. EXAMPLES OF DESCRIPTIONS USING SOIL CLASSIFICATION

X1.1 The following examples show how the information required in 13.1 can be reported. The appropriate descriptive information from Practice D 2488 is included for illustrative purposes. The additional descriptive terms that would accompany the soil classification should be based on the intended use of the classification and the individual circumstances.

X1.1.1 *Well-Graded Gravel with Sand (GW)*—73 % fine to coarse, hard, subangular gravel; 23 % fine to coarse, hard, subangular sand; 4 % fines; Cc = 2.7, Cu = 12.4.

X1.1.2 *Silty Sand with Gravel (SM)*—61 % predominantly fine sand; 23 % silty fines, LL = 33, PI = 6; 16 % fine, hard, subrounded gravel; no reaction with HCl; (field sample smaller than recommended). *In-Place Conditions*—Firm, stratified and contains lenses of silt 1 to 2 in. thick, moist, brown to gray; in-place density = 106 lb/ft^3 and in-place moisture = 9 %.

X1.1.3 *Organic Clay (OL)*—100 % fines, LL (not dried) = 32, LL (oven dried) = 21, PI (not dried) = 10; wet, dark brown, organic odor, weak reaction with HCl.

X1.1.4 *Silty Sand with Organic Fines (SM)*—74 % fine to coarse, hard, subangular reddish sand; 26 % organic and silty dark-brown fines, LL (not dried) = 37, LL (oven dried) = 26, PI (not dried) = 6, wet, weak reaction with HCl.

X1.1.5 *Poorly Graded Gravel with Silt, Sand, Cobbles and Boulders (GP-GM)*—78 % fine to coarse, hard, subrounded to subangular gravel; 16 % fine to coarse, hard, subrounded to subangular sand; 6 % silty (estimated) fines; moist, brown; no reaction with HCl; original field sample had 7 % hard, subrounded cobbles and 2 % hard, subrounded boulders with a maximum dimension of 18 in.

X2. USING SOIL CLASSIFICATION AS A DESCRIPTIVE SYSTEM FOR SHALE, CLAYSTONE, SHELLS, SLAG, CRUSHED ROCK, ETC.

X2.1 The group names and symbols used in this standard may be used as a descriptive system applied to materials that exist in situ as shale, claystone, sandstone, siltstone, mudstone, etc., but convert to soils after field or laboratory processing (crushing, slaking, etc.).

X2.2 Materials such as shells, crushed rock, slag, etc., should be identified as such. However, the procedures used in this standard for describing the particle size and plasticity characteristics may be used in the description of the material. If desired, a classification in accordance with this standard may be assigned to aid in describing the material.

X2.3 If a classification is used, the group symbol(s) and group names should be placed in quotation marks or noted with some type of distinguishing symbol. See examples.

X2.4 Examples of how soil classifications could be incorporated into a description system for materials that are not naturally occurring soils are as follows:

X2.4.1 *Shale Chunks*—Retrieved as 2 to 4-in. pieces of shale from power auger hole, dry, brown, no reaction with HCl. After laboratory processing by slaking in water for 24 h, material classified as "Sandy Lean Clay (CL)"—61 % clayey fines, LL = 37, PI = 16; 33 % fine to medium sand; 6 % gravel-size pieces of shale.

X2.4.2 *Crushed Sandstone*—Product of commercial crushing operation; "Poorly Graded Sand with Silt (SP-SM)"—91 % fine to medium sand; 9 % silty (estimated) fines; dry, reddish-brown, strong reaction with HCl.

X2.4.3 *Broken Shells*—62 % gravel-size broken shells;

31 % sand and sand-size shell pieces; 7 % fines; would be classified as "Poorly Graded Gravel with Sand (GP)".

X2.4.4 *Crushed Rock*—Processed gravel and cobbles from Pit No. 7; "Poorly Graded Gravel (GP)"—89 % fine, hard, angular gravel-size particles; 11 % coarse, hard, angular sand-size particles, dry, tan; no reaction with HCl; Cc = 2.4, Cu = 0.9.

X3. PREPARATION AND TESTING FOR CLASSIFICATION PURPOSES BY THE WET METHOD

X3.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification using a wet-preparation procedure.

X3.2 Samples prepared in accordance with this procedure should contain as much of their natural water content as possible and every effort should be made during obtaining, preparing, and transportating the samples to maintain the natural moisture.

X3.3 The procedures to be followed in this standard assume that the field sample contains fines, sand, gravel, and plus 3-in. (75-mm) particles and the cumulative particle-size distribution plus the liquid limit and plasticity index values are required (see 9.8). Some of the following steps may be omitted when they are not applicable to the soil being tested.

X3.4 If the soil contains plus No. 200 (75-μm) particles that would degrade during dry sieving, use a test procedure for determining the particle-size characteristics that prevents this degradation.

X3.5 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X3.6 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X3.6.1 Separate the field sample into two fractions on a 3-in. (75-mm) sieve, being careful to maintain the natural water content in the minus 3-in. (75-mm) fraction. Any particles adhering to the plus 3-in. (75-mm) particles shall be brushed or wiped off and placed in the fraction passing the 3-in. (75-mm) sieve.

X3.6.2 Determine the air-dry or oven-dry weight of the fraction retained on the 3-in. (75-mm) sieve. Determine the total (wet) weight of the fraction passing the 3-in. (75-mm) sieve.

X3.6.3 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve. Determine the water content, in accordance with Test Method D 2216, of a representative specimen with a minimum dry weight as required in 7.2. Save the water-content specimen for determination of the particle-size analysis in accordance with X3.8.

X3.6.4 Compute the dry weight of the fraction passing the 3-in. (75-mm) sieve based on the water content and total (wet) weight. Compute the total dry weight of the sample and calculate the percentage of material retained on the 3-in. (75-mm) sieve.

X3.7 Determine the liquid limit and plasticity index as follows:

X3.7.1 If the soil disaggregates readily, mix on a clean, hard surface and select a representative sample by quartering in accordance with Practice C 702.

X3.7.1.1 If the soil contains coarse-grained particles coated with and bound together by tough clayey material, take extreme care in obtaining a representative portion of the No. 40 (425-μm) fraction. Typically, a larger portion than normal has to be selected, such as the minimum weights required in 7.2.

X3.7.1.2 To obtain a representative specimen of a basically cohesive soil, it may be advantageous to pass the soil through a ¾-in. (19-mm) sieve or other convenient size so the material can be more easily mixed and then quartered or split to obtain the representative specimen.

X3.7.2 Process the representative specimen in accordance with Procedure B of Practice D 2217.

X3.7.3 Perform the liquid-limit test in accordance with Test Method D 4318, except the soil shall not be air dried prior to the test.

X3.7.4 Perform the plastic-limit test in accordance with Test Method D 4318, except the soil shall not be air dried prior to the test, and calculate the plasticity index.

X3.8 Determine the particle-size distribution as follows:

X3.8.1 If the water content of the fraction passing the 3-in. (75-mm) sieve was required (X3.6.3), use the water-content specimen for determining the particle-size distribution. Otherwise, select a representative specimen in accordance with Practice C 702 with a minimum dry weight as required in 7.2.

X3.8.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 422. See 9.7 for the set of required sieves.

X3.8.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Method C 136. See 9.7 for the set of required sieves. The specimen should be soaked until all clayey aggregations have softened and then washed in accordance with Test Method C 117 prior to performing the particle-size distribution.

X3.8.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method C 117, being sure to soak the specimen long enough to soften all clayey aggregations, followed by Method C 136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75-μm) sieve.

X3.8.5 Calculate the percent fines, percent sand, and percent gravel in the minus 3-in. (75-mm) fraction for classification purposes.

X4. AIR-DRIED METHOD OF PREPARATION OF SOILS FOR TESTING FOR CLASSIFICATION PURPOSES

X4.1 This appendix describes the steps in preparing a soil sample for testing for purposes of soil classification when air-drying the soil before testing is specified or desired or when the natural moisture content is near that of an air-dried state.

X4.2 If the soil contains organic matter or mineral colloids that are irreversibly affected by air drying, the wet-preparation method as described in Appendix X3 should be used.

X4.3 Since this classification system is limited to the portion of a sample passing the 3-in. (75-mm) sieve, the plus 3-in. (75-mm) material shall be removed prior to the determination of the particle-size characteristics and the liquid limit and plasticity index.

X4.4 The portion of the field sample finer than the 3-in. (75-mm) sieve shall be obtained as follows:

X4.4.1 Air dry and weigh the field sample.

X4.4.2 Separate the field sample into two fractions on a 3-in. (75-mm) sieve.

X4.4.3 Weigh the two fractions and compute the percentage of the plus 3-in. (75-mm) material in the field sample.

X4.5 Determine the particle-size distribution and liquid limit and plasticity index as follows (see 9.8 for when these tests are required):

X4.5.1 Thoroughly mix the fraction passing the 3-in. (75-mm) sieve.

X4.5.2 If the cumulative particle-size distribution including a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 422. See 9.7 for the set of sieves that is required.

X4.5.3 If the cumulative particle-size distribution without a hydrometer analysis is required, determine the particle-size distribution in accordance with Test Method D 1140 followed by Method C 136. See 9.7 for the set of sieves that is required.

X4.5.4 If the cumulative particle-size distribution is not required, determine the percent fines, percent sand, and percent gravel in the specimen in accordance with Test Method D 1140 followed by Method C 136 using a nest of sieves which shall include a No. 4 (4.75-mm) sieve and a No. 200 (75-μm) sieve.

X4.5.5 If required, determine the liquid limit and the plasticity index of the test specimen in accordance with Test Method D 4318.

X5. RATIONALE

X5.1 Significant revisions were made to the standard which appeared as D 2487 – 83 from the previous version of D 2487 – 69 (1975). The changes are documented in the literature.[5]

X5.2 The 1992 edition differs from the previous edition in that the title was changed to better indicate the use of the standard and identifying it as the ASTM version of the Unified Soil Classification System.

[5] Howard, A.K., "The Revised ASTM Standard on the Unified Soil Classification System," Geotechnical Testing Journal, GTJODJ Vol 7, No. 4, December 1984.