Land Leveling by using plane method

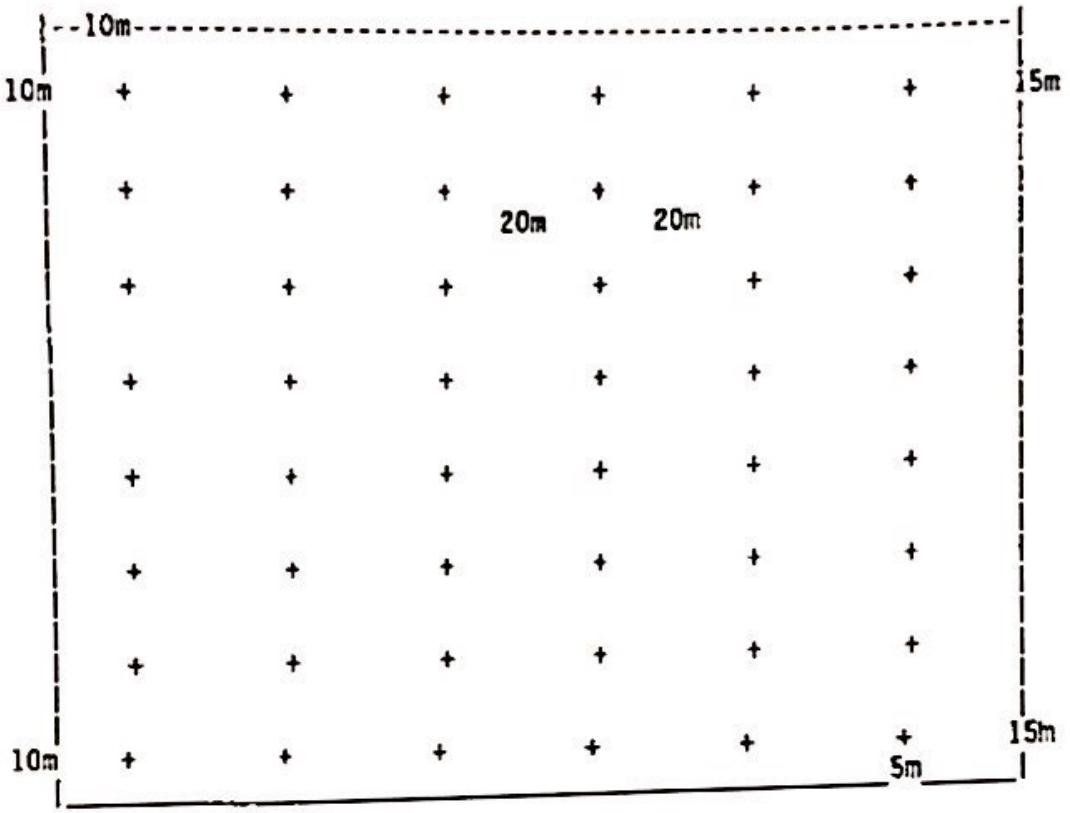

Fig.1. Grid poin

	A	B	C	D	E	F	Ave.
i	1.95	1.81	1.77	1.90	1.92	1.90	1.876
ii	1.80	1.71	1.62	1.78	1.69	1.68	1.712
iii	1.67	1.59	1.51	1.64	1.53	1.54	1.578
iv	1.43	1.39	1.46	1.51	1.53	1.54	1.455
v	1.21	1.32	1.46	1.50	1.52	1.48	1.418
vi	1.36	1.45	1.49	1.50	1.52	1.51	1.473
vii	1.48	1.47	1.49	1.47	1.48	1.51	1.484
viii	1.47	1.48	1.42	1.46	1.36	1.40	1.430
Ave.	1.549	1.529	1.531	1.599	1.575	1.560	1.557

Fig.2. Spot elevation

	A	B	C	D	E	F	Row
i	1.00	1.00	1.00	1.00	1.00	1.25	6.25
ii	1.00	1.00	1.00	1.00	1.00	1.25	6.25
iii	1.00	1.00	1.00	1.00	1.00	1.25	6.25
iv	1.00	1.00	1.00	1.00	1.00	1.25	6.25
v	1.00	1.00	1.00	1.00	1.00	1.25	6.25
vi	1.00	1.00	1.00	1.00	1.00	1.25	6.25
vii	1.00	1.00	1.00	1.00	1.00	1.25	6.25
viii	.75	.75	.75	.75	.75	.938	4.688
Col.	7.75	7.75	7.75	7.75	7.75	9.688	

Fig.3. Weighing factors

	A	B	C	D	E	F
i	-.21	-.06	-.01	-.13	-.15	-.12
ii	-.11	-.01	+.08	-.07	+.03	+.05
iii	-.04	+.05	+.14	+.02	+.13	+.13
iv	+.15	+.20	+.13	+.09	+.08	+.20
v	+.31	+.21	+.08	+.05	+.03	+.08
vi	+.11	+.03	-.01	-.01	-.02	0
vii	-.07	-.05	-.06	-.03	-.04	-.06
viii	-.11	-.11	-.05	-.08	+.03	0

Fig.4. Cut and fill depths

The plane equation is written as:

$$E(X,Y) + AX + BY + C \qquad [1]$$

E= Elevation of the X, Y coordinates

A and B = Regression Coefficients'

C= Elevation of the origin or reference point

Step 1 : Establish the grid system with a suitable grid spacing (say 20 m x 20 m)

Step 2: Determine the field grid point elevations.

Step 3 : Determine the parameters of the Plane Equation

a) Determine the weighing factors

The first step in evaluating the constants, A, B and C, is to determine the weighted average elevations of each grid point in the field. The purpose of the weighing is to adjust for any boundary stakes that represent larger or smaller areas than given by the standard grid dimension. The weighing factor is defined as the ratio of actual area represented by a grid point to the standard area. The grid point area is assumed to be the proportional area surrounding the stake or other identification of the grid point elevation. The weighing factor is:

$$\theta_{ij} = \frac{A_{ij}}{As} \qquad [2]$$

θ_{ij} = weighing factor of the grid point identified as the ith stake row and the jth stake column;

A_{ij} = area represented by the (i, j) grid point; and

As = area represented by the standard grid dimension.

b) Determine the average elevation of the rows and columns:

The next step is to determine the average elevation of each row and column.

1) For the ith row, E_i, is:

$$Ei = \frac{\sum_{J=1}^{M} \theta_{ij} E_{ij}}{\sum_{J=1}^{M} \theta_{ij}} \qquad [3]$$

in which:

M = number of stake columns; and
$\mathbf{E_{ij}}$ = elevation of the (i, j) coordinate found from field measurements E(X, Y).

2) A similar expression can be written for finding the average elevation of the jth stake column, E_j:

$$E_J = \frac{\sum_{i=1}^{N} \theta_{ij} E_{ij}}{\sum_{i=1}^{N} \theta_{ij}} \qquad [4]$$

where **N** is the number of stake rows.

c) Determine the coordinates of the centroid.

1) X – Coordinate (X)

The next step is to locate the centroid of the field with respect to the grid system. For convenience, an origin can be located one grid spacing in each direction from the first stake position, i.e. the initial stake position on the field. The distance from the origin to the centroid in the X dimension is found by:

$$X = \frac{\sum_{j=1}^{M} \theta_j X_j}{\sum_{j=1}^{M} \theta_j} \qquad [5]$$

X = x distance from origin to centroid;
$\mathbf{X_j}$ = x distance from origin to the jth stake column position; and

$$\theta_j = \sum_{i=1}^{N} \theta_{ij} \qquad [6]$$

2) The Y –Coordinate (Y)

Similarly,

$$Y = \frac{\sum_{i=1}^{N} \theta_i X_i}{\sum_{i=1}^{M} \theta_i} \qquad [7]$$

Y = y distance from the origin to centroid;
Y_i = y distance from origin to the ith stake row position; and

$$\theta_i = \sum_{J=1}^{M} \theta_{ij} \qquad [8]$$

3) Determine the average field elevation, EF.

This can be can be found by summing either Ei or Ej and dividing by the appropriate number of grid rows. This elevation corresponds to the elevation of the field centroid (X, Y).

d) Determine the best slope in X and Y directions:

1) The best fit slope in X direction

The next step is to compute a least squares line through the average row elevations in both field directions. The slope of the best fit line through the average X-direction elevation (Ej) is A and is found by:

$$A = \frac{\sum_{J=1}^{M} X_j E_j - \left(\sum_{j=1}^{M} X_j\right)\left(\sum_{j=1}^{M} E_j\right)}{\sum_{j=1}^{M} X_j^{\,2} - \left(\sum_{j=1}^{M} X_j\right)^2 / M} \qquad [9]$$

2) The best fit slope in Y direction

For the best fit slope in the Y-direction, the slope, B, is.

$$B = \frac{\sum_{i=1}^{N} y_i E_i - \left(\sum_{i=1}^{N} Y_i\right)\left(\sum_{i=1}^{N} E_i\right)}{\sum_{i=1}^{N} Y_i^{\,2} - \left(\sum_{i=1}^{N} Y_i\right)^2 / N} \qquad [10]$$

e) Determine the Parameter C (elevation of the origin or the reference point)

Finally, the plane equation can be solved to determine C. This can be achieved by substituting:

1) the elevation of centroid; 2) the X –coordinate of the centroid; 3) the Y-coordinate of centroid; 4) best fit slope in X-direction (A) and 5) best fit slope in Y- direction (B) in the plane equation (Equation 1) and solving for C

$$C = EF - AX - B Y \qquad [11]$$