Assessment and Analysis of Test Data

Presented by SARF

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Module A
Presentation of Data Sets

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Numbers

Natural numbers (N):

0, 1, 2, 3, 4, 5, 6, 7, 8, 9 etc.

Integers (Z):

No fractional or decimal component

21, 4, and −2048 are integers
9.75, 5½, and √2 are not integers

consists of the natural numbers 0, 1, 2 ,3 , ...
and
the negatives of the non-zero natural numbers −1, −2, −3, ...

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Numbers

Rational Numbers (Q):

can be written as a simple fraction (i.e. as a ratio)

$$\frac{p}{q}$$

Since *q* may be equal to 1, every integer is a rational number

Number	As a fraction	Rational?
5	5/1	yes
1.75	7/4	yes
0.001	1/1000	yes
0.111...	1.9	yes
v2 (square root of 2)	?	No!

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Numbers

Irrational Numbers :

cannot be written as a simple fraction (i.e. as a ratio)

$$1.5 = \frac{3}{2} \Big\} \text{Ratio}$$

Rational

$$\pi = 3.14159..... = \frac{?}{?} \Big\} \text{No Ratio}$$

Irrational

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Fundamental Operations

Summation Sign (Σ = sigma):

End at this value

$$\sum_{n=1}^{4} n = 1 + 2 + 3 + 4 = 10$$

Start at this value

What to sum

Examples:

$$\sum_{n=1}^{4}(2n+1) = 3+5+7+9 = 24$$

$$\sum_{i=1}^{3} i(i+1) = 1\cdot 2 + 2\cdot 3 + 3\cdot 4 = 20$$

$$\sum_{i=3}^{5} \frac{i}{i+1} = \frac{3}{4} + \frac{4}{5} + \frac{5}{6}$$

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Fundamental Operations

Average Least Dimension (ALD):

- ❖Measure at least 200 aggregate particles
- ❖Take the average of the 200 particles

$$ALD = \frac{\sum_{i=1}^{n} x_i}{n} = \frac{\sum_{i=1}^{200} x_1 + x_2 + x_3 + \ldots\ldots + x_{200}}{200}$$

Where:

x_i = the i-th ALD measurement (i.e. i = 1 to 200)

And

n = the number of chips measured (i.e. n = 200)

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Fundamental Operations

Logarithms

A logarithm answers the question:
How many of *one number* do we multiply to get *another number?*

Example:

How many 2s do we multiply to get 8?
Answer: 2 × 2 × 2 = 8, so we needed to multiply 3 of the 2s to get 8
So the logarithm is 3

$\boxed{\log_2(8) = 3}$ **because** $\boxed{2^3 = 8}$

Look at it this way:

$2^3 = 8$
$\log_2(8) = 3$

or

$a^x = y$
$\log_a(y) = x$

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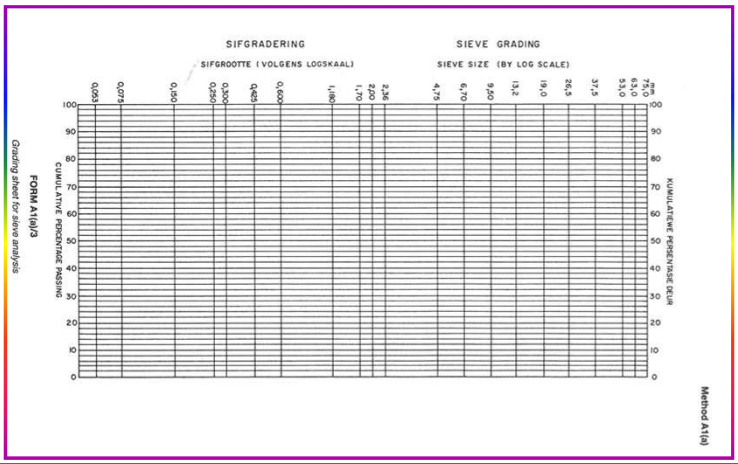
Fundamental Operations

Logs are also used in certain soil analysis procedures, such as:

- **Representing cumulative particle size distribution (gradings) graphically, the scale indicating the sieve sizes is logarithmic (TMH 1: Method A1(a))**



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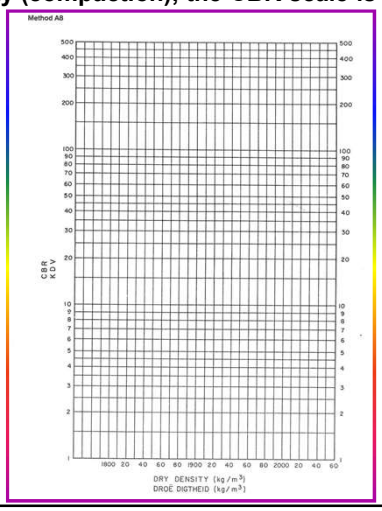
Fundamental Operations

Logs are also used in certain soil analysis procedures, such as:

- **CBR versus density (compaction), the CBR scale is logarithmic (TMH 1: Method A8)**



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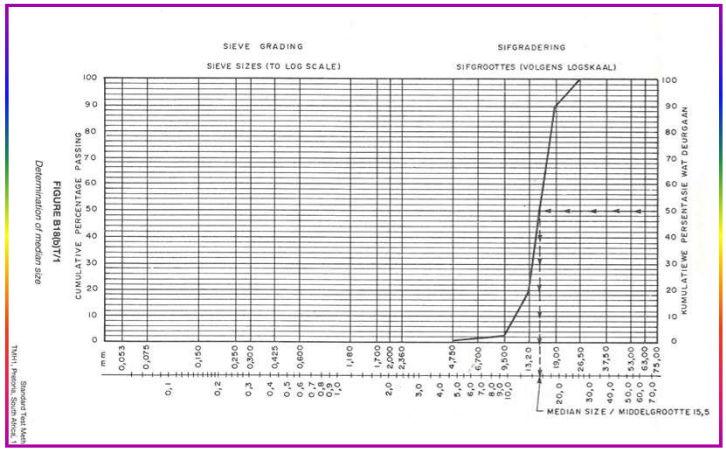
Fundamental Operations

Logs are also used in certain soil analysis procedures, such as:

- **To determine the median size of an aggregate grading, the function contains logarithmic variables (TMH1: Method B18(b)T)**



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Fundamental Operations

Random Numbers

Random numbers are numbers that occur in a sequence such that two conditions are met:

(1) the values are uniformly distributed over a defined interval or set, e.g.

Make use of set of real numbers between two prescribed numbers:

$$\{x: a < x < b\}$$

where:

$$a = 1;\ b = 9$$

Random Numbers:

$$\{3,7,5,1,9,3,2,8,7,5\}$$

(2) it is impossible to predict future values based on past or present ones

sample electromagnetic noise generated by the chaotic movement of electrons

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Fundamental Operations

Random Numbers

- algorithms have been devised that supposedly generate random numbers.
- The problem with these methods is that they violate condition (2) in the definition of randomness.
- The existence of any number-generation algorithm produces future values based on past and/or current ones.
- Digits or numbers generated in this manner are called **pseudorandom**

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Fundamental Operations

Random Numbers

Frequent use will be made of sets of real numbers between two prescribed real numbers. Such sets are called **bounded intervals**

the prescribed real numbers are called the **boundary points**

[and] imply the endpoint is included

(and) imply the endpoint is not included

Open Interval: **(a , b)** boundary points **not** included

where:

$$\{x:\ a < x < b\}$$

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Fundamental Operations

Random Numbers

Closed Interval: [a , b] boundary points **are** included

where:

$$\{x:\ a \le x \le b\}$$

Right - Closed Interval: (a , b] a is not included, b is included

where:

$$\{x:\ a < x \le b\}$$

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Fundamental Operations

Random Numbers

Left - Closed Interval: [a , b) a is included, b is not included

where:

$$\{x:\ a \le x < b\}$$

unbound

Set of Real Numbers R: (∞^-, ∞^+)

infinite negative real numbers

infinite positive real numbers

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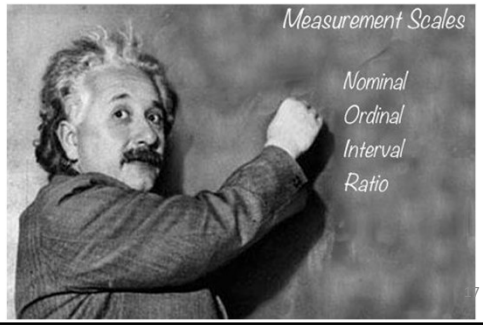
Fundamental Operations

Measurement Scales

- Measurement is the assignment of numbers to objects or events (variables) in a systematic fashion.
- Measurement scales are used to categorize and/or quantify these objects or events.
- Different measurement scales allow for different levels of exactness, depending upon the characteristics of the variables being measured.
- The scale is chosen depending on the information that the data is intending to represent.
- Four levels of measurement:



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Fundamental Operations

Measurement Scales

Nominal Scale:

- Used for labelling variables, without any quantitative value
- "Nominal" scales could simply be called "labels."
- Data is categorized and can't be arranged in an order from low to high

Examples:

Distress of a pavement is identified as:

"1-fracture" (cracking) or
"2-Deformation" (rutting)

What is your hair color?

- 1 – Brown
- 2 – Black
- 3 – Blonde
- 4 – Gray
- 5 – Other

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Fundamental Operations

Measurement Scales

Ordinal Scale:

- More precise than nominal scales
- Are basically sets of rankings
- Do not know the size of the differences between any data points, just that one is greater than the other
- Typical relations between classes are: "higher", "stronger", "more difficult", "more disturbed"

Example (1):

Pavement standard:

(1) materials complying with base course standard
(2) materials complying with sub base standard

base course standard higher (>) than sub base standard

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Fundamental Operations

Measurement Scales

Example (2): Mohs scale of hardness of minerals

Mohs value	Mineral
1	Talc
2	Gypsum
3	Calcite
4	Fluorite
5	Apatite
6	Orthoclase
7	Quartz
8	Topaz
9	Corundum
10	Diamond

Do not say : Apatite = 5 (5 is not an operational number, just point on scale, could just as easily have been (e))
Rather say: Hardness of Apatite is 5 on the Mohs scale

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Fundamental Operations

Measurement Scales

Interval Scale:

- ❑keeps the same rank characteristic as ordinal scales
- ❑interval scales also show the differences between each data point, i.e.the distances between any two numbers on the scale are of known size
- ❑allows for the *degree of difference* between items, but not the ratio between them

Example:

Thermometer readings on a Celsius scale.

The difference between 98.6 and 99.6 is the same as the difference between 101.8 and 102.8 – i.e. 1 degree.

The value of zero doesn't mean "the absence of heat."

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Fundamental Operations

Measurement Scales

Ratio Scale:

- ➢The most precise and powerful of scales
- ➢Ratio scales have all the components of an interval scale but here, the zero point is meaningful and means the absence of whatever it is you're measuring
- ➢Thus, you cannot have a negative data point using a ratio scale

Examples:

A score of 20 is 20 times greater than 1 (20:1) and 10 times greater than 2 (20:2) and twice as great as 10 (20:10)

Measuring something with a ruler would give you a measure in a ratio scale. Zero literally means "no length" (i.e., that it doesn't exist)

The cost of a cup of coffee, 2 cups are twice as expensive as 1 cup

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Fundamental Operations

ISO / SI System

- The International System of Units is called the SI System(abbreviated *SI* from *Systeme Internationale* (the French version of the name)
- It is a scientific method of expressing the magnitudes or quantities of important natural phenomena
- It is the modern form of the metric system
- It comprises a coherent system of units of measurement built around seven base units (Table 1):

Measurement	Unit	Symbol
Mass (not weight)	kilogram	kg
Length	meter	m
Temperature	kelvin	K
Time	second	s
Pure substance amount	mole	mol
Electric current	ampere	A
Light brightness (wavelength)	candela	cd

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Fundamental Operations

ISO / SI System

- 22 named and an indeterminate number of unnamed coherent derived units (Table 2)

Name	Symbol	Quantity	Expression in terms of other units	Expression in terms of SI Base units
becquerel	Bq	radioactivity (decays per units time)	1/s	s^{-1}
coulomb	C	electric charge or quantity of electricity	s•A	s•A
degree Celsius	°C	temperature relative to 273.15 K	K	K
farad	F	electric capacitance	C/V	$kg^{-1}•m^{-2}•s^{4}•A^{2}$
gray	Gy	absorbed dose of ionizing radiation	J/kg	$m^{2}•s^{-}$
henry	H	inductance	V•s/A = Wb/A	$kg•m^{2}•s^{-2}•A^{-2}$
hertz	Hz	frequency	1/s	s^{-1}
joule	J	energy, work, heat	N•m = C•V = W•s	$kg•m^{2}•s^{-2}$
katal	kat	catalytic activity	mol/s	s^{-1}•mol
lumen	lm	luminous flux	cd•sr	cd
lux	lx	illuminance	lm/m^{2}	m^{-2}•cd
newton	N	force, weight	$kg•m/s^{2}$	$kg•m•s^{-2}$
ohm	Ω	electric resistance, impedance, reactance	V/A	$kg•m^{2}•s^{-3}•A^{-2}$
pascal	Pa	pressure, stress	N/m^{2}	$kg•m^{-1}•s^{-2}$
radian	rad	angle	m/m	dimensionless
siemens	S	electrical conductance	1/Ω = A/V	$kg^{-1}•m^{-2}•s^{3}•A^{2}$
sievert	Sv	equivalent dose of ionizing radiation	J/kg	$m^{2}•s^{-2}$
steradian	sr	solid angle	m^{2}/m^{2}	dimensionless
tesla	T	magnetic field strength, magnetic flux density	$V•s/m^{2}$ = Wb/m^{2} = N/(A•m)	$kg·s^{-2}•A^{-1}$
volt	V	voltage, electrical potential difference, electromotive force	W/A = J/C	$kg•m^{2}•s^{-3}•A^{-1}$
watt	W	power, radiant flux	J/s = V•A	$kg•m^{2}•s^{-3}$
weber	Wb	magnetic flux	J/A	$kg•m^{2}•s^{-2}•A^{-1}$

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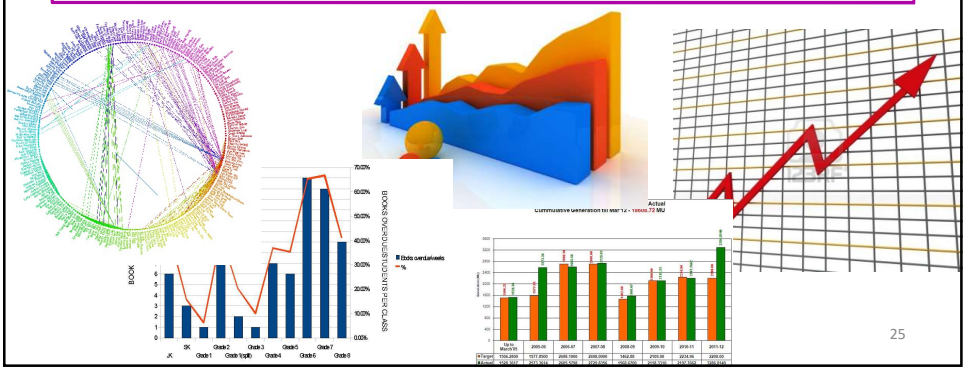
Fundamental Operations

Graphical Representation

- ❑A method of visually creating and manipulating data and statistical results
- ❑Used in order to gain better insight and understanding of a problem that is being studied
- ❑pictures can convey an overall message much better than a list of numbers



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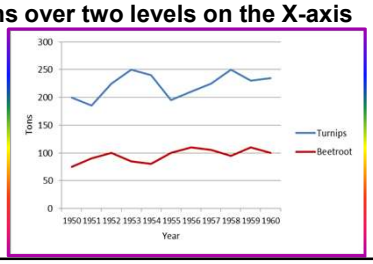
Fundamental Operations

Graphical Representation

Line Chart:

- ✓A line chart plots continuous data as points and then joins them with a line
- ✓provide a simple way to visually present a sequence of many values
- ✓Used to display long data rows
- ✓Can interpolate between data points
- ✓Can extrapolate beyond known data values (forecast)
- ✓Used to compare different graphs
- ✓to find and compare trends (changes over time)
- ✓if the X axis requires an interval scale
- ✓to display interactions over two levels on the X-axis



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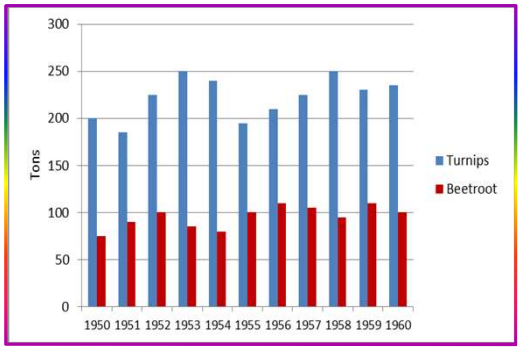
Fundamental Operations

Graphical Representation

Bar Chart:

- A bar chart displays discrete data in separate columns
- A double bar chart can be used to compare two data sets
- Bar charts are best to show amounts
- Can be plotted vertically or horizontally



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Fundamental Operations

Graphical Representation

Histogram:

- a histogram is a graphical representation showing a visual impression of the distribution of data
- It is similar to a Bar Chart, but a histogram groups numbers into ranges
- There should be no gaps between the bars in the histogram

Example:

You do a survey of your roads data base and want to find out how many roads of a certain length are in a certain district
You decide to divide the roads into lengths of 5 kilometres
The following results were obtained:

1 to 5 kilometres: 3 roads
6 to 10 kilometers: 30 roads
11 to 15 kilometers: 27 roads
16 to 20 kilometers: 50 roads
21 to 25 kilometers: 10 roads

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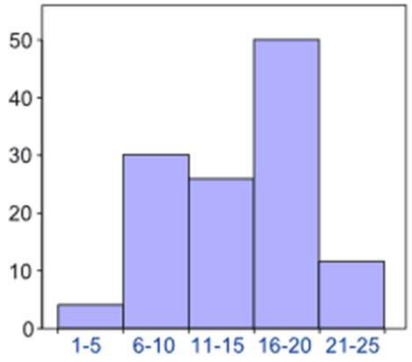
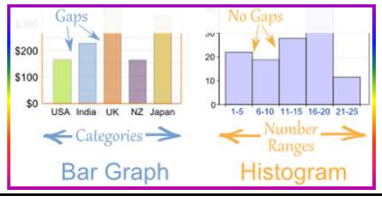
Fundamental Operations

Graphical Representation

Histogram:



There are 30 roads between 6 and 10 kilometres long



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Fundamental Operations

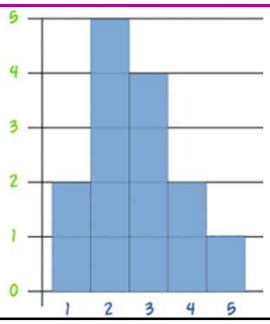
Graphical Representation

Frequency histograms (also frequency distribution):

A Frequency Histogram is a special histogram that uses vertical columns to show frequencies (how many times each score occurs)

Example:

You get the following scores: 1,1,2, 2, 2, 2, 2, 3, 3, 3, 3, 4, 4, 5



The frequency of number 2 is 5 i.e. The number 2 occurs 5 times

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Fundamental Operations

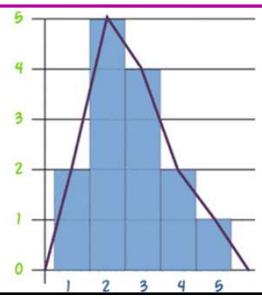
Graphical Representation

Frequency polygons:

The frequency of each class is indicated by points or dots drawn at the midpoints of each class interval. Those points are then connected by straight lines

Example:

Consider the same scores from the previous example.



A graph made by joining the middle-top points of the columns of a frequency histogram

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Fundamental Operations

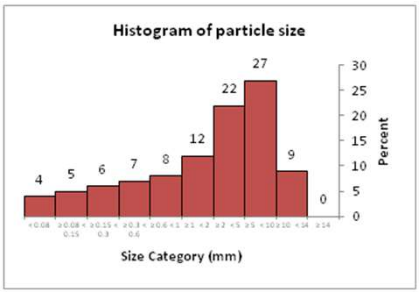
Graphical Representation

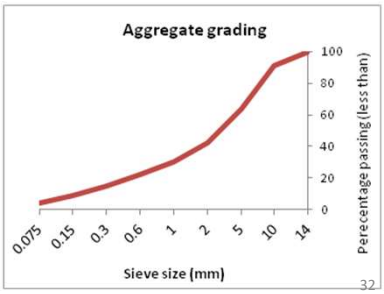
Cumulative frequency polygon:

a way of presenting data so that frequencies are accumulated as the value of data increases

Example:

The grading curve





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Fundamental Operations

Graphical Representation

Logarithmic Scale:

The logarithmic scale on a graph is used to accommodate large numbers and very small numbers on the graph in such a way that all the numbers can easily be distinguished from each other on one or both exes of the graph.

Example:

The grading curve:

- **The y-axis is normally indicated as cumulative percentage passing through the various sieves.**
- **The X-axis is indicated as a 3 cycle log scale, where the x-axis is divided into 3 regions between 0 an 1, 1 and 10 and 10 and 100 (0, 10^0, 10^1 and 10^2 respectively). (5 cycle if hydrometer test is done on the soil).**
- **If this would not have been implemented, the 0,075mm to 0,600mm sieve would be unreadable on the graph compared to the sieves above 4,75mm sieves (would be seen as a point).**

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Fundamental Operations

Graphical Representation

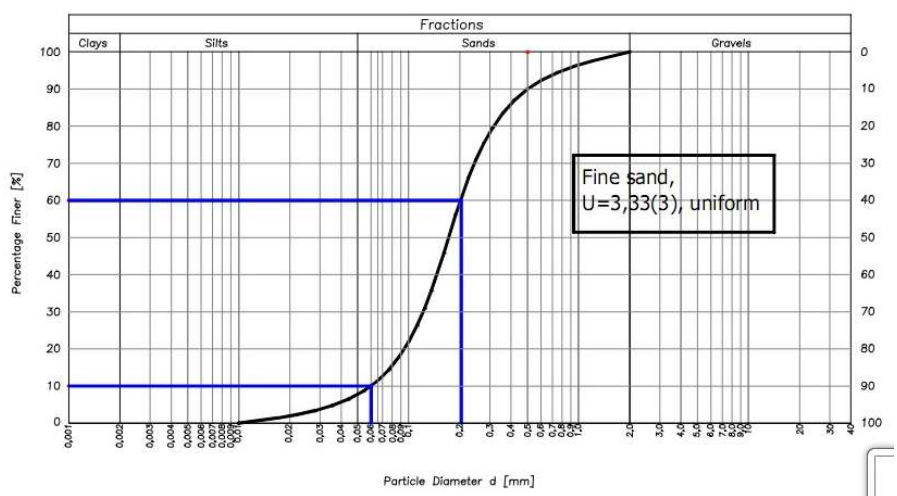

Figure 1. Particle-size distribution curve.

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End of Session A

Time to rest

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