TRAINING MANUAL

ON

SURVEYING FOR WATERCOURSE IMPROVEMENT

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Chapter – 1

INTRODUCTION

Surveying: Surveying is the art of making such measurements which will determine the relative positions of natural and man-made features on the surface of earth and plotting of these measurements to some suitable scale to form a map, plan or section. In practice, however, surveying is often used for determining positions of different features of earth in horizontal plane.

Leveling: Leveling is the art of determining and representing the relative heights or elevations of different points on the surface of earth. Leveling is usually used for determining positions of points in vertical plane.

Surveying and leveling are frequently considered as distinct operations, however, the term surveying includes leveling. In this manual, the term surveying will refer to both surveying and leveling

Differential Leveling: This method is used in order to find the difference in elevation between two points i) if they are too far apart ii) if the difference in elevation between them is too great iii) if there are obstacles intervening. This process is also known as compound or continuous leveling.

Importance of Surveying in Watercourse Improvement:

Watercourse design and construction works require information which is gathered by conducting different types of surveys. Lack of information results in poor design and incorrect construction of watercourse. Surveys are required to be conducted right from planning, design, up to construction phase of watercourse improvement. Reconnaissance survey in under taken in planning stage. Bench mark survey is undertaken to establish bench marks which are used in all watercourses improvement activities. Topographic survey is used to describe the topography of command area of watercourse. Profile survey is conducted to determine old and design F.S.L of water levels to ensure that bed of watercourse is properly laid for irrigating the whole command area.

Chapter – 2

Equipments used in Surveying and Leveling

The principal surveying instruments and accessories and their primary uses in watercourse improvement are as follows:

Tapes: Plastic tapes are now the most common type available. They usually come in lengths of 30 meters but may be obtained in 15 meter lengths. Measurements not requiring a high degree of accuracy, such as dimensions of existing bridge openings, short distances in cross sections and distances for strip cropping and orchard layouts are usually made with a tape.

Measuring Wheels. These are wheels of a known circumference mounted in a frame with a handle so that the wheel may be easily pushed along a line. The wheel is fitted with a trip meter which records the turns of the wheel over a distance between two points. The trip meter usually measures to a tenth of a meter. The measuring wheel is a useful method of obtaining the approximate length of a line. However, where the ground surface is rough, the accuracy of this method is significantly reduced.

Staff Rod: The staff rod is used for the purpose of measuring vertical distance. Figure illustrates a section of a staff rod. The width of a black line is 0.01 meter (1 centimeter) and the width of the white space between black lines is 0.01 meter. The numbers on the face of the staff give the distance in meters from the bottom of the rod as shown in figure-2.1.

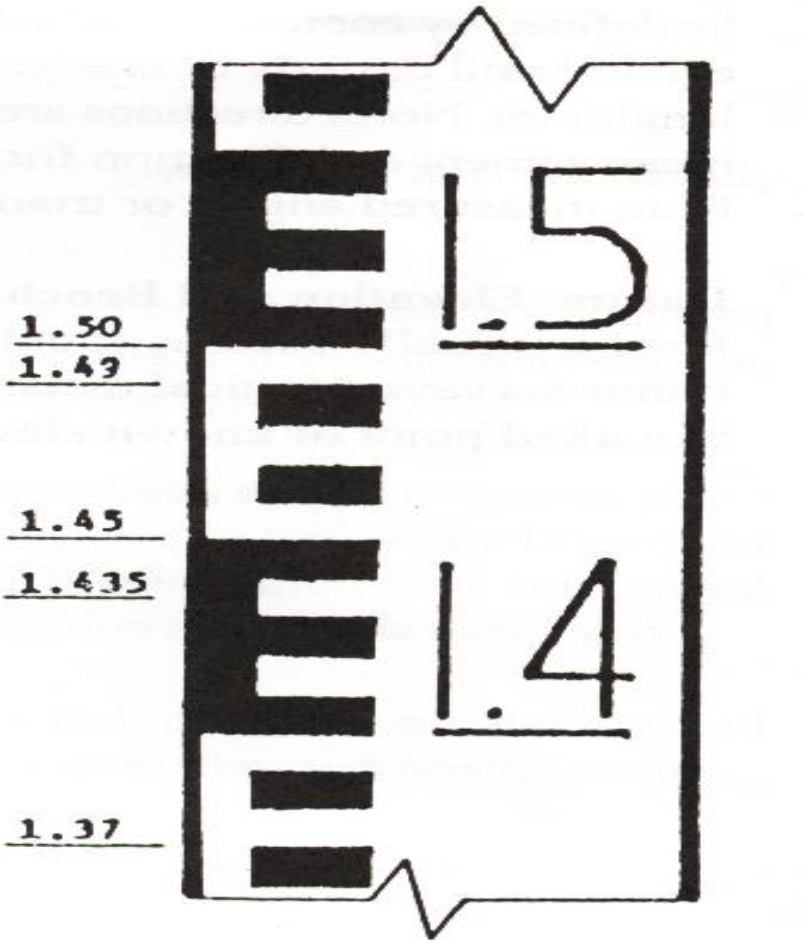


Figure 2.1 Part of Leveling Staff

Ranging Rods. The ranging rod is a one or two piece pole usually 2 m in length, painted red and white. It is generally used to establish a "“line of sight”.

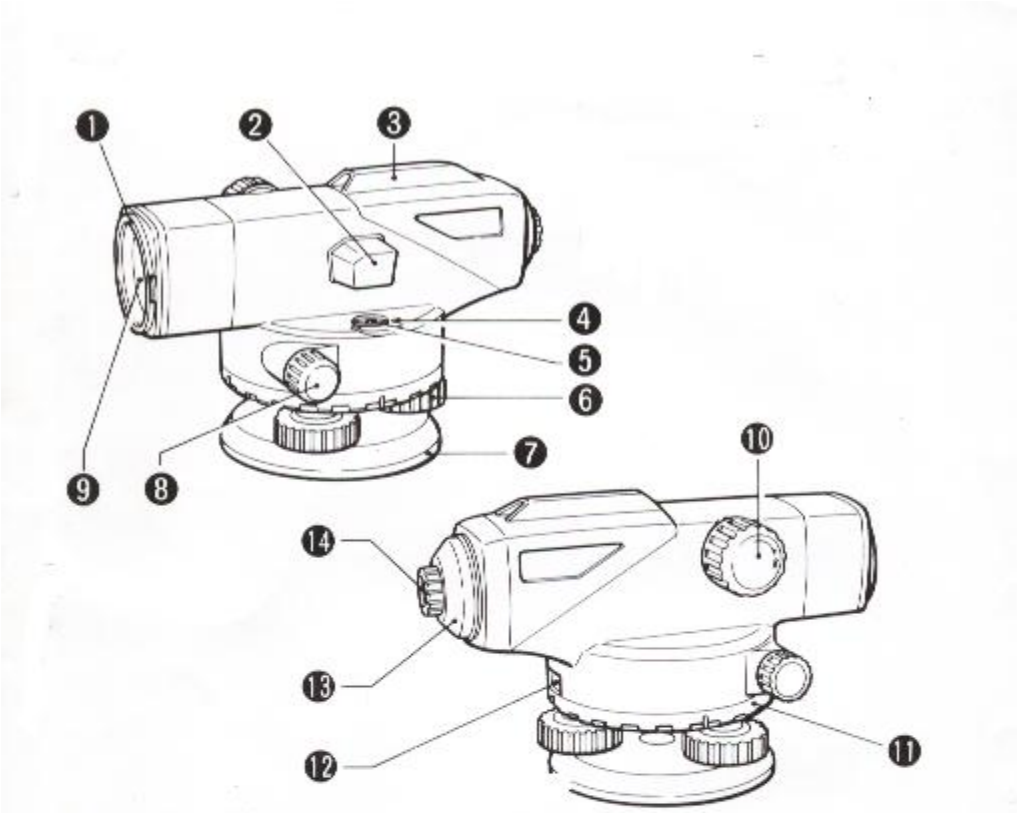
Field Book: Engineering field books are used for the recording of survey notes and layouts. They are valuable documents because of the time and expense involved in obtaining such data. It should not be used for scratch computations or notes which have no permanent value pertaining to engineering surveys. The format of field book is different for different types of surveys. The standard format being used for watercourse survey is shown in the table-2.1.

Figure-2.1: Field book sample.

Station	B.S	H.I	I.S	F.S	Elev.	Remarks
B.M	1.02	11.02	-	-	10.00	
0+00	-	-	1.21	-	9.81	
0+30	-	-	1.47	-	9.55	
0+50	-	-	2.11	-	8.91	
0+70	-	-	1.58	-	9.44	
0+90	0.98	10.40	-	1.60	9.42	TP
1+00	-	-	1.09	-	9.31	
1+40	-	-	1.21	-	9.19	
1+80	-	-	-	2.12	8.28	

Self Leveling Level (Dumpy Level): The self leveling level automatically levels its line of sight with great accuracy. It levels itself by means of a compensator after the circular spirit level is centered approximately. It is precise as well as simple and quick to operate.

This instrument is used primarily for measuring the vertical heights (elevations) of the points. However, horizontal distances and angles can also be measured by using this instrument. The parts of a dumpy level are shown in Figure 2.2.



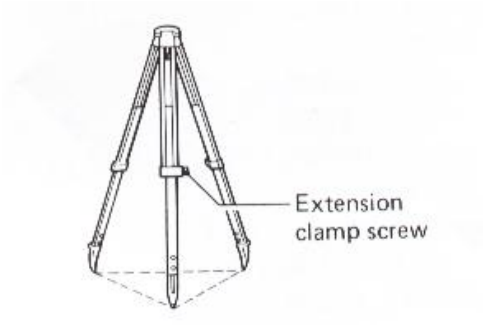
❶ Lens hood (Sliding type)
❷ Reflector
❸ Peep sight
❹ Circular level adjusting screw
❺ Circular level
❻ Levelling foot screw
❼ Base plate
❽ Horizontal fine motion screw
❾ Objective lens
❿ 2-speed focussing knob
⓫ Horizontal circle positioning ring
⓬ Horizontal circle window
⓭ Reticle adjusting screw cover
⓮ Eyepiece*

Figure 2.2 Parts of Dumpy Level

Preliminaries:

1. Setting up the instrument

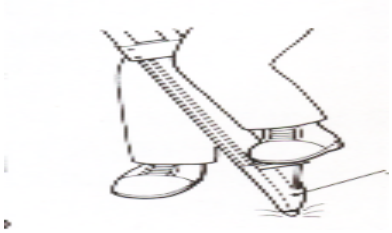
i) Unbuckle the band around the tripod legs and loosen the extension clamp screws.



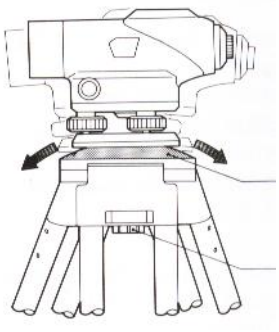
ii) With the tripod closed, extend the tripod legs until the tripod head is roughly at eye level, then re-tighten the clamp screws.

iii) Spread the tripod legs so that the leg tips form a regular triangle on the ground.

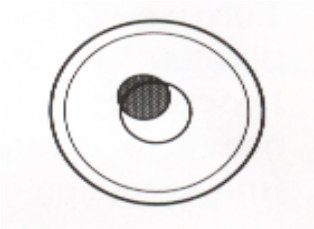
iv) Make sure that the tripod head is approximately level. Fix the tripod shoes firmly into the ground.



v) Hold the instrument on the tripod head and tighten the centering screw.

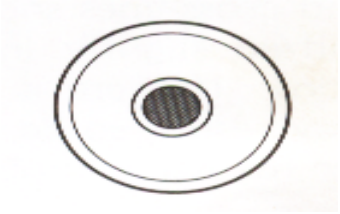


vi) When using the spherical head tripod, slightly loosen the centering screw, hold the base plate **7** in both hands, and slide it across the tripod head until the bubble is approximately centered in the circular level **5**.



vii) Tighten the centering screw.

viii) Adjust the leveling foot screws **6** until the bubble is exactly centered in the center circle.



2. FOCUSING AND SIGHTING

i) Sight a bright, featureless background.

ii) Turn the eyepiece **14** fully clockwise and focus the reticle by gradually turning the eyepiece anticlockwise while looking through the telescope. Stop turning just before the reticle image becomes blurred. In this way, frequent reticle focusing can be dispensed with since your eye is focused at infinity.

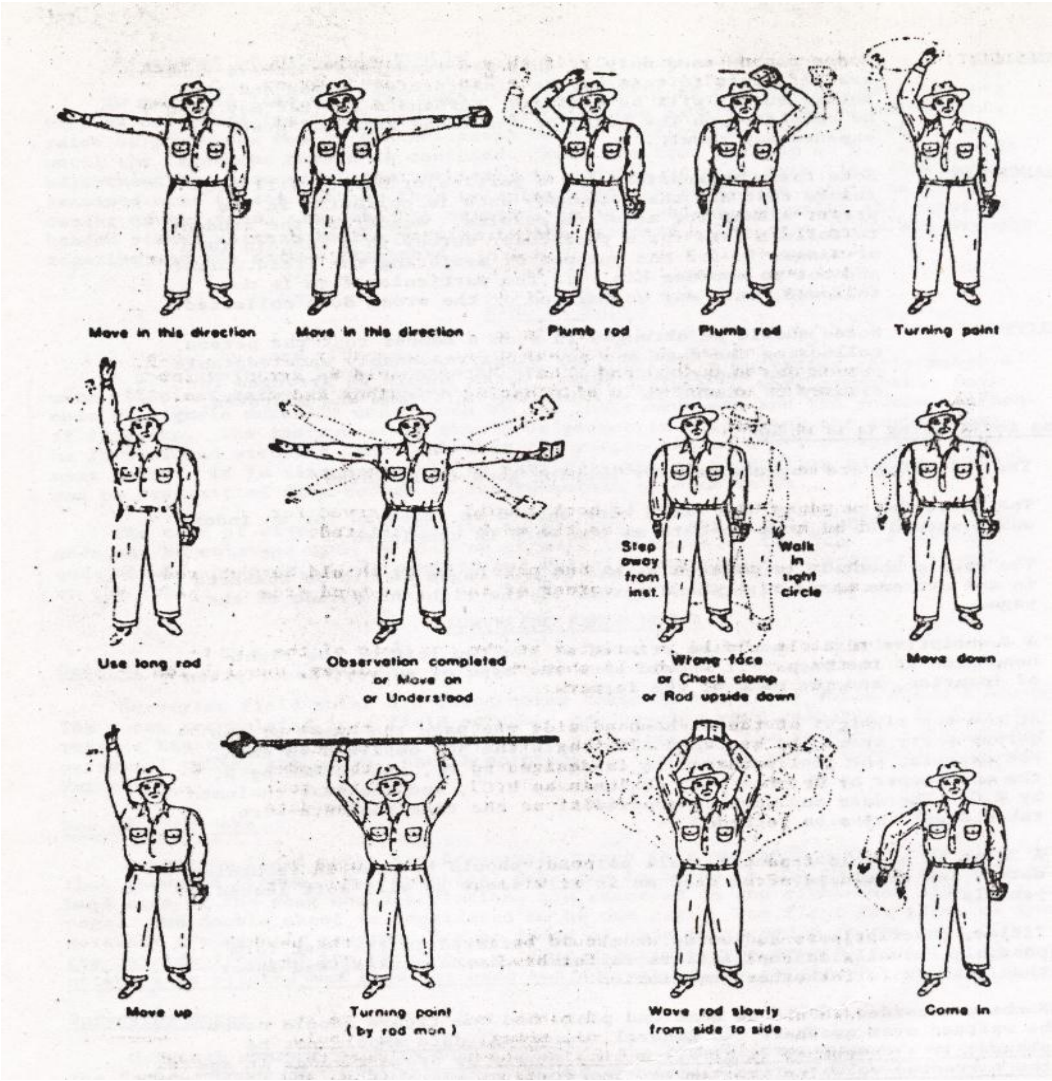
iii) Align the instrument on the staff using the peep sight **3** and turn the horizontal fine motion screw **8** to center the staff in the field of view.

Turn the 2-speed focusing knob **10** to eliminate parallax * between the staff and the reticle. (Focusing is coarse while the focusing knob feels heavy to rotate. The reverse rotation will give a fine focussing motion).

HAND SIGNALS:

A good system of hand signals between members of a surveying party make a more efficient means of communication than is possible by word of mouth. Any code of signals mutually understood by the instrument-man and Rodman is good if it works. The instrument-man should be prompt in signalling the Rodman when he is finished with "Shot" so that the Rodman can move off promptly to the next point. It is also desirable to have a system of signals so that numbers can be transmitted from Rodman to instrument-man or vice versa.

The code of signals illustrated in Figure 2.3 is suggested.



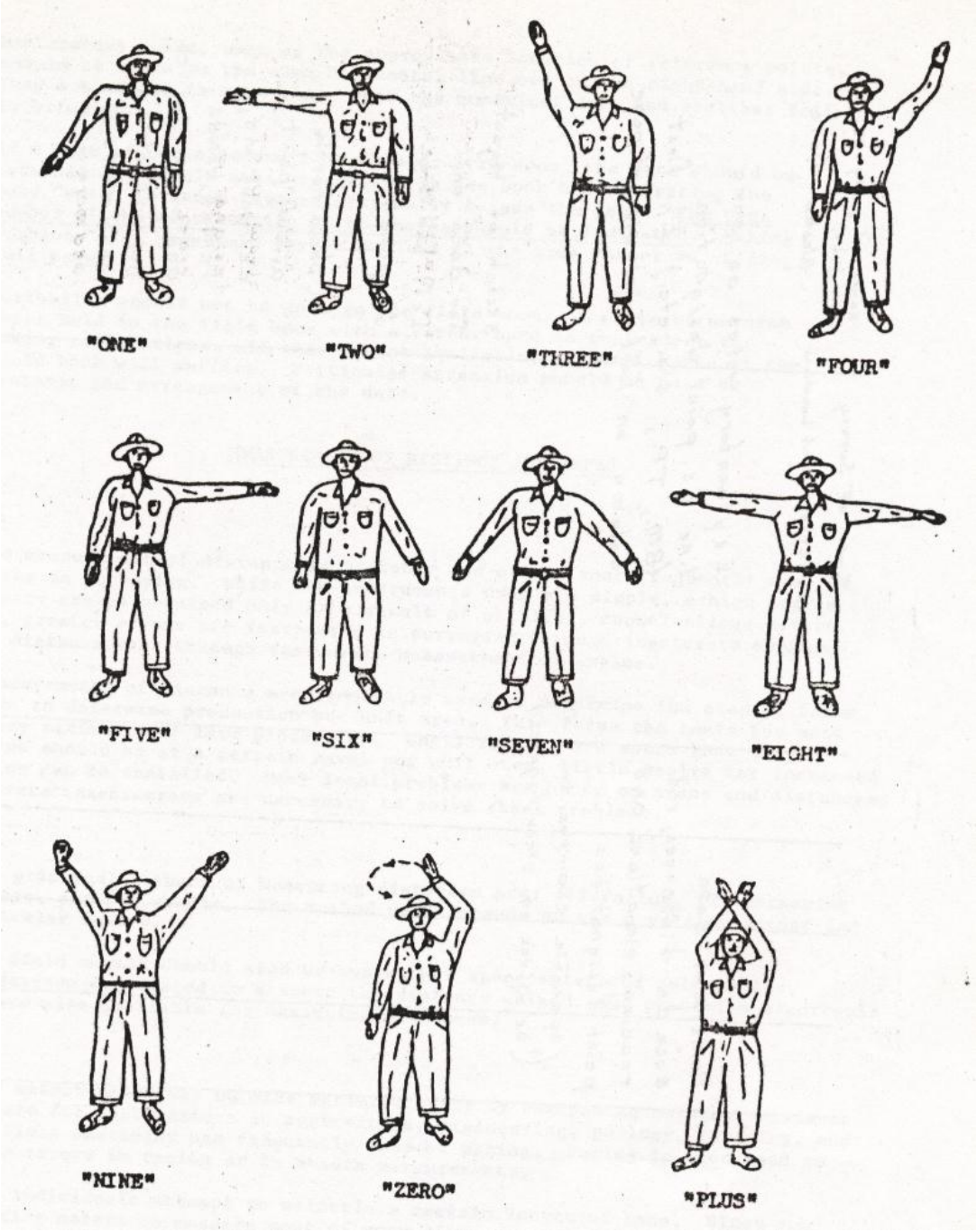


Figure-2.3: Hand Signals used in surveying

Chapter - 3

Fundamentals of Surveying & Leveling

Datum Surface:

A datum surface or line is any arbitrarily assumed level surface or line from which vertical distances are measured. Mean see level is usually used as standard datum, however assumed datum may be used for minor surveys.

Bench Mark:

It is permanent established mark, the elevation of which is known to use as reference point in obtaining the elevations of subsequent stations. The elevation may be assumed in case it is not known.

Back sight (B.S.):

A back sight (B.S) also termed as a back sight reading, is a staff (or rod) reading taken on a point of known elevation as on a bench mark or a change point. It is also called a plus sight. It is the first staff reading taken after the level is set up and leveled.

Foresight (F.S):

A foresight (F.S), also called a foresight reading, is a staff (or rod) reading on a point whose elevation is to be determined as on a change point. It is also termed as a minus sight. It is the last staff reading with the same setup of instrument denoting the shifting of the instrument. It must be remembered here that the foresight does not imply any direction, but it denotes the reading.

Intermediate Sight (I.S):

An intermediate sight (I.S.) is any other staff reading taken on a point of unknown elevation from the same set-up of the level. All sights taken between the backsight and the foresight are intermediate sights.

Elevation:

The vertical distance of point from the datum is elevation. It is also known as the reduced level (R.L.). The elevation of a point is plus or minus accordingly as the point is above or below the datum.

Elevation = H.I – I.S or F.S

Line of Collimation:

The line of collimation is the line joining the intersection of the cross-hairs to the optical center of the object glass and its continuation. It is also called the line of sight.

Axis of the telescope:

An axis of the telescope is a line joining the optical center of the object glass to the center of the eyepiece.

Change Point or Turning Point (T.P):

A change point (C.P.) is a point denoting the shifting of the level. It is a point on which the fore and back sights are taken. Any stable and well defined object such as boundary wall, rock, etc is used as a change point. A bench mark may also be taken as a change point. It is also called a turning point (T.P.).

Station:

A station is a point whose elevation is to be determined or a point which is to be established at a given elevation. It may be noted that it is point where the staff is held and not the point where the level is set up.

Height of Instrument (H.I.):

The height of horizontal line (line of sight) from the datum is called Height of Instrument (H.I.).

- H.I = B.S + Elevation

3. LEVELING PROCEDURE.

After the instrument has been leveled, a staff rod reading i.e back sight reading is taken on B.M and height of instrument is computed from this reading. A BS of 1.02 gives H.I of 11.02 as shown in the figure-3.1. A staff reading (I.S) is then taken for first short, at 0+30 for second short and so fourth until station 0+70 has been reached. A turning point is necessary whenever, it is difficult to sight the reading with the same set of instrument, so a TP is selected and F.S of 1.60 is taken on top of the stake. The instrument is carried to a new position along the line, releveled, and a B.S of 0.98 obtained on TP and new H.I is computed. Additional I.S can be taken along the line and process is continued until survey is completed. The detail of computations is shown in table-3.1

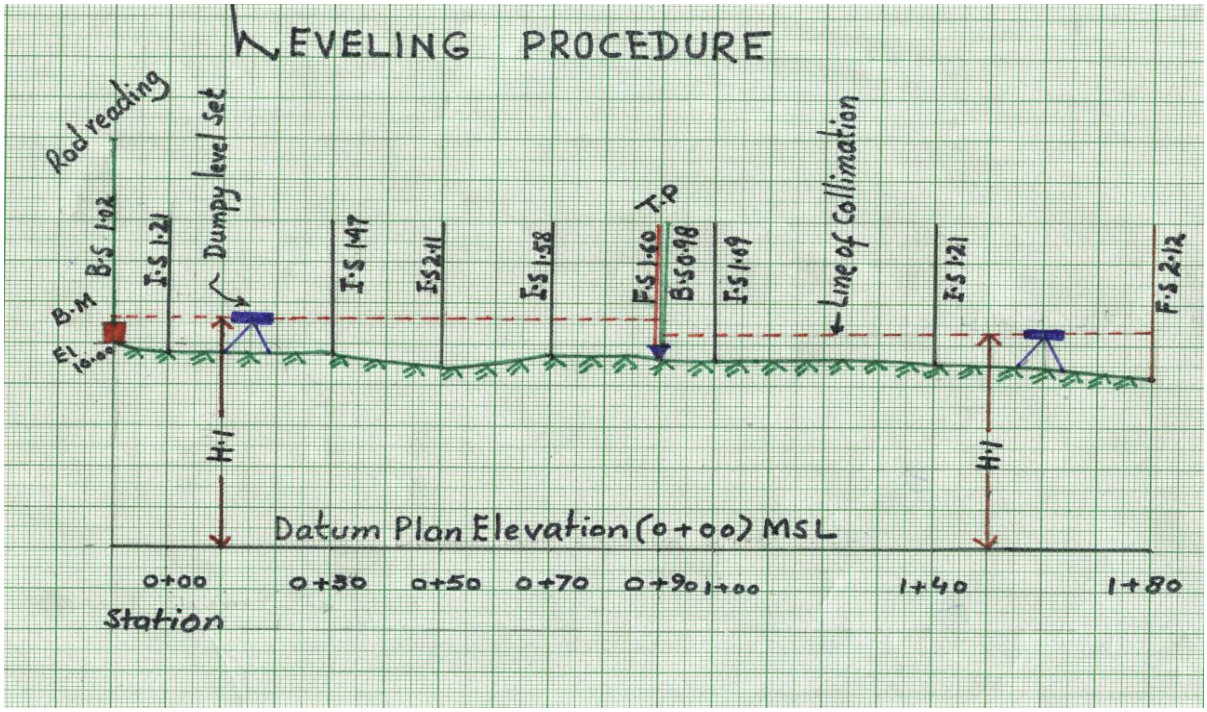


Figure-3.1: Leveling Procedure

Table-3.1: LEVELING PROCEDURE

Station	B.S	H.I	I.S	F.S	Elev.	Remarks
B.M	1.02	11.02	-	-	10.00	
0+00	-	-	1.21	-	9.81	
0+30	-	-	1.47	-	9.55	
0+50	-	-	2.11	-	8.91	
0+70	-	-	1.58	-	9.44	
0+90	0.98	10.40	-	1.60	9.42	TP
1+00	-	-	1.09	-	9.31	
1+40	-	-	1.21	-	9.19	
1+80	-	-	-	2.12	8.28	

Determination of Elevation:

The elevation of point is determined by subtracting its rod reading from height of instrument. Suppose elevation of BM is 10.00 meter. Staff Rod reading at this point is 1.54 m. The relative rod reading of other place is 1.75m. Determine the elevation at that place.

B.M Elevation = 10.00 m
B.S = 1.54 m
F.S = 1.75 m
H.I = B.M Elevation + B.S
H.I = 10 + 1.54 = 11.54 m

Elevation = H.I – F.S
Elevation = 11.54 – 1.75 = 9.79 m

When the point will be higher, elevation will be higher but rod reading at this point will be lower and vice versa.

Determination of Horizontal Distance by Stadia Method.

Where it is desired to measure distance with great rapidity but not with very great accuracy, the stadia method is frequently employed. Surveying instruments equipped for stadia measurements have two additional horizontal crosshairs called stadia hairs as illustrated in Figures-3.2. They are placed in

such a manner, one above and one below the horizontal leveling crosshair, so that when a leveling rod is held 100 units away from the level, there will be 1.00 unit of staff visible between the top and bottom stadia hairs. Thus if a metric staff is held 100 metres from the instrument, a difference in vertical interval between the top and bottom stadia hairs will be 1 m. The difference between the rod reading of the top stadia hair and the rod reading of the bottom stadia hair is called the stadia interval. The distance in meters from the instrument to the rod is equal to the stadia interval (expressed in metres, tenths and hundredths) multiplied by 100.

For an example, refer to Figure 2.4. The top stadia hair reading is 1.38 and the bottom stadia hair reading is 0.68. Thus, the stadia interval is equal to 1.38 minus 0.68 or 0.70 metre. The distance from the instrument to the rod is equal to 0.70 multiplied by 100 which gives a distance of 70 meters.

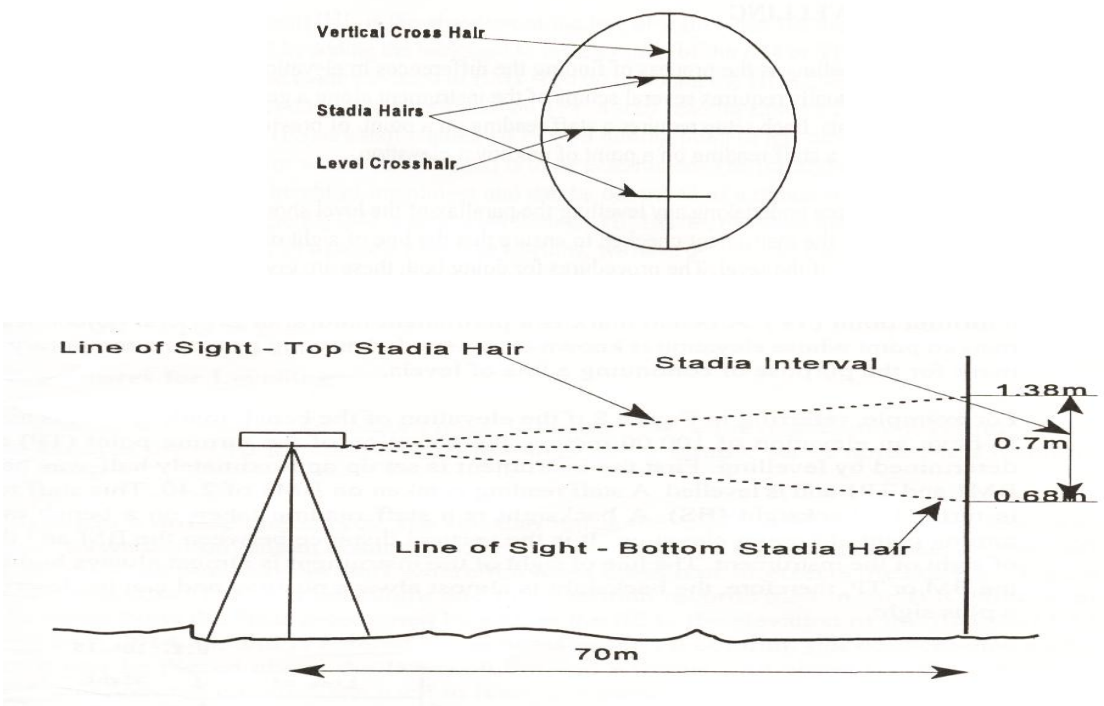


Figure-3.5: Measurement of distance by Stadia Method

Precautions for Surveying :

- Bubble should be centered carefully and it should be re-checked continuously during conducting surveying.
- Tripod should be set at suitable height so that field officer can easily take the reading.
- Foot screws of level set should be tightened properly.
- Tripod legs should be properly fixed in the ground.
- Pass on necessary instructions to the rod man before starting the survey.
- Rodman should be directed before start of survey that rod should always be kept in state.
- Staff rod should be checked before conducting survey so that it may not cause error.
- Survey should be preferably conducted in the morning or in the evening.
- Bench Marks should be established at proper and permanent places and their elevation should be marked, if possible.
- Ground should be leveled before taking the readings at turning point/change point and reading should be taken very carefully.
- Level set should be handled and shifted carefully.
- Acre numbers, square numbers and station distance should be carefully written on the field book.
- Level set should be handled and shifted very carefully.
- Survey must be closed.
- Level set equipment should be carefully packed after doing job.

Chapter – 4

Checking and adjustment of Instruments

A number of checks are conducted before using the instrument (Dumpy Level) for getting correct information. There are usually three types of checks before using the instrument in the field.

i. Parallax.

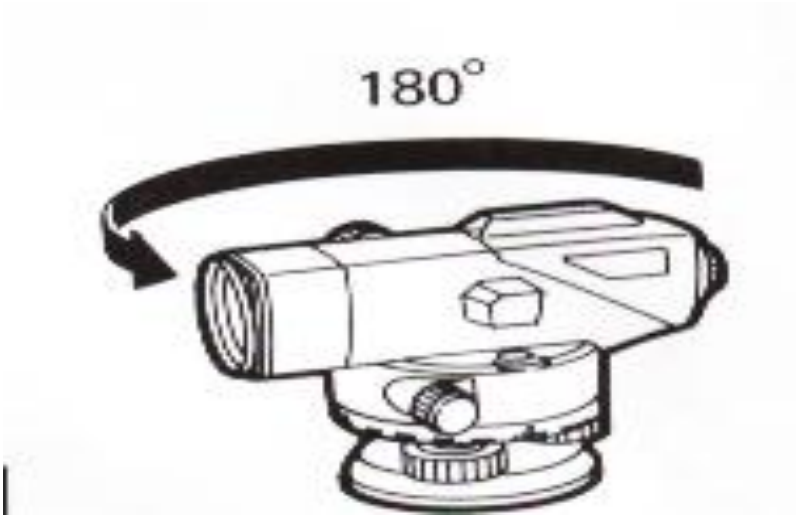
It is the apparent movement of the image relatively to the cross-hairs when the image formed by the objective does not fall in the plane of the diaphragm. It is due to poor focusing of the objective. It can be tested by moving the eye up and down. If the focusing is correct, the image appears fixed to the cross-hair when the eye is moved up and down. If the image appears to move in the same direction as that of the eye, it is in front of the diaphragm, and the objective must, therefore, be moved inwards by the focusing screw. If, however, the image appears to move in the direction opposite to that the eye, it is beyond the diaphragm towards the eye-piece, and the objective has, therefore, to be moved outwards by the focusing screw. The parallax is a source of error in observations and must therefore, be eliminated entirely by focusing the eye-piece for distinct vision of the cross-hairs, and then by focusing the objective. It may be noted that the parallax is wholly eliminated by means of the focusing screw.

It should be remembered that the adjustment of the eye-piece for distinct vision of the cross-hairs, when once made, requires no further attention, provided only one person is using the instrument, since it depends only upon the eyesight of the observer, but the objective must be focused whenever the distance of the staff from the level is changed.

ii) Checking for centrality of bubble

1) Adjust the leveling foot screws to centre the bubble in the circular level.

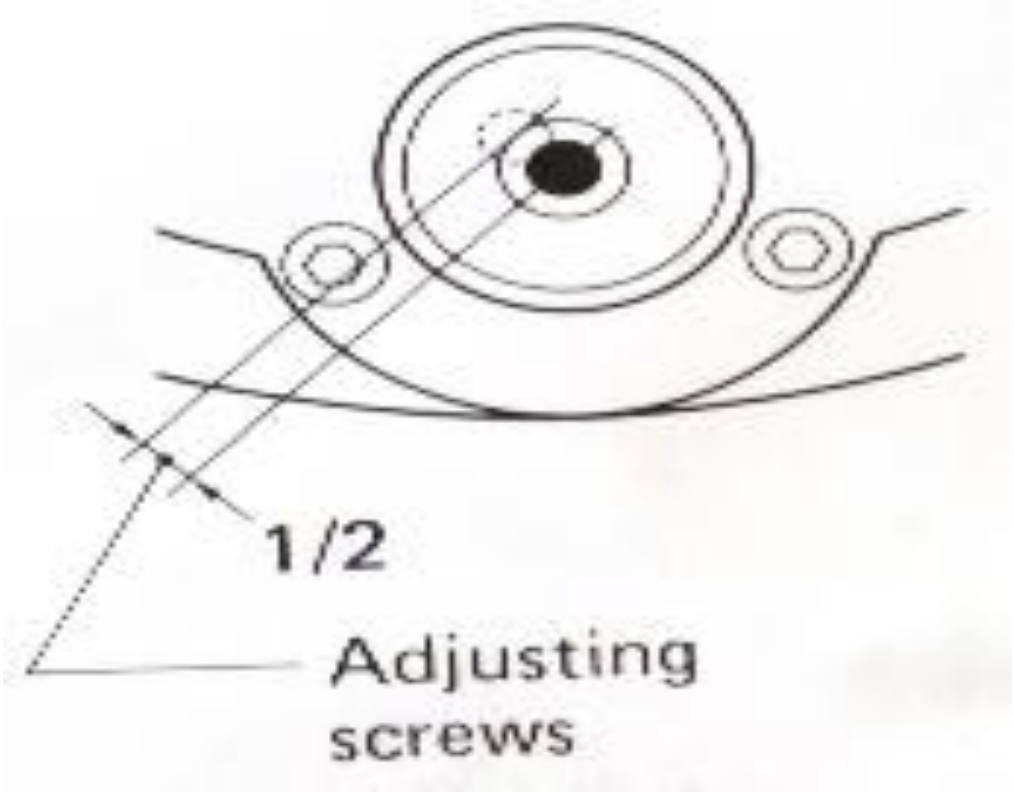
2) Turn the instrument 180^{O}



The bubble should not shift from the centre. If the bubble does move, adjust as follows:

3) Compensate for one-half of the shift by adjusting the leveling foot screws.

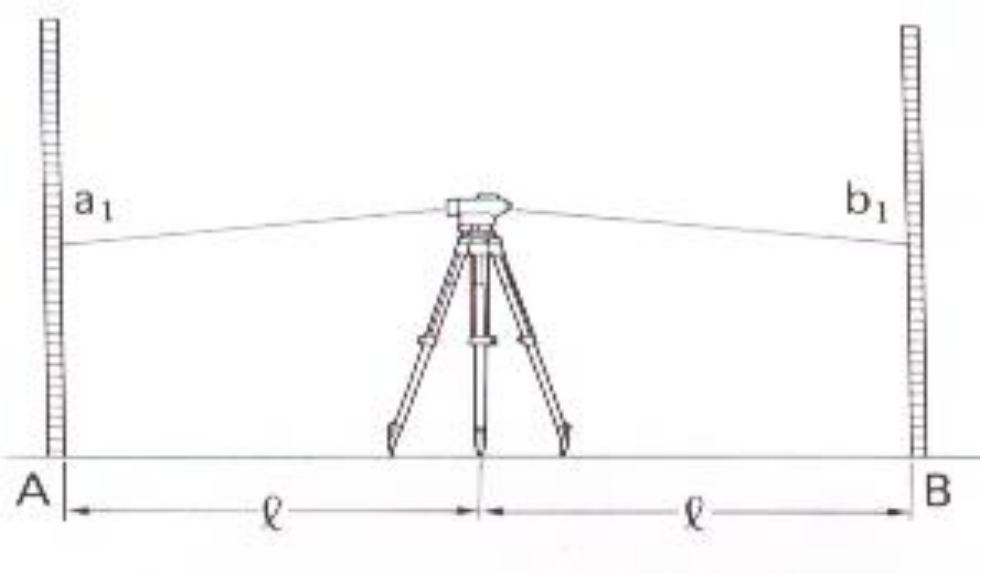
4) Eliminate the remaining half shift with the circular level adjusting screws using the hexagonal wrench.



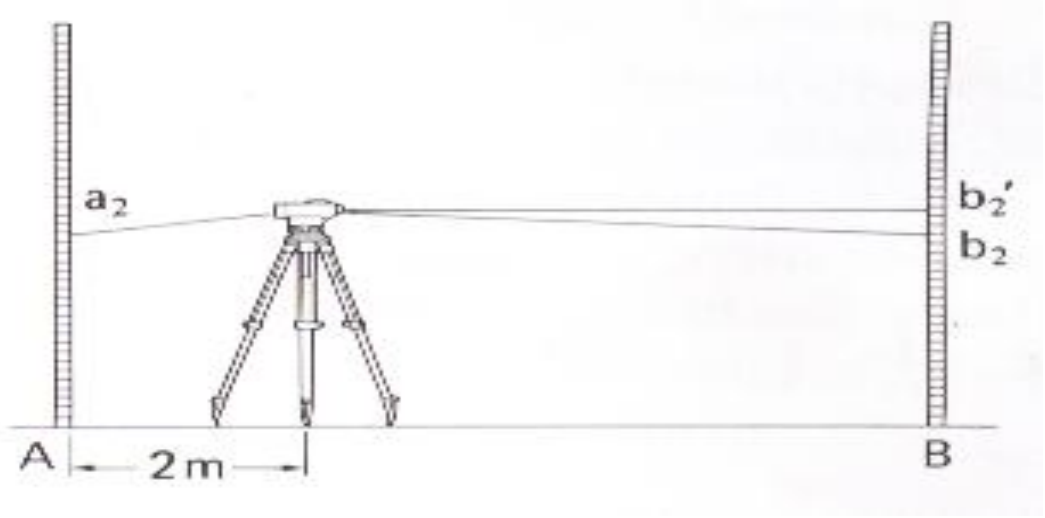
5) Repeat the above check and adjustment until no bubble shift occurs for any telescope direction.

iii) Checking Instrument for line of sight.

1) Set the instrument at a point halfway between points A and B. Take readings a_1 and b_1



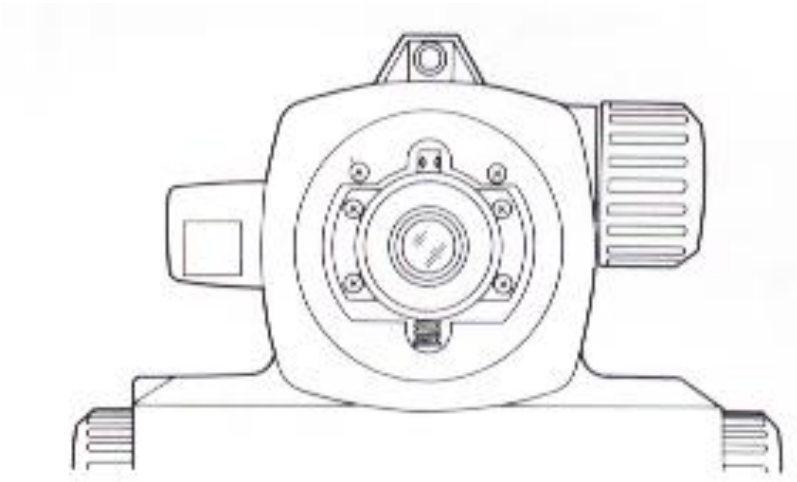
2) Set the instrument at a point 2m from point A. Take readings a_2 and b_2.



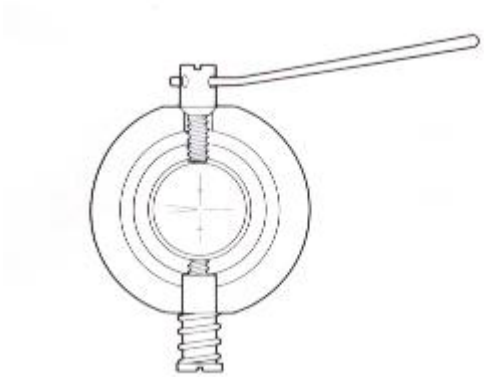
3) Leave the telescope in the foresight position.

4) Calculate b2’ = a2- (a1 – b1) If b2’ = b2, the horizontal cross line is normal and no adjustment is necessary. When the difference between b_2’ and $b_2$is great adjust the cross-line as follows

5) Unscrew and remove the adjusting screw cover



6) If the difference between b_2’ and b_2 is positive (negative), the horizontal reticle line should be raised (lowered). To raised the horizontal line, carefully, tightened the adjusting screw by a small amount using the adjusting pin. Determine the new b_2’ - b_2 difference and repeat the adjustment procedure until the difference is small. (to lower the horizontal line, loosen the adjusting the screw in the same way).



Chapter - 5

Different Types of Surveys Used in Watercourse Improvement

A number of surveys are conducted for gathering information to be used in designing and constructing the watercourse. Generally, four types of surveys are to be conducted. These include:

i) Reconnaissance Survey:

The preliminary inspection of the area to be surveyed is called reconnaissance Survey.

It is essential that the surveyor should have thorough knowledge of the ground to be surveyed and its principal features. On arriving at the ground, the surveyor should, therefore, walk over the whole area and thoroughly examine the ground so as to decide upon the best possible arrangement of the work. He should note the various boundaries, the positions of buildings, roads, streams, etc., the various difficulties that may intervene the proposed chain lines, and the suitable positions of stations. He should test the intervisibility of the selected stations by using ranging rods. The sizes of angles and the lengths of the survey lines may be estimated by eye. The lengths of the main boundaries may also be determined by pacing where feasible. Thus by careful reconnaissance, the surveyor obtains a fairly intimate knowledge of the shape and extent of the area to be surveyed, which will help him to form a fairly accurate idea of the difficulties in the work, time required for the work, and the most suitable positions for the main lines free from obstacles on the level ground. During the reconnaissance, the surveyor should prepare a neat hand sketch called an index sketch or key plan fairly resembling the plan of the ground, showing the

boundaries, the principal features such as buildings, roads, nallas, etc., the positions of the stations and chain lines which should be lettered or numbered and the directions in which the chain lines are to be measured by the arrow heads. The sketch is drawn in the field book.

Bench Mark Survey

A bench mark is a permanent established point, the elevation of which is known so it can be used as a reference point in obtaining the elevations of subsequent stations or restarting the survey. The permanent structures like the top of a mogha, culverts or nakkas along the watercourse may be used as bench marks. If nothing is available, bench marks may be constructed, using bricks, cement and sand. Bench marks are usually established in each square along the watercourse to facilitate watercourse profile survey and topographic survey of the watercourse command area. Bench marks should always be marked.

A bench mark survey is the process of determining the elevations of all the bench marks established along the watercourse. The pacca structure of mogha usually be the first bench mark whose elevation can be assumed. The figure-5.1 shows layout of Bench Marks Survey.

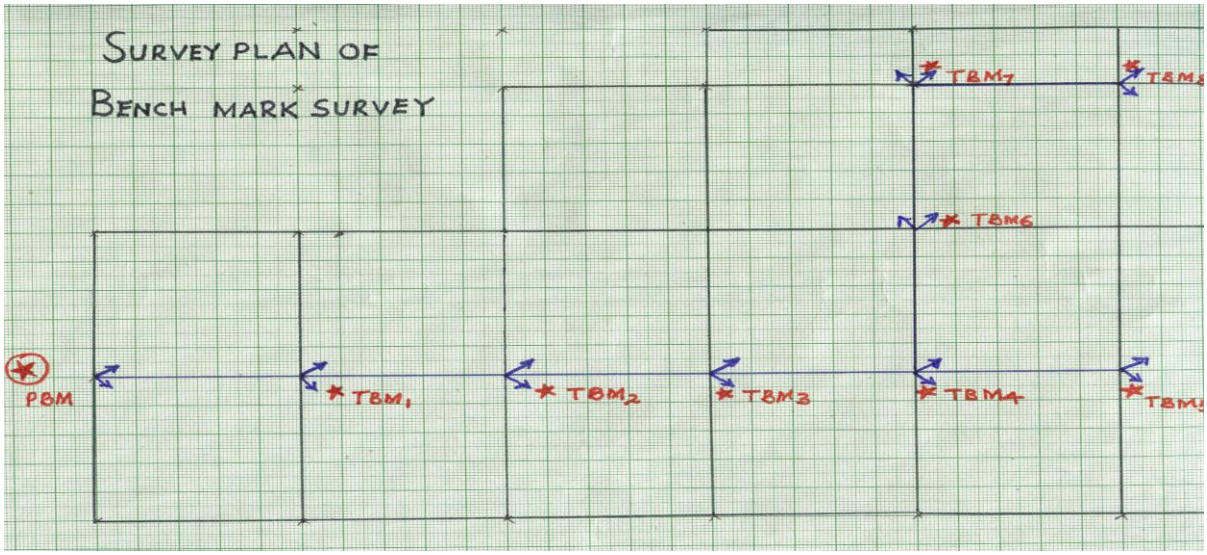


Figure 5.1 Lay Out of Bench Mark Survey

Procedure for Conducting Bench Mark Survey

1) Set up the level set at a point along the watercourse from where rod reading at top of mogha can be taken. The elevation of top of mogha is usually assumed 10.00 meter. After leveling the instrument, rod reading is taken on BM 1, say it is 0.34. This rod reading is called back sight and is recorded in the B.S column as shown in table-5.1.
2) Determine the height of instrument (H.I) by adding B.S to the elevation of B.M.1, 10.00+0.34=10.34 and enter in the H.I column.
3) Move the rod man towards B.M2 and take reading on B.M2 if possible with same set up of instrument, otherwise select a turning point (T.P). The level man takes a rod reading say 1.63 on T.P.1 and enter this in F.S column.
4) Determine the elevation of T.P by subtracting rod reading, 1.63 from the height of instrument 10.34 to give 8.71. This is entered in the elevation column.
5) The level man then picks up the level and moves away form the rod in the general direction of B.M2. He levels the instrument and takes a B.S on T.P. This is entered in B.S column.
6) A rod reading is taken at B.M2 with the same set up of instrument and entered in F.S column.
7) Determine the elevation of B.M2 by subtracting F.S from height of instrument.
8) Repeat the procedure till the elevations of all the bench marks are established.

Table-5.1: Sample Bench Mark Survey of W/C 586/L Showing Field book Enteries

Station	B.S	H.I.	F.S.	Elevation	Remarks	
BM1	**0.34**	**10.34**	**-**	**10.00**	**Elevation assumed**	
TP1	**2.45**	**11.16**	**1.63**	**8.71**		Weather Sunny, Calm.
TP2	**0.81**	**11.91**	**0.06**	**11.1**		August 20,1978
BM2	**3.98**	**11.91**	**3.98**	**7.93**		BM1=Crest of Mogha No.88230/L
TP3	**0.09**	**11.19**	**0.81**	**11.1**		BM2=Pipe culvert on
TP4	**1.98**	**10.71**	**2.46**	**8.73**		the main W/C in sq.
BM1						No.24 Surveyers: Mr. X.Y.Z

Closing of Survey.

To verify the accuracy of the leveling, a return check must be made. That is, the line of levels must be continued from BM2 back over a slightly different route to BM1, the initial starting point. To make the return check independent of the first line of levels, after the FS is taken on BM2, the engineer should lift up the level and reset it so that the HI will be at a slightly different elevation. This results in a BS on BM2 different from the FS and should result in a better check of the line of levels. When the engineer has return to BM1, he has closed the survey. All leveling exercises should be closed so that a check of the accuracy of the survey can be made.

Error of Closure.

The amount by which the original BM elevation and the BM elevation observed upon the return check fail to agree is called the error of closure.

If there have been no errors made in close survey or if the errors have been compensated, then the elevation determined for BM1 by the return check will the same as the original elevation of BM1. Generally these elevations are not the same because of errors in staff readings or instrument errors. The allowable error of the closure should not be more than 0.005 m per instrument setup.

6) **PROFILE SURVEY.**

A profile survey is the process of determining the elevations of a watercourse at a series of points at measured intervals along its length. The purpose of this survey is to determine the true slope of the water surface and watercourse bed. The stakes are usually set along the watercourse at 30, 50 or 100 meter intervals depending upon the detail required for the survey. In addition, the stakes are set at points where the watercourse changes direction. The distance along the watercourse are designated, for example, 0+00, 1+00, 2+00, etc. Remember that 0+00 designates the beginning of the watercourse. The digits to the left of the plus sign designate the distance in multiples of 100 meters and digits to the right of the plus sign designate the distance less than 100 meters. Thus, the distance 150 meters along the watercourse will be written as 1+50 meters. Fig-5.2 shows the layout of profile survey.

Procedure for Conducting Profile Survey.

i) Set the stakes at appropriate distances say 30 m along the watercourse at points where rod readings are taken.

ii) Set the instrument (Level Set) at a such a position from where maximum number of rod readings can be taken.

iii) Take the rod reading on bench mark (usually top of mogha) and determine the height of instrument.

iv) First two rod readings are taken of Bed and F.S.L of canal.

v) After wards, rod readings are taken of bed of watercourse,

vi) F.S.L of watercourse, one adjacent field on both sides of watercourse starting from the downstream of mogha upto end of watercourse.

vii) Rod readings are entered in field book as shown in the table-2.

viii) Profile is drawn as shown in figure 5.3

ix) Close the survey and check error of closure.

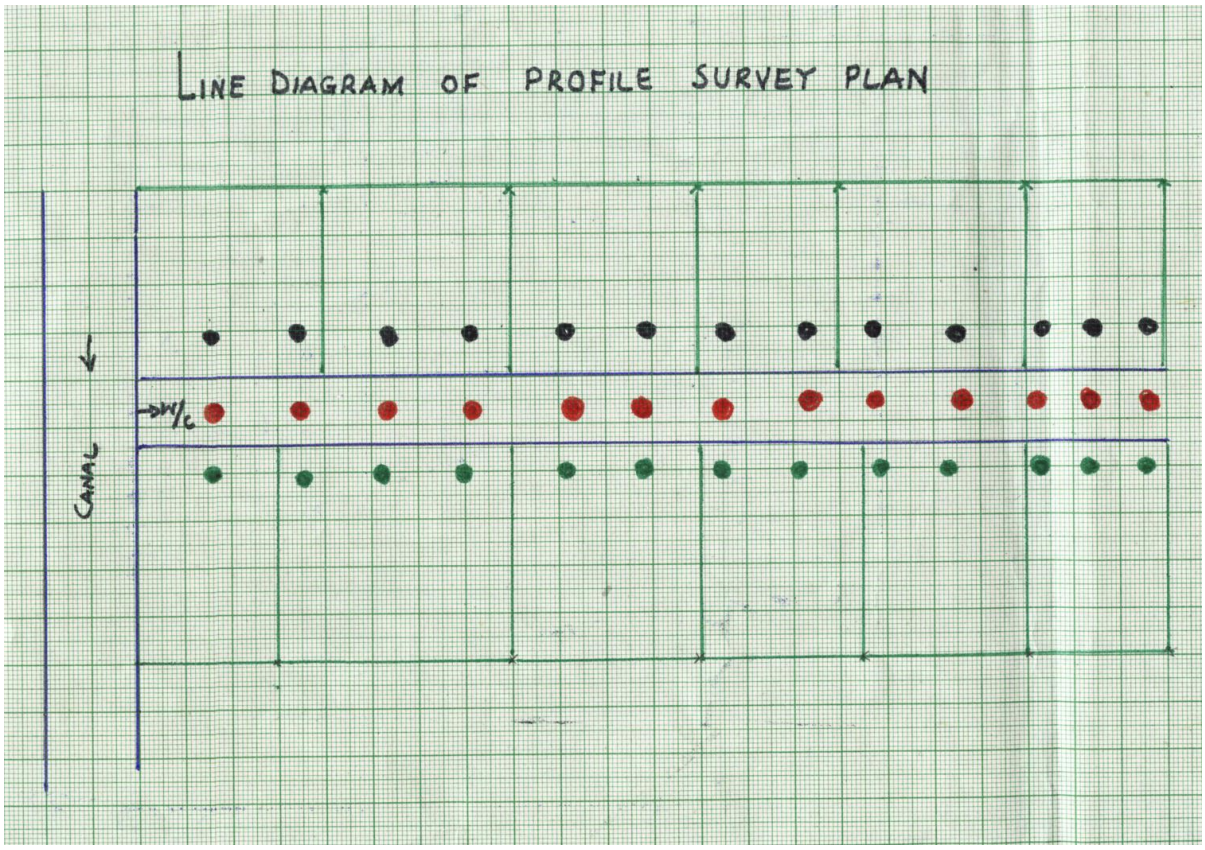


Figure-5.2: Line Diagram of Profile Survey

π-Furrukh
ϕ-Waris
Dt:16.09.2004

Table-5.2: PROFILE SURVEY OF W/C NO.586-L

RD	Station	B.S	H.I	F.S	I.S	Elevation	Remarks
0+00	P.B.M	1.56	11.56	-	-	10.00	On the pucca structure of outlet
0+00	FSL	-	-	-	2.21	9.35	
0+00	Bed	-	-	-	2.64	8.92	
0+30	FSL				2.21	9.35	
	Bed				2.64	8.92	
	L.S.F				2.38	9.18	
	R.S.F				2.38	9.18	
0+60	FSL				2.22	9.34	
	Bed				2.62	8.94	
	L.S.F				2.41	9.15	
	R.S.F				2.43	9.13	
0+90	FSL				2.22	9.34	
	Bed				2.61	8.95	
	L.S.F				2.42	9.14	
	R.S.F				2.46	9.10	
1+20	FSL				2.23	9.33	
	Bed				2.60	8.96	
	L.S.F				2.47	9.09	
	R.S.F				2.44	9.12	

1+50	FSL				2.26	9.30	
	Bed				2.64	8.92	
	L.S.F				2.46	9.10	
	R.S.F				2.49	9.07	
1+80	FSL				2.24	9.32	
	Bed				2.62	8.94	
	L.S.F				2.44	9.12	
	R.S.F				2.47	9.09	
2+10	FSL				2.26	9.30	
	Bed				2.66	8.90	
	L.S.F				2.45	9.11	
	R.S.F				2.46	9.10	
	TP1	2.10	11.18	2.48	-	9.08	
2+40	FSL				1.87	9.31	
	Bed				2.28	8.90	
	L.S.F				2.09	9.09	
	R.S.F				2.11	9.07	
2+70	FSL				1.91	9.27	
	Bed				2.26	8.92	
	L.S.F				2.08	9.10	
	R.S.F				2.07	9.11	
3+00	FSL				1.91	9.27	
	Bed				2.24	8.94	
	L.S.F				2.08	9.10	
	R.S.F				2.09	9.09	
3+30	FSL				1.92	9.26	

	Bed				2.25	8.93	
	L.S.F				2.06	9.12	
	R.S.F				2.10	9.08	
3+60	FSL				1.93	9.25	
	Bed				2.28	8.90	
	L.S.F				2.09	9.09	
	R.S.F				2.12	9.06	
3+90	FSL				1.93	9.25	
	Bed				2.27	8.91	
	L.S.F				2.10	9.08	
	R.S.F				2.11	9.07	
4+20	FSL				1.95	9.23	
	Bed				2.28	8.90	
	L.S.F				2.09	9.09	
	R.S.F				2.11	9.07	

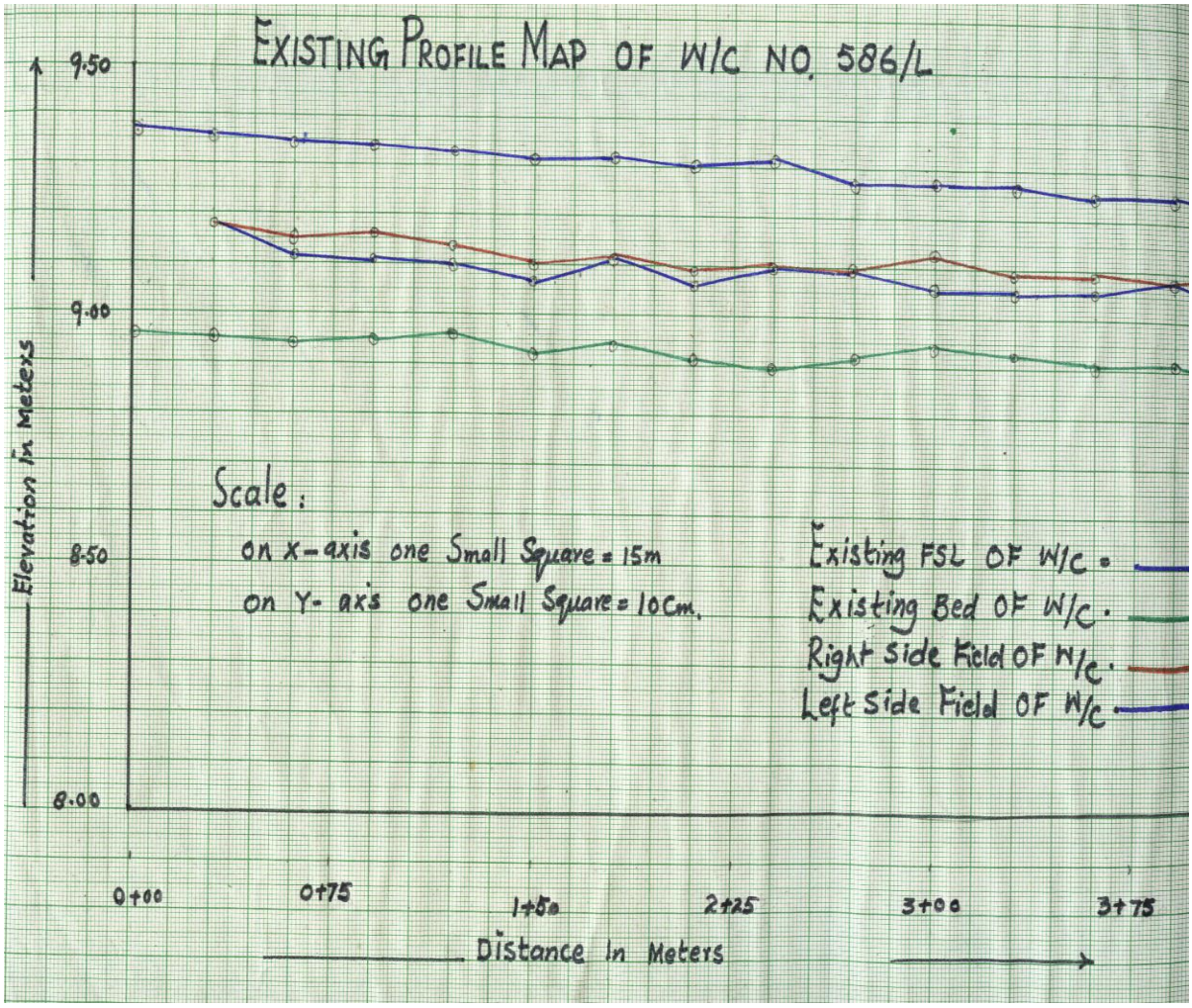


Figure-5.3: Profile Map of W/C No.586/L

TOPOGRAPHIC SURVEY

A topographic survey is the process of collecting data required for preparing a topographic map. In this survey, the arrangement of bunded units in watercourse command area with their elevations and the location of nakkas, culverts, roads and other important features of the area determined and recorded. A map obtained from the local Patwari, serves is a guide for locating the squares and acres at the time of survey. Fig-5.4 shows the layout of Topographic Survey.

Procedure for Conducting Topographic Survey:

1) Draw the existing layout map of watercourse command area showing, acres, squares and other features of the area.
2) Start the topographic survey from the nearest bench mark noting, elevations of bunded units, their dimensions, etc.
3) The elevations are recorded in field book as shown in Table-5.3.
4) Close the survey and check error of closure.
5) Draw the topographic map as shown in figure-5.4

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ϕ-Waris
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Table-5.3: TOPOGRAPHIC SURVEY OF W/C NO.586-L

Station	B.S	H.I	F.S	I.S	Elevation	Remarks
P.B.M	1.30	11.30	-	-	10.00	On the pucca structure of outlet
61/1	-	-	-	2.25	9.05	
61/2	-	-	-	2.30	9.00	

61/3	-	-	-	2.27	9.03	
61/4	-	-	-	2.15	9.15	
61/7	-	-	-	2.12	9.18	
61/8	-	-	-	2.20	9.10	
61/13	-	-	-	2.30	9.00	
61/19	-	-	-	2.15	9.15	
61/20	-	-	-	2.20	9.10	
62/1	-	-	-	2.20	9.10	
62/3	-	-	-	2.15	9.15	
62/5	-	-	-	2.30	9.00	
62/7	-	-	-	2.12	9.18	
62/9	-	-	-	2.18	9.12	
62/11	-	-	-	2.12	9.18	
62/13	-	-	-	2.17	9.13	
62/15	-	-	-	2.18	9.12	
62/17	-	-	-	2.20	9.10	
62/19	-	-	-	2.11	9.19	
62/21	-	-	-	2.13	9.17	
62/23	-	-	-	2.17	9.13	
62/25	-	-	-	2.10	9.20	
TP1	1.95	11.15	2.10	-	9.20	
63/1	-	-	-	2.15	9.00	
63/3	-	-	-	2.17	8.98	
63/5	-	-	-	2.14	9.01	
63/7	-	-	-	2.10	9.05	
63/9	-	-	-	2.16	8.99	

63/11	-	-	-	2.13	9.02	
63/13	-	-	-	2.15	9.00	
63/15	-	-	-	2.10	9.05	
63/17	-	-	-	2.08	9.07	
63/19	-	-	-	2.11	9.04	
63/21	-	-	-	2.15	9.00	
63/23	-	-	-	2.17	8.98	
63/25	-	-	-	2.19	8.96	
64/11	-	-	-	2.09	9.06	
TBM1	-	-	-	2.11	9.04	On the brick in 64/1 near W/C
69/18	-	-	-	2.18	8.97	
68/21	-	-	-	2.20	8.96	
TBM2	-	-	-	2.21	8.94	On the brick in 68/1 near W/C
72/25	-	-	-	2.31	8.84	
73/6	-	-	-	2.32	8.83	
TBM3	-	-	-	2.33	8.82	On the brick in 73/1 near W/C
72/1	-	-	-	2.32	8.83	
72/2	-	-	-	2.35	8.80	
72/3	-	-	-	2.36	8.79	
72/4	-	-	-	2.34	8.81	
72/5	-	-	-	2.35	8.80	
72/6	-	-	-	2.36	8.79	
72/7	-	-	-	2.32	8.83	
72/8	-	-	-	2.33	8.82	
72/9	-	-	-	2.33	8.82	
72/10	-	-	-	2.36	8.79	

72/11	-	-	-	2.34	8.81	
72/12	-	-	-	2.34	8.81	
72/13	-	-	-	2.34	8.81	
72/14	-	-	-	2.35	8.80	
72/15	-	-	-	2.35	8.80	
72/16	-	-	-	2.31	8.84	
72/17	-	-	-	2.32	8.83	
72/18	-	-	-	2.33	8.82	
72/19	-	-	-	2.36	8.79	
72/20	-	-	-	2.35	8.80	
72/21	-	-	-	2.35	8.80	
72/23	-	-	-	2.32	8.83	
72/24	-	-	-	2.31	8.84	
72/25	-	-	-	2.31	8.84	
73/19	-	-	-	2.37	8.78	
TBM4	-	-	-	2.30	8.85	On the brick in 78/1 near W/C
79/11	-	-	-	2.37	8.78	
78/15	-	-	-	2.39	8.76	
83/9	-	-	-	2.45	8.70	
84/12	-	-	-	2.45	8.70	
71/17	-	-	-	2.45	8.70	
80/18	-	-	-	2.46	8.69	
70/25	-	-	-	2.55	8.60	
81/24	-	-	-	2.56	8.59	
82/8	-	-	-	2.66	8.49	

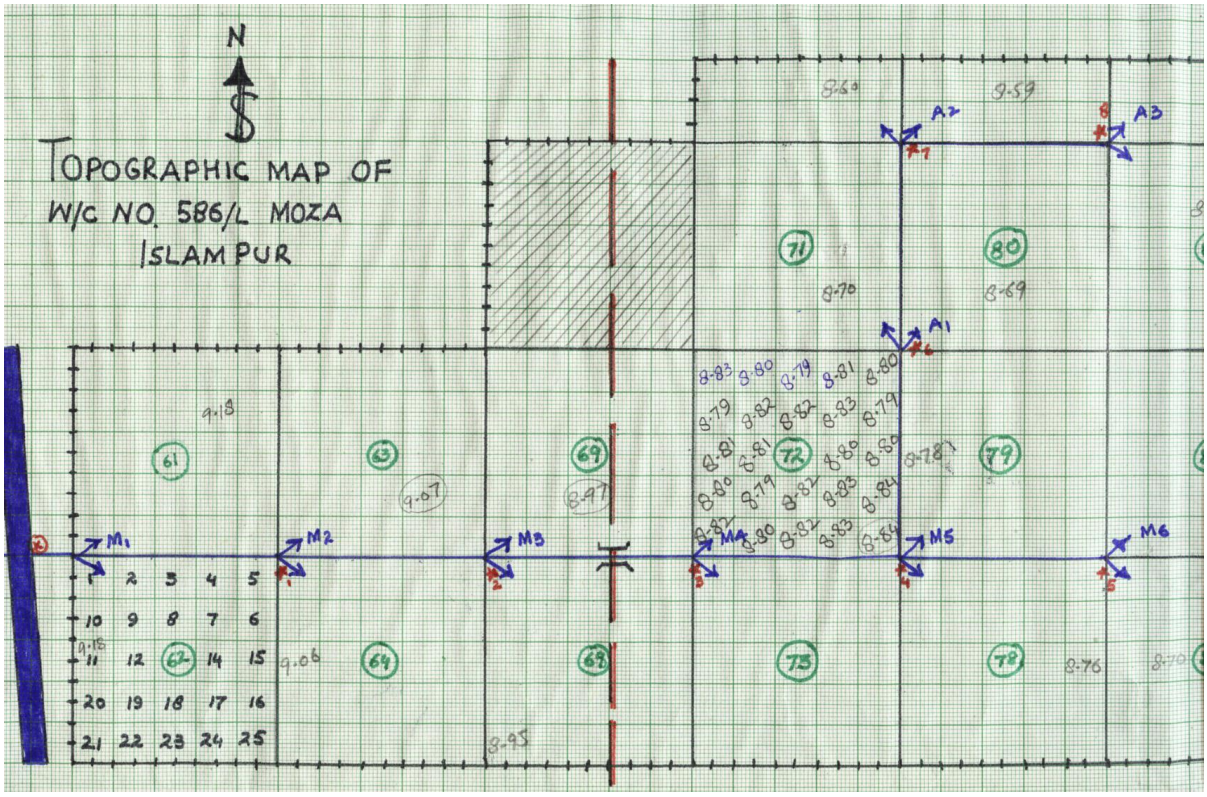

Figure-5.4: Topographic Map of W/C 586/L

Chapter – 6

Mapping and Contouring

Contour: Contour is a line of equal elevation. Contours are drawn for many purposes. The major uses of contours are following.

Use of Contours.

- **i.** By inspection of a contour map, information regarding the character of the tract of the country is obtained; whether it is undulating or mountainous, etc.
- **ii.** The most economical or suitable site for engineering works such as a reservoir, canal, sewer, road, or railway may be approximated.
- **iii.** Contours may be used to determine the area of the drainage basin and the capacity of the reservoir.
- **iv.** The sections may be easily drawn in any direction from the contours.
- **v.** Intervisibility of two given points can be ascertained from the map.
- **vi.** A route of a given grade line can be traced on the map.

Properties of Contours

1. Contour lines can never cross each other. In very steep areas two lines may touch, but never cross.
2. Adjacent contour lines are either of the same height or a vertical interval higher or lower.
3. A contour line cannot end, it must form a closed loop even though this may not be on the map.
4. The contours on either side of a particular line both be greater or smaller than middle line.

Procedure for Drawing of Contours.

Contours are most commonly drawn by conducting a grid survey. Following steps are taken to draw contours from grid survey.

Step-1: A square grid of stakes is set across the area to be surveyed at an appropriate distance apart.

Step-2: The elevations of ground at each stake is determined using level set.

Step-3: The location of stakes is plotted on the map and elevation is recorded against each stake as shown in Figure-6.1

Step-4: Take difference of highest and lowest field elevations i.e. 7.20 m

Step-5: A suitable vertical contour interval is determined depending upon the steepness of topography, keeping in view the elevation difference i.e 0.9 m

Step-6: Add contour interval to the lowest field elevation to draw the first contour line. I.e. 50.1 + 0.9 = 51.0

Step-7: Draw contour line of said elevation by interpolating between lower and higher elevations.

Step-8: Continue the process until highest field elevation is reached.

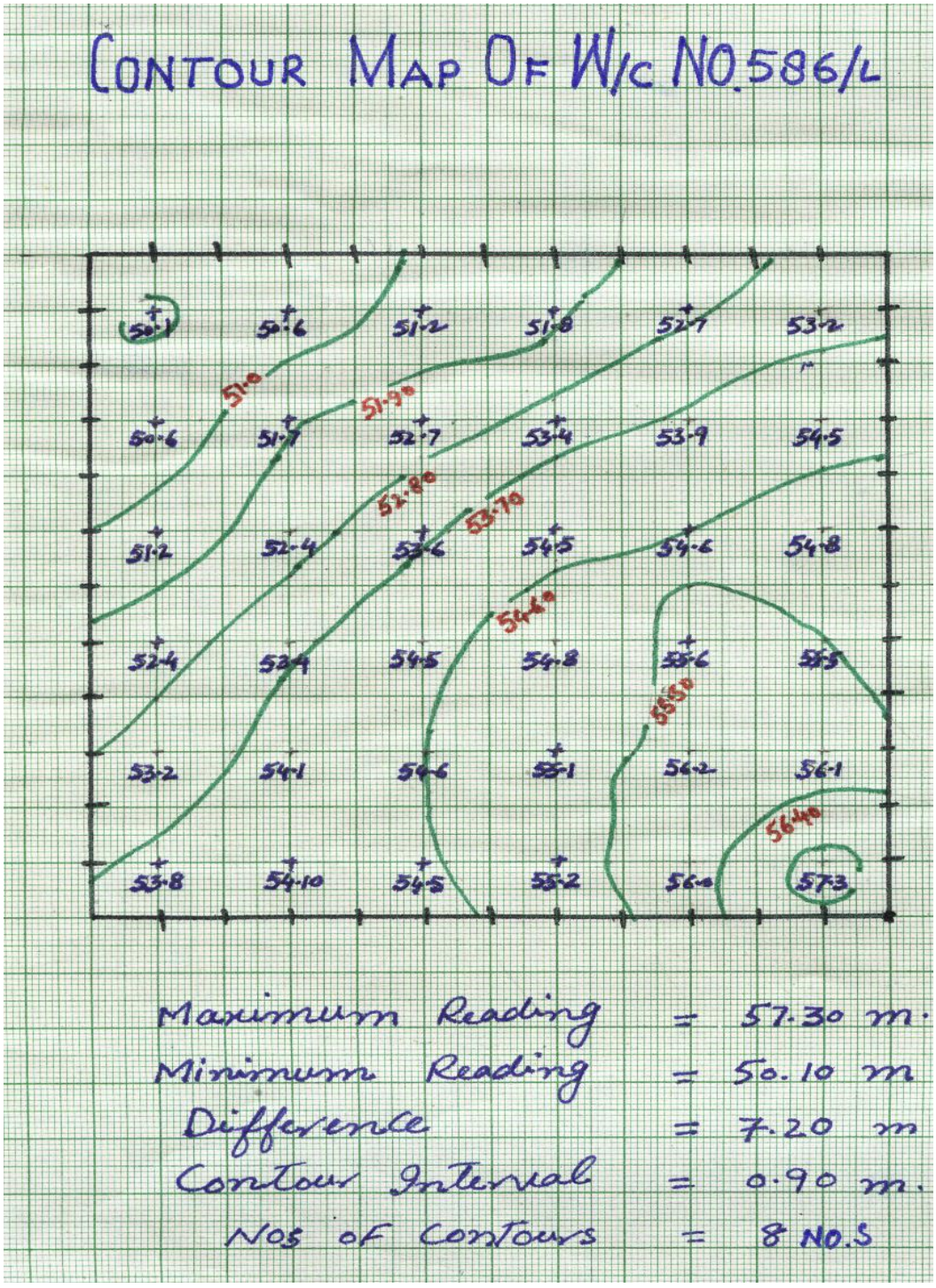

Figure-6.1: Contour Map of W/C 586/L

Mapping: The result of gathering data utilizing the survey techniques is the production of a topographic map. The topographic map is a scale drawing of a portion of earth survey showing natural and artificial features of land and showing variation of elevation of the earth surface.

Topo maps are widely used in engineering works. Maps are used in connection with construction projects, irrigation and drainage problems.

A topographic map of the proposed area is essential for planning and design process. In most cases, a suitable map will not be available and it will be necessary to carry out topographic survey of the area. Topographic map of watercourse command area or similar such agricultural areas are best representation of survey taken for that area. Thus the maps should be neatly plotted in a standardized format and actual representation of the topography of the area. The following points must be considered for plotting the best map.

1. The canal irrigated area of the Punjab is laid out in a regular grid pattern aligned roughly North/South. The smallest unit is an acre, which measures 60m by 66m in the north/south and east/west direction respectively. The individual 1 acre blocks are combined into 25 acre block (5x5) which are demarcated in field by wider bunds. These boundaries are called "Cut lines". To represent the areas on map, scale 1:5000 (1cm=50m) is used. Therefore one acre block would measure 12mm by 13.2 mm on the map.
2. Determine the North direction in the field and it should be represented on the top of map with proper sign.

   The following is field method for determine North direction.

   Establish a point O in the field and insert a perpendicular rod at this point in the field as shown in figure 6.2. Mark a circle from center O. Now mark points on circle where reflection of perpenducular rod touches the circle before and after noon 12 O clock. That will be point a1 and a2 and draw line between a1 x a2. Draw a perpendicular from center O which cut the line a1 x a2 from its center. This will represent (ON) North direction.

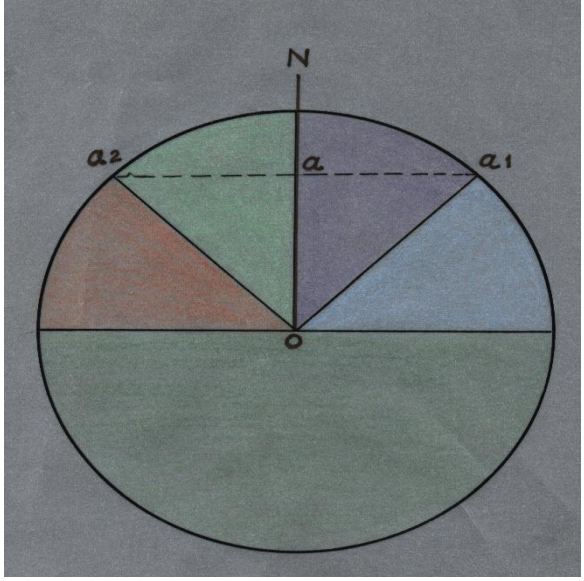

Figure-6.2: Determination of North Direction

3. Establish the horizontal distances according to scale in X and Y directions on map and mark Sq.No., acres No.
4. Draw the exact position of existing and proposed channel, watercourses, structures, roads, railway and house on map.
5. Incorporate the elevations (vertical) of each field and location of all bench marks should be clearly marked on map.
6. Standard legends should be used on the map. The standard legend adopted by On Farm Water Management are shown as under

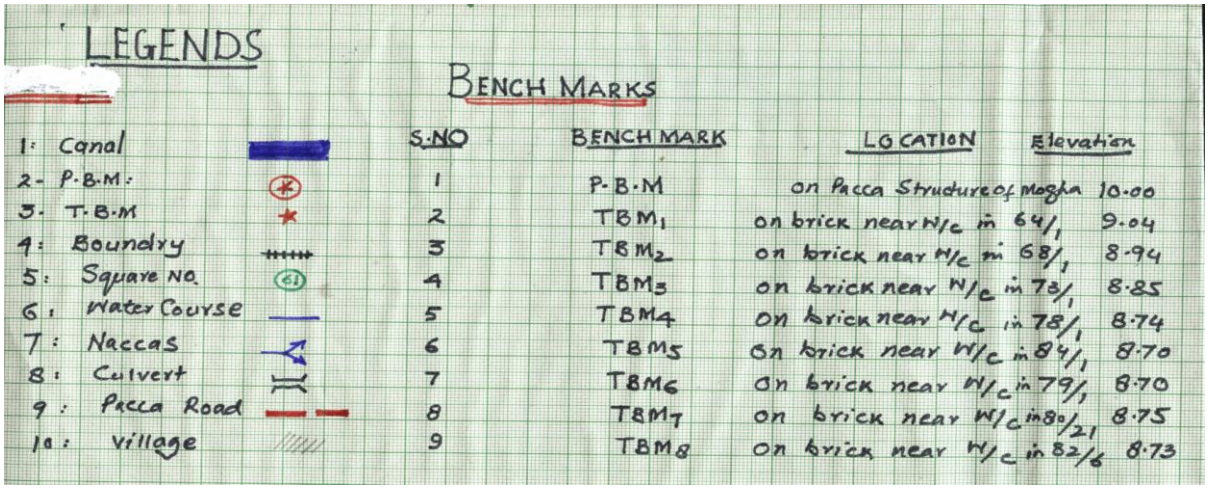

Figure-6.3: Standard Legends

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