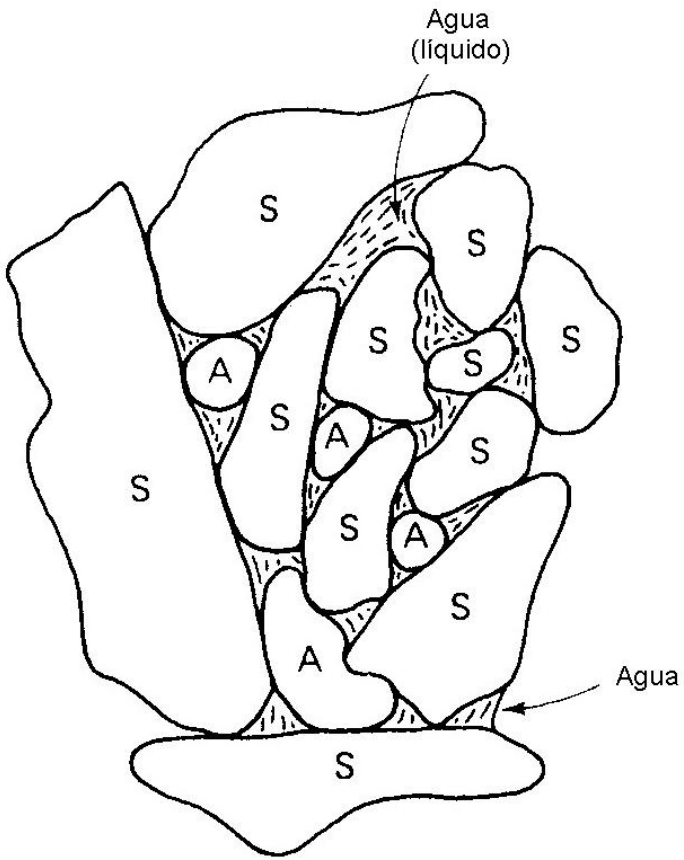
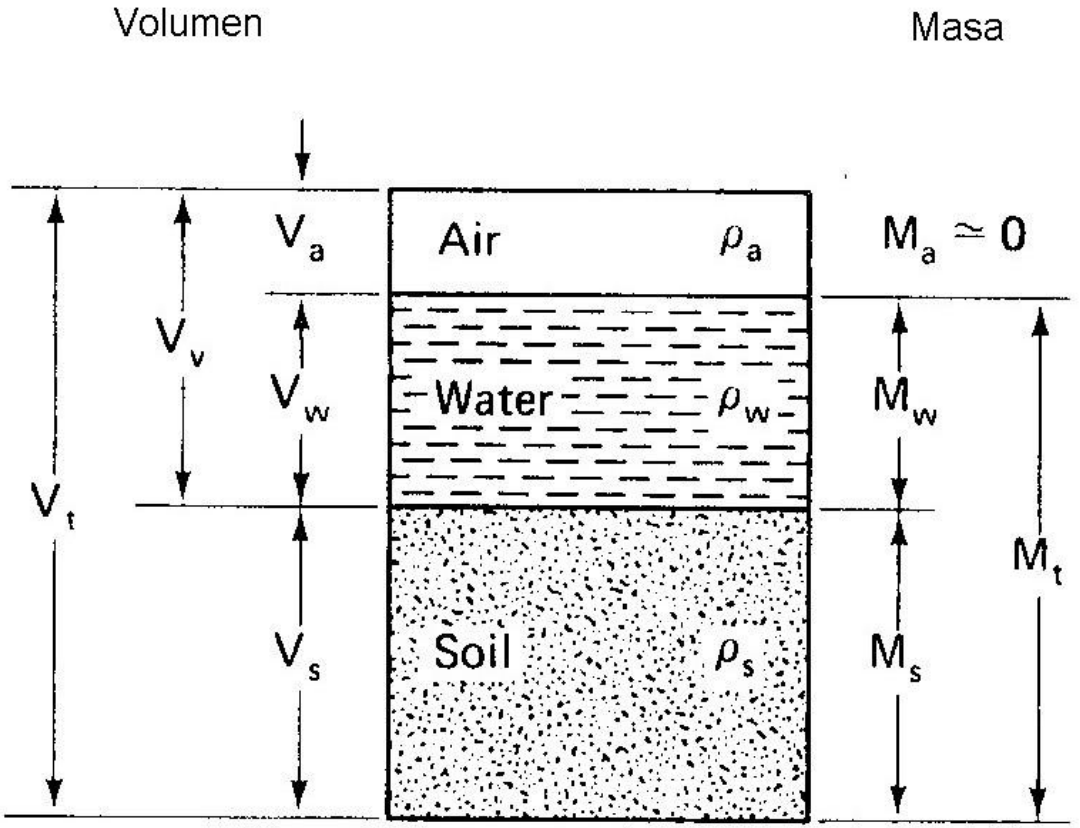
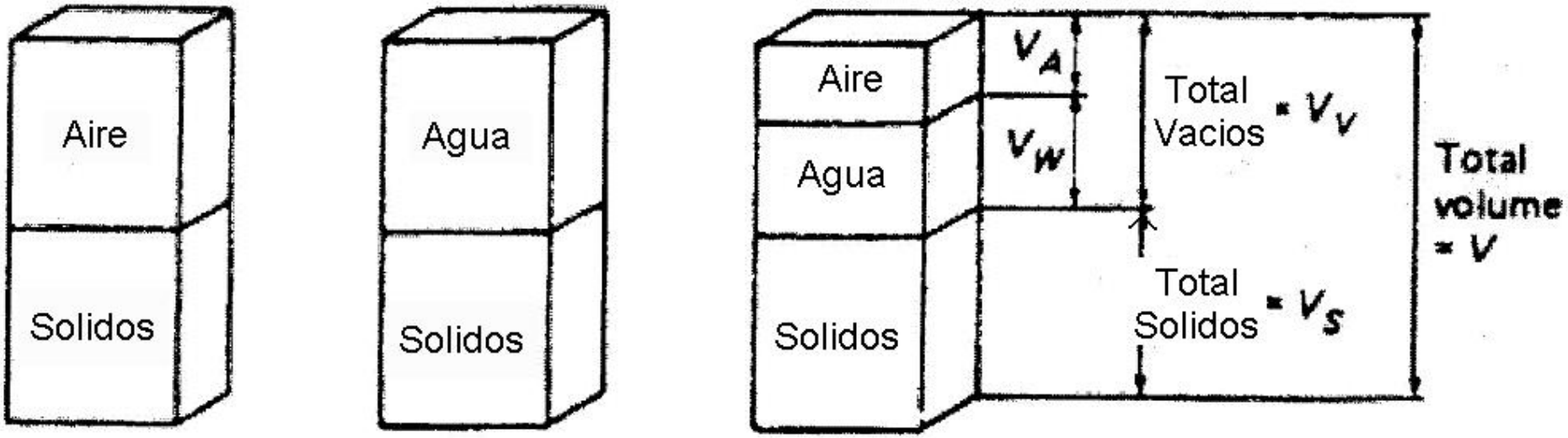
Clase 3

Prof.: Ricardo Moffat

- Definiciones básicas
- Relaciones entre las fases


Agua
(líquido)
S
A
Agua


Volumen
Masa
V_a
Air
ρ_a
$M_a \simeq 0$
V_v
V_w
Water
ρ_w
M_w
V_t
M_t
V_s
Soil
ρ_s
M_s



Fases del suelo

Definiciones

- Humedad (Contenido de agua)

w = (masa de agua in huecos) / (masa de sólidos)

$$w = \frac{M_w}{M_s}$$

Usualmente en porcentaje (%)

- Saturación (Grado de saturación)

S = (volumen de agua en huecos) / (volumen total de vacío)

$$S = \frac{V_w}{V_v}$$

Usualmente expresado en %

S = 0 o 0 % Suelo seco

S= 1.0 o 100% Suelo saturado

- Índice de poros (índice de vacíos)

e = (volumen total de poros) / (volumen total de sólidos)

$$e = \frac{V_v}{V_s}$$

- Porosidad

n = (Volumen total de poros) / (volumen total)

$$n = \frac{V_v}{V_t} = \frac{V_v}{(V_s + V_v)}$$

- Volumen específico (υ)

υ= volumen total de suelo que contiene un volumen unitario de sólidos

$$\upsilon = 1 + e$$

- Peso específico o gravedad específica de los sólidos

$$G = \frac{\gamma_s}{\gamma_0}$$

Arenas y Gravas	G = 2.65 aproximadamente
Arcillas	G = 2.75 aproximadamente

γ_0 : peso unitario del agua a 4°C ~ γ_w

Pesos unitarios

- Peso unitario total

$$\gamma_t = \frac{W}{V} = \frac{G + Se}{1+e} \cdot \gamma_w = \frac{1+w}{1+e} \cdot G \cdot \gamma_w$$

- Peso unitario del agua

$$\gamma_w = \frac{W_w}{V_w}$$

- Peso unitario de los sólidos

$$\gamma_s = \frac{W_s}{V_s}$$

Product	Specific Weight - γ	
	Imperial Units (lb/ft^3)	SI Units (kN/m^3)
Ethyl Alcohol	49.3	7.74
Gasoline	42.5	6.67
Glycerin	78.6	12.4
Mercury	847	133.7
SAE 20 Oil	57	8.95
Seawater	64	10.1
Water	62.4	9.81

Temperature - t - (^oC)	Density - ρ - (kg/m^3)	Specific Weight - γ - (kN/m^3)
0	999.9	9.806
5	1000	9.807
10	999.7	9.804
20	998.2	9.789
30	995.7	9.765
40	992.2	9.731
50	988.1	9.690
60	983.2	9.642
70	977.8	9.589
80	971.8	9.530
90	965.3	9.467
100	958.4	9.399

- Peso unitario seco

$$\gamma_d = \frac{W_s}{V} = \frac{G}{1+e} \cdot \gamma_w = \frac{G \cdot \gamma_w}{1+\frac{w \cdot G}{S}} = \frac{\gamma_t}{1+w}$$

- Peso unitario sumergido (Boyante)

$$\gamma_b = \gamma_t - \gamma_w = \frac{G-1-(1-S)}{1+e} \cdot \gamma_w$$

Si el suelo esta saturado S = 1.0

Relaciones

- Relación entre e y n

$$n = \frac{e}{1+e} \qquad e = \frac{n}{1-n}$$

- Relación importante

$$G \cdot w = S \cdot e$$

Valores típicos de e y n en suelos granulares

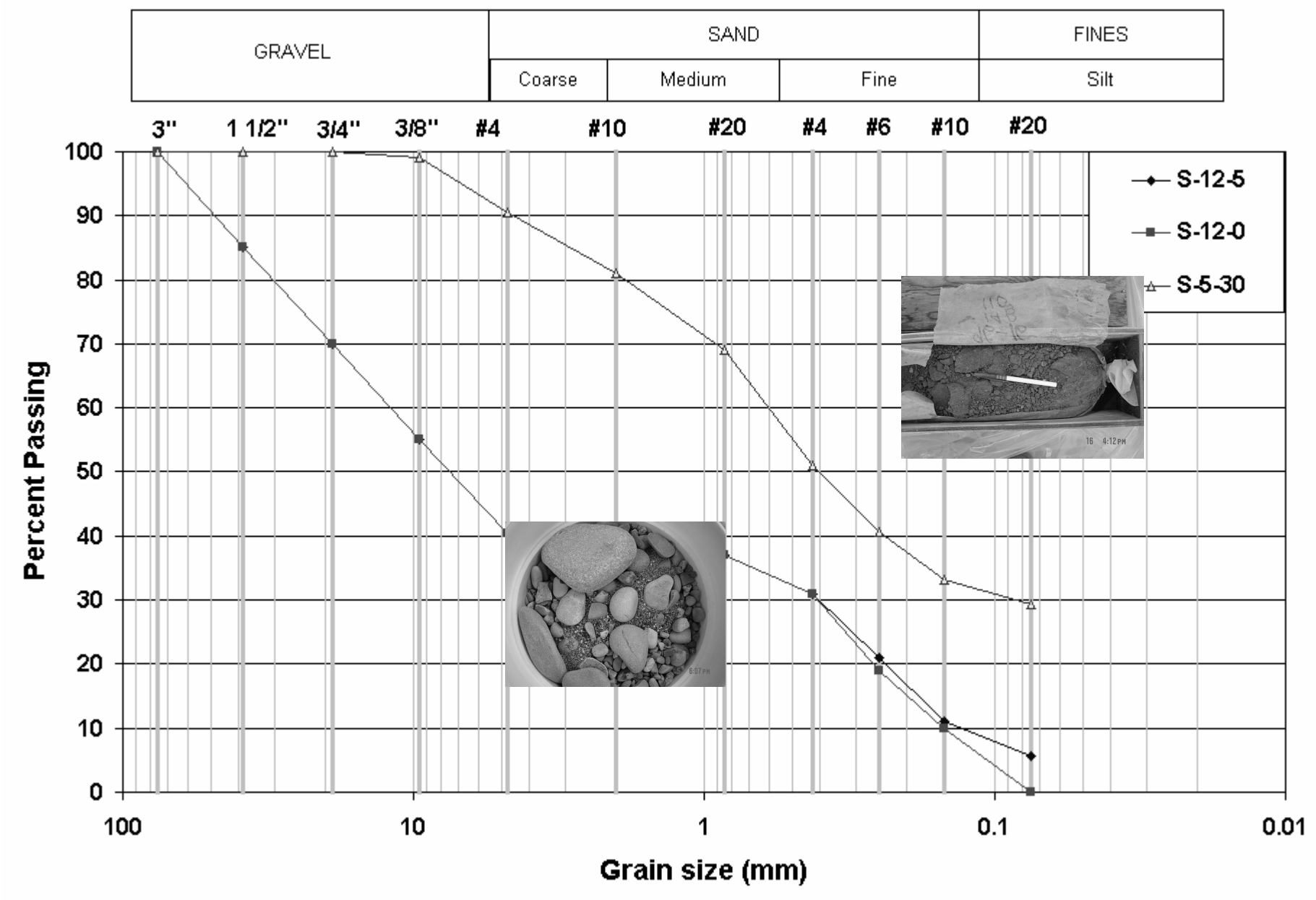
Descripción	Relación de vacíos		Porosidad (%)		Peso específico seco (ton/m^3)	
	$e_{máx}$	$e_{mín}$	$n_{máx}$	$n_{mín}$	$\gamma_{d\,mín}$	$\gamma_{d\,máx}$
Esferas uniformes	0.92	0.35	47.6	26.0	—	—
Arena de Otawa normalizada	0.80	0.50	44	33	1.47	1.76
Arena limpia uniforme	1.0	0.40	50	29	1.33	1.89
Limo inorgánico	1.1	0.40	52	29	1.28	1.89
Arena limosa	0.90	0.30	47	23	1.39	2.03
Arena fina a gruesa	0.95	0.20	49	17	1.36	2.21
Arena micácea	1.2	0.40	55	29	1.22	1.92
Arena limosa y grava	0.85	0.14	46	12	1.42	2.34

B.K. Hough, *Basic Soils Engineering*. Copyright © 1957, The Ronald Press Company, Nueva York.

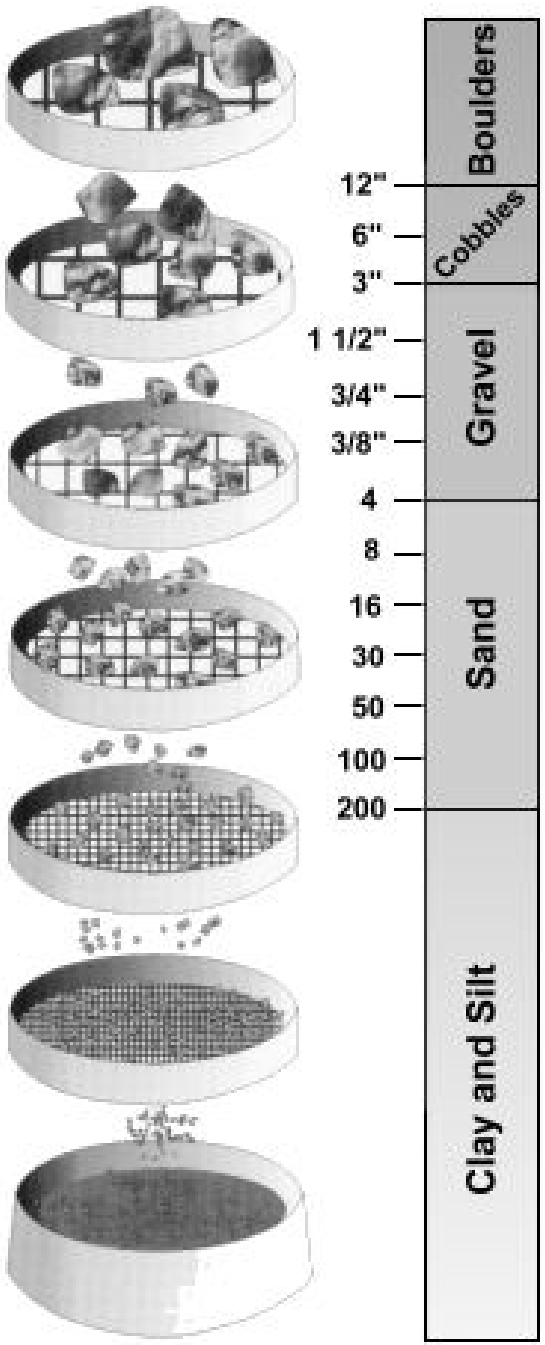
Typical Values of Soil Index Properties

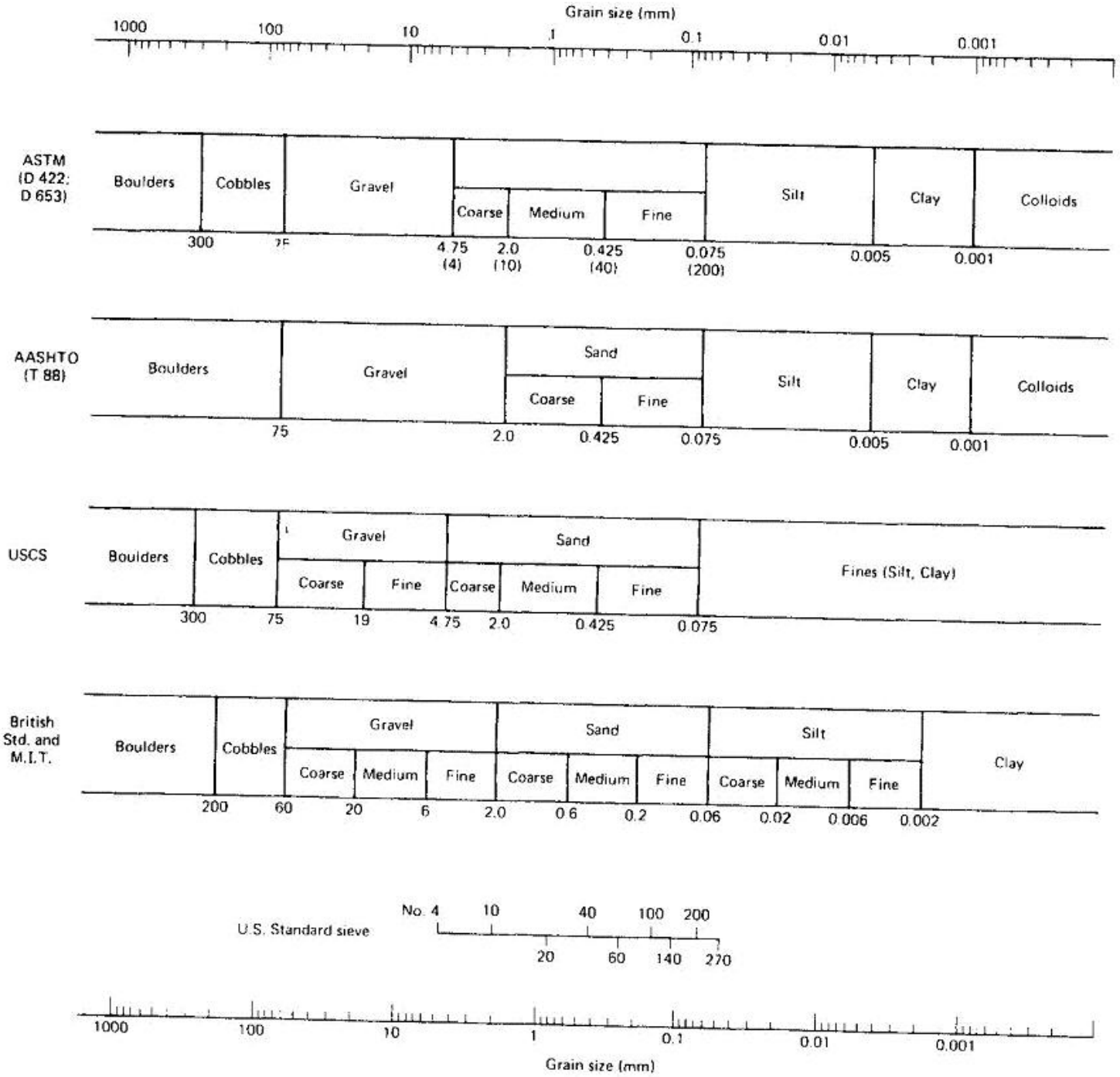
	Particle Size and Gradation				Voids[1]					Unit Weight[2] (lb./cu.ft.)						
	Approximate Size Range (mm)		Approx. D_{10} (mm)	Approx. Range Uniform Coefficient C_u	Void Ratio			Porosity (%)		Dry Weight			Wet Weight		Submerged Weight	
	D_{max}	D_{min}			e_{max} loose	e_{cr}	e_{min} dense	n_{max} loose	n_{min} dense	Min loose	100% Mod. AASHO	Max dense	Min loose	Max dense	Min loose	Max dense
GRANULAR MATERIALS																
Uniform Materials																
a. Equal Spheres (theoretical values)	–	–	–	1.0	0.92	–	0.35	47.6	26	–	–	–	–	–	–	–
b. Standard Ottawa SAND	0.84	0.59	0.67	1.1	0.80	0.75	0.50	44	33	92	–	110	93	131	57	69
c. Clean, uniform SAND (fine or medium)	–	–	–	1.2 to 2.0	1.0	0.80	0.40	50	29	83	115	118	84	136	52	73
d. Uniform, Inorganic SILT	0.05	0.005	0.012	1.2 to 2.0	1.1	–	0.40	52	29	80	–	118	81	136	51	73
Well-graded Materials																
a. Silty SAND	2.0	0.005	0.02	5 to 10	0.90	–	0.30	47	23	87	122	127	88	142	54	79
b. Clean, fine to coarse SAND	2.0	0.05	0.09	4 to 6	0.95	0.70	0.20	49	17	85	132	138	86	148	53	86
c. Micaceous SAND	–	–	–	–	1.2	–	0.40	55	29	76	–	120	77	138	48	76
d. Silty SAND & GRAVEL	100	0.005	0.02	15 to 300	0.85	–	0.14	46	12	89	–	146[3]	90	155[3]	56	92
MIXED SOILS																
Sandy or Silty CLAY	2.0	0.001	0.003	30 to 50	1.8	–	0.25	64	20	60	130	135	100	147	38	85
Skip-graded Silty CLAY with stones or gravel	250	0.001	–	–	1.0	–	0.20	50	17	84	–	140	115	151	53	89
Well-graded GRAVEL, SAND, SILT & CLAY mixture	250	0.001	0.002	25 to 1000	0.70	–	0.13	41	11	100	140	148[4]	125	156[4]	62	94
CLAY SOILS																
CLAY (30%-50% clay sizes)	0.05	0.5μ	0.001	–	2.4	–	0.50	71	33	50	105	112	96	133	31	71
Colloidal CLAY (>0.002 mm: 50%)	0.01	10Å	–	–	12	–	0.60	92	37	13	90	106	71	128	8	66
ORGANIC SOILS																
Organic SILT	–	–	–	–	3.0	–	0.55	75	35	40	–	110	87	134	25	69
Organic CLAY (30% - 50% clay sizes)	–	–	–	–	4.4	–	0.70	81	41	30		100	81	125	18	62

Granulometría



Sieve Test

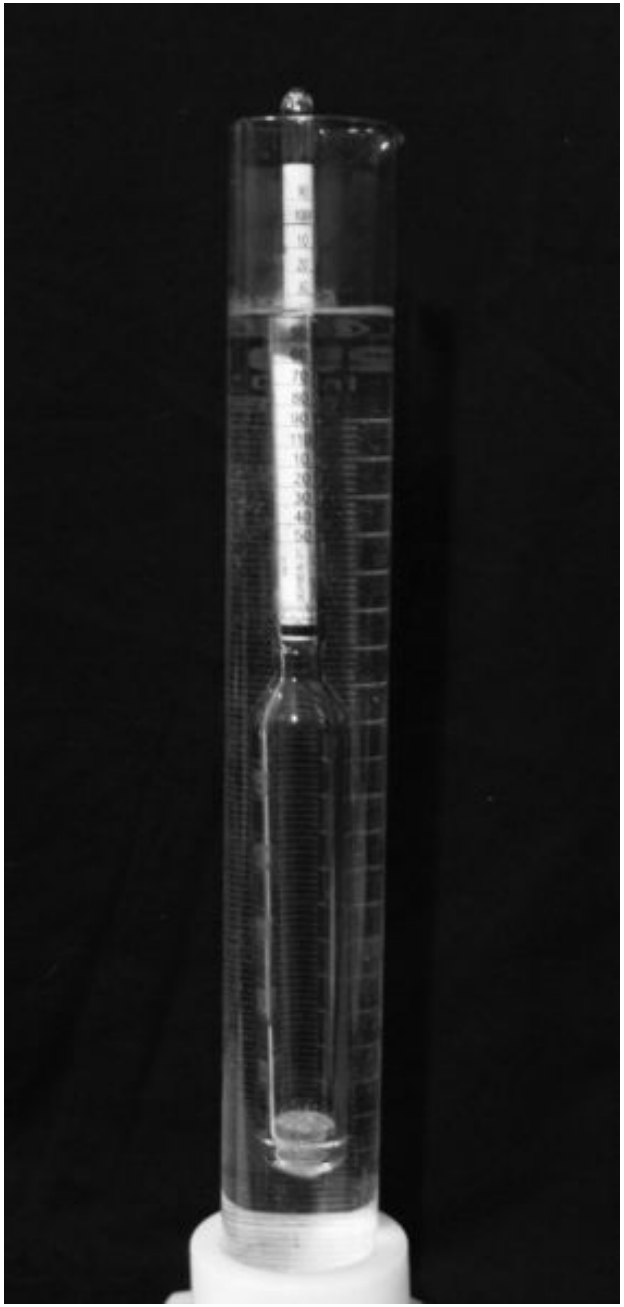

Boulders
Cobbles
Gravel
Sand
Clay and Silt
12"
6"
3"
1 1/2"
3/4"
3/8"
4
8
16
30
50
100
200



Holtz&Kovacs (1981)

Mallas para granulometría

ASTM C136 y D 422



Hidrómetro (ASTM D422)