Lab No. (2)

Calculate the frictional velocity u_*

Aims: To calculate the frictional velocity u_* and the length of the surface roughness Z_0 from the graph.

Tools:

1- Air tunnel.

2- Hot-wire anemometer.

4- Obstacles.

Theoretical part :

Shear stress τ can be defined using the Frictional velocity u_*, since:

$$\tau = \rho u_*^2 \dots\dots\dots (1)$$

Shear stress τ is defined as the rate of momentum transfer per unit area during a given time. u_* is the Turbulence velocity, which is a disturbance in wind speed caused by an external force. The result of the change is either in the horizontal or vertical direction, which means:

$$u_* = u' = w' \dots\dots\dots (2)$$

where u' and w' are the turbulent velocities in the horizontal and vertical directions, respectively.

u_* can be calculated using the log wind profile equation:

$$\ln(z) = \frac{k}{u_*} u(z) + \ln z_\circ \dots\dots\dots (3)$$

Where the relationship between u(z) on the x axis and $\ln(z)$ on the y axis is a linear relationship so the formula of straight line (y= a + b x) can be similar to equation (3) in the neutral condition . so we can determine u_* using slope value as shown :

$$u_* = \frac{k}{\text{slope}} \dots\dots\dots\dots\dots.\dots (4)$$

Where

k: is the (Von Karman) constant and its value k = (0.4).

in the same way the roughness length $z_{\circ}$ can be determined using equation below :

$$z_{\circ} = \exp(a) \ldots \ldots \ldots (5)$$

Where (a) is the intercept in Z-axis.

methodology:

1- Turn on the wind tunnel.

2- Record the wind speed using Hot-wire anemometer for different heights (every 2.5 cm.).

3- Record the data as in the following table:

freq	Z(m)	$\ln(z)$	u(m/s)	u^2	Ln Z × u
1	0.025				
2	0.05				
3	0.075				
4	0.1				
5	0.125				
6	0.15				
7	0.175				
8	0.2				
9	0.225				
10	0.25				
n=10		$\sum$ Ln (Z)	$\sum$ u	$\sum u^2$	$\sum$ Ln Z × u

4- Draw the linear regression between u(z) on the (x) axis and $\ln(z)$ on the (y) axis.

5- Extract the slope value from the graph or through the relationship:

$$slope = \frac{\sum \ln z\, u(z) - \left(\frac{(\sum u(z))(\sum \ln z)}{n}\right)}{\sum\left(u_{(z)}^2\right) - \frac{(\sum u(z))^2}{n}}$$

where: n is the number of Record.

Then calculate the u_* value from equation (4).

6- calculate the value of intercept (a) from the formula below:

$$a = ave\ (\ln z) - slope * (ave\ u(z))$$

whereas:

$ave\ (\ln z)$: is the rate of lnz.

slope : is the slope of a straight line.

ave u(z) : the average of recorded wind speed.

7- calculate the value of $z_\circ$ through equation No (5).