3. DETAILED INVESTIGATION

3.1 DETAILS SURVEY

After the final selection of the bridge site, the surveyor proceeds with a detailed investigation of the selected site. The detailed investigation includes tentative bridge position, its area, geo-technical survey of the area, topographic survey, site photographic survey and miscellaneous data collection.

3.1.1 Survey Layout

Once a preliminary design of the bridge is acceptable, the type of the bridge, its span, the probable locations of its foundations are guessed. As per the requirement of wind-guy arrangement determined by the technical criteria, probable area and locations of foundations are also laid out.

A sketch plan and profile of bridge with proposed positions of foundations has to be drawn at site. Minimum Area to be covered by the topographic survey:

For bridges **without wind-guy** arrangement,

- A profile along the bridge axis covering up to 25m behind the main anchorage blocks.

For bridges **with wind-guy** arrangement,

- A profile along the bridge axis covering up to 25m behind the main anchorage blocks **and** a topographic plan covering the area of 10m upstream and 10m downstream from the tentative location of the wind-guy foundations.

In suspension type of bridge, in the preliminary design, the backstay distance from tower position is assumed for maximum tower height. The survey area should cove 10m back of main anchor foundation.

3.1.2 Geological Survey

The detailed geological survey is carried out after the final selection of the bridge site/axis. In case of SSTB bridges, geological survey as per chapter 2.3.1 is sufficient. No further study is necessary.

In case of LSTB bridges, further detailed geological survey is necessary as per following checklist.

Check List no. 3	for rock investigation of each sample found at the site.
Check List no. 4	for geological plane investigation for exposed rock around the foundations and banks.
Check List no. 5	Transit Cross Profile (optional, only required when the geological condition of the site is very dough full)
Check List no. 6	for soil investigation of each excavated open pit around the foundation location.

Check List No.3: Rock Investigation

Bridge Name: ____________________ Name: __________________________

Location: _______________________ Bank: ___________________________

S.N.	Description	Sample			
		1	2	3	4
1.	General Information				
1.a	Location				
1.b	Bank				
1.c	Sample depth				
1.d	Photo no.				
1.e	GPI no.				
2.	Identification Procedure				
2.a	Layers				
2.b	Hammer sound test (hardness)				
2.c	Bounding of grains / layers				
2.d	Quartz test (scratch hammer)				
2.e	Calcite test (Hcl reaction)				
2.f	Texture (grain size & shape)				
2.g	Colour				
2.h	Fracture pattern				
2.i	Bedding (with thickness)				
2.j	Special characters				
3.	Rock type				
4.	Weathering grade				
5.	Photograph no.				

Remarks:

1.a tower, TA or Main anchorage MA
1.e geological plane investigation (check list no. 4)
2.a. No/yes, laminated, foliated, banded
2.b Brittle / dull
2.c well / not well
2.d no / yes, slight / strong / very strong, at joint or at rock mass
2.f coarse / medium / fine / very fine / angular / rounded
2.h plane / curve, regular / irregular
2.i clear / not so clear / not clear
4. sound (I), fairly weathered (II), highly weathered (III)

Check List No. 4: Geological Plane Investigation (GPI)

Bridge No.: ___________________________ Name: _________________________________

Location: ______________________________ Bank: __________________________________

Type of Rock: __________________________ Sample No.: ____________________________

Weathering grade: ______________________ GPI No.: _______________________________

Type of plane (1)	Dip of rock or plane	Number per m length or spacing	Two dimension extension in % (2)	Surface texture (3)	Opening in mm	Filling or coating (4)	Remarks (5)

Remarks:

1) such as fracture, shear, seam, major or minor fault, bedding, slope
2) 100% for continuous plane
3) smooth, slightly smooth, rough, very rough
4) clay, calcite, silt, sand, etc
5) use coding like “watch out”, “forget” , etc

Check List No. 5: Transit Cross-Profile

Bridge No.: ____________________________ Name: ___________________________________

Location: _______________________________ Bank: ___________________________________

Station	Azimuth	Slope		Distance	Geological observation within the profile (with sketch)
		+	-		

Check List No.: 6 **Soil Investigations**

Bridge Name: ______________________ Bank: __________________________________

Bridge type: _______________________ Location: _______________________________

Pit No.: ___________________________ Investigated by: _________________________

Date: ____________________________

Soil section for each stratum (sketch)	Depth from surface (m)	Sample no.	Compactness	Grain shape	USCS soil classification & color of each stratum	Boulders in size > 60mm diameter			Wetness	Permeability	Geological denomination	Remarks
						Max. size (mm)	% of volume	Rock type				
		Compactness H: high M: Medium L: Low		Shape A: Angular SA: Sub angular R: Rounded					W: wet D: dry WT: water table	P: Pervious SP : semi pervious I: impervious	Soil type by origin	

Remarks:

Pit size: min 80cm x 150cm
Pit depth: up to estimated bottom of the foundation or to the bedrock

3.1.3 Selection of the Detail Design Parameters

CHECK LIST NO. 7: DESIGN PARAMETERS

Bridge No: **Name:** **Checked by:**

Parameter	LEFT BANK				RIGHT BANK			
	Tower Foundation	Main (Cables) Foundation	Windguy Cable Foundation		Tower Foundation	Main (Cables) Foundation	Windguy Cable Foundation	
			Up-stream	Down-stream			Up-stream	Down-stream
Subsoil								
at depth (m)								
USCS Classification								
ϕ_1 (deg)								
γ_2 (kN/m^3)								
σ_{perm} (kN/m^2)								
G.W.L at depth (m)								
min. Embedding (m)								
Back-filling								
ϕ_2 (deg)								
γ_2 (kN/m^3)								
Rock								
type								
at depth (m)								
ϕ_{SL} (deg)								
σ_{perm} (kN/m^2)								
k-Value (/)								
min. Embedding (m)								
Rock stabilization at base:								
- back half (single)								
- front half (sing./double)								
- dir./incl. (gon)								

3.1.4 Miscellaneous Data Collection

The surveyor has to collect information about availability of construction materials such as sand, boulders, gravels etc. Also information about the local labour rate, porter rate, availability of labour, etc. has to be collected.

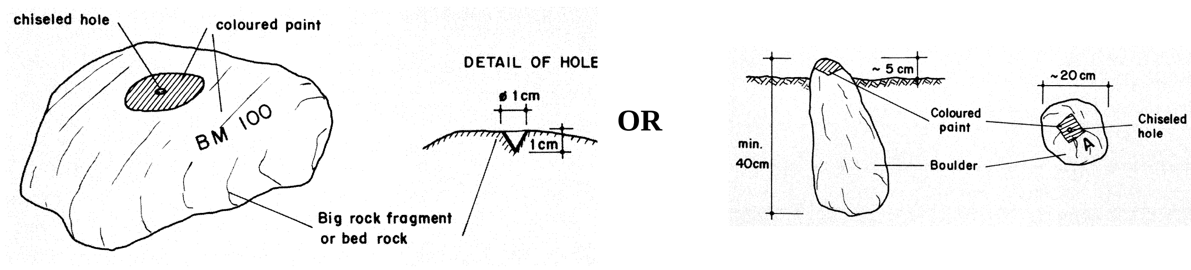
3.2 TOPOGRAPHIC SURVEY

After the final selection of the bridge site, the surveyor proceeds with the topographic survey.
The purpose is to:

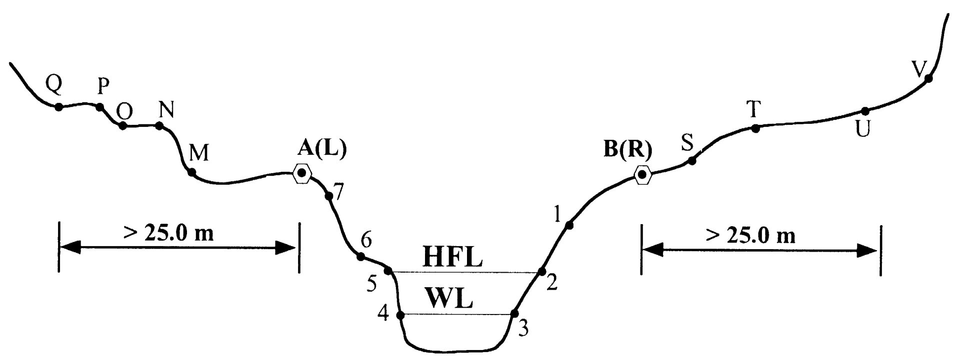
- provide a topographic map of the bridge site with details relevant to the bridge design
- establish axis pegs and bench marks for use during construction of the bridge

3.2.1 Setting of Bridge Centerline

Fix the bridge centreline with two permanent axis points **A (or L)** on the left bank and **B (or R)** on the right bank. The permanent axis points **A** and **B** should be fixed on a rock outcrop along the bridge centreline, if available. If a rock outcrop is not available, these points should be marked on a boulder sufficiently embedded in the ground as per the sketch below:

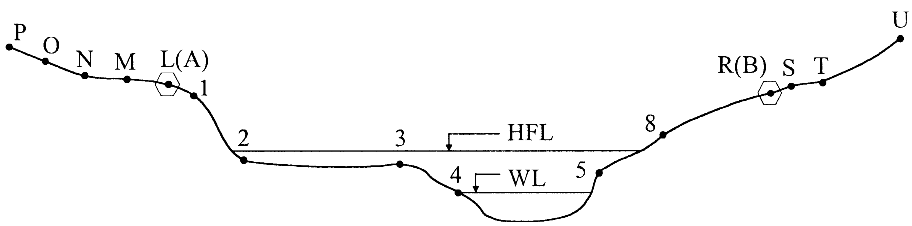


In the SSTB standard, only a cross section of the bridge axis is sufficient.
Additional survey points along the centreline should be fixed to survey the bridge axis profile as shown in the sketch below. These survey points should be fixed at the breaking points of the slope and terraces, which will accurately indicate the topography of the bridge axis. The profile should extend 25 m behind the main anchorage block up to the edge of the river flow.

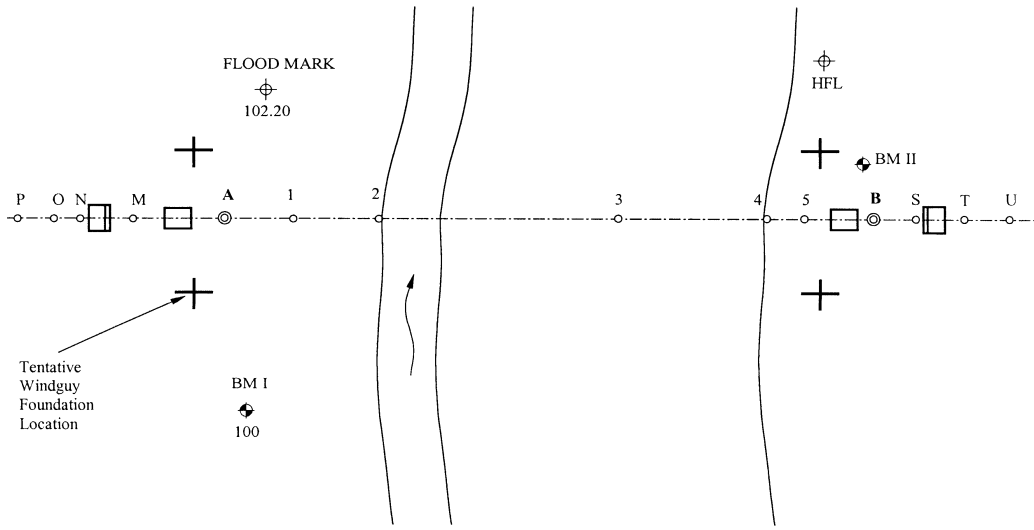


Draw a sketch of the profile/cross section of the bridge axis (centreline) showing the axis points **A** and **B**, all the survey points and topographic features, including the tentative position of the bridge foundations, low water level and high flood level.

Profile/Cross Section (Example)



Draw a plan view showing the bridge axis (centreline), axis points **A** and **B,** all the bench marks and fixed objects like trees, houses, etc. Give the distances and directions from the reference points so that the axis points and benchmarks can be located during the construction. A plan view is necessary only when a windguy arrangement needs to be considered in the bridge design.



Plan (Example)

3.2.2 Survey Methods

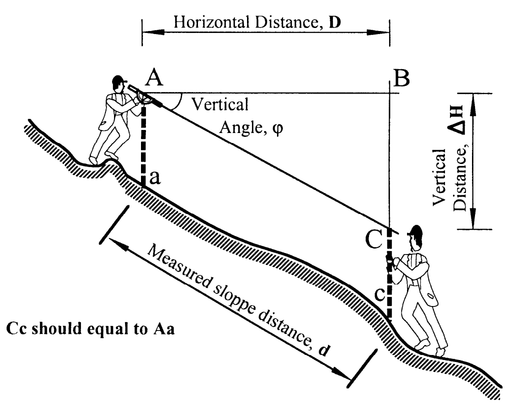
There are two options for conducting the topographic survey. Depending upon the span and type of the bridge, a profile along the bridge axis or a more detailed survey including contour lines will be necessary.

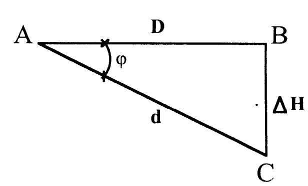
In general a Windguy Arrangement is not required for bridges with spans up to 120 m.

- A detailed **profile** along the selected bridge axis is sufficient for bridges without a windguy arrangement. A topographic profile can be made with an Abney level, however for fixing the precise levels, a Level Instrument is necessary.
- For bridges requiring a windguy arrangement, a more detailed topographic survey is necessary, from which a detailed contour plan can be plotted. A Theodolite should be used to conduct this type of survey.

3.2.2.1 Survey by Abney Level

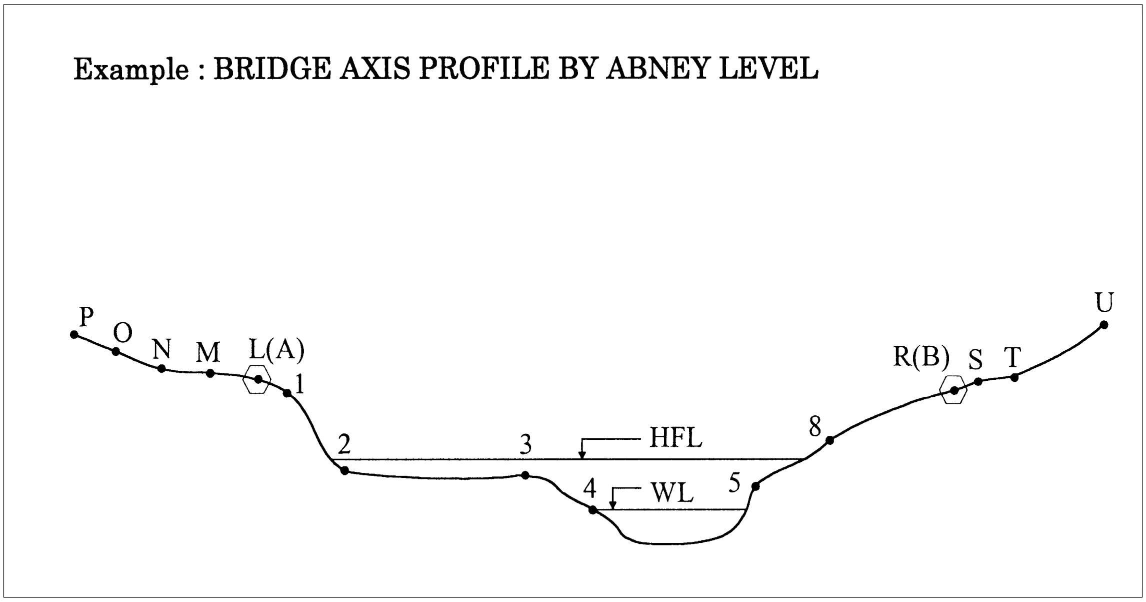
The main function of the Abney Level is to measure the **vertical angle** φ. By measuring the slope distance **d** between the survey points with a measuring tape, the horizontal distance **D** and the vertical difference of elevation **ΔH** can be calculated. The calculation is as below (refer to sketch):





Horizontal distance, $D = d \times \cos\varphi$

Vertical distance, $\Delta H = d \times \sin\varphi$



Bridge Name : Tokre Ghat	District : Nawalparasi	Surveyed by : Chuda Mani	Date : 27.11.2055

STATION	POINTS	SLOPE DISTANCE d m	VERTICAL ANGLE [Observed] φ	VERTICAL ANGLE [Corrected] φ'	HORIZONTAL DISTANCE D m	VERTICAL DISTANCE ±	VERTICAL DISTANCE ΔH	REDUCED LEVEL (ELEVATION) H m	REMARKS (Description of Points)
A	B		-0°50'	-1°10'					Observation for vertical
B	A		+1°30'	+1°10'					angle error correction
A								**100.00**	Datum Level (Assumed)
	M	3.35	+7°20'	+7°0'	3.32	+	0.40	100.41	
	N	8.00	+6°20'	+6°0'	7.95	+	0.84	100.84	
	O	13.00	+11°0'	+10°40'	12.77	+	2.40	102.40	
	P	17.25	+13°0'	+12°40'	16.83	+	3.78	103.78	
	1	4.20	-23°40'	-24°0'	3.84	-	1.70	98.30	
	3	27.50	-18°40'	-19°0'	26.00	-	8.95	91.05	HFL= El_3+1.0m
	4	34.90	-19°40'	-20°0'	32.80	-	11.94	88.06	
	5	47.30	-15°10'	-15°30'	45.58	-	12.64	87.36	Water Level (WL)
B								**98.67**	
	3	41.80	-10°10'	-10°30'	41.10	-	7.62	91.05	
	8	12.40	-19°40'	-20°0'	11.65	-	4.24	94.43	
	S	2.80	+19°30'	+19°10'	2.64	+	0.92	99.59	
	T	5.45	+14°40'	+14°20'	5.28	+	1.35	100.02	
	U	15.20	+23°30'	+23°10'	13.97	+	5.98	104.65	
3								**91.05**	
	2	17.00	+1°50'	+1°30'	17.00	+	0.44	91.49	
	B	41.80	+10°50'	+10°30'	41.10	+	7.62	98.67	

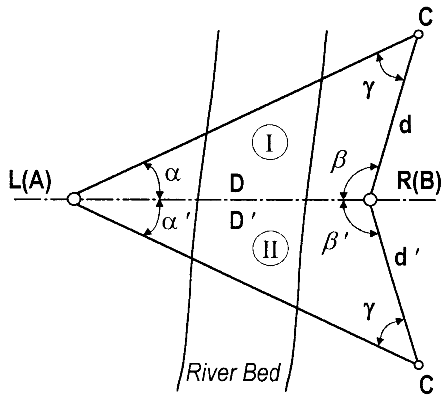
3.2.2.2 Survey by Theodolite

When the span of the bridge is more than 120 m or when a windguy arrangement needs to be included in the bridge design, the survey is conducted with a theodolite.

For proper use of a theodolite, refer to the respective instruction manual that comes with the theodolite or Reference 4: LSTB Manual.

Profile Along Bridge Axis:

Fix the bridge centreline as described in Chapter 3.2.1. Measure the distance between the axis points **A** and **B** by the horizontal triangulation method. Triangulation is done by measuring all three angles of a triangle and the length of one side, as illustrated in the sketch below and in the example given on the following page.



For accuracy, double triangulation is necessary. The procedure is:

Ist Triangulation

1. Set out a peg at **C** in such a way that the distance **B - C** can be easily measured. The length 'd' should be at least 20% of the distance **A - B**
2. Measure the distance **B - C** = **d** accurately with a measuring tape. Measure this distance several times and calculate the mean distance.
3. Set up the theodolite at **B** and measure the horizontal angle ∠ **ABC = β** from face left and face right
4. Set up the theodolite at **C** and measure the horizontal angle ∠ **ACB = γ** from face left and face right
5. Set up the theodolite at **A** and measure the horizontal angle ∠ **BAC = α** from face left and face right
6. Sum up these angles **(δ=β+γ+α)**, which should theoretically be equal to 180° or 200g. If the sum is not equal to 180° or 200g , the difference Δ should be equally distributed to all the three angles so that the sum becomes 180° or 200^g
7. Calculate the distance **A – B = D** using the trigonometric formula, **D** = $\frac{d \times \sin\gamma}{\sin\beta}$

IInd Triangulation

1. Repeat the procedure as above and calculate the distance **A – B = D'**
2. Calculate the final distance **D =** $\frac{D + D'}{2}$

   Use the standard form "Triangulation" for recording the readings and calculations as given in the example on the following page.

Example:

TRIANGULATION

Bridge Name : Kolimora District : Achham Surveyed by : L . N . Tripathi Date : March 1997

1st Triangulation

Sketch:

d_1 = 10.836
d_2 = 10.840
d_3 = 10.838
d_{mean} = 10.838 m $D = d_{mean} \times \frac{\sin\gamma}{\sin\beta}$ = 127.034 m

INSTRUMENT STATION	PEG	HORIZONTAL CIRCLE FACE RIGHT	HORIZONTAL CIRCLE FACE LEFT	ANGLE FACE RIGHT	ANGLE FACE LEFT	ANGLE MEAN	
A	B	000.000	199.994	161.558	161.558	161.558	$= \alpha_o$
	C	161.559	361.552				
B	A	000.000	199.998	2.883	2.883	2.883	$= \beta_o$
	C	397.117	197.115				
C	A	000.000	199.992	35.570	35.570	35.570	$= \gamma_o$
	B	35.570	235.562				
					$\delta = \alpha_o + \beta_o + \gamma_o =$	200.011	

$\Delta = (200^g \text{ or } 180^o) - \delta$ = − 0.011
$\alpha = \alpha_o \pm \Delta/3$ = 161.553
$\beta = \beta_o \pm \Delta/3$ = 2.880
$\gamma = \gamma_o \pm \Delta/3$ = 35.567

If $\delta > \pm\ 0.02^g$ or 0.018^o repeat the angle readings

2nd Triangulation

Sketch:

d_1 = 12.163
d_2 = 12.161
d_3 = 12.165
d_{mean} = 12.163 m $D = d_{mean} \times \frac{\sin\gamma}{\sin\beta}$ = 127.113 m

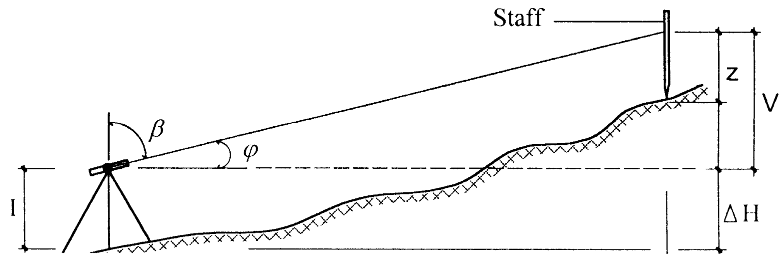
INSTRUMENT STATION	PEG	HORIZONTAL CIRCLE FACE RIGHT	HORIZONTAL CIRCLE FACE LEFT	ANGLE FACE RIGHT	ANGLE FACE LEFT	ANGLE MEAN	
A	B	000.000	199.994	5.918		5.917	$= \alpha_o$
	C	394.082	194.078				
B	A	000.000	199.998	109.730	109.730	109.730	$= \beta_o$
	C	109.730	309.728				
C	A	84.353	284.351	84.353	84.351	84.352	$= \gamma_o$
	B	000.000	200.000				
					$\delta = \alpha_o + \beta_o + \gamma_o =$	199.999	

$\Delta = (200^g \text{ or } 180^o) - \delta$ = + 0.001
$\alpha = \alpha_o \pm \Delta/3$ = 5.917
$\beta = \beta_o \pm \Delta/3$ = 109.731
$\gamma = \gamma_o \pm \Delta/3$ = 84.352

If $\delta > \pm\ 0.02^g$ or 0.018^o repeat the angle readings

Elevation of Axis Points and Bench marks:

It is necessary to establish the elevations of the Axis Points **A** and **B** and the Bench marks. This is done by vertical triangulation as shown in the sketch below and as per the example given in the following pages.



The procedure is as follows:

1. Select the first Bench Mark **BM I** on a rock or big boulder near the axis point **A** and fix it as 100.00 m
2. Select the bench mark **BM II** near the axis point **B.**
3. Measure the **horizontal** distance **D from A** to **BM I** accurately with a tape.
4. Measure the **horizontal** distance **D from B** to **BM II** accurately with a tape.
5. Take the distance **D** between the axis points **A** and **B** from the triangulation (refer to the previous chapter)
6. Set up the theodolite at the axis point **A** and measure the vertical angle to the axis point **B** and the vertical angle to **BM I**. Take the middle hair reading **Z** and measure the instrument height **I**.
7. Set up the theodolite at the axis point **B** and measure the vertical angle to the axis point **A** and the vertical angle to **BM II**. Take the middle hair reading **Z** and measure the instrument height **I**.
8. Set up the theodolite at **BM I,** measure the vertical angle to the axis point **A**. Take the middle hear reading **Z,** and measure the instrument height **I**.
9. Set up the theodolite at **BM II,** measure the vertical angle to the axis point **B**. Take the middle hair reading **Z**, and measure instrument height **I.**
10. Calculate the followings for all readings:

Vertical Distance $\mathbf{V} = \mathbf{D} \times \mathbf{tan}\,\varphi$ or $\mathbf{V} = \dfrac{\mathbf{D}}{\mathbf{tan}\,\beta}$

Elevation difference $\mathbf{\Delta H} = \mathbf{V - Z + I}$ for upward vertical angle reading
$\mathbf{\Delta H} = \mathbf{V + Z - I}$ for downward vertical angle reading

11. Calculate the Elevations of **A, B, BM I** and **BM II**, starting from **BM I** to **A** to **B** to **BM II**

Elevation of **A = El. of BMI ± ΔH**
Elevation of **B = El. of A ± ΔH**
Elevation of **BMII = El. of B ± ΔH**

Insert the readings and calculations in the Survey form of **"Summary of Triangulation and Elevations of Pegs and Benchmarks"** as per the example given on the following page.

Example:

SUMMARY of TRIANGULATION and ELEVATIONS of PEGS and BENCHMARKS

Bridge Name : Kolimora District : Achham Surveyed by : L. N. Tripathi Date : March 1997

1. Summary of Triangulation

1[st] Triangulation D_1 = 127·034 m

2[nd] Triangulation D_2 = 127·113 m

Difference ΔD = 0·079 m

Mean Distance $D = \frac{D_1+D_2}{2}$ = 127·07 m

$\Delta D/D$ = 0·0006

If $\Delta D/D > 0.0025$ repeat the triangulation

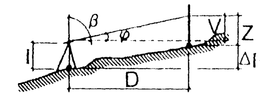
REDUCED LEVELS: BMI = 100.00

BMII = 102·91

A = 100·770

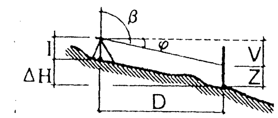
B = 102·150

2. Elevation



$\Delta H = V - Z + I$

$$V = D \times \tan\varphi = \frac{D}{\tan\beta}$$



$\Delta H = V + Z - I$

Instrument Station	Staff Station	Instrument Height I (m)	I (cm)	Middle Hair Z (m)	Z (cm)	Horizontal Distance D (m)	D (cm)	Vertical Angle: Face Right / Face Left	Vertical Angle: Mean (Left + Right)/2	Vertical Distance V (m)	V (cm)	Difference in Elevation ΔH (m)	ΔH (cm)	Mean (m)	Mean (cm)
A	B	1	25	0	20	127	07	99839 300172	0166	+0	53	+1	38	1	38
B	A	1	17	0	10	127	07	101231 298771	1230	-2	46	-1	39		
A	BMI	1	25	0	30	4	87	121635 278372	21631	-1	72	-0	77	0	77
BMI	A	1	20	0	40	4	87	100317 299683	0317	-0	02	+0	78		
B	BMII	1	17	0	50	9	02	99310 300698	0694	+0	10	+0	77	0	76
BMI	B	1	18	0	20	9	02	112130 287878	12126	-1	74	-0	76		

Topographic Detail Survey:

The topographic detail survey is necessary to represent the topography of the bridge site by means of a map (plan) with contour lines. The topographic detail survey uses the tacheometric method. The tacheometric survey is done with a Theodolite with stadia hairs (having constant value of 100) and a levelling staff.

Checking the Stadia Hair:

Check the stadia hair of the theodolite before doing the detail survey by tacheometry. For this, measure a distance of about 40 m using stadia readings and compare them with actual tape measurements. If the difference between the stadia measurement and the tape measurement is more than 0.2%, the calculation of the horizontal and vertical distances needs to be corrected. The distances should be corrected for error Δ as per the following Formula.

$$\mathbf{D} = (100l \pm \Delta) \times \cos^2\varphi \qquad \mathbf{V} = (50l \pm \Delta) \times \sin 2\varphi$$

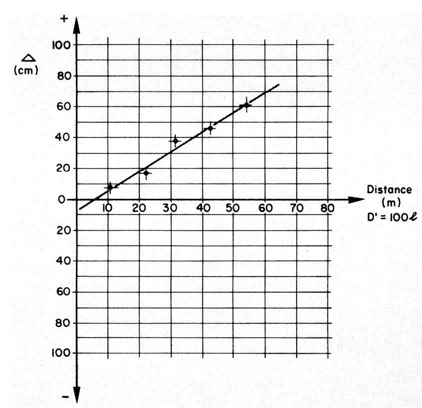
Δ is calculated before the survey by the following procedure:

1. Put the theodolite on a horizontal spot and level it.
2. Level the telescope of the theodolite so that the vertical angle is 0.
3. Put pegs at approximate distances of 10, 20, 30, 40 and 50 m.
4. Measure the distance between the vertical axis of the theodolite and the pegs accurately with the tape.
5. Take the stadia hair readings with the theodolite at each peg.
6. Calculate the horizontal distance to each peg by tacheometric calculation.
7. Determine the difference (error) between the tape measurement and the tacheometric measurement for each peg.
8. Plot the graph for **Δ correction.**

Example: Δ - Corrections

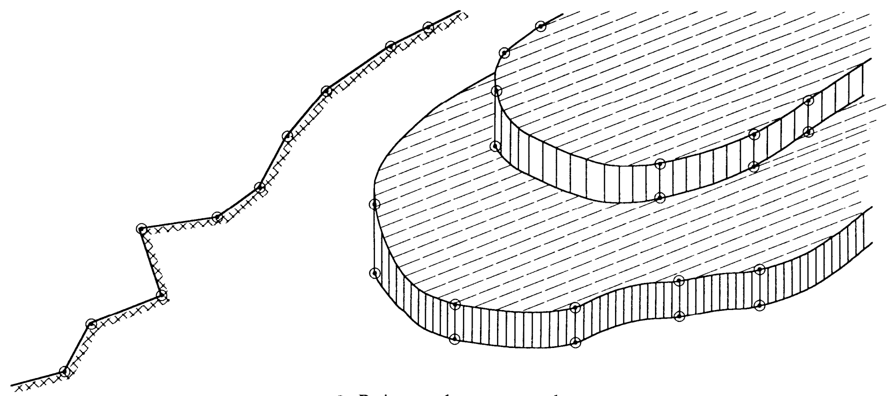
Top hair l_1 (cm)	Bottom hair l_2 (cm)	Difference $l = l_1 - l_2$ (cm)	Distance D' = l x 100 (m)	Tape Measurement Distance, D (m)	Correction Δ = D – D' (cm)
118.70	108.30	10.40	10.40	10.48	+ 8
135.90	114.20	21.70	21.70	21.87	+ 17
140.75	109.80	30.95	30.95	31.33	+ 38
160.25	118.05	42.20	42.20	42.66	+ 46
120.20	66.45	53.75	53.75	54.36	+ 61

The graph is used for the calculation of the tacheometric error for the horizontal distances.



Tacheometric Survey:

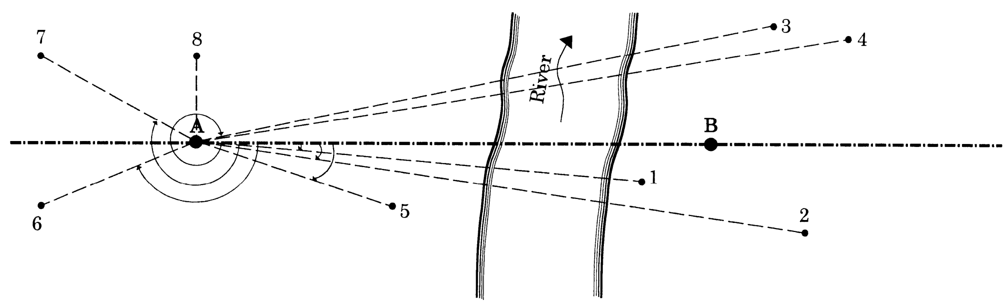
All topographic details are taken by the tacheometric survey. Tachometric details are mainly taken from the axis points **A** and **B** (theodolite stations). If the area of the survey cannot be covered by these two points, details should be taken from additional points. The survey points (staff points) should be taken at the break points of the slopes, terraces, fields and other features representing the actual topography of the ground as shown in the sketch below. The survey points should also include other details such as houses, trees, foot trails, rocks, river banks, high flood level, water level at survey time etc.



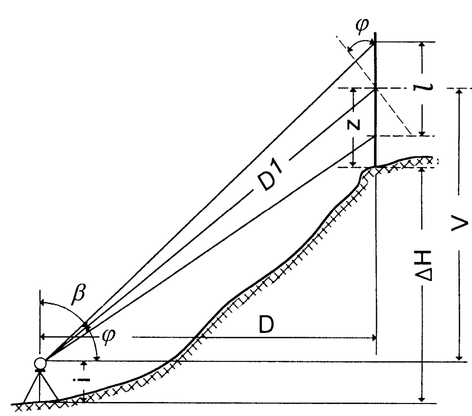
⊙ Points to be measured

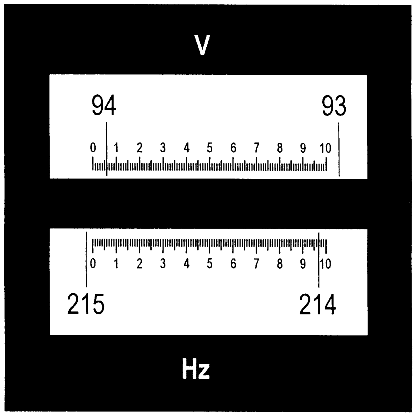
The procedure of the survey is as follows:

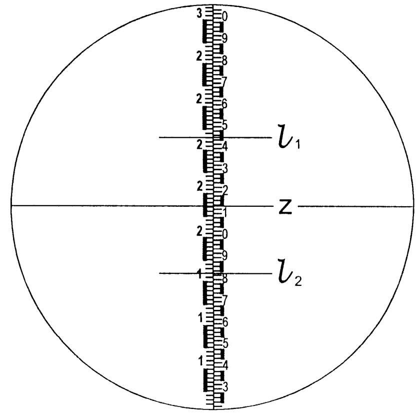
1. Set up the theodolite at the axis point **A.** Measure the instrument height **I**
2. Fix the 0 reading of the horizontal circle along the bridge axis towards **B** as illustrated in the following sketch.



3. Take the readings of the horizontal circle, the vertical circle, the top hair, the middle hair and the bottom hair for each survey point (staff point), after proper sighting to the respective survey points, as illustrated in the sketch of step 2 above and the sketch below.







Vertical Angle, $\beta = 94^g\ 06^c$
Horizontal Angle $\alpha = 214^g$ 97c

Top Hair, l_1 = 2.455
Bottom Hair, l_2 = 1.844
Middle Hair, Z = 2.15

4. Record the readings into the “Tacheometry ” survey sheet as shown in the example on the following page.
5. Set up the theodolite on the axis point **B.** Measure the instrument height **I.**
6. Fix the zero reading of the horizontal circle along the bridge axis towards **A.**
7. Take the details, which were not covered from the axis point **A,** following the procedure from steps 3-4.
8. Calculate the horizontal and vertical distances and the elevations of the survey points with the help of the tacheometric formulas given in the “Tacheometry” survey sheet as shown in the example on the following page.

Topographic Maps:

From the field survey data, it is necessary to prepare the following topographic maps to a scale of 1:100 or 1:200

- Profile along the bridge axis
- Contour plan of the bridge site to scale (**only when a windguy arrangement is necessary**)

Profile Along the Bridge Axis:
Plot the profile along the bridge axis as per the following steps (refer to the example of the plotted bridge axis profile given on the following page).

1. Choose the scale of the drawing. The vertical and horizontal scales should be the same.
2. Choose the datum level so that the points with the lowest and highest elevations are within the drawing area.
3. Choose the position of the axis point A so that the farthest survey points on the right and left banks from the axis point A are within the drawing area.
4. Plot the axis point B as per its elevation and horizontal distance from the axis point A.
5. Draw the survey points of the bridge axis according to the horizontal distance and elevations as per the data from the “Bridge Axis Profile by Abney Level” survey sheet or the “Tacheometry” survey sheet from the axis point A. Refer also to the sketch of the bridge profile prepared during the field survey.

6. Similarly, draw the remaining survey points of the bridge axis from the axis point B.
7. Join all the survey points by straight lines. This will represent the bridge axis profile.
8. Draw horizontal lines with the elevations of the high flood level and the water level at the time of the survey.

Contour Plan of the Bridge Site:

The contour plan represents the overall topography of the bridge site by means of contour lines. A contour line is a continuous line passing through points of equal elevation.
A contour plan is necessary only when a windguy arrangement is to be considered in the bridge design. In most of the cases of short span trail bridges, a windguy arrangement will not be necessary, and a contour plan is not required for the bridge design.

The method of plotting a detailed contour plan is not discussed here. For further information, refer to topographic survey books or the Reference-4: LSTB Survey Manual. A sample of a contour plan is presented on the following page.

TACHEOMETRY

Page No. 1

Bridge Name : kolimora | District : Achham | Surveyed by : L. N. Tripathi | Date : March 1997

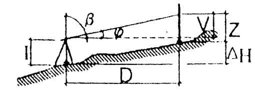
$\ell = \ell_1 - \ell_2$

$D = 100 \times \ell \times \cos^2\varphi = 100 \times \ell \times \sin^2\beta$

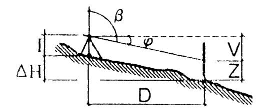
$V = 50 \times \ell \times \sin 2\varphi = 50 \times \ell \times \sin 2\beta$

or $V = D \times \tan\varphi = \dfrac{D}{\tan\beta}$

H = R.L. of Station $\pm \Delta H$



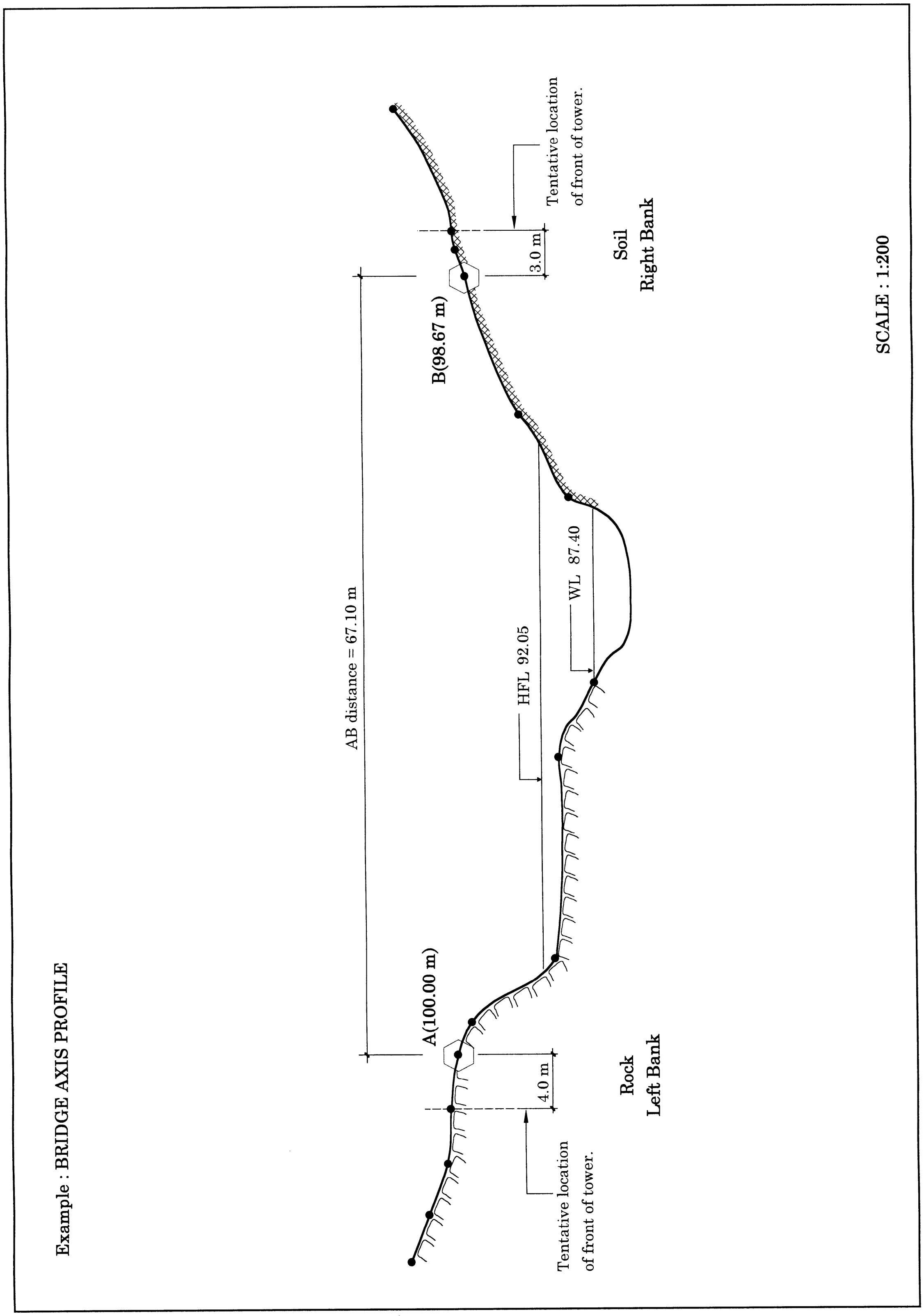
$\Delta H = V - Z + I$



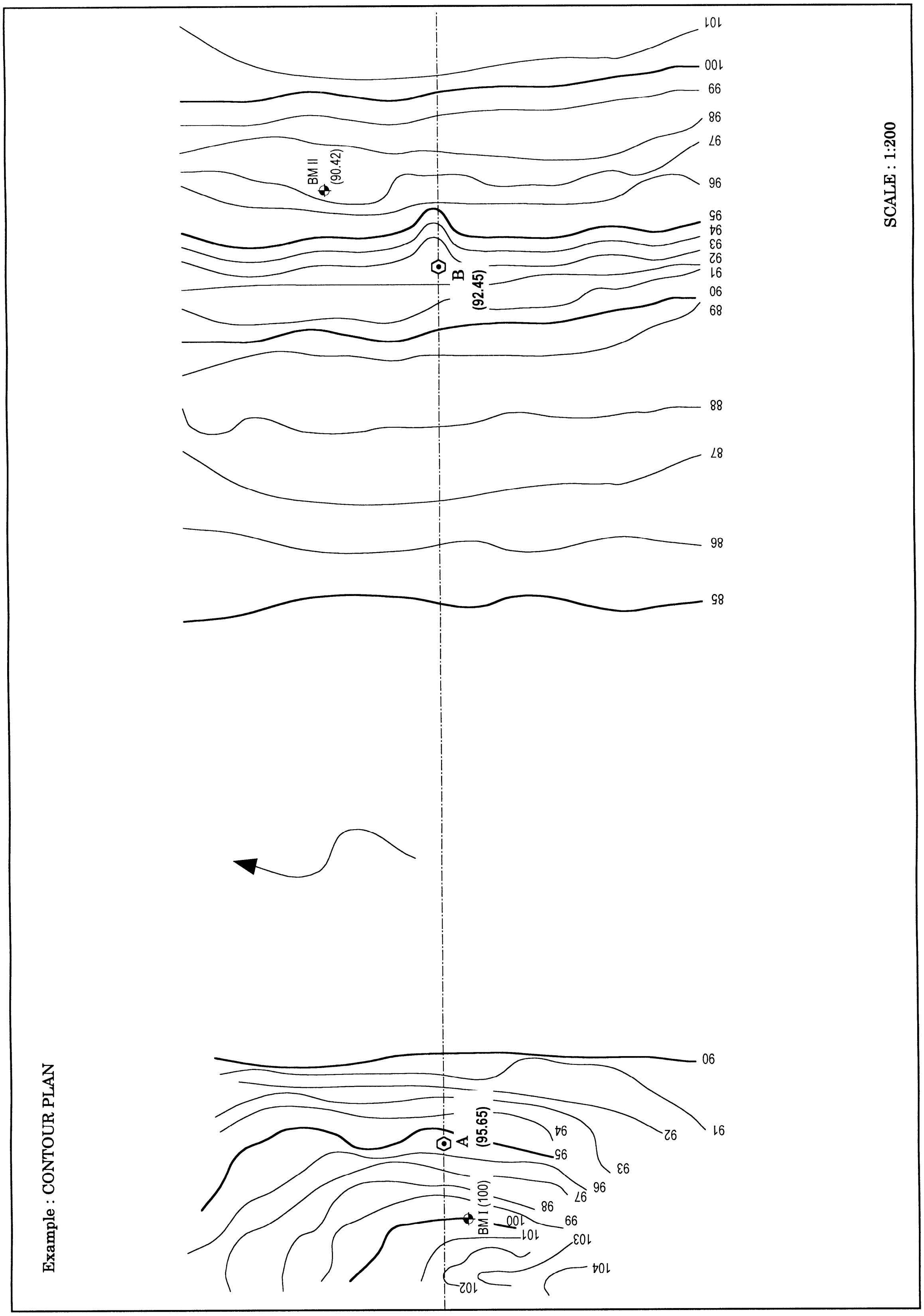
$\Delta H = V + Z - I$

STATION HEIGHT OF INSTRUMENT, I m	STAFF STATION	HORIZONTAL CIRCLE α g/°	HORIZONTAL CIRCLE α c/′	VERTICAL CIRCLE β g/°	VERTICAL CIRCLE β c/′	TOP HAIR ℓ_1 m	MIDDLE HAIR z m	BOTTOM HAIR ℓ_2 m	STAFF INTERCEPT ℓ m	HORIZONT. DISTANCE D m	VERTICAL DISTANCE +/- V m	DIFF. IN ELEVATION +/- ΔH m	REDUCED LEVEL H m	REMARKS (Description of Staff Station)
B/1.17	BM1	398	680	101	070	1512	0856	0200	1312	13116	-0189	-0189	10026	
	A	000	000	100	912	1370	0735	0100	1270	12697	-0138	-0138	10077	
	R/B	394	670	102	470	1930	1265	0600	1330	13280	-0525	-0525	09690	
	4	392	420	103	382	1430	0765	0100	1330	13262	-0664	-0664	09550	
	5	392	418	104	120	1500	0850	0200	1300	12945	-0807	-0807	09408	D/s Rocky Part
	6	394	708	104	820	1688	1044	0400	1288	12806	-0958	-0958	09256	
	7	391	540	107	480	1470	0835	0200	1270	12525	-1445	-1445	08770	
	8	394	520	107	130	1340	0720	0100	1240	12245	-1332	-1332	08883	W.G.?
	9	397	260	106	920	1278	0689	0100	1178	11647	-1222	-1222	08993	
	10	395	193	108	962	1300	0750	0200	1100	10783	-1486	-1486	08729	
	11	398	277	110	236	1116	0608	0100	1016	09899	-1549	-1549	08666	Rocky nose
	12	392	053	111	586	1120	0610	0100	1020	09865	-1759	-1759	08455	
	13	396	850	106	424	1550	0925	0300	1250	12373	-1228	-1228	08987	
	14	398	080	106	240	1898	1299	0700	1198	11865	-1179	-1179	09035	Rocky bank edge
	Axis	000	000	105	260	1760	1180	0600	1160	11521	-0955	-0955	09260	
	Axis	000	000	104	752	1380	0791	0200	1180	11734	-0839	-0839	09375	
	Axis	000	000	103	330	1700	1095	0500	1200	11967	-0619	-0619	09596	Below cliff
	18	398	326	104	412	1400	0800	0200	1200	11942	-0792	-0792	09423	Edge
	19	004	940	103	570	1280	0790	0100	1180	11762	-0622	-0622	09593	Edge of cliff
	20	007	430	102	620	1880	1290	0700	1180	11780	-0497	-0497	09718	do
	21	011	127	100	370	1960	1330	0700	1260	12599	-0089	-0089	10126	
	22	012	852	099	078	1650	0975	0300	1350	13497	0215	0215	10430	

Example: Tacheometry



Example: Profile



Example: Contour Plan

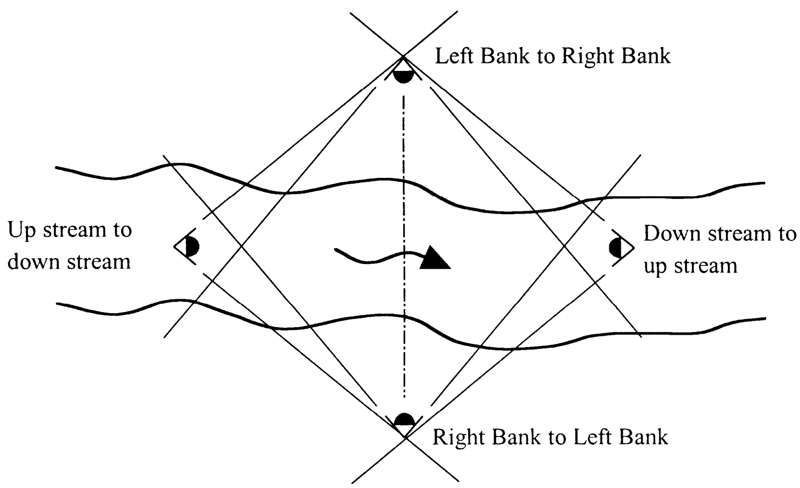
3.3 SITE PHOTOGRAPHS

Photographs of the bridge site are required to support its technical feasibility / topography and to facilitate the designing of the bridge.

The following photographs are useful:

- An overall view of the bridge site from upstream indicating the approximate location of the bridge foundations and the axis line.
- An overall view of the bridge site from downstream indicating the approximate location of the bridge foundations and the axis line.
- View of the right bank from the left bank with the approximate location of the bridge foundations.
- View of the left bank from the right bank with the approximate location of the bridge foundations.
- An overall top view (if possible).
- A close-up view of the axis points and the bench marks.
- A view of the soil test pits at the location of the bridge foundation blocks.
- Other relevant photos.

Take the above photographs from the positions as per the sketch below. If one picture does not cover the necessary area, take several pictures from the same spot with sufficient overlapping. Present all the photographs systematically with respective captions.



3.4 SURVEY REPORT

The technical survey report consists of:

- Filled in Survey Forms and Checklist
- Topographic map

1. Profile along the bridge axis in scale
2. Contour plan of the bridge site in scale (**only if a windguy arrangement is necessary**).