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# 1. SURVEY AND BRIDGE SITE SELECTION

Survey and Bridge Site Assessment is the basis for planning and design and forms the main resource for bridge construction. The main objective of the Survey and Bridge Site Assessment is to identify the proper bridge site by considering socio-economic as well as technical points of view. Survey and Bridge Site Assessment is done in the following two stages:

**Social Feasibility Survey and Technical Survey**

## 1.1 SOCIAL FEASIBILITY SURVEY

A Social Feasibility Survey is necessary to justify the construction of a requested bridge. For ranking and prioritizing the vast number of requests, the following socio-economic indicators are of utmost importance:

- Level of local participation
- Size of area of influence
- Size of traffic flow
- Socio-economic benefits produced by the proposed bridge

One of the major indicators reflecting the real need of the bridge is the degree of participation by the local community or beneficiaries in the construction of the requested bridge. These indicators are assessed and measured from different points of view depending on the need and purpose of the bridge. A detailed Social Feasibility Survey is not included in this Technical Handbook, for further details refer to Social Organization Support (SOS) Manual.

**Local Persons contacted:**

Write down the names of local persons contacted or consulted during the survey work.

| **Name / Address** | **Occupation** |
|---|---|
| 1……………………………………………. | ……………………………………….. |
| 2……………………………………………. | ……………………………………….. |
| 3……………………………………………. | ……………………………………….. |
| 4……………………………………………. | ……………………………………….. |
| 5……………………………………………. | ……………………………………….. |
| 6……………………………………………. | ……………………………………….. |

### 1.2 TECHNICAL SURVEY

The technical survey includes:

- Bridge site selection and
- Topographic survey of the selected bridge site

## 2. PREPARATION FOR SURVEY

The following preparatory work must be completed before going to the field for survey:

- Collect maps with tentative location of the bridge and any available background information.
- Collect the survey equipment.

Survey equipment consists of the following materials:

**For Survey by Abney Level**

- Abney Level, Survey Form & Checklist
- Measuring Tape (50 or 100m and 3m)
- Nylon Rope (Min. 50m)
- Masons Thread and Plumb Bob
- Red Enamel Paint and Paint Brush
- Marker Pen, Scale and A3 Graph Paper
- Camera and Film Roll
- Hammer
- Ranging rod (can be prepared at site also)
- Note Book, Calculator & Pencil

**For Survey by Theodolite**

- Theodolite
- Staff and Plumb Bob
- Measuring Tape (50m and 3m)
- Red Enamel Paint and Paint Brush
- Marker Pen, Scale and A3 Graph Paper
- Camera and Film Roll
- Hammer
- Survey Form and Checklist
- Note Book & Pencil
- Calculator

## 3. GENERAL DATA COLLECTION

General data is required for needs assessment and construction planning of the proposed bridge. Collect the following general data and information:

### 3.1 LOCATION OF BRIDGE SITE

| | *Left Bank* | *Right Bank* |
|---|---|---|
| VDC | | |
| Ward No. | | |
| Ilaka No. | | |
| District No. | | |
| Zone | | |

Draw a bridge site location map covering the proposed bridge's area of influence as shown in the example below. The map should contain the following information:

- River system with names and river flow direction
- Location of proposed bridge and traditional crossing point
- Location of the nearest bridge (approximate walking distance from the proposed bridge site)
- Existing trail system and, if required, specify length of new trail for access to the proposed bridge
- Location of the next villages, health post, school and other important places with approximate distances from the bridge site

**Bridge Site Location Map:**

N

## 3.2 NATURE OF CROSSING AND FORDABILITY

Assess period of time the river cannot be crossed in one year?

………………….. whole year

………………….. months per year only

………………….. days during high flood only

What type of crossing facility is available at present? ……………………………………………………………………………….

## 3.3 TRAFFIC VOLUME

Traffic volume at the crossing is one of the key indicators in the need assessment of the bridge. Information should be collected by 2 methods. Count traffic volume at the traditional crossing point for at least one day. And then interview the local people to form a broader impression of the traffic volume throughout the year.

| | | ***Average number of traffic per day*** |
|---|---|---|
| **Goods traffic** | Porters | |
| | Pack animals | |
| **Non-goods traffic** | Persons | |
| | Animals | |

Determine the purpose of the traffic by interviewing the persons crossing and the local people as per the table below. This will indicate the importance of the crossing.

| ***Access to*** | ***Yes*** | ***No*** |
|---|---|---|
| School | | |
| Health post/Hospital | | |
| Bazaar/Market | | |
| Post office/Telephone | | |
| Road head | | |
| Farming | | |
| Others (specify) | | |

## 3.4 WIDTH OF WALKWAY

The standard width of walkway in this handbook is 70 cm or 106 cm.
In most cases the 70 cm walkway is sufficient. In stances of heavy traffic, mule and pack animal passage carrying bulky goods, or if the crossing is on a main trail, a 106 cm walkway is necessary.
Discuss this issue with the local people, informing them that more work, especially collection of stones, is required for the 106 cm walkway.

Recommended width of walkway: 70 cm ☐ 106 cm ☐

**Tentative preliminary required number of mandays**:

Mandays for skilled Labor: = **1.3 x span [m] + 400**

Mandays for unskilled Labor: = **5 x Span [m] + 1300**

### 3.5 LOCAL PARTICIPATION

*Assess the availability of local participation for bridge building from within the concerned local community*

| ***By Whom*** | ***Type of Participation/Support*** |
|---|---|
| Local Community | |
| User's Committee | |
| VDC | |
| DDC | |
| Local NGO | |
| Individual | |

### 3.6 TRANSPORTATION DISTANCE

| ***Type of Ttransport*** | ***Name of nearest Roadhead/Airstrip etc.*** | ***Distance from site up to Rroadhead/Airstrip*** | | |
|---|---|---|---|---|
| | | ***Km/Kosh*** | ***Porter days*** | ***By Mule, days*** |
| Served by Trucks | | | | |
| Served by Tractors | | | | |
| Airstrip | | | | |
| Helipad | | | | |

### 3.7 AVAILABILITY OF LOCAL MATERIALS

Assess the availability of local materials needed for the bridge construction.
*Do not overestimate haulage distance. Identify the nearest collection place for stone, gravel and sand.

| ***Description*** | ***Haulage Distance*, m*** | ***Remarks*** |
|---|---|---|
| Stones | | |
| Natural Gravel | | |
| Sand | | |
| Wood | | |
| Bamboo | | |

### 3.8 AVAILABILITY OF LOCAL BRIDGE BUILDERS

Are there any local bridge builders? If yes, record their names.

| ***Names*** | ***Skill (Mason, Bridge Fitter)*** | ***Village / Address*** |
|---|---|---|
| | | |
| | | |
| | | |
| | | |

### 3.9 TEMPORARY CROSSING

Is temporary crossing is necessary during the construction of the bridge ? ☐ Yes ☐ No

If yes, what kind of temporary crossing do you propose? ☐ Ferry ☐ Cable car ☐ Temporary bridge, ..…. m span.

## 4. BRIDGE SITE SELECTION

The main purpose of the technical field survey is to select the appropriate bridge site. The site should optimally serve the local people. The selected site must be economically justified and have along life span:

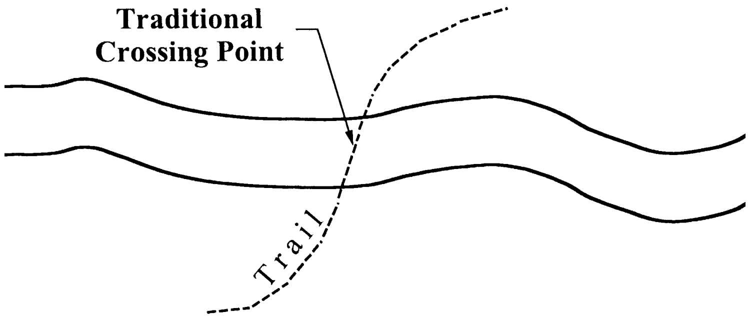
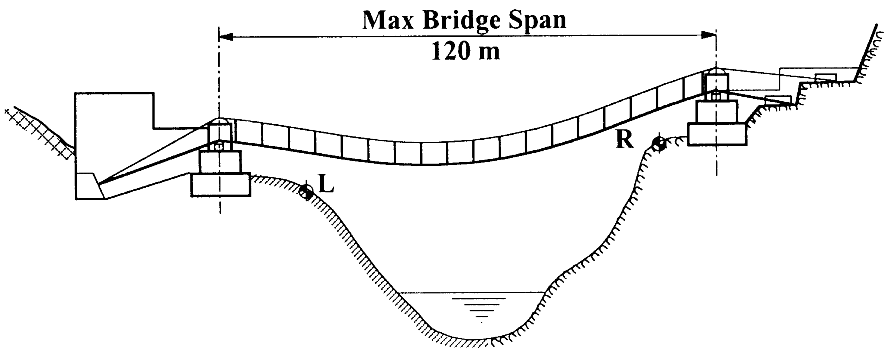
- fulfill the general conditions (listed below)
- have **Favorable** river conditions
- have stable bank and slope conditions
- have shortest possible span

### 4.1 GENERAL CONDITION

The bridge site should fulfill a number of general conditions:

- Traditional crossing point
- Maximum bridge span
- Minimum free board
- Space for the bridge foundations

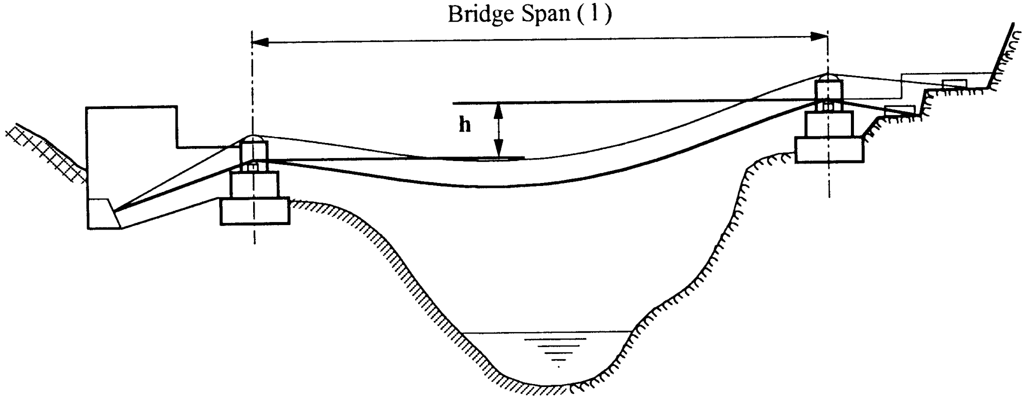
⇒ **Use the checklist on following pages to evaluate the general condition at the survey site:**

| ***Features*** | ***Condition*** | ***Site Assessment*** | |
|---|---|---|---|
| | | ***Favorable*** | ***Unfavorable*** |
| **Traditional crossing point**<br>The bridge site should be selected at or near to the traditional crossing point.<br><br><br>• For minor river, detoure from the tradditional crossing point is not acceptable.<br>• For major river, detour up to 500 m u/s and 500 m d/s from the traditional crossing point may be acceptable. | **Favorable**: Selected site is at or nearby traditional crossing point<br><br>**Unfavorable**: Selected site is far from the traditional crossing point | | |
| **Bridge span**<br>At local level bridge can be built only up to 120 m span.<br><br><br>• Measure tentative span.<br>• Compare with the limit. | **Favorable**: span, $\ell$ is equal or shorter than120 m<br><br>**Unfavorable**: span, $\ell$ is longer than 120 m<br><br>Approximate span m | | |

<table>
<thead>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
</thead>
<tbody>
<tr>
<td>

**Level Difference between two Banks**

The level difference between the two foundation blocks should not be more than $\ell/25$.




- Locate the tentative position of the bridge foundations at both banks.
- Measure the level difference between the foundations of two banks.
- Compare with the condition.

</td>
<td>

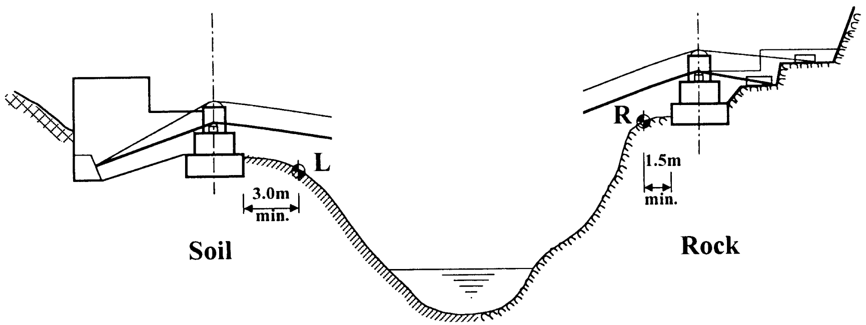
**Favorable**: **h** is equal or less than $\ell/25$

**Unfavorable**: **h** is bigger than $\ell/25$

</td>
<td></td>
<td></td>
</tr>
<tr>
<td>

**Space for Foundation**

Foundation should be placed at least 3 m behind the soil slope and 1.5 m behind the rock slope.

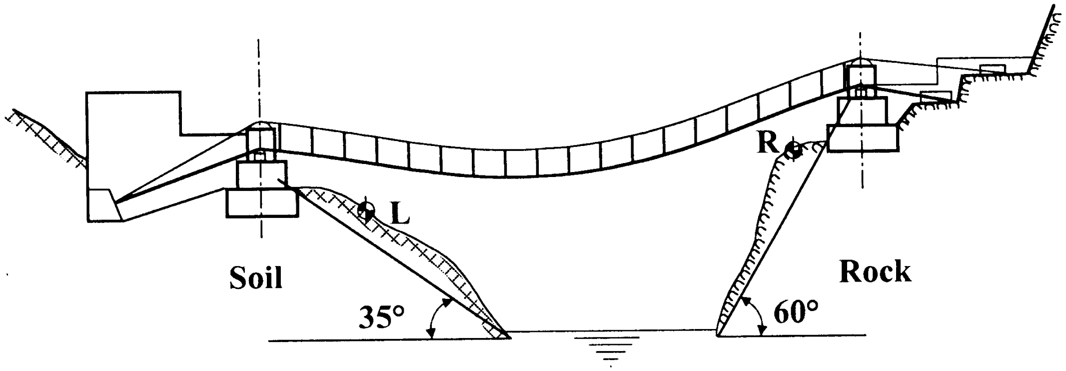


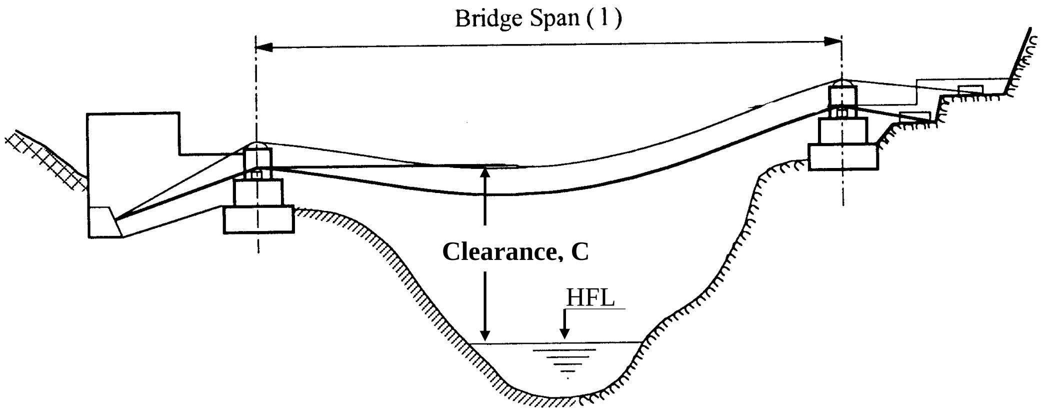

</td>
<td>

**Favorable**: Condition can be fulfilled

**Unfavorable**: Condition can not be fulfilled

</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

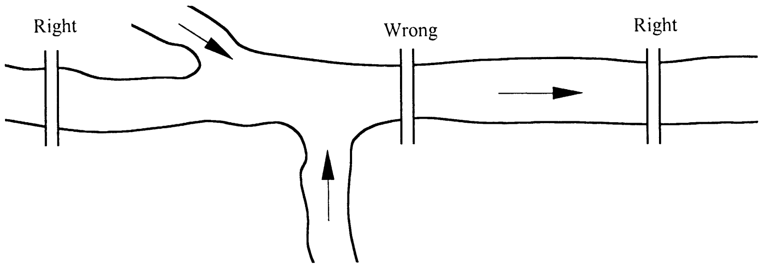
<table>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
<tr><td>Slope Profile<br>Bridge foundation should be placed behind the line of the angle of internal friction. (Angle of internal friction is the angle of slope of soil or rock at which it is still stable and does not slide).<br><br><br>• Draw a slope line of 35° (angle of internal friction) in case of Soil slope and 60° in case of Rock slope.<br>• Foundation should be placed behind this line.<br>• Check if these conditions can be fulfilled.</td><td>Favorable: Condition can be fulfilled<br><br>Unfavorable: Condition can not be fulfilled</td><td>RB<br>LB</td><td>RB<br>LB</td></tr>
</table>

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **Free Board**<br>Clearance between (Free board) the lowest point of the bridge and the highest flood level (HFL) should not be less than 5 m. For this, sufficient clearance between lower walkway saddle and HFL should be maintained.<br><br><br>**span**<br>up to 55 m<br>55 - 65 m<br>66 - 85 m<br>86 - 110 m<br>111 - 120 m<br>• Identify HFL by local observation and villagers' information.<br>• Calculate available clearnace and compare with the requirement.<br>• **Exception**: At flat or wide river banks free board may be reduced. At gorge free board has to be increased. | **Favorable** **Unfavorable**<br>Clearance between lower foundation saddle and HFL is:<br>**not less than:** / **less than:**<br>7.5 m / 7.5 m<br>8.0 m / 8.0 m<br>9.0 m / 9.0 m<br>10.0 m / 10.0 m<br>10.5 m / 10.5 m<br>: | ☐ | ☐ |

## 4.2 RIVER CONDITION

The selected bridge site must have favorable river condition. Accordingly, a bridge should be located:
a) on a straight reach of the river, b) beyond the disturbing influence of larger tributaries, c) on well defined banks.

Use the following check list to evaluate the river condition:

<table>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
<tr><td>River Flow<br>In order to protect the bridge from sudden over-flooding and strong erosion, the bridge site should not be located near the confluence area of two rivers.<br><br></td><td>Favorable: Bridge site far from the confluence<br>Unfavorable: Bridge site near the confluence</td><td></td><td></td></tr>
<tr><td>River Bed<br>The river bed at the selected bridge site should be stable without the possibility of erosion or filling up with bed load (boulders, gravel, silt, or sand)<br><br>River bed filled up after heavy flood</td><td>Favorable: River bed is not erosive not filling up<br>Unfavorable: River bed is erosive or filling up</td><td></td><td></td></tr>
</table>

### 4.3 SLOPE AND BANK CONDITION

A bridge should be located at the site with safe and stable slope and bank condition. The surveyor must identify any potential instability features or failure modes of the soil or rock slope and bank.

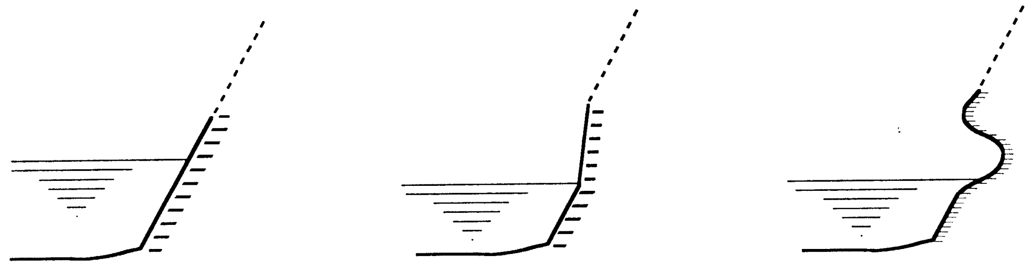
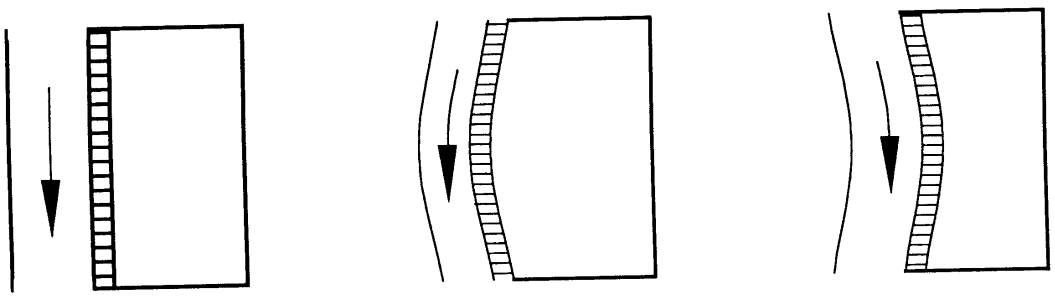
**If the slope and bank is soil, potential instability features and failure modes are:**

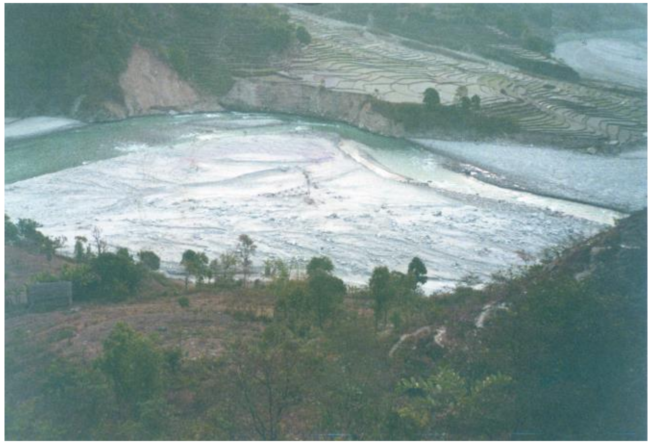
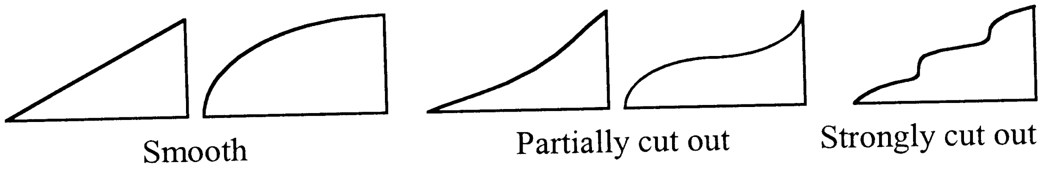
- bank erosion
- toppling instability of the bank
- erosion of the slope
- land slide

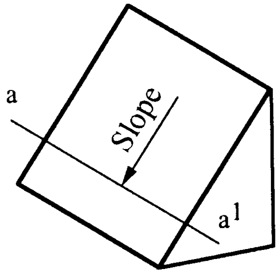
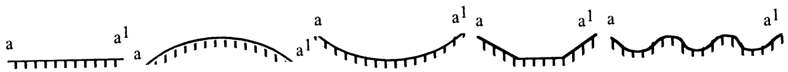
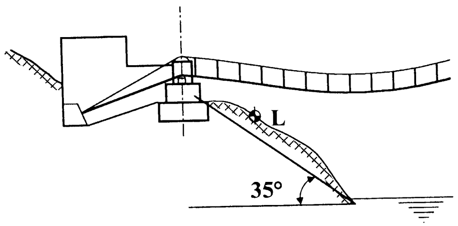
**If the slope and bank is rock, potential instability features and failure modes are:**

- plain failures in a rock slide along the slope.
- wedge failure leading to the fall of rock mass.
- toppling, leading to the fall of rock blocks.
- rotational slide, similar to the landslide in a soil slope. Such failure is likely when the material of the rock is very weak (soft rock) and the rock mass is heavily jointed and broken into small pieces.

To avoid the above instability features, use the following checklist to evaluate the slope and bank of the selected site

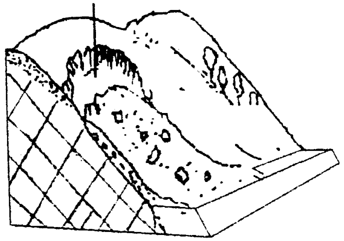
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | ***Favorable*** | ***Unfavorable*** |
| **If the River Bank or Slope is SOIL**<br>**Bank Profile**<br>Bank profile should be smooth.<br><br>Smooth Partially cut out Strongly cut out | **Favorable**: Bank profile is smooth to partially cut out<br><br>**Unfavorable**: Bank profile is strongly cut out | RB<br>LB | <br><br>RB<br>LB |
| **River Bank Contour**<br>The bridge site should be located at the straight reach of the river to avoid the river from undercutting or bank erosion.<br>Favourable Unfavourable<br><br>Straight Convex Concave | **Favorable**: River contour is straight or convex<br><br>**Unfavorable**: River contour is concave | | |

| Features | Condition | Site Assessment | |
|---|---|---|---|
| | | Favorable | Unfavorable |
| **Bank Erosion**<br>The river bank should not show sign of erosion.<br><br>Bank erosion due to high river current | **Favorable**: No Fresh erosion<br><br>**Unfavorable**: Presence of Fresh erosion | ☐ | ☐ |
| **Slope Profile**<br>Select applicable profile from pictures given below. The slope profile should be smooth.<br><br> | **Favorable**: Slope profile is smooth to partially cut out<br><br>**Unfavorable**: Slope profile is strongly cut out | ☐ RB<br>☐ LB | ☐ RB<br>☐ LB |

| ***Features*** | ***Condition*** | ***Site Assessment*** | |
|---|---|---|---|
| | | ***Favorable*** | ***Unfavorable*** |
| **Transverse Slope**<br>The transverse slope should be smooth.<br><br><br>Transverse slope strongly cut out<br><br><br>Smooth Partially cut out Strongly cut out | **Favorable**: Transverse slope is smooth to partially cutout<br><br>**Unfavorable**: Transverse slope is strongly cutout | RB<br>LB | RB<br>LB |
| **Slope Inclination**<br>Slope inclination should be less than 35º.<br><br><br>Estimate the slope inclination and compare it with the condition. If the site has an **unfavourable** slope inclination, it can still be selected provided the general condition of slope profile is fulfilled. | **Favorable**: Slope inclination is equal or smaller than 35º<br><br>**Unfavorable**: Slope inclination is bigger than 35º | RB<br>LB | RB<br>LB |

<table>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
<tr><td>River Undercutting<br>Bridge site should be free from river undercutting which may lead to landslide.<br><br>Landslide caused by river undercutting<br><br>Inclined Trees<br>Selected site should not have inclined trees which indicate an active land slide.<br><br>Inclined trees on landslide mass</td><td>Favorable: No river undercutting<br><br>Unfavorable: River undercutting is active or there is potential<br><br>Favorable: Inclined trees not present<br><br>Unfavorable: Inclined trees present</td><td>RB<br>LB<br><br>RB<br>LB</td><td>RB<br>LB<br><br>RB<br>LB</td></tr>
</table>

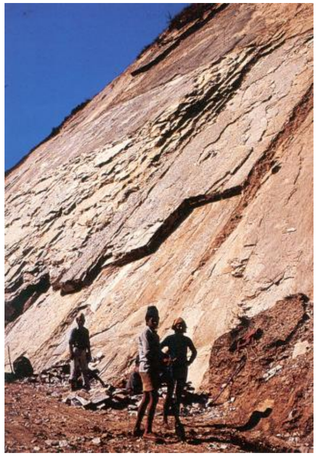
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **Seepage or Swampy Area**<br>The bank slope should not have any seepage or swampy area which may lead to slope instability. | **Favorable**: Seepage or swampy area is absent<br>**Unfavorable**: Seepage or swampy area is present | RB<br>LB | RB<br>LB |
| **Gully Erosion**<br>No signs of gully erosion should exist within the vicinity of the selected site.<br><br>Active gully erosion<br>• Observe if any rivulets are within the vicinity of the selected site.<br>• If rivulet exists, examine the dimension of the gully cutting. | **Favorable**: No sign of gully erosion or only light gully erosion<br>**Unfavorable**: Heavy gully erosion exists | RB<br>LB | RB<br>LB |

<table>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
<tr><td>Slipped (Slump) Soil Mass<br>The bridge should not be located on already slipped soil masses.<br><br>Slope with slipped soil mass<br><br><br>Slop failure model<br>• Examine and identify of soil mass movement by observing traces of back scars on the slope.</td><td>Favorable: There are no back scars or signs of soil mass movement<br><br>Unfavorable: There are back scars or signs soil mass movement</td><td>RB<br>LB</td><td>RB<br>LB</td></tr>
</table>

<table>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
<tr><td>

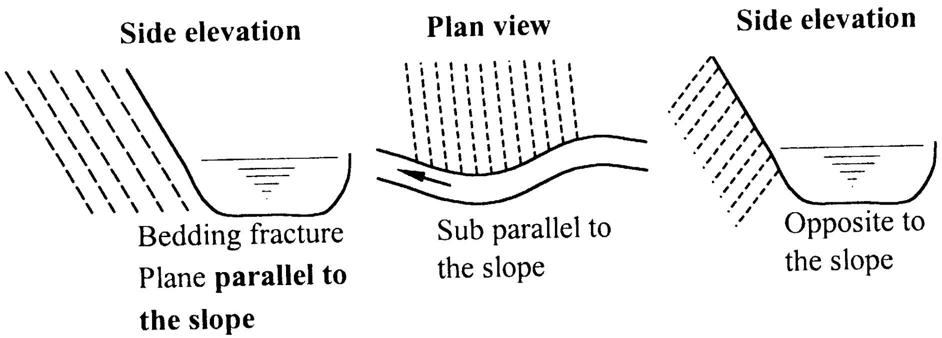
**If the river bank is ROCK**

**Plain Failure**
Plain failure leads to the slide of rock layers along the slope. The rock bank/slope of the selected site should not have any feature of plain failure.



Bedding plain is **parallel to the slope** and plain failure is active.

Site is extremely **unfavorable**.




- Identify bedding/fracture plain (layers of rock)
- Check its direction and inclination
- Compare with the condition

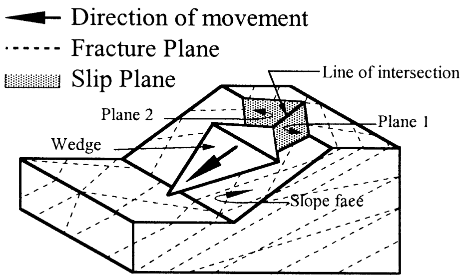
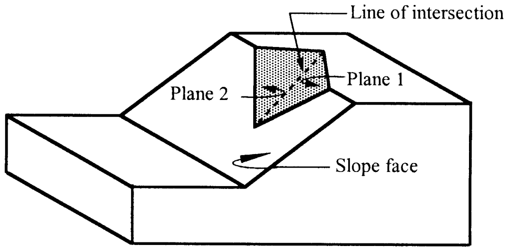
</td><td>

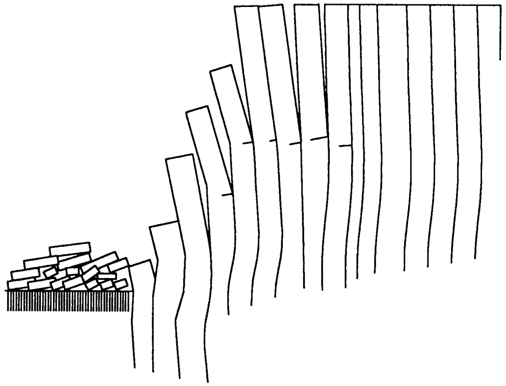
**Favorable**:

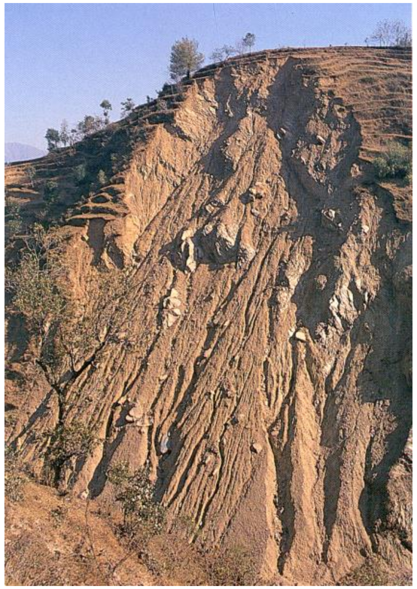
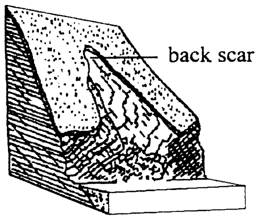
**Plain failure will not take place, if**
- Bedding/fracture plain is sub-parallel to the slope
- Bedding/fracture plain is parallel to the slope but inclination is less than 35°

**Unfavorable**:
**Plain failure will take place, if**
- Bedding/fracture plain is parallel to the slope and inclination is greater than 35°
- Presence of old slided rocks

</td><td>RB<br>LB<br>RB<br>LB</td><td>RB<br>LB</td></tr>
</table>

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **Wedge Failure**<br>Any form of wedge failure leads to sliding of rock masses. The rock bank/slope should not have wedge failures or potential wedge failures.<br><br>Trace of wedge failure<br><br><br>**Wedge Failure Model**<br><br><br>**Wedge Failure**<br>• Identify if there are fracture plains facing each other (intersecting)<br>• Check the inclination of the intersection line<br>• Compare with the condition | **Favorable**:<br>**Wedge failure will not take place, if**<br>• There are no fracture plains facing each other<br>• There are two or more intersecting fracture plains but the inclination of its line of intersection is less than 35º<br>• There are two or more intersecting fracture plains but the inclination of its line of intersection is opposite to the slope<br>**Unfavorable**:<br>**Wedge failure will take place, if**<br>• There are two or more intersecting fracture plains and the inclination of its intersection line is more than 35º to the slope<br>• Presence of old slided wedge | RB<br>LB<br>RB<br>LB | RB<br>LB<br>RB<br>LB |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **Toppling Failure**<br>The rock bank/slope should not have any features of toppling failure. | | | |
| <br>Potential toppling failure | **Favorable**:<br><br>**Toppling will not take place, if**<br>• the Rock slope is less than 60$^o$ | RB<br>LB | |
| | • there is no formation of rock blocks | RB<br>LB | |
| | • there is formation of rock block but b/h (width of the block/height of the block) is > 1 | RB<br>LB | |
| <br>**Topling Failure model** | **Unfavorable**:<br><br>**Toppling will take place, if**<br>• there is formation of vertically elongated rock blocks in the steep slope > 60$^o$ and the blocks are tilted towards slopes | | RB<br>LB |
| | • old toppled rock blocks are present | | RB<br>LB |
| • Identify if there is formation of vertically elongated rock blocks (cubes) due to vertical and horizontal fracture planes/joints<br>• Estimate inclination of the slope<br>• Estimate inclination and orientation of the rock block and compare with the conditions | | | |

<table>
<tr><th rowspan="2">Features</th><th rowspan="2">Condition</th><th colspan="2">Site Assessment</th></tr>
<tr><th>Favorable</th><th>Unfavorable</th></tr>
<tr>
<td>Translational Failure (Slide)<br>The rock slope should not have any potential of translational failure.<br><br>Translational failure (sliding) of soft rock slope<br><br><br>failure(slide) model<br>• Identify type of rock and its weathering grade<br>• Estimate inclination of the slope<br>• compare with the conditions</td>
<td>Favorable:<br>Sliding will not take place, if<br>• slope is hard rock<br>• slope is soft rock but not weathered<br>• slope is soft rock and weathered but not steeper than 40°<br>Unfavorable:<br>Sliding will take place, if<br>• Slope is highly weathered soft rock and steep > 40°<br>• Presence of back scar or old slide</td>
<td>RB<br>LB<br>RB<br>LB<br>RB<br>LB</td>
<td>RB<br>LB<br>RB<br>LB</td>
</tr>
</table>

## 4.4 EVALUATION OF THE BRIDGE SITE

After completing investigation of the site as per chapter 4.1 to 4.3, categorize the bridge site as

**Good** ☐ **Questionable** ☐ **Bad** ☐

| | | |
|---|---|---|
| **Good** | : | All or most of the features are **favorable** and if the surveyor is confident about the stability of the slopes. Proceed with further survey work. |
| **Questionable** | : | Most of the features are **favorable** and some are **unfavorable**. The site is questionable. In this case, further detailed investigation by an experienced geo-technical engineer is necessary. For detail refer to the SBD Survey Manual. |
| **Bad** | : | Most of the features are **unfavorable**. Reject site. |

As far as possible, the bridge site should be selected at a location where protection works will not be required. If protection works are unavoidable determine the required special structures like retaining walls, drainage channels, etc. A tentative design with dimensions and location of these structures should be illustrated in a sketch showing a plan view and a typical section. But it is best to **avoid bridge sites which require river protection works.**

Write down remarks, if any and note also proposed special structures, if necessary: retaining walls, gabion walls, drainage, lining of existing irrigation canal, river protection works etc. Mention height, length and location of these structures and also reflect it in the sketch of plan (page no 34).

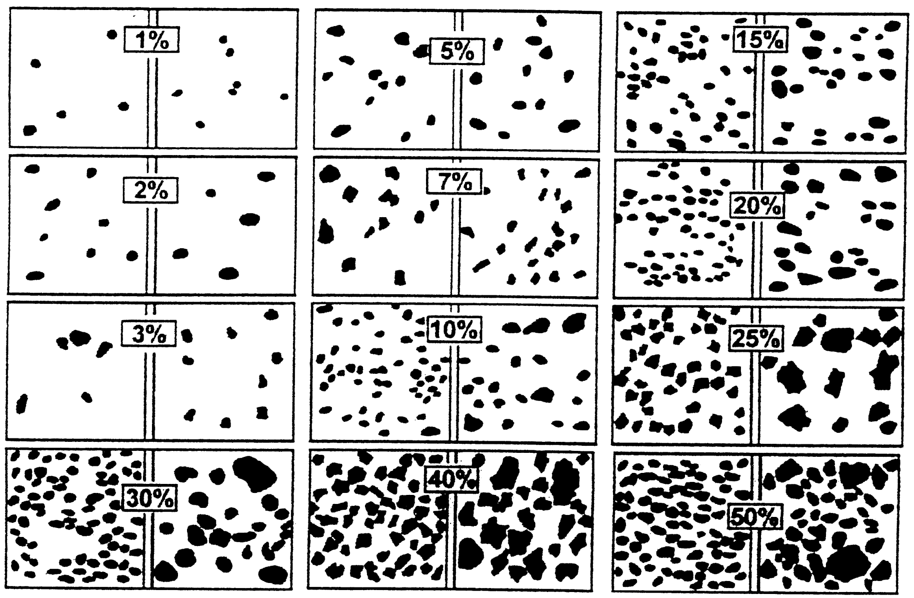
**Remarks:**

## 4.5 CLASSIFICATION OF SOIL AND ROCK

Identification of Soil and Rock type is required for appropriate foundation design. Soil and Rock can be broadly classified and categorized for the foundation design proposes as per the following tables.

| Soil Type | | How to identify | Soil Parameters | | Unit Weight $\gamma$, $kN/m^3$ | Applicable Foundation Design |
|---|---|---|---|---|---|---|
| | | | Bearing capacity $kN/m^2$ | Angle of internal Friction, $\varphi°$ | | |
| **Coarse Grained Soils** More than half of the materials are individual grains visible to the naked eye (grain size bigger than 0.06 mm) | **Gravelly Soils** | Estimate the percentage (%) of coarse grains larger than 6 mm<br><br>If, more than half of the coarse fraction is larger than 6 mm, the soil is Gravelly Soil | 400-600 **(400)** | 32-38 **(35)** | **19** | **Deadman Anchor** |
| | **Sandy Soils** | If, more than half of the coarse fraction is smaller than 6 mm grain size, the soil is Sandy Soil | 200-300 **(200)** | 31-37 **(33)** | **18** | |
| **Fine Grained Soils** More than half of the materials are individual grains **not** visible to the naked eye (grain size smaller than 0.06mm) | **Silty Soils** | Prepare moist soil ball from the soil sample and cut it with a knife. If, the cut surface is dull or scratched, the soil is Silty Soil | 150-200 **(150)** | 30-32 **(30)** | **17** | |
| | **Clay** | Prepare moist soil ball from the soil sample and cut it with a knife. If, the cut surface is smooth and shiny, the soil is Clay. | 100-200 **(100)** | 9-25 **(22)** | **16** | |

**Ratio of coarse grains**




For estimation of percentage (%) of coarse grain use the figure.

# Rock Classification

| Rock Type | Examples | How to identify | Degree of Fractures or Weathering | How to identify | Rock Parameters | | Applicable Foundation Design |
|---|---|---|---|---|---|---|---|
| | | | | | Bearing Capacity, kN/m² | Angle of Sliding Friction, φ° | |
| **Hard Rock** | Quartzite<br>Limestone<br>Granite,<br>Dolomite etc. | Gives metallic sound after hammer blow | Rock is sound and fresh to fairly weathered | Rock has no sign of weathering or only faint signs of weathering up to 1-5 cm thickness | 1500-2000 **(1500)** | 35-50 **(40)** | **Drum Anchor in Hard Rock** |
| | | | Highly fractured rock and fresh to fairly weathered | In the rock exists widely open cracks, fractures and bedding | 1500 | 35-50 **(40)** | **Drum Anchor in Fractured Rock** |
| **Soft Rock** | Phylite<br>Slate<br>Siltstone<br>Claystone<br>Schist etc. | Gives dull sound after hammer blow | Fresh | No sign of weathering | 1300 | 25-40 **(30)** | **Drum Anchor in Fractured Rock** |
| | | | Fairly to highly weathered | • Most of the original rock has been seriously altered<br>• Rock can be broken by hand | 600-750 **(650)** | 25-40 **(30)** | **Deadman Anchor** |

## 4.6 IDENTIFICATION OF SOIL AND ROCK

Excavate a test pit with a depth of up to the estimated foundation level (but not less than 2.0m) or up to the bed rock at the proposed foundation locations. If the bank/slope is soil, investigate each layer of soil in the pit and classify according to the Soil Classification chart, filling in the soil investigation table as per the following example.

**Right Bank** (at location of Main Anchorage Block) **SOIL**

| Sketch | Depth from Surface, m | Soil Type | Soil Parameter | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Bearing Capacity, $kN/m^2$ | Angle of Internal Friction, $\varphi$ | Unit Weight $\gamma$, $kN/m^3$ | |
| | | | | | | |

**Left Bank** (at location of Main Anchorage Block) **SOIL**

| Sketch | Depth from Surface, m | Soil Type | Soil Parameter | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Bearing Capacity, $kN/m^2$ | Angle of Internal Friction, $\varphi$ | Unit Weight $\gamma$, $kN/m^3$ | |
| | | | | | | |

**Right Bank** (at location of windguy block of up stream) **SOIL**

| Sketch | Depth from Surface, m | Soil Type | Soil Parameter | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Bearing Capacity, $kN/m^2$ | Angle of Internal Friction, $\varphi$ | Unit Weight $\gamma$, $kN/m^3$ | |
| | | | | | | |

**Left Bank** (at location of windguy block of up stream) **SOIL**

| Sketch | Depth from Surface, m | Soil Type | Soil Parameter | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Bearing Capacity, $kN/m^2$ | Angle of Internal Friction, $\varphi$ | Unit Weight $\gamma$, $kN/m^3$ | |
| | | | | | | |

**Right Bank** (at location of windguy block of down stream) **SOIL**

| Sketch | Depth from Surface, m | Soil Type | Soil Parameter | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Bearing Capacity, $kN/m^2$ | Angle of Internal Friction, φ | Unit Weight γ, $kN/m^3$ | |
| | | | | | | |

**Left Bank** (at location of windguy block of down stream) **SOIL**

| Sketch | Depth from Surface, m | Soil Type | Soil Parameter | | | Remarks |
|---|---|---|---|---|---|---|
| | | | Bearing Capacity, $kN/m^2$ | Angle of Internal Friction, φ | Unit Weight γ, $kN/m^3$ | |
| | | | | | | |

If the bank/slope is rock, investigate the rock type according to the Rock Classification chart, filling in the following rock investigation table.

**Right Bank** (at location of Main Anchorage Block) **ROCK**

| Rock Type | Degree of Fracture/Weathering | Rock Parameter | | Applicable Foundation Design | Remarks |
|---|---|---|---|---|---|
| | | Bearing Capacity, $kN/m^2$ | Angle of Sliding Friction, φ° | | |
| | | | | | |

**Left Bank** (at location of Main Anchorage Block) **ROCK**

| Rock Type | Degree of Fracture/Weathering | Rock Parameter | | Applicable Foundation Design | Remarks |
|---|---|---|---|---|---|
| | | Bearing Capacity, $kN/m^2$ | Angle of Sliding Friction, φ° | | |
| | | | | | |

**Right Bank** (at location of windguy block of up stream) **ROCK**

| Rock Type | Degree of Fracture/Weathering | Rock Parameter | | Applicable Foundation Design | Remarks |
|---|---|---|---|---|---|
| | | Bearing Capacity, $kN/m^2$ | Angle of Sliding Friction, $\varphi°$ | | |
| | | | | | |

**Left Bank** (at location of windguy block of up stream) **ROCK**

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

**Right Bank** (at location of windguy block of down stream) **ROCK**

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

**Left Bank** (at location of windguy block of down stream) **ROCK**

| | | | | | |
|---|---|---|---|---|---|
| | | | | | |

# 5. TOPOGRAPHIC SURVEY

After 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

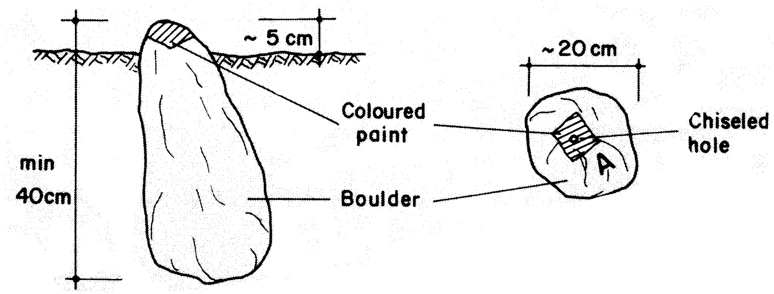
## 5.1 SURVEY AREA

Area to be covered by the topographic survey:,

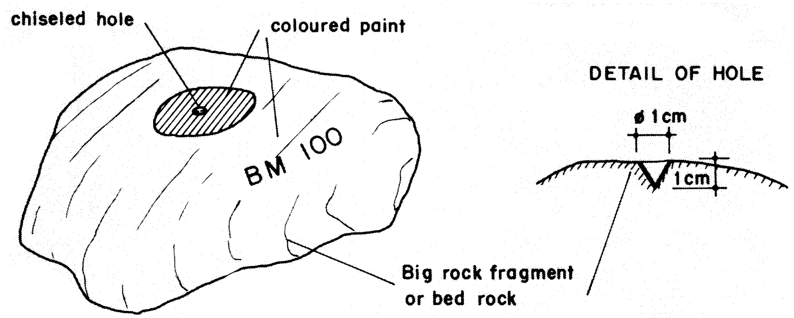
- A profile along the bridge axis covering up to 25m behind the main anchorage blocks, for bridges **without windguy** arrangement.
- A profile along the bridge axis covering up to 25m behind the main anchorage blocks **and** a topographic plan covering the area of 10m upstream and 10m downstream from the tentative location of the windguy foundations; for bridges **with windguy** arrangement

## 5.2 SETTING OF BRIDGE CENTERLINE

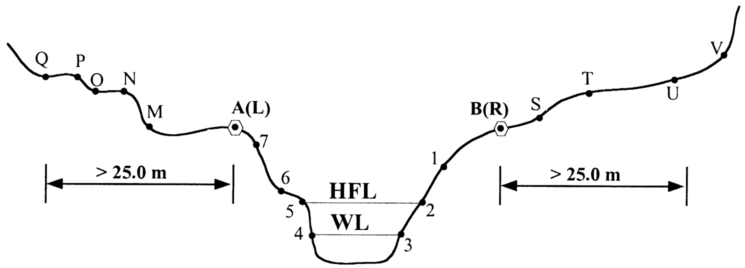
Fix the bridge centerline with two permanent axis points **L** on the left bank and **R** on the right bank. Permanent axis points **L** and **R** should be fixed on rock out crop along the bridge centerline, if available. If rock out crop is not available, these points should be marked on a boulder sufficiently embedded into the ground as per the sketch below:




**OR**




Additional survey points along the centerline should be fixed to survey the bridge axis profile as shown in the sketch below. These survey points should be fixed at breaking points of slope and terraces, which will accurately indicate the topography of the bridge axis. The profile should cover 25m behind the main anchorage block up to the edge of the river flow.



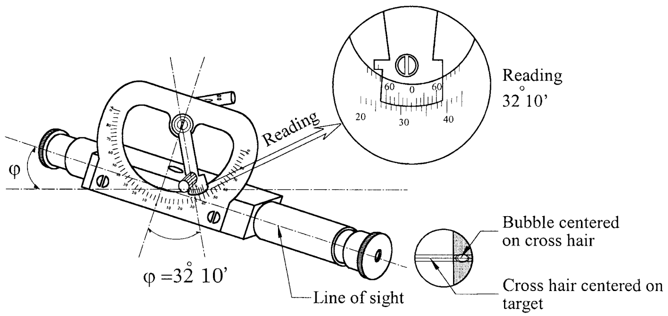
## 5.3 SURVEY METHODS

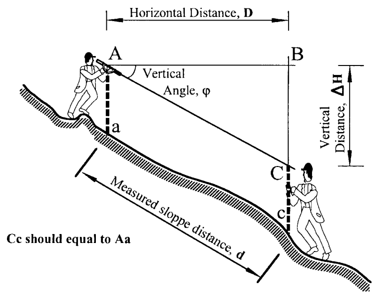
There are two options for conducting the topographic survey. Depending upon the span and type of bridge, a profile along the bridge axis or a more detailed survey including contour lines will be necessary.

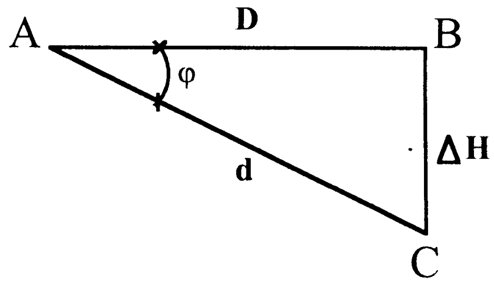
- **Profile along the Bridge axis**:
  Generally bridges up to 120 m do not need windguy arrangement. A detailed profile along the selected bridge axis is sufficient for this bridge design. A topographic profile can be taken by the Abney level, however for fixing precise levels a Level Instrument is necessary.
- For bridges over 120 m span, a Theodolite should be used to carry out the topographic survey.

## 5.4 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 principle of measuring the vertical angle by the Abney Level is illustrated in the sketch and procedure described below:



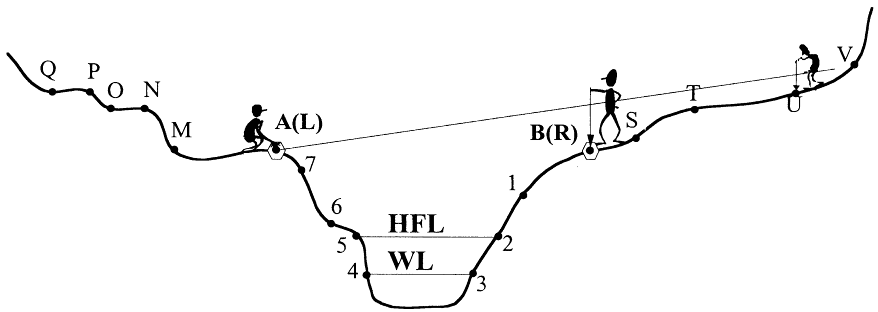




To take a profile along the bridge axis, the surveyor should first set the exact centerline as described in chapter 5.2. There are two methods of setting the centerline.

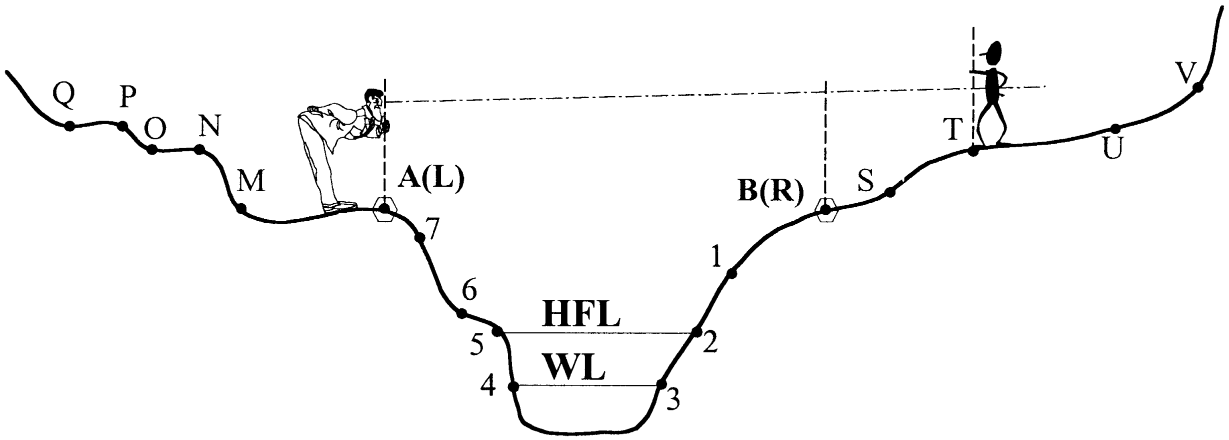
**By measurement tape or nylon rope and plumb bob:**

This method is accurate enough for span up to 50m. The survey points along the bridge centerline are fixed with the help of a measurement tape or nylon rope and a plumb bob as per procedure shown in the sketch below.



**By Bamboo or Wooden Sticks or Ranging Rods:**

This method is applied for span above 50m. In this method the survey points along the bridge centerline are fixed with the help of Bamboo or Wooden Sticks or Ranging Rods. Fix a Stick at each axis point **L** and **R** in **vertical** position. Now the surveyor can aim at other points along the bridge centerline line of **L** and **R**. By fixing in line additional survey points behind and in front of **L** and **R**, more points can be gained along the bridge centerline ranging as per the procedures shown in the sketch below:




Proceed with the survey of bridge profile after having fixed the centerline. Measure the vertical angles and sloped distances between the points of the centerline. The measured vertical angle between axis points **L–R** and **R–L** should be checked for error correction.

The "error-factor" is calculated with the following formula:

$$E = \frac{(\pm \varphi_{LR}) + (\pm \varphi_{RL})}{2} = \pm E \quad ; \quad \textbf{Corrected angle } \varphi' = \varphi \pm E$$

Compute the horizontal distances and elevations of the corresponding survey points with the corrected vertical angles as per trigonometry.

Enter the measurements and calculations into the **Bridge Axis Profile by Abney Level** sheet.

Draw a plan view with the bridge axis (centerline), axis points **L** and **R,** with all the benchmarks and fixed objects like trees, houses etc. Give 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 bridge design.

**Plan**
(indicate river flow and north direction)

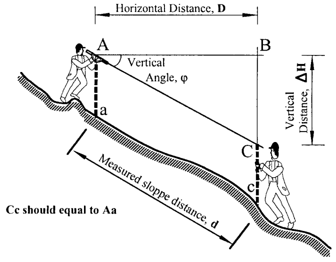
Draw a sketch of the profile/cross section of the bridge axis (centerline) with axis points **L** and **R**, with all the survey points and topographic features, including tentative position of the bridge foundations, low water level and high flood level.

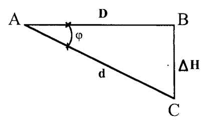
| **Profile/Cross Section** |
|---|
| |

# BRIDGE AXIS PROFILE BY ABNEY LEVEL

**Page No. 1**

| **Bridge Name :** | **District :** | **Surveyed by :** | **Date :** |
|---|---|---|---|




**D = d x Cosφ'**
**ΔH = d x Sinφ'**
**H = R.L. of Station ± ΔH**

| STATION | POINTS | SLOPE DISTANCE d m | VERTICAL ANGLE φ | Corrected VERTICAL ANGLE φ' | HORIZONTAL DISTANCE D m | VERTICAL DISTANCE | | REDUCED LEVEL (ELEVATION) H m | REMARKS (Description of Points) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ± | ΔH | | |
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Remarks:
1. Applicable only for suspended type bridge up to 100m span and suspension type up to 70m.
2. For other cases use Theodolite.

# BRIDGE AXIS PROFILE BY ABNEY LEVEL

**Page No. 2**

| **Bridge Name :** | **District :** | **Surveyed by :** | **Date :** |
|---|---|---|---|

| STATION | POINTS | SLOPE DISTANCE d m | VERTICAL ANGLE φ | Corrected VERTICAL ANGLE φ' | HORIZONTAL DISTANCE D m | VERTICAL DISTANCE | | REDUCED LEVEL (ELEVATION) H m | REMARKS (Description of Points) |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | ± | ΔH | | |
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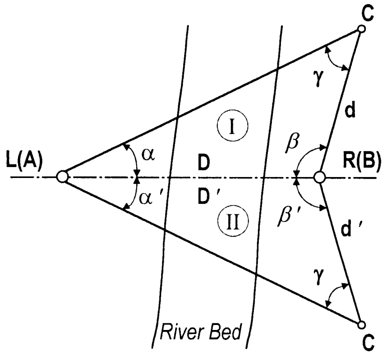
## SURVEY BY THEODOLITE

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.

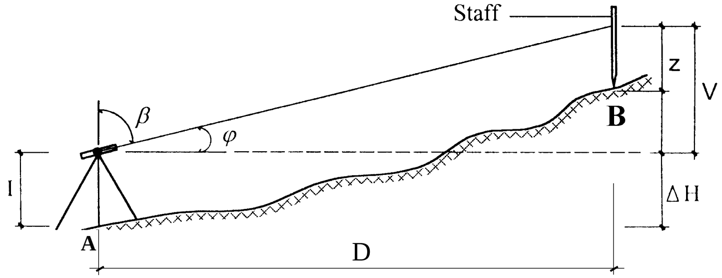
For proper use of a Theodolite, refer to the respective instruction manual, that comes with the Theodolite, and to the SBD Survey Manual.

**Profile Along Bridge Axis:**
Fix the bridge centerline as described in chapter 5.2. Measure distance between the axis points **L** and **R** by horizontal triangulation method. Triangulation is done by measuring all three angles of a triangle and length of one side as illustrated in the sketch below. For accuracy double triangulation is necessary.




Insert all the readings in the **Triangulation Survey Form** and calculate distance between axis points **L** and **R** by trigonometry formulas given therein.

**Elevation of Axis Points and Benchmarks:**
It is necessary to establish the elevations of Axis Points **L** and **R** and Benchmarks. Select elevation of one of the Bench mark $BM_1$ as 100.00m. Establish elevations of axis points and other benchmarks by vertical triangulation as illustrated in the sketch below.




Insert the readings in the Survey form of **Summary of Triangulation and Elevations of Pegs and Benchmarks** and calculate the Elevations (reduced levels) of the points by trigonometry formulas given therein**.**

# T R I A N G U L A T I O N

Bridge Name : District : Surveyed by : Date :

## 1st Triangulation

**Sketch:**

$d_1$ = --------------------

$d_2$ = --------------------

$d_3$ = --------------------

$d_{mean}$ – ________________ $D = d_{mean} \times \dfrac{\text{Sin } \gamma}{\text{Sin } \beta}$ = ________________

| INSTRUMENT STATION | PEG | HORIZONTAL CIRCLE FACE RIGHT | HORIZONTAL CIRCLE FACE LEFT | ANGLE FACE RIGHT | ANGLE FACE LEFT | ANGLE MEAN | |
|---|---|---|---|---|---|---|---|
| A | B | | | | | | $= \alpha_o$ |
| | C | | | | | | |
| B | A | | | | | | $= \beta_o$ |
| | C | | | | | | |
| C | A | | | | | | $= \gamma_o$ |
| | B | | | | | | |
| | | | | | $\delta = \alpha_o + \beta_o + \gamma_o =$ | | |

$\Delta = (200^g \text{ or } 180^o) - \delta$ = ________________

$\alpha = \alpha_o \pm \Delta/3$ = ________________

$\beta = \beta_o \pm \Delta/3$ = ________________

$\gamma = \gamma_o \pm \Delta/3$ = ________________

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

## 2nd Triangulation

**Sketch:**

$d_1$ = --------------------

$d_2$ = --------------------

$d_3$ = --------------------

$d_{mean}$ = ________________ $D = d_{mean} \times \dfrac{\text{Sin } \gamma}{\text{Sin } \beta}$ = ________________

| INSTRUMENT STATION | PEG | HORIZONTAL CIRCLE FACE RIGHT | HORIZONTAL CIRCLE FACE LEFT | ANGLE FACE RIGHT | ANGLE FACE LEFT | ANGLE MEAN | |
|---|---|---|---|---|---|---|---|
| A | B | | | | | | $= \alpha_o$ |
| | C | | | | | | |
| B | A | | | | | | $= \beta_o$ |
| | C | | | | | | |
| C | A | | | | | | $= \gamma_o$ |
| | B | | | | | | |
| | | | | | $\delta = \alpha_o + \beta_o + \gamma_o =$ | | |

$\Delta = (200^g \text{ or } 180^o) - \delta$ = ________________

$\alpha = \alpha_o \pm \Delta/3$ = ________________

$\beta = \beta_o \pm \Delta/3$ = ________________

$\gamma = \gamma_o \pm \Delta/3$ = ________________

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

# SUMMARY of TRIANGULATION and ELEVATIONS of PEGS and BENCHMARKS

| Bridge Name : | District : | Surveyed by : | Date : |
|---|---|---|---|

## 1. Summary of Triangulation

**$1^{st}$ Triangulation $D_1$** = ________________

**$2^{nd}$ Triangulation $D_2$** = ________________

**Difference $\Delta D$** = ________________

**Mean Distance** $D = \dfrac{D_1 + D_2}{2}$ = ______________

$\Delta D / D$ = ______________

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

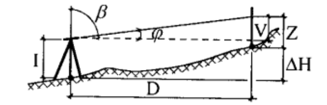
**REDUCED LEVELS: BMI = 100.00**

**BMII** = ________________

**A** = ________________

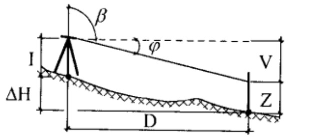
**B** = ________________

## 2. Elevation




$$\Delta H = V - Z + I$$

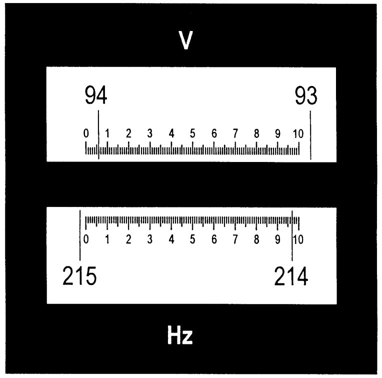
$$V = D \times \tan \varphi = \frac{D}{\tan \beta}$$

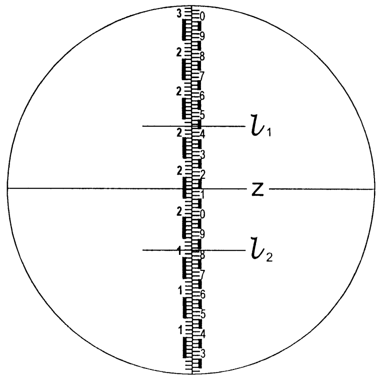


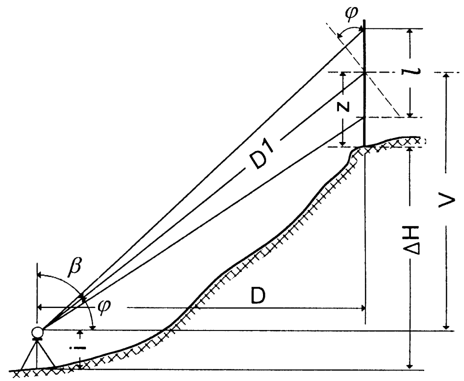

$$\Delta H = V + Z - I$$

| INSTRUMENT STATION | STAFF STATION | INSTRUMENT HEIGHT I | | MIDDLE HAIR Z | | HORIZONTAL DISTANCE D | | VERTICAL ANGLE | | VERTICAL DISTANCE V | | DIFFERENCE IN ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | FACE RIGHT | MEAN (Left + Right)/2 | | | Δ H | | MEAN | |
| | | m | cm | m | cm | m | cm | FACE LEFT | | m | cm | m | cm | m | cm |
| A | B | | | | | | | | | | | | | | |
| B | A | | | | | | | | | | | | | | |
| A | BMI | | | | | | | | | | | | | | |
| BMI | A | | | | | | | | | | | | | | |
| B | BMII | | | | | | | | | | | | | | |
| BMI | B | | | | | | | | | | | | | | |

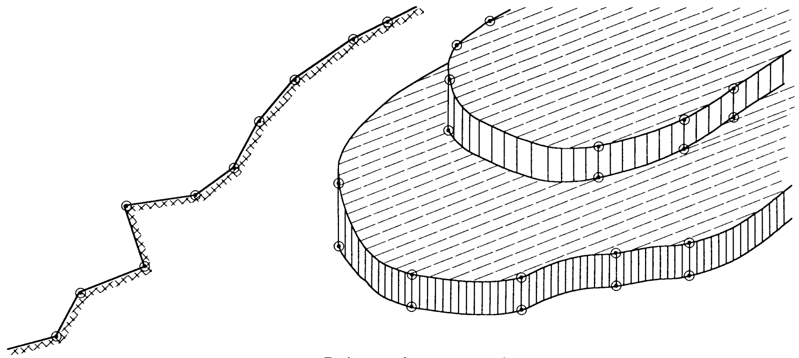
**Topographic Detail Survey:**
Topographic detail survey is necessary to represent the topography of the bridge site by means of the contour lines. This is done by tacheometric survey. Tacheometric survey is done by Theodolite with stadia hairs and leveling staff. The horizontal, vertical distances and position of the points are measured by horizontal and vertical angles and stadia hair readings as illustrated in the sketches below.




The survey points should be taken at break points of slopes, terraces, fields and other features representing the actual topography of the ground as shown in the sketch .



⊙ Points to be measured

Insert all the readings in the **Tacheometry Survey Form** and calculate the horizontal distances and elevations by the formulas given therein.

Check the stadia hair of the Thedolite before the survey. For this measure a distance of about 40m by stadia readings and actual measurement by a tape. If the difference between stadia measurement and tape measurement is more than 0.2%, corrections on calculation of horizontal and vertical distance should be applied. The distances should be corrected for error Δ as per following Formula.

$$\mathbf{D = (100xl+\Delta)\ x\ Cos^2\varphi} \qquad \mathbf{V = (50xl+\Delta)\ x\ Sin2\varphi}$$

# TACHEOMETRY

**Page No. 1**

| Bridge Name : | District : | Surveyed by : | Date : |
|---|---|---|---|

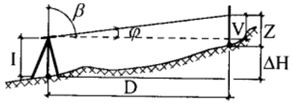
$\ell = \ell_1 - \ell_2$

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

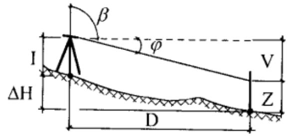
$V = 50 \times \ell \times \sin 2\varphi = 50 \times \ell \times \sin 2\beta$

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<br>HEIGHT OF INSTRUMENT, I<br>m | STAFF STATION | HORIZONTAL CIRCLE $\alpha$<br>g / ° | <br>c / ′ | VERTICAL CIRCLE $\beta$<br>g / ° | <br>c / ′ | TOP HAIR $\ell_1$<br>m | MIDDLE HAIR z<br>m | BOTTOM HAIR $\ell_2$<br>m | STAFF INTERCEPT $\ell$<br>m | HORIZONT. DISTANCE D<br>m | VERTICAL DISTANCE +/- V<br>m | DIFF. IN ELEVATION +/- $\Delta$ H<br>m | REDUCED LEVEL H<br>m | REMARKS (Description of Staff Station) |
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# TACHEOMETRY

**Page No. 2**

| Bridge Name : | District : | Surveyed by : | Date : |
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| STATION / HEIGHT OF INSTRUMENT, I m | STAFF STATION | HORIZONTAL CIRCLE $\alpha$ g / ° | | VERTICAL CIRCLE $\beta$ g / ° | | TOP HAIR $\ell_1$ m | MIDDLE HAIR z m | BOTTOM HAIR $\ell_2$ m | STAFF INTERCEPT $\ell$ m | HORIZONT. DISTANCE D m | VERTICAL DISTANCE +/- V m | DIFF. IN ELEVATION +/- $\Delta$ H m | REDUCED LEVEL H m | REMARKS (Description of Staff Station) |
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| | | g / ° | c / ′ | g / ° | c / ′ | | | | | | | | | |
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# TACHEOMETRY

**Page No. 3**

Bridge Name : District : Surveyed by : Date :

| STATION / HEIGHT OF INSTRUMENT, I m | STAFF STATION | HORIZONTAL CIRCLE $\alpha$ | | VERTICAL CIRCLE $\beta$ | | TOP HAIR $\ell_1$ m | MIDDLE HAIR z m | BOTTOM HAIR $\ell_2$ m | STAFF INTERCEPT $\ell$ m | HORIZONT. DISTANCE D m | VERTICAL DISTANCE +/- V m | DIFF. IN ELEVATION +/- $\Delta$ H m | REDUCED LEVEL H m | REMARKS (Description of Staff Station) |
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# TACHEOMETRY

**Page No. 4**

Bridge Name : District : Surveyed by : Date :

| STATION / HEIGHT OF INSTRUMENT, I m | STAFF STATION | HORIZONTAL CIRCLE $\alpha$ g / ° | HORIZONTAL CIRCLE $\alpha$ c / ′ | VERTICAL CIRCLE $\beta$ g / ° | VERTICAL CIRCLE $\beta$ c / ′ | TOP HAIR $\ell_1$ m | MIDDLE HAIR z m | BOTTOM HAIR $\ell_2$ m | STAFF INTERCEPT $\ell$ m | HORIZONT. DISTANCE D m | VERTICAL DISTANCE +/- V m | DIFF. IN ELEVATION +/- $\Delta$ H m | REDUCED LEVEL H m | REMARKS (Description of Staff Station) |
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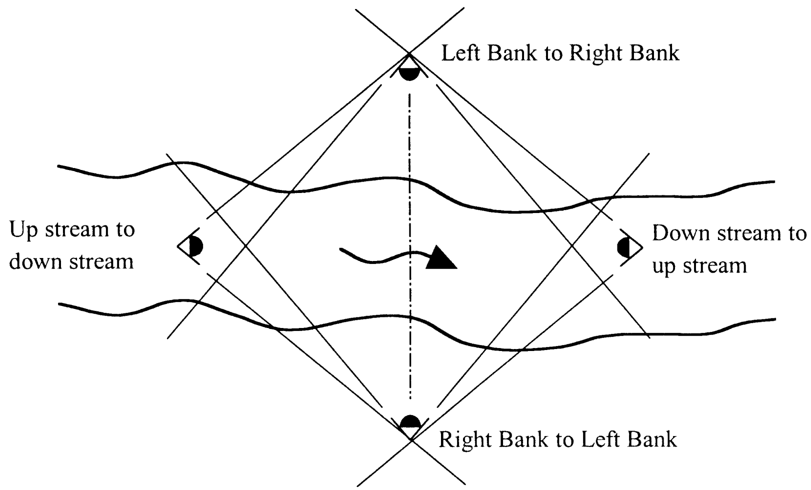
## 6. PHOTOGRAPHS

Photographs of the bridge site to support its technical feasibility / topography and facilitate the bridge design.
Take following photographs:

- Overall view of the bridge site from upstream indicating approximate location of bridge foundations and axis line
- Overall view of the bridge site from down stream indicating approximate location of bridge foundations axis line
- View of the right bank from left bank with approximate location of bridge foundations
- View of the left bank from right bank with approximate location of bridge foundations
- Over all top view (if possible)
- Close up view of axis points and bench marks
- Soil test pits at the location of bridge foundation blocks
- Other relevant photos

Take above photographs from the positions as per 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 on the following blank pages.

1. Overall view of the bridge site from upstream (with approximate location of bridge foundations on both R/B & L/B and axis line)

2. Overall view of the bridge site from downstream (with approximate location of bridge foundations on both R/B & L/B and axis line)

3. Overall view of the right bank (with approximate location of bridge foundation and axis line)

4. Overall view of the left bank (with approximate location of bridge foundation and axis line)

5. View of the right bank with proposed location of bridge foundation

6. View of the left bank with proposed location of bridge foundation

7. View of Axis Peg/Left Bank

8. View of Axis Peg/Right Bank

9. View of Bench Mark

10. Pit excavation at ……………………………….

11. Pit excavation at ……………………………….

12. Pit excavation at ……………………………….

13. Pit excavation at ……………………………….

14. Pit excavation at ……………………………….

15. Pit excavation at …………………………….

16. ……………….…………………………………….

17. ………………….……………………………….

18. ………………….……………………………….

19. ………………….……………………………….

20. ……………………….…………………………………….

# 7. 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 windguy arrangement is necessary**)

**Note Pad**