Edited and compiled by : His Majesty's Government of Nepal
Trail Bridge Section
Department of Local Infrastructure Development and Agricultural Roads / DoLIDAR
with the support of Helvetas Nepal

Published by : SKAT foundation
Resource Center for Development
Vadianstrasse 42, 9000 St. Gallen, Switzerland

First edition 2003

Project commissioned by : HELVETAS
Swiss Association for International Cooperation
Post Box 8042 Zürich, Switzerland

Financed by the Swiss Government
Swiss Agency for Development and Cooperation, SDC
Bern, Switzerland

Printed by : Dongol Printers, Kathmandu, Nepal

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Distributors : In Nepal
Trail Bridge Section, DoLIDAR, Lalitpur, Nepal

Outside Nepal
SKAT Foundation, Vadianstrasse 42, 9000 St. Gallen, Switzerland

Intermediate Technology Development Group (ITDG)
The Schumacher Center for Technology and Development, Bourton Hall, Rugby, UK.

**ISBN 3-908156-06-8**

The views, interpretations, and calculation in this Handbook are the author's and are not attributable to TBS and Helvetas. Anyone using this manual should verify the calculations according to the specific conditions of the site on which the bridges are to be constructed.

**FOREWORD**

A national decision was made by HMG to decentralize Trail Bridge building. Henceforth, the Central Government will be responsible for setting norms, standards, policies of trail bridges as well as for the co-ordination of bridge-providers. Local Governments on the other hand will be responsible to facilitate bridge building.

The manual on Long Span Trail Bridges (LSTB) as well as this manual on Short Span Trail Bridges (SSTB) contain all the norms and standards that must be observed by bridge builders. Likewise, the demarcation policy for the application of the two bridge types is compulsory.

Shrestha

Suraj B. Shrestha

Director General (officiating)
DoLIDAR

July 2003

The Trail Bridge Section (TBS) of the Department of Local Infrastructure and Agricultural Roads (DoLIDAR) is proud on its long-term collaboration with its Swiss Partners represented by Helvetas for project execution and SDC being the funding agent. The collaboration dates back to 1972 and has resulted in the construction of bridges reaching 2,000 not only on Main Trails but also off-Main Trails connecting numerous communities.

In 1989, HMG and Helvetas initiated a new project "Bridge Building at the Local Level (BBLL)" based on indigenous technologies that maximized local resources while minimizing the environmental impact. In its original form, Communities take the lead building their bridges off the main trail according to procedures developed by BBLL. The demand for these bridges that are generally of a short span has proven to be very high resulting in the construction of over 1000 "BBLL bridges" till today. Meanwhile, Local Governments have commenced a vital role supporting the Communities, which will eventually yield BBLL sustainable.

Inspired by BBLL's success, TBS has instigated the development of this Short Span Trail Bridge (SSTB), Suspension Type Handbook for application by any bridge building agent. This new Handbook is intended for national application complementing previous bridge designs that are now dedicated to bridges of a long span hence the name Long Span Trail Bridges (LSTB).

Meanwhile, a demarcation policy has been put in place, indicating the applications by the two bridge types, LSTB and SSTB. The Demarcation Policy essentially puts down a cut off point of 120 m span below which SSTB norms apply and above which LSTB norms apply. The reader is referred to the Policy for the details of the applications.

I, on behalf of DoLIDAR/TBS, acknowledge the valuable efforts put in by the project team and extend my sincere thanks to all those who were involved in the preparation of this Handbook.

Neeraj Shah
Senior Divisional Engineer
DoLIDAR/TBS

July 2003

Despite the rugged topography of the Himalayan State of Nepal, the people established and maintained a traditional trail network for centuries. Footpaths and mule trails are the lifelines for the exchange of goods, the sick going to health posts and the children going to school. Despite great efforts in road construction, a large part of the hill population will continue to depend on the traditional trail network for decades to come.

The Himalayan drainage system consists of countless rivers, which divide the hill areas into many micro economic areas. River crossings are the critical links for roads as well as for trails. For bridging shorter spans, the Nepalese have developed in numerous Regions simple, yet remarkable local techniques. This Handbook has standardized the indigenous local trail bridge types for spans of up to 120 meters, thereby making them conform to modern engineering practices. It encompasses the practical experience made under HELVETAS' local trail bridge programme named "Bridge Building at the Local Level," BBLL, and the Suspension Bridge Project SBP under HMG's Suspension Bridge Division SBD. The Handbook named "Short Span Trail Bridge Standard" is complementary to SBD's "Long Span Trail Bridge Standard" which is applicable for bridges exceeding 120 meter span.

The suspension bridge presented in this handbook represents the outcome of over 30 years experience of pedestrian trail bridge building in Nepal. In fact it even encompasses early practices made at the beginning of the 20th century, when some 30 suspension bridges were built by Scottish engineers arranged by the Rana rulers of that time. In the course of all these years, countless recommendations, suggestions and findings of innumerable engineers, overseers, sub-overseers, site supervisors and consultants of the joint Trail Bridge Programs between SDC/Helvetas and HMG's Suspension Bridge Division have been utilized.

We acknowledge with thanks the efforts provided by the project teams of HMG's Trail Bridge Section and Helvetas under the leadership of Gyanendra Rajbhandari and Robi Groeli. We also gratefully appreciate the careful statical analysis contributed by Dr. N.L. Joshi, Bridge Consultancy Nepal, and the external technical assessment for the dynamic behavior analysis of the superstructure by Dr. Heinrich Schnetzer, WGG Schnetzer Puskas, Switzerland. We also thank SKAT Consulting, Switzerland for their final technical editing of this Handbook. Many thanks go also to Om B. Khadka and L.D.Sherpa who converted all the standard drawings, sketches and photos onto the computer and also did all the desktop publishing.

Our sincere thanks go further to all persons who have been involved in the preparation of this Handbook and who forwarded their valuable comments and suggestions. We hope that this long awaited Handbook will be widely used by technicians appointed to construct a pedestrian trail bridge of limited span of up to 120 meters.

HELVETAS Nepal, Swiss Association for International Cooperation
P.O. Box 688 Kathmandu, Nepal

July 2003

# VOLUME I: GUIDELINES FOR SURVEY, DESIGN & CONSTRUCTION


1. INTRODUCTION ..... 1

1.1 BACKGROUND ..... 1

1.2 CONCEPT OF THE HANDBOOK ..... 1

1.3 PRESENTATION OF THE SUSPENSION BRIDGE TYPE ..... 2

1.4 TECHNICAL FEATURES AND LIMITATIONS ..... 2

1.5 USERS ..... 2

2. SURVEY AND BRIDGE SITE SELECTION ..... 3

2.1 SURVEY AND BRIDGE SITE SELECTION ..... 3

2.1.1 SOCIAL FEASIBILITY SURVEY ..... 4
2.1.2 TECHNICAL SURVEY ..... 4

2.2 PREPARATION FOR SURVEY ..... 4

2.3 GENERAL DATA COLLECTION ..... 5

2.3.1 LOCATION OF BRIDGE SITE ..... 5
2.3.2 NATURE OF CROSSING AND FORDABILITY ..... 6
2.3.3 TRAFFIC VOLUME ..... 6
2.3.4 WIDTH OF WALKWAY ..... 7
2.3.5 LOCAL PARTICIPATION ..... 7
2.3.6 TRANSPORTATION DISTANCE ..... 7
2.3.7 AVAILABILITY OF LOCAL MATERIALS ..... 8
2.3.8 AVAILABILITY OF LOCAL BRIDGE BUILDERS ..... 8
2.3.9 TEMPORARY CROSSING ..... 8

2.4 BRIDGE SITE SELECTION ..... 9

2.4.1 GENERAL CONDITION ..... 9
2.4.2 RIVER CONDITION ..... 13
2.4.3 SLOPE AND BANK CONDITION ..... 14
2.4.4 EVALUATION OF THE BRIDGE SITE ..... 23
2.4.5 CLASSIFICATION OF SOIL AND ROCK ..... 23
2.4.6 IDENTIFICATION OF SOIL AND ROCK ..... 25

2.5 TOPOGRAPHIC SURVEY ..... 26

2.5.1 SURVEY AREA ..... 26
2.5.2 SETTING OF BRIDGE CENTERLINE ..... 26
2.5.3 SURVEY METHODS ..... 28
2.5.4 SURVEY WTH AN ABNEY LEVEL ..... 28
2.5.5 SURVEY WITH A THEODOLITE ..... 34
2.5.6 TOPOGRAPHIC MAPS ..... 40

2.6 PHOTOGRAPHS ..... 44

2.7 SURVEY REPORT ..... 44

**3. BRIDGE DESIGN ..... 45**

3.1 BRIDGE TYPES ..... 45

3.2 BASIC DESIGN CONCEPT ..... 49

3.2.1 LOADINGS ..... 49
3.2.2 CONSTRUCTION MATERIALS ..... 50
3.2.3 STRUCTURAL ANALYSIS AND DESIGN ..... 54

3.3 DESIGN OF STANDARD SUSPENSION BRIDGE ..... 71

3.3.1 THE MAJOR COMPONENTS OF THE SUSPENSION TYPE BRIDGE ..... 71
3.3.2 DESIGN PROCEDURE ..... 71
3.3.3 DESIGNING THE POSITION OF THE WALKWAY & TOWER FOUNDATIONS ..... 73
3.3.4 CABLE DESIGN & STANDARD TOWER SELECTION ..... 78
3.3.5 DESIGN OF THE MAIN CABLE ANCHOR ..... 83
3.3.6 WALKWAY AND TOWER FOUNDATION DESIGN ..... 88
3.3.7 SUSPENDER LIST ..... 90
3.3.8 LIST OF DRAWINGS ..... 90
3.3.9 OTHER STRUCTURES ..... 90
3.3.10 GENERAL ARRANGEMENT DRAWING ..... 99

3.4 DESIGN EXAMPLE ..... 100

**4. BRIDGE STANDARD DRAWINGS ..... 101**

INTRODUCTION AND OVERVIEW OF DRAWINGS ..... 101

4.2 CONSTRUCTION DRAWINGS ..... 101

4.3 STEEL DRAWINGS ..... 105

4.4 CONCEPT OF THE STANDARD DRAWINGS ..... 106

4.5 RELATIONSHIP BETWEEN CONSTRUCTION AND STEEL DRAWINGS ..... 109

**5. CALCULATION OF QUANTITY AND COST ESTIMATE ..... 111**

5.1 IMPLEMENTATION BY THE COMMUNITY ..... 111

5.2 IMPLEMENTATION BY CONTRACTOR THROUGH PUBLIC TENDER ..... 112

**6. CONSTRUCTION ..... 113**

6.1 BRIDGE LAYOUT ..... 113

6.2 FOUNDATION EXCAVATION ..... 117

6.3 LOCAL MATERIAL COLLECTION ..... 118

6.3.1 STONES/BOULDERS ..... 118
6.3.2 SAND ..... 118
6.3.3 GRAVEL ..... 118

6.4 TRANSPORTATION AND STORAGE OF THE MATERIALS ..... 119
6.4.1 CEMENT TRANSPORTATION AND STORING ..... 119
6.4.2 STEEL PARTS TRANSPORTATION AND STORING ..... 119
6.4.3 WIRE ROPE TRANSPORTATION AND STORING ..... 119
6.5 MASONRY AND STONE DRESSING WORK ..... 122
6.5.1 REQUIREMENTS FOR BUILDING STONES ..... 122
6.5.2 QUARRYING ..... 122
6.5.3 STONE DRESSING ..... 123
6.5.4 STONE MASONRY LAYING ..... 124
6.6 CEMENT WORKS ..... 126
6.6.1 COMPOSITION AND MIXTURES ..... 126
6.6.2 TOWER AND WALKWAY FOUNDATIONS ..... 128
6.6.3 CABLE ANCHORS IN SOIL ..... 128
6.6.4 CONSTRUCTING DRUM ANCHORAGES IN ROCK ..... 130
6.6.5 WATER MANAGEMENT AND BACKFILLING ..... 132
6.6.6 FINISHING WORK ..... 132
6.7 BRIDGE ERECTION ..... 133
6.7.1 ERECTION OF TOWERS ..... 133
6.7.2 HOISTING OF MAIN CABLES AND SAG SETTING ..... 135
6.7.3 HOISTING OF SPANNING CABLES ..... 137
6.7.4 FITTING SUSPENDERS AND CENTER ROW OF STEEL DECK ..... 137
6.7.5 FINISHING THE WALKWAY STEEL DECK ..... 140
6.7.6 FITTING WIND BRACINGS ..... 140
6.7.7 FINISHING ERECTION WORKS ..... 142
**7. BRIDGE MAINTENANCE ..... 143**
7.1 INTRODUCTION ..... 143
7.2 ROUTINE MAINTENANCE ..... 143
7.3 MAJOR MAINTENANCE ..... 144

**VOLUME II : FORMS**
**FORM NO. 1: SURVEY FORM AND CHECKLIST**
**FORM NO. 2: BRIDGE DESIGN**
**FORM NO. 3: QUANTITY & COST ESTIMATE FOR COMMUNITY APPROACH**
**FORM NO. 4: QUANTITY & COST ESTIMATE FOR PUBLIC TENDER & CONTRACTING**

**VOLUME III : STEEL & CONSTRUCTION DRAWINGS**
(IN SEPARATE FOLDER)

# VOLUME I :

# GUIDELINES FOR SURVEY, DESIGN & CONSTRUCTION

His Majesty's Government of Nepal
Ministry of Local Development
Department of Local Infrastructure
Development and Agricultural Roads
Trail Bridge Section

SDC/Helvetas
Trail Bridge Sub-Sector Project

# 1. INTRODUCTION

## 1.1 BACKGROUND

For centuries, people have built simple and inexpensive bridges throughout Nepal. With the advent of modern development, organizations emerged which built suspension bridges where local resources appeared to be over burdened. In this manner, some five hundred sophisticated and costly bridges have been built over the last four decades which greatly facilitate the movement of goods and people along the major traffic arteries of this country.

At the same time, the intervention of extraneous agencies may have weakened the attitude of self-reliance of many communities. It is also widely understood that external agencies will never be able to meet all the demands for local river crossings. Hence the idea of reactivating and supporting the communities' own initiatives for improving their environment and infrastructure in the spirit of decentralization. In view of the absence of technical guidance material, it has become significant for technicians at the district level to have a tool for designing economic pedestrian bridges appropriate for communities living in rural areas.

Against this background, the development of the Short Span Trail Bridge Standard started in 1989, when both HMG and Helvetas concluded that the time had come to initiate a programme with a fresh approach to community Trail Bridge building in the hill areas of Nepal. The ultimate objective of this programme, named Bridge Building at the Local Level (BBLL) was to help reactivate, promote and support the people's problem solving and self-help ability for local bridge building. For achieving this goal the development of appropriate techniques for pedestrian trail bridges was of paramount importance.

The bridge design presented in this handbook is a further developed version of the indigenous local trail bridge types built by Nepali craftsmen for centuries. However, the kind of bridge portrayed here characterizes a "real" **suspension bridge!** Although the design procedures have been simplified as much as possible, the steel-part-fabrication made easier and the construction processes straight forward, considerable abilities are required to successfully construct this type of bridge. By recognizing the well-established skills of local trail bridge builders and the capabilities of craftsmen and steel-part fabricators, the components have been kept low in number and less demanding for manufacturers. Special efforts were made to make maximum use of construction materials locally available (boulders, stones, gravel and sand), but critical parts have been designed with an appropriate input of cement, and the exposed steel parts are all hot dip galvanized.

The suspension bridge presented here represents the outcome of over 30 years' experience in pedestrian trail bridge building in Nepal. In fact it even encompasses early practices made at the beginning of the 20th century, when some 30 suspension bridges were built by Scottish engineers arranged by the Rana rulers of that time. In the course of all these years, countless recommendations, suggestions and findings of innumerable engineers, overseers, sub-overseers, site supervisors and consultants of the joint Trail Bridge Programs between SDC/Helvetas and HMG's Suspension Bridge Division ideas have been utilized.

## 1.2 CONCEPT OF THE HANDBOOK

This Handbook provides technical guidelines for the construction of unstiffened pedestrian **suspension type** cable bridges. It applies to suspension bridge types only. For the construction of suspended type bridges (catwalk), refer to the separate Technical Handbook:

*Short Span Trail Bridge Standard, How to Build a Short Span Trail Suspended Bridge, 2002.*

This Handbook comprises three volumes and follows the actual step-by-step process of constructing a bridge. It starts with preparatory work for the site assessment and survey, design and cost estimate and ends with practical guidelines for bridge construction and maintenance.

The three volumes have been structured as follows:

**Volume I** This volume is the guidebook for site survey, bridge design, cost estimation and construction. It serves as a *Help and Reference* for using the pre-designed formats in Volume II and the drawings provided in Volume III.

**Volume II** Volume II provides all the necessary formats for survey, design & cost estimation.

**Volume III** Volume III contains all the standardized steel and construction drawings.

The above three volumes provide all the necessary information, drawings and formats for the construction of a suspension type cable bridge. The volumes are structured in such a way that well versed practitioners need to work with Volume II and III only, whereby Volume I serves as a reference for Volumes II and III. For more scientific background information, the respective engineering sources need to be consulted.

## 1.3 Presentation of the Suspension Bridge Type

The major structural elements of the suspension bridge presented in this Handbook are steel wire ropes of Ø 13, 26 and/or 32mm which are anchored by gravity soil or rock anchors at either side of the river. The superstructure is completely unstiffened and thus allows "some" reasonable degree of lateral, vertical and torsional vibrations.

For economic reasons steel has been used as little as possible, and cement has been applied for guarantying the durability of the structures. There are only four towers (pylons) the user can choose from. They are supported by hinged bearings at the bottom. Turnbuckle systems for fine adjusting the main cables are only provided at one anchor, whereas provisions for later adjusting the spanning cables turnbuckles are applied at both the walkway and tower foundations.

For reducing vibrations and uncomfortable swinging, the bridge deck has been reinforced by two 2" G.I. pipes underneath the walkway. These pipes can also be used for carrying drinking or irrigation water across the river.

Adequate measures have been foreseen to install wind-bracings when needed.

## 1.4 Technical Features and Limitations

The Short Span Trail Bridge Standard as presented in this manual conforms to mainly Indian Standard, but also Swiss and German codes and norms have been applied. All its components fulfill the necessary safety factors by applying the loadings prescribed in the LSTB(SBD) standard design.

All the construction materials conform to international specifications. The exposed steel parts are all hot dip galvanized, and should not be altered unless proven to fulfill standard norms.

> For practical, economic and safety reasons the span range for the Short Span Trail Bridge Standard presented in this Handbook is limited to 120 m.

Longer spans are possible but would require special engineering input. As with every standard design, not all site conditions are covered in this book. It is especially not applicable in unfavorable geological site conditions. At such sites, as mentioned above for longer spans, an engineer's input is mandatory.

## 1.5 Users

This Handbook along with the Forms and Drawings is intended to provide quick and reliable technical methods for survey, design and bridge-construction for engineers and overseers.

# 2. SURVEY AND BRIDGE SITE SELECTION

## 2.1 SURVEY AND BRIDGE SITE SELECTION

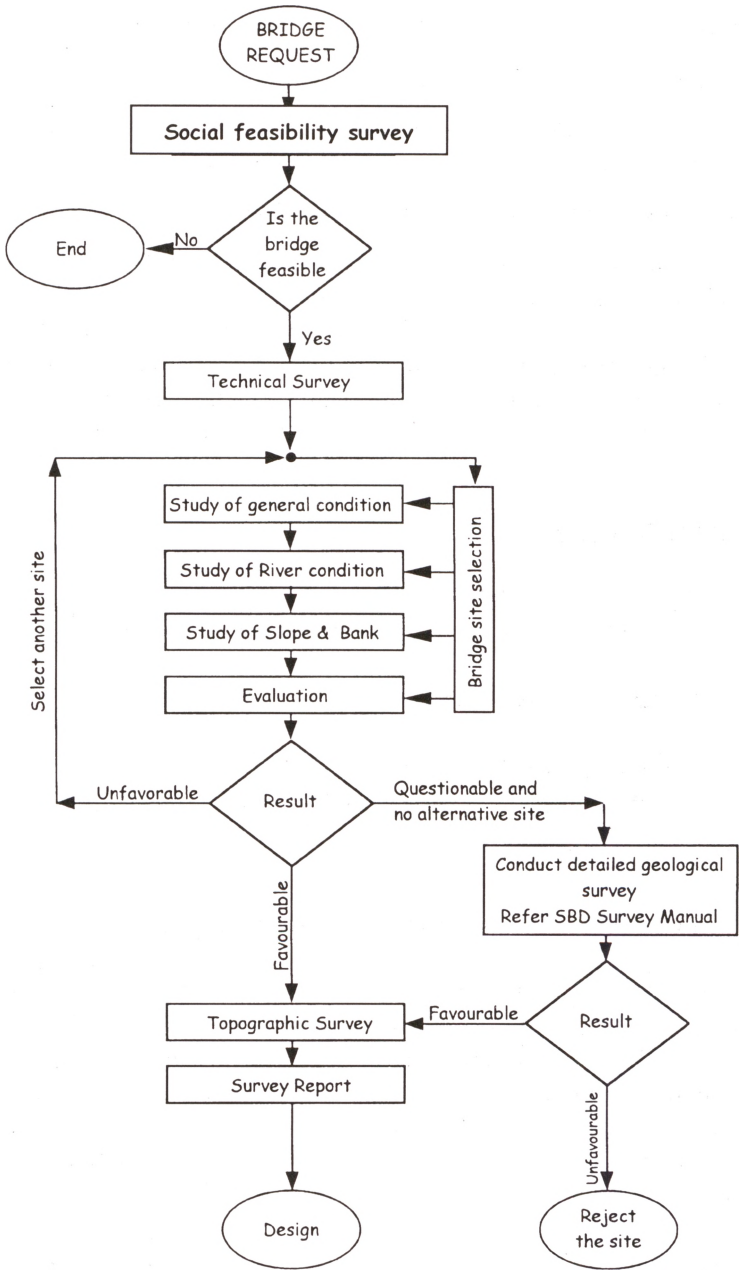
Careful Surveys and Bridge Site Assessments are the basis for proper planning and designing and form the main source for successful bridge construction. The main objective of the Survey and Bridge Site Assessment is to identify a proper bridge site by considering socio-economic as well as technical points of view. The survey and Bridge Site Assessment is done in the following two stages:

- **Social Feasibility Survey and**
- **Technical Survey**

*follow* **Form No. 1**
**Survey Form and Checklist**

Both surveys are of equal importance. The social feasibility survey establishes community ownership and responsibility, and the technical survey ensures that the bridge construction is sound and safe.

The Survey process follows as per the flow chart below:



### 2.1.1 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

The first step for conducting a social feasibility survey is to introduce the participants, the survey team and other groups who will be involved in the process of bridge construction. This is best done in the form of a **mass meeting** right at the spot or near the place where the bridge is going to be built. The mass meeting should have the following agenda:

- Verification of the proposed bridge site with official documentation together with the community
- Explanation of the bridge building process and the role of the community:

  *Phase I:* *Collection of local materials (sand, gravel, stones and boulders), dressing of stones and excavation work.*
  *Phase II:* *Carrying (portering) of construction materials from the nearest roadhead to the site.*
  *Phase III:* *Masonry and concrete work, cable pulling and fitting.*

- Explanation of the self-help nature of the project
- Evaluation and explanation of the bridge location regarding technical limitations and requirements (e.g. width of walkway see 2.3.4), costs and situation of local traffic
- Assessment of the capacity of the community, funds and technical support from outside

One of the major indicators reflecting the real need of the bridge is the degree of participation and the commitment demonstrated 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. However a Social Feasibility Survey is not included in this Technical Handbook. For this, one of the good references would be Social Organization Support (SOS) Manuals of BBLL Program, which has been developed based on long experience of well adopted community trail bridge building approach.

### 2.1.2 TECHNICAL SURVEY

The technical survey includes:

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

## 2.2 PREPARATION FOR SURVEY

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

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

The survey equipment consists of the following materials:

**For Survey by Abney Level**
- Abney Level, Survey Form & Checklist
- Measuring Tape (50 or 100m and 3m)
- Red Enamel Paint and Paint Brush
- Marker Pen, Scale and A3 Graph Paper
- Camera and Film Roll
- Hammer
- Ranging Rod (prepared at site)
- Calculator, Note Book & Pencil
- Nylon Rope (min. 50m) Masons Thread

**For Survey by Theodolite**
- Theodolite, Tripod & Staff
- 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
- Calculator, Note Book & Pencil
- Thread and Plumb Bob

## 2.3 GENERAL DATA COLLECTION

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

- Location of bridge site
- Availability of local materials
- Temporary crossing
- Transportation distance
- Traffic volume
- Local participation
- Nature of crossing and fordability
- Availability of local bridge builders

### 2.3.1 LOCATION OF BRIDGE SITE

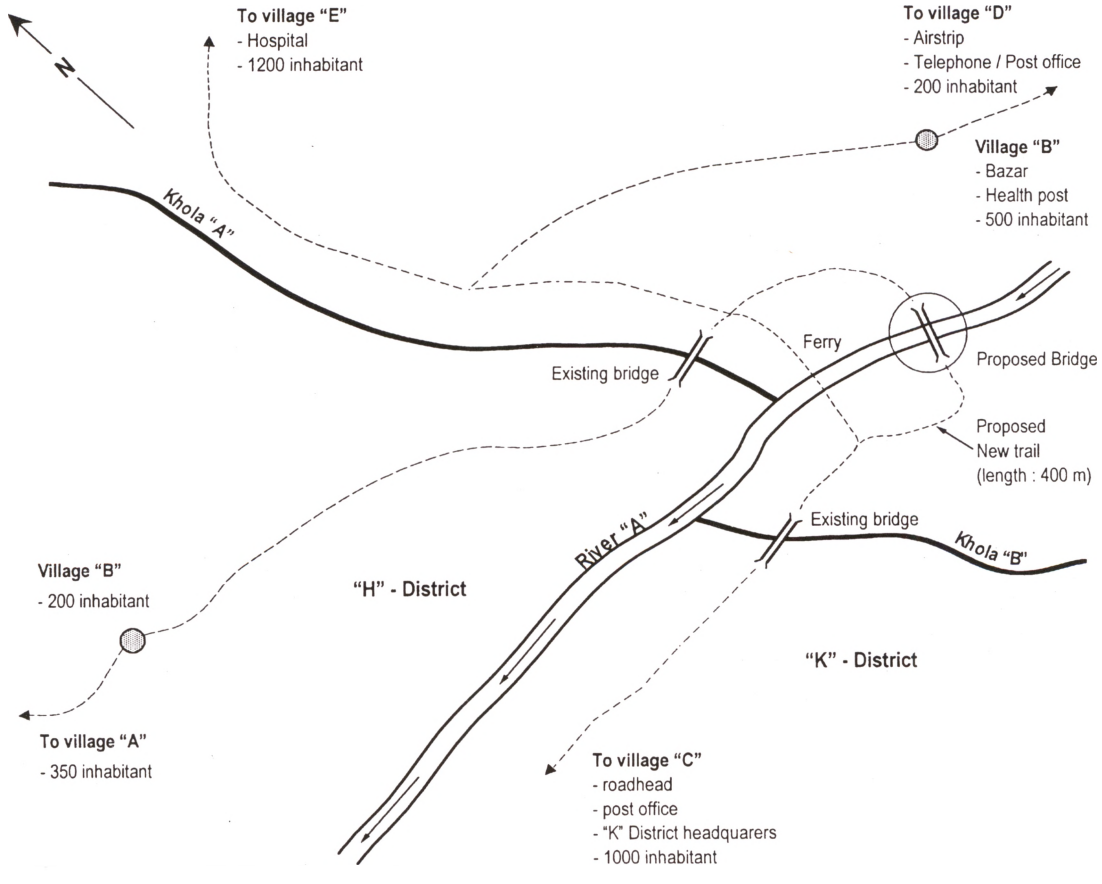
Describe the location of the bridge site:

| | *Left Bank* | *Right Bank* |
|---|---|---|
| VDC | | |
| Ward No. | | |
| Ilaka No. | | |
| District | | |
| 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 the length of the new trail for access to the proposed bridge
- Location of villages, health posts, schools and other important places with approximate distances to the bridge site

**Bridge Site Location Map (Example)**



### 2.3.2 NATURE OF CROSSING AND FORDABILITY

An examination of the present crossing situation is necessary to determine the need and priority of the requested bridge.

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

a. whole year
b. some months per year only
c. some days during high flood only

Situation (a) should be given first priority for construction and least priority given to situation (c).

Study the type of crossing facility available at present and also the location of the nearest bridge. Assess whether the available crossing facility or the existing nearest bridge is sufficient for the crossing or whether a new bridge is necessary.

### 2.3.3 TRAFFIC VOLUME

The traffic volume at the crossing is one of the key indicators in the need assessment of the bridge. The information should be collected by two methods. Count the 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. During traffic count origin and destination of the individual traffic also should be recorded. Origin and destination of the traffic will reflect the size of the influence area and the population of the beneficiaries of the proposed bridge.

| | | *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 the river and the local people as per the table below. This will indicate the importance of the crossing.

| *Access to* | *Yes* | *No* |
|---|---|---|
| Schools | | |
| Hospital / Health posts | | |
| Bazaar/Markets | | |
| Roadhead | | |
| Post office/Telephone | | |
| Farming | | |
| Others (specify) | | |

The most important crossing is one which provides access to schools, hospitals and health posts.

### 2.3.4 WIDTH OF WALKWAY

The standard width of the walkway adopted in this handbook is 70 cm or 106 cm for the Suspended Type Bridge. The walkway width for the Suspension type is fixed at 106 cm.

In most cases, the 70 cm walkway is sufficient in case of Suspended bridge. If there is heavy traffic, mule and pack animal passage carrying bulky goods, or if the crossing is on a main trail, a 106 cm walkway is mandatory. 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** | |
|---|---|---|
| **For Suspended Bridge**: | 70 cm ☐ | 106 cm ☐ |
| **For Suspension Bridge**: | | 106 cm ☐ |

### 2.3.5 LOCAL PARTICIPATION

The commitment and participation of the local people in the construction of the proposed bridge will truthfully indicate the need of the bridge. The stronger the commitment and participation, the higher is the need of the bridge.

For informing the community regarding how much labor work is generally necessary for constructing the bridge, the following formulas can be used to compute the **tentative preliminary number of mandays**:

| | | **For Suspended Bridge** | **For Suspension Bridge** |
|---|---|---|---|
| • Mandays for skilled Labor: | = | **1.3 x Span [m] + 400** | **1.6x Span [m] + 500** |
| • Mandays for unskilled Labor: | = | **5.0 x Span [m] + 1300** | **6.0 x Span [m] + 1400** |

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

| ***By Whom*** | ***Type of Participation*** |
|---|---|
| Local Community | |
| User's Committee | |
| VDC | |
| DDC | |
| Local NGO | |
| Individual | |
| Others (specify) | |

### 2.3.6 TRANSPORTATION DISTANCE

Information on the transportation distance from the nearest roadhead, airstrip and helipad to the site is required for planning the construction of the bridge.

| ***Type of Transport*** | ***Name of nearest Roadhead/Airstrip etc.*** | ***Distance up to Roadhead/Airstrip and Porter Distance up to Site from Roadhead/Airstrip*** | | |
|---|---|---|---|---|
| | | ***Km/Kosh*** | ***Porter Days*** | ***By Mule, Days*** |
| Served by Truck | | | | |
| Served by Tractor | | | | |
| Airstrip | | | | |
| Helipad | | | | |

### 2.3.7 AVAILABILITY OF LOCAL MATERIALS

Assess the availability of local materials needed for the bridge construction. Identify the nearest collection place for these materials.

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

### 2.3.8 AVAILABILITY OF LOCAL BRIDGE BUILDERS

In the villages nearby there may be local bridge builders who have already built some bridges. Their skill can be used in construction of the proposed bridge. If such people are available, record their names.

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

### 2.3.9 TEMPORARY CROSSING

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

If yes, what kind of temporary crossing do you propose? Ferry ☐ Cable Car ☐

Temporary Bridge, Span ☐ .....m

## 2.4 BRIDGE SITE SELECTION

There are two possible standard bridge types namely "Suspension" and "Suspended" (for detail refer to Chapter 3.1). The selection of the bridge type mainly depends on the prevailing topography of the bridge site.

The Suspended type bridge is selected when the bridge foundations can be placed at a sufficiently high position giving the required free board from the highest flood level. The Suspension type bridge is selected when the bridge site is in comparatively flat terrain and the suspended bridge is not feasible due to the constraint of the free board. The Suspension type bridge is more expensive (per meter cost), and needs more inputs in design and construction than the Suspended type.

Therefore, assess the possibility of the Suspended type which should be the first choice. The Suspended type is more preferable due to economic reasons and easy construction technology which is more appropriate for the community bridge building approach. For further details on selection of the bridge type, refer to Chapter 3.3.2.

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 be justified and have a long lifespan. It must :

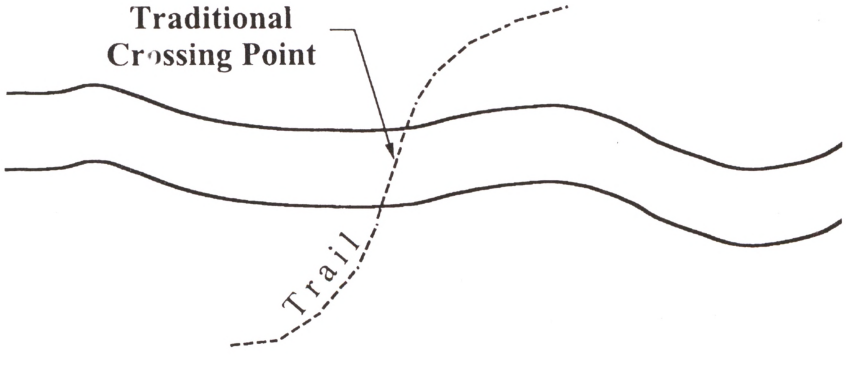
- fulfill the general condition
- have favorable river conditions
- have stable bank and slope conditions
- have the shortest possible span

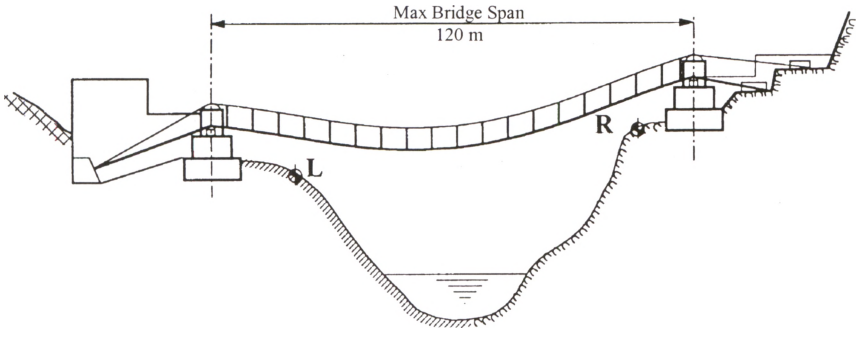
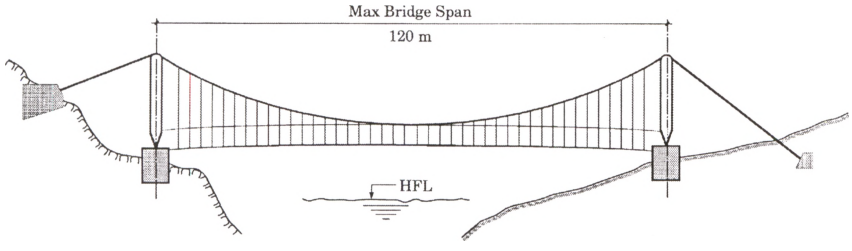
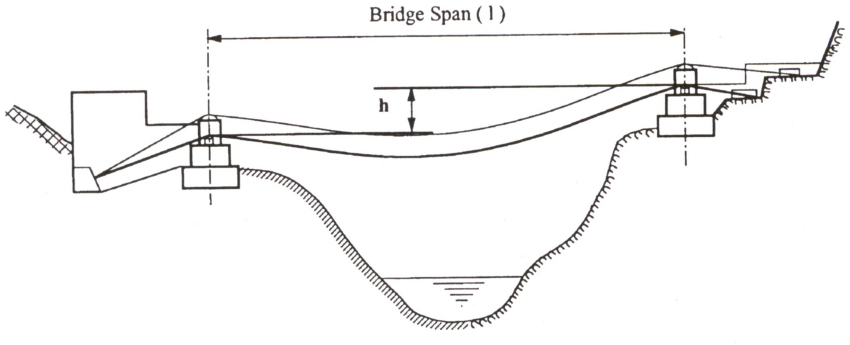
### 2.4.1 GENERAL CONDITION

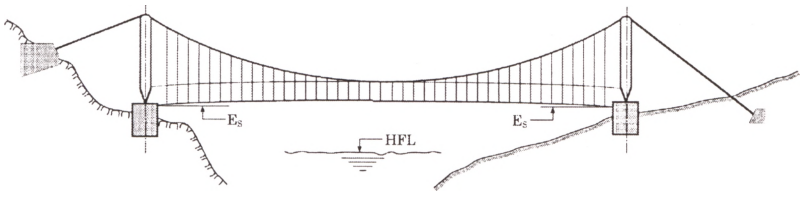
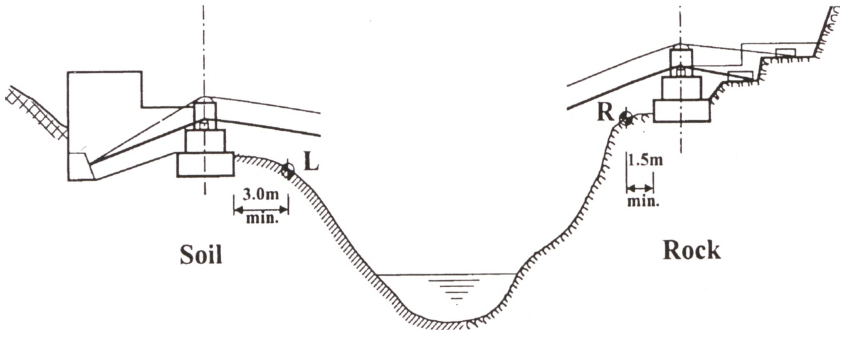
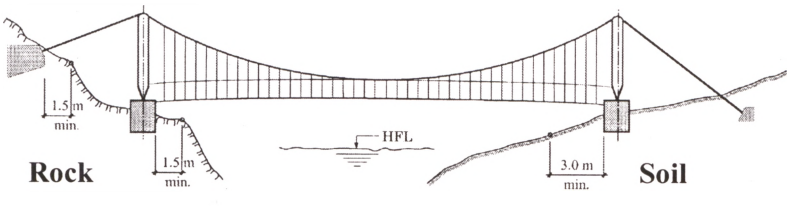
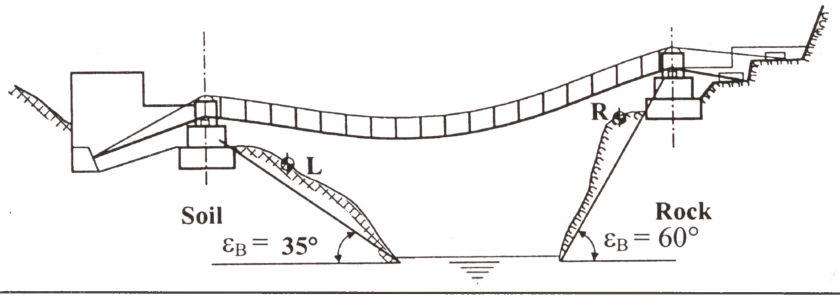
The bridge site should fulfill the following general conditions. They are:

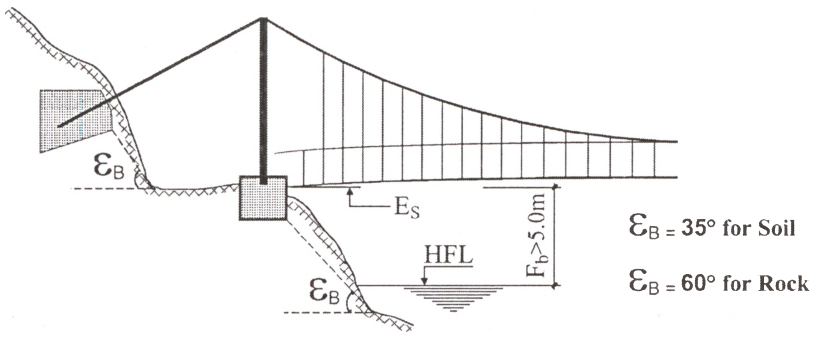
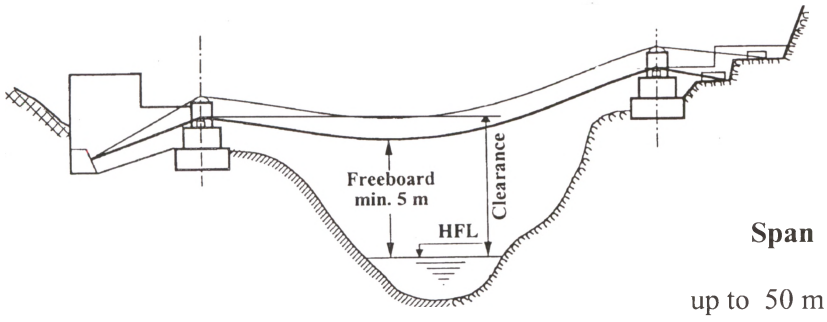
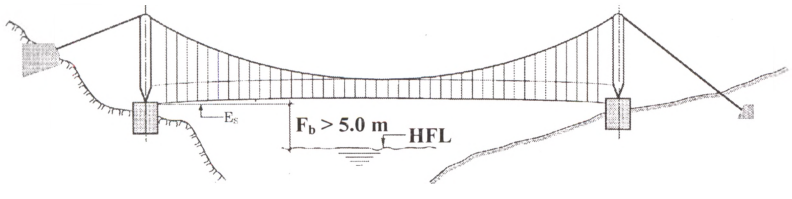
- close to traditional crossing point
- maximum bridge span of 120 m
- minimum free board from highest flood level
- safety distance for foundations

Use the following checklist to evaluate the general condition:

| *Features* | *Condition* |
|---|---|
| **TRADITIONAL CROSSING POINT**<br>The bridge site should be selected at or near the traditional crossing point.<br>  <br><br>• For a minor rivers, a detour from the traditional crossing point is not acceptable.<br>• For major rivers, a detour up to 500 m u/s and 500 m d/s from the traditional crossing point may be acceptable. | **Favorable**:<br>Selected site is at or near the traditional crossing point<br><br>**Unfavorable:**<br>Selected site is far from the traditional crossing point |

| *Features* | *Condition* |
|---|---|
| **BRIDGE SPAN**<br>The bridge span in this standard is limited to 120 m span.<br>**In Case of Suspended Type Bridge**:<br>  <br><br>**In Case of Suspension Type Bridge**:<br>  <br><br>• Measure tentative span<br>• Compare with the limit | **Favorable**:<br>span, $\ell$ is equal to or shorter than 120 m<br><br>**Unfavorable**:<br>span, $\ell$ is longer than 120 m |
| **LEVEL DIFFERENCE BETWEEN TWO BANKS**<br>**In Case of Suspended Type Bridge**:<br>The level difference **h** between the two foundation blocks should not be more than $\ell$ **/25**.<br>  <br><br>• Locate the tentative position of the bridge foundations on both banks<br>• Measure the level difference **h** between the foundations on the two banks<br>• Compare with the condition | **Favorable**:<br>**h** is equal to or less than $\ell$ /25<br><br>**Unfavorable**:<br>**h** is greater than $\ell$ /25 |

| *Features* | *Condition* |
|---|---|
| **In Case of Suspension Type Bridge**:<br>The Walkway and Tower Foundations on both the banks should be placed at the same level.<br>  <br><br>• Locate the tentative position of the Walkway and Tower Foundations on the lower bank<br>• Estimate the position of the Walkway and Tower Foundations on the other bank at the same level<br>• Compare with the condition | **Favorable**:<br>Walkway and Tower Foundations on both banks can be placed at the same level<br><br>**Unfavorable**:<br>Walkway and Tower Foundations on both banks can not be placed at the same level. |
| **SAFETY DISTANCE FOR FOUNDATION**<br>The Foundations should be placed at least 3 m behind the soil slope and 1.5 m behind the rock slope from the front edge of the riverbank.<br>**In Case of Suspended Type Bridge**:<br>  <br> | **Favorable:**<br>Condition can be fulfilled<br><br>**Unfavorable:**<br>Condition cannot be fulfilled |
| **In Case of Suspension Type Bridge**:<br>  <br> | |
| **SLOPE PROFILE**<br>The Bridge Foundation should be placed behind the line of the angle of internal friction. (The angle of internal friction is the angle of the slope of soil or rock at which it is still stable and does not slide).<br>**In Case of Suspended Type Bridge**:<br>  <br> | **Favorable:**<br>Condition can be fulfilled<br><br>**Unfavorable:**<br>Condition cannot be fulfilled |

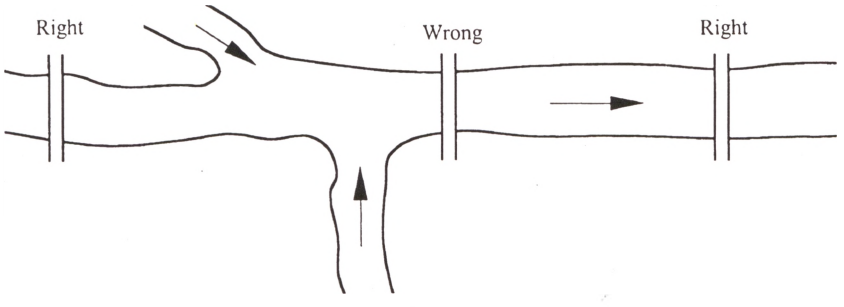
| *Features* | *Condition* |
|---|---|
| **In Case of Suspension Type Bridge**:   | **Favorable:** Condition can be fulfilled<br><br>**Unfavorable:**<br>Condition cannot be fulfilled |
| • Draw slope lines of 35° (angle of internal friction) in case of a soil slope and 60° in case of a rock slope.<br>• The foundations should be placed behind these slope lines.<br>• Check if these conditions can be fulfilled. | |
| **FREE BOARD**<br>**In case of Suspended Type Bridge**:   | **Favorable** **Unfavorable**<br>**The clearance** between the lower foundation saddle and the HFL is: |
| **Span**<br>up to 50 m<br>51 - 60 m<br>61 - 90 m<br>91 - 105 m<br>106 - 120 m | **not less than:** **less than:**<br>7.0 m 7.0 m<br>7.5 m 7.5 m<br>8.0 m 8.0 m<br>8.5 m 8.5 m<br>9.0 m 9.0 m |
| **In case of Suspension Type Bridge**:   | **Favorable**:<br>Freeboard is not less than 5.0m<br><br>**Unfavorable**:<br>Freeboard is less than 5.0m |
| • Identify the HFL by local observation and from villagers' information.<br>• Calculate the available clearance in case of the Suspended type or the free board in case of the Suspension type, and compare with the requirement.<br>• **Exception**: On flat or wide riverbanks the free board may be reduced. At gorges the free board may have to be increased. | **HFL** = Highest Flood Level |

### 2.4.2 RIVER CONDITION

The selected bridge site must have favorable river conditions. Accordingly, a bridge should be located:

- on a straight reach of the river
- beyond the disturbing influence of larger tributaries
- on well defined banks

Use the following checklist to evaluate the river condition:

| *Features* | *Condition* |
|---|---|
| **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> | **Favorable**:<br>Bridge site far from river confluences<br><br>**Unfavorable**:<br>Bridge site near river confluences |
| **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 | **Favorable**:<br>River bed is not erosive, not filling up<br><br>**Unfavorable**:<br><br>River bed is erosive or filling up |

### 2.4.3 SLOPE AND BANK CONDITION

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

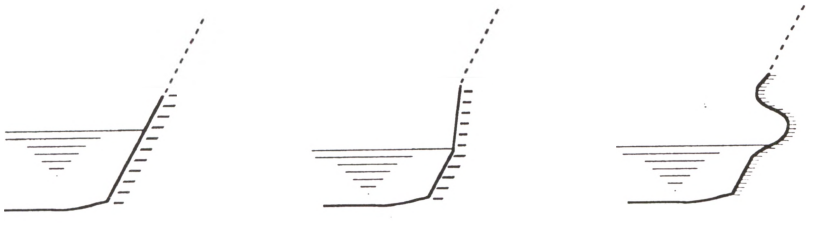
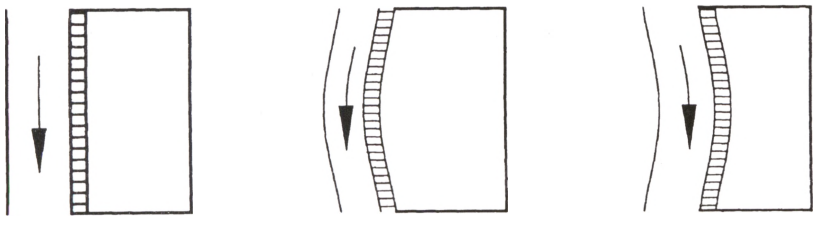
**If the slope and bank is soil, potential instability features and failure modes are:**

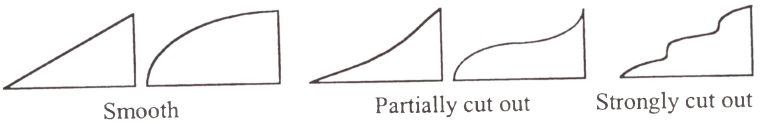
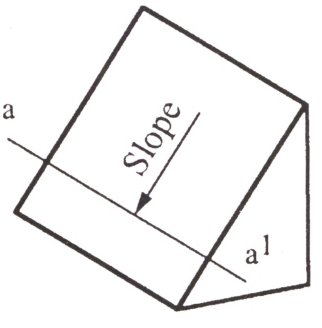
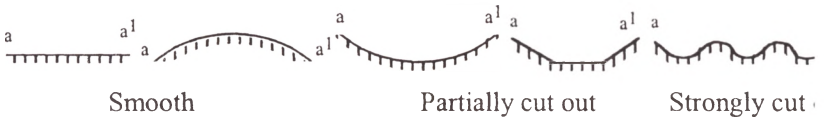
- bank erosion
- toppling instability of the bank
- erosion of the slope
- land slide

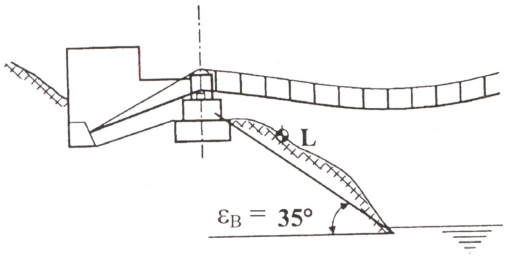
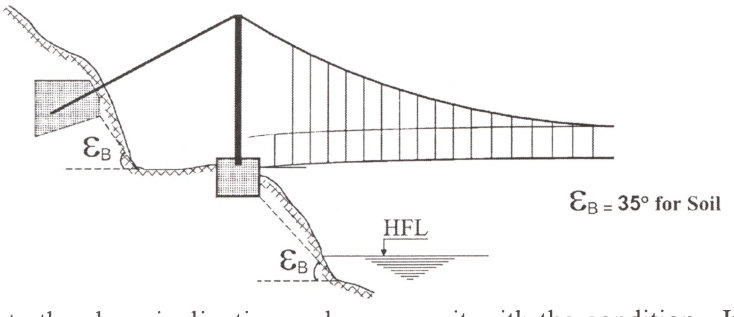
**If the slope and bank is rock, the potential instability features and failure modes are:**

- plain failures or a rockslide along the slope
- wedge failure leading to the fall of rock mass
- toppling leading to the fall of rock blocks
- translational Failure (slide) is similar to a 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.

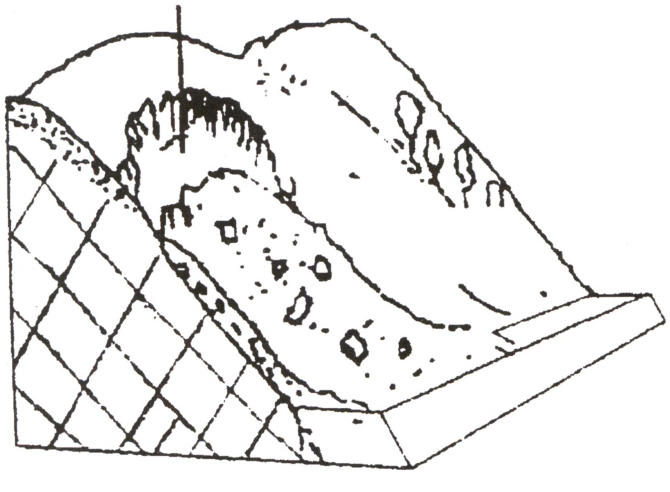
To avoid the above instability features, use the following checklist to evaluate the slope and bank of the selected site:

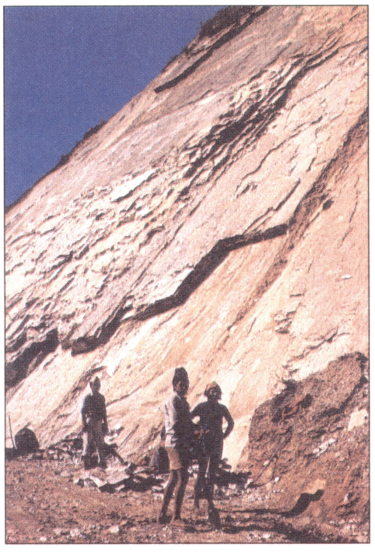
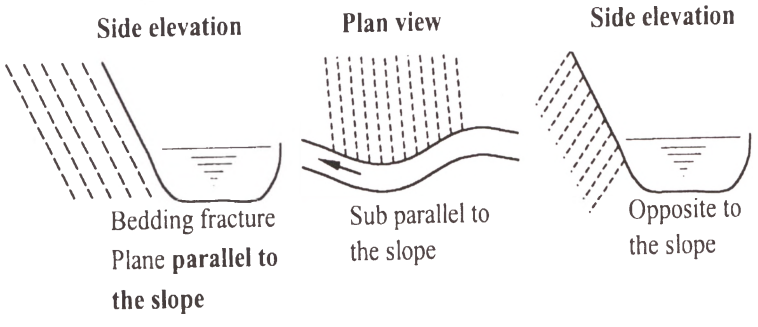
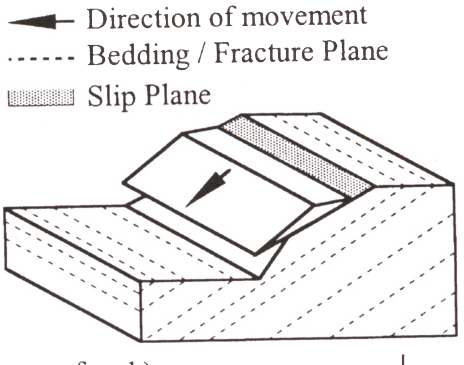
| *Features* | *Condition* |
|---|---|
| **IF THE RIVER BANK OR SLOPE IS SOIL**<br>**BANK PROFILE**<br>The bank profile should be smooth.<br>  <br>Smooth Partially cut out Strongly cut out | **Favorable**:<br>Bank profile is smooth to partially cut out<br><br>**Unfavorable**:<br>Bank profile is strongly cut out |
| **RIVER BANK CONTOUR**<br>The bridge site should be located at a straight reach of the river to avoid undercutting or bank erosion.<br>  <br>Straight Convex Concave | **Favorable:**<br>River contour is straight or convex<br><br>**Unfavorable**:<br>River contour is concave |

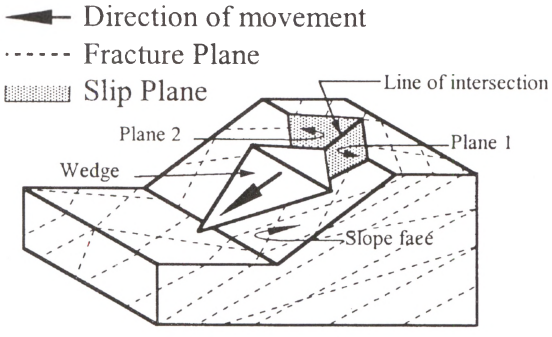
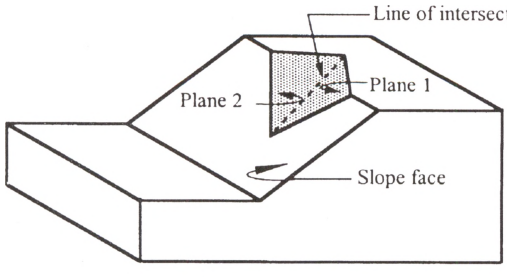
| *Features* | *Condition* |
|---|---|
| **BANK EROSION**<br>The river bank should not show any sign of erosion.<br> <br>Bank erosion due to high river current | **Favorable**:<br>No sign of fresh erosion<br><br>**Unfavorable**:<br>Presence of fresh erosion |
| **SLOPE PROFILE**<br>The slope profile should be smooth.<br>  <br>Smooth Partially cut out Strongly cut out | **Favorable:**<br>Slope profile is smooth to partially cut out<br><br>**Unfavorable**:<br>Slope profile is strongly cut out |
| **TRANSVERSE SLOPE**<br>The transverse slope should be smooth.<br> <br>Transverse slope strongly cut out |  <br><br>**Favorable**:<br>Transverse slope is smooth to partially cut out<br><br>**Unfavorable**:<br>Transverse slope is strongly cut out |
|  <br><br>Smooth Partially cut out Strongly cut | |

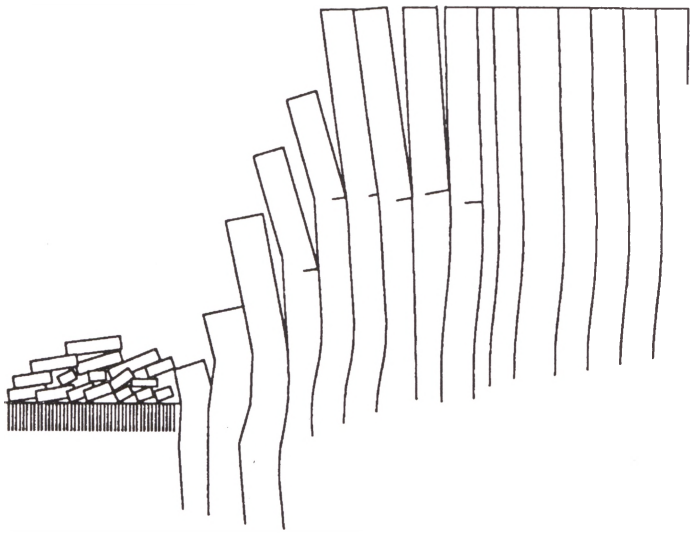
| *Features* | *Condition* |
|---|---|
| **SLOPE INCLINATION (SOIL SLOPE)**<br>The slope inclination should be less than 35°.<br><br>**In case of Suspended Type Bridge**:<br>  <br><br><br>**In case of Suspension Type Bridge**:<br>  <br><br>Estimate the slope inclination and compare it with the condition. If the site has an unfavorable slope inclination, it can still be selected provided the general condition of the slope profile is fulfilled. | **Favorable**:<br>Slope inclination is equal to or smaller than 35°<br><br>**Unfavorable**:<br>Slope inclination is greater than 35° |
| **RIVER UNDERCUTTING**<br>The bridge site should be free from river undercutting which may lead to landslide.<br><br> <br>Landslide caused by river undercutting | **Favorable**:<br>There is no river undercutting<br><br>**Unfavorable**:<br>River undercutting is active or there is potential for river undercutting |

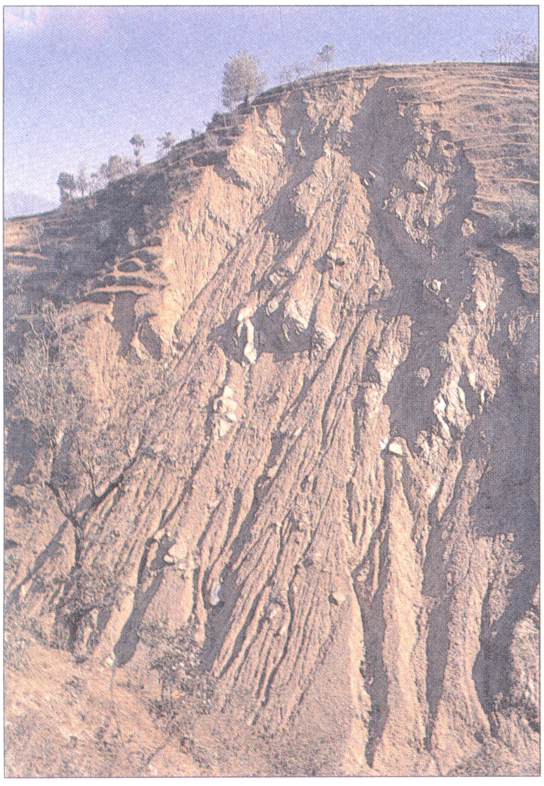
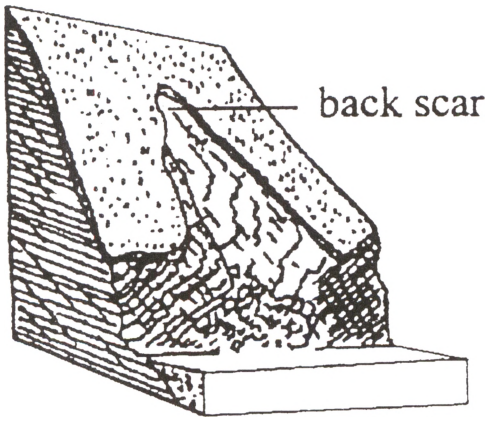
| *Features* | *Condition* |
|---|---|
| **INCLINED TREES**<br>The selected site should not have inclined trees, which indicate an active landslide.<br> <br>Inclined trees on landslide mass | **Favorable**:<br>Inclined trees are not present<br><br>**Unfavorable**:<br>Inclined trees are present |
| **SEEPAGE OR SWAMPY AREA**<br>The bank slope should not have any seepage or swampy area, which may lead to slope instability. | **Favorable**:<br>Seepage or swampy area is absent<br><br>**Unfavorable**:<br>Seepage or swampy area is present |
| **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 any rivulets exist, examine the dimension of the gully cutting. | **Favorable**:<br>No sign of gully erosion or only light gully erosion<br><br>**Unfavorable**:<br>Heavy gully erosion exists |

| *Features* | *Condition* |
|---|---|
| **SLIPPED (SLUMP) SOIL MASS**<br>The bridge should not be located on already slipped soil masses.<br><br> <br>Slope with slipped soil mass<br><br>**Back Scar**<br>  <br>**Slope Failure Model**<br><br>• Examine and identify any indication of soil mass movement. This can be done by observing traces of back scars on the slope. | **Favorable**:<br>There are no back scars or signs of soil mass movement<br><br>**Unfavorable**:<br>There are back scars or signs of soil mass movement |

| *Features* | *Condition* |
|---|---|
| **IF THE RIVER BANK OR SLOPE IS ROCK**<br><br>**PLAIN FAILURE**<br>Plain failures lead 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.<br><br>  <br><br>Bedding plain is **parallel to the slope** and plain failure is active.<br>**Site is extremely unfavorable!**<br><br>  <br><br><br>**Plain Failure Model**<br><br>  <br><br><br>• Identify bedding/fracture plain (layers of rock)<br>• Check its direction and inclination<br>• Compare with the condition | **Favorable**:<br><br>**Plain failure will not take place, if:**<br><br>• The bedding/fracture plain is sub-parallel or opposite to the slope<br><br>• The bedding/fracture plain is parallel to the slope, but inclination is less than 35°<br><br>**Unfavorable**:<br><br>**Plain failure will take place, if:**<br><br>• The bedding/fracture plain is parallel to the slope and inclination is greater than 35°<br><br>• There is presence of old rockslides |

| *Features* | *Condition* |
|---|---|
| **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> <br>Traces of wedge failure<br><br>  <br><br>**Wedge Failure Model**<br><br>  <br><br>**Wedge Failure**<br><br>• Identify if there are fracture plains facing each other (intersecting)<br>• Check the inclination of the line of intersection<br>• Compare with the condition | **Favorable**:<br><br>**Wedge failure will not take place, if**<br><br>• There are no fracture plains facing each other<br><br>• There are two or more intersecting fracture plains but the inclination of the line of intersection is less than 35°<br><br>• There are two or more intersecting fracture plains but the inclination of the line of intersection is opposite to the slope<br><br>**Unfavorable**:<br><br>**Wedge failure will take place, if**<br><br>• There are two or more intersecting fracture plains and the inclination of the line of intersection is greater than 35° to the slope<br><br>• There is presence of wedge that has slid down |

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

| *Features* | *Condition* |
|---|---|
| **TRANSLATIONAL FAILURE (SLIDE)**<br>The rock slope should not have any potential of translational failure.<br><br>  <br>**Translational failure (sliding) of soft rock slope**<br><br>  <br><br>**failure (slide) model**<br><br>• Identify the type of rock and its weathering grade<br>• Estimate the inclination of the slope<br>• Compare with the conditions | **Favorable**:<br><br>**Sliding will not take place, if the**<br><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><br>**Unfavorable**:<br><br>**Sliding will take place, if**<br><br>• The slope is highly weathered soft rock and steeper than 40°<br>• Back scars or old slides are present |

### 2.4.4 Evaluation of the Bridge Site

After completing investigation of the site as per Chapter 2.4.1 to 2.4.3, categorize the bridge site as

**Good** All or most of the features are favorable, and the surveyor is confident about the stability of the slopes, proceed with further survey work.

**Bad** Most of the features are unfavorable. Reject the site.

**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 Volume B of LSTB (SBD) Manual of Trail Bridge Section / DoLIDAR, Nepal.

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 wall, 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.**

### 2.4.5 Classification of Soil and Rock

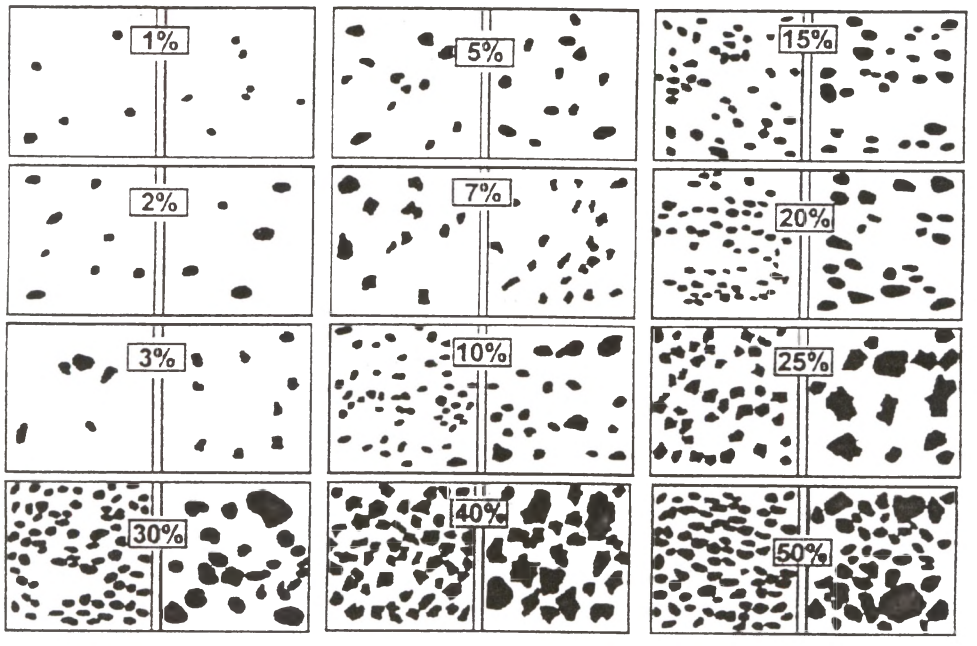
Identification of Soil and Rock types is required for appropriate foundation design. Soil and Rocks can broadly be classified as per the following tables.

## Soil Classification

| Soil Type | | How to Identify | Soil Parameters | | | Applicable Main Cable Anchor Block Design | |
|---|---|---|---|---|---|---|---|
| | | | Bearing Capacity, [kN/m$^2$] | Angle of Internal Friction, φ° | Unit Weight, γ [ kN/m$^3$] | For Suspended Type | For Suspension Type |
| **Coarse Grained Soils** More than half of the materials are of 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. 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** | **Deadman Anchor or Gravity Anchor Block** |
| | **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** | | |

For estimating the percentage (%) of coarse grains, use the following figure:

**Ratio of coarse grains**




## Rock Classification

| Rock Type | Examples | How to Identify | Degree of Fractures or Weathering | How to Identify | Rock Parameters | | Applicable Main Cable Anchor Design | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Bearing Capacity [kN/m$^2$] | Angle of Sliding Friction φ° | For Suspended Type | For Suspension Type |
| **Hard Rock** | Quartzite Limestone Granite, Dolomite etc. | Gives metallic sound at 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 | Drum Anchor in Hard Rock or Gravity Anchor Block |
| | | | Highly fractured rock and fresh to fairly weathered | In the rock shows widely open cracks, fractures and bedding | 1500 | 35-50 **(40)** | Drum Anchor in Fractured Rock | Drum Anchor in Fractured Rock or Gravity Anchor Block |
| **Soft Rock** | Phylite Slate Siltstone Claystone Schist etc. | Gives dull sound at hammer blow | Fresh | No sign of weathering | 1300 | 25-40 **(30)** | | |
| | | | Fairly to highly weathered | Most of the original rock has been seriously altered Rock can be broken by hand | 600-750 **(650)** | 25-40 **(30)** | Deadman Anchor | Gravity Anchor Block |

### 2.4.6 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 bedrock at the proposed foundation locations. Pit excavation and soil/rock investigation should be carried out at all foundation locations.

If the bank/slope is soil, investigate each layer of soil in the pit and classify the soil according to the Soil Classification Chart of page 23. Fill in the soil investigation table as per the following example.

**Example for Soil**

Location: Main Anchorage Foundation on Right Bank

| Sketch | Depth from Surface, [m] | Soil Type | Soil Parameter | | Remarks |
|---|---|---|---|---|---|
| | | | Bearing Capacity, [kN/m$^2$] | Angle of Internal Friction, φ | |
| | 0.0 | Top soil | | | |
| | 0.3 | Sandy Soil | | | |
| | 1.1 | Gravelly Soil | 400 | 35 | Foundation Design Parameter |

If the bank/slope is rock, investigate the rock type according to the Rock Classification Chart of page 24. Fill in the rock investigation table as per the following example.

**Example for Rock**

Location: Main Anchorage Foundation on Left Bank

| Rock Type | Degree of Fracture/Weathering | Rock Parameter | | Applicable Foundation Design | Remarks |
|---|---|---|---|---|---|
| | | Bearing Capacity, [kN/m$^2$] | Angle of Sliding Friction, φ | | |
| Hard Rock | Highly fractured and fairly weathered | 1500 | 40 | Drum anchorage foundation in fractured rock | |

## 2.5 TOPOGRAPHIC SURVEY

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

- provide a topographical 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

### 2.5.1 SURVEY AREA

Area to be covered by the topographical survey:

For bridges **without windguy** arrangement,

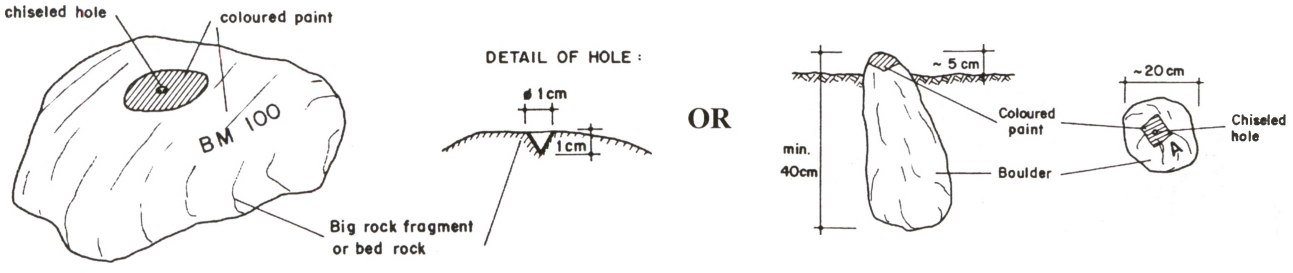
- a profile along the bridge axis covering up to 25m behind the main anchorage blocks.

For bridges **with windguy** arrangement,

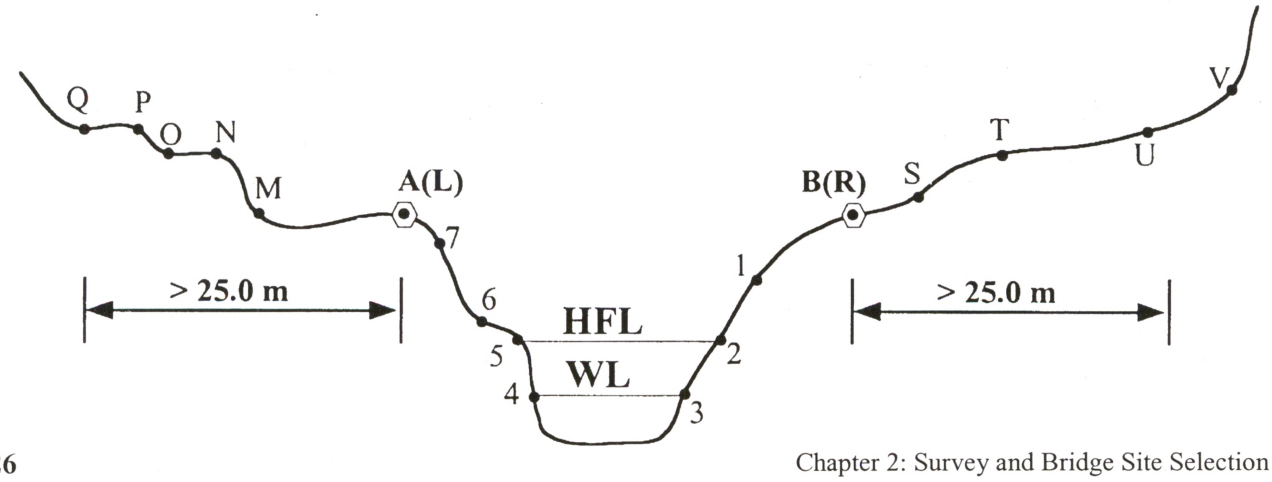
- a profile along the bridge axis covering up to 25m behind the main anchorage blocks **and** a topographical plan covering the area of 10m upstream and 10m downstream from the tentative location of the windguy foundations.

### 2.5.2 SETTING OF BRIDGE CENTERLINE

Fix the bridge centerline with two permanent axis points **A (L)** on the left bank and **B (R)** on the right bank. The permanent axis points **A (L)** and **B (R)** should be fixed on a rock outcrop along the bridge centerline, 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:

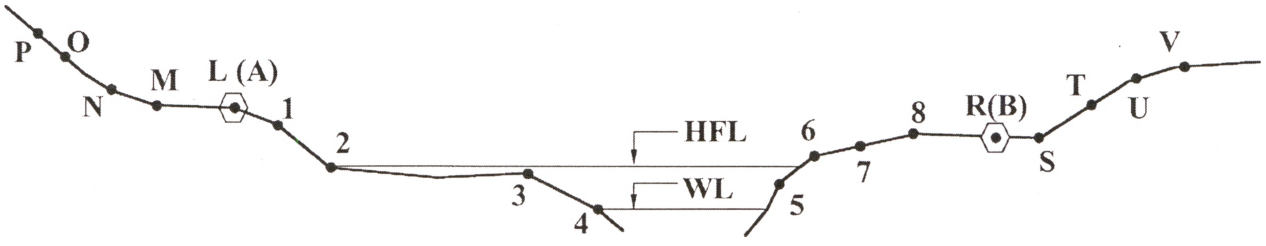



Additional survey points along the centerline should be fixed to survey the bridge axis profile as shown in the sketch below. These survey points should be fixed at the breaking points of slopes and terraces which will accurately indicate the topography of the bridge axis. The profile should extend 25m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



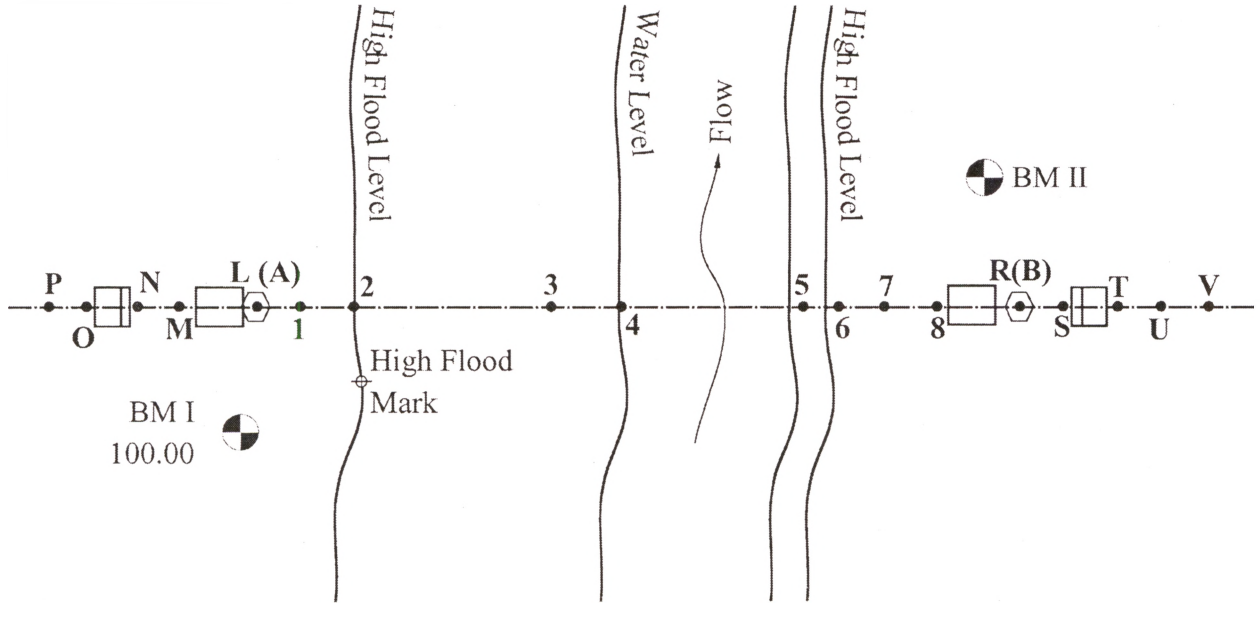
Draw a sketch of the profile/cross section of the bridge axis (centerline) with axis points **A** and **B**, and all the survey points and topographical features, including tentative position of the bridge foundations, low water level and high flood level.

**Profile/Cross Section (Example)**




Draw a plan view with the bridge axis (centerline), axis points **A (L)** and **B (R),** and all the Bench Marks and fixed objects like trees, houses, etc. Give distances and directions from the reference points so that the axis points and Bench Marks 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)**



### 2.5.3 SURVEY METHODS

There are two options for conducting the topographical 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, Windguy Arrangement is not required for bridges with a span of up to 120 m.

- For the Suspended Type Bridge, a detailed **profile** along the selected bridge axis is sufficient for bridges without windguy arrangement. A topographic profile can be made by means of an **Abney Level**, however, for fixing precise levels, a Level Instrument is necessary.

- For the Suspension Type Bridge, a detailed **profile** along the selected bridge axis is sufficient for bridges without windguy arrangement. However, a topographic profile must be made by means of a **Theodolite**.

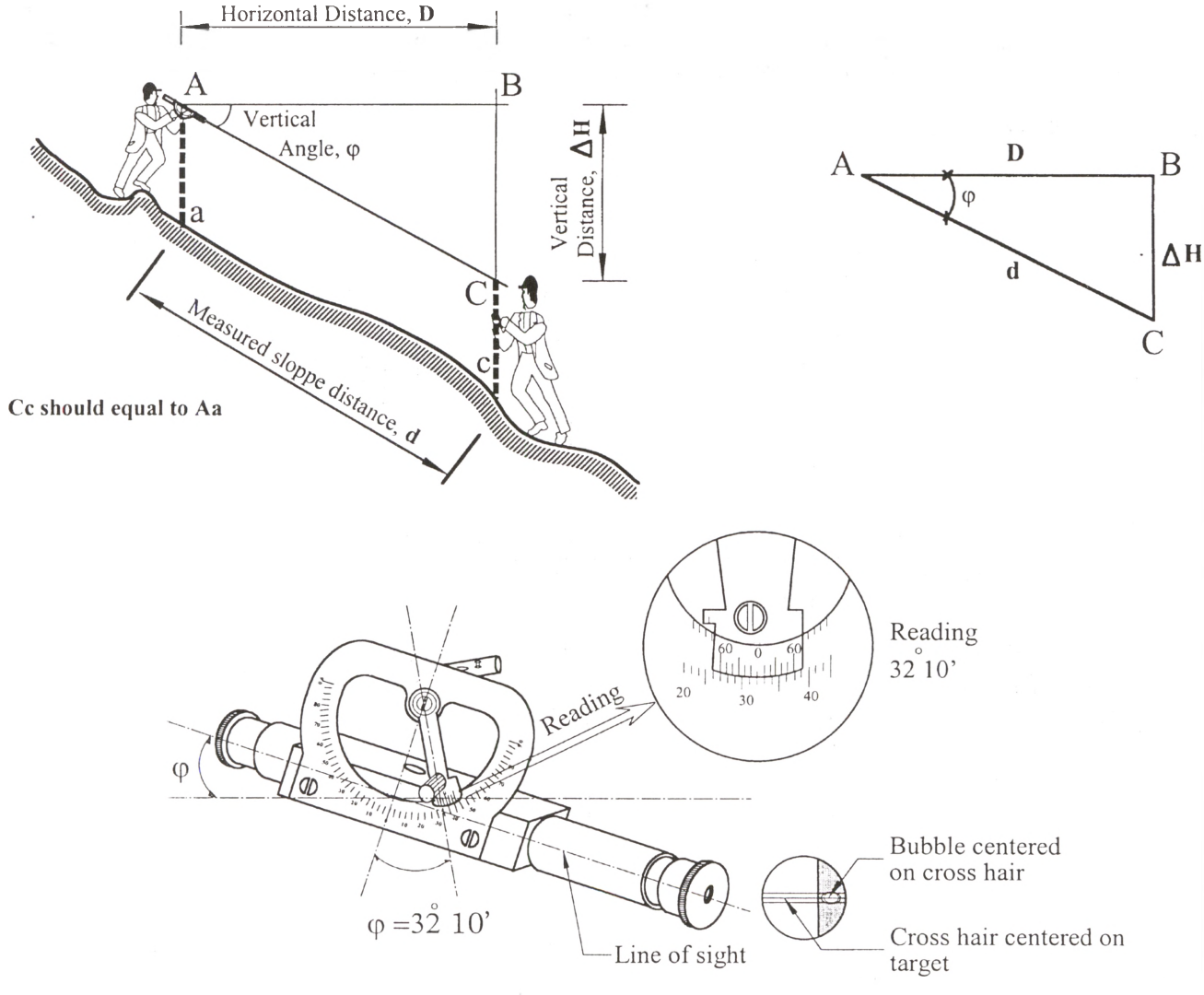
- For bridges requiring a windguy arrangement, a more detailed topographic survey is necessary, from which a detailed contour plan can be plotted. This type of survey should be done with a **Theodolite**.

### 2.5.4 SURVEY WTH AN ABNEY LEVEL

The main function of an 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.

**Measurement of Vertical Angle:**

The principle of measuring the vertical angle with an Abney Level is illustrated in the sketch and procedure described below:



The Procedure of measurement is as follows:

1. The Surveyor stands at point **A** with an Abney Level.
2. The Assistant stands at the target point **C** with a stick (or ranging rod). The target mark on the stick which the Surveyor sights must be at the same height above the ground as the Abney Level. For this, the height of the ranging rod should be equal to the height of the Surveyor's eye level.
3. The Surveyor holds the Abney Level to the eye and sights towards the target at point **C**, centering the cross hairs against the target.
4. The index arm is then adjusted until the bubble is centered against the target and the cross hairs.
5. When the bubble is centered horizontally and the cross hairs are aligned with the target, read the vertical angle on the arc.

**Measurement of Slope Distance d:**

The slope distance **d** between the survey points is measured with a measuring tape. Distances larger than 30m should be divided into sub-distances. The total distance can then be calculated by adding the sub-distances. Slope distances should be measured twice and the mean value should be taken as the accurate slope distance.

**Calculation of Horizontal and Vertical Distance and Elevations of Survey Points:**

| | |
|---|---|
| Horizontal distance **D** between **a** and **c** | **D = d x cos φ** |
| Vertical distance **ΔH** between **a** and **c** | **ΔH = d x sin φ** |
| Elevation of **c** | **H = Elevation of a ± ΔH** |

Add **+ΔH** if the sighting is upward, and subtract **-ΔH** if the sighting is downward.

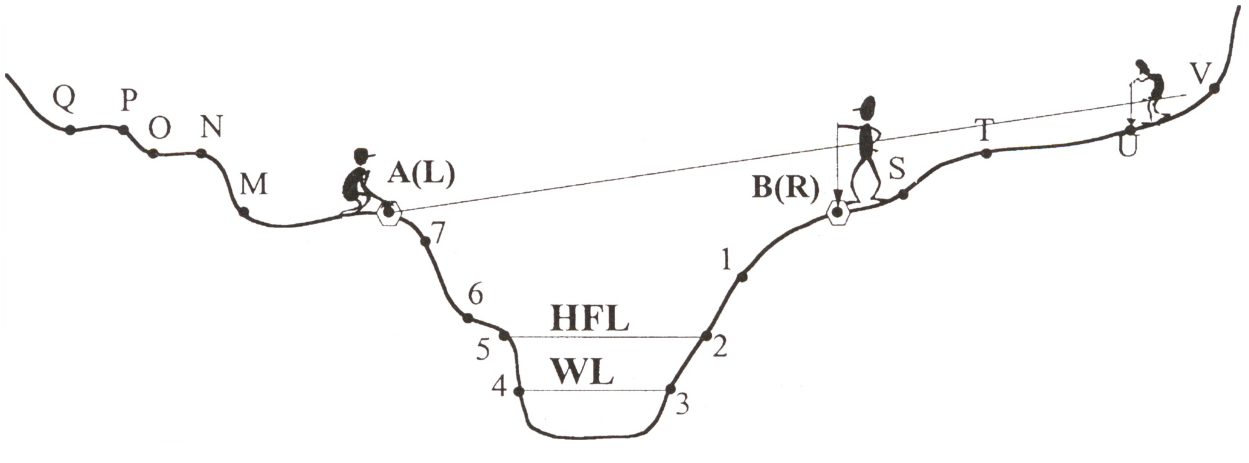
**d** = slope distance from **a** to **c**
φ = vertical angle from **a** to **c**

To take a profile along the bridge axis, the Surveyor should first set the exact centerline as described in Chapter 2.5.2. There are two methods of setting the centerline.

- **With Nylon Rope and Plumb Bob:**

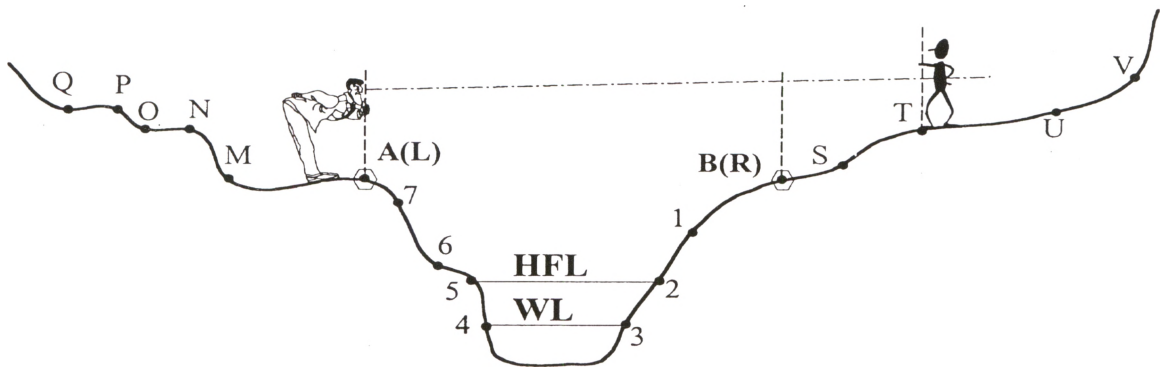
  This method is accurate only for spans of up to 50m. The survey points are fixed along the bridge centerline with the help of a nylon rope and plumb bob.

A nylon rope is stretched along the axis point **A** on the left bank and **B** on the right bank. Care should be taken that the tape or nylon rope is hanging freely and does not touch any obstacles. The survey points are then fixed along this rope with the plumb bob as per the procedures shown in the sketch below:



- **With Bamboo or Wooden Sticks or Ranging Rods:**

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




**Bridge Axis Profile:**
Proceed with the survey of the bridge axis profile after having fixed the centerline as per the following steps (refer to the example on page 33).

1. The survey starts from one of the fixed permanent axis points **A** or **B** and proceeds to the other survey points **M, N, O, P, 1, 3, 4, 5** or **S, T, U, V, 4, 5, 6** (refer example sketch of a bridge axis profile above).
2. Measure the vertical angles and slope distances between these survey points on the centerline. It is important that the sighted target is at the same height above the ground as the Abney Level while taking the readings.
3. Measure all the points **M, N, O, P, 1, 2, 3** starting from the permanent axis point **A,** as described in the second step above.
4. Similarly, measure all the points **S, T, U, V, 3, 4, 5, 6** starting from the permanent axis point **B.**
5. Measure the vertical angles from **A** to **B** and **B** to **A** to check the accuracy of the vertical angle readings.

Before calculating the horizontal and vertical distances, it is necessary to determine the accuracy of the measurement of the vertical angles. This can be done by comparing the measured vertical angle from **A** to **B** with the vertical angle from **B** to **A**. Both angle readings should be equal. Differences in these readings indicate an error in the angle measurements and needs correction.

The error factor **' E'** is calculated with the following formula:

$$\mathbf{E} = \frac{[\varphi_{AB}] - [\varphi_{BA}]}{2} \quad ; \quad \text{Corrected angle } \varphi' = [\varphi_{AB}] \pm \mathbf{E} \text{ or } \varphi' = [\varphi_{BA}] \mp \mathbf{E}$$

**Example: Error Correction of Measured Vertical Angles**

| | |
|---|---|
| Measured vertical angle from A to B | $\varphi_{AB}$ = – 0°50' (downhill sighted) |
| Measured vertical angle from B to A | $\varphi_{BA}$ = + 1°30' (uphill sighted) |
| Error factor | E = (1°30' - 0°50')/2 = 0°20' |
| Corrected angle | $\varphi'_{AB}$ = [- 0°50'] + 20' = 1°10' |
| Corrected angle | $\varphi'_{BA}$ = [+1°30'] - 20' = 1°10' |

All measured vertical angles should be corrected as:
Corrected angle $\varphi'$ = [$\varphi$] + E for downhill sighted (-) angles
Corrected angle $\varphi'$ = [$\varphi$] - E for uphill sighted (+) angles

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

**Example: Calculation of Horizontal Distance D and Elevation H of Survey Points:**

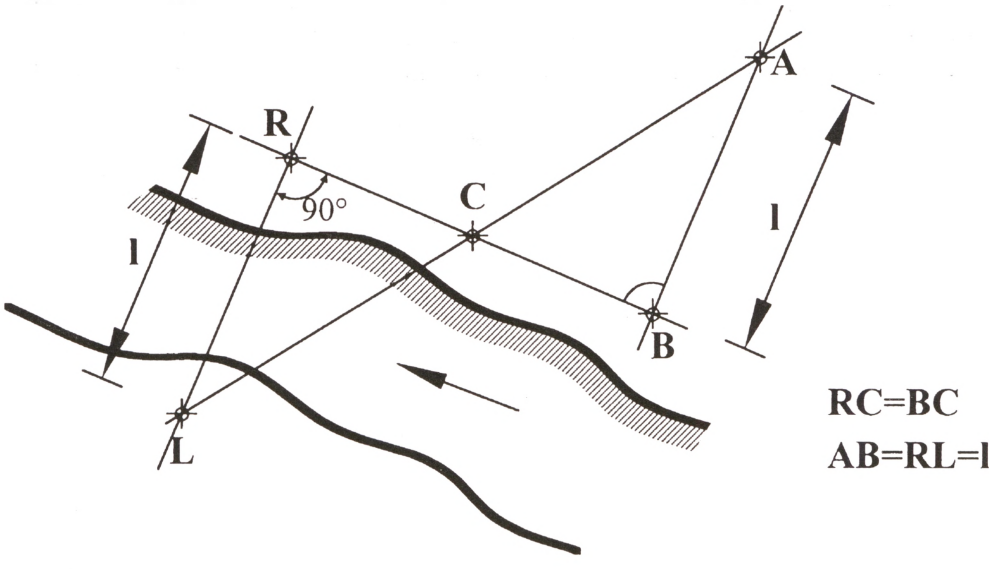
| | | | | |
|---|---|---|---|---|
| Elevation of | A | | = 100. 00 m | |
| Measured vertical angle from | A to M, | $\varphi_{AM}$ | = +7°0' (upward sighting) | |
| Corrected vertical angle from | A to M | $\varphi'_{AM}$ | = +7°0'- 0°20' = +6°40' | |
| Measured slope distance | A to M | d | = 13.35 m | |
| Horizontal distance between | A and M | D | = d x cos φ' = 13.35 x cos 6°40' | = **13.26 m** |
| Vertical distance between | A and M | ΔH | = d x sin φ' = 13.35 x sin 6°40' | = **+1.55 m** |
| Elevation of | M | H | = Elevation of 'A' + ΔH | = 100.0 + 1.55 = **101.55 m** |

Enter the measurements and calculations in the **Abney Level** survey sheet as per the example given on page 33.

**Measuring the River Width:**

In some cases, it might not be possible to directly measure the river width from one bank to the other bank with a tape. In such situations, the river width should be measured by an indirect method as described in the following example.

What is the width of the river l = Distance from **L** to **R** ?

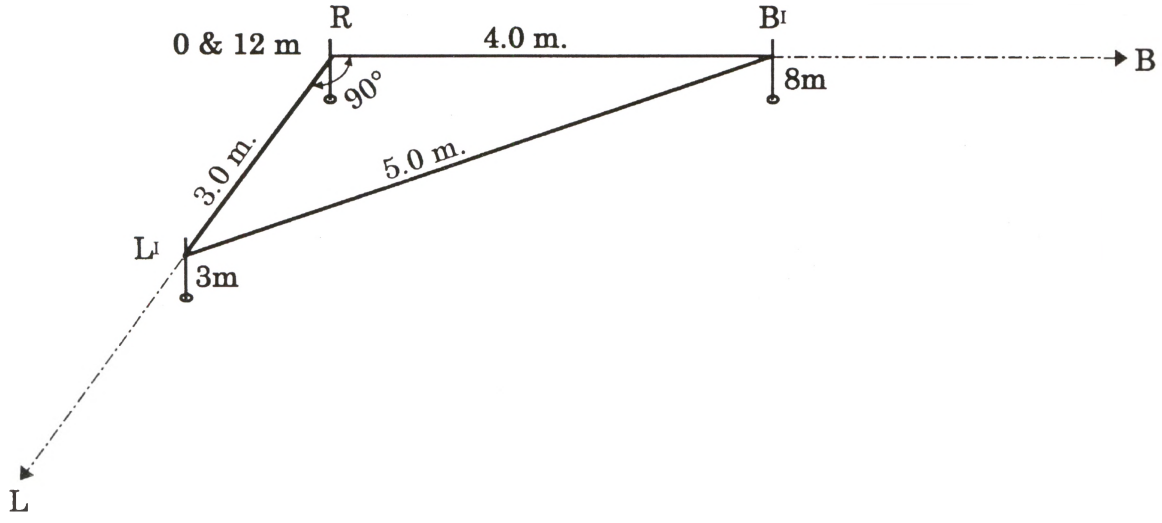



The procedure of the measurement is as follows:

1. Set a base line **R - B** along the river perpendicular to the line **L - R**. This can be done easily by the 3-4-5 method (see below: **Setting a Right Angle**).
2. On this base line **R - B,** mark the mid point **C** so that **RC** is equal to **CB**.
3. Set again a base line **B – A** perpendicular to the line **R – B** like in step #1.
4. Mark point **A** exactly by ranging through point **L – C**, so that all these three points lie in the same line of sight.
5. Measure the length **B – A**. This length will be equivalent to the river width **L - R = l**.

**Setting a Right Angle:**

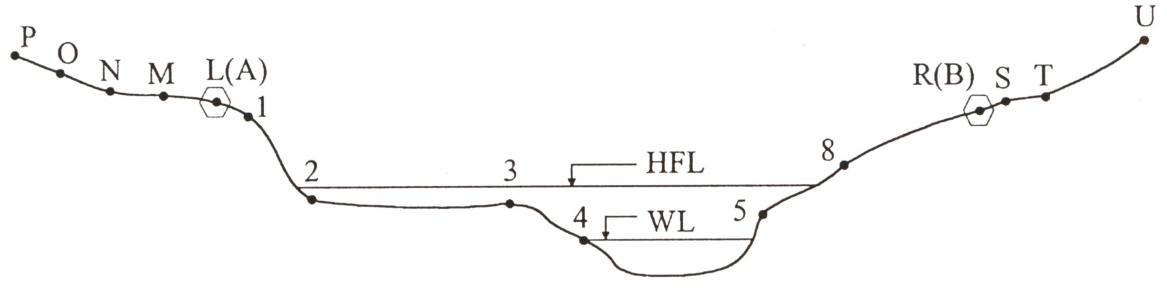
One simple method to set a right angle from a point of a base line is the 3-4-5 method. A measuring tape and three wooden pegs are needed, as shown in the sketch below:




The procedure of the measurement is as follows

1. The first person should hold the '0' and '12'm marks of the measuring tape and stand at point **R**.
2. The second person should hold the tape at the 3m mark, and a third person at the 8m mark of the tape. Stretch the tape as shown in the sketch above. A right angle triangle will be formed with the sides measuring 3, 4, and 5m.
3. The line **R – B'** is now perpendicular to the line **R – L'**.

## Example : BRIDGE AXIS PROFILE BY ABNEY LEVEL




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 angle error correction |
| B | A | | +1°30' | +1°10' | | | | | |
| 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 | |

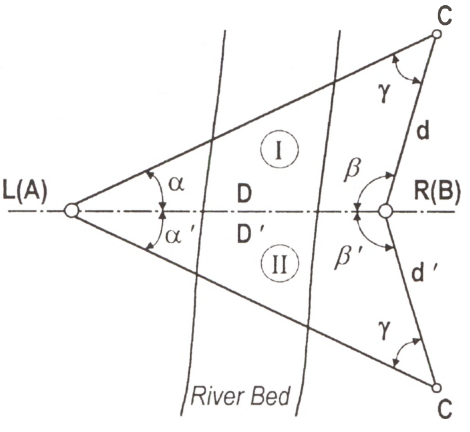
### 2.5.5 SURVEY WITH A THEODOLITE

When the span of a Suspended type 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 a **Suspension type bridge,** the survey is conducted with a **Theodolite** in any case.

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

**Profile Along Bridge Axis:**
Fix the bridge centerline as described in Chapter 2.5.2. Measure the distance between the axis points **A** and **B** by the horizontal triangulation method. Triangulation is done by measuring all the three angles of a triangle and the length of one side, as illustrated in the sketch below and the example given on page 35.




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

**I[st] Triangulation**

1. Set 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 be theoretically equal to 180° or 200$^{g}$. If the sum is not equal to 180° or 200$^{g}$, 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** with the trigonometric formula, $\mathbf{D} = \frac{d \times \sin\gamma}{\sin\beta}$

**II[nd] Triangulation**

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

Use the standard form "Triangulation" for recording the readings and calculations given in the example on page 35.

**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 | 0 0 0 0 0 0 | 1 9 9 9 9 4 | 1 6 1 5 5 8 | 1 6 1 5 5 8 | 1 6 1 5 5 8 | = $\alpha_o$ |
| | C | 1 6 1 5 5 9 | 3 6 1 5 5 2 | | | | |
| B | A | 0 0 0 0 0 0 | 1 9 9 9 9 8 | 2 8 8 3 | 2 8 8 3 | 2 8 8 3 | = $\beta_o$ |
| | C | 3 9 7 1 1 7 | 1 9 7 1 1 5 | | | | |
| C | A | 0 0 0 0 0 0 | 1 9 9 9 9 2 | 3 5 5 7 0 | 3 5 5 7 0 | 3 5 5 7 0 | = $\gamma_o$ |
| | B | 3 5 5 7 0 | 2 3 5 5 6 2 | | | | |
| | | | | $\delta = \alpha_o + \beta_o + \gamma_o$ = | | 2 0 0 0 1 1 | |

$\Delta$ = (200$^g$ or 180°) - $\delta$ = − 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° 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

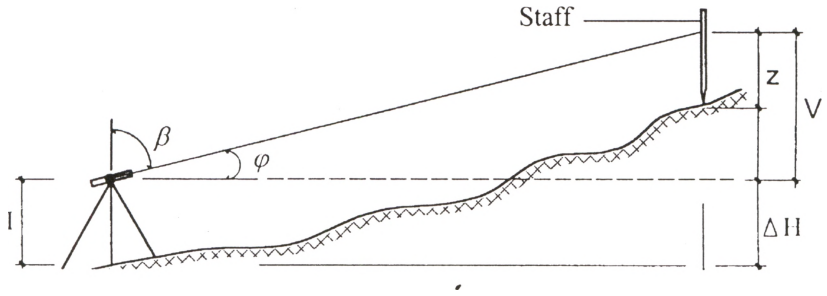
| INSTRUMENT STATION | PEG | HORIZONTAL CIRCLE FACE RIGHT | HORIZONTAL CIRCLE FACE LEFT | ANGLE FACE RIGHT | ANGLE FACE LEFT | ANGLE MEAN | |
|---|---|---|---|---|---|---|---|
| A | B | 0 0 0 0 0 0 | 1 9 9 9 9 4 | 5 9 1 8 | | 5 9 1 7 | = $\alpha_o$ |
| | C | 3 9 4 0 8 2 | 1 9 4 0 7 8 | | | | |
| B | A | 0 0 0 0 0 0 | 1 9 9 9 9 8 | 1 0 9 7 3 0 | 1 0 9 7 3 0 | 1 0 9 7 3 0 | = $\beta_o$ |
| | C | 1 0 9 7 3 0 | 3 0 9 7 2 8 | | | | |
| C | A | 8 4 3 5 3 2 | 8 4 3 5 1 | 8 4 3 5 3 | 8 4 3 5 1 | 8 4 3 5 2 | = $\gamma_o$ |
| | B | 0 0 0 0 0 0 | 2 0 0 0 0 0 | | | | |
| | | | | $\delta = \alpha_o + \beta_o + \gamma_o$ = | | 1 9 9 9 9 9 | |

$\Delta$ = (200$^g$ or 180°) - $\delta$ = + 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° 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 on page 37.




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 **BMII** near the Axis Point **B**.

3. Measure the **horizontal** distance **D from A** to **BMI** accurately with a tape.

4. Measure the **horizontal** distance **D from B** to **BMII** accurately with a tape.

5. Take the distance **D** between Axis Points **A** and **B** from the triangulation (refer to the previous chapter).

6. Set up the theodolite at the **A**xis Point **A** and measure the vertical angle to 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 **A**xis Point **B** and measure the vertical angle to 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 Axis Point **A**. Take the middle hair reading **Z,** and measure the instrument height **I**.

9. Set up the theodolite at **BM II,** measure the vertical angle to Axis Point **B**. Take the middle hair reading **Z**, and measure instrument height **I**.

10. Calculate the followings for all readings:

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

Elevation difference $\mathbf{\Delta H = V - Z + I}$ for upward vertical angle reading
$\mathbf{\Delta H = V + Z - I}$ 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 Bench Marks"** as per the example given on page 37.

**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

1st Triangulation $D_1$ = 127·034 m

2nd Triangulation $D_2$ = 127·113 m

Difference $\Delta D$ = 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

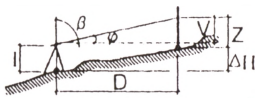
BMII = 102·91

A = 100·770

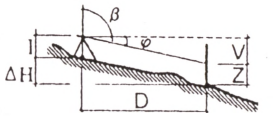
B = 102·150

## 2. Elevation

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




$\Delta H = V - Z + I$




$\Delta H = V + Z - I$

| INSTRUMENT STATION | STAFF STATION | INSTRUMENT HEIGHT I (m / cm) | MIDDLE HAIR Z (m / cm) | HORIZONTAL DISTANCE D (m / cm) | VERTICAL ANGLE: FACE RIGHT / FACE LEFT | MEAN (Left + Right) / 2 | VERTICAL DISTANCE V (m / cm) | DIFFERENCE IN ELEVATION: ΔH (m / cm) | MEAN (m / cm) |
|---|---|---|---|---|---|---|---|---|---|
| A | B | 1 25 | 0 20 | 1 27 07 | 99 83 9 / 300 17 2 | 0 16 6 | + 0 33 | + 1 38 | 1 38 |
| B | A | 1 17 | 0 10 | 1 27 07 | 101 23 1 / 298 77 1 | 1 23 0 | - 2 46 | - 1 39 | |
| A | BMI | 1 25 | 0 30 | 4 87 | 121 63 5 / 278 37 2 | 21 63 1 | - 1 72 | - 0 77 | 0 77 |
| BMI | A | 1 20 | 0 40 | 4 87 | 100 31 7 / 299 68 3 | 0 31 7 | - 0 02 | + 0 78 | |
| B | BMII | 1 17 | 0 50 | 9 02 | 99 31 0 / 300 69 8 | 0 69 4 | + 0 10 | + 0 77 | 0 76 |
| BMI | B | 1 18 | 0 20 | 9 02 | 112 13 0 / 287 87 8 | 12 12 6 | - 1 74 | - 0 76 | |

**Topographic Detail Survey:**

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

**Checking the Stadia Hair:**

Check the stadia hair of the theodolite before doing the detailed survey using 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:

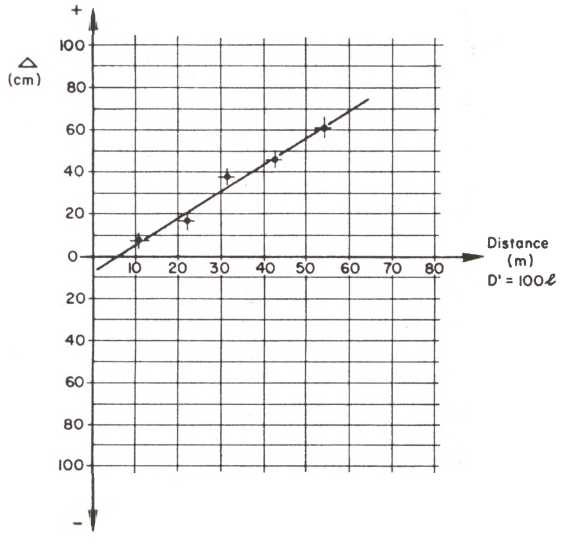
$$\mathbf{D} = (100l \pm \Delta) \times \cos^2 \varphi \qquad \mathbf{V} = (50l \pm \Delta) \times \sin 2\varphi$$

Δ is calculated before the survey as per the following procedure:

1. Put the theodolite on horizontal ground and level it.
2. Level the telescope of the theodolite so that the vertical angle is 0.
3. Put pegs at distances of approximately 10, 20, 30, 40 and 50 m.
4. Measure accurately the distance between the vertical axis of the theodolite and the pegs with a tape
5. Take the stadia hair readings by 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**

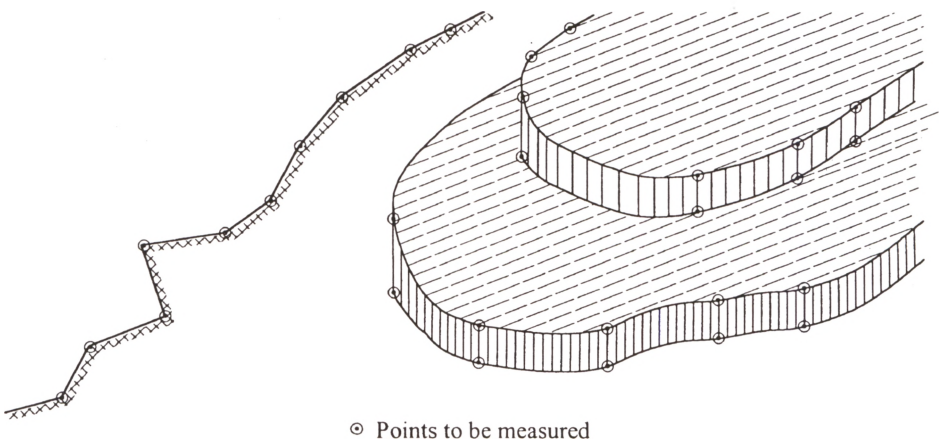
| Top hair $l_1$ (cm) | Bottom hair $l_2$ (cm) | Difference $l = l_1 - l_2$ (cm) | Distance $D' = l \times 100$ (m) | Tape Measurement Distance, D (m) | Correction $\Delta = D - D'$ (cm) |
|---|---|---|---|---|---|
| 118.70 | 108.30 | 10.40 | 10.40 | 10.48 | + 8 |
| 135.90 | 114.20 | 21.70 | 21.70 | 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

**Tachometric Survey:**

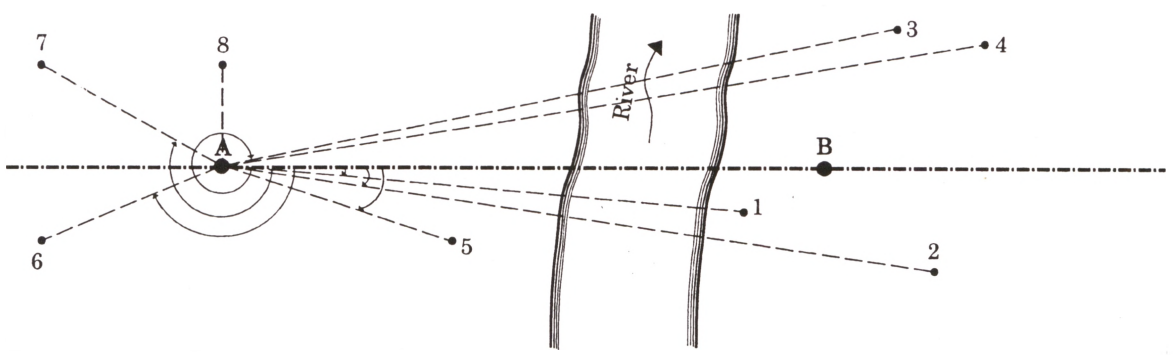
All topographic details are taken by the tacheometric survey. Tachometric details are mainly taken from the Axis Points A and B (theodolite stations). If the area of the survey cannot be covered by these two points, details should be taken from additional points. The survey points (staff points) should be taken at the break points of 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.



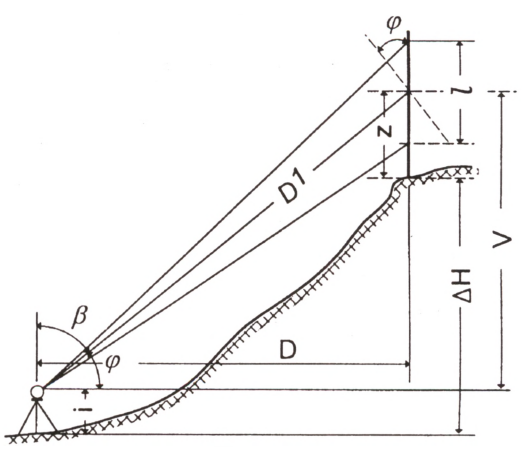
⊙ Points to be measured

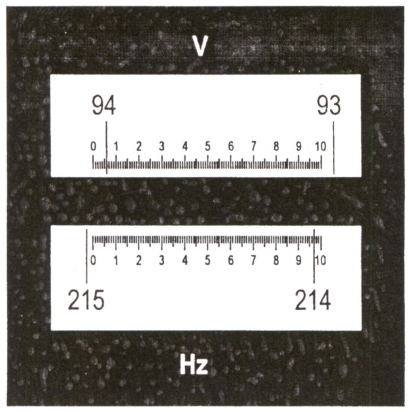
The procedure of the survey is as follows:

1. Set up the theodolite on 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:

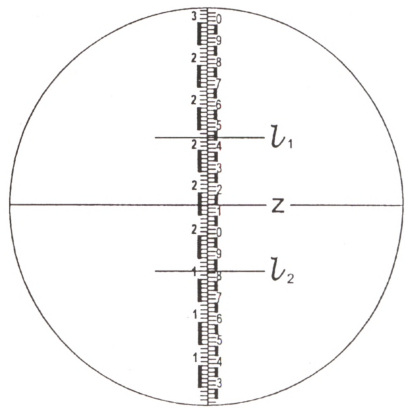



3. Take readings of the horizontal circle, the vertical circle, the top hair, the middle hair and the bottom hair after proper sighting to the respective survey points (staff point), as illustrated in the sketch of step 2 above and the sketch below.






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




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

4. Record the readings in the "Tacheometry " survey sheet as shown in the example on page 41.
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 Axis Point **A,** following the procedure from steps 3-4.
8. Calculate the horizontal and vertical distances and elevations of the survey points with the help of the tacheometric formulas given in the "Tacheometry" survey sheet as shown in the example on page 41.

### 2.5.6 TOPOGRAPHIC MAPS

As per the field survey data, it is necessary to prepare the following topographic maps in the scale 1:100 or 1:200:

- Profile along the bridge axis
- Contour plan of the bridge site in 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 page 42).

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 furthest survey point on the right bank and the left bank from the Axis Point **A** are within the drawing area.
4. Plot the Axis Point **B** as per its elevation and horizontal distance from 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 means of 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 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 elevation of the high flood level and the water level at the time of the survey.

**Contour Plan of the Bridge Site:**
A 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 Volume B of LSTB (SBD) Manual. A sample of a contour plan is presented on page 43.

# TACHEOMETRY



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

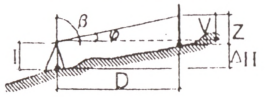
$\ell = \ell_1 - \ell_2$

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

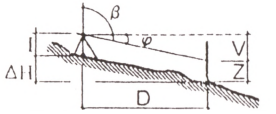
$V = 50 \times \ell \times \sin 2\varphi = 50 \times \ell \times \sin 2\beta$

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

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

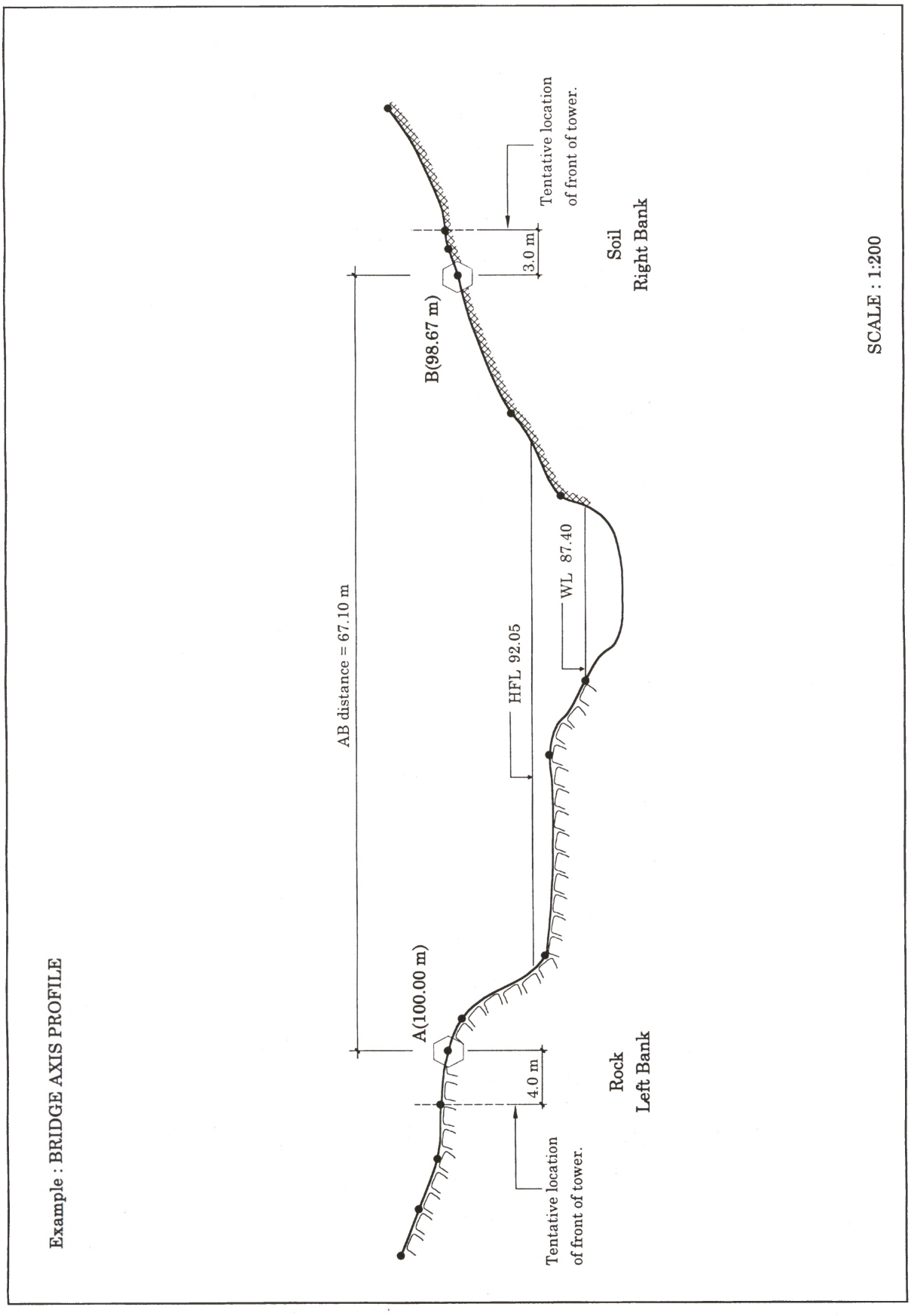


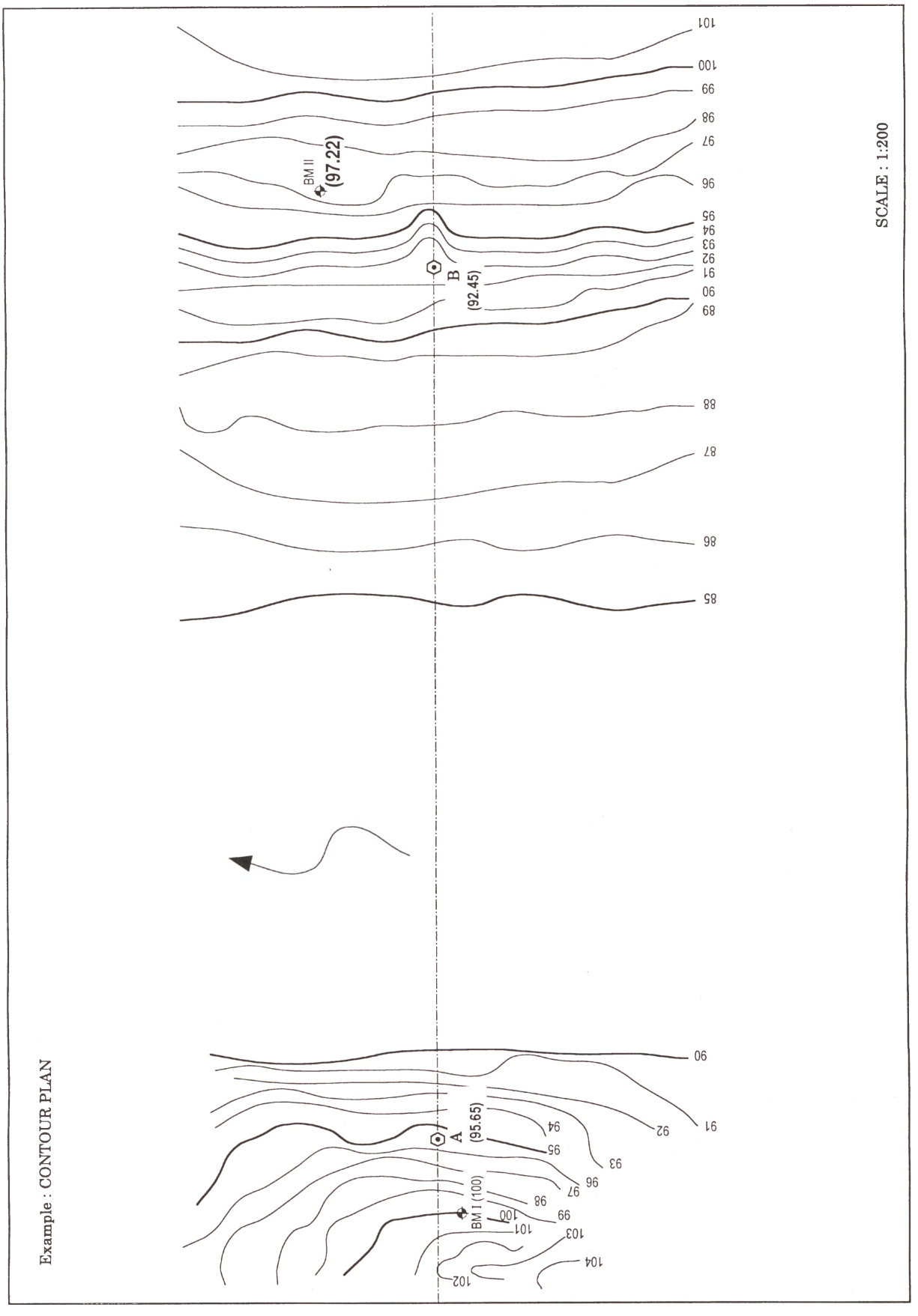

$\Delta H = V - Z + I$




$\Delta H = V + Z - I$

| 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 $\ell_1$ (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 +/- ΔH (m) | REDUCED LEVEL H (m) | REMARKS (Description of Staff Station) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| B/1·17 | BM1 | 39 | 68 | 101 | 07 | 1512 | 0856 | 0200 | 1312 | 131.16 | - 01.89 | - 01.89 | 100.26 | |
| | A | 00 | 00 | 100 | 312 | 1370 | 0735 | 0100 | 1270 | 126.97 | - 01.38 | - 01.38 | 100.77 | |
| | R/B | 39 | 46 | 102 | 47 | 1930 | 1265 | 0600 | 1330 | 132.80 | - 05.25 | - 05.25 | 096.90 | |
| | 4 | 39 | 24 | 103 | 38 | 1430 | 0765 | 0100 | 1330 | 132.62 | - 06.64 | - 06.64 | 095.50 | |
| | 5 | 39 | 24 | 104 | 12 | 1500 | 0850 | 0200 | 1300 | 129.45 | - 08.07 | - 08.07 | 094.08 | D/s Rocky Part |
| | 6 | 39 | 47 | 104 | 82 | 1688 | 1044 | 0400 | 1288 | 128.06 | - 09.58 | - 09.58 | 092.56 | |
| | 7 | 39 | 15 | 401 | 07 | 1470 | 0835 | 0200 | 1270 | 125.25 | - 14.45 | - 14.45 | 087.70 | |
| | 8 | 39 | 45 | 201 | 07 | 1340 | 0720 | 0100 | 1240 | 122.45 | - 13.32 | - 13.32 | 088.83 | W.G.? |
| | 9 | 39 | 72 | 601 | 06 | 1278 | 0689 | 0100 | 1178 | 116.41 | - 12.22 | - 12.22 | 089.93 | |
| | 10 | 39 | 51 | 931 | 08 | 1300 | 0750 | 0200 | 1100 | 107.83 | - 14.86 | - 14.86 | 087.29 | |
| | 11 | 39 | 82 | 771 | 10 | 1160 | 0608 | 0100 | 1016 | 098.99 | - 15.49 | - 15.49 | 086.66 | Rocky nose |
| | 12 | 39 | 20 | 531 | 11 | 1120 | 0610 | 0100 | 1020 | 098.65 | - 17.59 | - 17.59 | 084.55 | |
| | 13 | 39 | 68 | 501 | 06 | 1550 | 0925 | 0300 | 1250 | 123.73 | - 12.28 | - 12.28 | 089.87 | |
| | 14 | 39 | 80 | 801 | 06 | 1898 | 1299 | 0700 | 1198 | 118.65 | - 11.79 | - 11.79 | 090.35 | Rocky bank edge |
| | Axis | 00 | 00 | 105 | 26 | 1760 | 1180 | 0600 | 1160 | 115.21 | - 09.55 | - 09.55 | 092.60 | |
| | Axis | 00 | 00 | 104 | 75 | 1380 | 0791 | 0200 | 1180 | 117.34 | - 08.39 | - 08.39 | 093.75 | |
| | Axis | 00 | 00 | 103 | 33 | 1700 | 1095 | 0500 | 1200 | 119.67 | - 06.19 | - 06.19 | 095.96 | Below cliff |
| | 18 | 39 | 83 | 261 | 04 | 1412 | 1400 | 0800 | 0200 | 119.42 | - 07.92 | - 07.92 | 094.23 | Edge |
| | 19 | 00 | 49 | 401 | 03 | 5701 | 1280 | 0790 | 0100 | 118.62 | - 06.22 | - 06.22 | 095.93 | Edge of cliff |
| | 20 | 00 | 74 | 301 | 02 | 6201 | 1880 | 1290 | 0700 | 118.80 | - 04.97 | - 04.97 | 097.18 | do |
| | 21 | 01 | 12 | 701 | 00 | 3701 | 1960 | 1330 | 0700 | 126.00 | - 00.89 | - 00.89 | 101.26 | |
| | 22 | 01 | 28 | 520 | 99 | 0781 | 6500 | 0975 | 0300 | 135.01 | 02.15 | 02.15 | 104.30 | |


Example : BRIDGE AXIS PROFILE
SCALE : 1:200
Soil
Right Bank
Rock
Left Bank
B(98.67 m)
A(100.00 m)
AB distance = 67.10 m
HFL 92.05
WL 87.40
3.0 m
4.0 m
Tentative location of front of tower.
Tentative location of front of tower.


Example : CONTOUR PLAN
SCALE : 1:200
BM II
(97.22)
B
(92.45)
A
(95.65)
BM I (100)
101
100
99
98
97
96
95
94
93
92
91
90
89
88
87
86
85
90
91
92
94
95
93
96
97
98
99
100
101
103
104
102

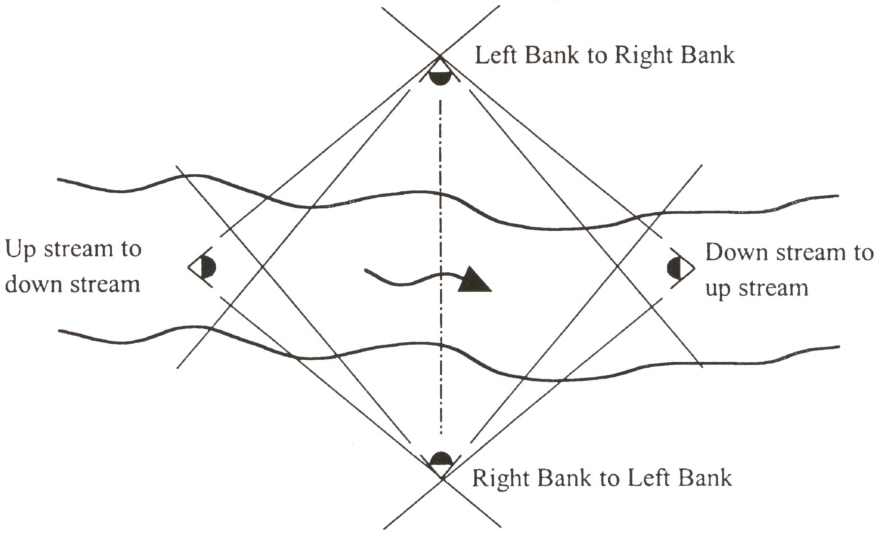
## 2.6 PHOTOGRAPHS

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

Take the following photographs:

- An overall view of the bridge site from upstream indicating the approximate location of the bridge foundations and the bridge axis line.
- An overall view of the bridge site from downstream indicating the approximate location of the bridge foundations the bridge axis line.
- A view of the right bank from the left bank with the approximate location of the bridge foundations.
- A 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 shown in 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.

## 2.7 SURVEY REPORT

A technical survey report consists of:

- Filled in Survey Forms and Checklist i.e., Form No. 1
- 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**)

# 3. BRIDGE DESIGN

## 3.1 BRIDGE TYPES

There are basically two types of cable bridges developed to trail bridge standard. They are:

- **Suspended Bridge Type**
- **Suspension Bridge Type**

☛ *follow* **Form No. 2 Bridge Design Form**

The selection of one of the above bridge types depends mainly on the topography of the bridge site.

### Suspension Bridge

This type of bridge has an upward cambered walkway. The main cables are hung over the towers and anchored to the main anchorage foundations. The walkway cables (Spanning cables) are anchored to the tower foundations. The main components of this bridge are: Main cables and Spanning cables, Towers, Walkway system, Main anchorage foundations and Walkway/Tower foundations.

This type of bridge is selected when the bridge site is comparatively flat terrain and the Suspended type bridge is not feasible due to insufficient free board.

The Suspension type bridge is more expensive and needs more inputs to design and construct than the Suspended type bridge.

A Suspension type bridge

The following chapters of this handbook deals only with the Suspension type bridge.

**Suspended Bridge**

This type of bridge has a downward sagging walkway. The sagging walkway cables are suspended below their anchorage. The cables are anchored to the main anchorage foundation on both the banks. The main components of this bridge are: Walkway cables and Handrail cables, Walkway system and Main anchorage foundations.

This type of bridge is selected where the bridge foundations can be placed at a sufficiently high position giving required free board from the highest flood level.

The Suspended type bridge is more economical and simpler to design and construct than the Suspension type bridge.

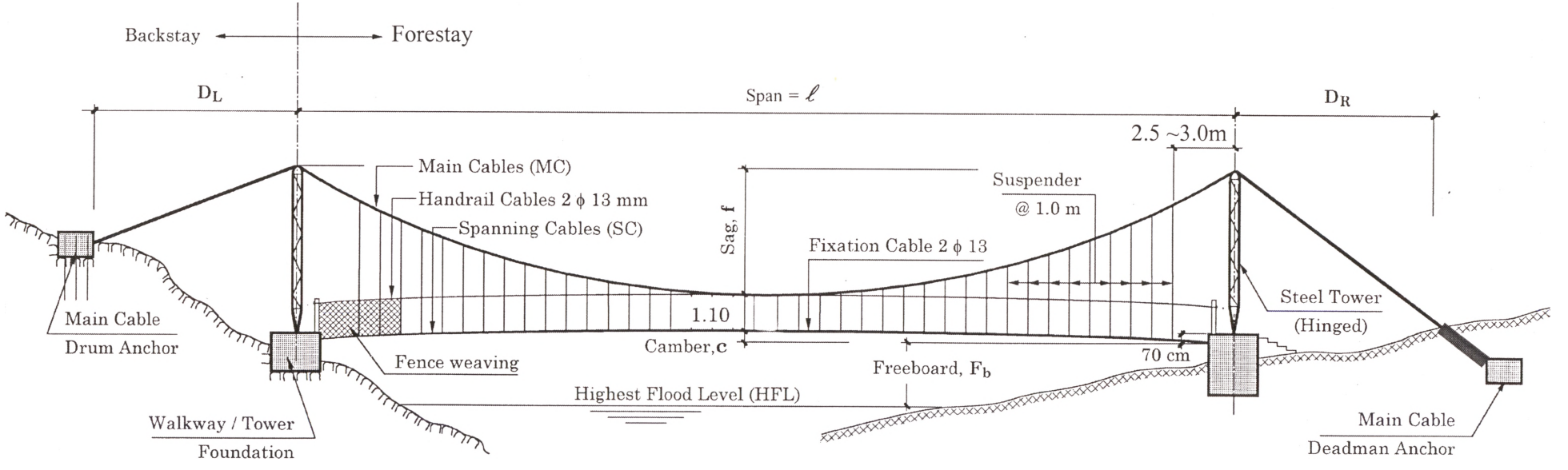
A Suspended type bridge

The following chapters of the handbook do not deal with the Suspended type bridge. For this type of bridge, refer to a separate handbook, *Short Span Bridge Standard, Technical Handbook, How to Build a Short Span Trail Suspended Bridge*.

- **Layout and Sections**

  A typical Plan and Profile of a Suspension type bridge is given on the following next pages.

# PEDESTRIAN SUSPENSION BRIDGE
## Typical Profile



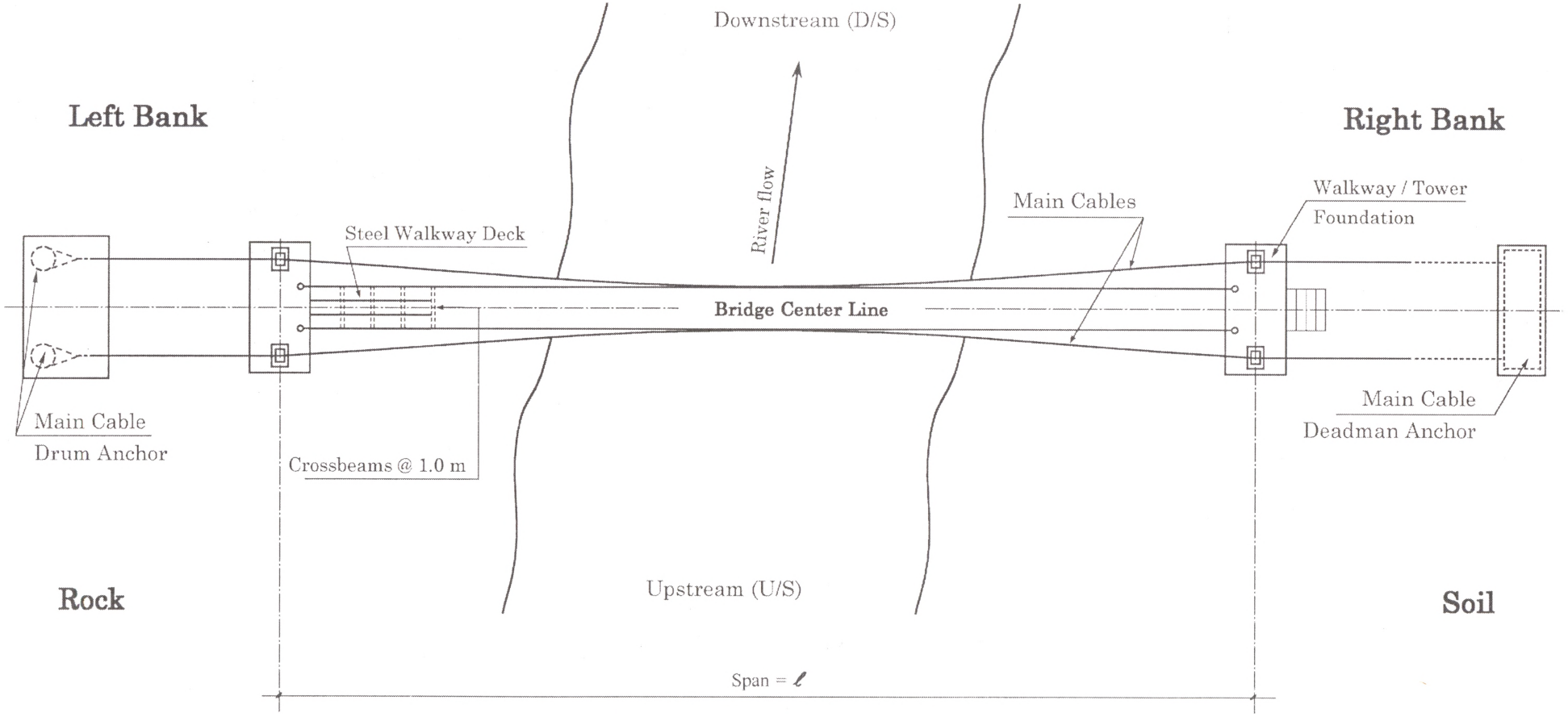

Rock

**Left Bank**

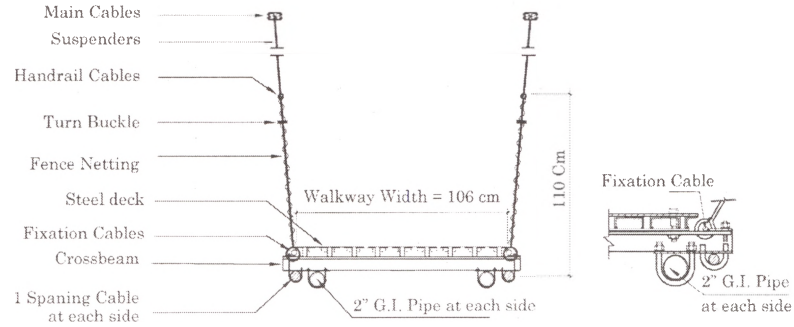
Soil

**Right Bank**

# PEDESTRIAN SUSPENSION BRIDGE
## Typical Plan



- **Walkway Section**




## 3.2 BASIC DESIGN CONCEPT

### 3.2.1 LOADINGS

For designing the bridge structure loadings, the LSTB standard (former SBD standard) is followed. The following are the probable loadings according to this standard.

- **Live load**

  The live load for smaller spans of up to 50m is equivalent to 400 kg/m$^2$ and for longer spans as per the formula,

$$\mathbf{P} = 300 + 100 \cdot \frac{50}{\ell}\ kg/m^2 \text{ or } 3 + \frac{50}{\ell}\ kN/m^2$$

- **Dead load**

  The dead load includes the weight of all permanent components of the bridge structure.

| Width of Walkway | 106 cm |
|---|---|
| Dead Load (**without** weight of Main & Spanning Cables) | ~ 75 kg/m or ~ 74 kN/m |

- **Wind Load**

  The design wind load is taken as a uniformly distributed load based on a wind speed of 160km/h acting horizontally to the walkway. This corresponds to a wind pressure of 1.3 kN/m$^2$ acting on the lateral bridge area of 0.3 m$^2$ per meter span. By maintaining a wind coefficient of 1.30 (acc. to Swiss Standard) the actual lateral design wind load is **0.50 kN** (1.3 x 1.3 x 0.3) per meter span. The Standard Steel Towers and Foundation Structures are sufficient to resist this design wind load.

  Wind load also affects the dynamic behavior of the bridge. For minimizing dynamic wind effects on the bridge, sufficient dead load of the walkway, a steel deck and the most favorable span to sag ratios have been introduced. Therefore, no lateral stabilizing measures (windguy system) has been considered in this standard short span suspension bridge design. However, for special cases (spans more than 120m or extreme windy areas exceeding wind speed of 160km/h) there is a provision for fixing a windguy system.
  (See also "Expertise on Windguy Arrangement for BBLL Standard Bridges" by Dr. Heinrich Schnetzer, WGG Schnetzer Pukas Ingenieure AG SIA/USIC Basel, Switzerland, Report No 1182-002).

- **Snow Load**

  The probability of the occurrence of a full load on a bridge loaded with snow is low. Moreover, the design live load itself is comparatively high. Therefore, it is considered that the snow load is already covered by the design live load.

- **Temperature effect**

  Loading (cable forces) according to temperature effect is negligible in comparison with other loading conditions. Therefore, temperature effect has not been considered for the standard bridge design.

- **Seismic Load**

  There is low probability of a full live load occurring at the time of an earthquake. Moreover, the design live load itself is comparatively high. Therefore, it is assumed that the seismic load is already covered by the design live load. A separate loading combination with seismic load has not been considered.

### 3.2.2 CONSTRUCTION MATERIALS

The construction materials used for the standard trail bridges are wire ropes (cables), steel parts, steel fixtures and fasteners (thimbles, bulldog grips, nuts and bolts), concrete and stone masonry. Specifications of these materials are based on the Indian Standard (IS). Refer to Volume A of LSTB (SBD) Manual of Trail Bridge Section/DoLIDAR, Nepal for detailed material specifications.

However, for frequently referred materials, the specifications are given below for quick reference.

- **Steel Wire Ropes (Cables)**

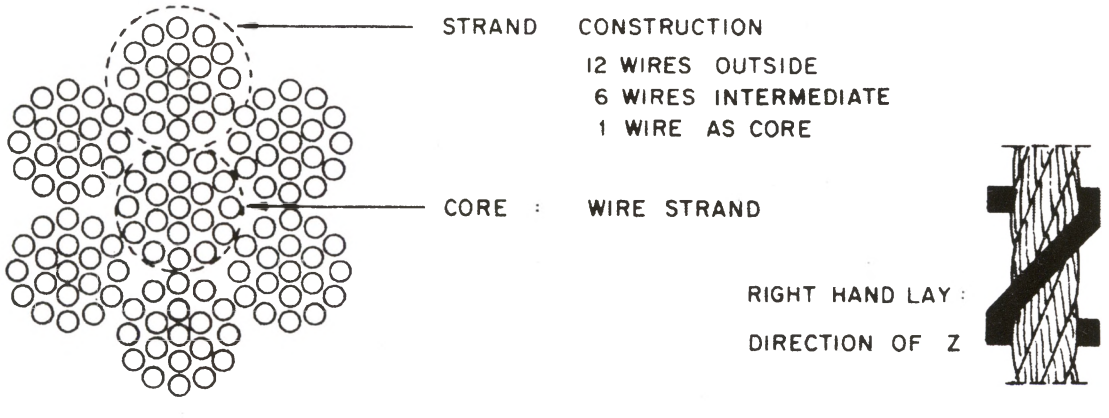
For more convenient stock keeping, handling and transportation only three cable diameters have been used. This also reduces the number of steel parts, logistics, and eventually, bridge costs.

Steel wire ropes should comply with all the requirements of:

| | |
|---|---|
| IS 1835 – 1977 | Steel wires for ropes |
| IS 6594 – 1977 | Technical supply conditions for wire ropes and strands |
| IS 9282 – 1979 | Specification for wire ropes and strands for suspension bridges |
| IS 9182 (part II) –1979 | Specification for lubricants for wire strands and ropes |

| **Nominal diameters:** | **13 mm** | **26 / 32 mm** |
|---|---|---|
| Rope Construction | 7 x 7 (6/1) | 7 x 19 (12/6/1) |
| Elongation | non pre-stretched | **pre-stretched** |
| Lay | RHO, right hand ordinary lay | |
| Core | WRC, Wire Strand Core | |
| Tensile strength of wire | 160 kg/mm$^2$ or 1.57 kN/mm$^2$ | |
| Preforming | Preformed | |
| Coating | Galvanized 'A' heavy | |
| Impregnation | Non-drying type and non-bituminous lubricant | |

| Nominal Diameter of Cable Mm | Weight kg/m | Weight N/m | Metallic Area [mm$^2$] | Minimum Breaking Load in Tones | Minimum Breaking Load in kN | Permissible load in Tones | Permissible load in kN |
|---|---|---|---|---|---|---|---|
| 13 | 0.64 | 6.3 | 73 | 10.5 | 103 | 3.5 | 34 |
| 26 | 2.51 | 24.6 | 292 | 39.3 | 386 | 13.1 | 129 |
| 32 | 3.80 | 37.3 | 442 | 59.6 | 585 | 19.9 | 195 |
| Modulus of Elasticity, E = 110 kN/mm$^2$ = 11 t/ mm$^2$ | | | | | | | |



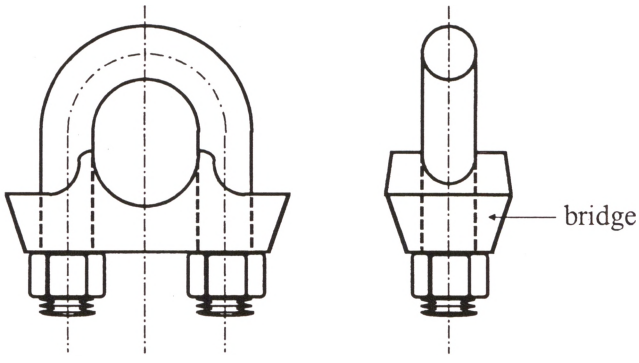

Cross-section and Lay of Wire Rope

- **Bulldog Grips**

  Bulldog Grips are used at the cable terminals to secure the cable ends.

  Bulldog grips should conform to IS 2361-1970 specifications for Bulldog Grips. The bridges must be dropforged and suitably scored to grip a round strand rope of right hand lay having six strands. Bridges, U-bolt and nuts should be hot dip galvanized with a minimum zinc coating of 40μm. The size of the bulldog grip should be equal to the size of the cable to be anchored or connected.

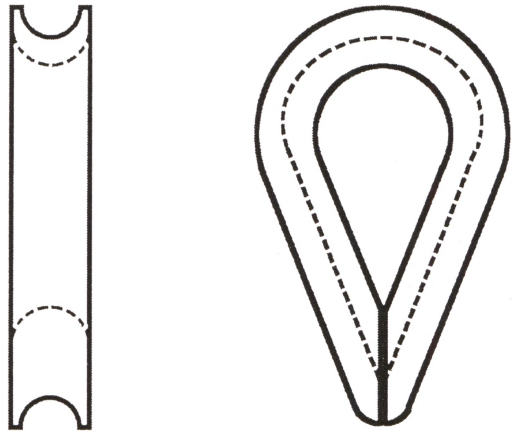
**Bulldog Grip**




- **Thimbles**

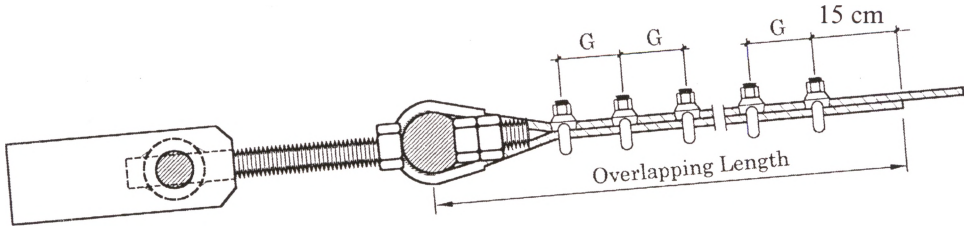
  Thimbles are of open type and should confirm to IS 2315-1978 specifications for Thimbles for Wire Ropes. They must be forged and hot-dip galvanized with a minimum zinc coating of 40μm. Thimbles are used at the cable terminals to avoid kinks. The size of the thimbles should be equal to the size of the cable to be anchored

**Thimble**



- **Methods of Applying Bulldog Grips to Wire Ropes**

  The method of applying bulldog grips to wire ropes is given in the following sketch:



The number of bulldog grips, gap and overlapping length should be as given in the following table.

| Diameter of Wire Rope, mm | Required Number, "n" of Bulldog Grips | Gap "G" cm | Overlapping Length "L" cm |
|---|---|---|---|
| 13 | 3 | 10 | 60 |
| 26 | 5 | 15 | 130 |
| 32 | 6 | 20 | 180 |

The bridge of the bulldog grips must be fitted on to the working part of the wire rope and the U-bolt on to the rope tail. The cable end should be protected from fraying with binding wire. For further details on cable anchor methods, refer to Chapter 6.6.3 and 6.6.4.

- **Structural Steel**

The steel grade should be of standard quality **Fe 410** and the structural steel should comply with the requirements of:

IS 226 – 1975 Structural Steel
IS 800 – 1984 General Construction in Steel

The tower design is based on the Swiss Standard SIA 161(1979) for Steel Structures.

**Mechanical Properties**
The steel should have the following mechanical properties :

Tensile Strength $f_t \geq 410$ N/mm$^2$
Yield Stress $f_y \geq 250$ N/mm$^2$
Permissible Tensile Stress $\sigma_{at} = 150$ N/mm$^2$
Modulus of Elasticity $E = 200$ kN/mm$^2$
Elongation $\delta \geq 23\%$

- **Fasteners**

Bolts, nuts and washers should be of grade C, property class 4.6 and should comply with the requirements of:

IS 1363 - 1984 (Part 1) Hexagonal Head Bolts and Nuts
IS 1367 – 1983 Threaded Fasteners

The fasteners should be hot dip galvanized with a minimum zinc coating of **40μm**.

- **Reinforcement Steel**

The reinforcement steel should be of steel grade **Fe415**, high yield deformed bars and should comply with the requirements of:

IS 1786 – 1985 High Strength Deformed Steel Bars for Concrete Reinforcement
IS 456 – 1978 Plain and Reinforced Concrete

**Mechanical Properties**
The reinforcement steel should have the following mechanical properties:

Yield Stress $f_y \geq 415$ N/mm$^2$
Permissible Tensile Stress $\sigma_{at} = 230$ N/mm$^2$
Modulus of Elasticity $E = 210$ kN/mm$^2$

- **Rust Prevention**

Rust prevention of steel parts should be done by **Hot-Dip Galvanization** according to:

IS 2629 - 1966 Recommended Practice for Hot-Dip Galvanization of Iron and Steel
IS 4759 - 1984 Specification for Hot-Dip Zinc Coating on Structural Steel

**Specifications for Hot-Dip Zinc Coating**

| Products | Minimum Mass of Coating | | Minimum Thickness of Coating |
|---|---|---|---|
| | g/m² | N/m² | μm |
| Structural Steel | 610 | 6.0 | 80 |
| Threaded work, Nuts & Bolts | 300 | 3.0 | 40 |

- **Wire Mesh Netting**

The wire for wire mesh netting should comply with the requirements of:

IS 280 - 1978 Mild Steel Wire for General Engineering Purposes
IS 4826 - 1979 Hot-dipped Galvanizing Coatings on Round Steel Wire

The diameter of the wire should be 12 SWG (2.64mm) and the zinc coating should not be less than 270 g/m². The average tensile strength of the wire should not be less than 380N/mm².

- **Concrete**

The concrete should comply with all the requirements of:

IS 456 – 1978 Plain and Reinforced Concrete
IS 269 – 1989 Ordinary Portland Cement of 53 Grade
IS 383 - 1970 Coarse and Fine Aggregate

The concrete grades used in the standard design are:

Concrete 1:3:6 (M10) for miscellaneous use
Concrete 1:2:4 (M15) for structures
Concrete 1:3:6 mixed with 40% boulder

- **Masonry**

The masonry should comply with all the requirements of:

IS 1597 – 1967 Code of Practice for Construction of Stone Masonry
IS 2250 – 1981 Preparation and Use of Masonry Mortars

The stone masonry used in the standard design are:

Chisel Dressed Stone Masonry in 1:4 cement : sand mortar
Hammer Dressed Stone Masonry in 1:6 cement : sand mortar
Dry Stone Masonry.

- **Unit Weight of Construction Materials**

The unit weight of the construction materials used in the standard design is given in the following table.

| Materials | Unit Weight, | |
|---|---|---|
| | kg/m³ | kN/m³ |
| Concrete | 2200 | 22.0 |
| Stone Masonry | 2100 | 21.0 |
| Steel | 7850 | 78.5 |
| Soil | 1800 | 18.0 |
| Water | 1000 | 10.0 |

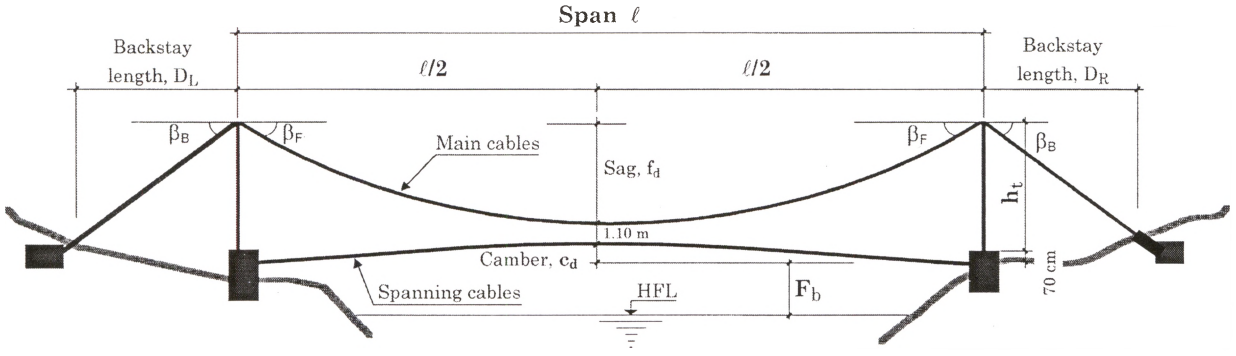
### 3.2.3 STRUCTURAL ANALYSIS AND DESIGN

The statical analysis is based on the calculation of forces and stresses in the structures due to external loadings. The calculated forces and stresses are compared with the permissible loads and stresses of these structures with some safety factors.

The Standard Suspension Bridge has been designed as per the following statical analysis and basic design concept. For more details of structural analysis and design calculations, refer to Volume A of the LSTB (SBD) Manual.

- **Bridge Geometry**

The geometry of the Suspension Bridge is as shown in the following sketch:




Where, $l$ = Bridge Span, the horizontal distance between the tower saddles

$D$ = Backstay distance, the horizontal distance between the tower axis and the hinge of the main cable anchorage or the front of the main cable Foundation

$D_R$ = Backstay distance of the main cable on the right bank

$D_L$ = Backstay distance of the main cable on the left bank

$f$ = Sag of the Main Cable, the vertical distance from the tower saddle to the lowest point of the Main Cable

$f_d$ = Sag of the Main Cable in a dead load case

$f_f$ = Sag of the Main Cable in a full load case

$c$ = Camber of the Spanning Cable, the vertical distance from the spanning cable anchorage to the highest point of the spanning cable

$c_d$ = Camber of the Spanning Cable in a dead load case

$\beta_F$ = Frontstay cable inclination at the tower saddle

$\beta_B$ = Backstay cable inclination at the tower saddle

$\beta_f$ = Cable inclination at full load

$\beta_{Ff}$ = Frontstay Cable inclination at the tower saddle in a full load case

$h_t$ = Tower Height

$F_b$ = Freeboard, the vertical clearance from the high flood level (HFL) to the Spanning Cable Anchor point

**Equation of the bridge geometry:**

$$\textit{Total Height of Tower} = h_t + 0.7m = f_d + c_d + 1.1m$$

$$\textit{Frontstay Cable Inclination} = \beta_F = \arctan\left(\frac{4f}{\ell}\right)$$

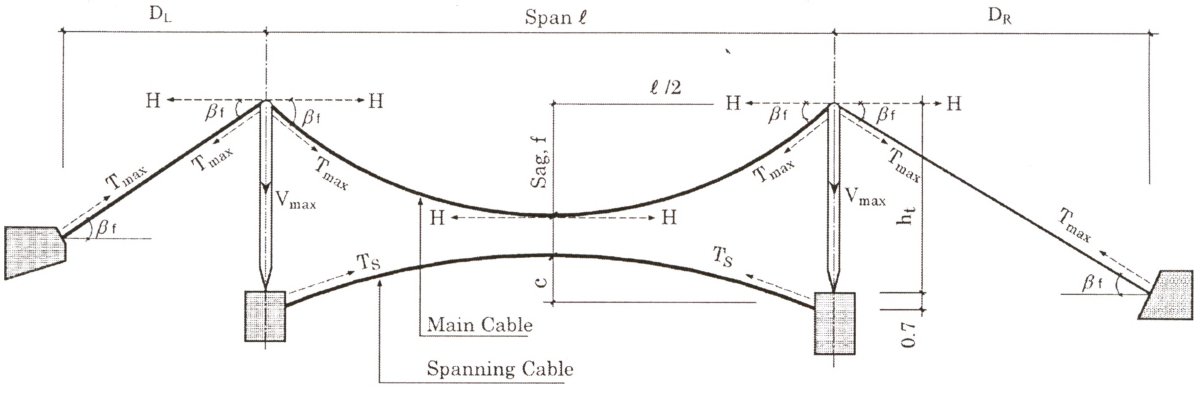
$$\textit{Backstay Cable Inclination} = \beta_B \approx \beta_{Ff} = \arctan\left(\frac{4f_f}{\ell}\right) = \beta_f$$

- **Selection of Bridge Geometry**

The selection of the bridge geometry means defining the bridge span "*l*", Tower height "$h_t$", main cable sag "$f_d$" and camber "$c_d$" of the spanning cable in a dead load case. The relation between these geometrical parameters of the bridge is given in the above "Equation of the bridge geometry". The optimum and rational design of a suspension bridge largely depends on the proper selection of the bridge geometry. For this purpose, many combinations of the bridge geometries are calculated and the final optimal results are presented in the **"Table: Selection of Cables and Standard Towers"** in Chapter 3.3.4.

**Bridge Span:**
For the sake of simplicity, the spans have been rounded off to the meter in the standard design (refer to **"Table: Selection of Cables and Standard Towers"** in Chapter 3.3.4.). One suspender at the middle of the span is a must. Hence, the distance from the tower axis to the 1st suspender will vary as per the odd/even length of the span in meters. The first cross beam is fixed without a suspender. For further details, refer also to the sub-chapter **"Suspenders",** which will be discussed later.

- **Cable Design**
  A cable hanging between two supports and carrying a uniformly distributed load **"q"** forms a parabola. Thus the Main Cables and the Spanning Cables are assumed to be of parabolic geometry. In the suspension type bridge, the main cables carry all the load. The Spanning Cables carry only the pretension load. It is assumed that when a bridge is in full load, the tension in the spanning cable will be zero. The following sketch represents the cable geometry and the forces acting on it.




**Bridge Geometry**

⇒ Sag of the Main Cable at mid span in Dead Load, $\mathbf{f_d = 0.075\,\mathit{l}\ to\ 0.14\,\mathit{l}}$

⇒ Camber of the Spanning Cable at mid span in Dead Load, $\mathbf{c_d = 0.015\,\mathit{l}\ to\ 0.03\,\mathit{l}}$

⇒ Cable Inclination at Saddles,

Frontstay Angle: $$\beta_F = \arctan\left(\frac{4f}{l}\right)$$

Backstay Angle: $$\beta_B \approx \beta_{Ff} = \beta_f = \arctan\left(\frac{4f_f}{l}\right)$$

⇒ Main Cable Length between tower saddles in Dead Load, $$L_{md} = l \cdot \left[1 + \frac{8}{3}\left(\frac{f_d}{l}\right)^2\right]$$

⇒ Spanning Cable Length between tower axis in Dead Load, $$L_{sd} = l \cdot \left[1 + \frac{8}{3}\left(\frac{c_d}{l}\right)^2\right]$$

**Forces**
The fundamental equations for the calculation of the cable forces are:

⇒ Total Horizontal Tension on the Main Cable in any Load case, $$H = \frac{g\,l^2}{8\mathrm{f}}$$

⇒ Total Maximum Tension on the Main Cable in any Load case, $$T_{max} = \frac{H}{\cos\beta_F}$$

⇒ Total Horizontal Tension on the Main Cable in Full Load case, $$H = \frac{g\,l^2}{8\mathrm{f}_f}$$

⇒ Total Maximum Tension on the Main Cable in Full Load case, $$T_{max} = \frac{H}{\cos\beta_f}$$

⇒ Total Horizontal Tension on the Main Cable in Full Load case, $$V_{max} = \frac{g_f\,l}{2}$$

**The Safety Factor for Cable Breaking Load is taken as $f_s \geq 3$.**

The dead load sag $\mathbf{f_d}$ is chosen to have an optimal bridge geometry. The hoisting sag $\mathbf{f_h}$ and the full load sag $\mathbf{f_f}$ are calculated as per the elastic theory by the iteration method based on the chosen dead load sag $\mathbf{f_d}$. The hoisting sag $\mathbf{f_h}$ is necessary for cable hoisting purpose while erecting the bridge. The full load sag $\mathbf{f_f}$ is necessary for the calculation of the maximum tension in the cable. The cable combination is designed as per the calculated maximum tension.

The Main Cables are selected to withstand the maximum tension in full load case with a safety factor of

$$f_s = T_{Break} / T_{max} \geq 3.$$

The Spanning Cables are selected as per the maximum tension $\mathbf{P_s}$ in load case [A] or [B] ("$\mathbf{P_s}$" and loading cases are discussed in sub-chapter **"Steel Towers"** at the bottom of this page) with safety of factor, $f_s = T_{Break} / T_{sA/B} \geq 3$.

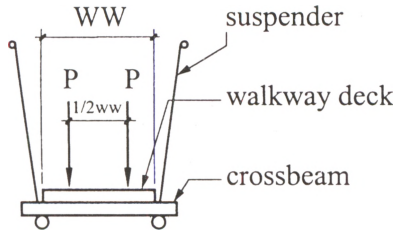
As per the above design concept and the optimum bridge geometry, a simplified cable combination chart has been developed and standardized for the suspension type bridge for spans up to 120m (refer to **"Table: Selection of Cables and Standard Towers"** in Chapter 3.3.4.). The Main and Spanning Cable combinations, the dead load sag $\mathbf{f_d}$, the hoisting sag $\mathbf{f_h}$ of the main cables, the camber $\mathbf{c_d}$ of the spanning cables, and the cable inclination under full load $\beta_f$ at the tower saddle for a given span is presented in this chart.

- **Steel Parts**

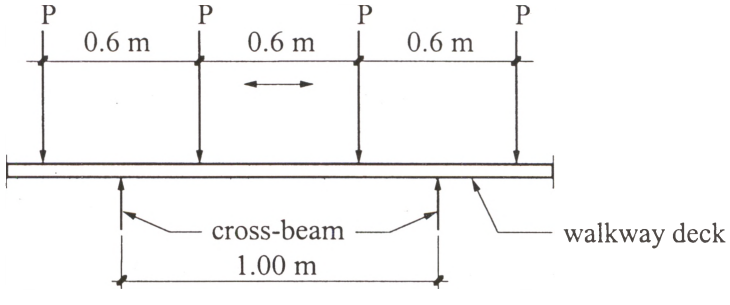
  The steel parts of the suspension type bridge are mainly subject to axial tension/compression, bending stress, shear stress, bond stress and buckling effect. All the steel parts are designed to withstand these forces and stresses with a safety factor of **fs = 1.6**.
  All the steel parts have been standardized according to the cable combinations and do not depend on the site condition.

- **Walkway Structure**

  The walkway structures (Steel deck, Cross beams, Suspenders) are designed for local loadings like all steel parts with a safety factor of **fs = 1.6**. A concentrated load **P = 150 kg** (weight of a porter with a load) positioned along the walkway as well as across the walkway has been considered as per the sketch below.




2 porters passing each other (P = 1.5 kN)




Porters standing in row (P = 1.5kN)

**Standard Walkway width (WW) is 106cm.**

- **Steel Towers**

  The Standard Steel Towers are designed as hinged. Different possible loading cases were considered in order to determine the worst case with respect to buckling and yielding of the most critical elements of the towers. Two loading cases, i.e. load combination with wind load are found most critical. They are:

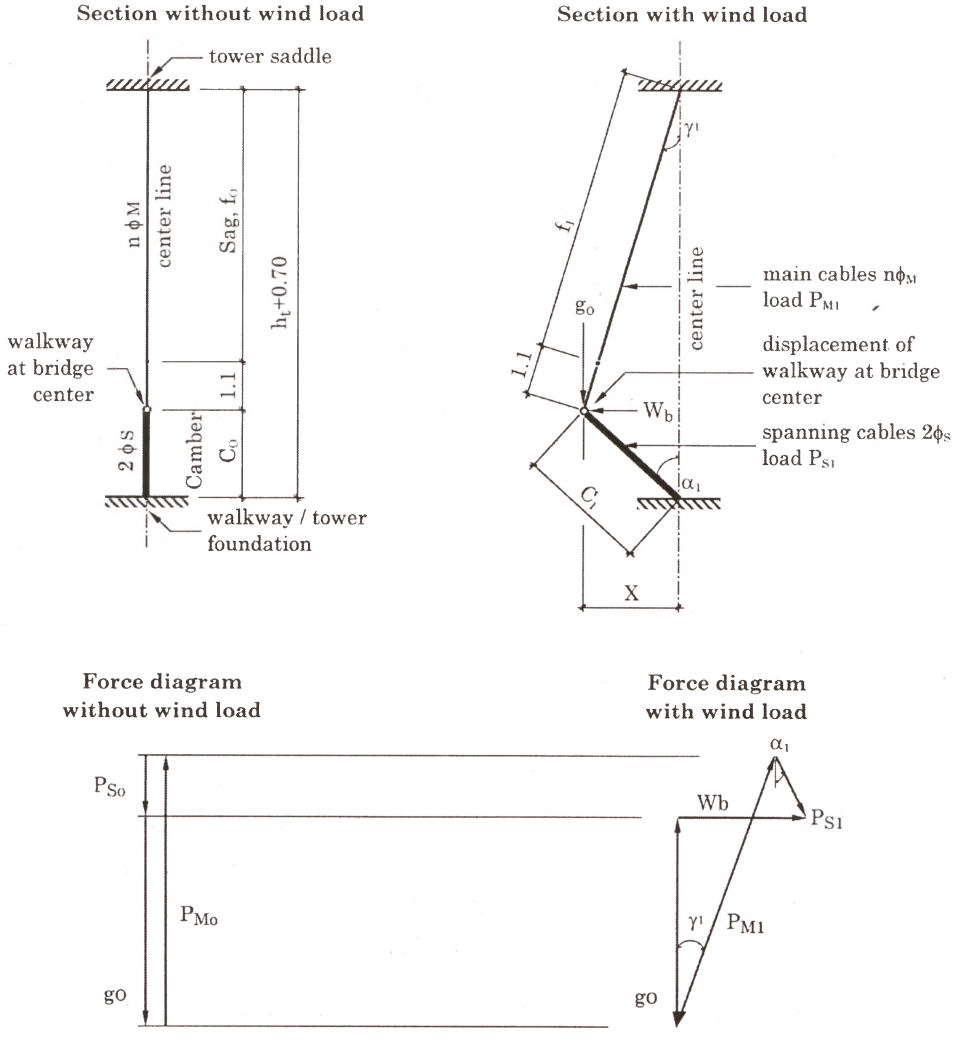
**Load Case [A] = Dead Load + Full Wind Load**
**Load Case [B] = Full Load + 1/3 Wind Load**

A global wind load of 1.7kN/m$^2$ (170kg/m$^2$) for exposed area, which is equivalent to a wind speed of 160 km/hr (refer to Chapter 3.2.1 Loading) has been considered for the design. The wind load is assumed to be a uniformly distributed horizontal load. Wind loads on different bridge elements are calculated based on the global wind load and the area exposed to the wind of the respective elements, which are:

on Walkway, $W_{ww}$ = 0.50 kN/m (50 kg/m)
on Main Cable, $W_M$ = 0.075 kN/m (7.5 kg/m)
on Suspenders, $W_s$ = 0.035 kN/m (3.5 kg/m)
on Tower , $W_t$ = 1.025 kN/m (102.5 kg/m)

The calculations are made under the assumption that all the wind loads are taken by the towers and ultimately by the walkway and tower foundations. No windguy arrangement is considered in the calculation.

The following simplified model is used for the statical analysis:




With reference to the above Force/Vector diagram, the forces are calculated as below:

Forces without wind load
Wind load, $W_b = W_M + W_s = 0$,
$P_{MO} - P_{SO} = g_O$

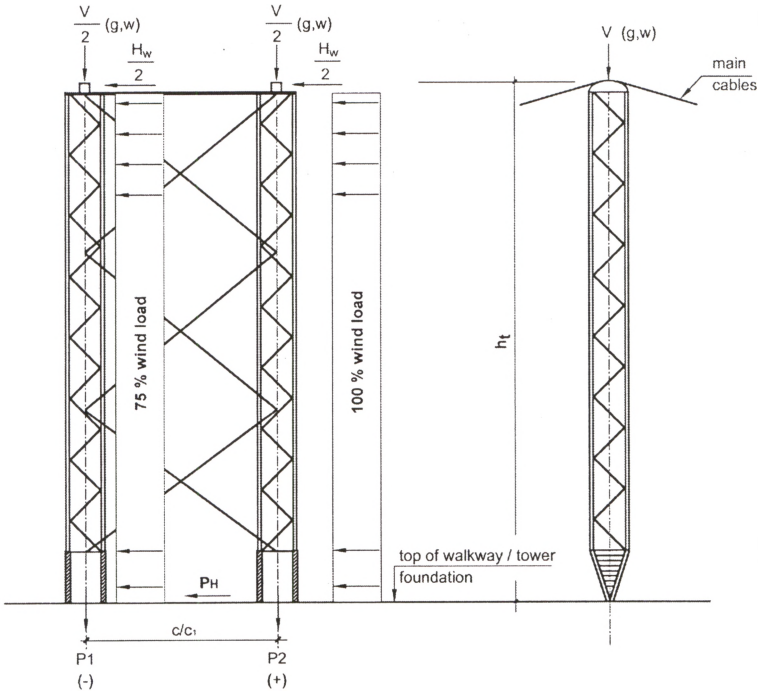
Forces with wind load
$P_{M1} \cdot Sin\ \gamma_1 + P_{S1} \cdot Sin\ \alpha_1 = W_b = W_{MO} + W_{sO}$
$P_{MO} \cdot Cos\ \gamma_1 - P_{S1} \cdot Cos\ \alpha_1 = g_O$

Where $P_M$ and $P_S$ are the forces on the main cables and spanning cables respectively.

The statical analysis with the above load combination is mainly to compute the displacement "**X**" and the sag "$\mathbf{f_1}$" and the corresponding forces on the main cables $\mathbf{P_{M1}}$ and $\mathbf{P_{S1}}$ for both load case [A] and [B]. The calculation is based on the elastic theory and iteration method. For the detailed calculation process, refer to Volume A of the LSTB (SBD) Manual. However, while calculating the stiffness, the constant factors "$\mathbf{C_{SO}}$" of the walkway system, additional stiffness of the steel cross beam/deck reinforced with pipes are also considered.

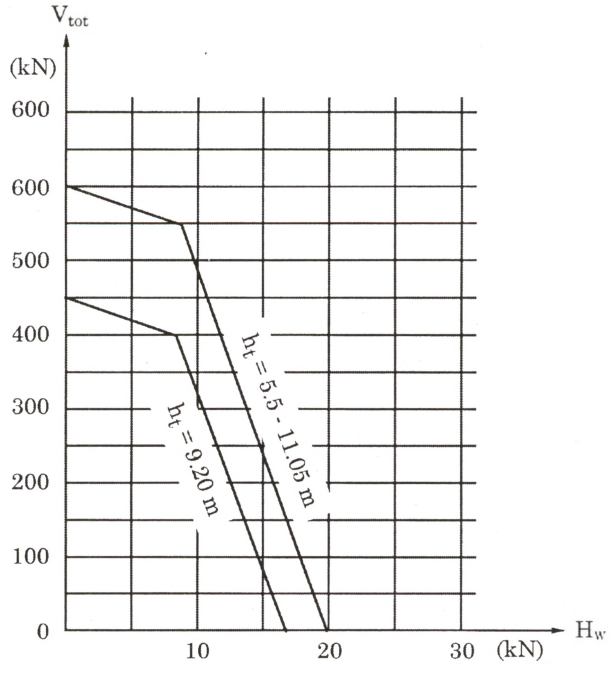
Further, as per the calculated "$\mathbf{P_{M1}}$" and "$\mathbf{P_{S1}}$", the possible maximum vertical load "$\mathbf{V_{tot}}$" and the horizontal load "$\mathbf{H_w}$" on the towers are computed. Similarly, the reactions on the tower base "$\mathbf{P_1}$", "$\mathbf{P_2}$" and "$\mathbf{P_H}$" are also computed (see figure below).

**Forces on Tower**




The design of the Standard Towers is based on the ETH (Swiss Federal Institute of Technology) Report and it follows the Swiss Standard SIA 161 (1979) for steel structures. The Tower Capacity Diagram as a function of "$\mathbf{V_{tot}}$" and "$\mathbf{H_w}$" of the proposed Standard Towers is presented bellow.

**Tower Capacity Diagram**



An appropriate Standard Tower is selected as per the calculated maximum vertical "$\mathbf{V_{tot}}$" and horizontal "$\mathbf{H_w}$" loads. The plotted point with the coordinates of "$\mathbf{V_{tot}}$" and "$\mathbf{H_w}$" in the "Tower Capacity Diagram" should be below the capacity line of the selected standard tower.

As per the above statical analysis and design concept, a simplified chart for the selection of towers has been developed and standardized for the suspension type bridge for different bridge spans of up to 120m in the **"Table: Selection of Cables and Standard Towers"** in Chapter 3.3.4..

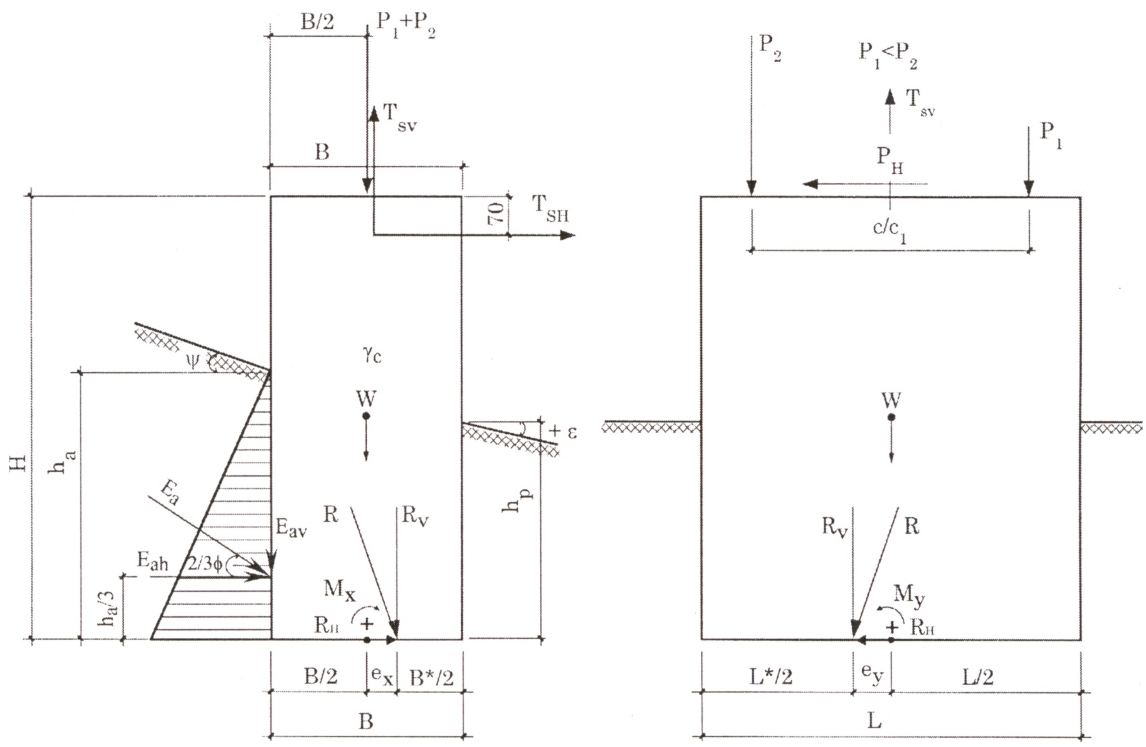
- **Design of Walkway and Tower Foundations.**

  The standard design does not have a windguy system. The foundations are designed to take a wind load satisfying the worst case from the load cases [A] and [B].
  The foundations are designed as per the static analysis and the principle of soil and rock mechanics. The design loads on the Walkway and the Tower Foundations are equivalent to the reactions on the tower base "$\mathbf{P_1}$", "$\mathbf{P_2}$" and "$\mathbf{P_H}$" and the tension on the spanning cables "**Ts**", which are calculated for both the load cases [A] and [B]. The soil and rock parameters are determined by a site investigation (refer to Chapter 2.4.5 and 2.4.6).

**Overall Stability of the Foundation:**
The following mode of failure and respective safety factors for the overall stability of the foundation block are considered in the design.

⇒ Sliding $\mathbf{F_{SL}}$ $\geq$ **1.5**
⇒ Toppling $\mathbf{B^*/2}$ $\geq$ **B/3 ; L*/2 ≥ L/3**
⇒ Maximum Ground Pressure $\sigma_{max} \leq \sigma_{perm}$ , Bearing capacity of soil or rock
⇒ Ground Shear Failure (Ultimate Bearing Capacity ) in case of soil

The design concept of the foundation is as given below:




*Safety factor against Sliding:* $$F_{sl} = \frac{Resisting Force}{Driving Force} = \frac{Rv \cdot \tan\phi_{sl}}{R_H} \geq 1.5$$

Where $R_V = W + (-P_1) + P_2 - T_{SV} + E_{av}$
$R_H = T_{SH} + E_{ah}$

*for the calculation of the Active Earth Pressure* $\mathbf{E_{ah}}$ *and* $\mathbf{E_{av}}$ *refer to sub-chapter* ***"Main Cable Deadman Anchor Block in Flat Ground"****, which will be discussed later in this chapter.*

***Safety factor against Overturning:***

The safety factor against overturning is checked by the eccentricity of the resultant force. The eccentricity should be within the limit of

$$B^*/2 \geq B/3 \text{ and } L^*/2 \geq L/3$$

Where $B^*/2 = B/2 - |e_x|$; $e_x = \Sigma M_X / R_V$;
$L^*/2 = L/2 - |e_Y|$; $e_y = \Sigma M_Y / R_V$;

$$\Sigma M_X = T_{SH} \cdot (H - 0.70) + E_{ah} \cdot H/3 - E_{av} \cdot B/2 - E_{ahp} \cdot h_p/3 + E_{avp} \cdot B/2$$
$$\Sigma M_Y = -P_1 \cdot (C/C_1)/2 + P_2 \cdot (C/C_1)/2 + P_H \cdot H$$

***Safety against Ground Bearing Pressure:***

$$\sigma_{max} = Z \cdot \frac{R_V}{B^* L^*} \leq \sigma_{perm}$$, permissible bearing pressure of soil/rock.

Where the Z – factor considers the location of the resultant force and is a function of (L*/2)/ L and (B*/2)/B. The values of Z – Factors are given in the table below.

**Value of Factor, Z**

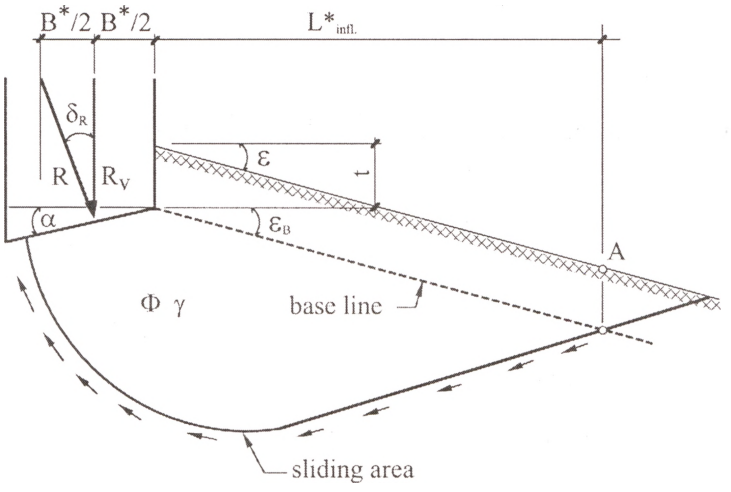
| Z - factor | (B* / 2) / B | | | | | |
|---|---|---|---|---|---|---|
| (L* / 2) / L | 0.50 | 0.45 | 0.40 | 0.35 | 0.30 | 0.25 |
| 0.5 | 1 | 1.17 | 1.28 | 1.33 | 1.33 | 1.33 |
| 0.45 | 1.17 | 1.30 | 1.36 | 1.39 | 1.39 | 1.39 |
| 0.4 | 1.28 | 1.36 | 1.41 | 1.43 | 1.43 | 1.43 |
| 0.35 | 1.33 | 1.39 | 1.43 | 1.46 | 1.47 | 1.47 |
| 0.3 | 1.33 | 1.39 | 1.43 | 1.47 | 1.49 | 1.50 |
| 0.25 | 1.33 | 1.39 | 1.43 | 1.47 | 1.50 | 1.50 |

Nevertheless, the minimum size of the foundation is governed by the geometric requirements to fix the tower, anchorage/other steel parts and also the topography.

***Safety against Ground Shear Failure (Ultimate Bearing Capacity):***

In our case, the horizontal force acting on the foundation is relatively greater than the vertical load. The safety against ground shear failure or bearing capacity depends mainly on the vertical load on the foundation. Therefore, in a majority of the cases, this failure mode is not the deciding factor in the foundation design. However, there is comparatively high vertical force acting on the walkway and the tower foundation, and ground shear failure may be the deciding factor in its design.

The ground shear failure analysis is carried out by Terzaghi's extended and amplified bearing capacity formula. Terzaghi's formula is extended and amplified with different co-efficients considering the foundation shape and topography of the ground. The analysis model is as shown in the figure below:




Safety against ground shear failure, $F_{BC} = P^*/P \geq 2.0$ for Terzaghi's formula,

where, P* - shear resistance of the ground (ultimate bearing capacity ) determined by Terzaghi's formula

P - vertical resultant force on the foundation

Terzaghi's formula for shallow foundation with continuous footing and horizontal ground,

$$P^* = B [c N_C + (\Upsilon t + q) N_q + 0.5 B \Upsilon N_\Upsilon],$$

cohesion factor "**c**" is not considered since the predominant soil type in Nepal is non-cohesive,

therefore, Terzaghi's formula above will be,

$$P^* = B [(\Upsilon t + q) N_q + 0.5 B \Upsilon N_\Upsilon]$$

In our case, safety against ground shear failure, $F_{BC} = P^*/R_v \geq 2.0$

where, P* - shear resistance of the ground (ultimate bearing capacity ) determined by Terzaghi's formula with correction factors for topography and shape of the foundation,

$R_v$ - vertical resultant force on the foundation

Terzaghi's formula with correction factors,

$$P^* = B^* L^* [(\Upsilon t + q) N_q S_q d_q i_q b'_q g_q + 0.5 \Upsilon B^* N_\Upsilon S_\gamma d_\gamma i_\gamma b'_\gamma g_\gamma]$$

where, $\Upsilon$ = unit weight of soil

t = embedded depth in front of the foundation

q = surcharge load, q = 0 in our case

$N_q = e^{\Pi \tan\phi} \tan^2(45° + 0.5\,\phi)$, co-efficient for embedded depth or surcharge load,

$N_\Upsilon \approx 1.8 (N_q - 1) \tan\phi$, co-efficient for effect of the foundation width,

shape correction factors considering limited length (L*) of continuous footing,

$S_q = 1 + (B^*/L^*) \tan\phi$

$S_\gamma = 1 - 0.4 (B^*/L^*)$

depth correction factors considering the embedded depth ($t = h_p$) of the foundation,
$d_q = 1 + 0.035 \tan\phi(1 - \text{Sin}\,\phi)^2 \arctan(t/B^*)$,

$d_\gamma = 1$

embedded depth in front of the foundation should be guaranteed up to the length of the influence area $L^*_{infl}$,
$L^*_{infl} = B^* \tan(45° + 0.5\phi)\, e^{0.5\,\Pi \tan\phi}$

correction factor for the inclination of the load,
$i_q = [1 - 0.5 \tan(\delta_R - \alpha)]^5$

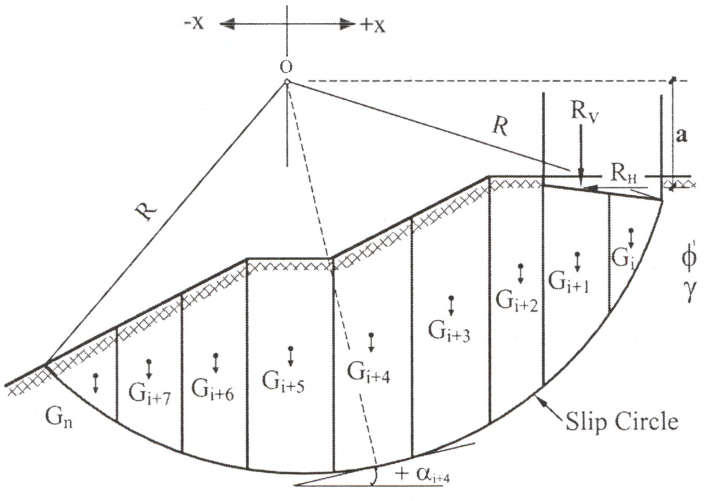
$i_\gamma = [1 - (0.7 - 0.0022\,\alpha°) \tan(\delta_R - \alpha)]^5$

correction factor for the inclination of the foundation base, $\alpha$,
$b'_q = e^{(-0.035\,\alpha° \tan\phi)}$

$b'_\gamma = e^{(-0.047\,\alpha° \tan\phi)}$

correction factor for the inclination of the base line ($\varepsilon_B$), which is approximately equal to the inclination of the ground slope ($\varepsilon$) but limited to the ground slope up to 15° only,
$g_q = g_\gamma = (1 - 0.5 \tan\varepsilon_B)^5$, $\quad \varepsilon_B \approx \varepsilon$

Experience shows that Terzaghi's amplified and extended formula with correction factors is no more reliable for foundations on steep slope ground. It gives relatively acceptable results only for a ground with a slope of less than 15°. Therefore, an overall slope stability analysis is made for slope ground of more than 15° inclination. The overall slope stability analysis is carried out by using Bishop's simplified method of slices. The method applied is as given below:




$$F = \frac{\sum_{i=1}^{n} [(G_i + V_i)\tan\phi'] \frac{1}{m_{\alpha i}}}{\sum_{i=1}^{n} [(G_i + V_i)\sin\alpha_i] + R_H \frac{a}{R}}$$

$$m_{\alpha i} = \cos\alpha_i \left[1 + \frac{\tan\phi' \tan\alpha_i}{F}\right]$$

where, in our case

$G_i$ = weight of the soil of the given slice "i"

$V_i$ = $R_V$, resultant vertical force on the foundation, which is applicable only at one slice and in other slices, $V_i = 0$.

H = $R_H$, resultant horizontal force on the foundation

$\phi'$ = 1.10 x $\phi$,

$\phi$ = angle of internal friction of the soil

$\alpha_i$ = tangential angle at the slip circle of given slice "i"

R = Radius of the slip circle

a = lever arm of "$R_H$"

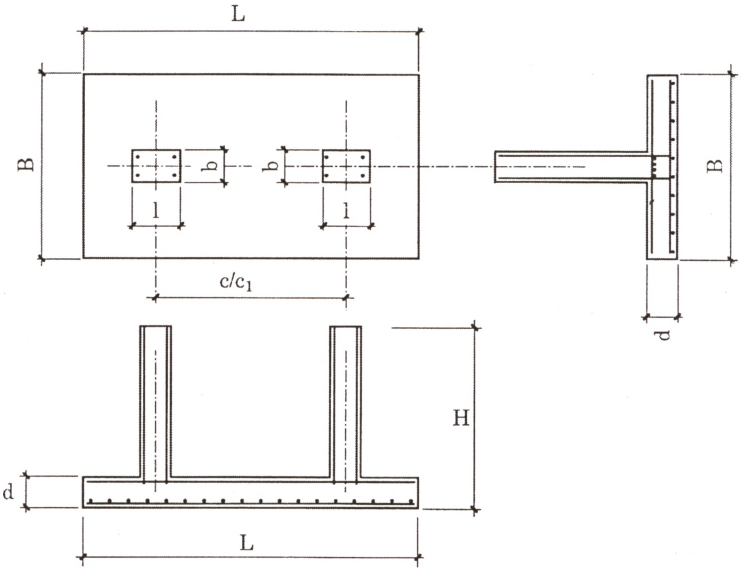
F = safety factor, which is taken as 1.5 for the Bishop's Method

As the factor of safety "F" appears on both the sides, a process of successive approximation is required. It is necessary to fix the center "**o**" corresponding to the critical slip circle with minimum safety factor. A computer program is also available to do this analysis.

As per the analysis, it is established that if the foundations are placed behind the slope line with the angle of internal friction "$\phi$", shear failure in general, will not occur.

**Design of the Reinforced Concrete Frame of the Foundation:**

The Concrete Frame of the walkway/tower foundation is designed as reinforced concrete columns and foundation with a combined footing. A typical design of the frame is as given below:



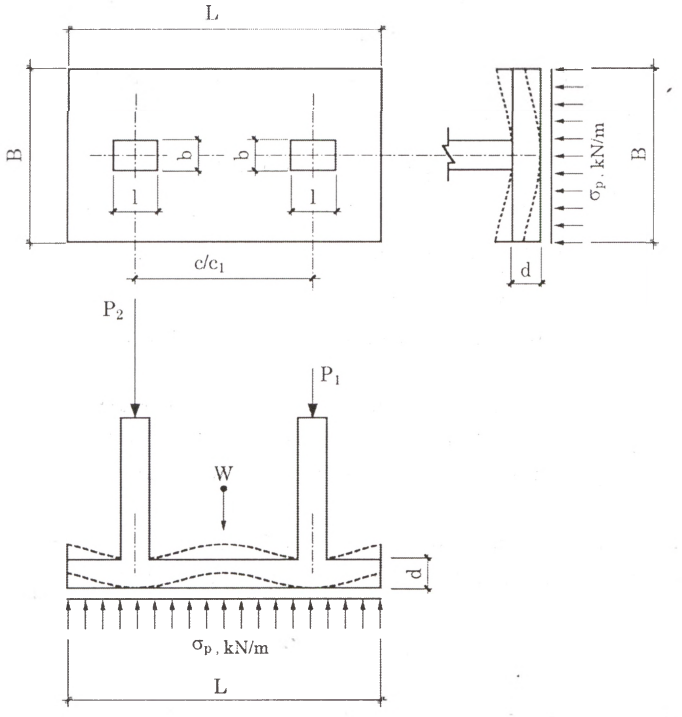

The cross sectional sizes of the columns **( b x l )** are designed to fulfill the geometric requirement to fix the tower legs and also to fulfill the criteria of the direct compressive stress on the columns:

Direct compressive stress on column, $\sigma_{ac} = P_1$ *or* $P_2 / b \times l \leq \sigma_{ac\ perm.}$, permissible direct compressive stress.

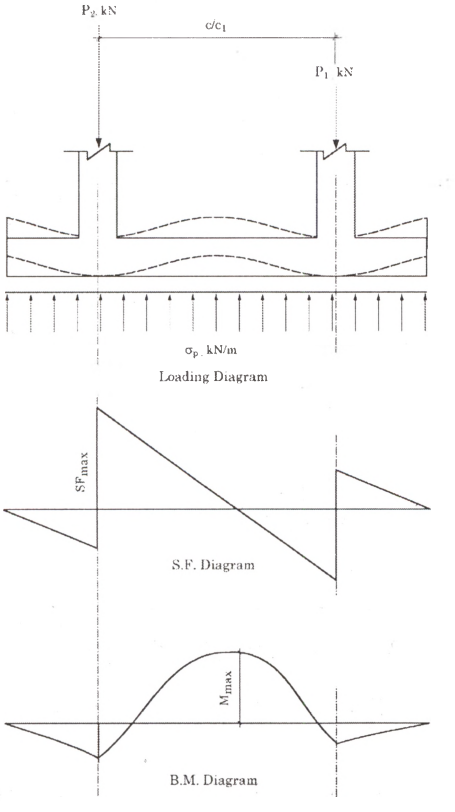
The size of the foundation **(B x L)** is also checked to fulfill the criteria of the maximum bearing pressure at the foundation.

Maximum bearing pressure at the foundation, $\sigma_{max} = (P_1 + P_2 + W) / L \times B \leq \sigma_{perm}$ , permissible bearing pressure of soil/rock.

A balanced section has been assumed for the reinforced concrete design of the frame. The concrete grade of M10 has been adopted. The following structural and loading model is used for the structural analysis.




A typical result of the structural analysis is as given in the diagram below:




The thickness of the foundation slab and the requirement of reinforcement steel is designed as per the structural analysis (Shear Force and Bending Moment diagram).

**Thickness of Foundation Slab:**

The thickness of the foundation slab "**d**" has been designed as per the maximum bending moment, and checked for punching shear due to vertical load from the column.

$$d = \sqrt{\frac{2M_{max}}{\xi(1-\xi/3)B\sigma_{c\ perm}}}$$

Where $\xi = n\mu\left(\sqrt{1+\frac{2}{n\mu}}-1\right)$;

$\mu = \frac{A_S}{d\,B}$; Ratio of Area of steel to area of concrete section

$n = \frac{E_S}{E_C}$ ; Ratio of modulus of elasticity of steel to concrete;

Required Area of steel:
in longitudinal direction of the foundation slab

$$A_S = \frac{M_{max\ (Long.)}}{\eta\, d\, \sigma_{t\ perm}}$$

in transverse direction of the foundation slab

$$A_S = \frac{M_{max\ (Trans.)}}{\eta\, d\, \sigma_{t\ perm}}$$

**Where** $\eta = 1 - \frac{1}{3(1+\frac{\sigma_t}{n\,\sigma_c})}$

$\sigma_t$ - permissible tensile stress of the reinforcement steel
$\sigma_c$ - permissible compressive stress of the concrete

- **Main Cable Anchor Blocks**

  There are mainly three basic types of main cable anchor blocks depending upon the soil/rock type and the prevailing topography:

  ⇒ Main Cable Gravity Anchor Block in soil/rock for Slope Topography

  ⇒ Main Cable Deadman Anchor Block in Soil for Flat Topography

  ⇒ Main Cable Drum Anchor Block in Rock

  The Main Anchor Blocks are designed to withstand the maximum tension of the main cables based on the cable structure analysis and considering the soil/rock parameters. The soil and rock parameters are to be determined by the site investigator (refer to Chapter 2.4.5 and 2.4.6).

**Main Cable Gravity Anchor Block in Soil/Rock for Slope Topography:**

This type of anchor block is designed for slope topography. The following mode of failure and respective safety factors are considered in the design.

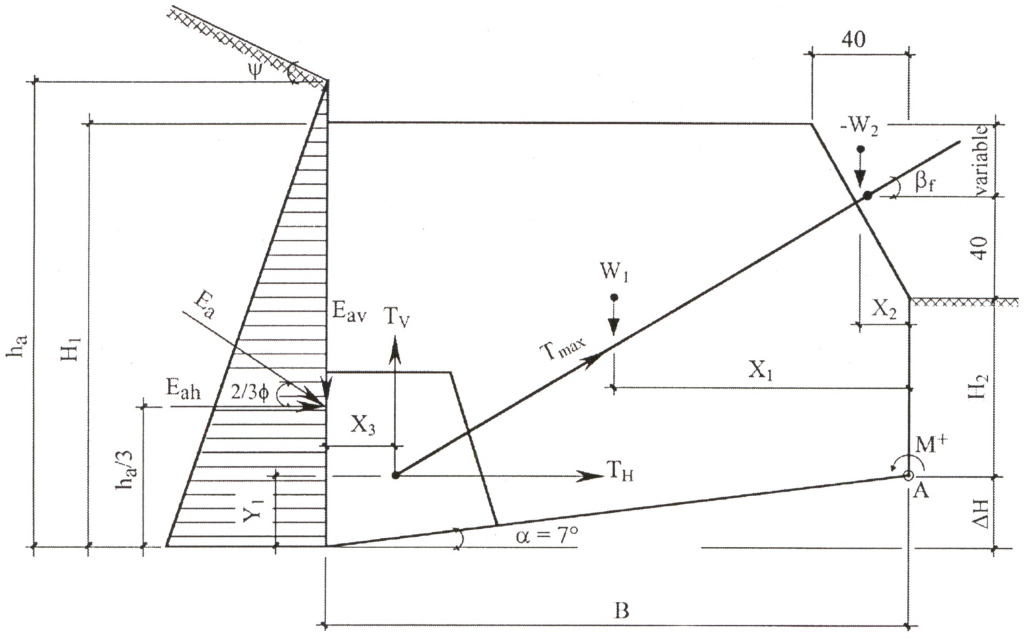
⇒ Sliding $F_{SL}$ **≥ 1.5**

⇒ Toppling $F_T$ **≥ 1.5**

⇒ Maximum Ground Pressure $\sigma_{max}$ < Bearing capacity of soil or rock

⇒ Ground Shear Failure (Ultimate Bearing Capacity ) in case of soil

The design concept of the anchor block is as given below:




The anchor blocks have been designed to satisfy the safety factor against sliding with the following theoretical basis:

***Safety factor against Sliding:*** $$F_{sl} = \frac{Resisting Force}{Driving Force} = \frac{R'_V \cdot \tan\phi_{sl}}{R'_H} \geq 1.5$$

Where $R'_V = R_V \cdot \cos\alpha + R_H \cdot \sin\alpha$; $R_V = W_1 - W_2 + E_{av} - Tv$

$R'_H = R_V \cdot \sin\alpha + R_H \cdot \cos\alpha$; $R_H = T_H + E_{ah}$

***Safety factor against Overturning:*** $$F_{ovt} = \frac{All\ Resisting\ Moments}{All\ Driving\ Moments} = \frac{\Sigma M_A^+}{\Sigma M_A^-} \geq 1.5$$

Where $\Sigma M_A^+ = W_1 \cdot X_1 - W_2 \cdot X_2 + E_{av} \cdot B$

$\Sigma M_A^- = T_V \cdot (B - X_3) + T_H \cdot (Y_1 - \Delta H) + E_{ah} \cdot (h_a/3 - \Delta H)$

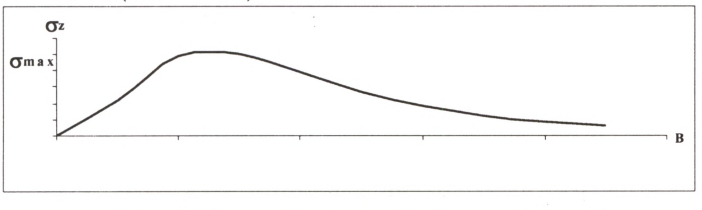
***Safety against Ground Shear Failure:***

The position of the anchor blocks should be behind the slope line of the internal angle of friction of the soil to guarantee the safety against Ground Shear failure. Same analysis method as described in page 60 is followed.

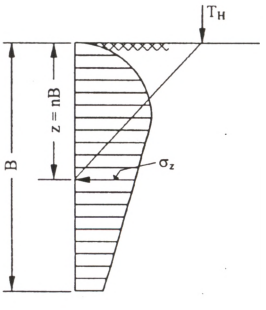
***Lateral Pressure at Side Walls:***

Further, a curtain wall with cement stone masonry of sufficient thickness has been provided to resist the lateral pressure resulting the bulging effect due to tension on the deadman beam. The lateral pressure "$\sigma_Z$" along the length of the foundation "**B**" has been calculated as lateral pressure against a rigid wall as per the elastic theory of soil mechanics with the following formula:

$$\sigma_Z = \frac{0.28T_H}{B^2}\left[\frac{n^2}{(0.16+n^2)^3}\right]; \qquad n = \frac{z}{B}$$



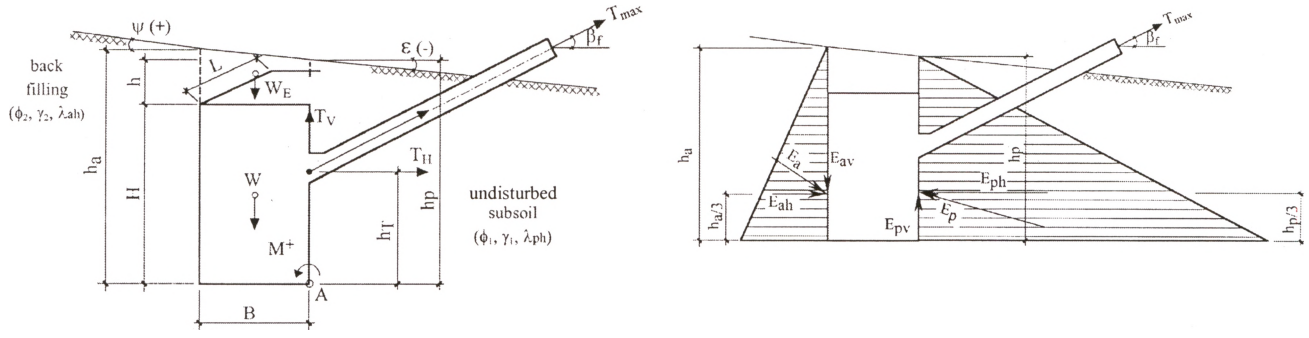

Distribution of lateral pressure $\sigma_z$ along **B**



**Main Cable Deadman Anchor Block in Soil for Flat Topography**

This type of anchor block is designed for soil in a flat topography. The advantage of earth resistance, i.e. passive earth pressure in front of the anchor block, is used in the design. This concept results in very economical anchor block designs.

The design concept of the deadman anchor block is as given below:




The following modes of failure and respective safety factors have been considered in the design.

⇒ Sliding $\mathbf{F_{SL} \geq 3.5}$

To prevent the anchor block from moving towards the soil in front, a high safety factor has been applied.

⇒ Toppling $\mathbf{F_T \geq 1.5}$

***Safety factor against Sliding:*** $$F_{sl} = \frac{H_{ult} + (W + W_E - T_V)\tan\phi_1}{T_H} \geq 3.50$$

Where $H_{ult} = E_{ph} - E_{ah} + 2\,E_{oL}$

$$E_{ph} = \lambda_{ph}\frac{h_p^{\,2}}{2} L\gamma_1; \qquad \lambda_{ph} = \frac{\cos^2\Phi_1}{\left[1-\sqrt{\frac{\sin(\Phi_1-\delta)\sin(\Phi_1+\varepsilon)}{\cos\delta\cos\varepsilon}}\right]^2}$$

$$E_{ah} = \lambda_{ah}\frac{h_a^{\,2}}{2} L\gamma_2; \qquad \lambda_{ah} = \frac{\cos^2\Phi_2}{\left[1+\sqrt{\frac{\sin(\Phi_2+\delta)\,\sin(\Phi_2-\psi)}{\cos\delta\cos\psi}}\right]^2}$$

$$E_{OL} = \frac{1}{6}\lambda_O\,\gamma_1\,h_p^{\,3}\tan\phi_1\left[\sqrt{\lambda_{ph}+\lambda_{ah}}\right]$$

***Safety factor against Overturning:*** $$F_{ovt} = \frac{\textit{All Resisting Moments}}{\textit{All Driving Moments}} = \frac{\Sigma M_A^{+}}{\Sigma M_A^{-}} \geq 1.5$$

**Where**

$M_A^{+} = W \cdot B/2 + W_E \cdot B/2 + E_{ph} \cdot h_p/3 + E_{av} \cdot B$

$M_A^{-} = T_H \cdot h_t + T_V \cdot 0 + E_{pv} \cdot 0 + E_{ah} \cdot h_a/3$

$E_{av} = E_{ah} \tan(2/3\phi_2)$

$E_{pv} = E_{ph} \tan(-1/2\phi_1)$

**Main Cable Drum Anchor Block in Hard Rock**

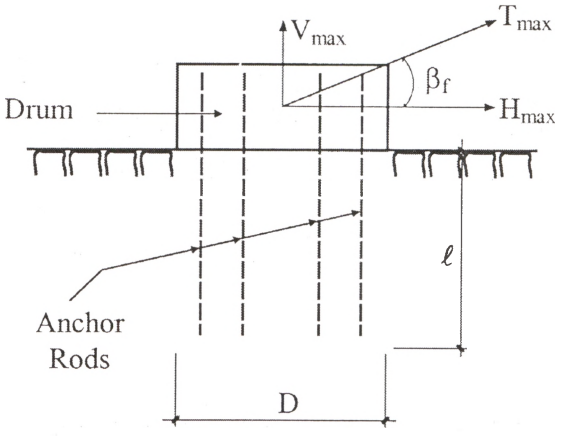
An RCC Concrete Drum with rock anchoring is used for foundations on sound hard rock. The sizes of the drum and anchorage rods are designed to withstand the shear forces due to the horizontal forces of the cables. It is also designed to resist the uplift forces on the Drum.

The required number of anchor rods, N is calculated as:

$$A_{st} = \frac{T_{max} \cos \beta_f}{\tau_{perm}}$$

$$N = \frac{4 A_{st}}{\pi d^2} \quad \text{or} \quad N = \frac{T_{max} \sin \beta_f}{\sigma_{B\,perm} \pi d l}$$

**N** is adopted whichever is greater from the above.




**Main Cable Drum Anchor Block in Fractured Hard Rock or Soft Rock**

A Drum anchorage without rock anchoring is used for foundations on fractured hard rock or fresh soft rock.

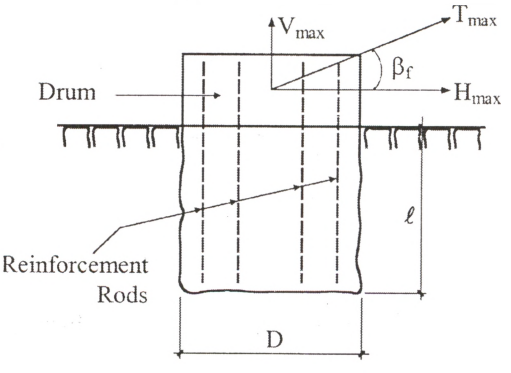
The size of the Drum is designed to withstand the shear failure due to the horizontal forces of the cables.

The Drum size and the number of reinforcement bars are determined as follows:

$$\left(\frac{\pi D^2}{4}\right) \tau_c + A_{st}\, \tau_{st} = T_{max} \cos \beta_f$$

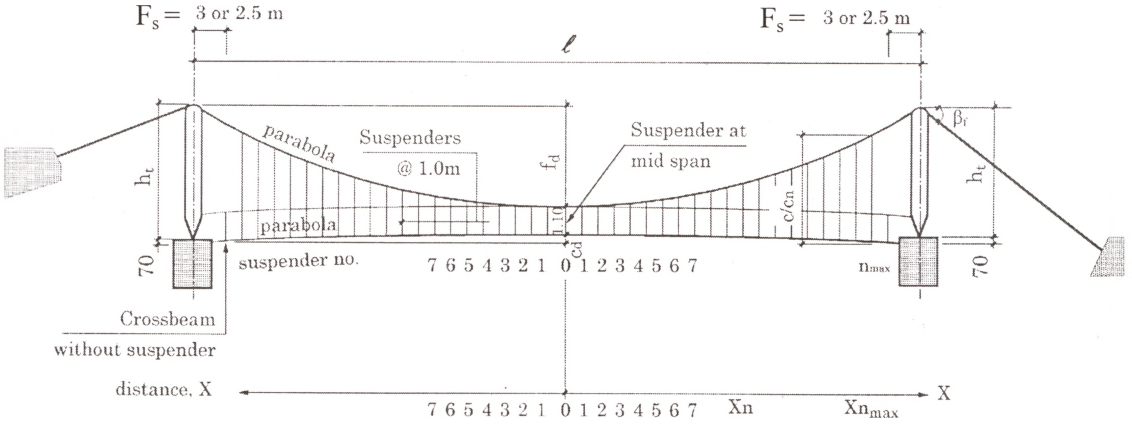
The required number of anchor rods, N is calculated as

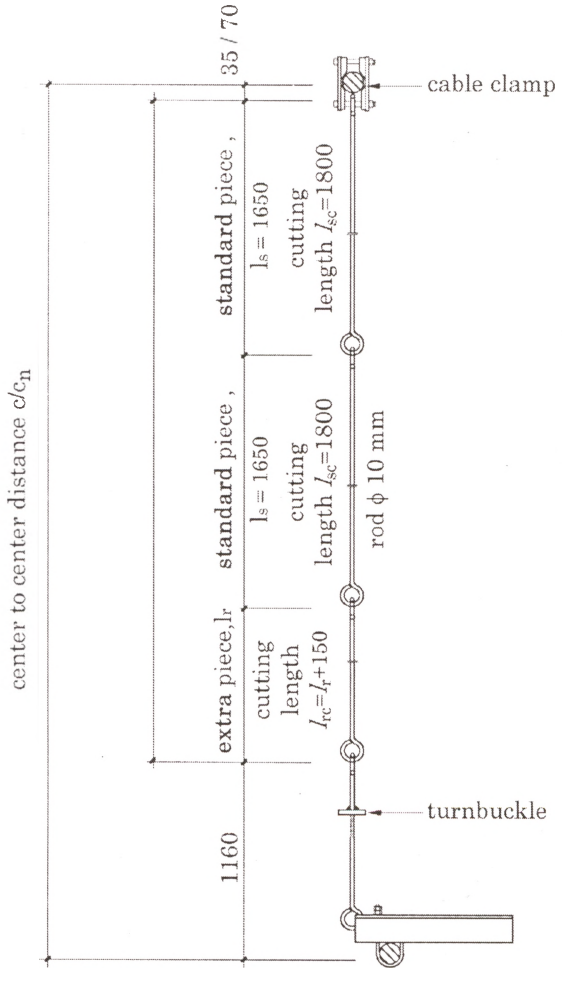
$$N = \frac{4 A_{st}}{\pi d^2}$$



- **Suspenders**

  The suspenders have been designed for the bridge geometry under dead load, i.e. $l$, $\mathbf{f_d}$ and $\mathbf{c_d}$ . The layout of the suspenders is as shown below:



The basic equation for the calculation of the suspender length is $c/c_n$ vertical center distance between the main cable to the spanning cable.

$$c/c_n = \frac{4(f_d + c_d)}{l^2} \cdot x_n^2 + 1.10\,\text{m}$$

Where, $X_n = (n - 1)$, in meters

$$n_{max} = 0.5 \cdot l - F_s + 1$$

Total Suspender Length,

$$l_n = c/c_n - 1160\text{mm}$$

Length of standard piece,

$$l_s = 1650\text{mm},$$

Cutting length of standard piece,

$$l_{sc} = 1800\ \text{mm}.$$

Number of standard pieces,

$$j_n = \text{INTEGER}\frac{l_n - 350}{1650}$$

Length of extra piece,

$$l_r = l_n - 1650\, j_n$$

Cutting length of extra piece,

$$l_{rc} = l_r + 150\ \text{mm}$$

Weight of suspender,

$$W_n = 1.116\, j_n + 0.62 \cdot 10^{-3}\, l_{rc},\ \text{kg}.$$

Total number of suspenders,

$$N = (0.5l - F_s) \cdot 4 + 2$$

Total weight of the suspenders,

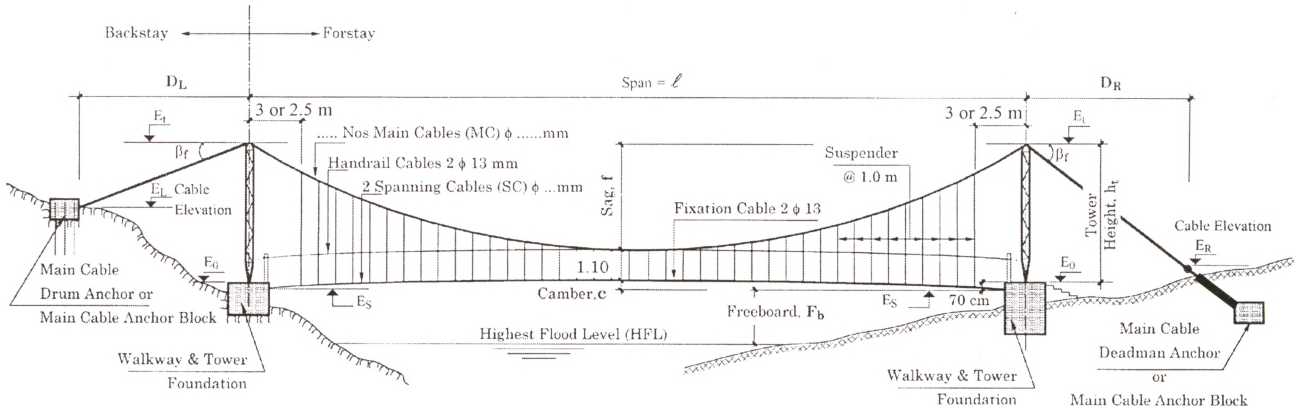
$$W = 2W_1 + 4 \cdot \sum_{n=2}^{n=\max} W_n$$

This **Chapter 3.2.3 Structural Analysis and Design** provides the background upon which the pre-calculations have been based. It is by far not exhaustive, but provides enough information to follow the methodologies applied.

## 3.3 DESIGN OF STANDARD SUSPENSION BRIDGE

### 3.3.1 THE MAJOR COMPONENTS OF THE SUSPENSION TYPE BRIDGE

The sketch below shows the major bridge components and parameters.




### 3.3.2 DESIGN PROCEDURE

For designing a standard bridge, follow the steps in sequence as follows:

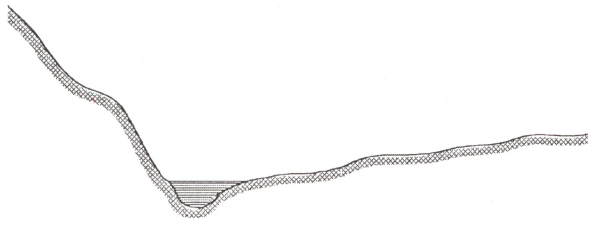
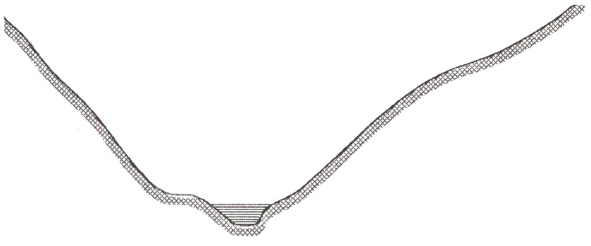
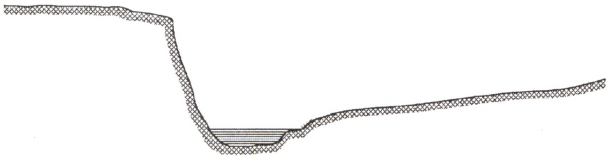
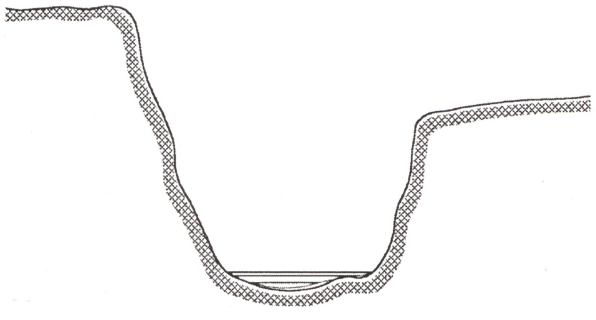
- Draw the bridge profile from the survey data

**Selection of Bridge Type**:

- According to the bridge profile, assess the possibility of designing a Suspended type bridge. It is more preferable due to the economic (cost per meter) reasons and easy construction technology, which is more appropriate for the community bridge building approach. For designing a Suspended type bridge, refer to "Short Span Trail Bridge (SSTB) Technical Handbook for Suspended Bridge".

- Guideline for selection of a bridge type as per the prevailing topography of the bridge site:

| Topography | Recommended Bridge Type |
|---|---|
| | The suspended bridge type (raised foundation blocks on both banks) may be feasible only for small spans. Most likely only the Suspension type may be feasible. It is necessary to assess both the types and adopt whichever is feasible and more cost effective. |

| Topography | Recommended Bridge Type |
|---|---|
|  | The Suspended bridge type (raised foundation blocks on the lower bank) may be feasible only for small spans. Most likely only the Suspension type may be feasible. It is necessary to assess both the types and adopt whichever is feasible and more cost effective. |
|  | Both the Suspended and Suspension types are feasible. It is necessary to assess both the types and adopt whichever is more cost effective. The Suspended type is preferable. |
|  | The Suspended type is most appropriate. If the Suspended type is not feasible, the Suspension type with one tower may also be feasible. The present handbook does not deal with this. Refer to the Volume A of LSTB (SBD) Manual for the design. The Suspension type with both towers is not feasible. |
|  | The Suspended type is most appropriate. |

- If both the Suspended and Suspension types are feasible, make a cost (total cost) comparison and adopt the more cost effective one.
- If the cost is nearly equal for both the bridge types, choose the Suspended type.
- Select the Suspension type only, if the Suspended type is not feasible for the given topography or it is more economical than the Suspended type.

**Steps for Designing a Suspension Type Bridge**:

- Fix the position of the Walkway and Tower foundations in the bridge profile.
- Determine the span of the bridge.
- Select the Bridge Geometry, i.e., Sag $\mathbf{f_d}$, Camber $\mathbf{c_d}$ and Tower Height $\mathbf{h_t}$ as per the span.
- Select the Main Cables, Spanning Cables and Tower Type as per the span.
- Design the Walkway & Tower Foundations.
- Fix the position of the Main Cable Anchor Blocks and determine the Backstay Distances.
- Design the Main Anchor Blocks.
- Calculate the lengths of the Suspenders.
- Transfer the bridge data in the bridge profile and prepare the General Arrangement Drawing.
- Compile and fill in the Standard Steel & Construction Design Drawings.
- Calculate the quantities of works and prepare a Cost Estimate.

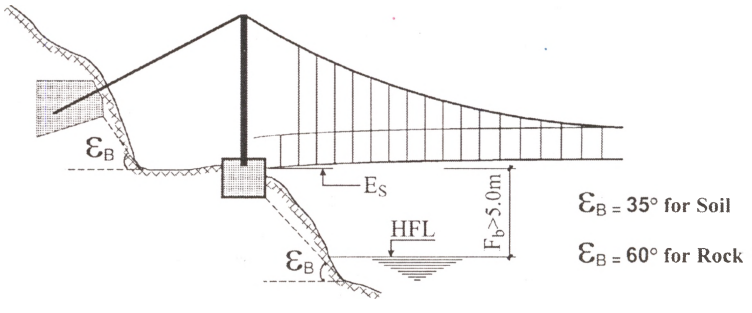
### 3.3.3 DESIGNING THE POSITION OF THE WALKWAY & TOWER FOUNDATIONS

Fix the position of the bridge foundations and the actual span of the bridge in the bridge profile. This bridge profile will be the basis for the layout of the bridge at the construction site. Fulfill the following criteria while fixing the position of the bridge foundations.

**Criteria for fixing the Bridge Foundations**

- The Bridge Foundations should be placed behind the line of angle of internal friction (safe slope line) of the soil or rock. This angle in general is 35° for soil and 60° for rock.
- The Bridge Foundations should be placed at least 3 meters back from the soil slope and 1.5 meters back from the rock slope.
- If the bank is flat and prone to flooding or excessive bank erosion, the foundations should be placed sufficiently back from the bank edge to ensure the long term safety of the bridge.
- The top of the Walkway and the Tower Foundation should be at the same level on both the banks.
- The height of the Walkway and the Tower Foundation should be as low as possible. However, it should not be less than 1.0m from the ground level which gives a 0.55m clearance between the spanning cable and the ground. For slope topography (both rock and soil), the Walkway and Tower Foundation height **H** has been fixed at 1.0m.
- The freeboard $\mathbf{F_b}$, between the lowest part of the bridge, i.e., the anchorage point of the spanning cable and the highest flood level, should generally be not less than 5.0 m

**Criteria for fixing the location of the Bridge Foundation**



### Procedure for fixing the Bridge Foundations

According to the above criteria, draw the bridge profile as per the following steps.

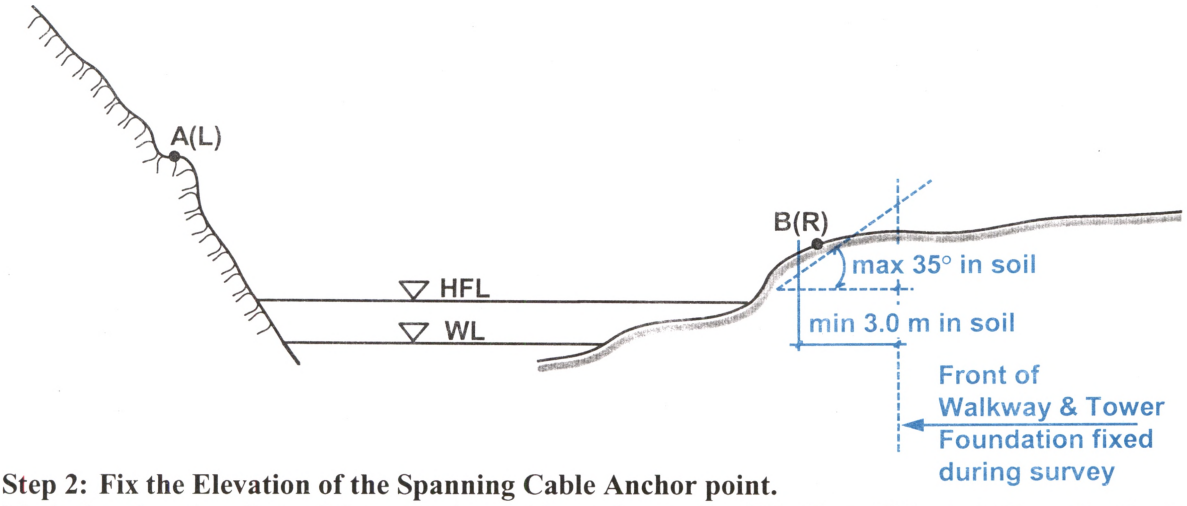
- Draw the bridge axis profile on an A3 size paper in the scale 1:200 (for up to 50m span) or 1: 400 (for spans above 50m) with all the details like axis points A and B, HFL, WL and the tentative location of the Walkway and Tower Foundations (if available in the survey data) on both banks based on the survey data as described in Chapter 2.5.6.
- Fix the position of the walkway and the tower foundations on both the banks as per the following procedure:

### Case-1: When the Tentative Position of the Walkway and the Tower Foundations has been fixed during the Survey.

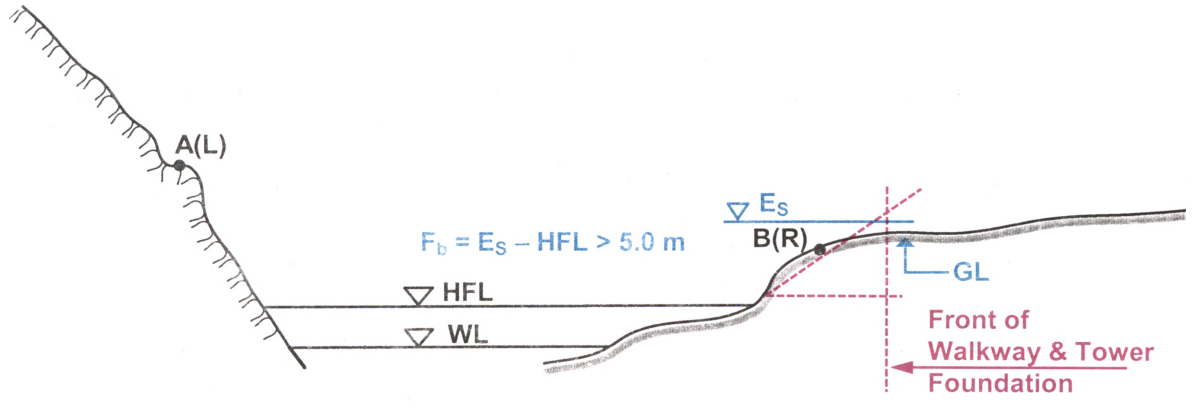
**Step 1: Fix the Front of the Walkway and the Tower Foundations on one bank.**
Mark the front of the foundations as fixed during the survey. Check the position of the front of the foundation on the lower bank or the bank which has a limited defined area for positioning the foundation.

Draw the safe slope line. The front of the foundation should be behind this slope line and also sufficiently back from the bank/slope edge. If the minimum required distance from the bank/slope edge is not sufficient or out of the safe slope line, shift its position backward.

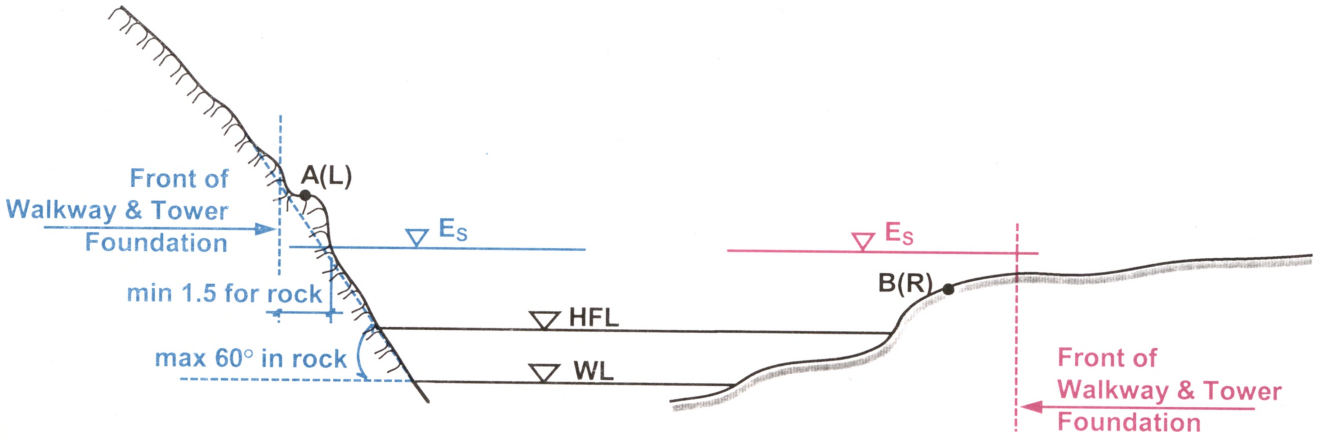
If the bank is flat and the bank height is low and prone to flooding or excessive bank erosion, the foundation should be placed sufficiently back from the bank edge to ensure a long term safety of the bridge.



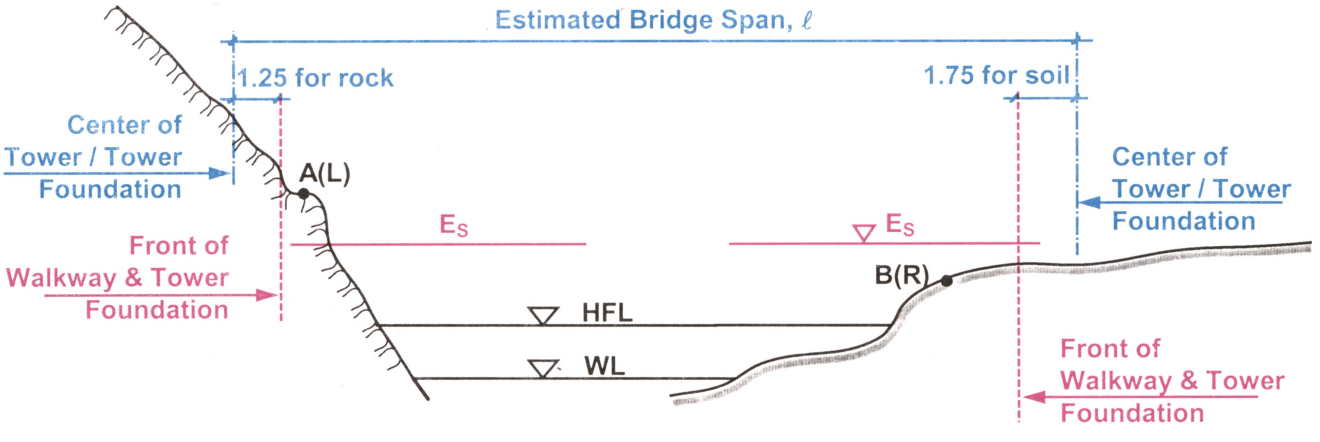

**Step 2: Fix the Elevation of the Spanning Cable Anchor point.**
Mark the elevation line of the spanning cable anchor point ($\mathbf{E_s}$). $\mathbf{E_s}$ = **G.L. + 0.55m**. Check the available freeboard $\mathbf{F_b}$. $\mathbf{F_b} = \mathbf{E_s} - \mathbf{HFL}$, which should not be less than 5.0m. If the freeboard is not enough rise the $\mathbf{E_s}$. In case of flat topography, raise the $E_s$ = G.L. + 1.55 or 2.55 or 3.55 (max.) till sufficient freeboard is achieved. In case of slope topography shift its position backward till sufficient freeboard is achieved.



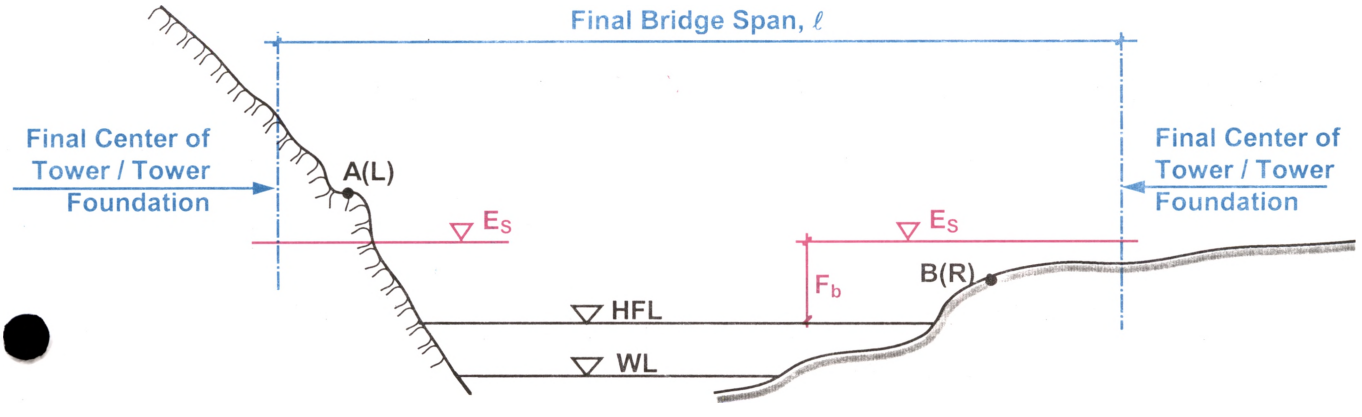
**Step 3: Fix the Front of the Walkway and Tower Foundations on the other bank.**
Once the elevation of the spanning cable anchor point $\mathbf{E_s}$ has been established on one bank, draw this elevation line towards the other bank..
Draw the safe slope line. Mark the front of the foundation according to the $\mathbf{E_s}$ line behind the safe slope line maintaining the minimum required distance from the bank/slope edge.




**Step 4: Determine the Bridge Span, *l*.**
Mark the center line of the towers on both the banks. The center line of the tower is 1.25m for rock and 1.75m for soil back from the front of the foundation. Calculate the bridge span which is the distance between the center lines of the Towers. Determine the final span round to the nearest meter.




**Step 5: Finalize the Bridge Profile.**
Finalize the bridge profile with the final span ***l*** (span should be fixed round to the meter) and the elevation of the spanning cable anchor points $\mathbf{E_s}$.

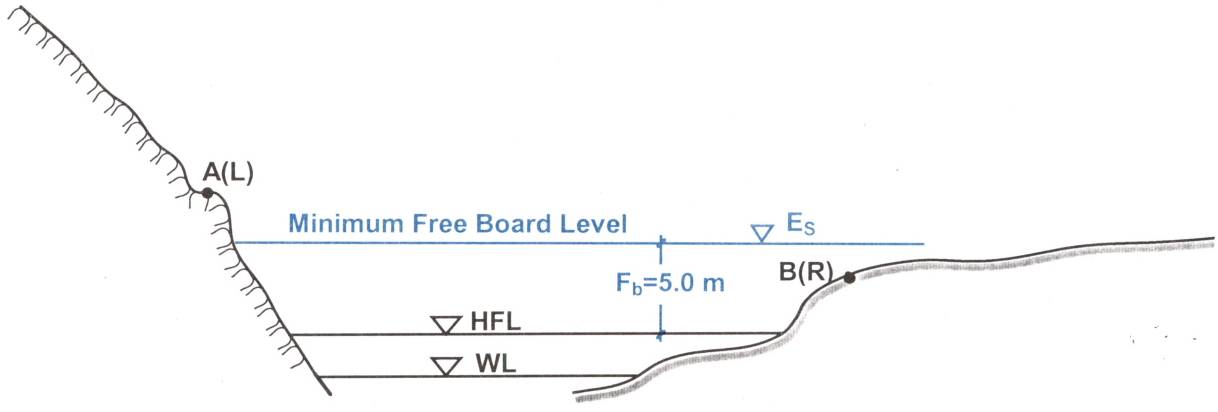


## Case-2: When the Position of the Walkway and the Tower Foundations has not been fixed during the Survey.

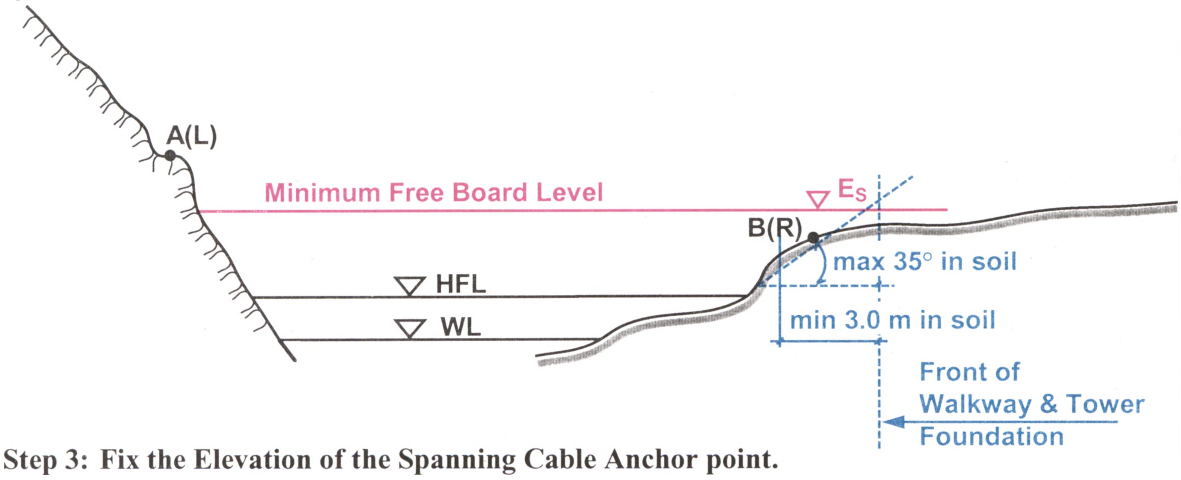
**Step 1: Fix the Front of the Walkway & Tower Foundations on one bank.**
Fix the position of the front of the tower on the lower bank or the bank which has a limited defined area for positioning the foundation.

Draw the safe slope line. The front of the foundation should be behind this slope line and also sufficiently back from the bank/slope edge.

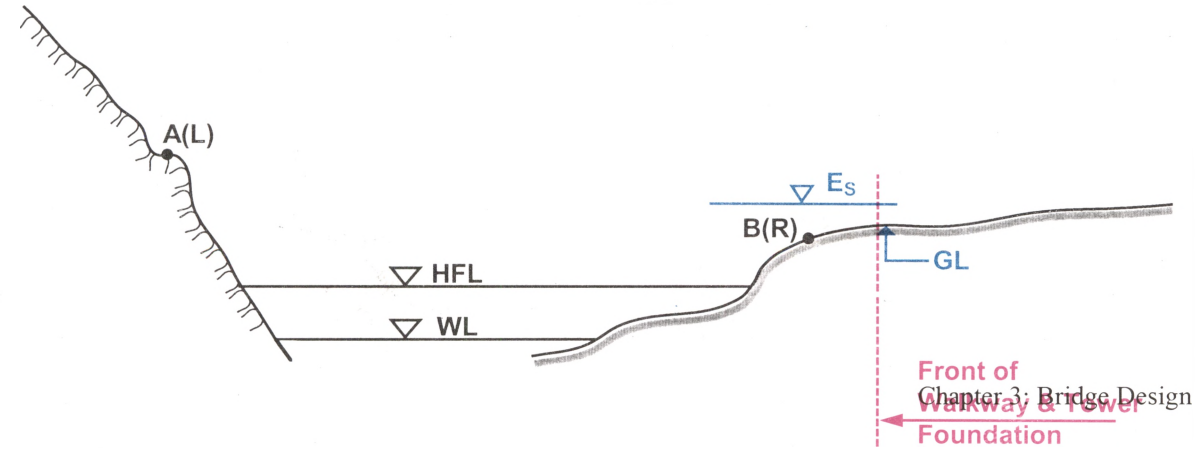
If the bank is flat and the bank height is low and prone to the flooding or excessive bank erosion, the foundation should be placed sufficiently back from the bank edge to ensure the long term safety of the bridge.



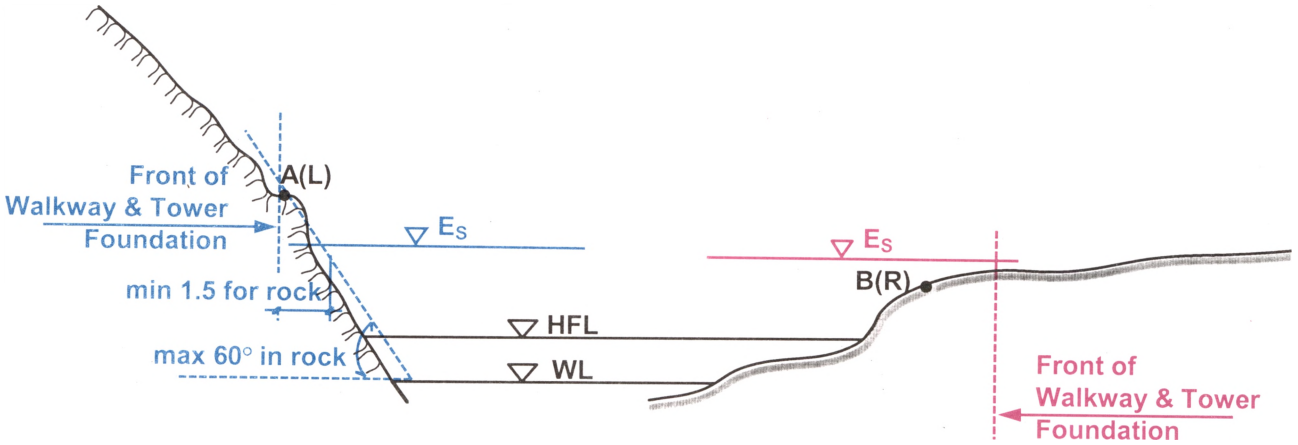

**Step 2: Fix the Freeboard Level.**
Mark the minimum freeboard level. The minimum freeboard from the highest flood level is 5.0 meters. The minimum freeboard level will be the lowest possible position (Elevation, $\mathbf{E_s}$) of the spanning cable anchor point.



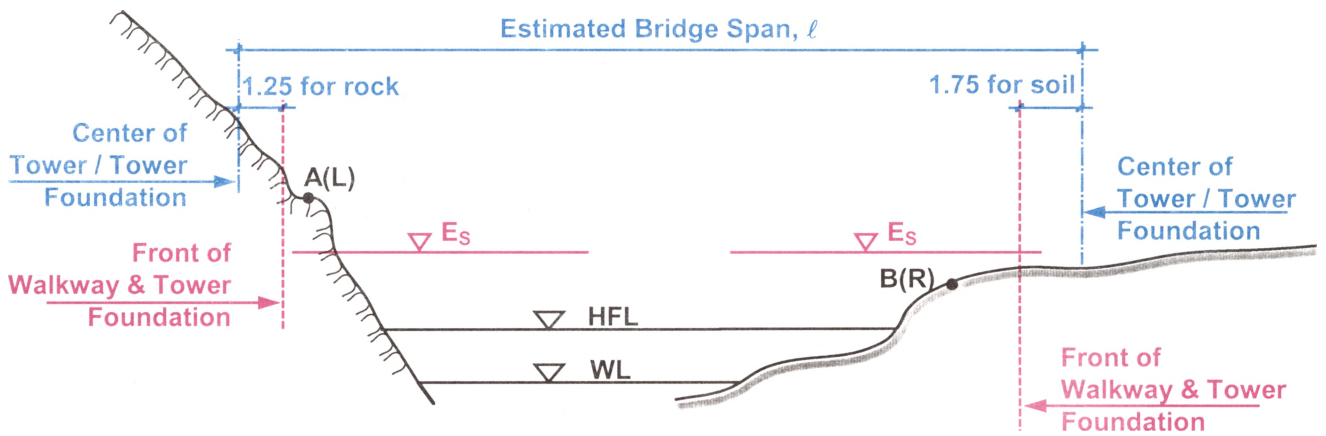

**Step 3: Fix the Elevation of the Spanning Cable Anchor point.**
Mark the elevation line of the spanning cable anchor point $\mathbf{E_s}$ at the minimum freeboard level. Check the height from the ground level **($E_s$ - G.L.)**, which should be 0.55 or 1.55 or 2.55 or 3.55 m (max). Adjust $\mathbf{E_s}$ accordingly.



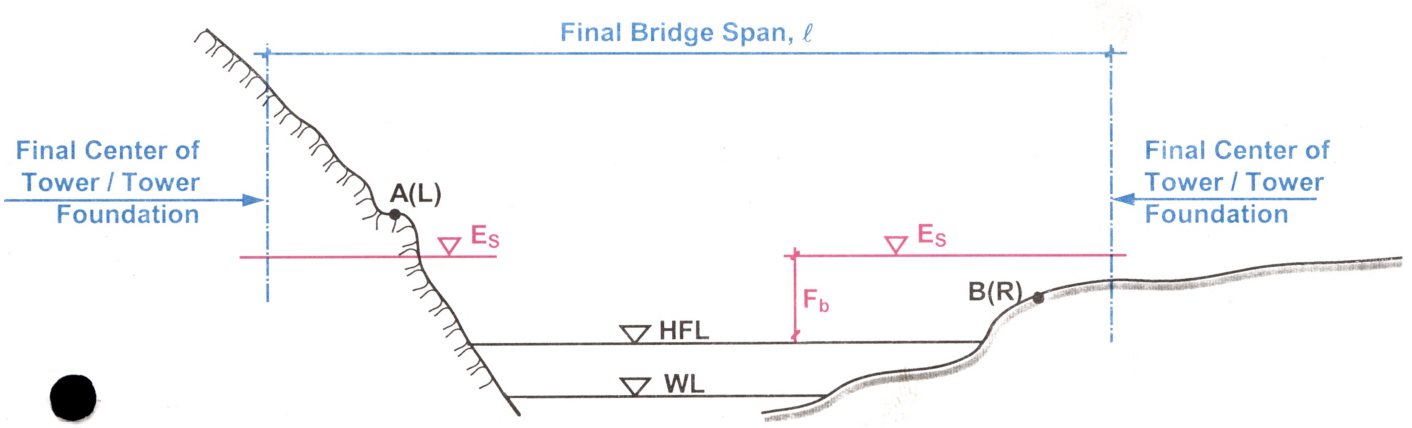
**Step 4: Fix the Front of the Walkway and the Tower Foundations on the other bank.**
Same as Step 3 of Case-1.




**Step 5: Fix the Bridge Span, *l*.**
Same as Step 4 of Case-1.




**Step 6: Finalize the Bridge Profile.**
Finalize the bridge profile with the final span ***l*** and the elevation of the spanning cable anchor points $\mathbf{E_s}$.



### 3.3.4 CABLE DESIGN & STANDARD TOWER SELECTION

Designing the cables for a Suspension bridge involves the selection of the required number and the diameter of the Main Cables and the Spanning Cables for the given bridge span.

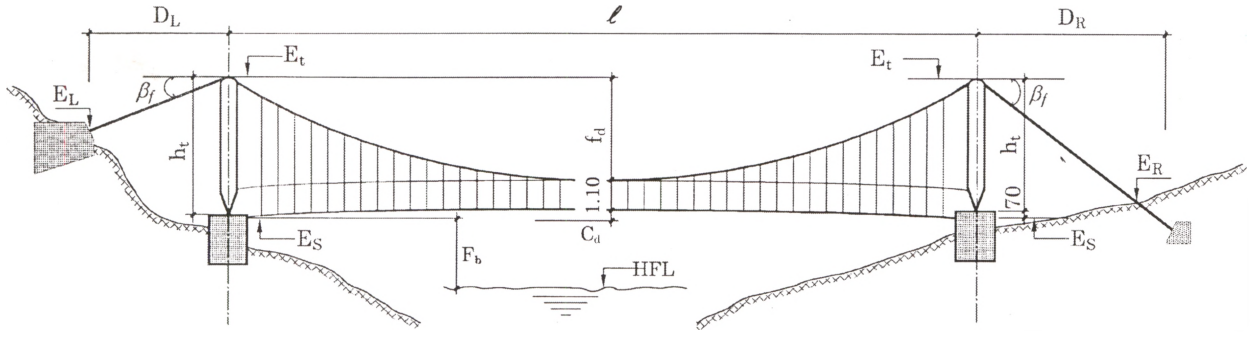
The standard table for the Selection of Cables and Standard Towers and the Bridge Geometry has been developed for spans of up to 120m. The design concept and the statical analysis followed while developing this standard table is as given in Chapter 3.2.3.

To design the cables and to select the type of standard tower, proceed as per the steps below:

- Determine the span of the bridge from the bridge profile as per Chapter 3.3.3.
- Select the number and diameter of the Main Cables, the diameter of the Spanning Cables and the type of Standard Tower from the **Selection of Cables and Standard Towers** according to the bridge span.

***Design the Cable Structure and Select the Standard Tower as per the following Checklist.***

## A. Survey Data & Calculation of Freeboard




1. Span of the Bridge (should be rounded off to the nearest meter) $\ell$ = ..... m

2. Elevation of the spanning cable at anchor point $E_s$ = ..... m

3. Highest Flood Level HFL = ..... m

4. **Freeboard** (min. 5.00m) $F_b = E_s - HFL$ = $F_b$ = ..... m

*(If the freeboard is less than 5.00m, try either to raise the elevation of the spanning cable anchor point by increasing the height of the Walkway & Tower Foundation or to adjust the span.)*

## B. Selection of Cables and Standard Towers (Pylon)

Select the Main and Spanning Cable combinations, the standard tower height $\mathbf{h_t}$ and the Bridge Geometry according to the span from the following table. The bridge geometry refers to the main cable dead load sag $\mathbf{f_d}$, the dead load camber $\mathbf{c_d}$ of the spanning cable and the main cable inclination at the tower saddle $\mathbf{ß_f}$ in the full load case.

**Table: Selection of Cables and Standard Tower**

| Span | Tower Height/ (Type) | Cables Nos. & diameter | | | Dead Load Sag | Hoisting Sag | Camber | Full load Backstay Angle |
|---|---|---|---|---|---|---|---|---|
| $l$ | $h_t$ | Main | Spanning | Windguy | $f_d$ | $f_h$ | $c_d$ | $ß_f$ |
| m | m | mm | mm | mm | m | m | m | deg. |
| 30.0 | 5.50 (1) | 2 ø 26 | 2 ø 26 | Not Required | 4.20 | 4.13 | 0.90 | 29.83 |
| 31.0 | | | | | 4.15 | 4.07 | 0.95 | 28.83 |
| 32.0 | | | | | 4.10 | 4.02 | 1.00 | 27.88 |
| 33.0 | | | | | 4.10 | 4.01 | 1.00 | 27.24 |
| 34.0 | | | | | 4.08 | 3.99 | 1.02 | 26.55 |
| 35.0 | | | | | 4.05 | 3.95 | 1.05 | 25.84 |
| 36.0 | | | | | 4.22 | 4.12 | 0.88 | 26.14 |
| 37.0 | | | | | 4.19 | 4.09 | 0.91 | 25.49 |
| 38.0 | | | | | 4.16 | 4.05 | 0.94 | 24.88 |
| 39.0 | | | | | 4.13 | 4.01 | 0.97 | 24.31 |
| 40.0 | | | | | 4.10 | 3.97 | 1.00 | 23.77 |
| 41.0 | | | | | 4.10 | 3.96 | 1.00 | 23.39 |
| 42.0 | | | | | 4.10 | 3.96 | 1.00 | 23.03 |
| 43.0 | | | | | 4.30 | 4.16 | 0.80 | 23.48 |
| 44.0 | | | | | 4.40 | 4.26 | 0.70 | 23.53 |
| 45.0 | | | | | 4.40 | 4.25 | 0.70 | 23.20 |
| 46.0 | | 2 ø 32 | 2 ø 32 | | 3.92 | 3.77 | 1.18 | 20.45 |
| 47.0 | | | | | 3.90 | 3.74 | 1.20 | 20.10 |
| 48.0 | | | | | 4.05 | 3.89 | 1.05 | 20.39 |
| 49.0 | | | | | 4.05 | 3.88 | 1.05 | 20.13 |
| 50.0 | | | | | 4.10 | 3.93 | 1.00 | 20.07 |
| 51.0 | | | | | 4.10 | 3.92 | 1.00 | 19.83 |
| 52.0 | | | | | 4.10 | 3.91 | 1.00 | 19.61 |
| 53.0 | | | | | 4.10 | 3.90 | 1.00 | 19.40 |
| 54.0 | | | | | 4.10 | 3.88 | 1.00 | 19.20 |
| 55.0 | | | | | 4.25 | 4.04 | 0.85 | 19.46 |
| 56.0 | 7.35 (2) | | | | 5.47 | 5.30 | 1.48 | 22.82 |
| 57.0 | | | | | 5.44 | 5.26 | 1.51 | 22.46 |
| 58.0 | | | | | 5.41 | 5.22 | 1.54 | 22.12 |
| 59.0 | | | | | 5.38 | 5.18 | 1.57 | 21.79 |
| 60.0 | | | | | 5.35 | 5.13 | 1.60 | 21.48 |
| 61.0 | | | | | 5.35 | 5.12 | 1.60 | 21.26 |
| 62.0 | | | | | 5.45 | 5.22 | 1.50 | 21.32 |
| 63.0 | | | | | 5.65 | 5.42 | 1.30 | 21.65 |
| 64.0 | | | | | 5.85 | 5.63 | 1.10 | 21.97 |
| 65.0 | | | | | 5.95 | 5.72 | 1.00 | 22.01 |

**Table: Selection of Cables and Standard Tower (continued)**

| Span | Tower Height/(Type) | Cables Nos. & diameter | | | Dead Load Sag | Hoisting Sag | Camber | Full load Backstay Angle |
|---|---|---|---|---|---|---|---|---|
| *l* | $h_t$ | Main | Spanning | Windguy | $f_d$ | $f_h$ | $c_d$ | $ß_f$ |
| m | M | mm | mm | mm | m | m | m | deg. |
| 66.0 | 9.20 (3) | 2 ø 32 | 2Ø 32 | Not Required | 7.02 | 6.81 | 1.78 | 24.48 |
| 67.0 | | | | | 6.99 | 6.77 | 1.81 | 24.15 |
| 68.0 | | | | | 6.96 | 6.73 | 1.84 | 23.83 |
| 69.0 | | | | | 6.93 | 6.69 | 1.87 | 23.54 |
| 70.0 | | | | | 7.20 | 6.97 | 1.60 | 23.97 |
| 71.0 | | | | | 7.40 | 7.17 | 1.40 | 24.22 |
| 72.0 | | | | | 7.60 | 7.37 | 1.20 | 24.47 |
| 73.0 | | | | | 7.70 | 7.46 | 1.10 | 24.47 |
| 74.0 | | | | | 7.65 | 7.40 | 1.15 | 24.14 |
| 75.0 | | | | | 7.65 | 7.40 | 1.15 | 23.93 |
| 76.0 | 11.05 (4) | 4 ø 26 | | | 8.57 | 8.36 | 2.08 | 25.38 |
| 77.0 | | | | | 8.54 | 8.33 | 2.11 | 25.07 |
| 78.0 | | | | | 8.51 | 8.29 | 2.14 | 24.77 |
| 79.0 | | | | | 8.48 | 8.25 | 2.17 | 24.48 |
| 80.0 | | | | | 8.45 | 8.22 | 2.20 | 24.20 |
| 81.0 | | | | Ø 26 (Optional only) | 8.42 | 8.18 | 2.23 | 23.93 |
| 82.0 | | | | | 8.39 | 8.14 | 2.26 | 23.67 |
| 83.0 | | | | | 8.36 | 8.10 | 2.29 | 23.41 |
| 84.0 | | | | | 8.33 | 8.06 | 2.32 | 23.16 |
| 85.0 | | | | | 8.30 | 8.02 | 2.35 | 22.92 |
| 86.0 | | | | | 8.27 | 7.98 | 2.38 | 22.68 |
| 87.0 | | | | | 8.24 | 7.94 | 2.41 | 22.46 |
| 88.0 | | | | | 8.21 | 7.90 | 2.44 | 22.24 |
| 89.0 | | | | | 8.35 | 8.04 | 2.30 | 22.34 |
| 90.0 | | | | | 8.55 | 8.24 | 2.10 | 22.56 |
| 91.0 | | | | | 8.85 | 8.54 | 1.80 | 22.96 |
| 92.0 | | | | | 9.05 | 8.74 | 1.60 | 23.16 |
| 93.0 | | | | | 9.25 | 8.95 | 1.40 | 23.36 |
| 94.0 | | | | | 9.25 | 8.94 | 1.40 | 23.20 |
| 95.0 | | | | | 9.20 | 8.87 | 1.45 | 22.96 |
| 96.0 | | 4 ø 32 | | | 7.98 | 7.68 | 2.67 | 20.00 |
| 97.0 | | | | | 8.05 | 7.75 | 2.60 | 20.00 |
| 98.0 | | | | | 8.13 | 7.82 | 2.52 | 20.00 |
| 99.0 | | | | | 8.20 | 7.89 | 2.45 | 20.00 |
| 100.0 | | | | | 8.28 | 7.96 | 2.37 | 20.00 |

**Table: Selection of Cables and Standard Tower (continued)**

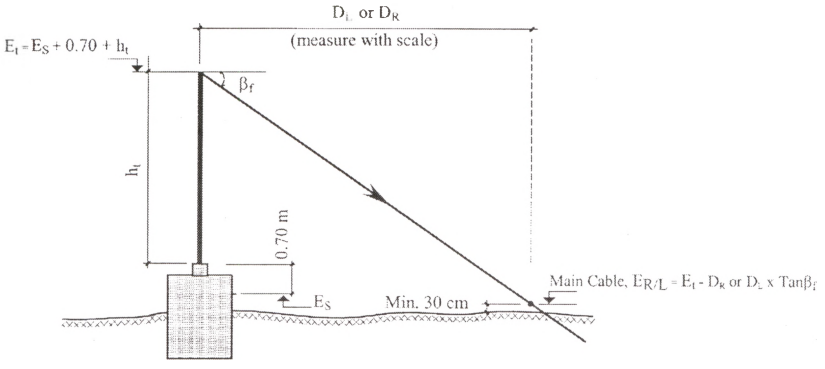
| Span | Tower Height/(Type) | Cables Nos. & diameter | | | Dead Load Sag | Hoisting Sag | Camber | Full load Backstay Angle |
|---|---|---|---|---|---|---|---|---|
| $l$ | $h_t$ | Main | Spanning | Windguy | $f_d$ | $f_h$ | $c_d$ | $ß_f$ |
| m | m | mm | mm | mm | m | m | m | deg. |
| 101.0 | | | | | 8.35 | 8.03 | 2.30 | 20.00 |
| 102.0 | | | | | 8.40 | 8.07 | 2.25 | 20.00 |
| 103.0 | | | | | 8.50 | 8.17 | 2.15 | 20.00 |
| 104.0 | | | | | 8.57 | 8.23 | 2.08 | 20.00 |
| 105.0 | | | | | 8.65 | 8.31 | 2.00 | 20.00 |
| 106.0 | | | | | 8.71 | 8.36 | 1.94 | 20.00 |
| 107.0 | | | | | 8.80 | 8.45 | 1.85 | 20.00 |
| 108.0 | | | | | 8.85 | 8.49 | 1.80 | 20.00 |
| 109.0 | | | | | 8.94 | 8.58 | 1.71 | 20.00 |
| 110.0 | 11.05 | 4 ø 32 | 2 ø 32 | ø 26 (Optional only) | 9.00 | 8.63 | 1.65 | 20.00 |
| 111.0 | | | | | 9.00 | 8.62 | 1.65 | 19.88 |
| 112.0 | | | | | 8.95 | 8.55 | 1.70 | 19.70 |
| 113.0 | | | | | 8.95 | 8.54 | 1.70 | 19.60 |
| 114.0 | | | | | 8.95 | 8.53 | 1.70 | 19.50 |
| 115.0 | | | | | 8.90 | 8.46 | 1.75 | 19.34 |
| 116.0 | | | | | 8.90 | 8.45 | 1.75 | 19.24 |
| 117.0 | | | | | 8.85 | 8.38 | 1.80 | 19.09 |
| 118.0 | | | | | 8.85 | 8.37 | 1.80 | 19.00 |
| 119.0 | | | | | 8.85 | 8.36 | 1.80 | 18.92 |
| 120.0 | | | | | 8.85 | 8.34 | 1.80 | 18.83 |

## C. Fixing the Back Stay Lengths ($D_L$ and $D_R$) and the Main Cable Anchorage Elevations ($E_L$ and $E_R$)

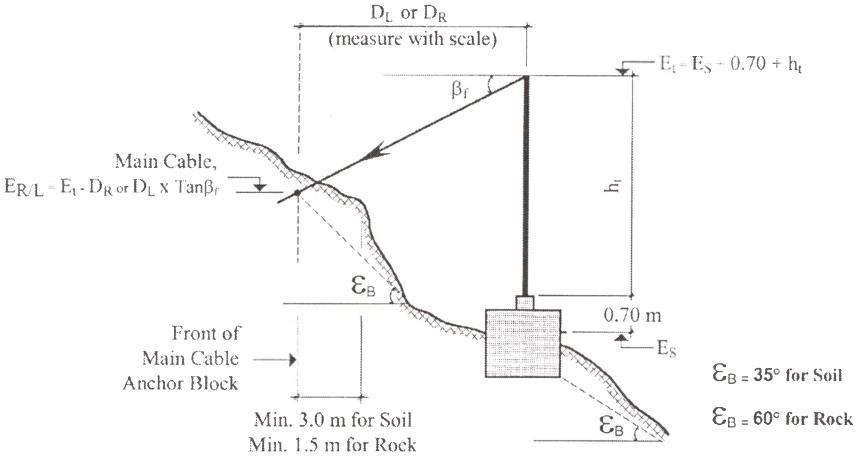
Fix the position of the Main Anchorage Foundation Blocks on both the banks in the bridge profile as per the steps below:

- Draw the centerline of the towers on both the banks in the bridge profile and mark the tower top (saddle) with the elevation $\mathbf{E_t = E_s + 0.70 + h_t}$.
- From the tower top, draw a line at the angle $ß_f$ towards the ground level. Fix the position of the main cable anchor point along this line by considering the topography and the geological condition of the bridge site as per the following sketch.

**In flat topography (up to ground slope angle 15°):**




**In slope topography:**




Measure the $D_L$ or $D_R$ backstay distance with a scale in the bridge profile.

- Calculate the Main Cable Anchor Elevation ($E_R$ and $E_L$) as per the following formula.

  $E_R = E_t - D_R \times \tan ß_f$, $E_L = E_t - D_L \times \tan ß_f$

## D. Calculation of Cable Lengths

| Type of Cable | dia (mm) | Nos. | Backstay Length [m] | | Cutting Length* [m/pc] |
|---|---|---|---|---|---|
| | | | $D_L$ | $D_R$ | |
| Main Cable | ..... | ..... | ..... | ..... | |
| Spanning Cable | ..... | 2 | 0 | 0 | |
| Handrail Cable | 13 | 2 | 0 | 0 | |
| Fixation Cable | 13 | 2 | 0 | 0 | |
| Windguy Cable** (Optional) | 26 | 1 (U/S) | 0 | 0 | |
| | | 1 (D/S) | 0 | 0 | |
| Windties** (Optional) | 13 | 1 | 0 | 0 | |

*** Cutting Length:**

Main Cable = 1.08 x Span + 1.15 ($D_L$+$D_R$) + Anchorage Length on the Right Bank + Anchorage Length at Left Bank.

Calculate the Anchorage Lengths only after selecting of the Main Cable Anchor Blocks.

Spanning Cable = 1.03 x Span + 3.5 m.
Handrail Cable = Span
Fixation Cable = Span

* * Windguy Cable = Refer to Design of Windguy Arrangement (Chapter 3.3.9 A)
** Windties = Refer to Design of Windguy Arrangement (Chapter 3.3.9 A)

## E. Calculation of ($f_h$) Hoisting Sag

*This calculation has to be made after the tower erection is completed.*

| | | |
|---|---|---|
| 1. Actual Span measured in the field | $\ell$ | = ..... m |
| 2. Hoisting Sag (from **"Table: Selection of Cables and Standard Tower"** as per actual span) | $f_h$ | = ..... m |
| 3. Tower Height | $h_t$ | = ..... m |
| 4. Marking Point on Tower (from steel tower base) at hoisting sag elevation = | $h_t - f_h$ | = ..... m |

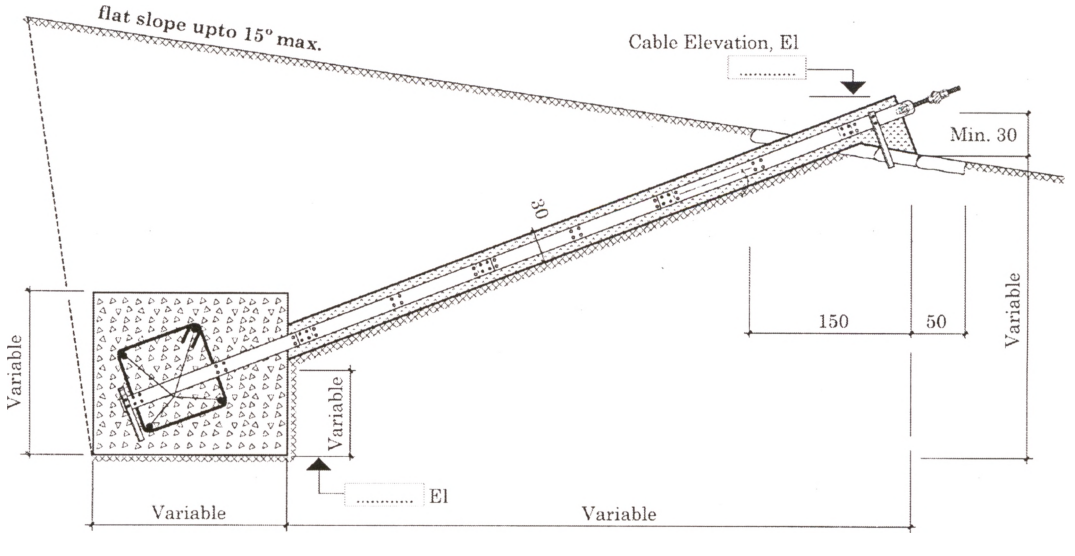
### 3.3.5 Design of the Main Cable Anchor

The standard designs for the Main Cable Anchor Blocks have been developed for all possible cases for spans of up to 120m. The Standard Anchor Blocks have been developed by following the design concept and statical analysis as presented in Chapter 3.2.3.

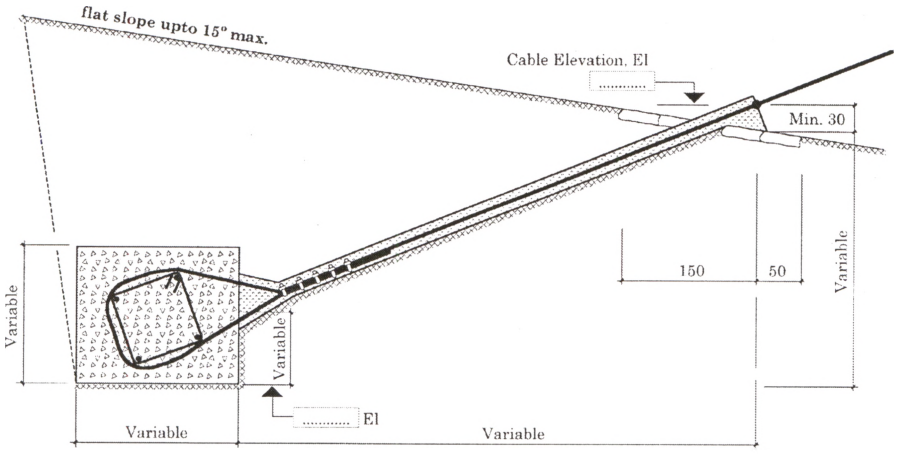
The design of the Main Cable Anchor Blocks is mainly to select the standard anchor block types suitable to the given cable combination, geology and topography of the site. Fill in the required data in the corresponding selected drawings.

There are basically six typical designs of the Main Anchor Blocks, depending on the flat or hill slope topography, and the soil or rock type. These typical designs are illustrated below.

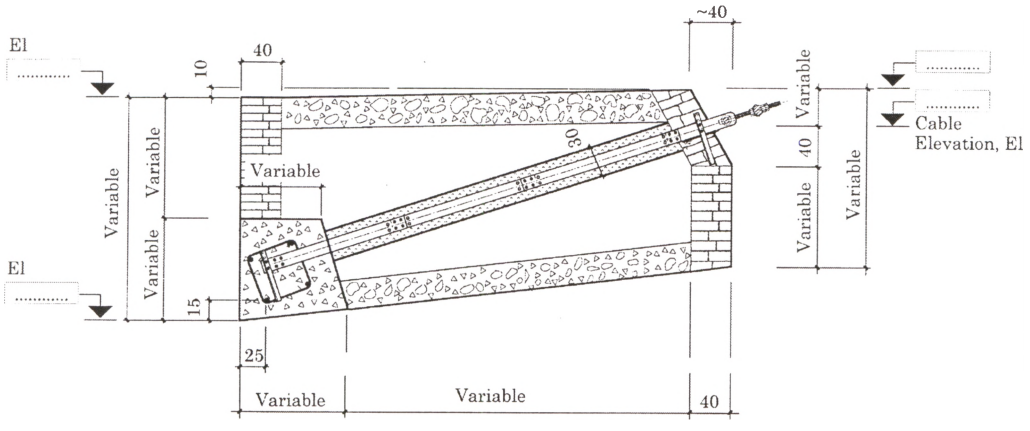
**1. Main Cable Deadman Anchor Block with turn buckle on Flat Topography**



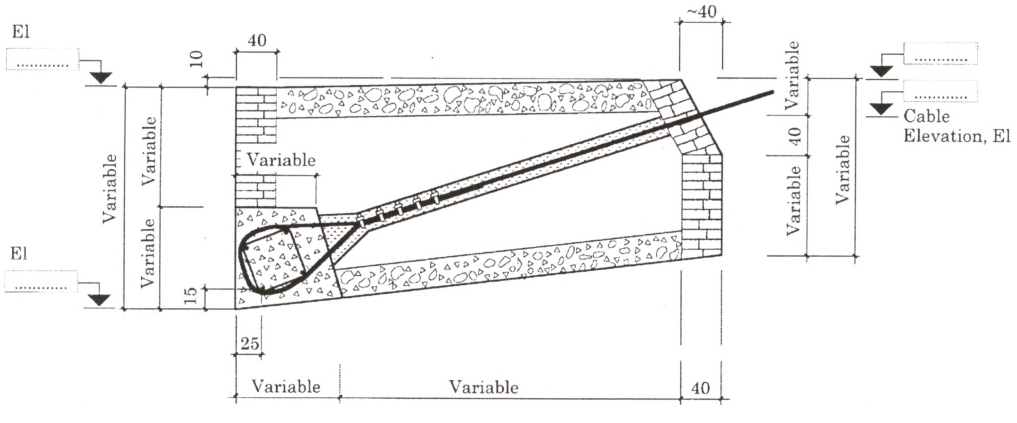
## 2. Main Cable Deadman Anchor Block with direct cable connection on Flat Topography



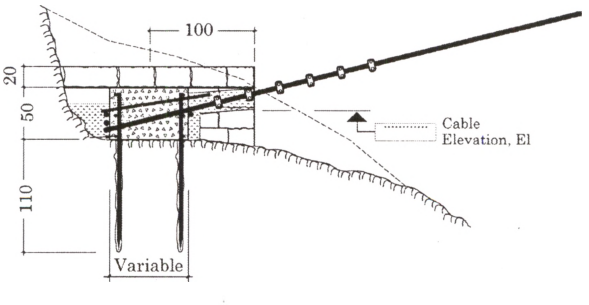

## 3. Main Cable Gravity Anchor Block with turn buckle on Hill Slope Topography



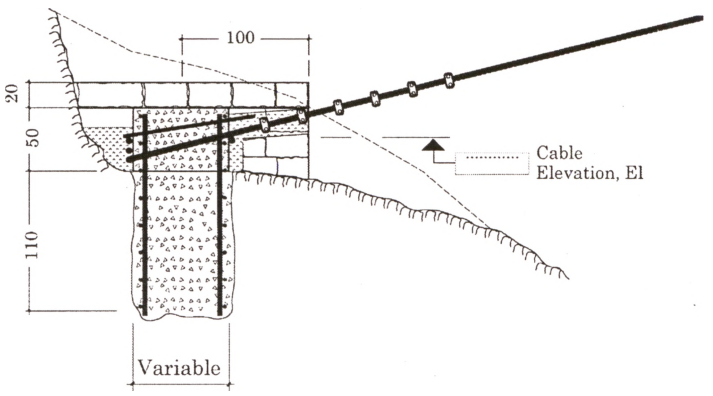

## 4. Main Cable Gravity Anchor Block with direct cable connection on Hill Slope Topography




## 5. Main Cable Drum Anchor Block in Hard Rock



### 6. Main Cable Drum Anchor Block in Fractured Hard Rock or Soft Rock




To select the main anchor block type proceed as follows:

- Define the number and the diameter of the main cables (refer Chapter 3.3.4).
- Define the topography of the ground where the anchor block will be placed as whether flat or slope. The topography is defined as flat if the ground slope is less than 15°, and slope if the ground slope is more than 15°.
- Define the soil or rock type from Form No 1: Survey Form and Checklist, Chapter 4.6.
- Select the anchor block type and the corresponding drawing from the selection tables according to the above design data.

***Design the Main Anchor Blocks as per the following checklist.***

#### A. Design Data

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist**

| | | | |
|---|---|---|---|
| • **Main Cables: Nos. .....∅.....mm** | | | |
| ***Right Bank Condition*** | | | |
| **Geology**: | Soil ☐ | | |
| If **Soil**, how is the Ground Surface? | Flat ☐ (up to 15° slope) | or | Hill Slope ☐ (more than 15° slope) |
| What is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ |
| ***Left Bank Condition*** | | | |
| **Geology** | Soil ☐ | | |
| If **Soil**, how is the Ground Surface? | Flat ☐ (up to 15° slope) | or | Hill Slope ☐ (more than 15° slope) |
| What is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ |

## B. Selection of Anchor Types

Select the appropriate Anchor Types for the Right and Left Banks according to the above design data.

Except for the Drum Rock Anchors, all Main Cable Anchors are either designed *with Turnbuckle* or for *Direct Cable Connection.* One Main Cable Anchor should always have a Turnbuckle for fine adjustment during sag setting, whereas for economic reasons, the cable anchor on the other bank should always have a direct cable connection.

The rules for selecting the anchor blocks are the following:

- Select an Anchor Block with a turnbuckle for one bank and an Anchor Block with a direct cable connection for the other bank. Always choose the more convenient bank for the Main Cable Anchor with turnbuckle.
- If one bank is soil and the other bank is rock, always select a Drum Anchor for the rocky bank.
- If both banks are rocky, select an Anchor Block for one bank and a Drum Anchor for the other bank.

**Procedure for selection:**

- According to the Soil type and Slope of the ground or the Rock type, refer to the respective tables for selection of the Anchor Types as per below.

| | | | |
|---|---|---|---|
| for Soil and Flat Ground | (Cable Connection with Turnbuckle) | : | **Table 2.1** |
| for Soil and Flat Ground | (Direct Cable Connection) | : | **Table 2.2** |
| for Soil and Hill Slope | (Cable Connection with Turnbuckle) | : | **Table 2.3** |
| for Soil and Hill Slope | (Direct Cable Connection) | : | **Table 2.4** |
| for Hard, Soft or Fractured Rock | (Cable Connection with Turnbuckle) | : | **Table 2.5** |
| for Hard Rock | (Direct Cable Connection ) | : | **Table 2.6** |
| for Fractured Hard Rock or Soft Rock | (Direct Cable Connection) | : | **Table 2.7** |

- **Match the design data in the table:**

  The number and diameter of the Main Cables → if Soil, Soil type → select Anchor type and corresponding. Drawing No. for the right bank and the left bank respectively .

- **Fill in the required data in the selected drawings.**

## C. Anchor Type Selection Tables

- ***In Soil and Flat Ground***

**Table 2.1:** Selection of the Main Cable Deadman Anchor in Soil and Flat Ground (Cable Connection with Turnbuckle)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | DA 1 | 42/1Ncon |
| 2x32 | All | DA 2 | 42/3Ncon |
| 4x26 | All | DA 3 | 44/1Ncon |
| 4x32 | All | DA 4 | 44/3Ncon |

**Table 2.2:** Selection of the Main Cable Deadman Anchor in Soil and Flat Ground (Direct Cable Connection)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | DA 5 | 42/2Ncon |
| 2x32 | All | DA 6 | 42/4Ncon |
| 4x26 | All | DA 7 | 44/2Ncon |
| 4x32 | All | DA 8 | 44/4Ncon |

- ***In Soil and Hill Slope***

**Table 2.3:** Selection of the Main Cable Anchor Block in Soil and Hill Slope (Cable Connection with Turnbuckle)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | AB 1 | 42/5Ncon |
| 2x32 | All | AB 2 | 42/7Ncon |
| 4x26 | All | AB 3 | 44/5Ncon |
| 4x32 | Gravelly or Sandy | AB 4 | 44/7Ncon |
| | Silty | AB 5 | 44/9Ncon |

**Table 2.4:** Selection of the Main Cable Anchor Block in Soil and Hill Slope (Direct Cable Connection)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | AB - 6 | 42/6Ncon |
| 2x32 | All | AB - 7 | 42/8Ncon |
| 4x26 | All | AB - 8 | 44/6Ncon |
| 4x32 | Gravelly or Sandy | AB - 9 | 44/8Ncon |
| | Silty | AB - 10 | 44/10Ncon |

- ***In Hard, Soft or Fractured Rock***

**Table 2.5:** Selection of the Main Cable Anchor Block in Hard, Soft or Fractured Rock (Cable Connection with Turn Buckle)

| Main Cable, mm | Anchor Type | Drawing No |
|---|---|---|
| 2x26 or 2x32 | AB - 11 | 45Ncon |
| 4x26 or 4x32 | AB - 12 | 46Ncon |

- ***In Hard Rock***

**Table 2.6:** Selection of the Main Cable Drum Anchor in Hard Rock (Direct Cable Connection)

| Main Cable, mm | Anchor Type | Drawing No |
|---|---|---|
| 2x26 or 2x32 | DR-1 | 47Ncon |
| 4x26 or 4x32 | DR-2 | 48Ncon |

- ***In Fractured Hard Rock or Soft Rock***

**Table 2.7:** Selection of the Main Cable Drum Anchor in Fractured Hard Rock or Soft Rock (Direct Cable Connection)

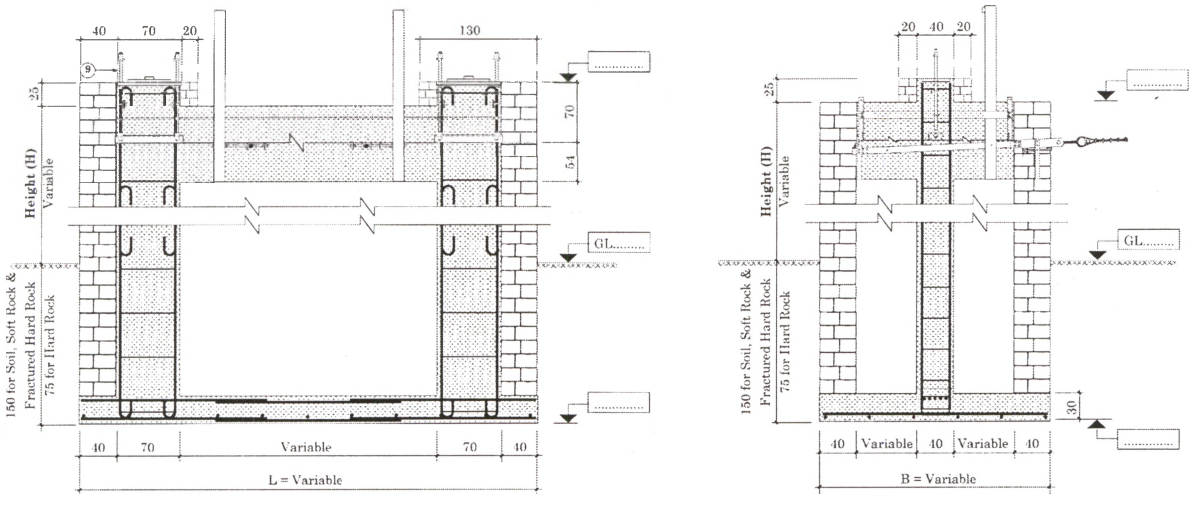
| Main Cable, mm | Anchor Type | Drawing No |
|---|---|---|
| 2x26 or 2x32 | DR-3 | 49Ncon |
| 4x26 or 4x32 | DR-4 | 50Ncon |

### 3.3.6 WALKWAY AND TOWER FOUNDATION DESIGN

The standard designs of the Walkway and Tower Foundations have been developed for all possible cases for spans of up to 120m. The standard foundation designs have been developed by following the design concept and statical analysis as presented in Chapter 3.2.3.

The design of the Walkway and the Tower Foundations is mainly to select the standard foundation types as per the cable combinations, geology and topography of the site. Fill in the required data in the corresponding selected drawings.

A typical design is as illustrated below.




## A. Design Data

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist**

| | | | | |
|---|---|---|---|---|
| • **Main Cable:** **Nos... Ø.....mm**<br>• **Spanning Cable:** **Nos 2 Ø..... mm** | | | | |
| ***Right Bank Condition*** | | | | |
| **Geology**:<br>If **Soil**, what is the Soil Type? | Soil ☐ | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| Foundation Block Height (**H**) from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Foundation Block Height (**H**) from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| ***Left Bank Condition*** | | | | |
| **Geology**<br>If **Soil**, what is the Soil Type? | Soil ☐ | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| Foundation Block Height (**H**) from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Foundation Block Height (**H**) from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

## B. Selection of Walkway & Tower Foundations

Select the appropriate Walkway & Tower Foundations for the Right and Left Banks according to the above design data.

**Procedure for selection:**

- According to the Soil or Rock type, refer to the respective table for selection of the Walkway and Tower Foundations as per below.

| | | |
|---|---|---|
| In Soil | : | **Table 3.1** |
| In Hard Rock | : | **Table 3.2** |
| In Fractured Hard Rock or Soft Rock | : | **Table 3.3** |

- If the bank is rock, always take the foundation block height **H** as 1.0m,
  If the bank is soil and in hill slope, always take the foundation block height **H** as 1.0m.
  If the bank is soil on flat ground, but the foundation block height **H** as needs to be raised, always take the foundation block height as 1.0 or 2.0 or 3.0 or 4.0m (maximum). **H** is limited to a maximum of 4.0m.

- **Match the design data in the table:** Number and Diameter of Main Cables → Foundation Block Height → if Soil, Soil type → select Foundation type and corresponding Drawing No. for right bank and left bank respectively.

- **Fill in the required data in the selected drawings.**

## C. Walkway & Tower Foundations Selection Tables

- ***In Soil***

**Table 3.1**: Selection of Walkway & Tower Foundations in Soil

| Main Cable | Foundation Block Height (H) m | Soil Type | Foundation Type | Drawing No. |
|---|---|---|---|---|
| 2x26 and 2x32mm | 1.0 | All | TF-1 | 92/1Ncon |
| | 2.0 | All | TF-2 | 92/2Ncon |
| | 3.0 | All | TF-3 | 92/3Ncon |
| | 4.0 | All | TF-4 | 92/4Ncon |
| 4x26mm | 1.0 | All | TF-6 | 94/1Ncon |
| | 2.0 | All | TF-7 | 94/2Ncon |
| | 3.0 | Gravelly/Sandy | TF-8 | 94/3Ncon |
| | | Silty | TF-9 | 94/4Ncon |
| | 4.0 | Gravelly/Sandy | TF-10 | 94/5Ncon |
| | | Silty | TF-11 | 94/6Ncon |
| 4x32mm | 1.0 | All | TF-6 | 94/1Ncon |
| | 2.0 | All | TF-7 | 94/2Ncon |
| | 3.0 | Gravelly/Sandy | TF-8 | 94/3Ncon |
| | | Silty | TF-9 | 94/4Ncon |
| | 4.0 | Gravelly/Sandy | TF-10 | 94/5Ncon |
| | | Silty | TF-11 | 94/6Ncon |

- ***In Hard Rock***

**Table 3.2**: Selection of Walkway & Tower Foundations in Hard Rock

| Main Cable | Foundation Block Height (H) m | Foundation Type | Drawing No. |
|---|---|---|---|
| 2x26 or 2x32mm | 1.0 | TF-5 | 92/5Ncon |
| 4x26 or 4x32mm | 1.0 | TF-12 | 94/7Ncon |

- ***In Fractured Hard Rock or Soft Rock***

**Table 3.3**: Selection of Walkway & Tower Foundations in Fractured Hard Rock or Soft Rock

| Main Cable | Tower Block Height (H) m | Foundation Type | Drawing No |
|---|---|---|---|
| 2x26 or 2x32mm | 1.0 | TF-1 | 92/1Ncon |
| 4x26 or 4x32mm | 1.0 | TF-6 | 94/1Ncon |

### 3.3.7 SUSPENDER LIST

Suspenders are designed for the bridge geometry under dead load, i.e. $l$, $f_d$ and $c_d$ . The layout of the suspenders and its geometrical calculation is based on the design calculations as given in Chapter 3.2.3. As per the said suspender layout and the geometrical calculation for suspender lengths, a computer program **"Suspender Design"** has been developed.

**A. Calculation of Suspender List**

Calculate the Suspender List using the computer program **"SSTB Design"** which is included in the CD-ROM at the back cover page of this Handbook.

The calculation is based on the fixed geometry of the bridge as per the **table: Selection of Cables and Standard Towers in** Chapter 3.3.4. The only input data required for the calculation is the span, $l$.

**B. Procedure for the Suspender List calculation**

- Open the computer program **SSTB Design** > **"Suspender Design"**
- Enter the input data: Bridge Name, Bridge Span and width of Walkway and Tower Foundation
- Print result.

Attach the printout of the Suspender List with the drawing of the suspenders.

### 3.3.8 LIST OF DRAWINGS

Select the required Steel Drawings and Construction Drawings according to the selected Main Cables, Towers, Main Cable Anchorage Blocks and Walkway / Tower foundations. For more details, refer to Chapter 4: Bridge Standard Drawings.

In addition, prepare a General Arrangement drawing for individual bridge designs. For this refer to Chapter 3.3.10: General Arrangement Drawing.

### 3.3.9 OTHER STRUCTURES

Besides the bridge structure, some other adjacent structures may be required for overall bridge stability and for safety measures. These are the following structures.

A. Windguy Arrangement
B. Retaining Structures
C. Slope Protection works
D. River Bank Protection

**A. Windguy Arrangement (Optional)**

The design maximum wind speed is calculated as 160km/h for Nepal (see also Chapter 3.2.1 Loadings), and has favorable nature of the wind flow (no cyclone, no typhoon and no tornado). Theoretical calculations show that there is no need for a windguy arrangement for Suspension type bridges with spans of up to 120m. (See also "Expertise on Windguy Arrangement for BBLL Standard Bridges by Dr. Heinrich Schnetzer, WGG Schnetzer Pukas Ingenieure AG SIA/USIC Basel, Switzerland, Report No 1182-002).

Therefore, no Windguy Arrangement is necessary in this standard suspension bridge. All the towers and foundation structures are designed to withstand the maximum design wind pressure without a windguy arrangement. However, during high wind time (the frequency and duration of such times are very low) the comfort while crossing the bridge will be significantly reduced and it may even be risky. Therefore, no traffic should be allowed to cross the bridge during such windy times.

For special cases, i.e., when the bridge span is more than 120m or in extremely windy areas with wind speeds in excess of 160km/hr and unfavorable nature of the wind flow, a windguy system is mandatory.

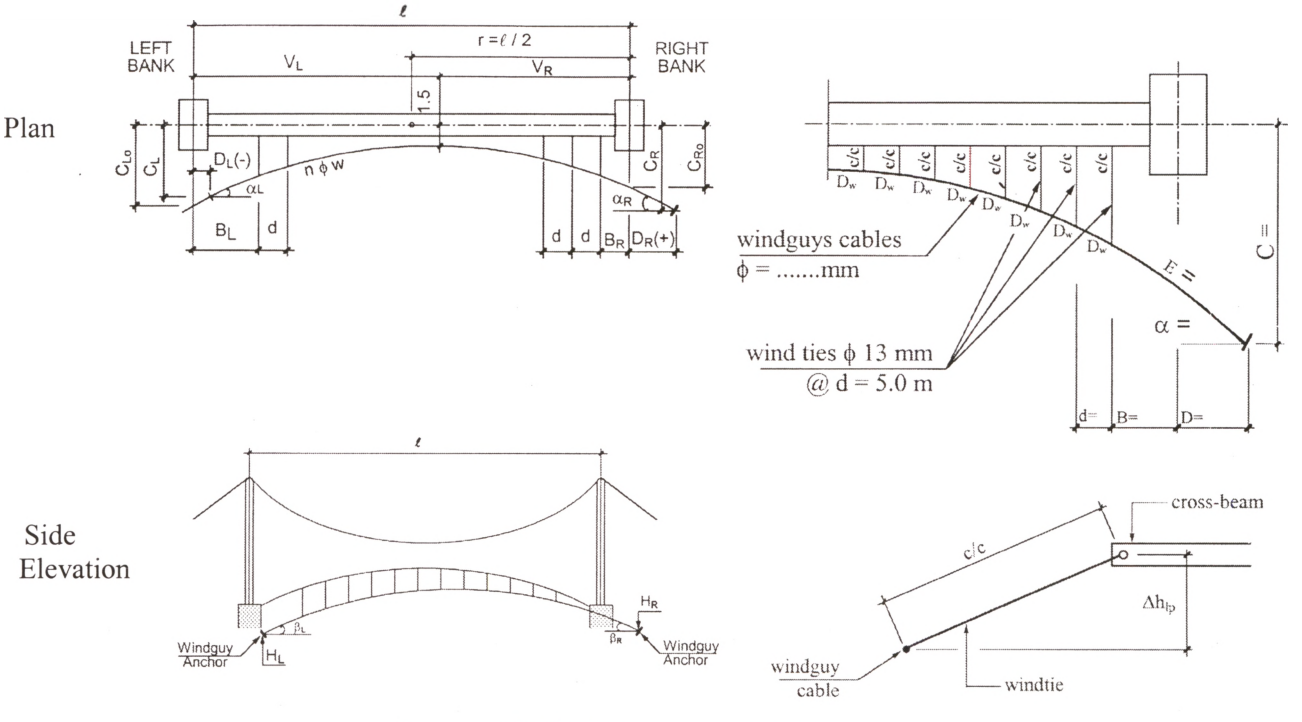
⇒ **Design of Windguy Arrangement**

For detailed design calculations of the Windguy Arrangement, refer to Volume A of the LSTB (SBD) Manual.

The design of the Windguy Arrangement is to

- select the diameter of the windguy cable and windties cable
- calculate the geometry of the windguy arrangement
- select the windguy cable anchor blocks

A general layout of the Windguy Arrangement is shown in figure below.




**Layout of Windguy Arrangement**

A computer program **"Windguy Design"** has been developed for the calculation. The calculation is based on the layout of the Windguy Arrangement as per the above Figure 3 and a the fixed geometry of the bridge in dead load case as per the **Table: Selection of Cables and Standard Towers** in Chapter 3.3.4.

Calculate the Windguy Arrangement using the computer program **"SSTB Design"** which is included in the CD-ROM at the back cover page of this Handbook.

⇒ **Procedure for Windguy Arrangement Design**

- Open computer program **SSTB Design > "Windguy Design"**.
- Give input data: Bridge Name, Bridge Span and Elevation of Steel Tower Base.

Follow the calculation procedure as below:

- Give the tentative of the first windtie position $\mathbf{B_L}$ and $\mathbf{B_R}$ as per the topography. The program will adjust to the nearest actual values.
- Give the level of the windguy anchorage on the right bank $\mathbf{H_L}$ and the left bank $\mathbf{H_R}$. $\mathbf{H_L}$ and $\mathbf{H_R}$ should be at or below the level of the spanning cable at the anchorage point (Es).
- Give (select) the windguy anchor position on the right bank (or the left bank), i.e. $\mathbf{C_R}$ and $\mathbf{D_R}$ or ($\mathbf{C_L}$ and $\mathbf{D_L}$). Accordingly, the windties listing will be from the right bank to the left bank or vise versa.
- Input the value of $\mathbf{V_R}$ (distance up to the vertex of the windguy cable) if the selected windguy anchor position is on the right bank or $\mathbf{V_L}$ if the selected windguy anchor position is on the left bank.
- Check the span and sag ratio of the windguy cable, *l*/b. It should be not less than 8 and not more than 10. If this condition is not met, input a new **V** till the *l*/b is within the recommended limit.
- Check the lowest point of the windguy cable "$\mathbf{\Delta h_{lp}}$". It should not be negative (-). If the $\Delta h_{lp}$ is negative, input new $\mathbf{H_L}$ and $\mathbf{H_R}$ with **a** lower value.
- Input value of $\mathbf{D_{Lo}}$ (or $\mathbf{D_{Ro}}$) = 0. The result will show $\mathbf{C_{Lo}}$ (or $\mathbf{C_{Ro}}$), and horizontal angle $\alpha_L$ (or $\alpha_R$).
- Draw a straight line with the given $\mathbf{C_{Lo}}$ (or $\mathbf{C_{Ro}}$), and horizontal angle $\alpha_L$ (or $\alpha_R$). Fix the windguy anchor position on the left bank (or the right bank) along this line. The anchorage block should be placed on safe ground and at the optimum foundation location so that it has sufficient embedded depth and also so that deep excavation can be avoided.
- After fixing the anchorage position, measure the actual $\mathbf{C_L}$ (or $\mathbf{C_R}$ ). The result will give the $\mathbf{D_L}$ (or $\mathbf{D_R}$).
- Draw longitudinal sections along the windguy cables at the foundations and determine the exact position of the front of the foundations ($\mathbf{D_R}$ , $\mathbf{C_R}$ **and** $\mathbf{D_L}$, $\mathbf{C_L}$ ) and the windguy cable elevations ($\mathbf{H_R}$, $\mathbf{H_L}$ ).
- If the final position of the foundations does not match the design as above, repeat the calculation process from the second bullet till all the foundations are located at the optimum positions.
- Print out the results. The results will give:

  position of the anchorage blocks,

  diameter of the windguy cable,

  c/c inclined distance (length) of the windties,

  cutting length of the windties,

  horizontal c/c distance of the windties and

  inclined distance $D_w$ (interval between the windties).

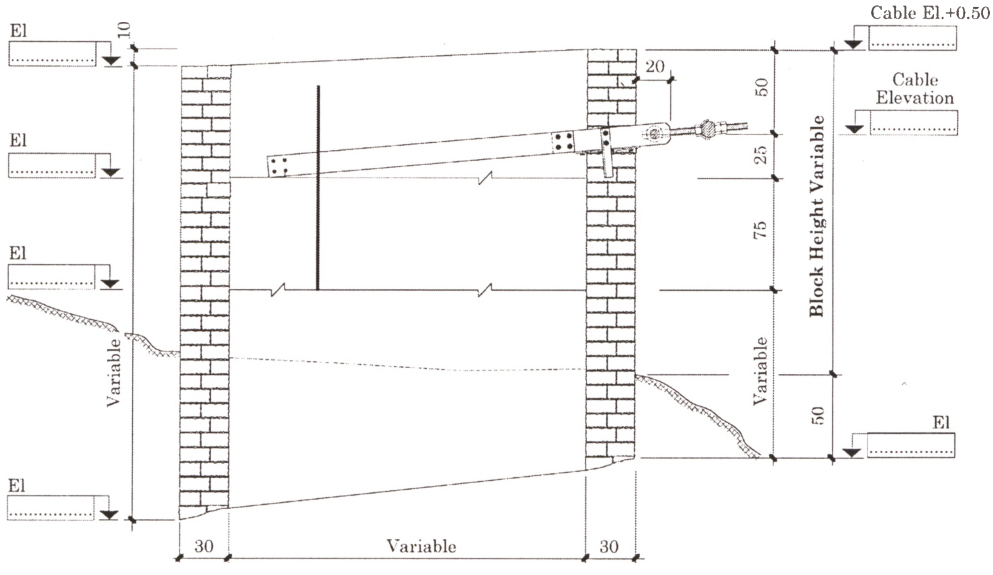
- Calculate the Windguy Arrangement for both upstream and downstream.

Attach the printout of the results with the drawing of the Windguy Clamp and also transfer it to the General Arrangement Drawing.

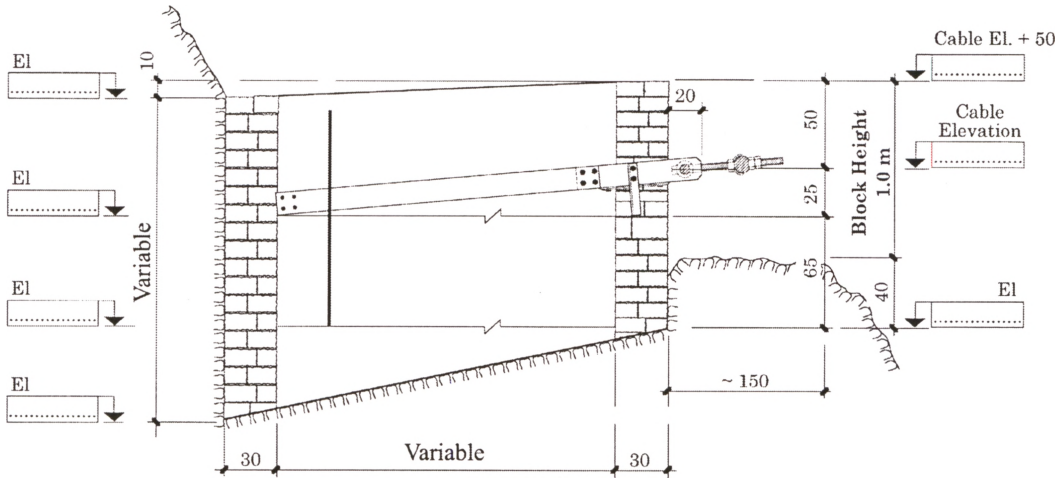
⇒ **Windguy Anchorage Foundation Blocks Design (Optional)**

The design concept and the statical analysis are the same as for the main anchor blocks. Accordingly, the standard anchor blocks have been developed. Basically, there are four typical standard anchor blocks as described below.

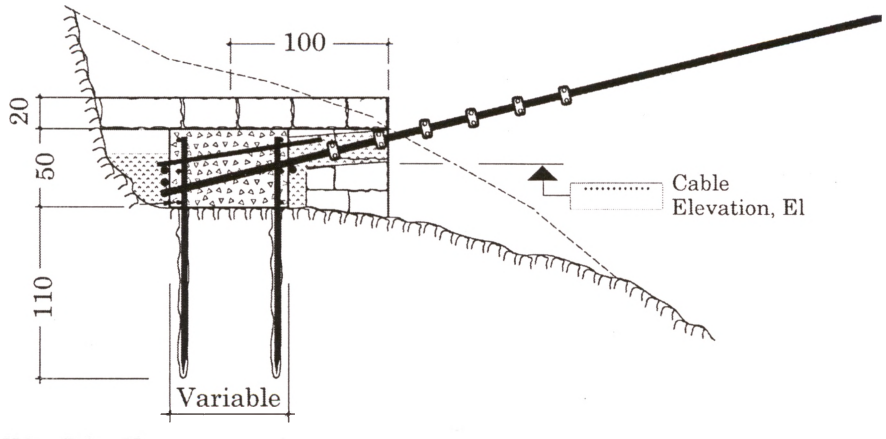
1. Gravity Anchor Block in Soil



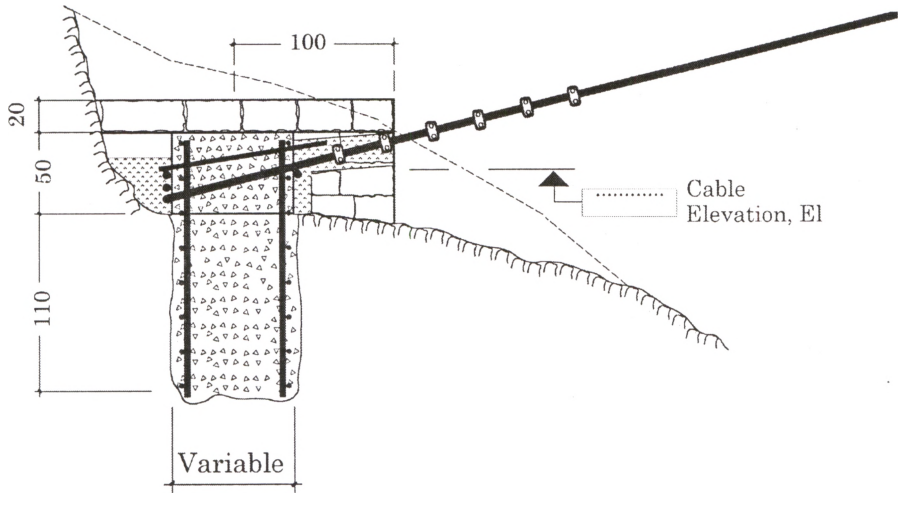

2. Gravity Anchor Block in Rock




3. Drum Anchor Block in Hard Rock



4. Drum Anchor Block in Fractured Hard Rock and Soft Rock




- **Design Data**

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist.**

| | | | | |
|---|---|---|---|---|
| • **Windguy Cable: …..nos. ∅ …….mm** | | | | |
| ***Right Bank / Upstream*** | | | | |
| **Geology**: | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| ***Right Bank / Downstream*** | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

| *Left Bank / Upstream* | | | | |
|---|---|---|---|---|
| **Geology**: | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| *Left Bank / Downstream* | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

- **Selection of Standard Windguy Cable Anchor Blocks**

  Select appropriate Windguy Cable Anchor Blocks for U/S and D/S for the Right and Left Banks according to the above design data. Following are the rules for selection of the anchor blocks.

  - If the bank is rock, always take the block height as 1.0m.
  - If the bank is soil on a hill slope, always take the block height as 1.0m.
  - If one bank is soil and the other bank is rock, always select a Drum Anchor for the rocky bank.
  - If both banks are rocky, select an Anchor Block for one bank and a Drum Anchor for the other bank.
  - If the bank is soil but on flat ground and the anchor block height needs to be raised, always take the foundation block height as 1.0, or 2.0, or 3.0, or 4.0 m (maximum).

  **Procedure for selection:**

  According to the Soil or Rock type, refer to respective table for selection of Windguy Cable Anchor Blocks as per below.

  | | | |
  |---|---|---|
  | In Soil | : | **Table 4.1** |
  | In all types of Rock (Anchor Block) | : | **Table 4.2** |
  | In Hard Rock (Drum Anchor) | : | **Table 4.3** |
  | In Fractured Hard Rock or Soft Rock (Drum Anchor) | : | **Table 4.4** |

  **In the tables match the design data:** Diameter of Windguy Cable → Soil or Rock type → Block Height → select Anchor Block type and corresponding Drawing No.

- Fill in the required data in the selected drawings.

### Selection Tables for Windguy Anchor Blocks

- ***In Soil***

**Table 4.1:** Selection of Windguy Cable Anchor Block in Soil

| Windguy Cable [mm] | Anchor Block Height | Soil Type | Anchor Type | Drawing No. |
|---|---|---|---|---|
| 26 | 1 | All | WAB - 1 | 55/1Acon |
| | 2 | All | WAB – 2 | 55/2Acon |
| | 3 | All | WAB – 3 | 55/3Acon |
| | 4 | All | WAB – 4 | 55/4Acon |

- ***In Hard, Fractured or Soft Rock***

**Table 4.2:** Selection of Windguy Cable Anchor Block in all types of Rock

| Windguy Cable [mm] | Anchor Type | Drawing No. |
|---|---|---|
| 26 | WAB - 5 | 56Acon |

- ***In Hard Rock***

**Table 4.3:** Selection of Windguy Cable Drum Anchor in Hard Rock

| Windguy Cable [mm] | Anchor Type | Drawing No. |
|---|---|---|
| 26 | WDR - 1 | 57Acon |

- ***In Fractured or Soft Rock***

**Table 4.4:** Selection of Windguy Cable Drum Anchor in Fractured or Soft Rock

| Windguy Cable [mm] | Anchor Type | Drawing No. |
|---|---|---|
| 26 | WDR - 2 | 58Acon |

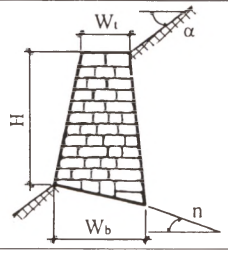
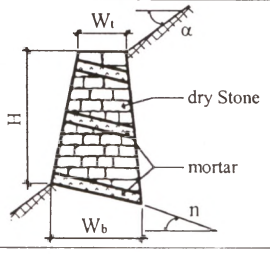
## B. Retaining structures

Retaining structures are necessary to retain the earth (soil, fractured rock and weathered soft rock) behind the anchorage blocks of the bridge. There are many options for retaining structures. But for trail bridges, the most feasible are retaining walls. Retaining walls can be of gabion boxes, rubble masonry and dry stone masonry. For the short-span trail bridges, dry stone retaining walls or breast walls are preferable since they require only local materials.

The choice between retaining wall and breast wall depends on different factors, such as the available space behind the blocks, the required height of the protection, soil conditions etc.

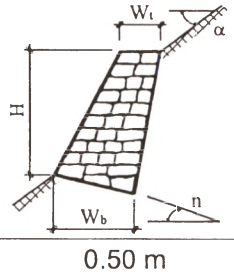
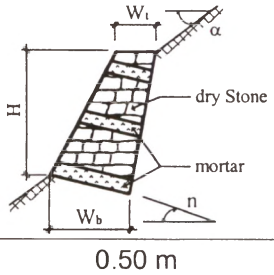
Retaining walls are used when the earth to be retained is loose soil with a great protection height. For the design of the retaining wall, use the following table.

## Retaining Walls

| Type | Dry Stone | Banded Dry Stone / Masonry |
|---|---|---|
| Section |  |  |
| Top width, $W_t$ | 0.6 - 1.0 m | 0.6 - 1.0 m |
| Base width, $W_b$ | 0.5 - 0.7 H | 0.6 - 0.65 H |
| Front batter | varies | varies |
| Back batter | varies | vertical |
| Inward dip of foundation, n | 1 : 3 | 1 : 3 |
| Foundation depth | ≥ 0.50 m | ≥ 0.50 - 1 m |
| Range of height, H | 1 - 6 m | 6 - 8 m |
| Hill slope angle, α | < 35° | 20° |

Breast walls are used when the earth to be retained is fractured or weathered rock, or compact soil with temporarily unstable nature. For designing breast walls, use the following table.

## Breast Walls

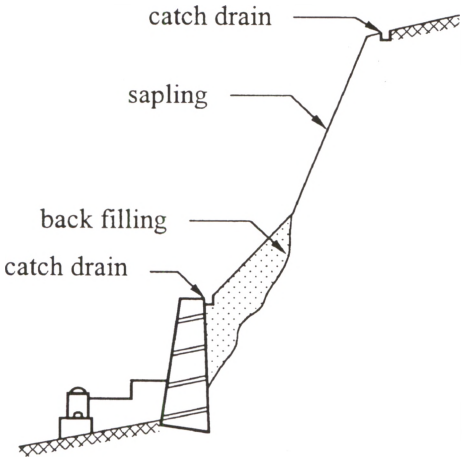
| Type | Dry Stone | | | Banded Dry Stone / Masonry |
|---|---|---|---|---|
| Section |  | | |  |
| Top width, $W_t$ | 0.50 m | | | 0.50 m |
| Base width, $W_b$ | 0.29H | 0.3H | 0.33H | > 0.5H |
| Back batter | 3 : 1 | 4 : 1 | 5 : 1 | 3 : 1 |
| Inward dip of foundation, n | 1 : 3 | 1 : 4 | 1 : 5 | 1 : 3 |
| Foundation depth | ≥ 0.50 m | ≥ 0.50 m | ≥ 0.50 m | ≥ 0.50 m |
| Range of height, H | < 6 m | < 4 m | < 3 m | 3 - 8 m |
| Hill slope angle, α | 35 - 60° | | | 35 - 60° |

## C. Slope Protection Measures

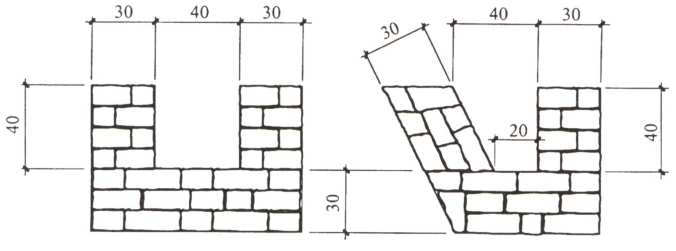
Slope protection measures depend on the factors influencing slope instability. It is recommended that a bridge site be selected, where there are no slope instability features (refer to Chapter 2.4.3). However, it is often necessary to drain out the surface runoff and seepage water from the slope as a slope protection measure.

Water should be collected as close as possible to its origin and safely channeled to a nearby watercourse. The surface drainage can be catch drain on the slope or drainage around the anchorage foundation or a combination of both.

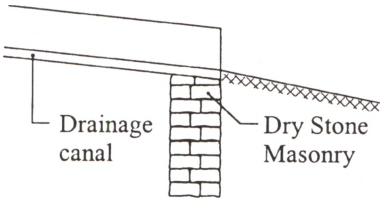
The choice depends on the position of the anchorage foundation and the profile of the natural terrain as shown in the sketch below.



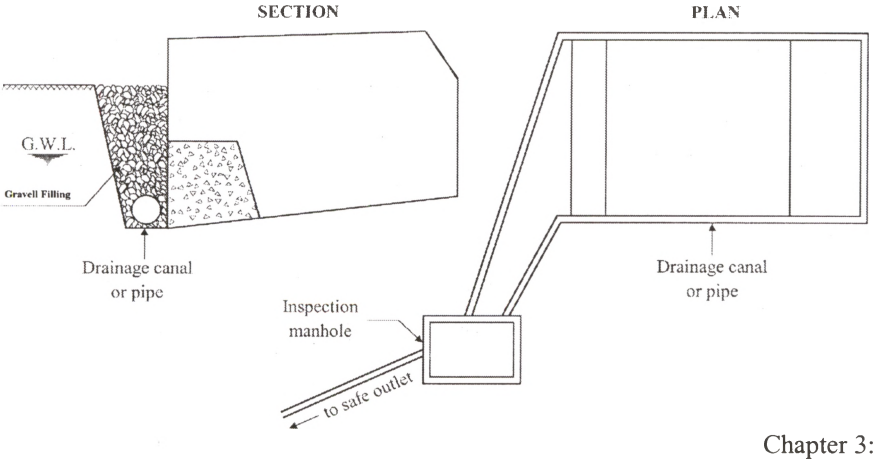

The drain should be open type. The following design shows the typical sections of the drain.



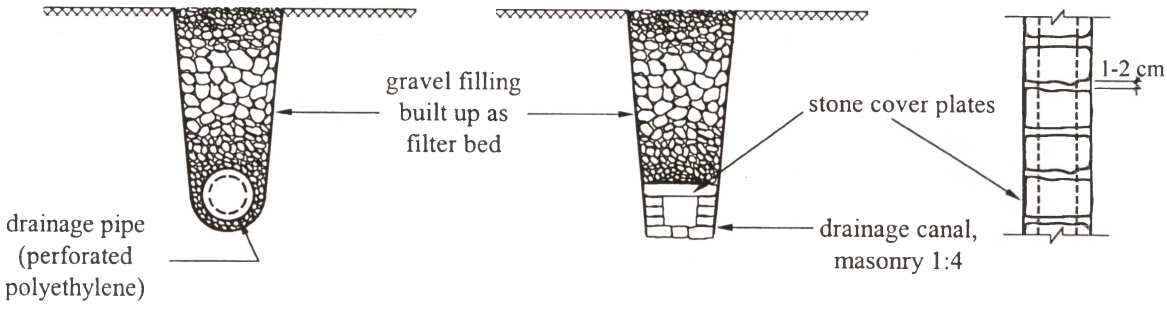

To avoid self-scouring, the drain outlet should be protected as shown in the following sketch.




In seepage area, sub-surface drainage is required around the anchorage foundation. A typical layout design of the sub-surface drain is as shown in the sketch below.



A typical design of the sub-surface drain is as shown in the sketch below.




### Bio-Engineering

Surface drainage alone may not be sufficient to protect unstable slopes. The most effective method for stabilizing such slopes is bio-engineering in combination with light civil structures such as catch drains, check dams, cascades, etc. This is a cheap and easy method. The main concept of this method is to grow trees and plants such as shrubs or grasses. Deep rooted and fast growing trees and plants are most suitable for this purpose. The proper selection of plant types is most important, and it should be based upon local experience. Some of the vegetation measures are:

- planted grass lines: contour/horizontal or down slope/vertical or random planting
- grass seeding
- turfing
- shrub and tree planting
- shrub and tree seeding
- fascines (bundles of live branches are laid in shallow trenches)

For more and in-depth details about bio-engineering techniques refer to the respective literature and manuals. One of the recommended manuals is *Road Side Bio-Engineering, Reference Manual* by John Howell, published by HMG/Department of Roads.

## D. River Bank Protection

River protection works are of a temporary nature and costly. They require frequent maintenance to keep the structures functional. Therefore, avoid bridge sites which require river protection works as far as possible. This is a complex subject and cannot be covered by this handbook. For details refer to Volume A of LSTB (SBD) Manual.

### 3.3.10 General Arrangement Drawing

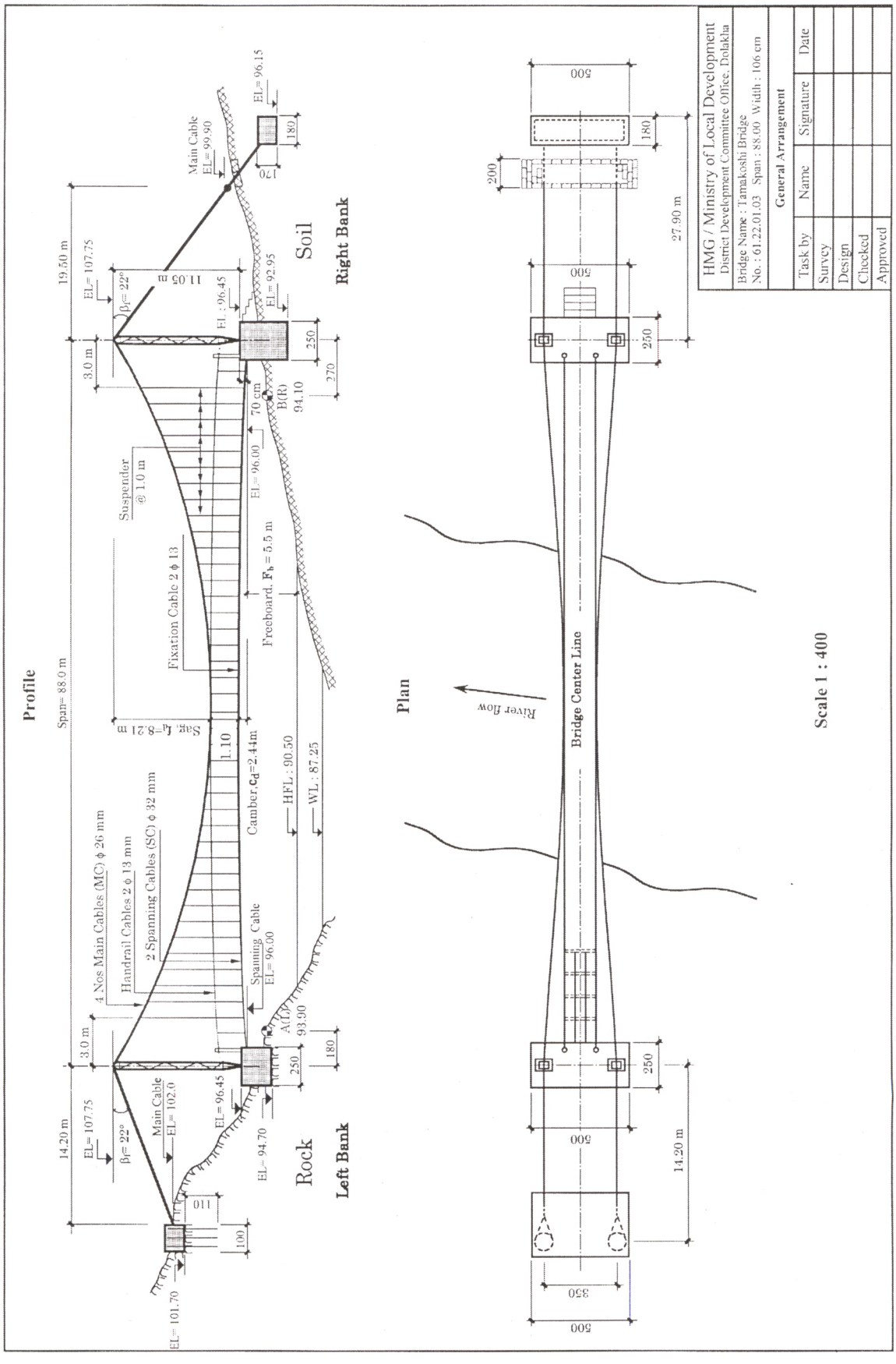
General Arrangement (GA) drawing shows the overall plan and profile of the bridge. The GA should reflect the major components of the bridge and its geometry for dead load case including the elevations of the tower tops, cable anchor points, the foundations and general dimensions. The GA is required for an overall view of the designed bridge and also for layout of the bridge before construction.

Draw the GA on the same bridge profile as already done under Chapter 3.3.3, and mention the following data on the plan and the profile of the bridge:

- Span $l$, tower height $\mathbf{h_t}$ dead load sag $\mathbf{f_d}$, dead load camber $\mathbf{c_d}$, and backstay angle $\beta_f$
- Backstay distance $D_R$ and $D_L$
- Distance from the axis points A and B (which were fixed during the survey) and the center of the towers
- Main cable elevations at the tower saddles (top of the tower), elevation of the lowest point of the main cable
- Spanning cable elevation at the anchor point
- All bridge foundation levels
- The LWL, HFL and available freeboard $\mathbf{F_b}$
- Overall dimensions of the bridge structures and their elevations

The completed GA should be sufficient for the layout of the bridge. An example of the GA drawing of a bridge is given in the following Chapter 3.4 Design Example.

## 3.4 DESIGN EXAMPLE



# 4. BRIDGE STANDARD DRAWINGS

## INTRODUCTION AND OVERVIEW OF DRAWINGS

The Bridge Standard Drawings represent the centerpiece of the Short Trail Bridge Standard. They are composed as a unit component system and are categorized into two groups:

- **Construction Drawings**
- **Steel Drawings**

**see Volume III**
Steel & Construction Drawings

*Both drawing groups are linked with each other and depending on the bridge design the required drawings are to be selected.*

**Legend for the Drawing Numbers and Suffixes:**

| | Drawing No. | Suffix | Bridge or Drawing Type |
|---|---|---|---|
| STEEL DRAWINGS | 08 | **A** | For **A**ll Bridge Types |
| | 07 | **N** | For Suspensio**n** Bridge Types |
| CONSTRUCTION DRAWINGS | 56 | **Ncon** | **con**struction drawings |
| | **Anchor Types for Main Cables** | | |
| | | **DA 5** | **D**eadman **A**nchor Type **5** |
| | | **AB 7** | **A**nchor **B**lock Type **7** |
| | | **DR 3** | **D**rum **R**ock Type **3** |
| | **Anchor Types for Windguy Cables** | | |
| | | **WAB 2** | **W**indguy **A**nchor **B**lock Type **2** |
| | | **WDR 1** | **W**indguy **D**rum **R**ock Anchor Type **1** |
| | **Walkway and Tower Foundations** | | |
| | | **TF 11** | **T**ower **F**oundation Type **11** |

## 4.2 CONSTRUCTION DRAWINGS

Construction drawings for suspension bridges consist of three different drawing groups.

These are:

- **Main Cable Anchor Drawings**
- **Walkway and Tower Foundation Drawings**
- **Windguy Cable Anchor Drawings**

In the following Tables, the above different drawing groups are shown in relation to various Ground Conditions:

**Construction Drawings for Main Cable Anchors in Different Soil and Rock Conditions:**

| Ground Condition | | | Anchor Type | Main Cables | | | Turnbuckle or Direct Cable Connection | Drawing No. |
|---|---|---|---|---|---|---|---|---|
| | | | | Nos | $c/c_1$ [m] | $\phi$ [mm] | | |
| SOIL | FLAT GROUND | All Soil Types: Gravelly, Sandy or Silty | DEADMAN ANCHORS "DA" TYPES | 2 | 2.50 | 26 | With Turnbuckle<br>Direct Cable Connection | 42/1Ncon<br>42/2Ncon |
| | | | | | | 32 | With Turnbuckle<br>Direct Cable Connection | 42/3Ncon<br>42/4Ncon |
| | | | | 4 | 3.50 | 26 | With Turnbuckle<br>Direct Cable Connection | 44/1Ncon<br>44/2Ncon |
| | | | | | | 32 | With Turnbuckle<br>Direct Cable Connection | 44/3Ncon<br>44/4Ncon |
| | HILL SLOPE | All Soil Types: Gravelly, Sandy or Silty | GRAVITY BLOCK ANCHORS "AB" TYPES | 2 | 2.50 | 26 | With Turnbuckle<br>Direct Cable Connection | 42/5Ncon<br>42/6Ncon |
| | | | | 4 | 3.50 | | With Turnbuckle<br>Direct Cable Connection | 44/5Ncon<br>44/6Ncon |
| | | | | 2 | 2.50 | 32 | With Turnbuckle<br>Direct Cable Connection | 42/7Ncon<br>42/8Ncon |
| | | Gravelly or Sandy Soil | | 4 | 3.50 | | With Turnbuckle<br>Direct Cable Connection | 44/7Ncon<br>44/8Ncon |
| | | Silty Soil | | 4 | 3.50 | 32 | With Turnbuckle<br>Direct Cable Connection | 44/9Ncon<br>44/10Ncon |
| ROCK | Soft or Fractured Rock | | | 2 | 2.50 | 26 or 32 | With Turnbuckle | 45Ncon |
| | | | | 4 | 3.50 | 26 or 32 | With Turnbuckle | 46Ncon |
| | Hard Rock | | DRUM ROCK ANCHORS "DR" TYPES | 2 | 2.50 | 26 or 32 | Direct Cable Connection | 47Ncon |
| | | | | 4 | 3.50 | 26 or 32 | Direct Cable Connection | 48Ncon |
| | Soft or Fractured Rock | | | 2 | 2.50 | 26 or 32 | Direct Cable Connection | 49Ncon |
| | | | | 4 | 3.50 | 26 or 32 | Direct Cable Connection | 50Ncon |

## Construction Drawings for Walkway and Tower Foundations in Different Soil and Rock Conditions:

| Ground Condition | | Main Cables | | Block Height [m] | Foundation Type | Drawing No. |
|---|---|---|---|---|---|---|
| | | Nos | $\phi$ [mm] | | | |
| SOIL | All Soil Types: Gravelly, Sandy or Silty | 2 | 26 or 32 mm | 1.0 | TF 1 | 92/1Ncon |
| | | 2 | | 2.0 | TF 2 | 92/2Ncon |
| | | 2 | | 3.0 | TF 3 | 92/3Ncon |
| | | 2 | | 4.0 | TF 4 | 92/4Ncon |
| | | 4 | | 1.0 | TF 6 | 94/1Ncon |
| | | 4 | | 2.0 | TF 7 | 94/2Ncon |
| | Gravelly or Sandy | 4 | | 3.0 | TF 8 | 94/3Ncon |
| | | 4 | | 4.0 | TF 10 | 94/5Ncon |
| | Silty | 4 | | 3.0 | TF 9 | 94/4Ncon |
| | | 4 | | 4.0 | TF 11 | 94/6Ncon |
| ROCK | Soft or Fractured Rock | 2 | | 1.0 | TF 1 | 92/1Ncon |
| | | 4 | | | TF 6 | 94/1Ncon |
| | Hard Rock | 2 | | | TF 5 | 92/5Ncon |
| | | 4 | | | TF 12 | 94/7Ncon |

## Construction Drawings for Windguy Cable Anchors in Different Soil and Rock Conditions:

| Ground Condition | | Windguy Cable $\phi$ [mm] | Block Height [m] | Foundation Type | Drawing No. |
|---|---|---|---|---|---|
| SOIL | All Soil Types: Gravelly, Sandy or Silty | One Cable $\phi$ 26 mm | 1.0 | WAB 1 | 55/1Ncon |
| | | | 2.0 | WAB 2 | 55/2Ncon |
| | | | 3.0 | WAB 3 | 55/3Ncon |
| | | | 4.0 | WAB 4 | 55/4Ncon |
| ROCK | All Rock Types | | 1.0 | WAB 5 | 56Ncon |
| | Hard Rock | | Drum Type | WDR 1 | 57Ncon |
| | Fractured or Soft Rock | | | WDR 2 | 58Ncon |

## Summary of all Construction Drawings

| Drawing Titles | | | Drawing Nos. |
|---|---|---|---|
| FITTING DETAILS | | Walkway Fitting for Suspension Bridge for 106 cm Walkway Width | 19Ncon |
| MAIN CABLE ANCHORS | DEADMAN ANCHORS IN FLAT GROUND | 2 Cables $\phi$ 26mm, $c/c_1$ = 2.50m, with Turn Buckle, all Soil Types | 42/1Ncon |
| | | 2 Cables $\phi$ 32mm, $c/c_1$ = 2.50m, with Turn Buckle, all Soil Types | 42/3Ncon |
| | | 4 Cables $\phi$ 26mm, $c/c_1$ = 3.50m, with Turn Buckle, all Soil Types | 44/1Ncon |
| | | 4 Cables $\phi$ 32mm, $c/c_1$ = 3.50m, with Turn Buckle, all Soil Types | 44/3Ncon |
| | | 2 Cables $\phi$ 26mm, $c/c_1$ = 2.50m, Direct Cable Connection, all Soil Types | 42/2Ncon |
| | | 2 Cables $\phi$ 32mm, $c/c_1$ = 2.50m, Direct Cable Connection, all Soil Types | 42/4Ncon |
| | | 4 Cables $\phi$ 26mm, $c/c_1$ = 3.50m, Direct Cable Connection, all Soil Types | 44/2Ncon |
| | | 4 Cables $\phi$ 32mm, $c/c_1$ = 3.50m, Direct Cable Connection, all Soil Types | 44/4Ncon |
| | GRAVITY BLOCK ANCHORS IN HILL SLOPES | 2 Cables $\phi$ 26mm, $c/c_1$ = 2.50m, with Turn Buckle, all Soil Types | 42/5Ncon |
| | | 2 Cables $\phi$ 32mm, $c/c_1$ = 2.50m, with Turn Buckle, all Soil Types | 42/7Ncon |
| | | 4 Cables $\phi$ 26mm, $c/c_1$ = 3.50m, with Turn Buckle, all Soil Types | 44/5Ncon |
| | | 4 Cables $\phi$ 32mm, $c/c_1$ = 3.50m, with Turn Buckle, gravelly or sandy Soil | 44/7Ncon |
| | | 4 Cables $\phi$ 32mm, $c/c_1$ = 3.50m, with Turn Buckle, silty Soil | 44/9Ncon |
| | | 2 Cables $\phi$ 26mm, $c/c_1$ = 2.50m, Direct Connection, all Soil Types | 42/6Ncon |
| | | 2 Cables $\phi$ 32mm, $c/c_1$ = 2.50m, Direct Connection, all Soil Types | 42/8Ncon |
| | | 4 Cables $\phi$ 26mm, $c/c_1$ = 3.50m, Direct Connection, all Soil Types | 44/6Ncon |
| | | 4 Cables $\phi$ 32mm, $c/c_1$ = 3.50m, Direct Connection, gravelly or sandy Soil | 44/8Ncon |
| | | 4 Cables $\phi$ 32mm, $c/c_1$ = 3.50m, Direct Cable Connection, silty Soil | 44/10Ncon |
| | | 2 Cables $\phi$ 26 or 32mm, $c/c_1$ = 2.50m, with Turn Buckle, all Rock Types | 45Ncon |
| | | 4 Cables $\phi$ 26 or 32mm, $c/c_1$ = 3.50m, with Turn Buckle, all Rock Types | 46Ncon |
| | DRUM ROCK ANCHORS | 2 Cables $\phi$ 26 or 32mm, $c/c_1$ = 2.50m, Direct Connection, in hard Rock | 47Ncon |
| | | 4 Cables $\phi$ 26 or 32mm, $c/c_1$ = 3.50m, Direct Connection, in hard Rock | 48Ncon |
| | | 2 Cables $\phi$ 26 or 32mm, $c/c_1$ = 2.50m, Direct Connection, fractured/soft Rock | 49Ncon |
| | | 4 Cables $\phi$ 26 or 32mm, $c/c_1$ = 3.50m, Direct Connection, fractured/soft Rock | 50Ncon |
| WALKWAY AND TOWER FOUNDATIONS | | 2 Main Cables $c/c_1$ = 2.50m, Block Height 1.0m, all Soil Types & soft Rock | 92/1Ncon |
| | | 2 Main Cables $c/c_1$ = 2.50m, Block Height 2.0m, all Soil Types | 92/2Ncon |
| | | 2 Main Cables $c/c_1$ = 2.50m, Block Height 3.0m, all Soil Types | 92/3Ncon |
| | | 2 Main Cables $c/c_1$ = 2.50m, Block Height 4.0m, all Soil Types | 92/4Ncon |
| | | 2 Main Cables $c/c_1$ = 2.50m, Block Height 1.0m, in hard Rock | 92/5Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 1.0m, all Soil Types & soft Rock | 94/1Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 2.0m, all Soil Types | 94/2Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 3.0m, in gravelly or sandy Soil | 94/3Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 3.0m, in silty Soil | 94/4Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 4.0m, in gravelly or sandy Soil | 94/5Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 4.0m, in silty Soil | 94/6Ncon |
| | | 4 Main Cables $c/c_1$ = 3.50m, Block Height 1.0m, in hard Rock | 94/7Ncon |
| WINDGUY CABLE ANCHORS *OPTIONAL* | | 1 Cable $\phi$ 26mm, Block Height 1.0m, for all Soil Types | 55/1Acon |
| | | 1 Cable $\phi$ 26mm, Block Height 2.0m, for all Soil Types | 55/2Acon |
| | | 1 Cable $\phi$ 26mm, Block Height 3.0m, for all Soil Types | 55/3Acon |
| | | 1 Cable $\phi$ 26mm, Block Height 4.0m, for all Soil Types | 55/4Acon |
| | | 1 Cable $\phi$ 26mm, Block Height 1.0m, for all Rock Types | 56Acon |
| | | 1 Cable $\phi$ 26mm, Drum Type in hard Rock | 57Acon |
| | | 1 Cable $\phi$ 26mm, Drum Type in fractured or soft Rock | 58Acon |

## 4.3 STEEL DRAWINGS

### Summary of all Steel Drawings

| Drawing Titles | | Drawing Nos. |
|---|---|---|
| WALKWAY CROSS BEAM | Crossbeam for Walkway Width = 106 cm | 07N |
| STEEL DECK | Steel deck Standard Panel, length = 198 cm / width = 34 cm | 08A |
| | Steel deck Special Panel, length = 223 cm / width = 34 cm | 10A |
| WINDGUY PARTS | Windties Cable Clamps for Windguys Cable ø 26 or 32 mm | 11A |
| | Windguys Cable Anchorage for one Cable End ø 26 or 32 mm | 50A |
| SUSPENDERS | Suspenders for 2 Main Cables $\phi$ 26 or 32mm | 31N |
| | Suspenders for 4 Main Cables $\phi$ 26 or 32mm | 32N |
| MAIN CABLE ANCHORS | Main Cable Anchorage for 2 Main Cables $\phi$ 26 or 32mm | 42N |
| | Main Cable Anchorage for 4 Main Cables $\phi$ 26 or 32mm | 44N |
| WALKWAY & TOWER FOUNDATION | Walkway and Tower Foundation, $c/c_1$ = 2.50m, $c/c_2$ = 383mm | 92N |
| | Walkway and Tower Foundation, $c/c_1$ = 3.50m, $c/c_2$ = 383mm | 94N |
| TOWERS | Guide for selecting Towers, Main Cables and Spanning Cables | 99N |
| | Assembly and Layout for Tower No. 1, Height 5.50 m | 141N |
| | Assembly and Layout for Tower No. 2, Height 7.35 m | 142N |
| | Assembly and Layout for Tower No. 3, Height 9.20 m | 143N |
| | Assembly and Layout for Tower No. 4, Height 11.05 m | 144N |
| | Base Element for Tower Nos. 1, 2, 3 or 4 | 100N |
| | Intermediate Element for Tower Nos. 1, 2 or 3 | 109N |
| | Intermediate Element for Tower No. 4 | 110N |
| | Top Element for Tower Nos. 1, 2 or 3 | 119N |
| | Top Element for Tower No 4 | 121N |
| | Saddle for Tower Nos. 1, 2, 3 or 4 | 135N |

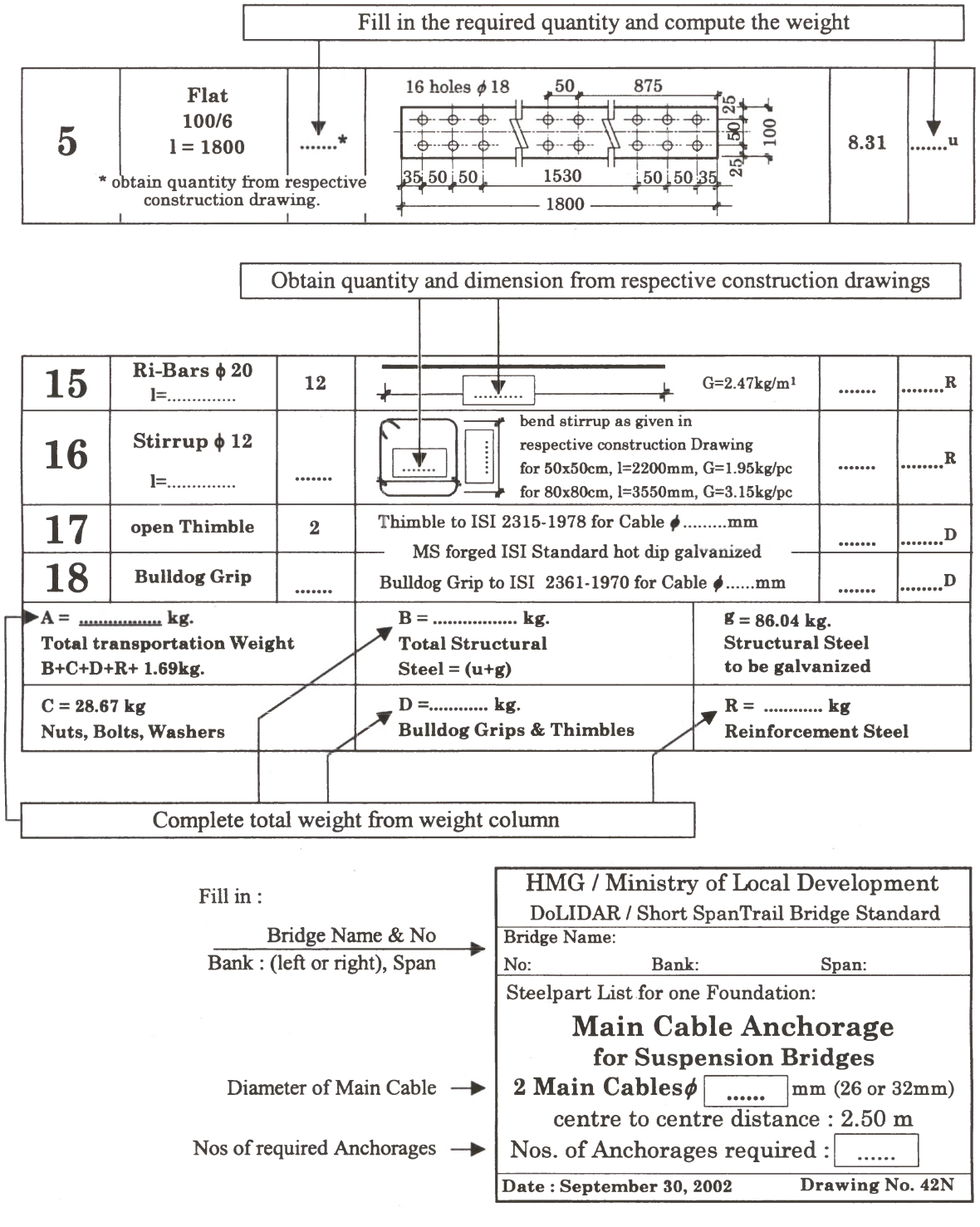
## 4.4 CONCEPT OF THE STANDARD DRAWINGS

**Steel Drawings**

Each drawing provides the necessary information and specifications for manufacturing the desired steel parts. The required quantity of steel parts has to be filled in the space provided in the title of the drawing.

Specific items such as reinforcement rods and flats for Main Cable Anchorages have to be filled in the empty spaces in the material lists.

**Example:**



From the total weights of each drawing, the grand total for each steel category has to be added up as follows:

**A :** Means the entire weight of the steel including galvanization to be transported to the site.

**B :** This is the total structural steel, raw or untreated **(u+g)**. This includes steel profiles, plates and flats but not reinforcement bars and other steel items.

**C :** This is the weight of the Nuts, Bolts and Washers (galvanized weight).

**D :** This is the weight of the Bulldog Grips or Thimbles and other items, if required (galvanized weight).

**R :** This is the raw weight of the Reinforcement Steel or Plain Rods. They are never galvanized.

**The Total Transportation Weight A = B + C + D + R**

**g :** The small g indicates the weight of the structural steel to be galvanized. This weight is part or can be the sum of the total structural steel (B), but it is not an additional weight.

The above distinctions have been made for quotation purposes because the price per kg (or piece) of the different items varies greatly. Reinforcement steel is usually much cheaper than structural steel; and nuts and bolts are much more expensive than structural steel, etc. The weight of the steel to be galvanized is necessary to obtain the price for galvanization **separately,** excluding the cost of the steel itself.

The steel drawings are usually not necessary at the construction site, but for assembly and identification of the steel parts, a copy of each steel drawing should be available. Also for maintenance at a later stage, copies of the steel drawings are useful.

**Construction Drawings**

The construction drawings are the actual site drawings. A complete set is absolutely necessary at the site.

- **Walkway Fitting Drawing for 106cm Walkway Width**
- **Main Cable Anchorages**

  For the Main Cable Anchorages, there are three main categories of drawings

  ⇒ Deadman Anchors for Flat Ground of up to 15° slope
  ⇒ Gravity Block Anchors for Hill Slopes of more than 15°
  ⇒ Drum Rock Anchors for Fractured or Soft Rock or Hard Rock

  With these three groups of Main Cable Anchorages, the optimal kind of anchor can be applied. The selection depends upon the prevailing Soil/Rock condition on the respective river banks and the number and diameter of the Main Cables.

- **Walkway and Tower Foundations**

  Depending on the Soil/Rock conditions the number of Main Cables and the required Block Height, Walkway and Tower Foundations are to be selected. There are five options for the two Main Cables with $c/c_1 = 2.50$m, and seven options for the four Main Cables with $c/c_1 = 3.50$m.

- **Windguy Cable Anchors**

  There are two categories of anchor types for anchoring the windguy cables.

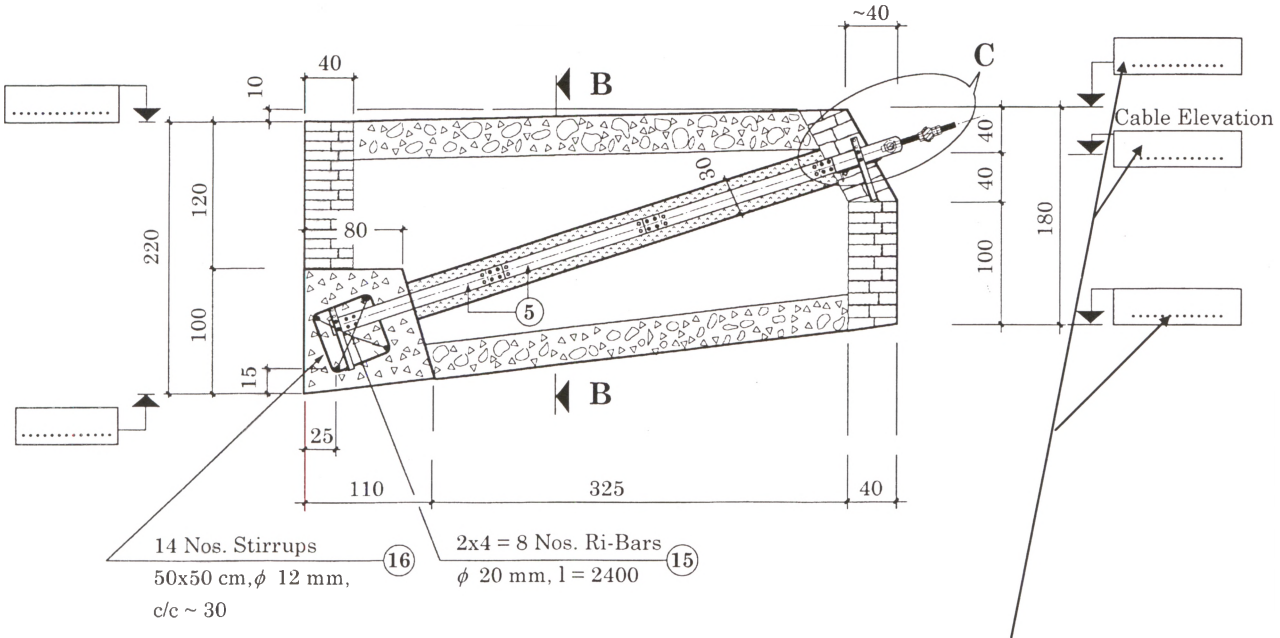
  ⇒ Gravity Block Anchors for different Soil/Rock conditions with variable Block Heights (five types)
  ⇒ Drum Rock Anchors for fractured or soft Rock or for hard Rock (two types)

All drawing types are complete designs and fulfill their respective parameters selected in the design form. Also, in all drawings, the necessary quantities of construction materials have already been calculated as far as possible. They have to be filled in their respective tables given in the cost estimate Form No. 3 or 4.

It is absolutely necessary to fill in the Elevations and Cable diameters as indicated in the drawings. The levels are to be determined in the topographic profile of the survey, whereas the cable diameter can be taken from the design form.

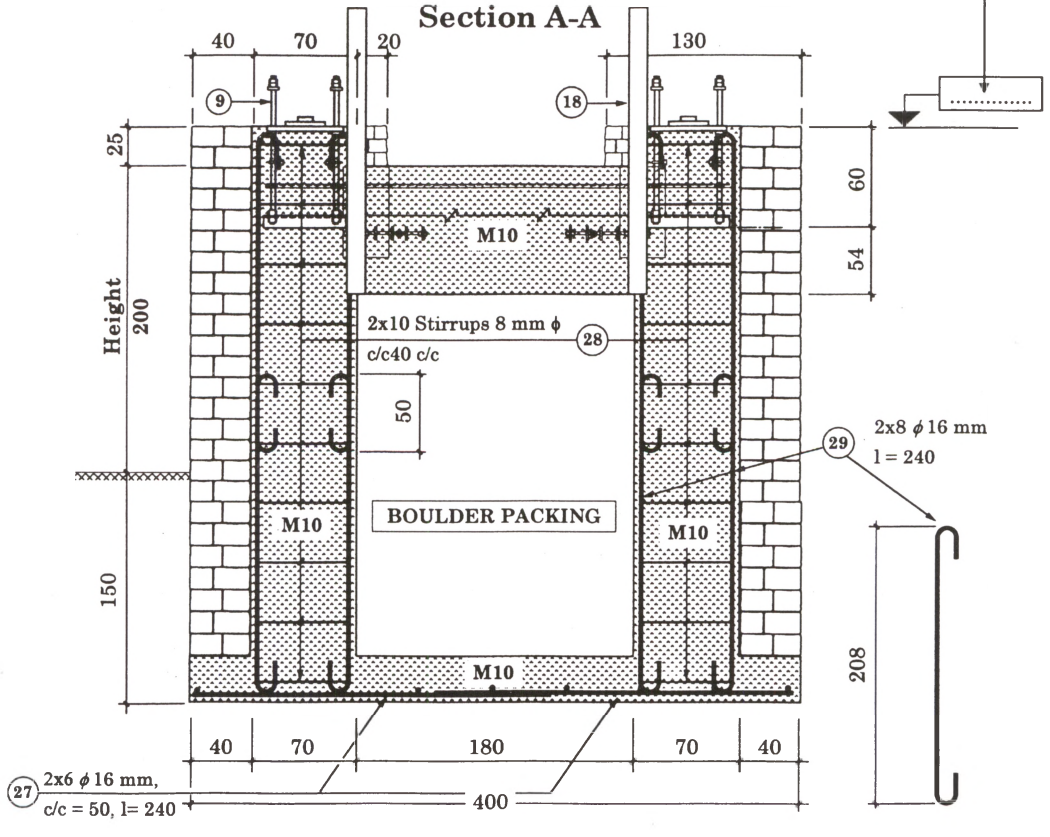
**Examples of Construction Drawings:**

**Main Cable Anchor Block:**




**Walkway and Tower Foundation:**

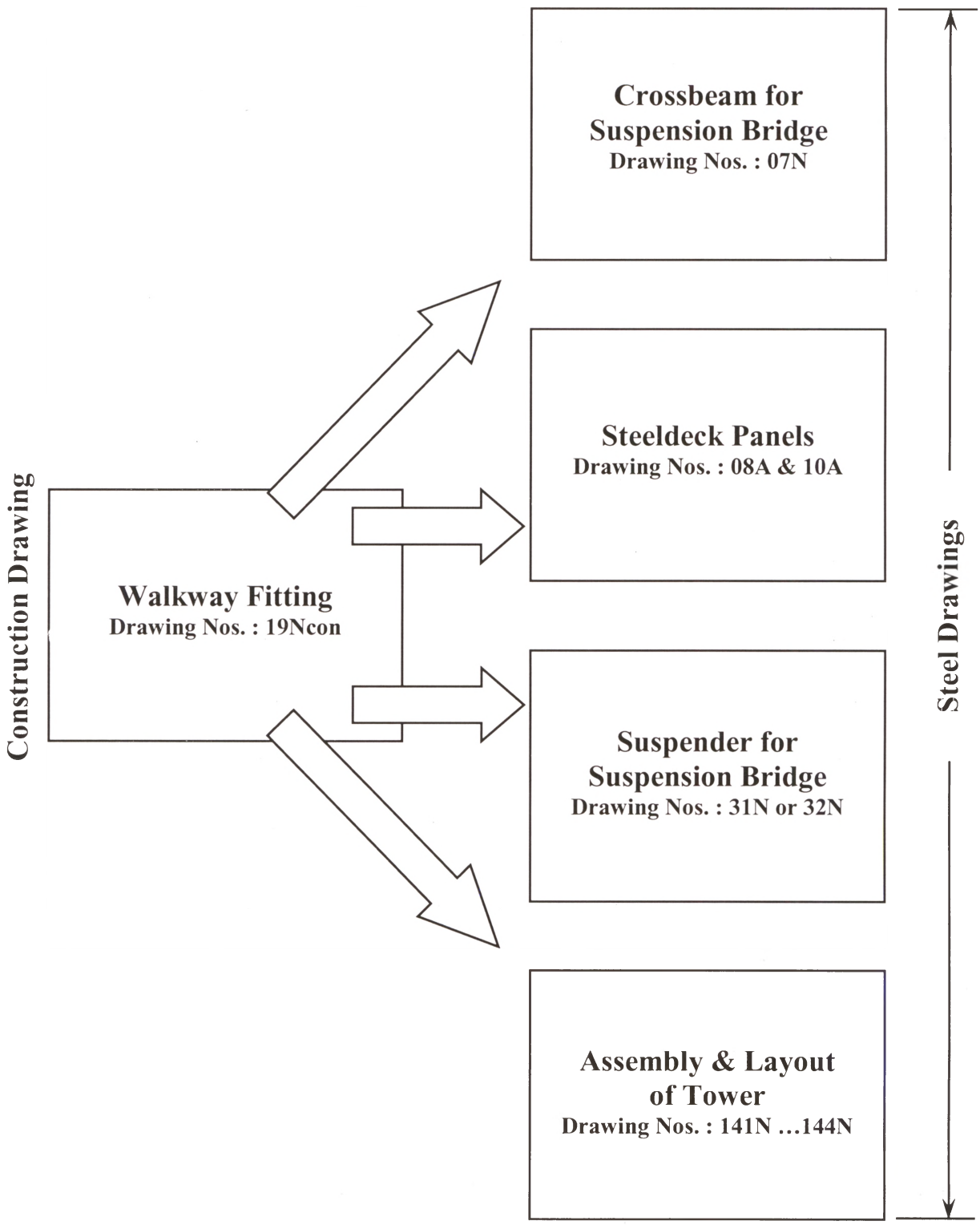
**Fill in all respective Elevations.**



## 4.5 Relationship between Construction and Steel Drawings

Each Construction Drawing has related Steel Drawings. Their respective related drawing numbers are mentioned on the drawing itself, and also the respective steel parts numbers are shown on the construction drawing for easy reference.

The Construction Drawings "Walkway Fitting", Nos. *19Ncon* show the elements of the superstructure of the bridge. The related Steel Drawings are the Steel Crossbeam, Steel deck, Suspender and Tower Drawings.



The Steel Drawings for the cable anchorages Nos. *42N, 44N and 50A* are related to the corresponding Construction Drawings Nos. *42/1Ncon...44/1Ncon*...and *55/1Acon*.

The Steel Drawings for the walkway and tower foundations Nos. *92N,* and *94N* are related to the corresponding Construction Drawings Nos. *92/1Ncon*...and *94/1Ncon*.

# 5. CALCULATION OF QUANTITY AND COST ESTIMATE

Calculation of quantities and cost estimate is required for the purpose of planning and implementation. The selected approach of implementation determines the methodology of calculating the quantities and the cost estimate. There are basically two approaches of implementation. These are:

- **Implementation by the Community**

☛ **Form No. 3**
**Quantity & Cost Estimate for Community Approach**

- **Implementation by Contractor through Public Tender**

☛ **Form No. 4**
**Quantity & Cost Estimate for Public Tender & Contracting**

Standard forms for calculation of the quantities and the cost estimate for both implementation approaches are presented in Volume II as Form No. 3 and Form No. 4. The methodology of calculating the quantities and preparing the cost estimate for the two approaches of implementation, and how to use the respective Forms is described in the chapter below.

## 5.1 IMPLEMENTATION BY THE COMMUNITY

Use Form No. 3: Cost Estimate (Mode of Execution: Community Approach).
To calculate the quantities and to prepare the cost estimate in Form No. 3, follow in sequence the procedure outlined below:

- **Quantity Calculation**

⇒ Calculate the quantities of the cables from Form No. 2: Cable Design. Fill in the Quantity Calculation Sheet of Wire Rope (Cables). This sheet will show the cable lengths of each diameter and the total weight of the cables.

⇒ Calculate the quantities of the Steel Parts and Steel Deck from the corresponding steel drawings. Fill in the Quantity Calculation Sheet of Steel Parts and Steel Deck.

⇒ Calculate the quantities of the Earth Works from the General Arrangement Drawing. Fill in the Quantity Calculation Sheet of Construction.

⇒ Calculate the quantities of other construction works from the corresponding Construction Drawings. Fill in the Quantity Calculation Sheet of Construction.

⇒ Prepare a list of construction materials according to the calculated quantities of construction works.

⇒ Calculate the transportation weights for cables and other construction materials not available locally.

⇒ Calculate the quantities of Works and Labor.

- **Rate Analysis**

Prepare the rate analysis for fabrication of steel parts, steel decks and road transportation (items of external support to the community) as per unit quantity, unit cost and standard norms.

- **Abstract of Cost**

Compute the abstract of cost of the bridge as per the quantities of works (from Quantity Calculation Sheets) and the rates (from Rate Analysis) for each item of works, and summarize the cost as per the category of works.

- **Summary of Estimated Cost**

⇒ **Bridge Cost:** Calculate the Estimated Bridge Cost by summarizing the Abstract of Cost.

Also calculate the bridge cost per m span.

⇒ **Contribution:** Estimate the expected contribution from different partners.

⇒ **Breakdown of the Contribution:**

Break down the contribution as Local Contribution and Outside Contribution.

- **Summary of Actual Cost**

In the majority of cases, the actual bridge cost will not be the same as estimated. Therefore, calculate the actual bridge cost after completion of the bridge.

## 5.2 Implementation by Contractor through Public Tender

Use Form No. 4: Cost Estimate (Mode of Execution: Contractor).

To calculate the quantities and to prepare the cost estimate in Form No. 4, follow in sequence the procedure outlined below:

- **Quantity Calculation**

⇒ Calculate the quantities of the cables from Form No. 2: Cable Design.

Fill in the Quantity Calculation Sheet of Wire Rope (Cables).

⇒ Calculate the quantities of the Steel Parts from the corresponding steel drawings.

Fill in the Quantity Calculation Sheet of Steel Parts and Steel Deck.

⇒ Calculate the quantities of the Earth Works from the General Arrangement Drawing.

Fill in the Quantity Calculation Sheet of Construction.

⇒ Calculate the quantities of other construction works from the corresponding Construction Drawings.

Fill in the Quantity Calculation Sheet of Construction

⇒ Prepare a list of construction materials according to the calculated quantities of construction works.

⇒ Calculate the transportation weights for cable and other construction materials not available locally.

- **Rate Analysis**

Prepare the Rate Analysis for all items of works as per unit quantity, unit cost and standard norms. The Rate Analysis should include all taxes and overheads of the contractor.

- **Abstract of Cost**

Compute the Abstract of Cost of the bridge as per the quantities of works (from Quantity Calculation Sheets) and the rates (from Rate Analysis) for each item of works. The Abstract of Cost should also include a contingency amount of 5%. This contingency amount will cover miscellaneous costs of the project.

- **Summary of Estimated Cost**

Calculate the Estimated Bridge Cost by summarizing the Abstract of Cost. Finally, also calculate the bridge cost per m span.

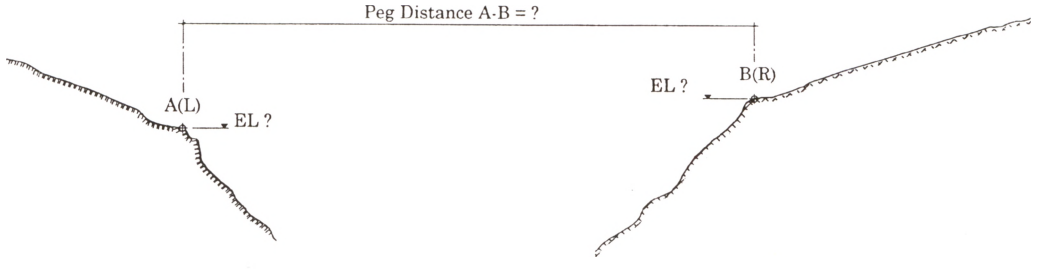
# 6. CONSTRUCTION

## 6.1 BRIDGE LAYOUT

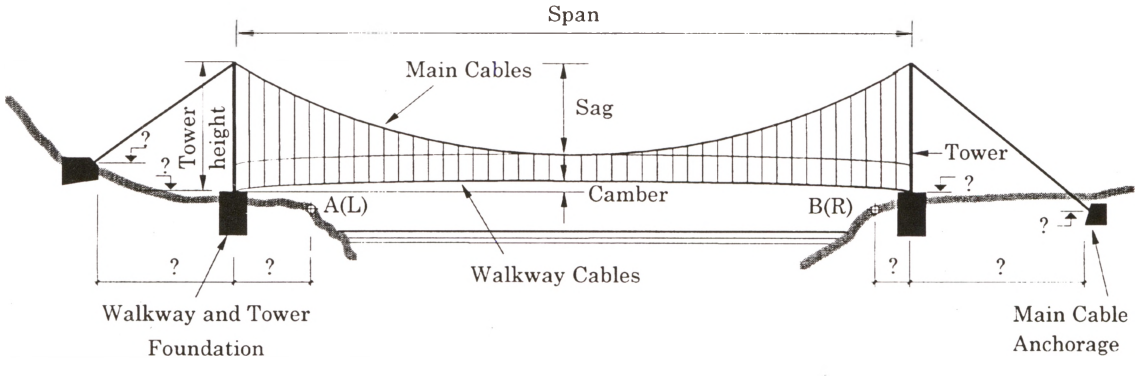
The Bridge Layout is to fix the bridge position and foundations at the site as per the design.

**Procedure for General Bridge Layout** (refer to General Arrangement 'GA' Drawing):

- Find the existing pegs and Bench Marks.
- Measure the horizontal distance between the axis pegs A (L) and B(R), and compare with the measurement given in the General Arrangement.
- Check the elevations of the axis pegs A (L) and B(R), and compare with the elevations given in the GA.

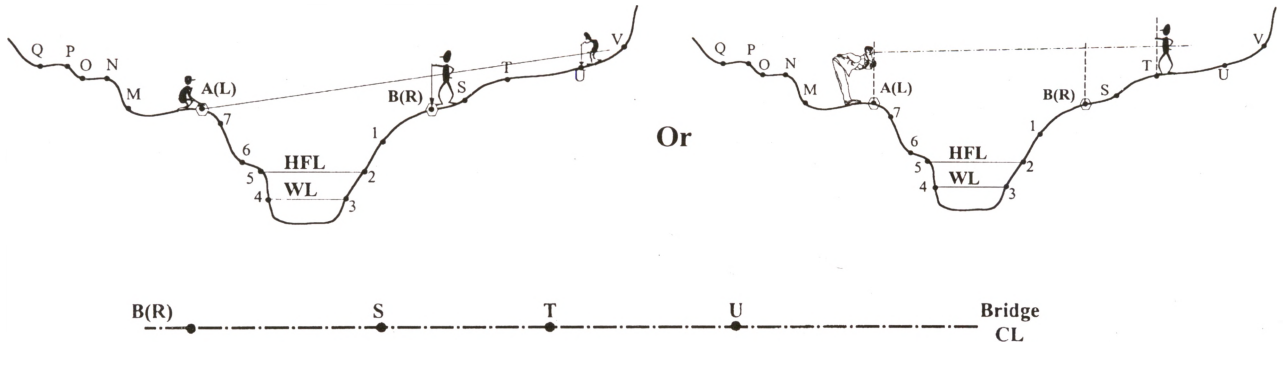



- If the horizontal distance between the axis pegs A (L) and B(R) and their elevations are not similar to the measurements given in the GA, readjust the design according to the actual measurements.
- If the horizontal distance between the axis pegs A (L) and B(R) and their elevations are identical to the measurements given in the GA, fix the position of all the foundation blocks as shown in the following sketch and procedure.




**Procedure for Detailed Foundation Layout:**

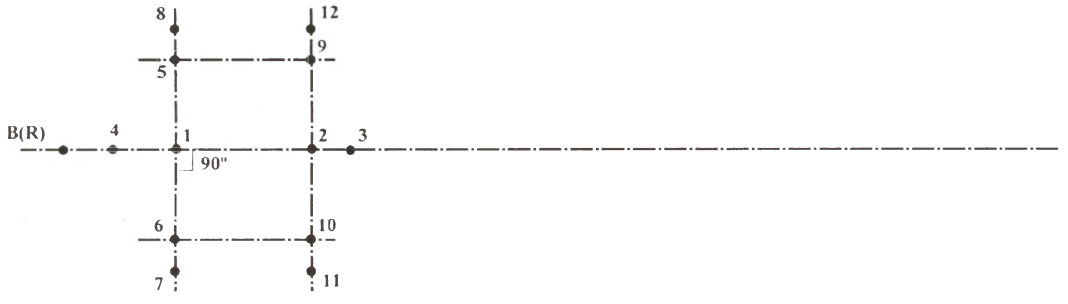
- Align the centerline of the bridge by joining the permanent points with mason threads or by ranging between the axis pegs 'A' and 'B' as shown in the following sketches.



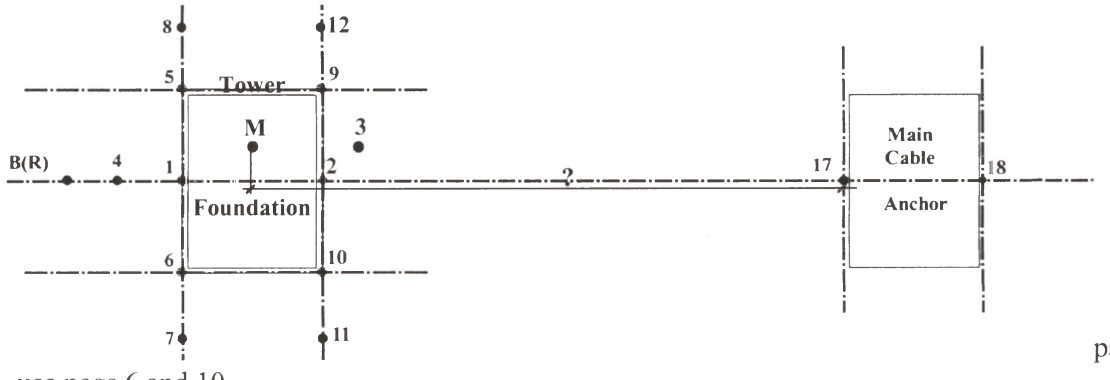
- Mark the front of the tower foundation on the bridge centerline (peg 1) with reference to the axis peg. The distance between the front of the tower foundation and the axis peg is given in the GA.

- Check the location of the front of the tower to ensure that it is at a sufficient distance (minimum 3m for soil slope and 1.5m for rock slope) from the bank edge. (Refer to Chapter 3.3.3).
- Measure the length of the foundation from peg 1 and fix peg 2. Set up two additional centerline pegs at a safe distance for the excavation works (pegs 3 and 4).

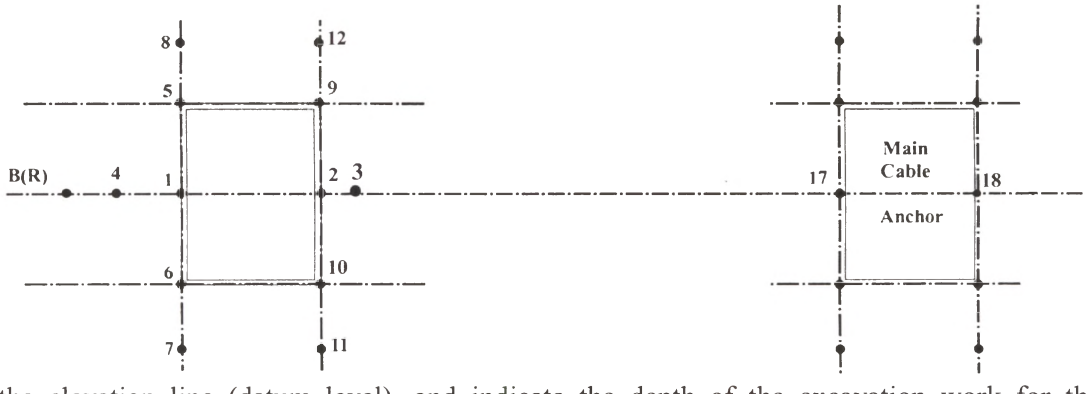
- Draw an offset line (right angle) through pegs 1 and 2 by the 3-4-5 method (refer to Chapter 2.5.4). Starting from peg 1, set out pegs 5, 6, 7 and 8 for the reference line of the front edge, and from peg 2 for pegs 9, 10, 11 and 12 for the back edge of the tower foundation.




- Determine the center point of the tower foundation and measure the distance between the tower axis and the front of the main cable anchor and fix peg 17. Draw an offset line through peg 17 as a reference line of the front edge. Set up one additional centerline peg at a safe distance behind and proceed as above.




- Dete pstream edge, use pegs 6 and 10.




- Fix the elevation line (datum level), and indicate the depth of the excavation work for the tower foundation and the main cable anchor as per the elevations shown in the GA and Anchorage Drawings.

## Setting out Windguy Cable Anchorages

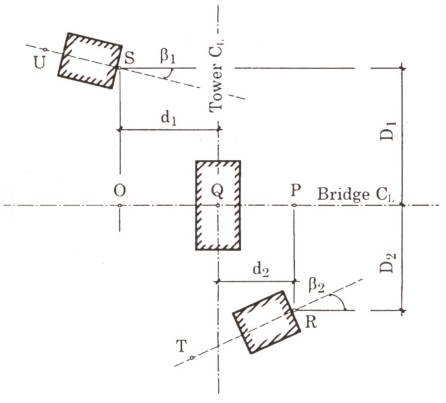
In the General Arrangement, the location of the windguy cable anchorages is usually given in reference to the tower and bridge centerline: $D_1$, $d_1$, $D_2$, $d_2$.
The correct direction is given by the angles $\beta_1$, $\beta_2$.

**Plan:**

**$D_1$, $D_2$** = Distances measured from the bridge axis to the front (centerline) of the windguy cable anchorage block.

**$d_1$ $d_2$** = Distances measured from the tower centerline to the front of the windguy cable anchorage block.

**$\beta_1$, $\beta_2$** = Angle between the windguy cable and the direction of the bridge centerline.




**Procedure:**

- Measures the distances $d_1$ and $d_2$ from point Q along the bridge centerline, peg out points O, P.
- Set up the theodolite at O and P and measure the distances $D_1$ and $D_2$ perpendicular to the centerline of the bridge, peg out points R and S.
- Set up the theodolite at R and S and set out reference lines R - T, S - U.

  $\sphericalangle$ PRT $= \beta_2 + 90^o$ ($\beta_2 + 100^g$)

  $\sphericalangle$ OSU $= \beta_1 + 90^o$ ($\beta_1 + 100^g$)

  Peg out points T and U. The reference lines R - T and S - U are the centerlines of the windguy cable anchorages.
- Check if the ground levels at points S, U, R and T correspond approximately to the layout given in the General Arrangement.

If the ground levels are correct:

- Set out the windguy cable anchorage blocks in the same way as for the Main Anchor Foundation.

## Setting out Windguy Cable Anchorages in Case of Obstacles

If it is not possible to set out the windguy cable anchorages, according to the above procedure due to obstacles (rock, trees, etc.), it can also be done by using other points like R' and S'.

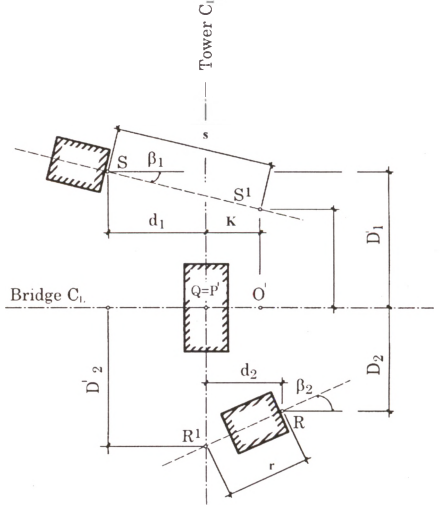
**Plan:**

$$D'_1 = D_1 - (d_1 + k) \cdot tg\beta_1$$

$$D_2' = D_2 + d_2 \cdot tg\beta$$

$$s = \frac{d_1 + k}{\cos \beta_1}$$

$$r = \frac{d_2}{\cos \beta_2}$$



**Procedure:**

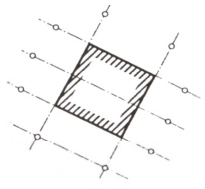
- Choose points P' and O' and measure the distance k from the tower centerline to P' and O'.
- Set up the theodolite at O', and measure the distance $D'_1$ and $D'_2$ perpendicular to the centerline of the bridge and determine R' and S'.
- Set up the theodolite at R' and S' and set out reference lines R' - R and S' - S.

Measure the distances r, s and peg out points R, S.

**Notes:**

- The points O', P' can also be at the river bed if it will facilitate setting out the reference lines.
- Reference lines for the windguy anchorages are to be set out in the same way as employed for the main anchorages.

A bench mark should be set up for checking the elevation.



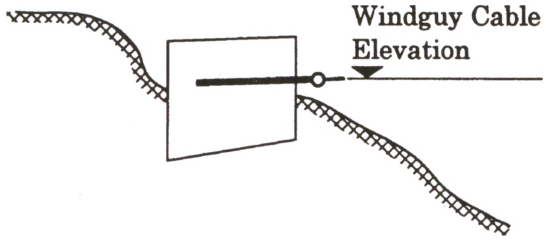
**Setting out Windguy Cable Anchorages in Case of Incorrect Survey**

In some instances, the elevation of the ground near the windguy anchorages may not coincide with the General Arrangement. In such cases, the layout of the anchorage block position can be revised at the site.

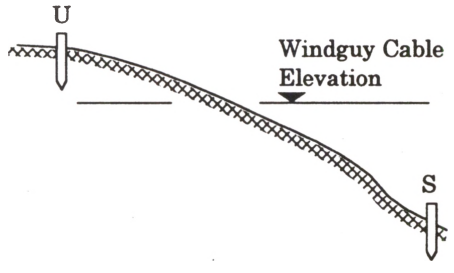
Proceed as follows:

1. Prepare a new profile drawing along the reference lines R - T and S - U and indicate the windguy cable elevation according to the General Arrangement (first phase).
2. Relocate the windguy cable anchorage block in such a way that its position in relation to the ground is similar to the layout given in the General Arrangement (second phase).
3. Draw the new location of the anchorage block in the profile drawing and transmit the data to the design office which will prepare a revised design.
4. Make sure that the windguy cable is still long enough.

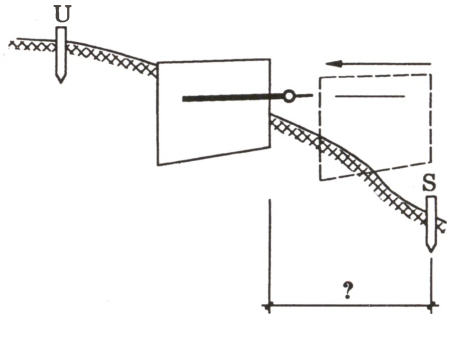
**Layout as per General Arrangement :**




**1st PHASE :**




**2nd PHASE :**



## 6.2 FOUNDATION EXCAVATION

### In Soil:

The foundations should be excavated with slopes to provide stability in the cut slope. The cut slope in soil should generally not exceed 3:1 (V:H). The foundations should be excavated stagewise. Trenches should be excavated vertically with sheeting, or must be banked with slopes which afford the necessary stability.

All safety requirements for the protection of personnel during excavation must be met.

**Slope Pitch**

- in well consolidated stable ground, maximum slope pitch 3:1 (3m vertical, 1m horizontal)
- in moderately consolidated but stable soil, maximum slope pitch 2:1 (2m vertical, 1m horizontal)
- in non-cohesive ground, maximum slope pitch 1:1 (1m vertical, 1m horizontal)

If slope stability is impaired by unfavorable strata morphology, artesian water, intermediate friction layers, vibration, etc. the slope pitch must be reduced.

> The most important point to be borne in mind during excavation is the fact that almost every bridge foundation bed is inclined. It is not allowed to excavate horizontally and form the incline with fill material!

To ensure that the foundation bed is clean and undisturbed, the bottom 10cm should be excavated only shortly before the concrete is poured.

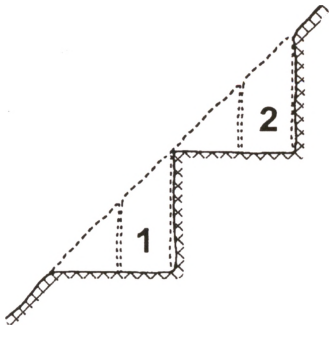
During all excavation stages, the excavation depth should be accurately maintained. For this, establish an elevation line (datum level) and measure the foundation depths with fixed sticks.

All the excavated soil should be safely disposed of without damaging the existing vegetation down hill, thus not affecting the environment.

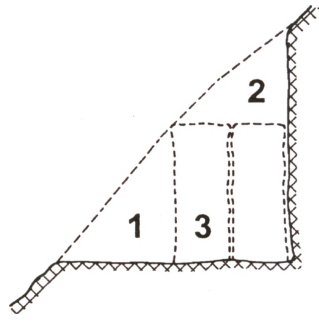
### In Rock:

Rock excavation is necessary to prepare the platform for a drum anchorage or for a rock block anchorage. The rock should be excavated manually without blasting.

Excavation in rock is done by first drilling holes to weaken the rock, and then using crowbars to break it up and dig out the pieces. The cutting can be carried out by forming steps, as shown in the following sketches.




1st Stage

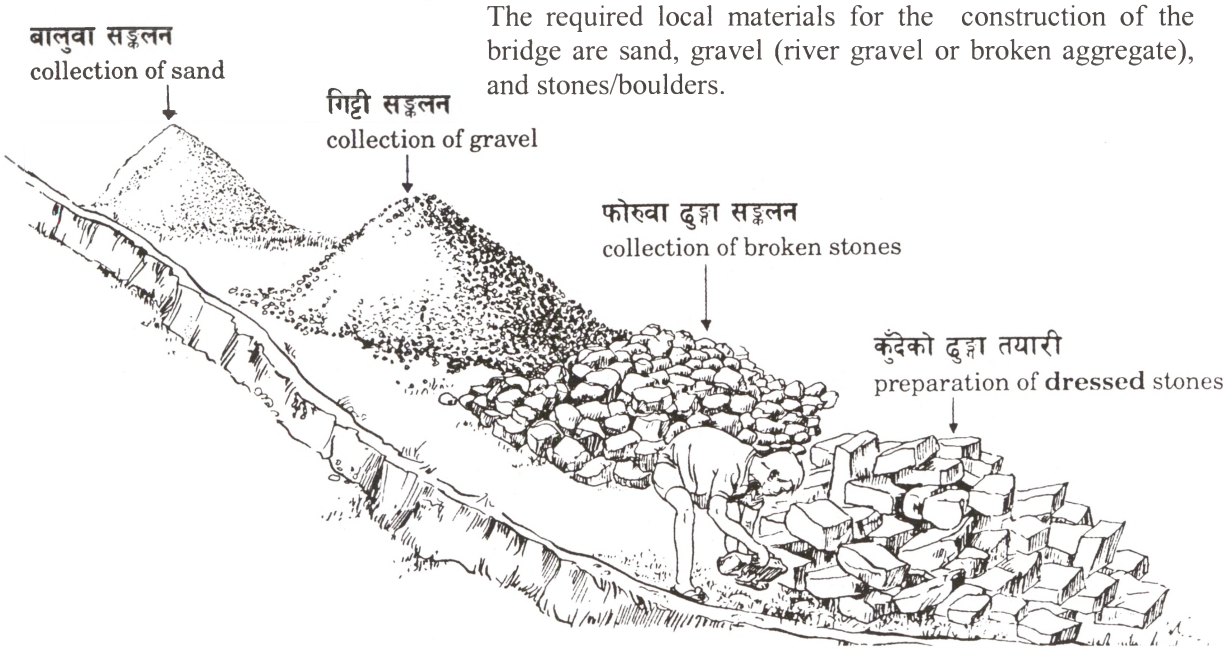



2nd Stage

Further details about drum anchorage foundation in rock is given in Chapter 6.6.4.

## 6.3 LOCAL MATERIAL COLLECTION

The required local materials for the construction of the bridge are sand, gravel (river gravel or broken aggregate), and stones/boulders.




### 6.3.1 STONES/BOULDERS

The best stone collection is from a rock quarry. The rock should be unweathered, hard and dense with a metallic sound.

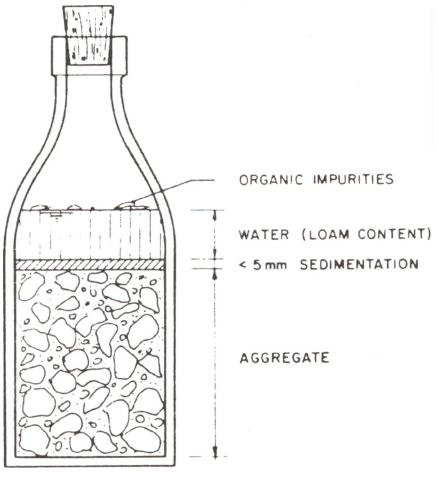
In unavoidable cases, boulders from river deposits can also be collected. However, this can be used only for filling purposes (broken stone filling). In any case, stones from a rock quarry are necessary for the masonry works.

The quality requirements for stones/boulders are further detailed in Chapter 6.5.1.

### 6.3.2 SAND

Sand can be collected from river deposits or from a quarry. The quality of the sand should be assessed before collection. Check the sand visually for impurities such as mica, clay, loam, mud organic materials, etc. If such impurities are unavoidable, it is recommended that the sand be washed before use. Sand containing significant quantities of mica should be rejected. The grain size of the collected sand should not be too fine.

Fill a bottle with sand and water and shake vigorously, and leave to settle. If the sand is clean, the sedimentation will be less than 5mm after two hours. And the water above will only be slightly cloudy.




The quality requirements for sand are further detailed in Chapter 6.6.1.

### 6.3.3 GRAVEL

Gravel can be collected from river deposits or by breaking boulders into the necessary size. The required sizes and their proportion should be

5 to 20mm - 40%
20 to 40mm - 60%

Gravel should be of hard rock origin. Gravel of unsuitable rock such as mica, marl and sandstone should be rejected. Likewise, flat and flaky particles should also be rejected. The collected gravel should be free from organic contaminants like clay, loam, mud or stone dust, etc.

The quality requirements for gravel are further detailed in Chapter 6.6.1.

## 6.4 TRANSPORTATION AND STORAGE OF THE MATERIALS

Materials other than local materials have to be transported from the roadhead to the site by porter or other means. These materials are mainly Cement, Steel Parts and Wire Ropes.

### 6.4.1 CEMENT TRANSPORTATION AND STORING

Utmost care should be taken during transportation and storage of the cement. The prime importance is the proper packing of the cement before transportation to make it watertight and airtight. For this, cement bags as received from the market or factory should be double packed by additional packing in Nylon Bags with a plastic layer inside. Re-opening the bags (especially when transporting by mules) is not permitted before use at the site.

The following rules must be observed while storing the cement:

- Cement must always be stored under a roof with adequate protection from rain. A raised plank floor is necessary to protect the cement from damp.
- Storage must be arranged in such a way that the oldest batch can be used first.

### 6.4.2 STEEL PARTS TRANSPORTATION AND STORING

There is a great chance of damage to steel parts during loading/unloading and transportation. The most common types of damage are:

- Deformation of tower parts, suspenders or steel decks due to mishandling during loading and unloading.

  All the steel parts should be loaded and unloaded carefully to avoid such damage. Do not allow steel parts to fall from a height.

  Similarly, the following rules must be observed while transporting and storing the steel parts to avoid any damage.

  - Galvanized **and** non-galvanized steel parts must always be stored under a roof with adequate protection from rain, and they should not be in contact with the ground.
  - Galvanized steel parts should not be transported or stored together with salt or acid.
  - Steel parts should be stacked and stored element/component-wise by avoiding mixing up the different elements. This way, any element or component can be easily located during the erection of the bridge.
  - All fixtures (nuts/bolts, washers, thimbles and bulldog grips) should be packed/marked and stored separately according to their sizes.
  - Steel parts, particularly suspenders and reinforcement bars, should not be bent during carriage and storage.

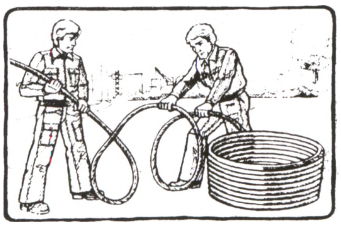
### 6.4.3 WIRE ROPE TRANSPORTATION AND STORING

It is vital to handle and transport the cables carefully in order to avoid causing any damage like kinks, splices and broken strands. Some examples of damage caused to cables due to mishandling and improper transportation are shown in the photographs below.

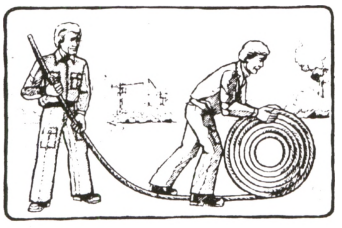
Also pulling or dragging the cable along the road during transportation is not permitted.

To avoid such harm, follow the handling and transportation methods as described below.

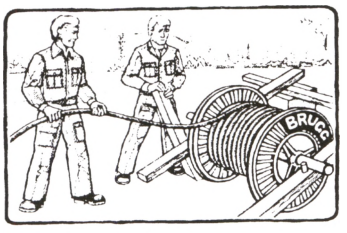
- **Method of Unreeling Light Cables with the Help of a Reel Support**



Wrong

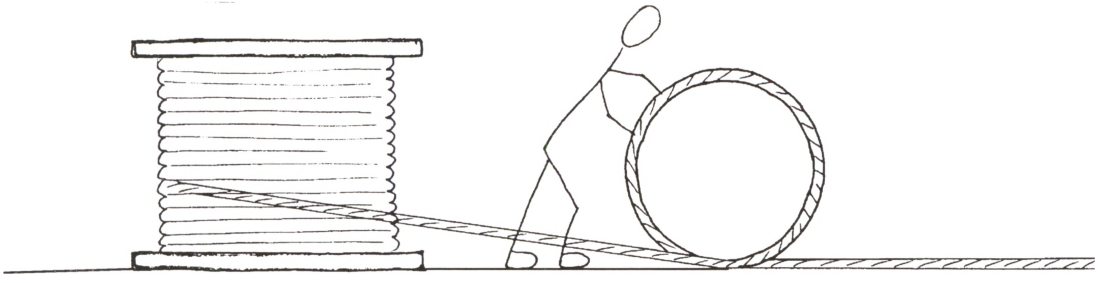


Correct

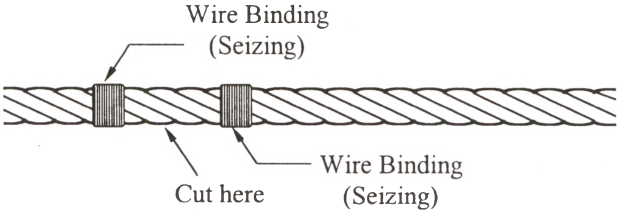



Correct

- **Method of Unreeling Cables by Unrolling Each Loop Taken from the Reel.**



Before cutting the cable, ends should be secured by a binding-wire (seizing) as shown in the following sketch to avoid loosening of the cable wires.



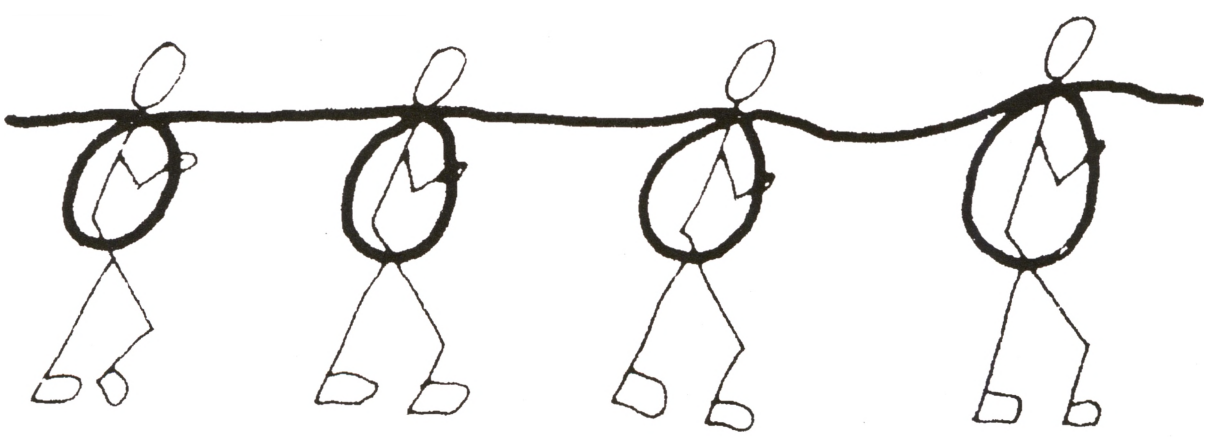

- **Method of Transportation by Porters**

There are mainly two methods of transporting cables as illustrated in the following photos.

Transporting a cable on the Shoulder (for short distances).

Bundled Cable Transportation (for longer distances)

Transporting cables as shown in the sketch below is wrong and should not be practiced.



Wrong method of cable transportation.

## 6.5 MASONRY AND STONE DRESSING WORK

### 6.5.1 REQUIREMENTS FOR BUILDING STONES

Building stones must be of high strength, density and durability. A good building stone should be hard, tough, compact grained and uniform in texture and color.

Crystalline stones are superior to non-crystalline stones. Metamorphic rocks are more durable than sedimentary rocks. Sedimentary rocks have been formed by water sediments of clay, sand or gravel, which got cemented together by lime, silica etc. Originally metamorphic rocks were either of volcanic or sedimentary origin, but have subsequently been formed and shaped by movements of the earth's crust imposing high pressure and heat.

A good building stone absorbs no or very little water and must be free from decay, cracks and sand-holes.

### 6.5.2 QUARRYING

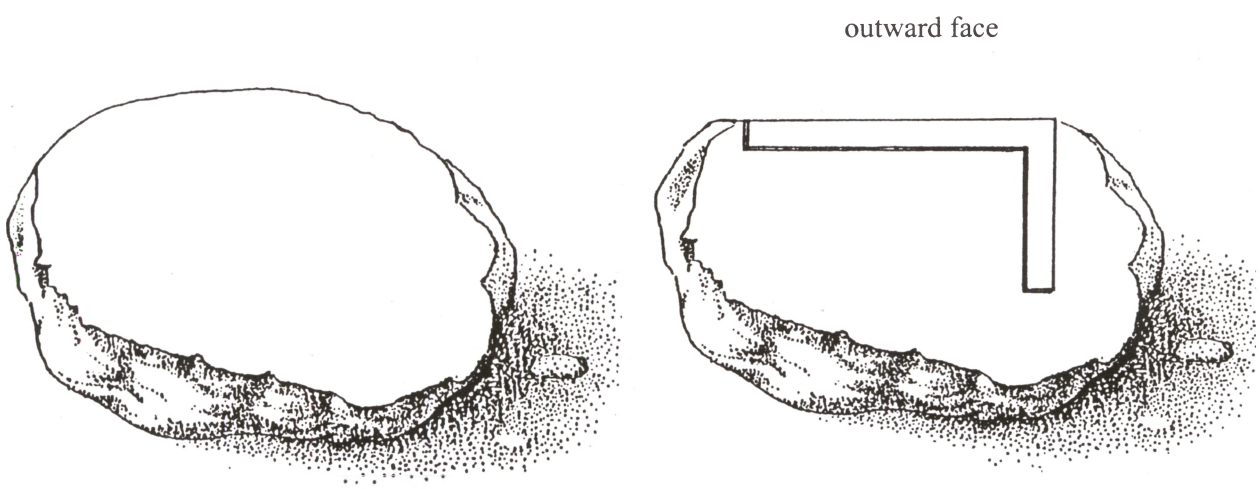
Rocks for stone masonry works should be broken from a quarry using crowbars and wedges. Natural fractures and bedding planes of stratification are the weak features of the rock. These natural joints make it convenient to break and separate one block from another.

It is advised that only when natural joints do not exist that artificial fissures be made by drilling a line of holes in rows along the desired breaking line. By inserting conical wedges and driving them in succession with a hammer the rock will crack along the face of the holes.

However it is generally worthwhile to search for quarries with existing natural joints like dominant bedding planes, since the broken stones are much easier to dress.

Boulders fallen from rocky slopes can also be used as building stones.

**Building stones** are first dressed to obtain two parallel planes, then the outward faces are dressed well with the help of a square bottom as shown below.




Stones from riverbeds are generally very hard and durable, and can be used as filling stone, but are not suitable for stone dressing.

### 6.5.3 STONE DRESSING

Broken stones from the quarry should be dressed with a hammer and chisel to the required sizes. Depending on the **function** of the stone in stone masonry construction, the following types of stones have to be prepared:

- **Corner Stone:** Corner stones are placed at each corner of the stone masonry structure.

  The recommended sizes are:

  | | | |
  |---|---|---|
  | Length | : | 30 - 85 cm |
  | Width | : | min. 30 cm |
  | Height | : | min. 10 cm |

- **Face Stone:** Only one face of this stone faces the outside; the recommended sizes are:

  | | | |
  |---|---|---|
  | Length | : | 30 - 75 cm |
  | Width | : | min. 30 cm |
  | Height | : | min. 10 cm |

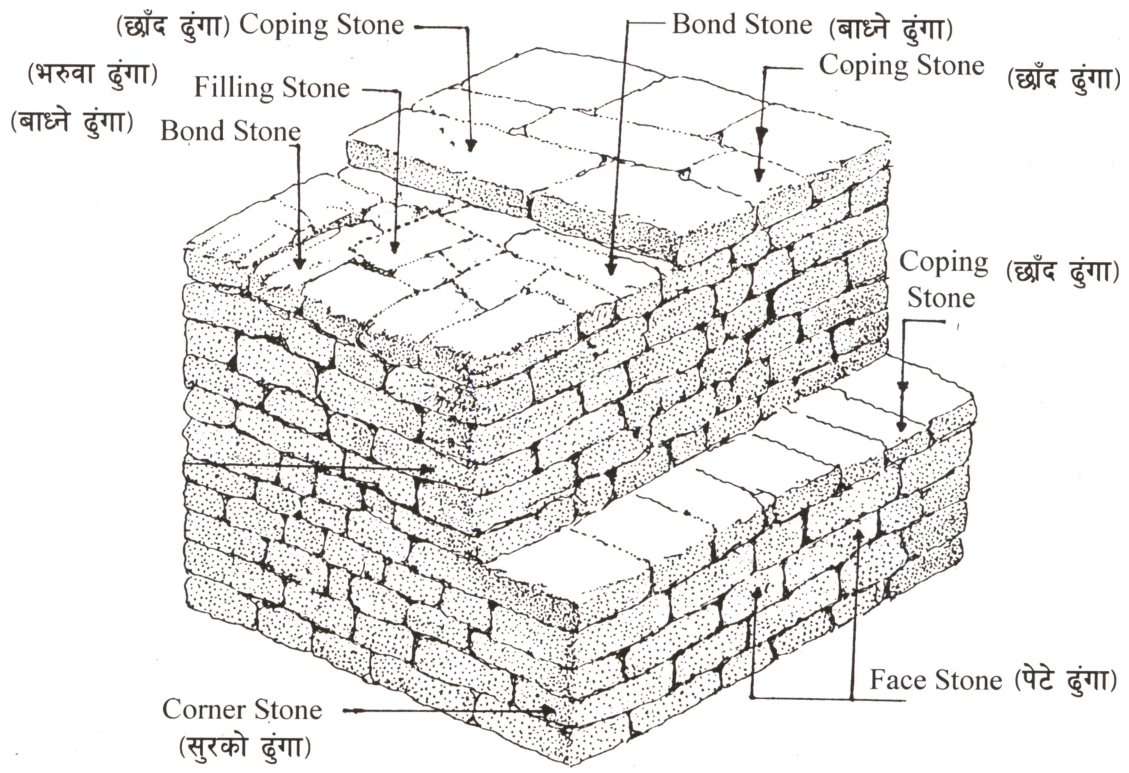
- **Bond Stone:** Like the face stone, only one face shows outside, but it extends to the interior of the structure. Bond stones, also called **through stones,** go right through walls of up to 85 cm thickness or more. The recommended sizes are:

  | | | |
  |---|---|---|
  | Length | : | 45 - 85 cm |
  | Width | : | min. 30 cm (face side) |
  | Height | : | min. 10 cm |

- **Coping Stone:** Coping stones are put on top or at the steps of stone masonry structures. They should be larger and heavier than the stones below:

  | | | |
  |---|---|---|
  | Length | : | as large as possible |
  | Width | : | as large as possible |
  | Height | : | min. 10 cm |

- **Filling Stone:** Filling stones do not need to be dressed and are placed inside the stone masonry structure mainly to gain gravity load.



### 6.5.4 STONE MASONRY LAYING

There are many different kinds of stone masonries. For constructing anchor blocks and towers, only **coursed** (in layers of equal height) stone masonry is applied.

There are two types of stone masonries used for bridge construction:

- **Coursed Random Rubble Stone Masonry**

  The stones are hammer-dressed, except the inside face. The gaps between the beds and the joints shall not exceed 12 mm.
  All **Face Stones** tail into the wall twice their height.

  **Bond Stones** running right through the wall are inserted at 150 cm intervals at the least.

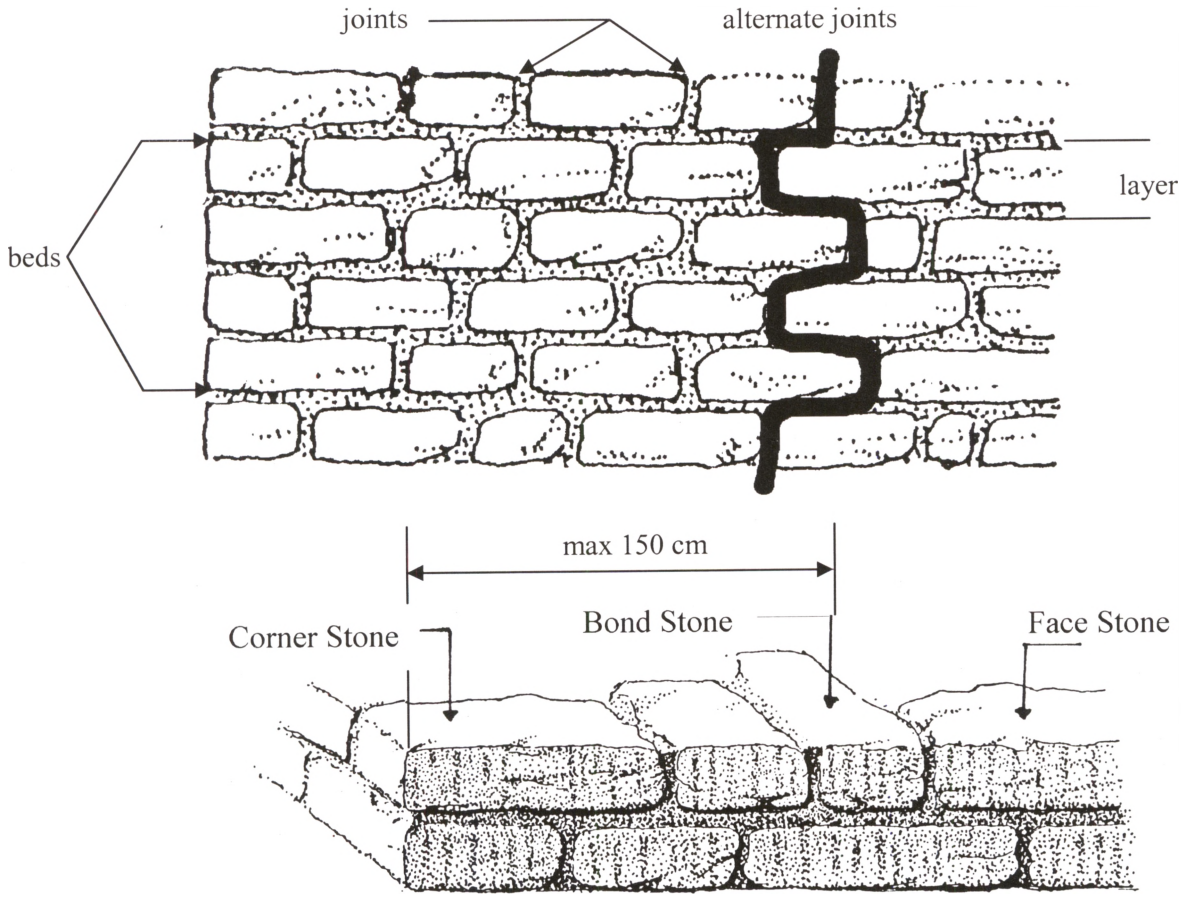
- **Coursed Block Stone Masonry**

  The stones are chisel-dressed at all faces, except the inside face. The joints are dressed at right angles to the face. The gaps between the beds and the joints should not exceed 6 mm.

  All **Face Stones** tail into the wall twice their height.

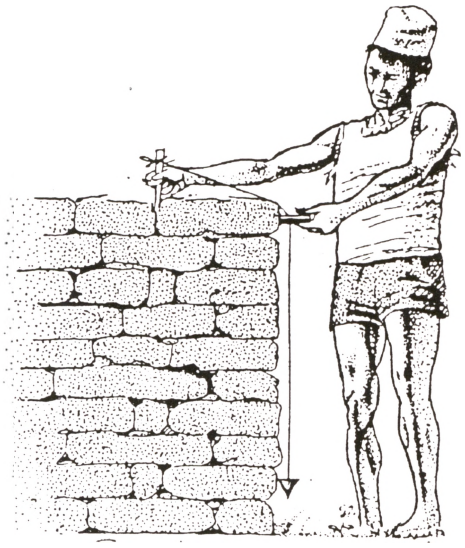
  **Bond Stones** running right through the wall are inserted on each course at 150 cm intervals at the least.

Course Stone Masonry must be made in **layers** of equal height. Individual layer heights may vary, but should never be less than 10 cm. **Alternate** joints should be made between the layers above and below as shown in the following sketch.

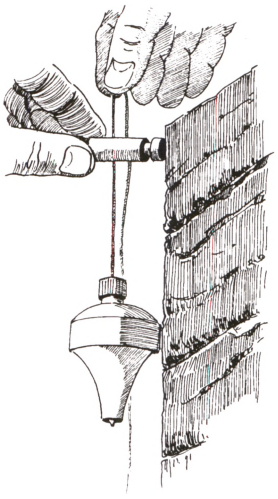



In a reasonably well-made stone masonry, the inner friction between the beds amounts to approximately 35°.

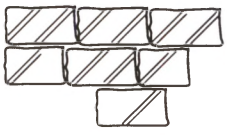
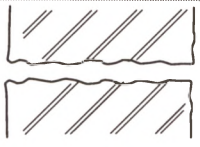
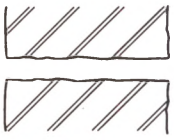
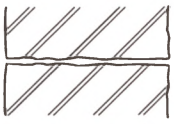
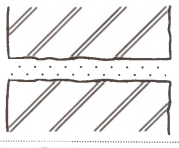
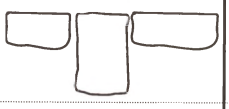
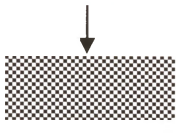
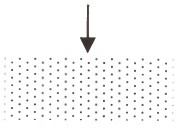
The verification of the corners and faces has to be done carefully with a plumb-bob.



Correct use of plumb-bob



The **Strength** of stone masonry structures depends mainly on the qualities described in the table below.

| **...bigger...** | **The Strength of Stone Masonry is...** | | | **...smaller...** |
|---|---|---|---|---|
| ...with rectangular stones. | | **Form or Shape** | | ...with irregular stones. |
| ...the less stones are used. | | **Number** |  | ...the more stones are used. |
| ...the rougher the joints are. |  | **Roughness of joints** |  | ...the smoother the joints are. |
| ...the smaller the beds are. |  | **Bed** |  | ...the bigger the beds are. |
| ...the more compact the stones are. | | **Height & Width** | | ...the slimmer the stones are. |
| ...the better the bond across is. |  | **Bond Across (in plan view)** | | ...the worse the bond across is. |
| ...the higher the strength of the mortar is. |  | **Strength of Mortar** |  | ...the lower the strength of the mortar is. |

## 6.6 CEMENT WORKS

### 6.6.1 COMPOSITION AND MIXTURES

Cement concrete is a mixture of the following four components:

- **Cement**

  Ordinary Portland Cement commonly used for general construction works.

- **Sand**

- **Gravel**

- **Water**

**Cement** is very sensitive to humidity and moisture; therefore it should never be stored for a long time. In the rainy season, cement bags have to be packed in additional sealed plastic bags plus additional nylon bags for protecting the cement against water and damage.

**Sand** should be clean, sharp, angular, hard and durable. Sand must be well washed and cleaned of mud or any organic material before use. A well-graded sand should be used for cement works. All or most of the sand should pass through a 3 mm sieve or mesh wire. However, it should not be too fine, only 15% of the sand at the most can be smaller than 150 microns, which is like dust.

**Gravel** should be clean, hard, angular and non-porous. Usually riverside gravel makes the best aggregate for preparing concrete. The corn size of gravel should be smaller than 40 mm (1½ inches) but bigger than 5 mm.

**Water** from rivers or lakes is usually suitable for making cement mixtures. Do not use water from ponds or swamps, it may contain a lot of organic materials.

The main characteristics of any cement work is given by the mix proportions of their components:

- **Cement Mortar = A mix of Cement and Sand**

- **Cement Concrete = a mix of Cement, Sand and Gravel**

Of course, **Water** is added in both cases, but the mix proportions of cement, sand and gravel give the main characteristics of any cemented work.

**Mixing** the above components thoroughly is of utmost importance. Hand mixing should be done on a clean watertight platform. Cement and sand should first be mixed dry, and then gravel added. Now the whole mixture should be turned over three times dry. Then mixing should take place for at least five minutes by slowly sprinkling water until the concrete is of a uniform color.

The table below depicts the most commonly used mix proportions and required quantities:

**Quantities for various Types of Cement Works**

| Type of Cement Work | Mix. proportions | | | Dry required quantities for **one cubic meter** wet: | | | | |
|---|---|---|---|---|---|---|---|---|
| | **Cement** | **Sand** | **Gravel** | **Cement bags @ 50 kg** | kg | **Sand** [$m^3$] | **Gravel** [$m^3$] | **Stones** or **Boulders** [$m^3$] |
| **Cement Mortars** | 1 | 1 | - | 20.4 | 1020 | 0.71 | - | - |
| | 1 | 2 | - | 13.6 | 680 | 0.95 | - | - |
| | 1 | 3 | - | 10.2 | 510 | 1.05 | - | - |
| | 1 | 4 | - | 7.6 | 380 | 1.05 | - | - |
| | 1 | 6 | - | 5.0 | 250 | 1.05 | - | - |
| **Cement Plaster** (20 mm includes 12% waste) | 1 | 4 | - | 0.18 | 9 | 0.024 | - | - |
| | 1 | 6 | - | 0.12 | 6 | 0.024 | - | - |
| **Cement Stone Masonries** | 1 | 4 | uncoursed stone masonry | 2.66 | 133 | 0.37 | - | 1.1 |
| | 1 | 6 | | 1.75 | 87.5 | 0.37 | - | 1.1 |
| | 1 | 4 | coursed stone masonry | 2.28 | 114 | 0.32 | - | 1.1 |
| | 1 | 6 | | 1.50 | 75 | 0.32 | - | 1.1 |
| **Cement Concretes** (plain or reinforced) | 1 | 4 | : 8 | 3.4 | 170 | 0.47 | 0.94 | - |
| | 1 | 3 | : 6 (M10) | 4.4 | 220 | 0.47 | 0.89 | - |
| | 1 | 2 | : 4 (M15) | 6.4 | 320 | 0.45 | 0.85 | - |
| | 1 | 1½ | : 3 (M20) | 8 | 400 | 0.42 | 0.84 | - |
| **"Plum" Concrete** | 1 | 3 | : 6 with 50% boulders | 2.64 | 132 | 0.28 | 0.54 | 0.50 |

*Source: Indian Practical Civil Engineers' Handbook, Section 20*

The amount of **Water** should be about half the volume of cement. One 50-kg bag of cement has a volume of approximately 35 liters, which is equal to approximately two kerosene tins.

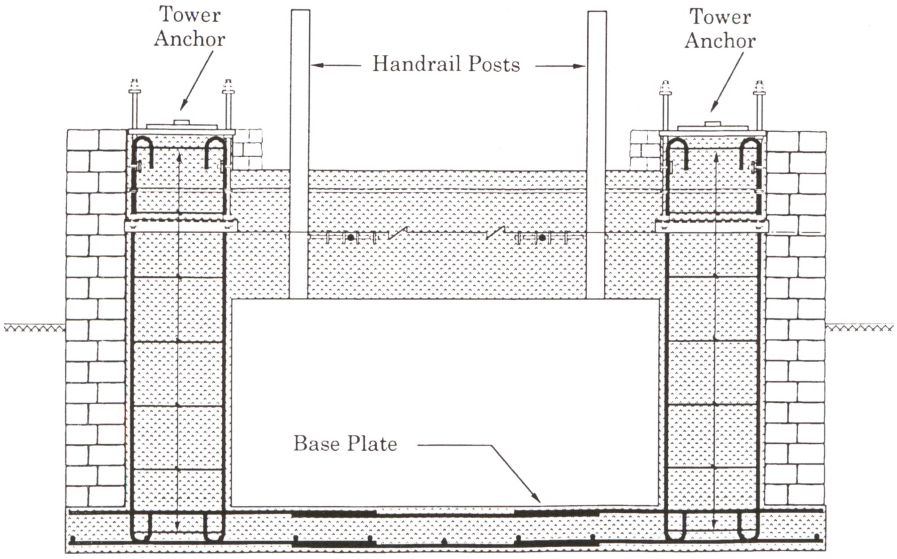
**Concrete** and **Mortar** should be placed in its final position within one hour. After placing, it should be well compacted with the help of rods in order to remove any air pockets. For concrete of high quality, good compaction is essential. This may mean extra work during placing, but on no account should more water be added for reducing the compacting work. Concreting should never be done if it is raining.

**Curing** means keeping completed cement works wet until the setting process is completed. If concrete works are not kept continuously wet during the setting process, cement mortar, cement stone masonry work and especially concrete do not develop their full strength. Curing should be done for at least 28 days.

For increasing the strength of concrete, ribbed Tor-Steel bars are added which makes Reinforced Cement Concrete or RCC.

### 6.6.2 TOWER AND WALKWAY FOUNDATIONS

The tower and walkway foundations are built for providing a safe base for the towers and for the firm anchoring of the spanning cables, fixation cables and handrail cables. This structure also stands for the bridge entrance.

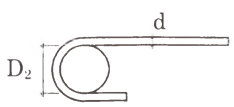


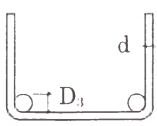

For this structure, the proper and precise placing of the reinforcement bars is very important. The bars usually come pre-bent from the workshop, but can also be bent at the site if required.

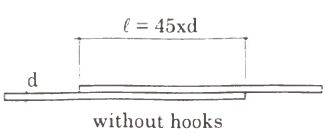
$D_1$ = 15 x d

$D_2$ = 6 x d, for rod $\varnothing \leq$ 20mm
8 x d, for rod $\varnothing >$ 20mm

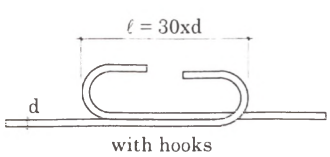
$D_3$ = 4 x d, for rod $\varnothing \leq$ 16mm





without hooks



with hooks

Reinforcement steel is fixed with binding wire, so that no displacement can happen during concreting.

### 6.6.3 CABLE ANCHORS IN SOIL

Cable Anchors in Soil or Soil Anchors are constructed either as:

- **Deadman Anchor or**

- **Gravity Block Anchor**

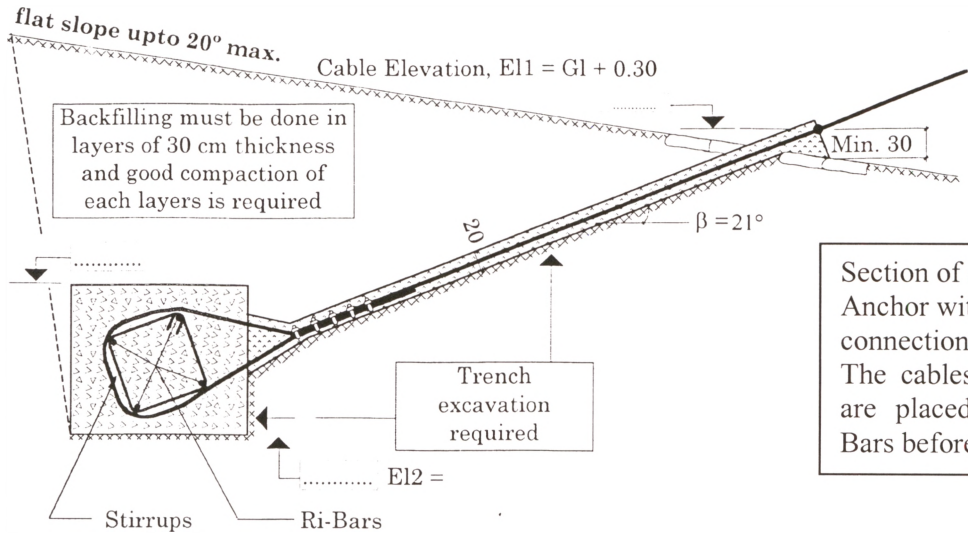
For both Soil Anchor Types (Deadman and Block Anchors), ready-made design drawings are provided for Anchors *with Turnbuckles* or Anchors with *Direct Cable Connection*. One Cable Anchor should always have a Turnbuckle which allows fine adjustment of the cables during erection time. For economic reasons, the cable anchor on the other bank should always have a direct cable connection.

Always choose the more convenient bank for the Main Cable Anchor with Turnbuckle.

For the Main Cable Anchor with Direct Cable Connection the Main Cables have to be fixed during the construction of the particular Anchor Type. The Main Cables, therefore have to be ready during the time of construction. Make sure that the Main Cables are deposited at a safe distance from the bank of the river during construction time.

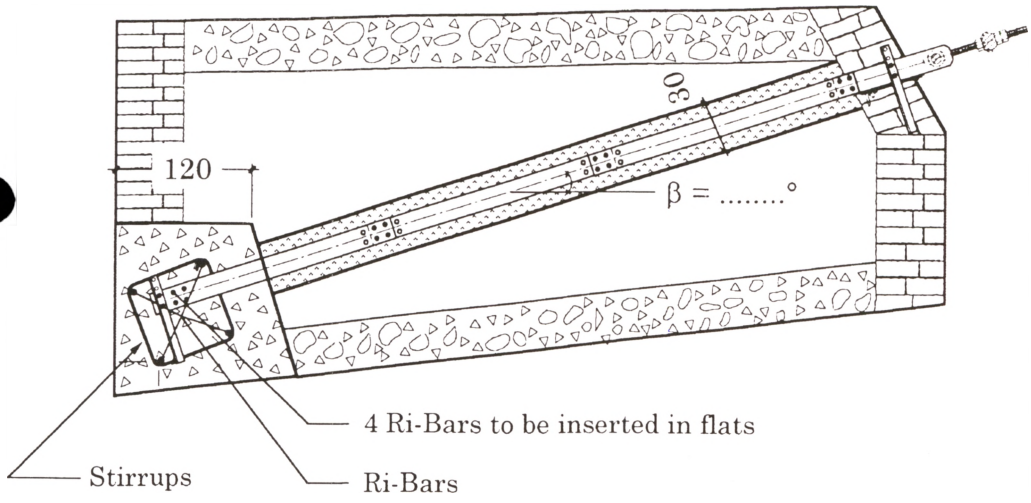
For both the Soil - Anchor Types (Deadman and Block Anchor), ready-made design drawings are provided for Anchor with Turnbuckles or Anchors with direct cable connections. For details, refer to Volume III, Steel & Construction Drawings. These drawings contain all the information about assembly and location of each steel part.

**Example of a Deadman Anchor without Turnbuckle:**



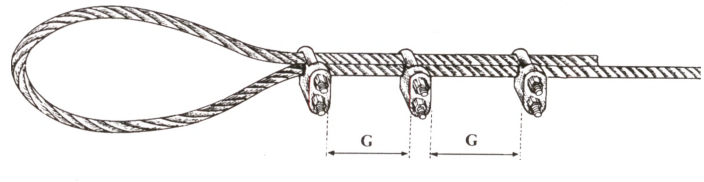

Section of a Deadman Anchor with direct cable connection.
The cables for soil anchors are placed around the Ri-Bars before concreting.

**Example of a Gravity Block Anchor with Turnbuckle:**




In the Turnbuckle case, steel flats are joined till the rear (back) of the gravity block where a solid reinforced cement concrete (RCC) beam is constructed. The ends of the flats are anchored by 4 Ri-Bars which have to be ***inserted*** through the 4 holes provided at the end of the flats.

| Nos. & Spacing of Bulldog Grips | | |
|---|---|---|
| **Cable ϕ mm** | **Nos.** | **G** |
| **13** | **3** | **10 cm** |
| **26** | **5** | **15 cm** |
| **32** | **6** | **20 cm** |



### 6.6.4 CONSTRUCTING DRUM ANCHORAGES IN ROCK

There are two types of Drum Anchorages in Rock:

- **Drum Anchor in Hard Rock**
- **Drum Anchor in Soft or Highly Fractured Rock**

**Drum Anchorages in Hard Rock** are made by drilling holes of 32 mm diameter ( = diameter of crowbar) into the rock. Clean the boreholes of dust and debris by flushing them with water.

Fill the holes with cement mortar 1:1 before the anchor rods are inserted.

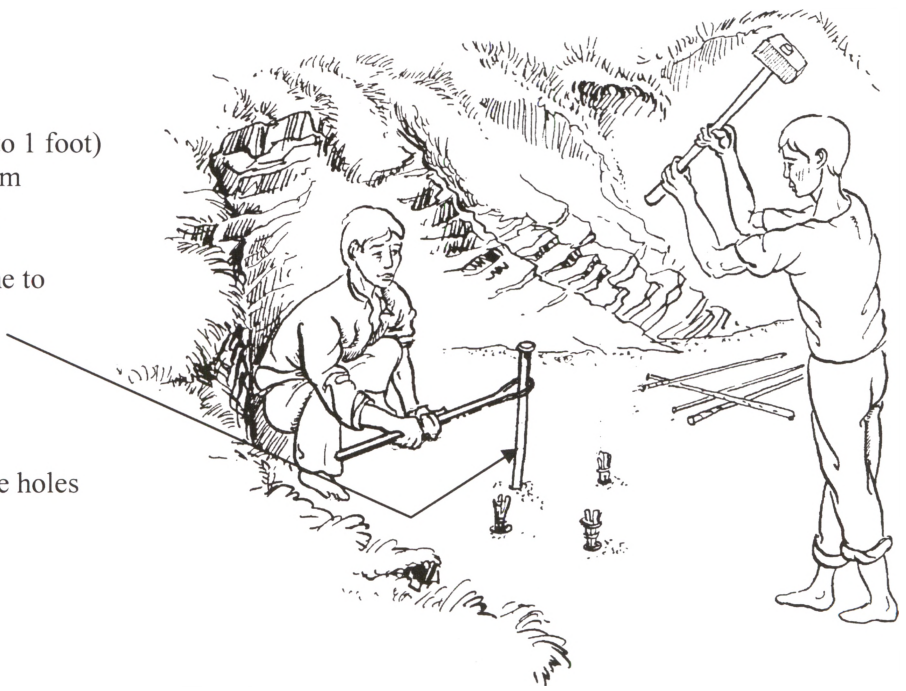
The formwork for the drum is made using a chitra (bamboo mat) or a plain G.I. sheet lined with a plastic sheet.

Use binding wire around the chitra to prevent the bamboo mat from bulging during concreting.

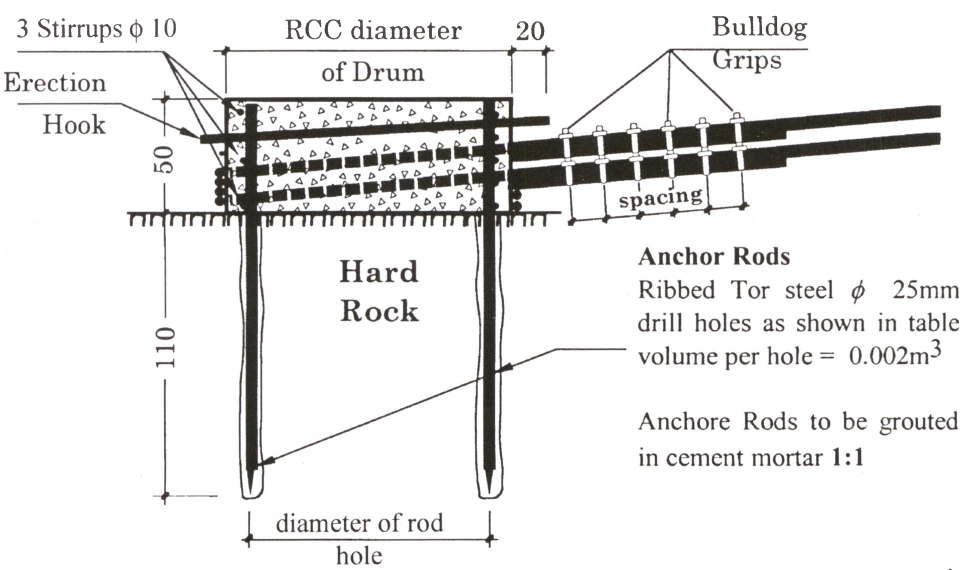
Drilling starter holes (up to 1 foot) for Anchor Rods of a Drum Anchorage in Hard Rock.

Rotate the chisel from time to time.

Use a crowbar to make the holes deeper.

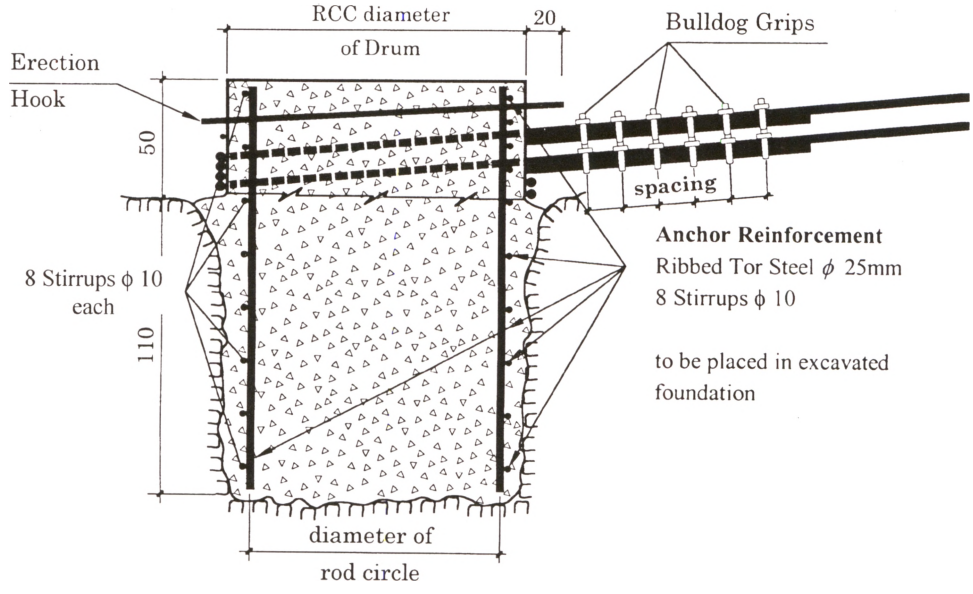


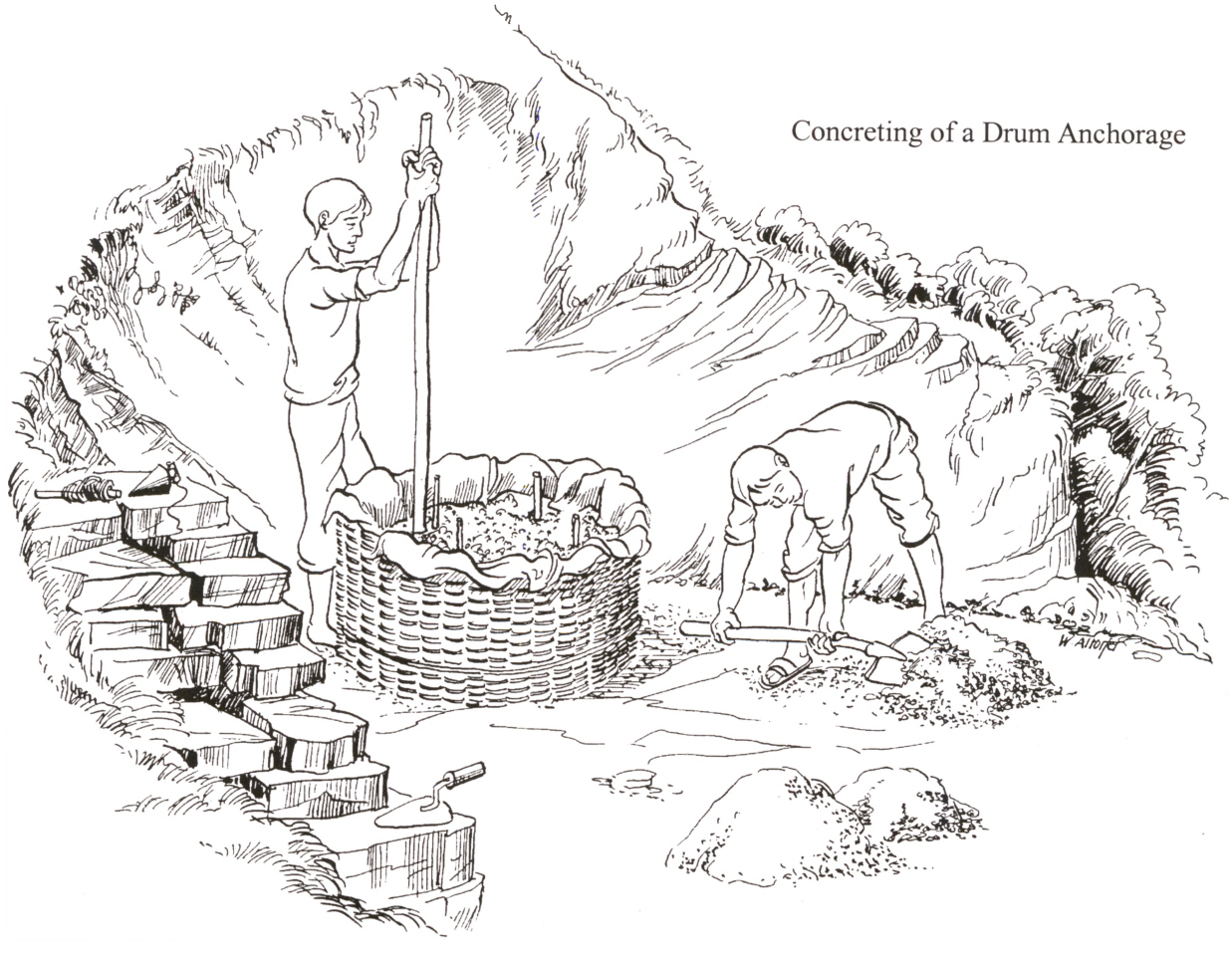
**Typical Cross Section of RCC Drum in Hard Rock**



**Drum Anchorages in Soft or Fractured Rock** are **not** done by drilling holes, but by excavating a round pit. The Anchor Reinforcement has to be placed into the pit and is fixed with the help of stirrups. The excavated pit is then filled and well compacted with concrete 1 : 2 : 4 up to the ground level. At this stage, the anchor rods should protrude (stick out) approx. 50 cm. The formwork for the drum is made using a chitra (bamboo mat) lined with a plastic sheet bound together with binding wire.

**Typical Cross Section of RCC Drum in Soft or Fractured Rock**



Concreting of a Drum Anchorage

### 6.6.5 Water Management and Backfilling

The life expectancy of a bridge largely depends on proper water management.

Any **water seepage** encountered during excavation should be intercepted as close as possible to its origin, and channeled safely to a nearby watercourse. Especially vulnerable is the place **behind the Deadman Beam!** If in doubt, or in case of unusual humidity or water seepage, provide a drain behind the Deadman Beam with a side outlet. Sometimes, water seepage occurs during the rainy season only. Inquire with the local people.

**Divert surface water** and provide drainage channels as necessary. Do not hamper existing irrigation channels, rather improve and adjust them with some cement works. Discuss solutions with the local people and decide on the spot.

As a general rule divert water as far away from the bridge foundations as possible.

For managing surface water well, also fill in the gaps around completed anchor blocks well above the existing surface. Back filling prevents surface water from flushing out the excavations.

**Do Back Fill !!!**

### 6.6.6 Finishing Work

Provide finishing structures like retaining walls, staircases, small trail improvements, adjustments to nearby houses, etc. if they add functional value to the bridge.

Never do cement pointing or other non-functional works.

Also check the vegetation and plant life in the vicinity of the bridge. Plant some new trees if possible, especially if some had to be cut down in order to build the bridge.

## 6.7 BRIDGE ERECTION

As soon as the anchor blocks and tower foundations are completed, the bridge erection works can be started. Bridge erection and fitting works are somewhat difficult and dangerous, and require especially skilled laborers who will not suffer from giddiness. Because of this somewhat risky work, the necessary safety precautions should strictly be followed and the respective responsibilities should be clarified before starting the work.

### 6.7.1 ERECTION OF TOWERS

The towers must be temporarily fixed during erection, because they rest as a line load on the base plate which acts like a hinge. In order to avoid serious accidents during erection, the towers must be temporarily fixed at their base. For this purpose, temporary side struts have been provided at the tower and walkway foundation with an additional 8 angles for each tower (see position B-5 of Base Element Drawing No. 100N). The angles are supplied with holes at one end only, the exact position of the required hole at the other end must be marked at the site when erecting the base element.

First fix both the Base Elements at the bottom and put them in an exactly vertical position. Fix the temporary angles at the bottom of each side, then mark the required position of the hole at the other end of the angle. Also give a position number to each angle so that they won't get mixed up. Have one hole of ø 17mm drilled at the site or at the nearest workshop.

For tower erection, refer to the respective Assembly and Layout Drawings.

- Check Steel parts for labels and numbers put by the manufacturer.
- Use steel-cones for easy fitting works and tighten the nuts and bolts fully only after the next diagonal bracing has been put in place.

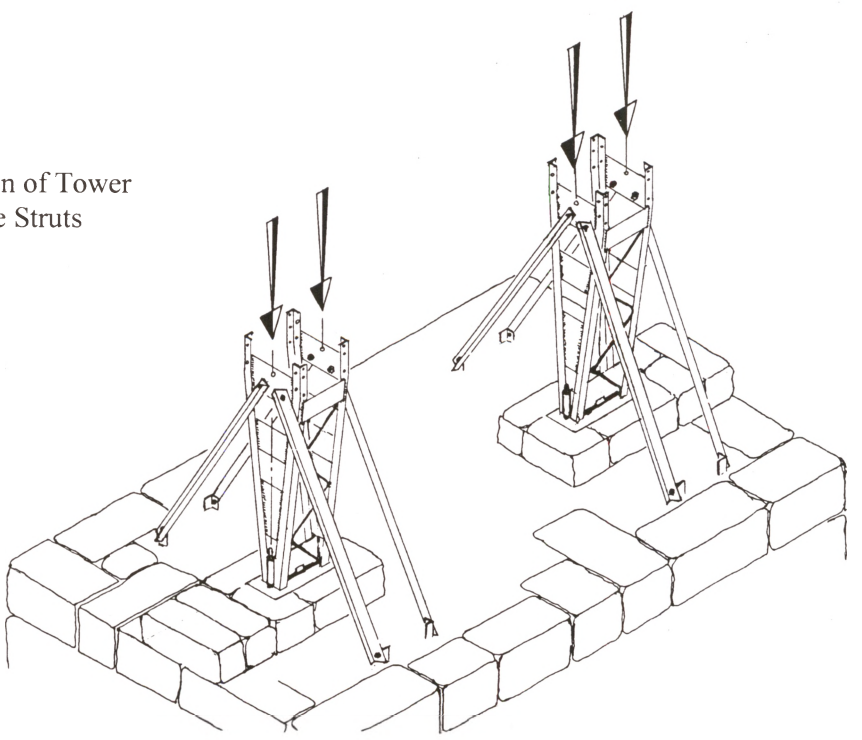
Each tower consists of the following parts :

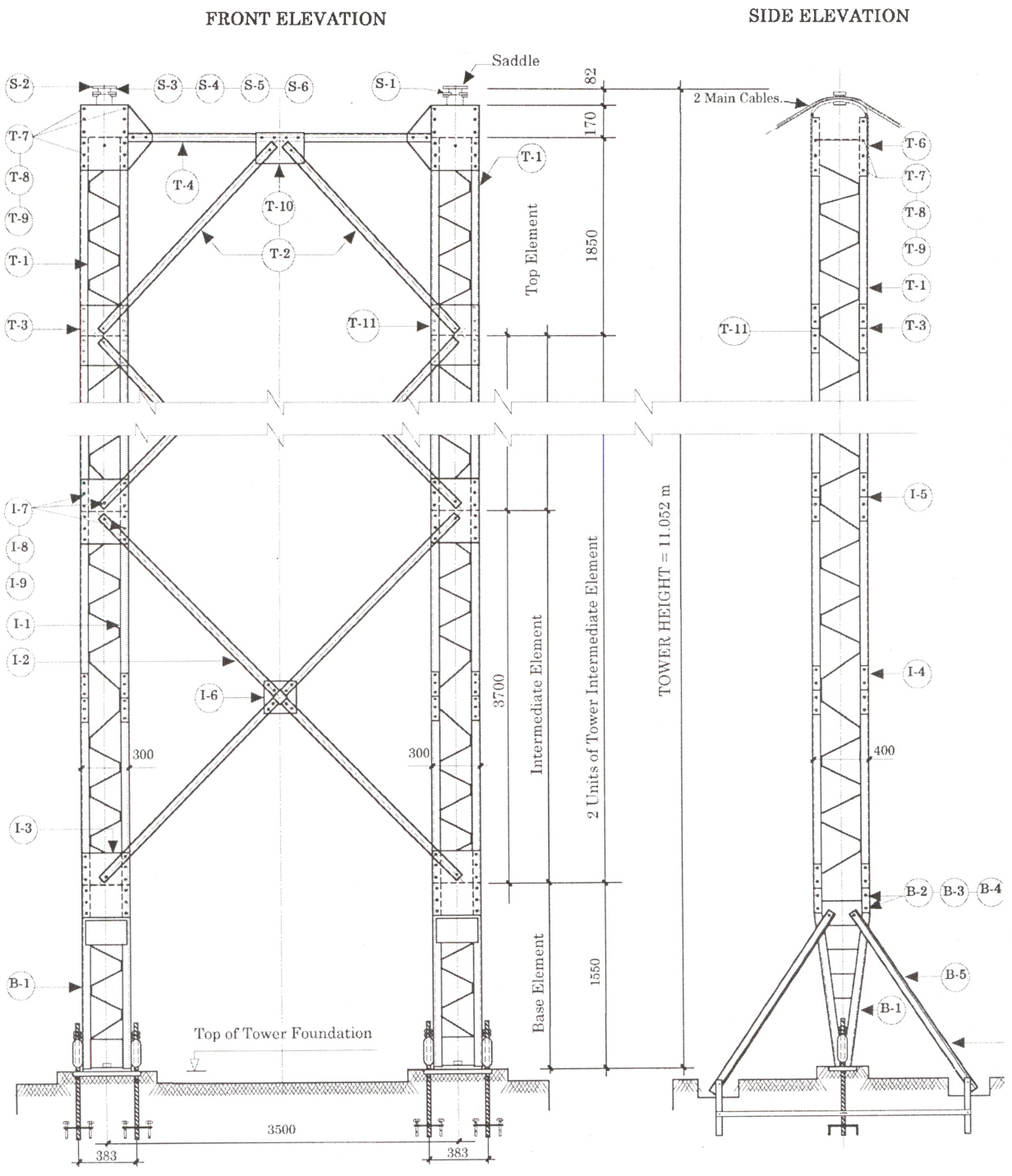
| Type of element | Part Nos. in Steel Drawing |
|---|---|
| Base Element | **B** |
| Intermediate Element | **I** |
| Top Element | **T** |
| Saddle | **S** |

Retighten all Nuts and Bolts firmly after fixing the Elements.

***After the bridge has been erected, the cable clamps on the top of the pylon must be firmly tightened, and then all the side struts (angles) must be removed.***

Temporary fixation of Tower Base with side Struts



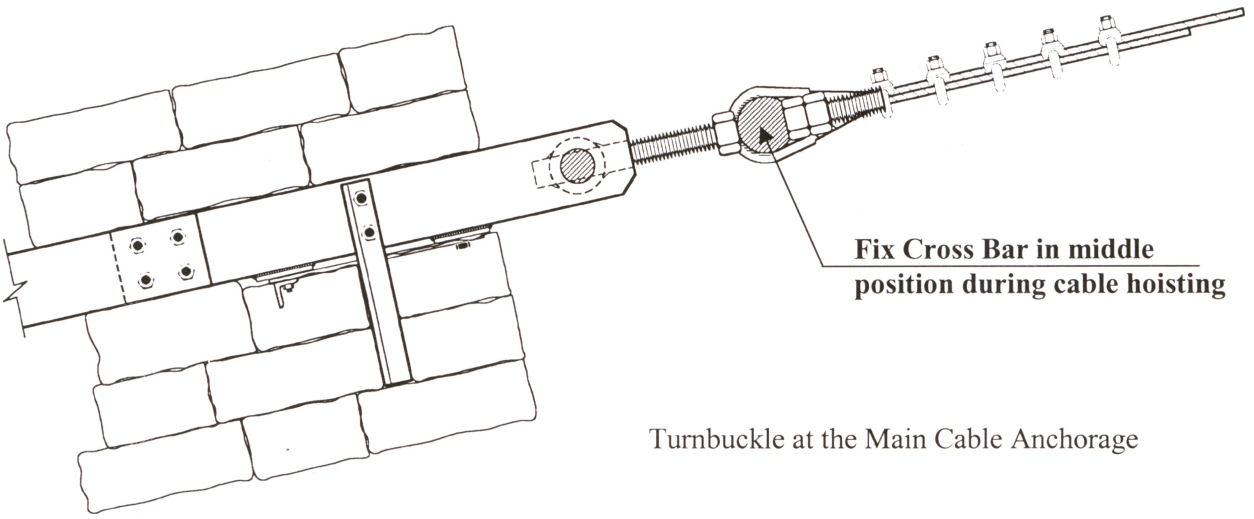



**Assembly and Layout of Tower No. 4**

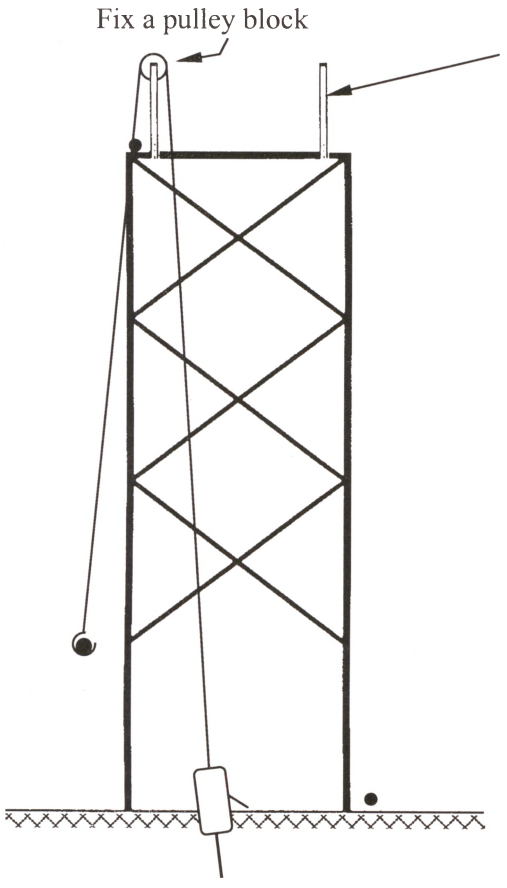
### 6.7.2 Hoisting of Main Cables and Sag Setting

Usually, the main cables are pulled across the river with the help of nylon ropes. In case of a deep or turbulent river, attach an empty airtight plastic can (jerry can) at the end of the cable. This will prevent the cable-end from getting stuck between stones and rocks lying on the riverbed.

Make sure that the respective Main Cables are pulled on either side of the Tower and Walkway Foundations. Fix them temporarily at the respective Turnbuckle at the Main Cable Anchor.




Turnbuckle at the Main Cable Anchorage

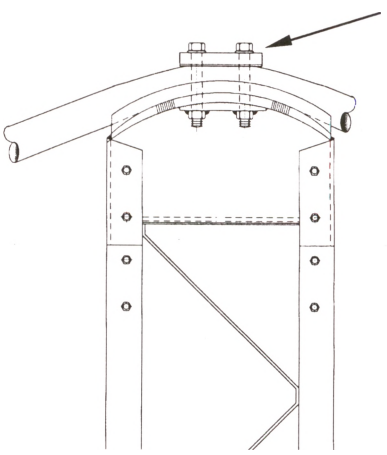



Main Cables at either side of the Tower

Temporary device for lifting the main cables (supplied with Top Element)

Lift the cables one by one, first the inner then the outer cables.

Once the cables are in the saddle groove, immediately secure them with the saddle cover plate, but do not tighten the bolts so that the cables can still slide during erection time.



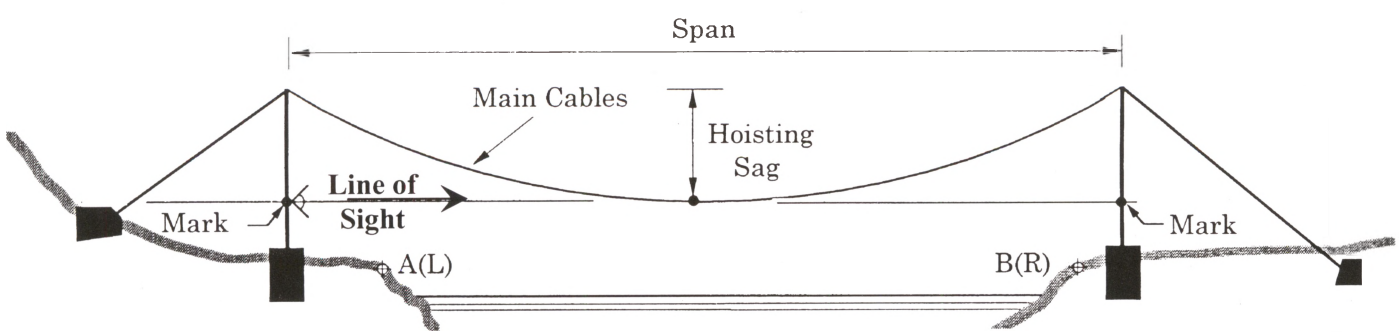
Keep saddle cover plate loose during bridge erection time, but tighten it firmly before removing the temporary side struts at the bottom of the tower.

**The hoisting sag setting of the Main Cables is one of the most important tasks during the erection of the bridge.**

The towers should stand exactly vertical, the saddle cover plates are loose, and the temporary side struts are fixed. With this arrangement, the main cables can slide over the saddles when the bridge is being erected and the cables become longer; and the towers remain in vertical position in dead load.

With a leveling instrument, the exact hoisting sag is fixed in the following way:

- Mark the elevation of the hoisting sag on both the towers with permanent paint.
- Now set up the leveling instrument on the tower foundation so that its line of sight matches with the mark on the tower across the river. Setting up the leveling instrument at the prescribed hoisting sag elevation has to be done by trial and error, and may require several attempts. Make use of the three adjustment wheels of the leveling instrument when the eyesight is close to the mark.
- Pull the Main Cables until they reach a level of about 20 cm higher than the hoisting sag.
- Clamp the cables around the thimbles at the cross bar of the Turnbuckle of the main cable anchorage. Make sure that the crossbar is **in the middle position** of the threaded anchor bars when clamping the main cables, secured with two nuts in the front and one in the back (see page 135).
- The Main Cables should be left in this "over pulled" position for at least 12 hours so that some relaxation can take place.
- Now move the Turnbuckles to achieve the exact sag setting. For compensating elongations due to change in air temperature, recheck the hoisting sag at different times of the day and make the necessary adjustments. It is recommended to adjust the final sag setting during the hot day after noon, when the cables have accumulated maximum heat, i.e., during maximum elongation condition.
- The hoisting sags of all the Main Cables must be identical at any point of time.




Also check the sags from time to time when the fitting works are going on. Different elongations may take place due to dissimilar hidden cable relaxations when the tension increases. Adjust possible sag differences with the help of the turnbuckles at the main cable anchor so that the Main Cables are always parallel and compare the dead load sag with the pre-calculated values.

### 6.7.3 Hoisting of Spanning Cables

Fix the Spanning Cables at the Turnbuckles of the Tower and Walkway Anchorage on one river bank. Make sure that the crossbar of the turnbuckles are at the **outermost position** secured with two nuts each so that more tension can be applied when all the fitting work is completed.
Pull the cables across the river and secure them at the corresponding turnbuckles on the other bank (crossbar at the outermost position).

It is not necessary to achieve the sag corresponding to the required dead load camber, since this requires very high pulling forces. Just make sure that both the Spanning Cables are hanging approximately parallel and are high enough over the highest water-level of the river.
It is much easier to adjust the spanning cables when the suspender is being fitted (see Chapter 6.7.4).

### 6.7.4 Fitting Suspenders and Center Row of Steel Deck

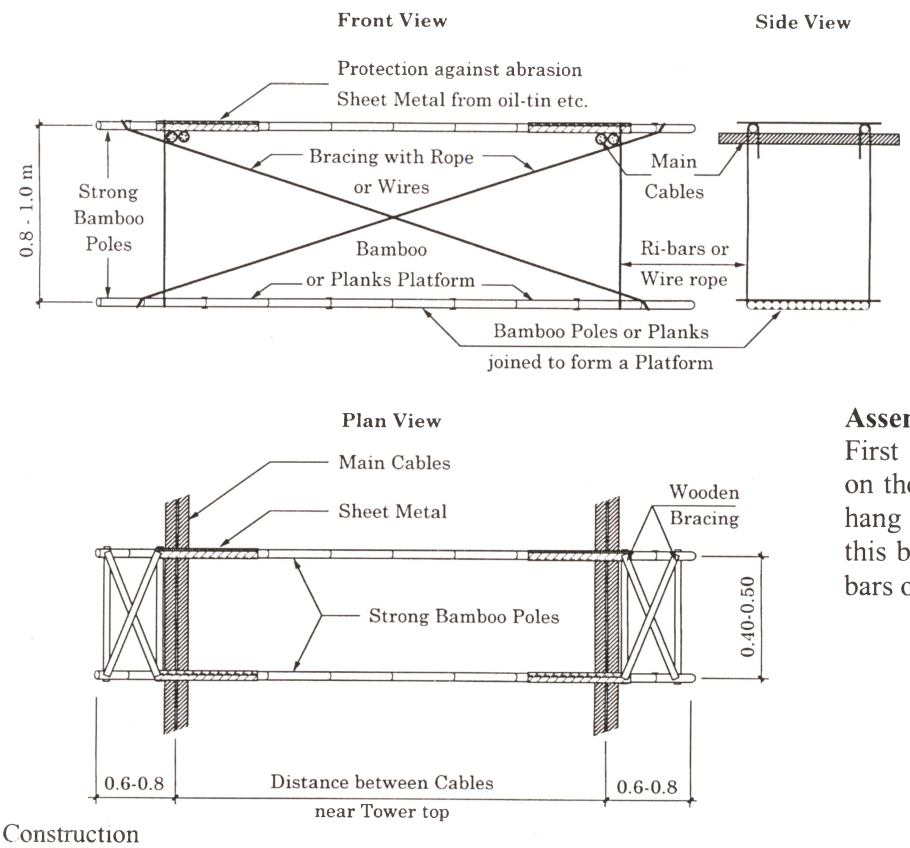
Fitting the suspenders and walkway elements is the most difficult and daring job.
As mentioned already in the beginning of this Chapter 6.7, adequate safety precautions should be strictly followed and the respective responsibilities should be clarified.

The suspender fitting work should start from **both** the towers and proceed towards the center of the bridge. This procedure is easier and has more advantages than starting the fitting work from the center. However, in order to achieve a proper symmetry of the suspenders, the **central suspender** must be fitted first.

The only disadvantage will arise when finishing the fitting works at the middle of the bridge. Due to inaccuracies, the remaining spacing at the center of the bridge might be either too long or too short. For minimizing this imprecision, the required distances to the towers and the center have to be rechecked after fitting 10 suspenders.

**Preparation for Suspender Fitting Works:**

- Lay out all the suspenders in sequence on the ground.
- Prepare all crossbeams, J-hooks and steel deck.
- Prepare two fitter platforms, one for the main cables and one for the spanning cables, and two gauged sticks of exactly 1.00m length.

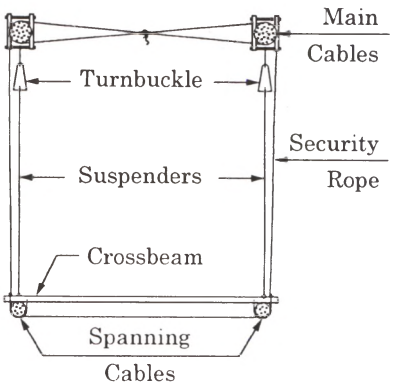


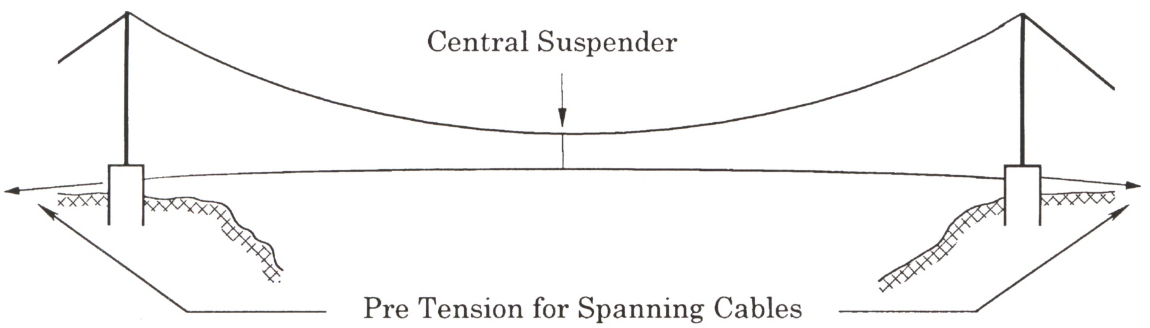

**Assembly:**
First fit the top portion on the main cables, then hang the platform under this by using either steel bars or cables.

**Fitting the Central Suspender :**

With the help of the fitting platform, the suspender in the center has to fitted first. Determine and reconfirm the center with a tape and level instrument, then fit the first suspender-pair at the center of the bridge. To avoid excessive load on the center suspender during erection time, bind all cables (spanning and main cables) together as shown in the sketch below with a security rope.

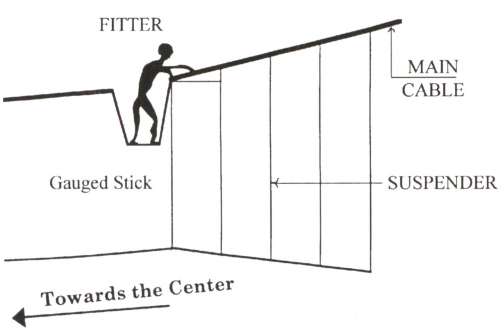
The **security rope** supports the suspender in the middle during erection work.

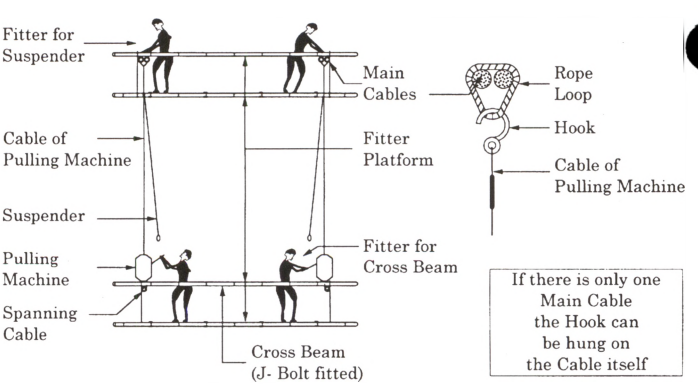



Tighten the spanning cable to some extent; now the cables are ready to be fixed to the suspenders.

**Sketches and Procedures for Fitting Operations:**




- Start the fitting work from both sides of the bridge and work towards the center of the bridge;
- Fix one cable car on top of the main cables and one on top of the spanning cables;
- Fix the first two suspenders to the main cables at the prescribed distance from the tower;
- Lift the spanning cable until the suspenders can be connected with the threaded rod of the walkway crossbeam.

*Note: The first crossbeam at the bridge entrance is fitted without a suspender (see Drw. No. 19Ncon).*

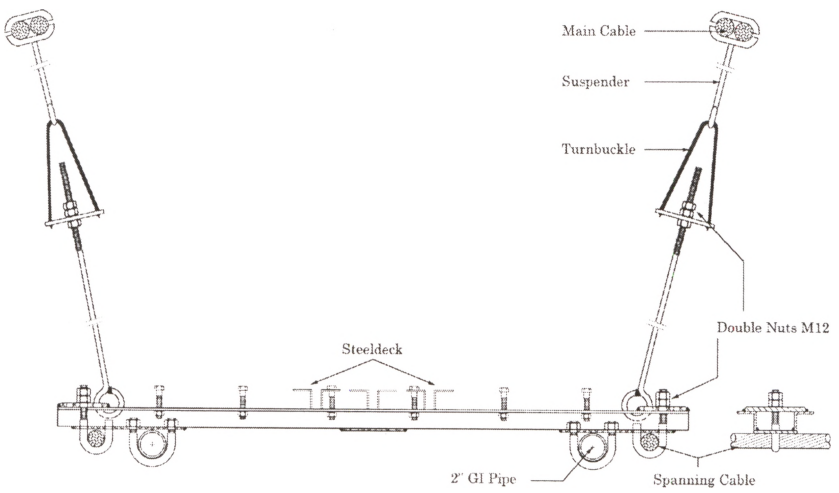
- In order that the suspenders are fixed exactly 1m apart, use gauged sticks for exact fitting;
- Re-adjust the spanning cables from both the banks as the suspenders are being fitted;
- After fitting ten pairs of suspenders, check the distances to the tower and to the center;
- Adjust only inaccuracies by moving the crossbeams;
- Gradually start fitting the **center row only** with standard steel deck panels as shown in Drawing No. 19 Ncon.

When the center is reached, there will be some extra length of spanning cable. For adjusting this, pull the spanning cables from both the banks with the tirefor machine through the loose J-hooks. Make sure that the middle row of the steel deck is fitted when doing this work.

- When all the suspenders have been fixed, tighten the spanning cables with the cable pulling machine as much as possible before fitting the 2" G.I. pipes below the crossbeams and before fitting the rest of the steel deck panels.
- Fix the handrail cables by pulling them through the suspender-rings just above the suspender turnbuckle, and secure them to the handrail posts by winding the cable end twice around the post.

**Fitting the 2" G.I. Pipes :**

Two 2" G.I. pipes have to be mounted from below to the steel deck cross beams. This provides additional vertical but also lateral stability to the entire walkway. These pipes can also be used for transferring water across the river as per local requirement.




The G.I. pipes have to be fitted before the outer rows of the steel decks are mounted in the following way:

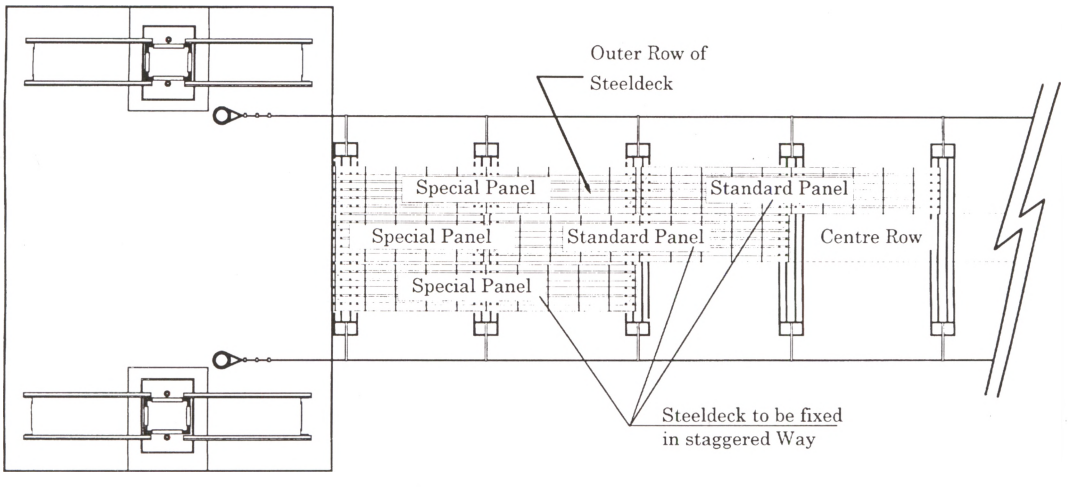
- Lay two pipes of 6m length end to end on the ground and join them together firmly. Use a 2" die set and jute threads to make the joint water tight.
- In the same way, also fix half of the "union" at each end of the 12m piece.
- Now carry the 12m pipe to the bridge, pass it through the suspenders by securing it with nylon ropes until the entire 12m piece is on the outside of the suspenders.
- Now bring the pipe into proper position underneath the walkway, and secure it immediately with the U-clamps and join it with the "union".
- In case a union coincides with a crossbeam, cut the pipe and make a new thread with the die set.

***This work requires special attention. While passing the pipe outside the suspenders, several workers are necessary and sufficient ropes are required to secure the pipe at all times.***

### 6.7.5 FINISHING THE WALKWAY STEEL DECK

Now the remaining steel deck panels can be fitted. Fit them in a staggered way as shown below. Adjust the end of the walkway with "Special Panels"; and cut off any extra length with a hacksaw as required.

- If wood is used for the bridge deck, the planks should be 2 meters long and at least 4 cm thick. They should also be fitted in a staggered way. Use washers below the Bolt Heads. The distance between the Crossbeams is 1 meter.

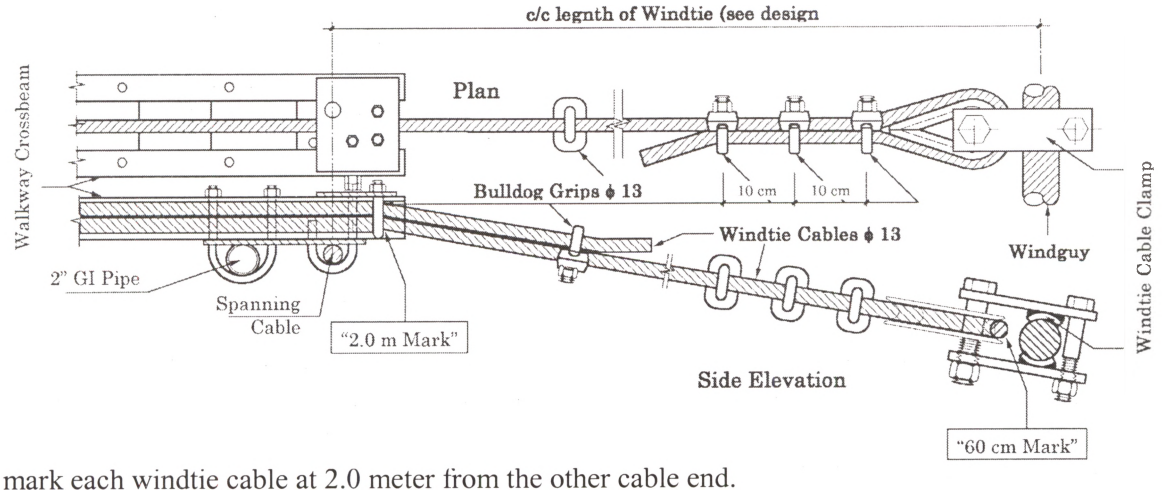



*Note: Make sure that all U-clamps which hold the G.I. pipes have been tightened firmly before fitting the steel deck.*

### 6.7.6 FITTING WIND BRACINGS

Wind bracings might be required to protect the superstructure from excessive wind forces.

- Cut the windtie cable according to the calculations resulting from the design form;
- Mark each cable at 60 cm from the end;
- Fit a thimble and bulldog grips so that the "60 cm mark" is at the top of the thimble;




- Now mark each windtie cable at 2.0 meter from the other cable end.

The windtie cables are now ready to be fixed to the windguy cable. For this, fix the cut windtie cables at intervals of 5.0 m to the windguy cable; take starting measurements from the design form or the general arrangement.

Make sure that the windtie cable clamps and bulldog grips are firmly tight, and that the nuts are locked against the threaded plates of the windtie cable clamp, because these connections are no more accessible after hoisting.

**Hoisting Windguy Cables :**

- Place the windguy cable in position along the bridge deck outside the suspenders;
- Pass the respective windties through the walkway beam and clamp them loosely at the "2.0m Mark" as shown in the above sketch;

***Note: The steel deck in the center row at this location must be removed for this purpose.***

- Fix one bulldog grip with the windtie from the other side just outside the crossbeam;
- After fixing all the windties, attach both cable-ends of the windguy cable to the respective windguy anchors (crossbar at the outermost position). Simultaneously apply tension to both the windguy cables to avoid any unsymmetrical lateral load to the bridge, then tighten all clamps at the "2.0m Mark".

**Adjusting the Windguy / Tie - Cables :**

- The windties can be adjusted by loosening the bulldog grips at both sides of the crossbeam;
- Loosen also one bulldog grip outside the crossbeam, but make sure that the grip on the other side is tight !
- Now allow the first windtie - pair to balance off any unsystematic forces;
- Then grasp the cable under tension (only one cable) from the middle of the crossbeam and lift it as required. (Use a crowbar and wooden logs as shown in the picture below);

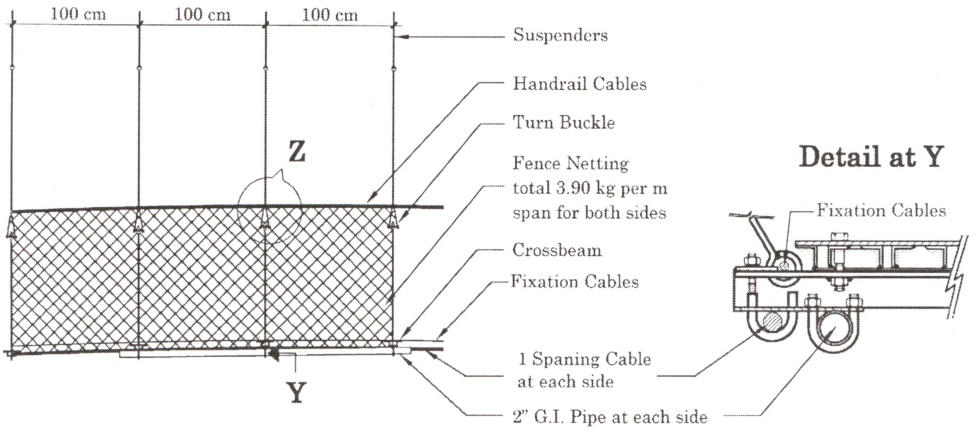
- Use a crowbar and wooden logs to hold this position.
- Now push the loose cable-end of the second windtie through the loose bulldog grip outside the crossbeam and clamp it to the cable under tension;
- Now do the same with the other end, and finally again clamp both the cables to the crossbeam.

This procedure should be repeated until all the windties are tight. The adjustment length is not limited and can also be done again at a later stage.

### 6.7.7 Finishing Erection Works

Now there remains the fitting of the fixation cable, the wire mesh and some final adjustments (See also Drawing No. 19Ncon in Volume III of this handbook).

Like the handrail cable, the fixation cable is to be passed through the rings at the bottom of the suspenders. Anchor the fixation cables to the spanning cable anchor.

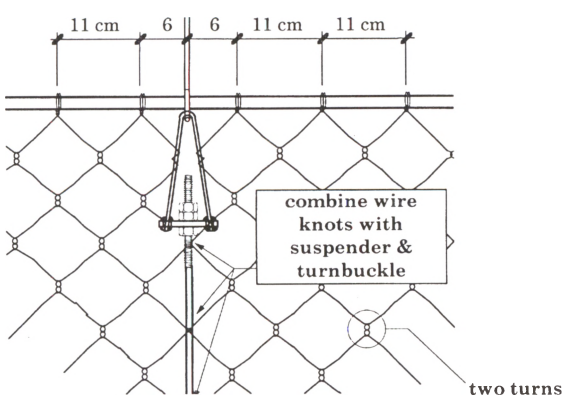


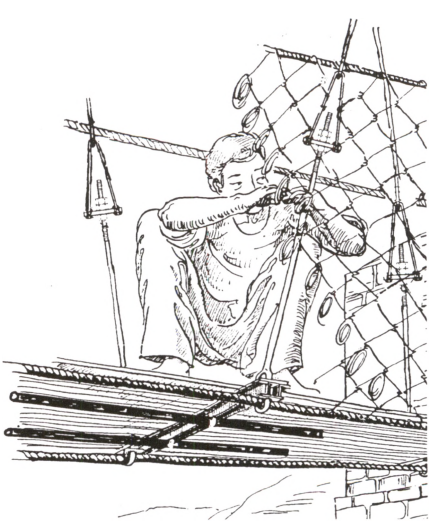

The fencing is woven on the spot between the handrail and the fixation cables with gabion wire (12 SWG ≙ ø 2.64 mm)

Preparing Coils .....

Cutting Length is 4.20 Meters

...for fence weaving



Finally the whole bridge should be aligned with the help of the turnbuckles at the suspenders so that the walkway forms a smooth parabola.

If a wind bracing system (windguys and windties) is in place, recheck whether all the cables are tight and align the walkway so that it is perfectly straight.

# 7. BRIDGE MAINTENANCE

## 7.1 INTRODUCTION

Maintenance of trail bridges is very crucial for keeping the mule and foot trails functional throughout the year. It is extremely essential to guarantee their permanent and safe use, maintain them in usable condition, and to preserve the investment made on these bridges. In order to determine the required maintenance, regular inspection of the bridge should be made after completion of the construction work.

The bridge maintenance work consists of the following two categories:

- **Routine Maintenance**
- **Major Maintenance**

A brief description of these two maintenance categories is given in the following sub-chapters.

## 7.2 ROUTINE MAINTENANCE

Routine maintenance is a preventive type of maintenance and should be done regularly. It is important to protect the bridges from developing big and irreparable damage and assure long term use by keeping them in a serviceable condition. After completion of the bridge construction, routine maintenance should be carried out on a regular basis. In general, the work involved in routine maintenance is simple in nature.

Routine maintenance work includes the following important tasks:

1. **Cleaning around the most important bridge elements**

   Cleaning and removing all sorts of debris, dirt, plants and bushes in and around the drainage channels, the cable anchorage terminals, the tower base, the area around the foundations, the area below the bridge entrance and the bridge access trails.

2. **Fixing and re-tightening of bridge parts**

   Fixing and re-tightening of walkway wire mesh, nuts and bolts, bulldog grips, etc. which have become loose.

3. **Repairing the walkway deck**

   Re-tightening of loose nuts and bolts of the steel decks and J-Hooks.

4. **Minor repairing of gabion boxes for bank and slope protection purposes**

   Inspection and checking of the slope and riverbank protection structures and execution of minor repair work.

5. **Reporting of the bridge condition**

   Inspection and checking the general condition of all the bridge parts and structures and reporting to the concerned DDC and/or VDC to seek their necessary support in case of big landslides, bank erosion, etc. which may damage the bridge foundations and structures, or even cause the bridge to collapse.

Routine maintenance work can be carried out either by forming a Bridge Maintenance Committee (BMC) or by appointing a bridge warden. In both the cases, one trained person must be assigned to inspect the bridge regularly. S/he should preferably live close to the bridge and should be equipped with some basic tools.

Primarily the concerned VDCs are responsible for ensuring that routine maintenance is done. The DDCs, who bear the overall responsibility, shall monitor the routine maintenance and support the VDCs in cases beyond their capacity.

## 7.3 MAJOR MAINTENANCE

Major maintenance (MM) work includes all works which need proper planning, survey, design and cost estimates. A certain level of knowledge and skill is required to execute the major maintenance of the bridges.

Major maintenance work includes the following tasks:

6. **Replacing rotten wooden planks with galvanized steel decks.**
7. **Replacing rotten wooden crossbeams with galvanized steel beams.**
8. **Repairing of windguy arrangements/system.**
9. **Repair, adjustment or replacement of suspenders including adjustment of camber of suspension bridges.**
10. **Re-painting of all non-galvanized steel parts.**
11. **Re-tensioning of all loose cables and adjusting bridge alignment.**
12. **Coaltar treatment of all non-galvanized threads.**
13. **River bank and slope protection works.**

The existing bridges which were constructed in the past with wooden walkway decks and non-galvanized steel need major maintenance work in the first instance. These bridges may require almost all tasks mentioned above under major maintenance.

Major maintenance responsibilities are gradually operationalized at the district level by imparting technical know-how, methods and practices for carrying out maintenance work and providing material support. The DDCs are becoming better prepared to implement major maintenance works and are responsible for independent execution or with the support of the Trail Bridge Section (TBS), or other concerned bridge building agencies.

Reference Documents for Maintenance:

A. Bridge Maintenance Concept, Suspension Bridge Division, DoLIDAR, HMG/N, August 2000.

B. Routine Maintenance Manual for Trail Bridges, Suspension Bridge Division, HMG/N 1999.

C. Directives on Execution of Routine Maintenance of Main Trail Bridges through Bridge Wardens, Suspension Bridge Division, DoLIDAR, HMG/N, Shrawan 2057.

D. Local Bridge Repair, Maintenance and Management, BBLL, Kathmandu.

# VOLUME II : FORMS

(MAKE PHOTOCOPY FOR USE)

**FORM NO. 1 : SURVEY FORM & CHECKLIST**

**FORM NO. 2 : BRIDGE DESIGN**

**FORM NO. 3 : QUANTITY & COST ESTIMATE FOR COMMUNITY APPROACH**

**FORM NO. 4 : QUANTITY & COST ESTIMATE FOR PUBLIC TENDER & CONTRACTING**

# Form No. 1 : Survey Form & Checklist

# SURVEY FORM AND CHECKLIST

(toal 60 pages)

| | | |
|---|---|---|
| Crossing Name | : | |
| River | : | |
| District | : | |
| Surveyed by | : | |
| Date | : | |

# Table of Content

**1. SURVEY AND BRIDGE SITE SELECTION ____ 1**

1.1 Social Feasibility Survey ____ 1
1.2 Technical Survey ____ 2

**2. PREPARATION FOR SURVEY ____ 2**

**3. GENERAL DATA COLLECTION ____ 2**

3.1 Location of Bridge Site ____ 2
3.2 Nature of Crossing and Fordability ____ 4
3.3 Traffic Volume ____ 4
3.4 Width of Walkway ____ 4
3.5 Local Participation ____ 5
3.6 Transportation Distance ____ 5
3.7 Availability of Local Materials ____ 5
3.8 Availability of Local Bridge Builders ____ 6
3.9 Temporary Crossing ____ 6

**4. BRIDGE SITE SELECTION ____ 6**

4.1 General Condition ____ 7
4.2 River Condition ____ 13
4.3 Slope and Bank Condition ____ 14
4.4 Evaluation of the Bridge Site ____ 25
4.5 Classification of soil and Rock ____ 26
4.6 Identification of Soil and Rock ____ 28

**5. TOPOGRAPHICAL SURVEY ____ 35**

5.1 Survey Area ____ 35
5.2 Setting of Bridge Centerline ____ 35
5.3 Survey Methods ____ 36
5.4 Survey with an Abney Level ____ 36
5.5 Survey with a Theodolite ____ 42

**6. PHOTOGRAPHS ____ 50**

**7. SURVEY REPORT ____ 57**

# 1. SURVEY AND BRIDGE SITE SELECTION

A 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 a 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 and population of beneficiaries
- 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 this, one of the good reference would be Social Organization Support (SOS) Manual of BBLL Program, which has been developed based on the long experience of well adopted community trail bridge building approach.

**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

A technical survey includes:

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

## 2. PREPARATION FOR SURVEY

The following preparatory work must be completed before going to the field to do the 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 with an 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 and Pencil

**For Survey with a 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 and 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:

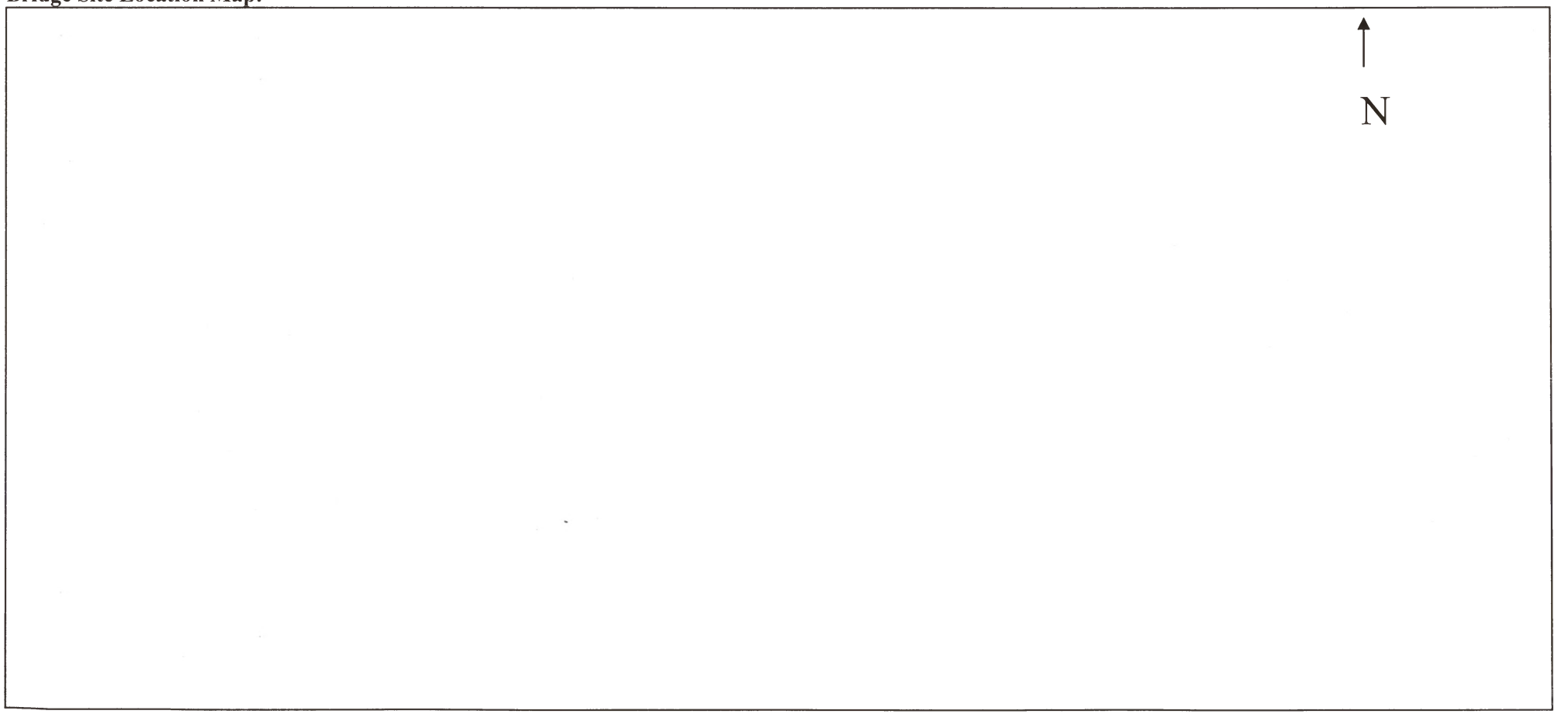
### 3.1 LOCATION OF BRIDGE SITE

| | *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:**



## 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 two 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.
During traffic count origin and destination of the individual traffic also should be recorded.

Origin and destination of the traffic will reflect the size of the influence area and the population of the beneficiaries of the proposed bridge. Traffic count should be done in the separate sheets and presented in the format as per sample sheet given in the pages 58 / 59.

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.

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

| *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 adopted in this handbook is 70 cm or 106 cm for the Suspended Type Bridge. The walkway width for Suspension type is fixed at 106 cm. In most cases the 70 cm walkway is sufficient in case of Suspended bridge. If there is heavy traffic, mule and pack animal passage carrying bulky goods, or if the crossing is on a main trail, a 106 cm walkway is mandatory. 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**

**For Suspended Bridge**: 70 cm ☐ 106 cm ☐

**For Suspension Bridge**: 106 cm ☐

## 3.5 LOCAL PARTICIPATION

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

**Tentative preliminary required number of mandays:**

| | | For Suspended Bridge | For Suspension Bridge |
|---|---|---|---|
| Mandays for skilled Labor: | = | **1.3 x span [m] + 400** | **1.6 x Span [m] + 500** |
| Mandays for unskilled Labor: | = | **5.0 x Span [m] + 1300** | **6.0 x Span [m] + 1400** |

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

## 3.6 TRANSPORTATION DISTANCE

| *Type of Transport* | *Name of nearest Roadhead/Airstrip etc.* | *Distance up to Roadhead/Airstrip and porter distance up to site from Roadhead/Airstrip* | | | |
|---|---|---|---|---|---|
| | | *Km/Kosh* | | *Porter days* | *By Mule, days* |
| | | Blacktop | Earthen | | |
| 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. Usually theses materials are available at the vicinity of the bridge site.

| *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 a temporary crossing 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

There are two possible standard bridge types namely "Suspension" and "Suspended" (for details refer to Chapter 3.1 of "SSTB Technical Handbook for Trail Suspension Bridge, Vol. I"). Selection of the bridge type depends mainly on the prevailing topography of the bridge site.

The Suspended type bridge is selected when the bridge foundations can be placed at a sufficiently high position giving the required freeboard from the highest flood level. The Suspension type bridge is selected only when the bridge site is in comparatively flat terrain and the suspended bridge is not feasible due to the insufficient freeboard. The Suspension type bridge is more expensive (per meter cost) and needs more inputs in design and construction than the Suspended type.

Therefore, ***assess the possibility of the Suspended type, which should be the first choice***. The Suspended type is more preferable due to economic reasons and easy construction technology which is more appropriate for the community bridge building approach. The ***Suspension Type Bridge can be selected only in the case when the Suspended type is not feasible***. For further details on the selection of the bridge types, refer to Chapter 3.3.2. of "SSTB Technical Handbook for Trail Suspension Bridge, Vol. I".

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 be justified and have a long life span:

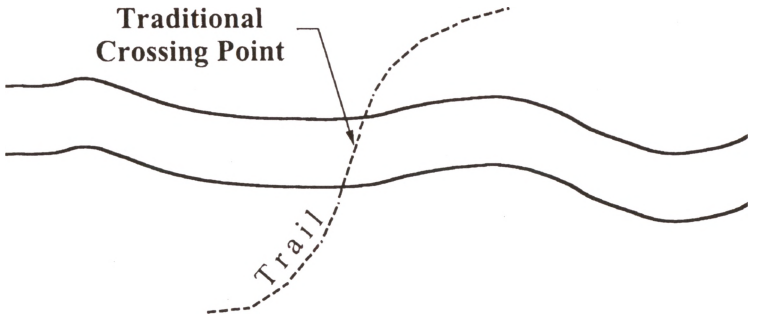
- fulfill the **General** conditions
- have **Favorable** river conditions
- have **Stable** bank and slope conditions
- have **Shortest** possible span

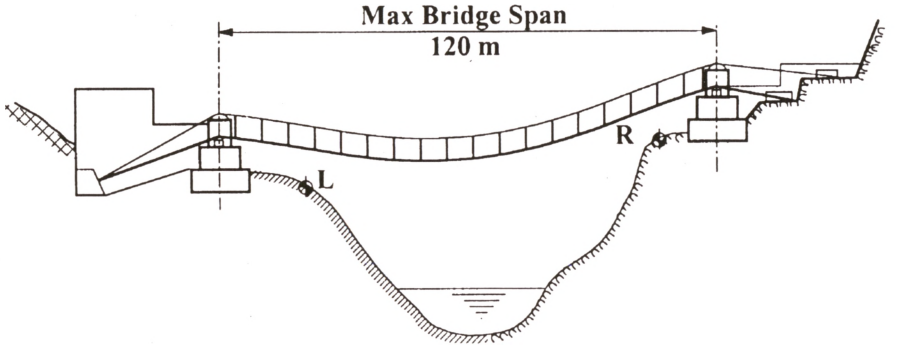
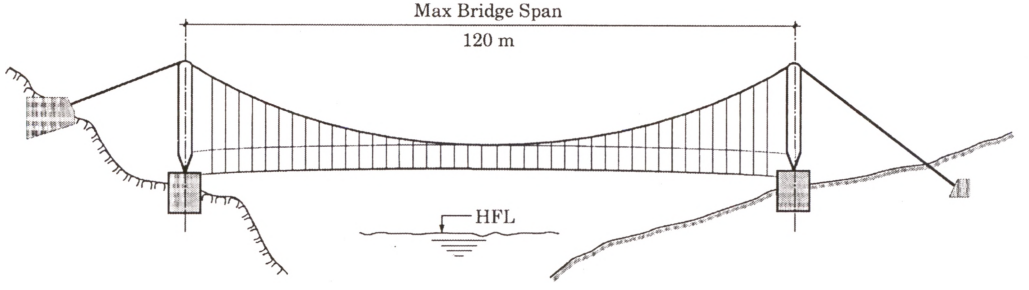
## 4.1 GENERAL CONDITION

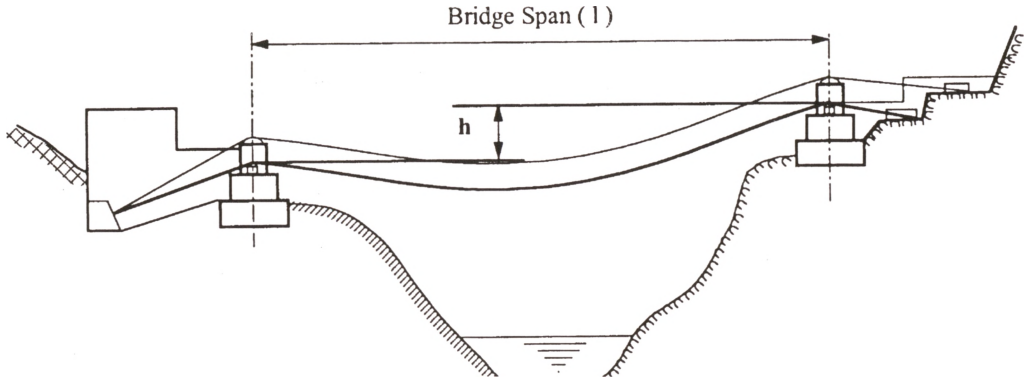
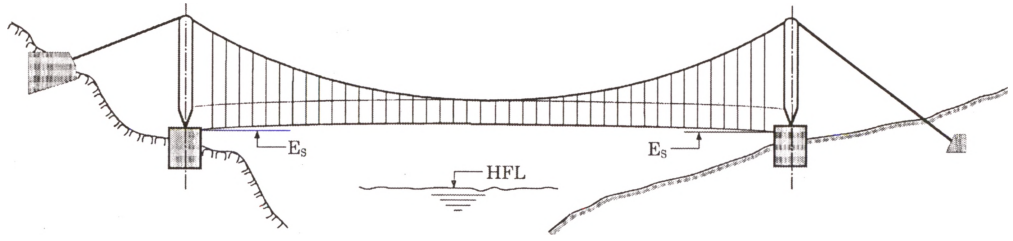
The bridge site should fulfill the following general conditions. They are:

- close to traditional crossing point
- maximum bridge span of 120 m
- minimum freeboard from highest flood level
- Safety distance for foundations

⇒ **Use the checklist on the 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 the traditional crossing point.<br>  <br><br>• For a minor rivers, a detour from the traditional crossing point is not acceptable.<br>• For major rivers, a 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 near the traditional crossing point<br><br>**Unfavorable**: Selected site is far from the traditional crossing point | ☐ | ☐ |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **BRIDGE SPAN**<br>The bridge span in this standard is limited to 120m.<br>**For Suspended Type Bridge**:<br>  <br> | **Favorable**: Span, $\ell$ is equal or shorter than 120m | ☐ | |
| **For Suspension Type Bridge:**<br>(Choose this option only if the Suspended type bridge is not feasible)<br>  <br> | **Unfavorable**: Span, $\ell$ is longer than 120m | | ☐ |
| • Measure tentative span.<br>• Compare with the limit. | **Approximate span** ☐ m | | |

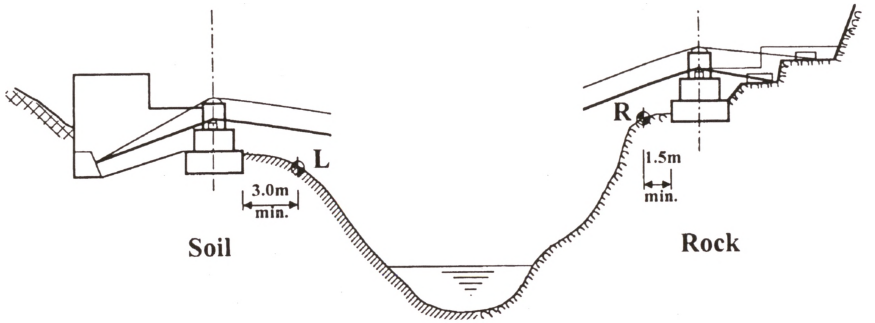
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **LEVEL DIFFERENCE BETWEEN TWO BANKS**<br>**For Suspended Type Bridge**:<br>The level difference between the two foundation blocks should not be more than $\ell$/25.<br>  <br><br>• Locate the tentative position of the bridge foundations on both the banks.<br>• Measure the level difference between the foundations on the two banks.<br>• Compare with the condition. | **Favorable**: **h** is equal or less than $\ell$/25<br><br>**Unfavorable**: **h** is greater than $\ell$/25 | ☐ | ☐ |
| **For Suspension Type Bridge**:<br>(Choose this option only if the Suspended type bridge is not feasible)<br>Walkway and Tower Foundations on both the banks should be placed at the same level.<br>  <br><br>• Locate the tentative position of the Walkway and Tower Foundations on the lower bank.<br>• Estimate the position of the Walkway and Tower Foundations on the other bank at the same level.<br>• Compare with the condition. | **Favorable**:<br>Walkway and Tower Foundation on both the banks can be placed at the same level<br><br>**Unfavorable**:<br>Walkway and Tower Foundation on both the banks cannot be placed at the same level. | ☐ | ☐ |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |

**SAFETY DISTANCE FOR FOUNDATION**

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

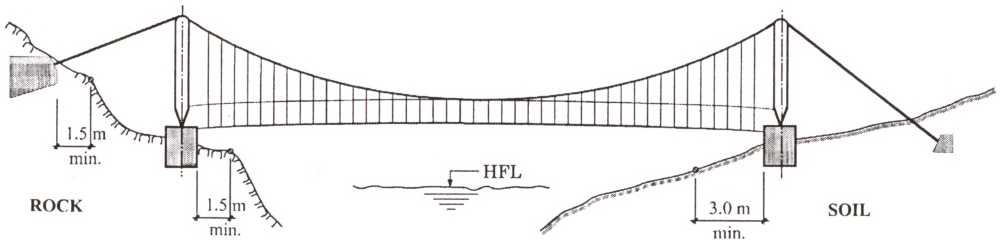
**For Suspended Type Bridge**:

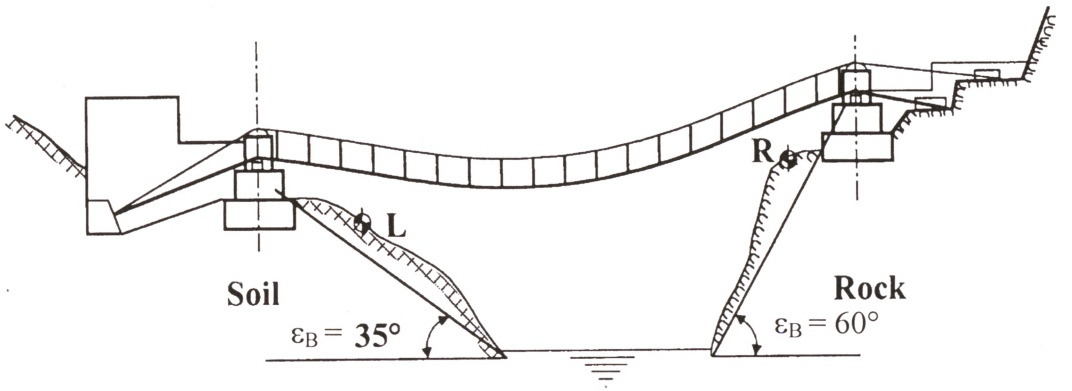
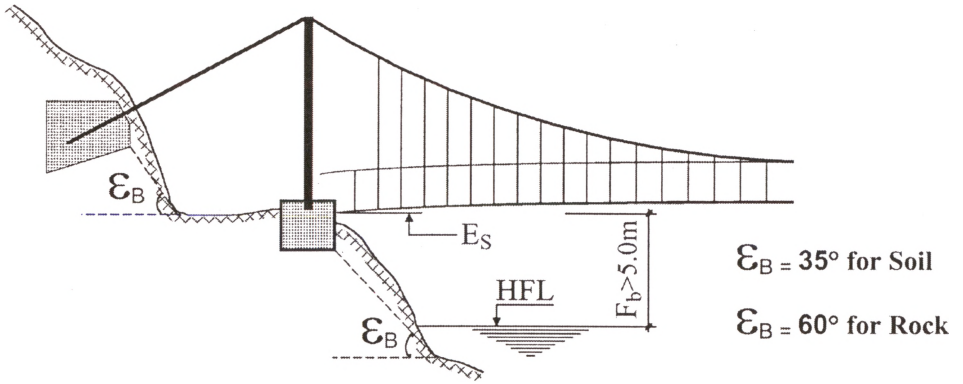


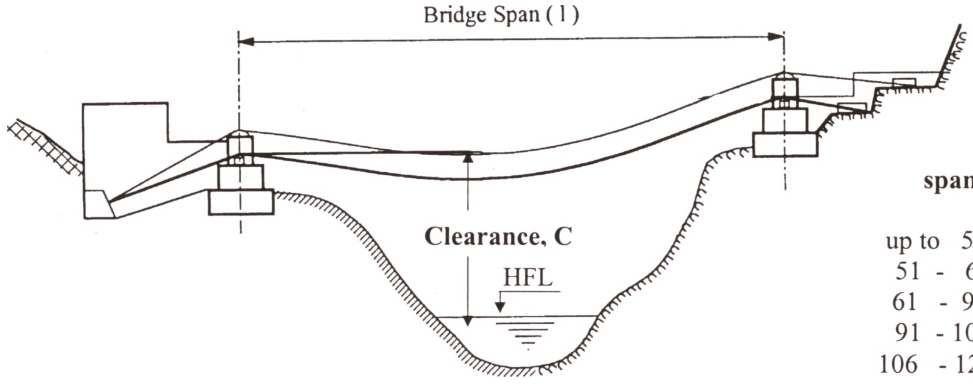
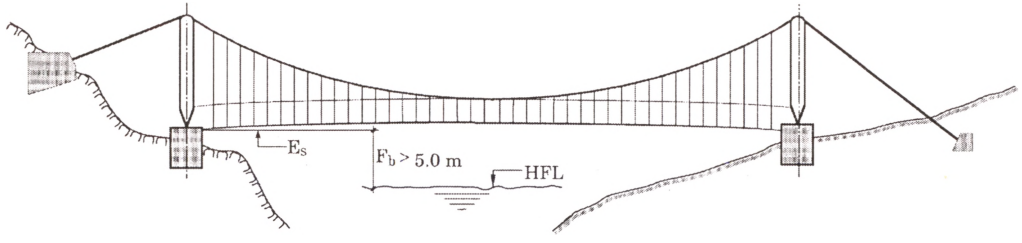

**Favorable**: Condition can be fulfilled ☐

**Unfavorable**: Condition cannot be fulfilled ☐

**For Suspension Type Bridge**:
(Choose this option only if the Suspended type bridge is not feasible)



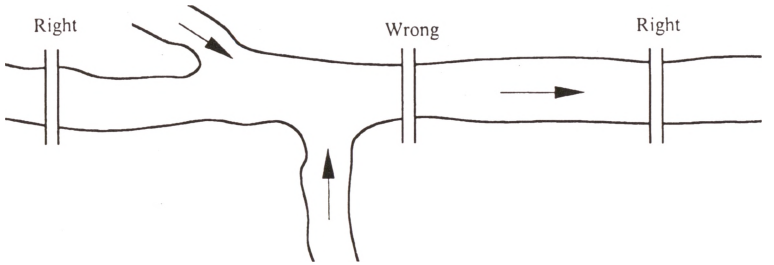
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **SLOPE PROFILE**<br>The bridge foundation should be placed behind the line of the angle of internal friction. (The angle of internal friction is the angle of slope of soil or rock at which it is still stable and does not slide.)<br><br>**For Suspended Type Bridge**: | | | |
|  | | | |
| **For Suspension Type Bridge**:<br>(Choose this option only if the Suspended type bridge is not feasible) | **Favorable**: Condition can be fulfilled | RB<br>LB | |
|  | **Unfavorable**: Condition cannot be fulfilled | | RB<br>LB |
| • Draw slope lines of 35° (angle of internal friction) in case of Soil slope and 60° in case of Rock slope.<br>• The foundations should be placed behind these lines.<br>• Check if these conditions can be fulfilled. | | | |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **FREE BOARD**<br>Clearance (Freeboard) between the lowest point of the bridge and the highest flood level (HFL) should be not less than 5m. For this, sufficient clearance between the lower walkway saddle and the HFL should be maintained.<br>**For Suspended Type Bridge**: | | | |
|  <br>**span**<br>up to 50 m<br>51 - 60 m<br>61 - 90 m<br>91 - 105 m<br>106 - 120 m | **Favorable** **Unfavorable**<br>Clearance between the lower foundation saddle and the HFL is:<br>**not less than** **less than:**<br>7.0 m 7.0 m<br>7.50 m 7.5 m<br>8.0 m 8.0 m<br>8.5 m 8.5 m<br>9.0 m 9.0 m | ☐ | ☐ |
| **For Suspension Type Bridge**:<br>(Choose this option only if the Suspended type bridge is not feasible)<br>  | **Favorable:**<br>Freeboard is not less than 5.0 m<br>**Unfordable:**<br>Freeboard is less than 5.0 m | ☐ | ☐ |
| • Identify the HFL by local observation and villagers' information.<br>• Calculate the available clearanace in case of Suspended type or Freeboard in case of Suspension type and compare with the requirement.<br>• **Exception**: At flat or wide river banks, the freeboard may be reduced.<br>At a gorge, the freeboard has to be increased. | **HFL** = Highest Flood Level | | |

## 4.2 River Condition

The selected bridge site must have a 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 checklist to evaluate the river condition:

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **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. | | | |
|  | **Favorable**: Bridge site far from the confluence | ☐ | |
| | **Unfavorable**: Bridge site near the confluence | | ☐ |
| **RIVERBED**<br>The riverbed at the selected bridge site should be stable without the possibility of erosion or filling up with bed load (boulders, gravel, silt, or sand) | | | |
| | **Favorable**: Riverbed is not erosive and not filling up | ☐ | |
| Riverbed filled up after heavy flood | **Unfavorable**: River bed is erosive or filling up | | ☐ |

## 4.3 Slope and Bank Condition

A bridge should be located at a 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.

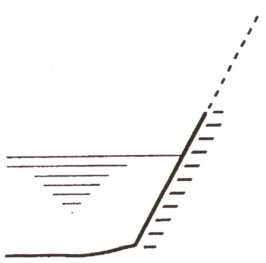
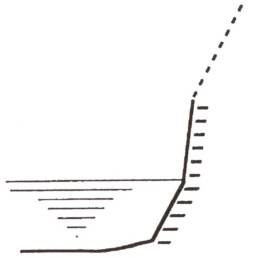
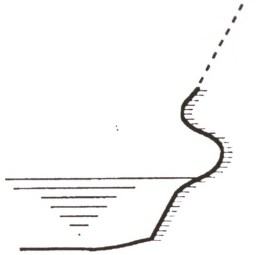
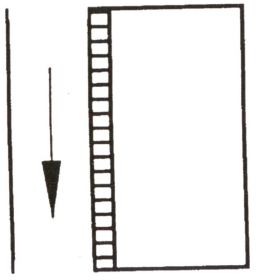
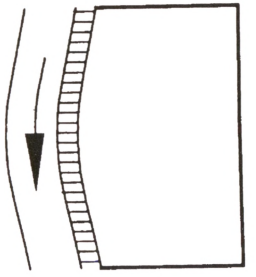
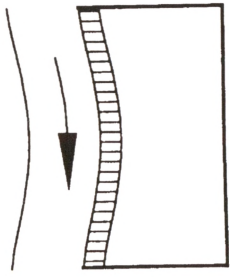
**If the slope and bank is soil, the potential instability features and failure modes are:**

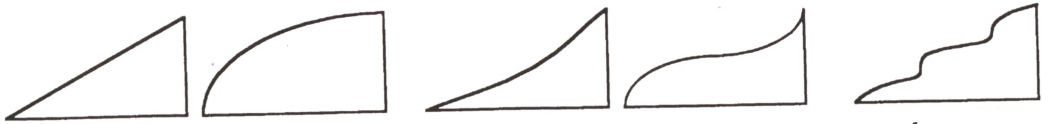
- bank erosion
- toppling instability of the bank
- erosion of the slope
- land slide

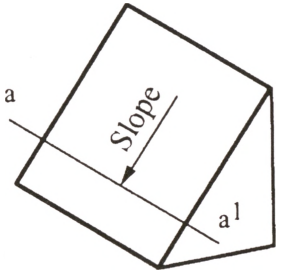
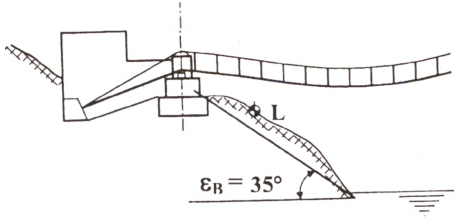
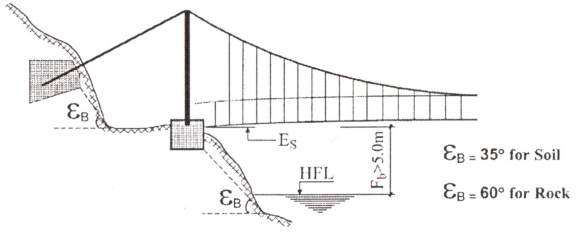
**If the slope and bank is rock, the potential instability features and failure modes are:**

- plain failures or a rockslide along the slope
- wedge failure leading to the fall of rock mass
- toppling, leading to the fall of rock blocks
- translational failure (slide), similar to a 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.

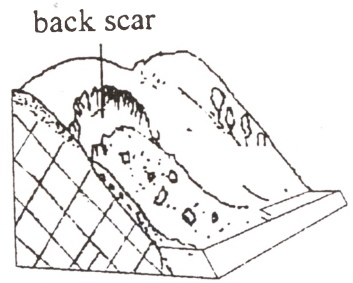
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **IF THE RIVER BANK OR SLOPE IS SOIL** | | | |
| **BANK PROFILE** | | | |
| Bank profile should be smooth. | | | |
|  Smooth | **Favorable**: Bank profile is smooth to partially cut out | RB<br>LB | |
|  Partially cut out | **Unfavorable**: Bank profile is strongly cut out | | RB<br>LB |
|  Strongly cut out | | | |
| **RIVER BANK CONTOUR** | | | |
| The bridge site should be located at a straight reach of the river to avoid undercutting or bank erosion. | | | |
|  Straight | **Favorable**: River contour is straight or convex | RB<br>LB | |
| Favourable  Convex | | | |
| Unfavourable  Concave | **Unfavorable**: River contour is concave | | RB<br>LB |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **BANK EROSION**<br>The riverbank should not show signs of erosion.<br><br> <br>Bank erosion due to high river current | **Favorable**: No Fresh erosion | RB<br>LB | |
| | **Unfavorable**: Presence of Fresh erosion | | RB<br>LB |
| **SLOPE PROFILE**<br>Select an applicable profile from the pictures given below. The slope profile should be smooth.<br><br>  <br>Smooth Partially cut out Strongly cut out | **Favorable**: Slope profile is smooth to partially cut out | RB<br>LB | |
| | **Unfavorable**: Slope profile is strongly cut out | | RB<br>LB |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **TRANSVERSE SLOPE**<br>The transverse slope should be smooth. | | | |
| <br>Transverse slope strongly cut out | **Favorable**: Transverse slope is smooth to partially cutout | RB<br>LB | |
|  | **Unfavorable**: Transverse slope is strongly cutout | | RB<br>LB |
| <br>Smooth Partially cut out Strongly cut out | | | |
| **SLOPE INCLINATION**<br>Slope inclination should be less than 35°. | | | |
| **For Suspended type**<br>  | **Favorable**: Slope inclination is equal to or less than 35° | RB<br>LB | |
| **For Suspension type**<br>  | **Unfavorable**: Slope inclination is greater than 35° | | RB<br>LB |
| 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. | | | |

| *Features* | *Condition* | | *Site Assessment* | |
|---|---|---|---|---|
| | | | *Favorable* | *Unfavorable* |
| **RIVER UNDERCUTTING**<br>• The bridge site should be free from river undercutting which may lead to landslide. | | | | |
| <br>Landslide caused by river undercutting | **Favorable**: | No river undercutting | RB<br>LB | |
| | **Unfavorable**: | River undercutting is active or there is potential | | RB<br>LB |
| **INCLINED TREES**<br>The selected site should not have inclined trees which indicate an active landslide. | | | | |
| <br>Inclined trees on landslide mass | **Favorable**: | Inclined trees not present | RB<br>LB | |
| | **Unfavorable**: | Inclined trees present | | RB<br>LB |

| *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 | RB<br>LB | |
| | **Unfavorable**: Seepage or swampy area is present | | 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 | **Favorable**: No sign of gully erosion or only light gully erosion | RB<br>LB | |
| | **Unfavorable**: Heavy gully erosion exists | | RB<br>LB |
| • Observe if any rivulets are within the vicinity of the selected site.<br>• If a rivulet exists, examine the dimension of the gully cutting. | | | |

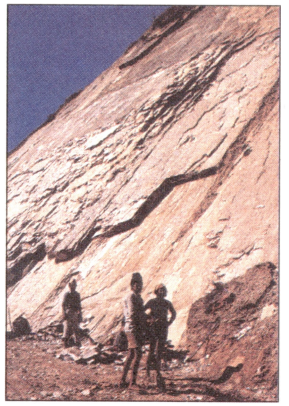
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **SLIPPED (SLUMP) SOIL MASS**<br>The bridge should not be located on already slipped soil masses. | | | |
| <br>Slope with slipped soil mass | | | |
|  <br>**Slop failure model** | | | |
| | **Favorable**: There **are no** back scars or signs of soil mass movement | RB<br>LB | |
| | **Unfavorable**: There **are** back scars or signs of soil mass movement | | RB<br>LB |
| • Examine and identify soil mass movement by observing traces of back scars on the slope. | | | |

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |

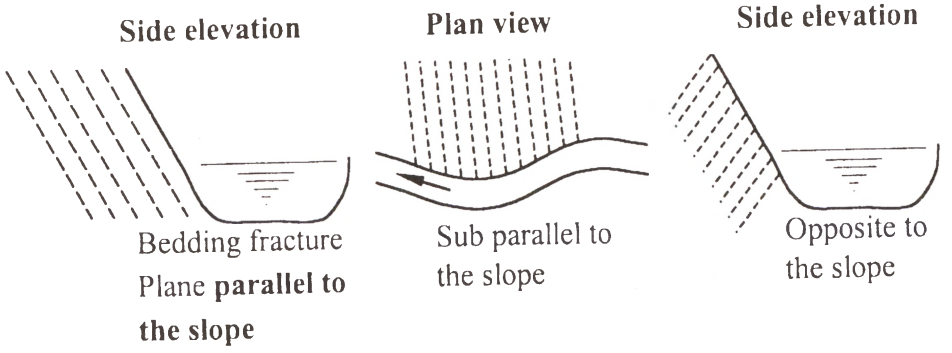
## IF THE RIVER BANK IS ROCK

**PLAIN FAILURE**

Plain failure leads to the sliding of rock layers along the slope. The rock bank/slope of the selected site should not have any features 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.

**Favorable**:

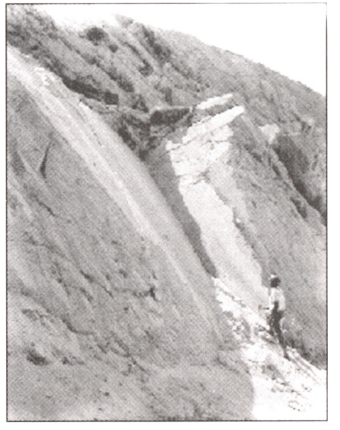
**Plain failure will not take place if**

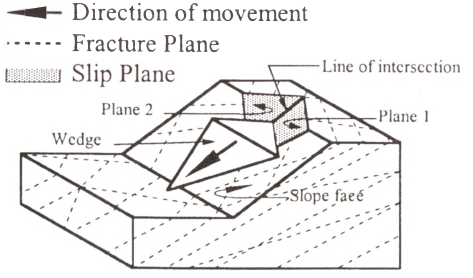
- The bedding/fracture plain is sub-parallel or opposite to the slope — RB
- The bedding/fracture plain is parallel to the slope but the inclination is less than 35° — LB

**Unfavorable**:

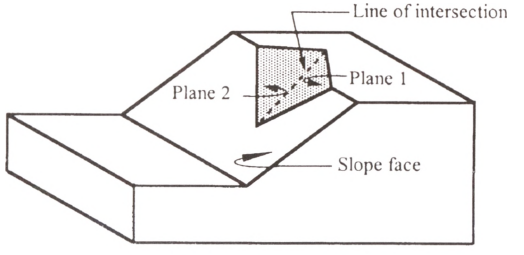
**Plain failure will take place if**

- The bedding/fracture plain is parallel to the slope and the inclination is greater than 35° — RB
- There is presence of rocks that have slid down — LB

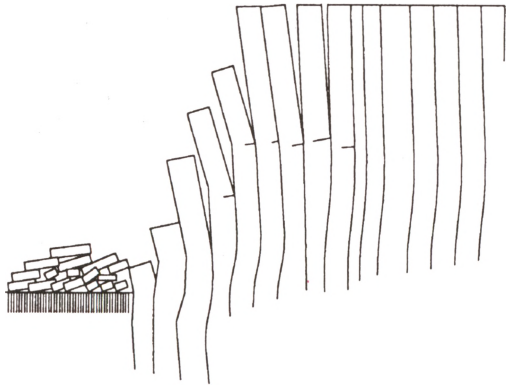
| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **WEDGE FAILURE**<br>Any form of wedge failure leads to sliding of rock masses. The rock bank/slope should not have wedge failures or potential wedge failures. | | | |
|  <br>Trace of wedge failure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

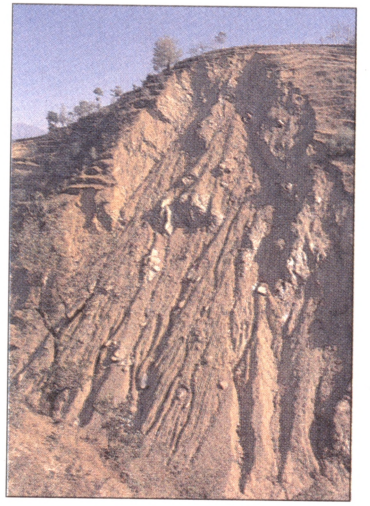
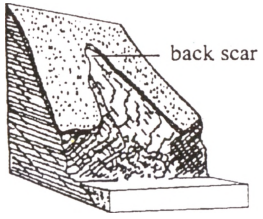



**Wedge Failure Model**




**Wedge Failure**

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

| *Features* | *Condition* | *Site Assessment* | |
|---|---|---|---|
| | | *Favorable* | *Unfavorable* |
| **TRANSLATIONAL FAILURE (SLIDE)**<br>The rock slope should not have any potential of translational failure. | | | |
|  <br>**Translational failure (sliding) of soft rock slope** | **Favorable**: | | |
| | **Sliding will not take place if**<br>• The slope is hard rock | RB | |
| | • The slope is soft rock but not weathered | LB | |
| | • The slope is soft rock and weathered but not steeper than 40° | | |
| | **Unfavorable**: | | |
| | **Sliding will take place if**<br>• The Slope is highly weathered soft rock and steeper than > 40° | | RB |
| | | | LB |
|  <br><br>**failure(slide) model** | • There is presence of back scar or old slides | | |
| • Identify the type of rock and its weathering grade.<br>• Estimate the inclination of the slope.<br>• Compare with the conditions. | | | |

## 4.4 Evaluation of the Bridge Site

After completing the 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.

**Bad** : Most of the features are **unfavorable**. Reject the site.

**Questionable** : Most of the features are **favorable** and some are **unfavorable**. The site is questionable. In this case, a further detailed investigation by an experienced geo-technical engineer is necessary. For details refer to Volume B of LSTB (SBD) Manual of Trail Bridge Section, DoLIDAR, Nepal.

**Selected Bridge Type**: **Suspended** ☐ (Always try to select the Suspended type Bridge) **Suspension** ☐ (Select only in exceptional cases when the Suspended type bridge is not feasible or uneconomic)

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 any remarks, and note also the proposed special structures, if necessary: retaining walls, gabion walls, drainage, lining of existing irrigation canal, river protection works, etc. Mention the height, length and location of these structures, and also reflect it in the sketch of the plan (page no. 38).

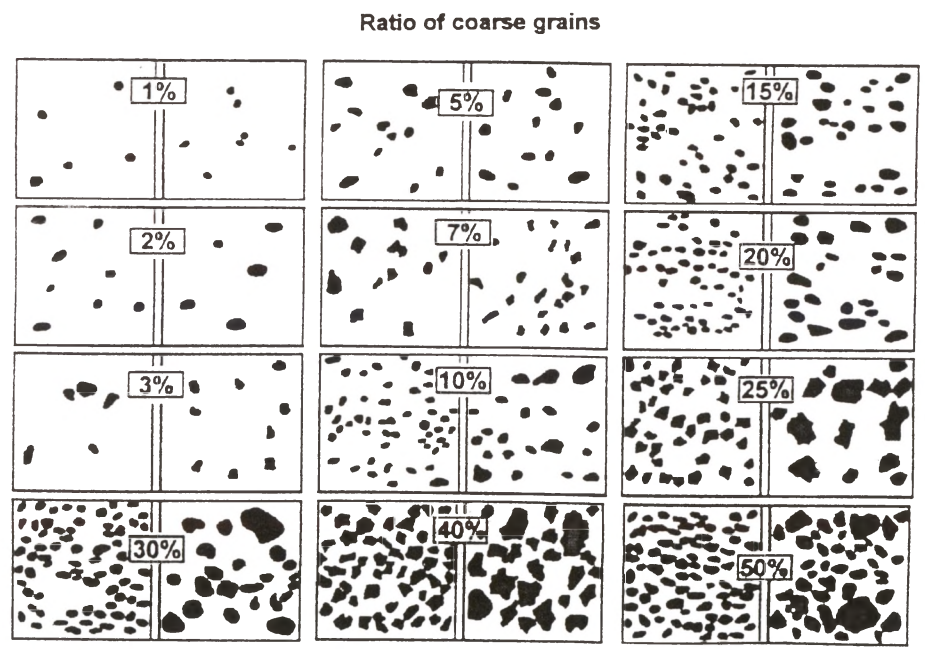
**Remarks:**

## 4.5 CLASSIFICATION OF SOIL AND ROCK

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

| Soil Type | | How to identify | Soil Parameters | | | Applicable Main Cable Anchor Design | |
|---|---|---|---|---|---|---|---|
| | | | Bearing capacity kN/ $m^2$ | Angle of internal Friction, φ° | Unit Weight γ, $kN/m^3$ | For Suspended Type | For Suspension Type |
| **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>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** | **Deadman Anchor or Gravity Anchor Block** |
| | **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 a 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 a 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** | | |

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



# Rock Classification

| Rock Type | Examples | How to Identify | Degree of Fractures or Weathering | How to Identify | Rock Parameters | | Applicable Main Cable Anchor Design | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Bearing Capacity [kN/m$^2$] | Angle of Sliding Friction φ° | For Suspended Type | For Suspension Type |
| **Hard Rock** | Quartzite Limestone Granite, Dolomite etc. | Gives metallic sound at 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** | **Drum Anchor in Hard Rock or Gravity Anchor Block** |
| | | | Highly fractured rock and fresh to fairly weathered | In the rock shows widely open cracks, fractures and bedding | 1500 | 35-50 **(40)** | **Drum Anchor in Fractured Rock** | **Drum Anchor in Fractured Rock or Gravity Anchor Block** |
| **Soft Rock** | Phylite Slate Siltstone Claystone Schist etc. | Gives dull sound at hammer blow | Fresh | No sign of weathering | 1300 | 25-40 **(30)** | | |
| | | | Fairly to highly weathered | Most of the original rock has been seriously altered Rock can be broken by hand | 600-750 **(650)** | 25-40 **(30)** | **Deadman Anchor** | **Gravity Anchor Block** |

## 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 bedrock at the proposed foundation locations. Pit excavation and soil/rock investigation should be carried out at all foundation locations.

If the bank/slope is soil, investigate each layer of soil in the pit and classify according to the Soil Classification chart of page 26. Fill in the following soil investigation tables.

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

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

**Right Bank** (at location of Walkway and Tower Foundation in case of Suspension Type Bridge) **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 Walkway and Tower Foundation in case of Suspension Type Bridge) **SOIL**

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

**Windguy Block is Optional and investigate if only Applicable.**

**Right Bank** (at location of windguy block upstream)

**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 downstream)

**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 upstream )

**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 downstream )

**SOIL**

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

If the bank/slope is rock, investigate the rock type and classify according to the Rock Classification chart of page 27. Fill in the following rock investigation table:

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

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

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

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

**Right Bank** (at location of Walkway and Tower Foundation in case of Suspension Type Bridge) **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 Walkway and Tower Foundation in case of Suspension Type Bridge) **ROCK**

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

**Windguy Block is Optional and investigate if only Applicable.**

**Right Bank** (at location of windguy block upstream ) **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 downstream) **ROCK**

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

**Left Bank** (at location of windguy block upstream) **ROCK**

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

**Left Bank** (at location of windguy block downstream) **ROCK**

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

# 5. TOPOGRAPHIC SURVEY

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

- provide a topographical 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

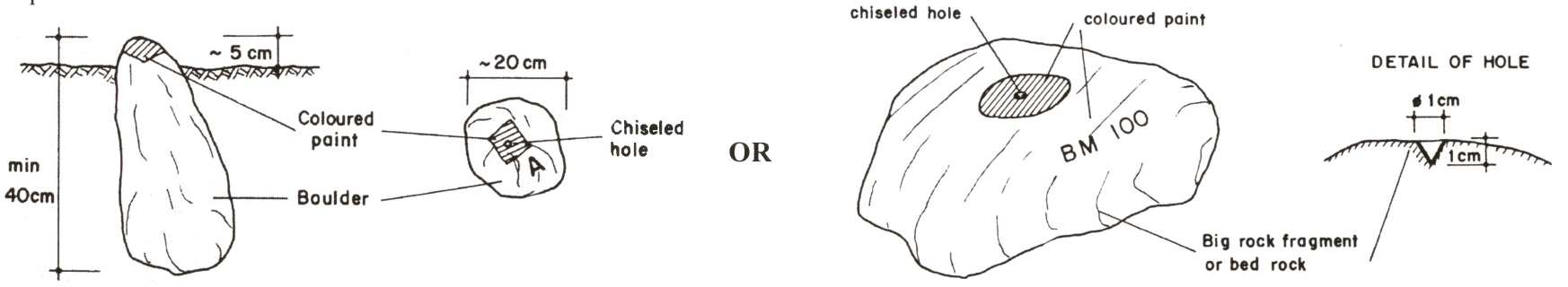
## 5.1 SURVEY AREA

Area to be covered by the topographical survey:

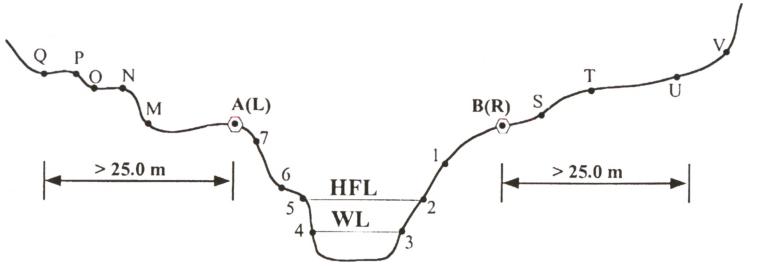
- A profile along the bridge axis extending up to 25m behind the main anchorage blocks, for bridges **without windguy** arrangement.
- A profile along the bridge axis extending up to 25m behind the main anchorage blocks **and** a topographical plan extending up to 10m upstream and 10m downstream from 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. The permanent axis points **L** and **R** should be fixed on a rock outcrop along the bridge centerline, 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:




Additional survey points should be fixed along the centerline 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 extend 25m behind the main anchorage block and up to the edge of the river flow.



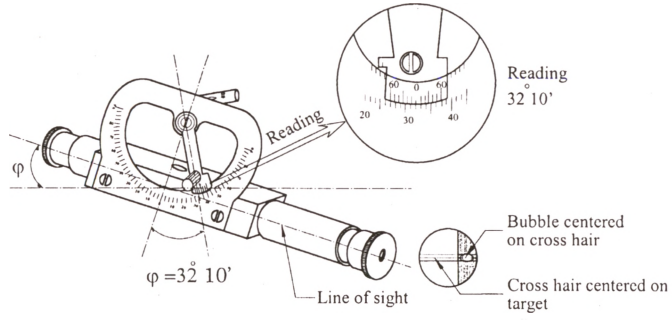
## 5.3 SURVEY METHODS

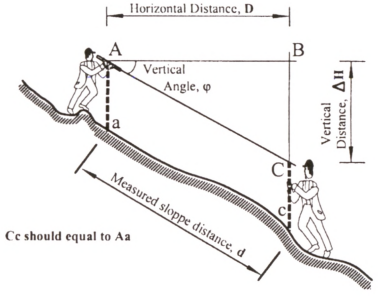
There are two options for conducting the topographical survey. Depending upon the span and type of the bridge, a profile along the bridge axis or a more detailed survey including contour lines will be necessary.

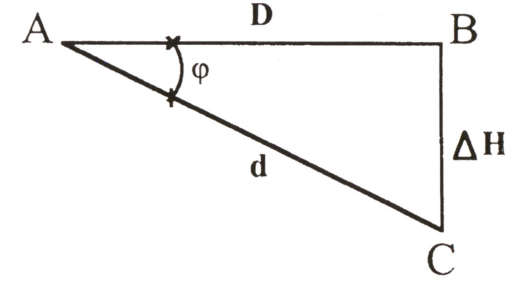
- For the Suspended Type Bridge, a detailed **profile** along the selected bridge axis is sufficient for bridges without windguy arrangement. A topographical profile can be made by means of an **Abney Level**, however, for fixing precise levels, a Level Instrument is necessary.
- For the Suspension Type Bridge, a detailed **profile** along the selected bridge axis is sufficient for bridges without windguy arrangement. However, a topographical profile must be made by means of a **Theodolite**.
- For bridges requiring a windguy arrangement, a more detailed topographical survey is necessary, from which a detailed contour plan can be plotted. This type of survey should be done by a **Theodolite**.

## 5.4 SURVEY WITH AN ABNEY LEVEL

The main function of an 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 with an Abney Level is illustrated in the sketch and procedure described below:

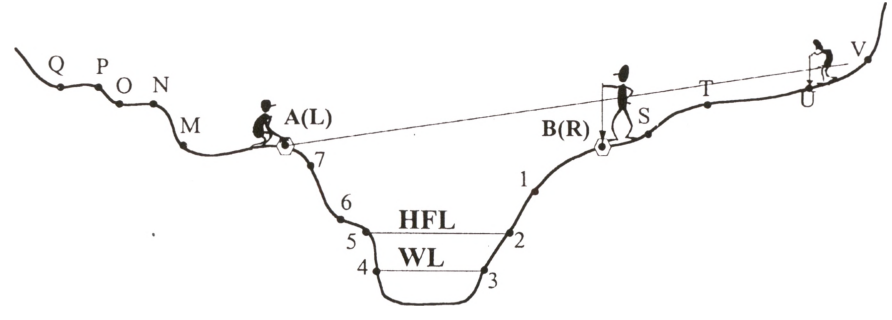


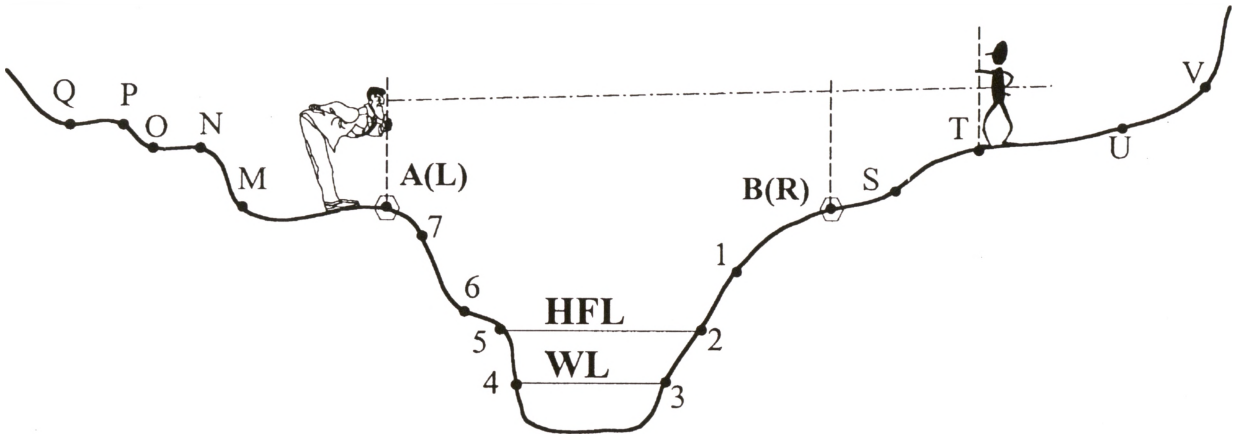

To take a profile along the bridge axis, the surveyor should first set the exact centerline as described in Chapter 5.2. There are two methods of setting the centerline.

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



**With Bamboo, Wooden Sticks or Ranging Rods:**

This method is used for spans above 50m. In this method the survey points are fixed along the bridge centerline with the help of Bamboo, Wooden Sticks or Ranging Rods. Fix a stick at each axis point **L** and **R** in a **vertical** position. Now the surveyor can aim at other points along the bridge centerline between **L** and **R**. By fixing additional survey points in line 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 the 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:

$$E = \frac{[\varphi_{LR}] - [\varphi_{RL}]}{2} = \pm E \qquad ; \qquad \textbf{Corrected angle } \varphi' = \varphi \pm E$$

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

Enter the measurements and calculations in the **Bridge Axis Profile by Abney Level** sheet (page no. 40 and 41).

Draw a plan view with the bridge axis (centerline), axis points **L** and **R,** with all the bench marks and fixed objects like trees, houses etc. Give distances and directions from the reference points so that the axis points and bench marks 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**
(indicate river flow and north direction)

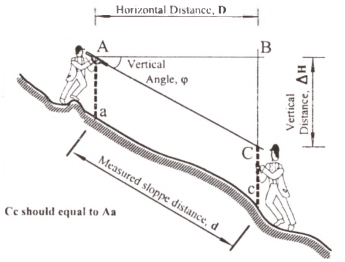
Draw a sketch of the profile/cross section of the bridge (centerline) with axis points **L** and **R**, with all survey points and topographical features, including tentative position of the bridge foundations, low water level and high flood level.

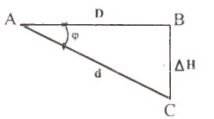
**Profile/Cross Section**

# BRIDGE AXIS PROFILE WITH AN 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 ± | VERTICAL DISTANCE ΔH | REDUCED LEVEL (ELEVATION) H m | REMARKS (Description of Points) |
|---|---|---|---|---|---|---|---|---|---|
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Remarks: 1. Applicable only for suspended type bridge up to 120m span.
2. For other cases use a Theodolite.

# BRIDGE AXIS PROFILE WITH AN ABNEY LEVEL



| 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 ± | VERTICAL DISTANCE ΔH | REDUCED LEVEL (ELEVATION) H m | REMARKS (Description of Points) |
|---|---|---|---|---|---|---|---|---|---|
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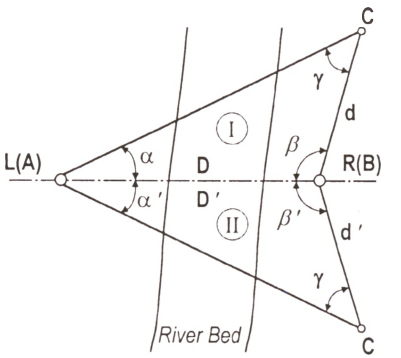
## 5.5 SURVEY WITH A THEODOLITE

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

For a Suspension type bridge the Survey is conducted with a **Theodolite** in any case.

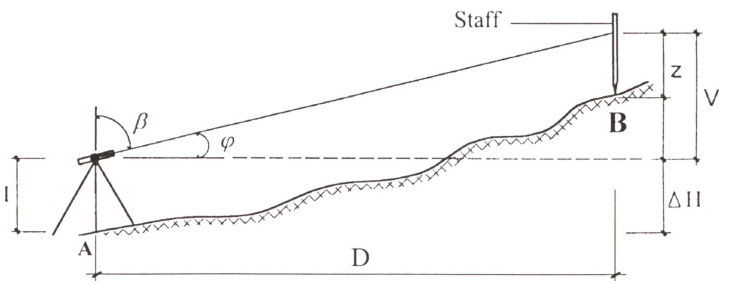
For proper use of a Theodolite, refer to the respective instruction manual, that comes with the Theodolite, and to Volume B of LSTB (SBD) Manual.

**Profile Along Bridge Axis:**
Fix the bridge centerline as described in Chapter 5.2. Measure the distance between the axis points **L** and **R** by the horizontal triangulation method. Triangulation is done by measuring all the three angles of a triangle and the 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 the distance between the axis points **L** and **R** using the trigonometry formulas given therein.

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




Insert the readings in the survey form **Summary of Triangulation and Elevations of Pegs and Bench Marks** and calculate the Elevations (reduced levels) of the points using the trigonometry formulas given therein.

# TRIANGULATION

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

## 1st Triangulation

**Sketch:**

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

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

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

$d_{mean}$ – _____ $D = d_{mean} \times \frac{\sin \gamma}{\sin \beta}$ = _____

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

$\Delta$ = (200$^g$ 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:**

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

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

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

$d_{mean}$ = _____ $D = d_{mean} \times \frac{\sin \gamma}{\sin \beta}$ = _____

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

$\Delta$ = (200$^g$ 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

1st Triangulation $D_1$ = _____

2nd Triangulation $D_2$ = _____

Difference $\Delta D$ = _____

Mean Distance $D = \frac{D_1+D_2}{2}$ = _____

$\Delta D/D$ = _____

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

REDUCED LEVELS: BMI = 100.00

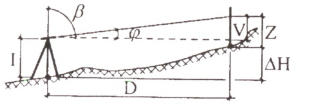
BMII = _____

A = _____

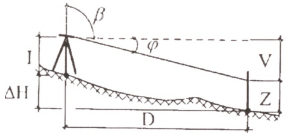
B = _____

## 2. Elevation

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




$\Delta H = V - Z + I$

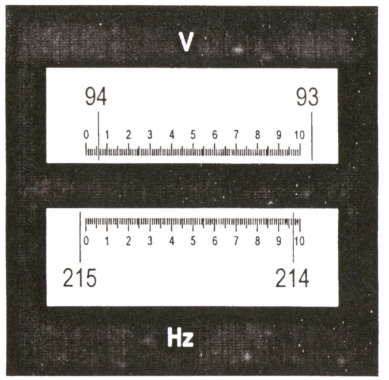


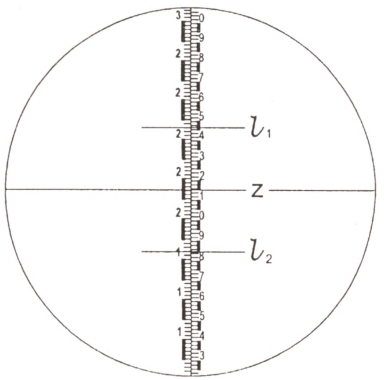

$\Delta H = V + Z - I$

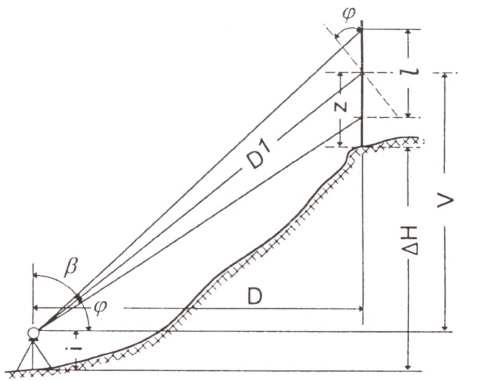
| INSTRUMENT STATION | STAFF STATION | INSTRUMENT HEIGHT I | | MIDDLE HAIR Z | | HORIZONTAL DISTANCE D | | VERTICAL ANGLE | | MEAN (Left + Right) / 2 | VERTICAL DISTANCE V | | DIFFERENCE IN ELEVATION | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | FACE RIGHT | | | | | 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 | | | | | | | | | | | | | | | |

**Topographical Detail Survey:**

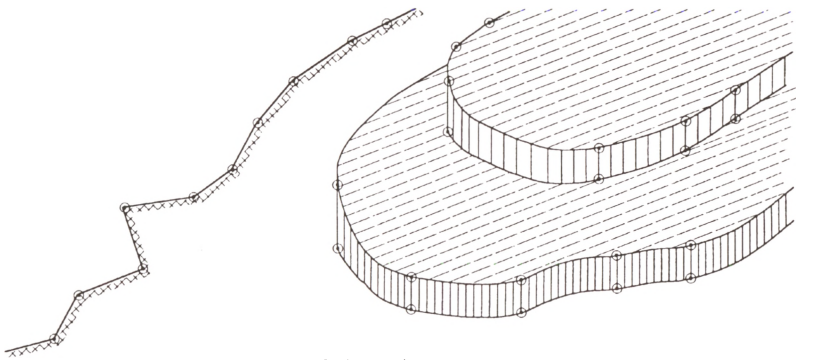
A Topographical detail survey is necessary to represent the topography of the bridge site by means of contour lines. This is done by a tacheometric survey. A Tacheometric survey is done with a Theodolite with stadia hairs and leveling staff. The horizontal and vertical distances and positions of the 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 the break points of slopes, terraces, fields and other features representing the actual topography of the ground as shown in the sketch .




Insert all the readings in the **Tacheometry Survey Form** and calculate the horizontal distances and elevations using 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 using a tape. If the difference between the stadia measurement and the tape measurement is more than 0.2%, corrections in the calculation of the horizontal and vertical distances should be applied. The distances should be corrected for error Δ as per the following Formula.

$$D = (100 \times l + \Delta) \times \cos^2\varphi \qquad V = (50 \times l + \Delta) \times \sin 2\varphi$$

# TACHEOMETRY



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

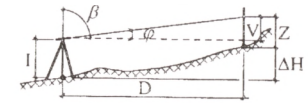
$\ell = \ell_1 - \ell_2$

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

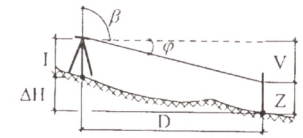
$V = 50 \times \ell \times \sin 2\varphi = 50 \times \ell \times \sin 2\beta$

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

$H = \text{R.L. of Station} \pm \Delta H$




$\Delta H = V - Z + I$




$\Delta H = V + Z - I$

| STATION<br>HEIGHT OF INSTRUMENT, I<br>m | STAFF STATION | HORIZONTAL CIRCLE α<br>g / ° | <br>c / ′ | VERTICAL CIRCLE β<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 +/- Δ H<br>m | REDUCED LEVEL H<br>m | REMARKS (Description of Staff Station) |
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# TACHEOMETRY



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

| STATION<br>HEIGHT OF INSTRUMENT, I<br>m | STAFF STATION | HORIZONTAL CIRCLE α<br>g / ° | <br>c / ′ | VERTICAL CIRCLE β<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 +/- Δ H<br>m | REDUCED LEVEL H<br>m | REMARKS (Description of Staff Station) |
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# TACHEOMETRY



Bridge Name : District : Surveyed by : Date :

| STATION<br>HEIGHT OF INSTRUMENT, I<br>m | STAFF STATION | HORIZONTAL CIRCLE α<br>g / ° | <br>c / ′ | VERTICAL CIRCLE β<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 +/- Δ H<br>m | REDUCED LEVEL H<br>m | REMARKS (Description of Staff Station) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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# TACHEOMETRY

**Page No. 4**

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

| STATION<br>HEIGHT OF INSTRUMENT, I<br>m | STAFF STATION | HORIZONTAL CIRCLE α<br>g / ° | <br>c / ′ | VERTICAL CIRCLE β<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 +/- Δ H<br>m | REDUCED LEVEL H<br>m | REMARKS (Description of Staff Station) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
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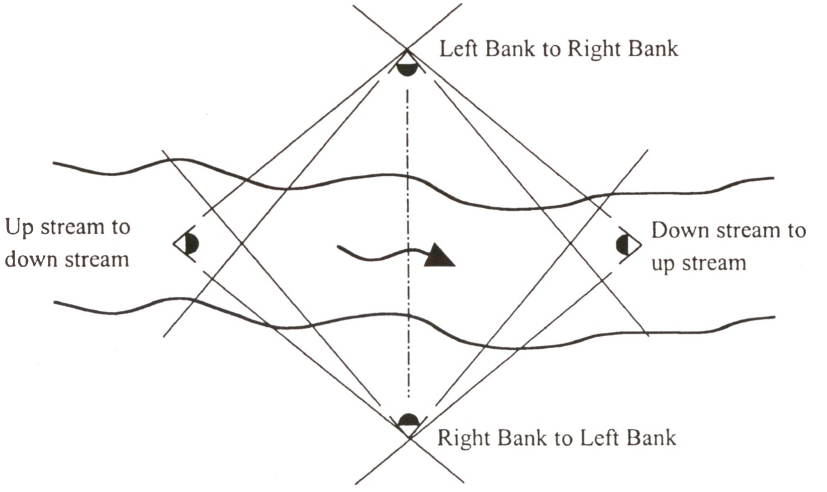
## 6. PHOTOGRAPHS

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

- An overall view of the bridge site from upstream indicating the approximate location of the bridge foundations and the bridge the axis line.
- An overall view of the bridge site from downstream indicating the approximate location of the bridge foundations and the axis line.
- A view of the right bank from the left bank with the approximate location of the bridge foundations.
- A 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 shown in 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 on the following blank pages.

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

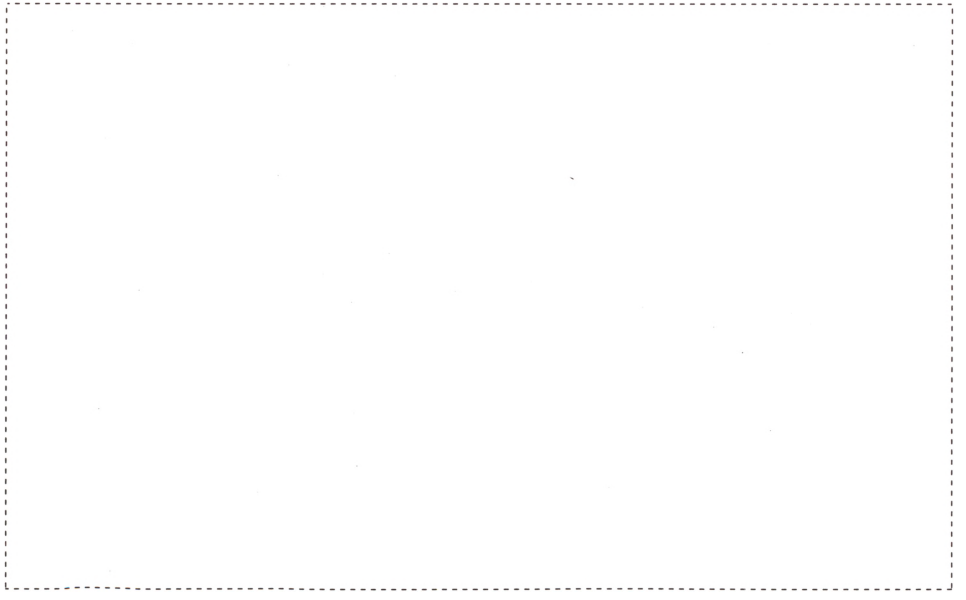
2. An overall view of the bridge site from downstream (with approximate location of the bridge foundations on both the R/B & L/B and the axis line)

3. An overall view of the right bank (with approximate location of main anchorage foundation and the axis line)

4. An overall view of the left bank (with approximate location of main anchorage foundation and the axis line)

5. A view of the right bank with proposed location of walkway / tower foundation

6. A view of the left bank with proposed location of walkway / tower foundation



7. A view of the Axis Peg/Left Bank

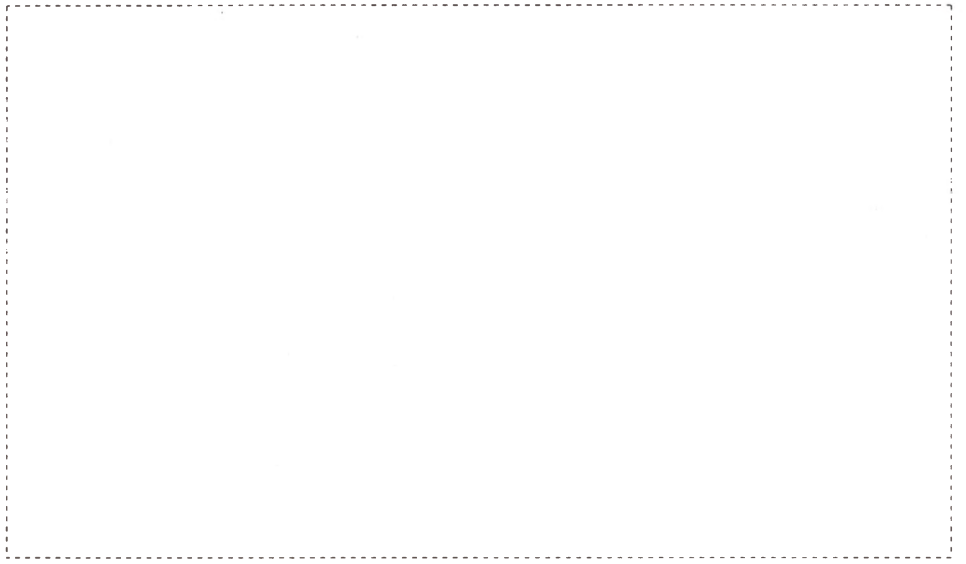
8. A view of the Axis Peg/Right Bank

9. A view of Bench Mark

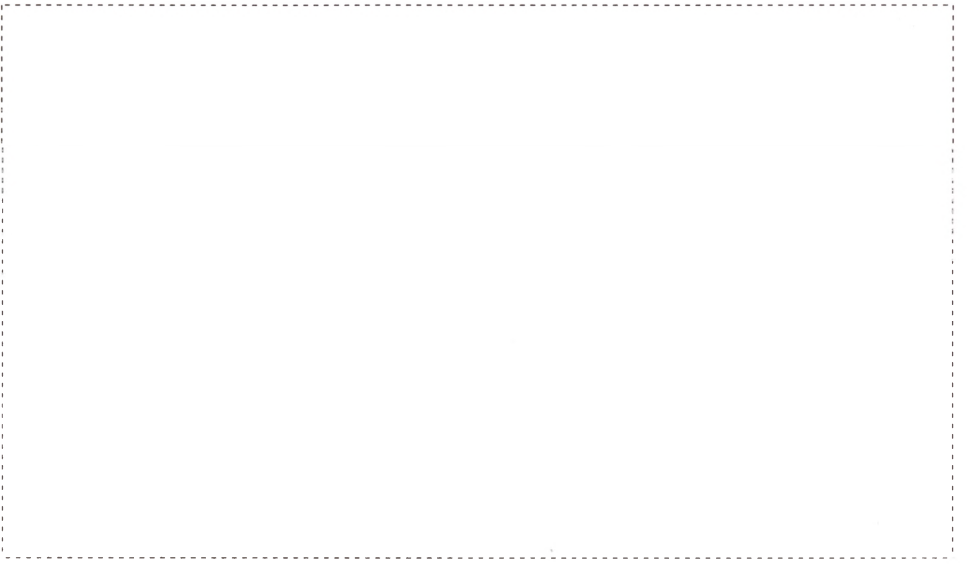
10. Pit excavation at .....

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

A technical survey report consists of:

- Filled in Survey Forms and Checklist i.e., Form No. 1
- Topographical 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**)

## Traffic Count Sheet

Name of Traffic Surveyor : _____

Date and Day of Traffic Survey : _____ Time (from ..... to .....)

### HUMAN TRAFFIC

| S.N. | Traffic category (numbers) | | | Origin | Destination | Expected time saving after bridge construction | Access to* | Remarks |
|---|---|---|---|---|---|---|---|---|
| | Porters | Travelers | | | | | | |
| | | Male | Female | | | | | |
| 1 | | | | | | | | |
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| 23 | | | | | | | | |
| 24 | | | | | | | | |
| Total | | | | | | | | |

*Refer Page 4

# Traffic Count Sheet

## ANIMAL TRAFFIC

| S.N. | Traffic category (numbers) | | Origin | Destination | Expected time saving after bridge construction | Remarks |
|---|---|---|---|---|---|---|
| | Porter | Animal | | | | |
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
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| 22 | | | | | | |
| 23 | | | | | | |
| 24 | | | | | | |
| Total | | | | | | |

**Note Pad**

# Form No. 2: Bridge Design

# Form No. 2

## Bridge Design
(total 23 pages)

1. Cables and Standard Tower Selection
2. Main Cable Anchor Blocks
3. Walkway & Tower Foundations
4. Windguy Cable Anchor Blocks
5. Suspender List
6. Windguy Arrangement
7. Bridge Standard Drawings

Bridge No & Name: .....

River Name: .....

District Name: .....

Designed by: .....

Approved by: .....

Date: .....

**Bridge No:** ..... **Bridge Name :**..... **District:**.....

**Span:** ..... . **m,** **Walkway Width : 106cm**

# 1. Cables and Standard Tower Selection for Suspension Bridge Type

## A. Survey Data & Calculation of Freeboard

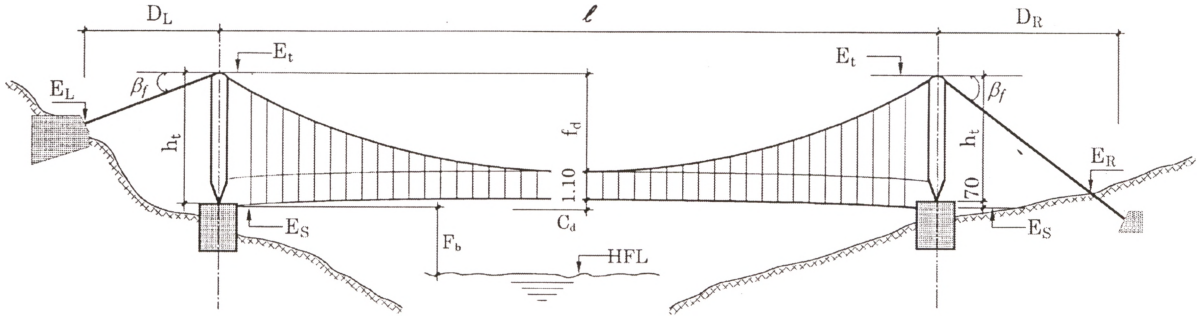


**Figure 1.1 Bridge Geometry**

1. Span of the Bridge (should be rounded off to the nearest meter) $\ell$ = ..... m

2. Elevation of the Spanning Cable Anchor Point $\mathbf{E_s}$ = ..... m

3. Highest Flood Level **HFL** = ..... m

4. **Freeboard** (min. 5.00m) $\mathbf{F_b}$ = $\mathbf{E_s}$ **- HFL** = $\mathbf{F_b}$ = ..... m

*(If the freeboard is less than 5.00m, try either to raise the elevation of the spanning cable anchor point by increasing the height of the Walkway and Tower Foundation, or to adjust the span to gain the required elevation.)*

## B. Selection of Cables and Standard Tower (Pylon)

Select the Main and Spanning Cable combinations, standard tower type and tower height $\mathbf{h_t}$ and the Bridge Geometry according to the span from the following table No1.1. The Bridge Geometry refers to main cable dead load sag $\mathbf{f_d}$, dead load camber $\mathbf{c_d}$ of spanning cable and the main cable inclination at tower saddle $\beta_f$ in full load case.

**Table No. 1.1: Selection of Cables and Standard Towers**

| Span | Tower Height/(Type) | Cables Nos. and Diameter | | | Dead Load Sag | Hoisting Sag | Camber | Full load Backstay Angle |
|---|---|---|---|---|---|---|---|---|
| $l$ | $h_t$ | Main | Spanning | Windguy | $f_d$ | $f_h$ | $c_d$ | $ß_f$ |
| m | m | mm | mm | mm | m | m | m | deg. |
| 30.0 | 5.50 (1) | 2 ø 26 | 2 ø 26 | Not Required | 4.20 | 4.13 | 0.90 | 29.83 |
| 31.0 | | | | | 4.15 | 4.07 | 0.95 | 28.83 |
| 32.0 | | | | | 4.10 | 4.02 | 1.00 | 27.88 |
| 33.0 | | | | | 4.10 | 4.01 | 1.00 | 27.24 |
| 34.0 | | | | | 4.08 | 3.99 | 1.02 | 26.55 |
| 35.0 | | | | | 4.05 | 3.95 | 1.05 | 25.84 |
| 36.0 | | | | | 4.22 | 4.12 | 0.88 | 26.14 |
| 37.0 | | | | | 4.19 | 4.09 | 0.91 | 25.49 |
| 38.0 | | | | | 4.16 | 4.05 | 0.94 | 24.88 |
| 39.0 | | | | | 4.13 | 4.01 | 0.97 | 24.31 |
| 40.0 | | | | | 4.10 | 3.97 | 1.00 | 23.77 |
| 41.0 | | | | | 4.10 | 3.96 | 1.00 | 23.39 |
| 42.0 | | | | | 4.10 | 3.96 | 1.00 | 23.03 |
| 43.0 | | | | | 4.30 | 4.16 | 0.80 | 23.48 |
| 44.0 | | | | | 4.40 | 4.26 | 0.70 | 23.53 |
| 45.0 | | | | | 4.40 | 4.25 | 0.70 | 23.20 |
| 46.0 | | 2 ø 32 | 2 ø 32 | | 3.92 | 3.77 | 1.18 | 20.45 |
| 47.0 | | | | | 3.90 | 3.74 | 1.20 | 20.10 |
| 48.0 | | | | | 4.05 | 3.89 | 1.05 | 20.39 |
| 49.0 | | | | | 4.05 | 3.88 | 1.05 | 20.13 |
| 50.0 | | | | | 4.10 | 3.93 | 1.00 | 20.07 |
| 51.0 | | | | | 4.10 | 3.92 | 1.00 | 19.83 |
| 52.0 | | | | | 4.10 | 3.91 | 1.00 | 19.61 |
| 53.0 | | | | | 4.10 | 3.90 | 1.00 | 19.40 |
| 54.0 | | | | | 4.10 | 3.88 | 1.00 | 19.20 |
| 55.0 | | | | | 4.25 | 4.04 | 0.85 | 19.46 |
| 56.0 | 7.35 (2) | | | | 5.47 | 5.30 | 1.48 | 22.82 |
| 57.0 | | | | | 5.44 | 5.26 | 1.51 | 22.46 |
| 58.0 | | | | | 5.41 | 5.22 | 1.54 | 22.12 |
| 59.0 | | | | | 5.38 | 5.18 | 1.57 | 21.79 |
| 60.0 | | | | | 5.35 | 5.13 | 1.60 | 21.48 |
| 61.0 | | | | | 5.35 | 5.12 | 1.60 | 21.26 |
| 62.0 | | | | | 5.45 | 5.22 | 1.50 | 21.32 |
| 63.0 | | | | | 5.65 | 5.42 | 1.30 | 21.65 |
| 64.0 | | | | | 5.85 | 5.63 | 1.10 | 21.97 |
| 65.0 | | | | | 5.95 | 5.72 | 1.00 | 22.01 |

Table No. 1.1 (continued)

| Span | Tower Height/(Type) | Cables Nos. and Diameter | | | Dead Load Sag | Hoisting Sag | Camber | Full load Backstay Angle |
|---|---|---|---|---|---|---|---|---|
| $l$ m | $h_t$ m | Main mm | Spanning mm | Windguy mm | $f_d$ m | $f_h$ m | $c_d$ m | $ß_f$ deg. |
| 66.0 | 9.20 (3) | 2 ø 32 | 2Ø 32 | Not Required | 7.02 | 6.81 | 1.78 | 24.48 |
| 67.0 | | | | | 6.99 | 6.77 | 1.81 | 24.15 |
| 68.0 | | | | | 6.96 | 6.73 | 1.84 | 23.83 |
| 69.0 | | | | | 6.93 | 6.69 | 1.87 | 23.54 |
| 70.0 | | | | | 7.20 | 6.97 | 1.60 | 23.97 |
| 71.0 | | | | | 7.40 | 7.17 | 1.40 | 24.22 |
| 72.0 | | | | | 7.60 | 7.37 | 1.20 | 24.47 |
| 73.0 | | | | | 7.70 | 7.46 | 1.10 | 24.47 |
| 74.0 | | | | | 7.65 | 7.40 | 1.15 | 24.14 |
| 75.0 | | | | | 7.65 | 7.40 | 1.15 | 23.93 |
| 76.0 | 11.05 (4) | 4 ø 26 | | | 8.57 | 8.36 | 2.08 | 25.38 |
| 77.0 | | | | | 8.54 | 8.33 | 2.11 | 25.07 |
| 78.0 | | | | | 8.51 | 8.29 | 2.14 | 24.77 |
| 79.0 | | | | | 8.48 | 8.25 | 2.17 | 24.48 |
| 80.0 | | | | | 8.45 | 8.22 | 2.20 | 24.20 |
| 81.0 | | | | Ø 26 (Optional only) | 8.42 | 8.18 | 2.23 | 23.93 |
| 82.0 | | | | | 8.39 | 8.14 | 2.26 | 23.67 |
| 83.0 | | | | | 8.36 | 8.10 | 2.29 | 23.41 |
| 84.0 | | | | | 8.33 | 8.06 | 2.32 | 23.16 |
| 85.0 | | | | | 8.30 | 8.02 | 2.35 | 22.92 |
| 86.0 | | | | | 8.27 | 7.98 | 2.38 | 22.68 |
| 87.0 | | | | | 8.24 | 7.94 | 2.41 | 22.46 |
| 88.0 | | | | | 8.21 | 7.90 | 2.44 | 22.24 |
| 89.0 | | | | | 8.35 | 8.04 | 2.30 | 22.34 |
| 90.0 | | | | | 8.55 | 8.24 | 2.10 | 22.56 |
| 91.0 | | | | | 8.85 | 8.54 | 1.80 | 22.96 |
| 92.0 | | | | | 9.05 | 8.74 | 1.60 | 23.16 |
| 93.0 | | | | | 9.25 | 8.95 | 1.40 | 23.36 |
| 94.0 | | | | | 9.25 | 8.94 | 1.40 | 23.20 |
| 95.0 | | | | | 9.20 | 8.87 | 1.45 | 22.96 |
| 96.0 | | 4 ø 32 | | | 7.98 | 7.68 | 2.67 | 20.00 |
| 97.0 | | | | | 8.05 | 7.75 | 2.60 | 20.00 |
| 98.0 | | | | | 8.13 | 7.82 | 2.52 | 20.00 |
| 99.0 | | | | | 8.20 | 7.89 | 2.45 | 20.00 |
| 100.0 | | | | | 8.28 | 7.96 | 2.37 | 20.00 |

Table No. 1.1 (continued)

| Span | Tower Height/(Type) | Cables Nos. and Diameter | | | Dead Load Sag | Hoisting Sag | Camber | Full load Backstay Angle |
|---|---|---|---|---|---|---|---|---|
| $l$ | $h_t$ | Main | Spanning | Windguy | $f_d$ | $f_h$ | $c_d$ | $ß_f$ |
| m | m | mm | mm | mm | m | m | m | deg. |
| 101.0 | 11.05 (4) | 4 ø 32 | 2 ø 32 | ø 26 (Optional only) | 8.35 | 8.03 | 2.30 | 20.00 |
| 102.0 | | | | | 8.40 | 8.07 | 2.25 | 20.00 |
| 103.0 | | | | | 8.50 | 8.17 | 2.15 | 20.00 |
| 104.0 | | | | | 8.57 | 8.23 | 2.08 | 20.00 |
| 105.0 | | | | | 8.65 | 8.31 | 2.00 | 20.00 |
| 106.0 | | | | | 8.71 | 8.36 | 1.94 | 20.00 |
| 107.0 | | | | | 8.80 | 8.45 | 1.85 | 20.00 |
| 108.0 | | | | | 8.85 | 8.49 | 1.80 | 20.00 |
| 109.0 | | | | | 8.94 | 8.58 | 1.71 | 20.00 |
| 110.0 | | | | | 9.00 | 8.63 | 1.65 | 20.00 |
| 111.0 | | | | | 9.00 | 8.62 | 1.65 | 19.88 |
| 112.0 | | | | | 8.95 | 8.55 | 1.70 | 19.70 |
| 113.0 | | | | | 8.95 | 8.54 | 1.70 | 19.60 |
| 114.0 | | | | | 8.95 | 8.53 | 1.70 | 19.50 |
| 115.0 | | | | | 8.90 | 8.46 | 1.75 | 19.34 |
| 116.0 | | | | | 8.90 | 8.45 | 1.75 | 19.24 |
| 117.0 | | | | | 8.85 | 8.38 | 1.80 | 19.09 |
| 118.0 | | | | | 8.85 | 8.37 | 1.80 | 19.00 |
| 119.0 | | | | | 8.85 | 8.36 | 1.80 | 18.92 |
| 120.0 | | | | | 8.85 | 8.34 | 1.80 | 18.83 |

The above Cable Combinations and Towers have been calculated for the following specifications and bridge geometry as per Figure 1:

**Cables:** construction 7 x 19, wire strand core, **160 kg/mm²** (1.57 kN/mm²) tensile strength of wire

**Safety Factor:** minimum **3**

**Live load** $p = (300 + \frac{5000}{span})\ kg/m^2$ or $(3 + \frac{50}{span})\ kN/m^2$

or

**p = 400 kg/m²** (4 kN/m²) if the span is 50.0 m or less

**Backstay Angle** $\beta_f \cong$ **18° to 30°**

**Camber** $c_d =$ **1.5% to 3% of the span**

**Safety factor for Tower = 1.6**

***Example:*** *Span = **88m***

⇒ *selected cable combination:*

*Main Cables : **nos. 4∅26mm***
*Spanning Cables : **nos. 2∅ 32mm***
*Windguy Cable : **not applicable***
*Dead Load Sag, **fd = 8.21m***
*Dead Load Camber, **Cd = 2.44m***
*Backstay Angle, $\beta_f = 22°$*

⇒ *selected Tower:*

*Standard Tower Height, **$h_t$ = 11.05m / Type 4***

**Selected Cable combination, Bridge Geometry and Standard Towers from Table 1.1:**

| | | |
|---|---|---|
| MC | Main Cables: | **nos. .. ∅ .....mm** |
| SC | Spanning Cables: | **nos. 2 ∅ .....mm** |
| HRC | Handrail Cables: | **nos. 2 ∅ 13 mm** |
| FC | Fixation Cables: | **nos. 2 ∅ 13 mm** |
| WGC | Windguy Cables (optional): | **nos. 2 ∅ .....mm** |
| Dead Load Sag, | | **$f_d$ = .....m** |
| Dead Load Camber, | | $c_d$ = **.....m** |
| Standard Tower Type: | | **Type.....** |
| Tower Height, | | **$h_t$ = .....m** |

## C. Fixing the Backstay Lengths ($D_L$ and $D_R$) and Main Cable Anchorage Elevations ($E_L$ and $E_R$)

- Fix the position of the Main Anchorage Foundation Blocks and their Cable Anchorage Elevations on the right bank and the left bank in the bridge profile considering the topography and geological condition of the ground (refer to Chapter 3.3.4 of the Technical Handbook, Vol. I for detailed procedures).
- Measure the backstay length **$D_L$** and **$D_R$** with a scale in the bridge profile.
- Calculate the Main Cable Anchorage Elevation.

**Calculated Backstay Length ($D_L$ and $D_R$) and Main Cable Anchorage Elevations, ($E_L$ and $E_R$):**

| | |
|---|---|
| **$E_t$ = $E_s$ + 0.70 + $h_t$** | =.....m |
| $\beta_f$ (from Table 1.1) | =.....m |
| **$D_L$** (measured from the bridge profile) | =.....m |
| **$D_R$** (measured from the bridge profile) | =.....m |
| **$E_L$ = $E_t$ - ($D_L$ x Tan $\beta_f$)** | =.....m |
| **$E_R$ = $E_t$ - ($D_R$ x Tan $\beta_f$)** | =.....m |

## D. Calculation of Cable Lengths

| Type of Cable | dia (mm) | Nos | Backstay Length [m] | | Cutting Length* [m/pc] |
|---|---|---|---|---|---|
| | | | $D_L$ | $D_R$ | |
| Main Cable | ..... | ..... | ..... | ..... | |
| Spanning Cable | ..... | 2 | 0 | 0 | |
| Handrail Cable | 13 | 2 | 0 | 0 | |
| Fixation Cable | 13 | 2 | 0 | 0 | |
| Windguy Cable** (Optional) | 26 | 1 (U/S) | 0 | 0 | |
| | | 1 (D/S) | 0 | 0 | |
| Windties** (Optional) | 13 | 1 | 0 | 0 | |

* **Cutting Length:**

Main Cable = 1.08 x Span + 1.15 ($D_L$+$D_R$) + Anchorage Length on the Right Bank + Anchorage Length on the Left Bank.
Calculate the Anchorage Lengths only after selection of the Main Cable Anchor Blocks.

Spanning Cable = 1.025 x Span + 3.5 m.
Handrail Cable = Span
Fixation Cable = Span

* * Windguy Cable = Refer to Design of Windguy Arrangement (Chapter 6)
** Windties = Refer to Design of Windguy Arrangement (Chapter 6)

## E. Calculation of Hoisting Sag

*This calculation has to be made after the tower erection work has been completed.*

1. Actual Span measured in the field $\ell$ =..... m
2. Hoisting Sag (from Table No 1.1 as per actual span) $\mathbf{f_h}$ = ..... m
3. Tower Height $\mathbf{h_t}$ =..... m
4. Marking Point on Tower (from steel tower base) at hoisting sag elevation = $\mathbf{h_t} - \mathbf{f_h}$ = ..... m

# 2. Main Cable Anchor Design

## A. Design Data

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist**

| **Main Cables: Nos. .....Ø.....mm** | | | |
|---|---|---|---|
| ***Right Bank Condition*** | | | |
| **Geology**: | Soil ☐ | | |
| If **Soil**, how is the Ground Surface? | Flat ☐ (up to 15° slope) | or | Hill Slope ☐ (more than 15° slope) |
| What is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ |
| ***Left Bank Condition*** | | | |
| **Geology** | Soil ☐ | | |
| If **Soil**, how is the Ground Surface? | Flat ☐ (up to 15° slope) | or | Hill Slope ☐ (more than 15° slope) |
| What is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ |

## B. Selection of Anchor Types

Select the appropriate Anchor Types for the Right and Left Banks according to the above design data. Followings are the rules for selecting the anchor blocks:

- One Main Cable Anchor should always have turnbuckle for fine adjustment during sag setting, whereas for economic reasons, the main cable anchor on the other bank should always have a direct cable connection.
- Always select an Anchor Block with turnbuckle for one bank and an Anchor Block with direct cable connection for the other bank.
- If one bank is soil and the other bank is rock, always select a Drum Anchor for the rocky bank.
- If both banks are rocky, select an Anchor Block for one bank and a Drum Anchor for the other bank.

**Procedure for selection:**

- According to the Soil type and Slope of ground or the Rock type, refer to the respective tables for the selection of the Anchor Types as per below.

| | | |
|---|---|---|
| In Soil and Flat Ground | (Cable Connection with Turnbuckle) | : **Table 2.1** |
| In Soil and Flat Ground | (Direct Cable Connection) | : **Table 2.2** |
| In Soil and Hill Slope | (Cable Connection with Turnbuckle) | : **Table 2.3** |
| In Soil and Hill Slope | (Direct Cable Connection) | : **Table 2.4** |
| In Hard, Soft or Fractured Rock | (Cable Connection with Turnbuckle) | : **Table 2.5** |
| In Hard Rock | (Direct Cable Connection ) | : **Table 2.6** |
| In Fractured Hard Rock or Soft Rock | (Direct Cable Connection) | : **Table 2.7** |

- **In the table match the design data:** Number and Diameter of Main Cables → if Soil, Soil type → select Anchor type and corresponding Drawing No. for right bank and left bank respectively.

## Anchorage Type Selection Tables

- ***In Soil and Flat Ground (Ground slope up to 15°)***

**Table 2.1:** Selection of Main Cable Deadman Anchor in Soil and Flat Ground (Cable Connection with Turnbuckle)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | DA 1 | 42/1Ncon |
| 2x32 | All | DA 2 | 42/3Ncon |
| 4x26 | All | DA 3 | 44/1Ncon |
| 4x32 | All | DA 4 | 44/3Ncon |

**Table 2.2:** Selection of Main Cable Deadman Anchor in Soil and Flat Ground (Direct Cable Connection)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | DA 5 | 42/2Ncon |
| 2x32 | All | DA 6 | 42/4Ncon |
| 4x26 | All | DA 7 | 44/2Ncon |
| 4x32 | All | DA 8 | 44/4Ncon |

- ***In Soil and Hill Slope***

**Table 2.3:** Selection of Main Cable Anchor Block in Soil and Hill Slope (Cable Connection with Turnbuckle)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | AB 1 | 42/5Ncon |
| 2x32 | All | AB 2 | 42/7Ncon |
| 4x26 | All | AB 3 | 44/5Ncon |
| 4x32 | Gravelly or Sandy | AB 4 | 44/7Ncon |
| | Silty | AB 5 | 44/9Ncon |

**Table 2.4:** Selection of Main Cable Anchor Block in Soil and Hill Slope (Direct Cable Connection)

| Main Cable | Foundation Soil Type | Anchor Type | Drawing No |
|---|---|---|---|
| 2x26 | All | AB - 6 | 42/6Ncon |
| 2x32 | All | AB - 7 | 42/8Ncon |
| 4x26 | All | AB - 8 | 44/6Ncon |
| 4x32 | Gravelly or Sandy | AB - 9 | 44/8Ncon |
| | Silty | AB - 10 | 44/10Ncon |

- ***In Hard, Soft or Fractured Rock***

**Table 2.5:** Selection of Main Cable Anchor Block in Hard, Soft or Fractured Rock (Cable Connection with Turnbbuckle)

| Main Cable, mm | Anchor Type | Drawing No |
|---|---|---|
| 2x26 or 2x32 | AB - 11 | 45Ncon |
| 4x26 or 4x32 | AB - 12 | 46Ncon |

- ***In Hard Rock***

**Table 2.6:** Selection of Main Cable Drum Anchor in Hard Rock (Direct Cable Connection)

| Main Cable, mm | Anchor Type | Drawing No |
|---|---|---|
| 2x26 or 2x32 | DR-1 | 47Ncon |
| 4x26 or 4x32 | DR-2 | 48Ncon |

- ***In Fractured Hard Rock or Soft Rock***

**Table 2.7:** Selection of Main Cable Drum Anchor in Fractured Hard Rock or Soft Rock (Direct Cable Connection)

| Main Cable, mm | Anchor Type | Drawing No |
|---|---|---|
| 2x26 or 2x32 | DR-3 | 49Ncon |
| 4x26 or 4x32 | DR-4 | 50Ncon |

⇒ **Selected Main Cable Anchor type and corresponding Drawings from the Table above:**

Right Bank: Anchor Type....., Drawing No.....

Left Bank: Anchor Type....., Drawing No.....

*Example:*

**Design Data**

Fill in the following design data

| | | | |
|---|---|---|---|
| **Main Cable:** | **Nos. 4 ∅ 26 mm** | | |
| | ***Right Bank Condition*** | | |
| **Geology:** | Soil ☑ | | |
| If **Soil**, how is the Ground Surface? | Flat ☑ (up to 15° slope) | or | Hill Slope ☐ (more than 15° slope) |
| What is the Soil Type? | Gravelly ☐ | Sandy ☑ | Silty ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ |
| | ***Left Bank Condition*** | | |
| **Geology** | Soil ☐ | | |
| If **Soil**, how is the Ground Surface? | Flat ☐ (up to 15° slope) | or | Hill Slope ☐ (more than 15° slope) |
| What is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☑ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ |

⇒ ***Selected Anchorage type and corresponding drawings from the table above:***

| | |
|---|---|
| *Right Bank: Anchor Type DA-3,* | *Drawing No. 44/1 Ncon* |
| *Left Bank: Anchor Type DR-2,* | *Drawing No. 48 Ncon* |

# 3. Walkway and Tower Foundation Design

## A. Design Data

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist**

| | | | | |
|---|---|---|---|---|
| • **Main Cable:** | **Nos. …. ∅ ……. mm** | | | |
| • **Spanning Cable:** | **Nos. 2 ∅ ……. mm** | | | |
| ***Right Bank Condition*** | | | | |
| **Geology**: | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| ***Left Bank Condition*** | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, What is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock ☐ (only a few fractures) | Hard Rock ☐ (highly fractured) | Soft Rock ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

## B. Selection of Walkway and Tower Foundations

Select the appropriate Walkway and Tower Foundations for the Right and the Left Banks according to the above design data.

**Procedure for selection:**

- According to the Soil or Rock type, refer to the respective tables for the selection of the Walkway and Tower Foundations as per below.

  In Soil : **Table 3.1**
  In Hard Rock : **Table 3.2**
  In Fractured Hard Rock or Soft Rock : **Table 3.3**

- If the bank is rock, always take the foundation block height **H** as 1.0m,
  If the bank is soil on a hill slope, always take the foundation block height **H** as 1.0m.
  If the bank is soil on flat ground but the foundation block height **H** needs to be raised, always take the foundation block height as 1.0, or 2.0, or 3.0, or 4.0m (maximum).

- **In the table, match the design data:** Number and Diameter of Main Cables → Foundation Block Height, **H** → if Soil, Soil type → select Foundation type and corresponding Drawing No. for right bank and left bank respectively.

## Walkway and Tower Foundations Selection Tables

- ***In Soil***

**Table 3.1**: Selection of Walkway and Tower Foundations in Soil

| Main Cable | Foundation Block Height (H) m | Soil Type | Foundation Type | Drawing No |
|---|---|---|---|---|
| 2x26 and 2x32mm | 1.0 | All | TF-1 | 92/1Ncon |
| | 2.0 | All | TF-2 | 92/2Ncon |
| | 3.0 | All | TF-3 | 92/3Ncon |
| | 4.0 | All | TF-4 | 92/4Ncon |
| 4x26mm | 1.0 | All | TF-6 | 94/1Ncon |
| | 2.0 | All | TF-7 | 94/2Ncon |
| | 3.0 | Gravelly/Sandy | TF-8 | 94/3Ncon |
| | | Silty | TF-9 | 94/4Ncon |
| | 4.0 | Gravelly/Sandy | TF-10 | 94/5Ncon |
| | | Silty | TF-11 | 94/6Ncon |
| 4x32mm | 1.0 | All | TF-6 | 94/1Ncon |
| | 2.0 | All | TF-7 | 94/2Ncon |
| | 3.0 | Gravelly/Sandy | TF-8 | 94/3Ncon |
| | | Silty | TF-9 | 94/4Ncon |
| | 4.0 | Gravelly/Sandy | TF-10 | 94/5Ncon |
| | | Silty | TF-11 | 94/6Ncon |

- ***In Hard Rock***

**Table 3.2**: Selection of Walkway and Tower Foundations in Hard Rock

| Main Cable | Foundation Block Height (H) M | Foundation Type | Drawing No. |
|---|---|---|---|
| 2x26 or 2x32mm | 1.0 | TF-5 | 92/5Ncon |
| 4x26 or 4x32mm | 1.0 | TF-12 | 94/7Ncon |

- ***In Fractured Hard Rock or Soft Rock***

**Table 3.3**: Selection of Walkway and Tower Foundations in Fractured Hard Rock or Soft Rock

| Main Cable | Foundation Block Height (H) m | Foundation Type | Drawing No. |
|---|---|---|---|
| 2x26 or 2x32mm | 1.0 | TF-1 | 92/1Ncon |
| 4x26 or 4x32mm | 1.0 | TF-6 | 94/1Ncon |

⇒ ***Selected Walkway and Tower Foundations and corresponding drawings from the table above:***

Right Bank: Foundation Type....., Drawing No.....

Left Bank: Foundation Type....., Drawing No.....

*Example:*

**Design Data**

Fill in the following design data:

| | | | | |
|---|---|---|---|---|
| • **Main Cable:** | **Nos 4 ∅ 26 mm** | | | |
| • **Spanning Cable:** | **Nos 2 ∅ 32 mm** | | | |
| ***Right Bank Condition*** | | | | |
| **Geology**: | Soil ☑ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☑ | Silty ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☑ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| ***Left Bank Condition*** | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Foundation Block Height (H) from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☑ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Foundation Block Height (H) from Ground (data from bridge profile): | ☑ 1.0m in case of Rock | | | |

⇒ ***Selected Walkway and Tower Foundations and corresponding drawings from the table above:***

*Right Bank: Foundation Type TF-7, Drawing No. 94/2Ncon*

*Left Bank Foundation Type TF-12, Drawing No. 94/7Ncon*

# 4. Windguy Anchorage Foundation Blocks Design (Optional)

## A. Design Data

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist.**

| | | | | |
|---|---|---|---|---|
| **Windguy Cable: …..nos ∅ …….mm** | | | | |
| ***Right Bank / Upstream*** | | | | |
| **Geology**: | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Anchor Block Height from Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| ***Right Bank / Downstream*** | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

| *Left Bank / Upstream* | | | | |
|---|---|---|---|---|
| **Geology**: | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| *Left Bank / Downstream* | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

## B. Selection of Windguy Cable Anchor Blocks (Optional only)

Provision of a windguy cable arrangement is optional. For details refer to Chapter 6.
Select appropriate Windguy Cable Anchor Blocks for the Right and Left Banks according to the above design data. Followings are the rules for selection of the anchor blocks.

- If the bank is rock, always take block height as 1.0m.
- If the bank is soil in hill slope, always take block height as 1.0m.
- If one bank is soil and the other bank is rock, always select a Drum Anchor for the rocky bank.
- If both banks are rocky, select an Anchor Block for one bank and a Drum Anchor for the other bank.
- If the bank is soil but on flat ground and the Anchor Block Height needs to be raised, always take the foundation block height as 1.0, or 2.0, or 3.0, or 4.0m (maximum).

**Procedure for selection:**

- According to the Soil or Rock type, refer to the respective tables for selection of the Windguy Cable Anchor Blocks as per below:

| | | |
|---|---|---|
| In Soil | : | **Table 4.1** |
| In all types of Rock (Anchor Block) | : | **Table 4.2** |
| In Hard Rock (Drum Anchor) | : | **Table 4.3** |
| In Fractured Hard Rock or Soft Rock (Drum Anchor) | : | **Table 4.4** |

- **In the table, match the design data:** Diameter of Windguy Cable → Soil or Rock type → if soil → Anchorage Block Height → select Anchor Block type and corresponding Drawing No. for right bank upstream and downstream and for left bank upstream and downstream respectively.

Select the appropriate Windguy Cable Anchor blocks from the following table.

- ***In Soil***

**Table 4.1:** Selection of Windguy Cable Anchor Block in Soil

| Windguy Cable [mm] | Anchor Block Height | Soil Type | Anchor Type | Drawing No |
|---|---|---|---|---|
| 26 | 1 | All | WAB - 1 | 55/1Acon |
| | 2 | All | WAB – 2 | 55/2Acon |
| | 3 | All | WAB – 3 | 55/3Acon |
| | 4 | All | WAB – 4 | 55/4Acon |

- ***In Hard, Fractured or Soft Rock***

**Table 4.2:** Selection of Windguy Cable Anchor Block in all types of Rocks

| Windguy Cable [mm] | Anchor Type | Drawing No |
|---|---|---|
| 26 | WAB - 5 | 56Acon |

- ***In Hard Rock***

**Table 4.3:** Selection of Windguy Cable Drum Anchor in Hard Rock

| Windguy Cable [mm] | Anchor Type | Drawing No |
|---|---|---|
| 26 | WDR - 1 | 57Acon |

- ***In Fractured or Soft Rock***

**Table 4.4:** Selection of Windguy Cable Drum Anchor in Fractured or Soft Rock

| Windguy Cable [mm] | Anchor Type | Drawing No |
|---|---|---|
| 26 | WDR - 2 | 58Acon |

⇒ **Selected Windguy Cable Anchor and corresponding Drawings from the table above:**

| | | |
|---|---|---|
| Right Bank, Upstream: | Anchor Type....., | Drawing No..... |
| Downstream: | Anchor Type....., | Drawing No..... |
| Left Bank, Upstream: | Anchor Type....., | Drawing No..... |
| Downstream: | Anchor Type....., | Drawing No..... |

*Example*

## Design Data

☞ **Fill in the following Design Data from Form No. 1: Survey Form and Checklist.**

| | | | | |
|---|---|---|---|---|
| • **Windguy Cable:** | **∅ 26 mm** | | | |
| ***Right Bank / Upstream*** | | | | |
| **Geology**: | Soil ☑ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☑ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☑ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |
| ***Right Bank / Downstream*** | | | | |
| **Geology** | Soil ☑ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☑ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☑ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☐ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☐ 1.0m in case of Rock | | | |

| | | | | |
|---|---|---|---|---|
| ***Left Bank / Upstream*** | | | | |
| **Geology**: | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☑ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☑ 1.0m in case of Rock | | | |
| ***Left Bank / Downstream*** | | | | |
| **Geology** | Soil ☐ | | | |
| If **Soil**, what is the Soil Type? | Gravelly ☐ | Sandy ☐ | Silty ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | 1.0m ☐ | 2.0m ☐ | 3.0m ☐ | 4.0m ☐ |
| If **Rock**, what is the Rock Type? | Hard Rock (only a few fractures) ☑ | Hard Rock (highly fractured) ☐ | Soft Rock ☐ | |
| Anchor Block Height from the Ground (data from bridge profile): | ☑ 1.0m in case of Rock | | | |

⇒ ***Selected Windguy Cable Anchor and corresponding Drawings from the table above:***

*Right Bank, Upstream:* *Anchor Type...WAB - 2, Drawing No. 55/2Acon*
*Downstream:* *Anchor Type...WAB - 2, Drawing No. 55/2Acon*

*Left Bank, Upstream:* *Anchor Type...WDR - 1, Drawing No. 57Acon*
*Downstream:* *Anchor Type...WDR - 1, Drawing No. 57Acon*

## 5. Suspender List

Calculate the Suspender List using the computer program **"Suspender Design"** which is included in the CD-ROM at the back cover page of the "Technical Hand Book, Vol. I".

The calculation is based on the fixed geometry of the bridge as per Chapter 1 (Table 1.1) and the design of the suspender as per the figure below.

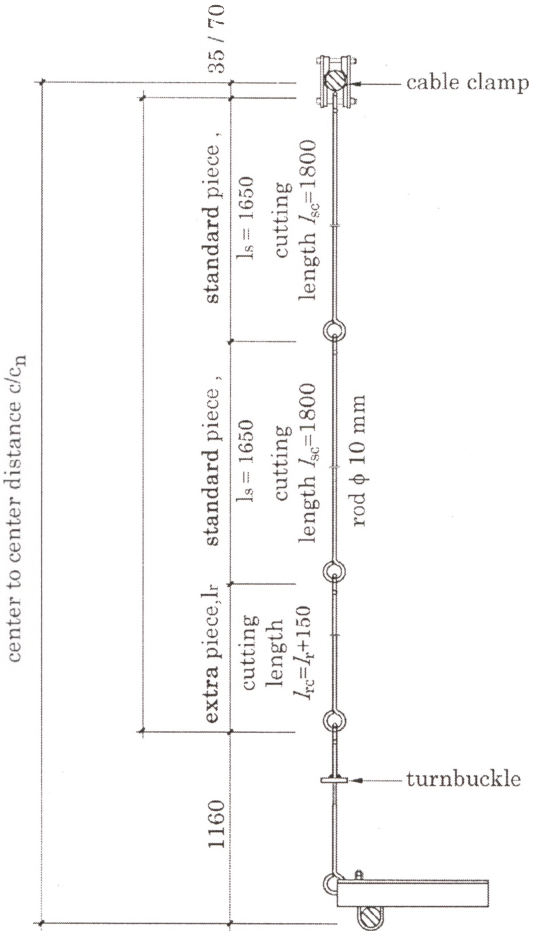


Figure 5.1: Typical Design of Suspender

The only input data required for the calculation is the span, $l$. The procedure for the Suspender List calculation is as follows:

- Open the computer program SSTB Design > "Suspender Design".
- Enter the input data: Bridge Name, Bridge Span and width "B" of the Walkway and Tower Foundation.
- Print result.

Attach the printout of the Suspender List with the drawing of the suspenders (Drawing No 31N or 32N).

## 6. Design of Windguy Arrangement

For Nepal, in general, no wind guy arrangement is necessary in this standard suspension bridge for spans of up to120m (for more details refer to Chapter 3.3.9 of the "Technical Hand Book, Vol. I").

For special cases, i.e., when the bridge span is more than 120m or in extremely windy areas with wind speeds in excess of 160 km/hr and unfavorable nature of the wind flow, a windguy system is mandatory.

For calculation of the Windguy Arrangement use the computer program **"Windguy Design"** which is included in the CD-ROM at the back cover page of the "Technical Hand Book, Vol. I".

The calculation is based on the fixed geometry of the bridge as per Chapter 1 (Table 1.1) and the figure below.

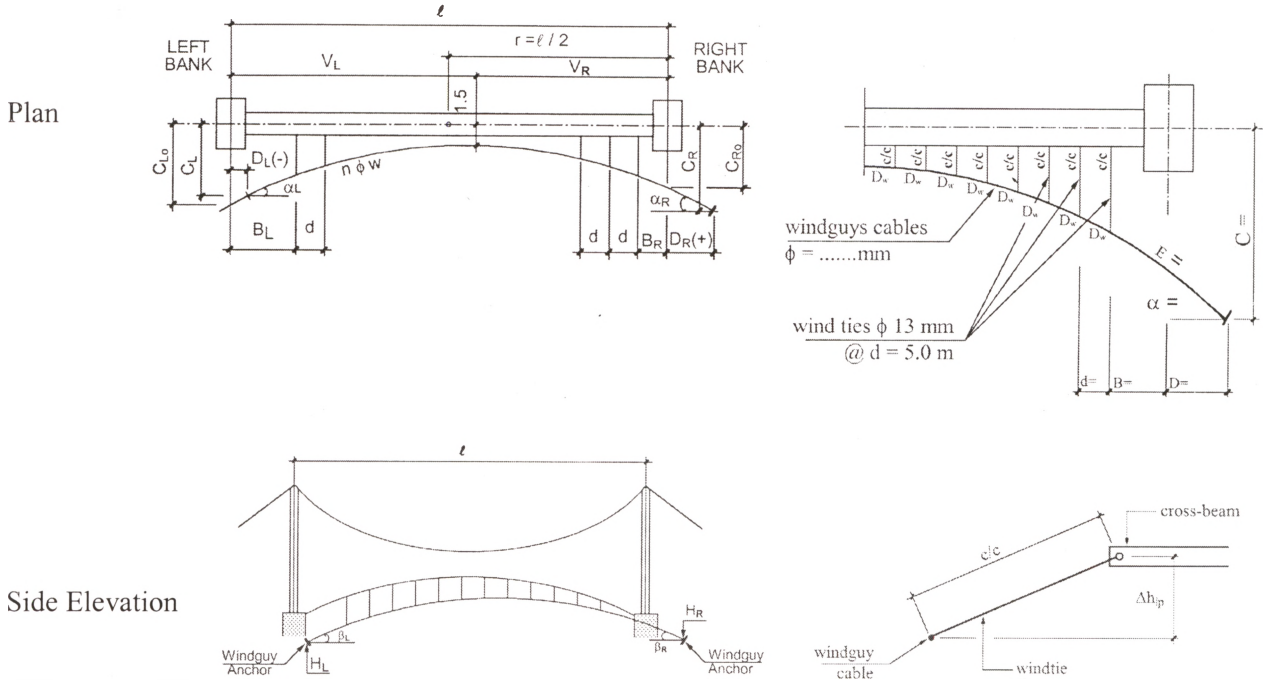


Figure 6.1: Layout of Windguy Arrangement

The calculation procedure is as following.

- Open the computer program SSTB Design > "Windguy Design".
- Enter the general input data: Bridge Name, Bridge Span and elevation of Steel Tower Base.
- Enter the tentative position of the first windtie $\mathbf{B_L}$ and $\mathbf{B_R}$ as per the topography. The program will adjust to the nearest actual values.
- Give the level of the windguy anchorage on the right bank $\mathbf{H_L}$ and the left bank $\mathbf{H_R}$. $\mathbf{H_L}$ and $\mathbf{H_R}$ should be at or below the level of the spanning cable at the anchorage point (Es).
- Give (select) the windguy anchor position on the right bank (or the left bank), i.e. $\mathbf{C_R}$ and $\mathbf{D_R}$ or ($\mathbf{C_L}$ and $\mathbf{D_L}$). Accordingly, the windties listing will be from right bank to left bank or vise versa.
- Input the value $\mathbf{V_R}$ (distance up to the vertex of the windguy cable) if the selected windguy anchor position is on the right bank or $\mathbf{V_L}$ if the selected windguy anchor position is on the left bank.
- Check the span and sag ratio of the wind guy cable, *l*/b. It should be not less than 8 and not more than 10. If this condition is not met, input new **V** till *l*/b is within the recommended limit.
- Check the lowest point of the windguy cable $\mathbf{\Delta h_{lp}}$. It should not be negative (-). If $\Delta h_{lp}$ is negative, input new $\mathbf{H_L}$and $\mathbf{H_R}$ with a lower value.
- Input the value of $\mathbf{D_{Lo}}$ ( or $\mathbf{D_{Ro}}$) = 0. The result will show $\mathbf{C_{Lo}}$ (or $\mathbf{C_{Ro}}$), and the horizontal angle $\alpha_L$ (or $\alpha_R$).
- Draw a straight line with the given $\mathbf{C_{Lo}}$ (or $\mathbf{C_{Ro}}$), and horizontal angle $\alpha_L$ (or $\alpha_R$). Fix the windguy anchor position on the left bank (or the right bank) along this line. The anchorage block should be placed on safe ground and at the optimum foundation location so that it has sufficient embedded depth and also so that deep excavation can be avoided.
- After fixing the anchorage position, measure the actual $\mathbf{C_L}$ (or $\mathbf{C_R}$ ). The result will give $\mathbf{D_L}$ ( or $\mathbf{D_R}$)
- Draw longitudinal sections along the windguy cables at the foundations and determine the exact position of the front of the foundations ($\mathbf{D_R}$ , $\mathbf{C_R}$ **and** $\mathbf{D_L}$, $\mathbf{C_L}$ ) and the windguy cable elevations ($\mathbf{H_R}$, $\mathbf{H_L}$ ).
- If the final position of the foundations does not match the design as above, repeat the calculation process from the second bullet till all the foundations are located at the optimum positions.
- Calculate the Windguy Arrangement for both upstream and downstream.

Attach the printout of the results (Windguy Arrangement) with the drawing of the Windtie cable Clamps (Drawing No. 11A) and also transfer it to the General Arrangement Drawing.

# 7. Bridge Standard Drawings

Select the required Steel Drawings and Construction Drawings from the design as above and the following drawing list.

## 7.1 Steel Drawings

| Drawing Title | | Drawing No. | Required Drawing |
|---|---|---|---|
| **Walkway and Anchors** | | | |
| Steel Crossbeams | Spanning Cable ∅ 26 or 32mm | 07N | 07N |
| Suspenders | for 2 main cables ∅ 26 or 32mm | 31N | ..... |
| | for 4 main cables ∅ 26 or 32mm | 32N | |
| Main Cable Anchors with Turnbuckle | for 2 main cables ∅ 26 or 32mm | 42N | ..... |
| | for 4 main cables ∅ 26 or 32mm | 44N | |
| Walkway and Tower Foundation | C/c1 = 2.5m | 92N | ..... |
| | C/c1 = 3.5m | 94N | |
| Steel Deck | Standard Panel | 08A | 08A |
| | Special Panel | 10A | 10A |
| **Towers** | | | |
| Assembly and Layout | Tower No.1, Height = 5.50m | 141N | ..... |
| | Tower No. 2, Height = 7.35m | 142N | |
| | Tower No. 3, Height = 9.20m | 143N | |
| | Tower No. 4, Height = 11.05m | 144N | |
| Base Element | Tower No.1, 2, 3 & 4 | 100N | 100N |
| Intermediate Element | Tower No.1, 2, & 3 | 109N | ..... |
| | Tower No. 4 | 110N | |
| Top Element | Tower No. 1, 2, & 3 | 119N | ..... |
| | Tower No. 4 | 121N | |
| Saddle | Tower No.1, 2, 3 & 4 | 135N | 135N |
| **Optional** | | | |
| Windguy Parts | Windtie Cable Clamps for One Cable ∅ 26 or 32mm | 11A | ..... |
| | Windguy Cable Anchorage for one Cable ∅ 26 or 32mm | 50A | ..... |

## 7.2 Construction Drawings

As per the design made through Chapters 2 to 4, fill in the required drawings in the following Drawing list.

| Drawing Title | Drawing No | Required Drawing |
|---|---|---|
| Walkway Fitting | 19Ncon | 19Ncon |
| Main Cable Anchors | 42/1Ncon, ……..…, 50 Ncon | RB: …… |
| | | LB: …… |
| Walkway and Tower Foundations | 92/1Ncon, ……..., 94/7 Ncon | RB: …… |
| | | LB: …… |
| Windguy Cable Anchors (Optional) | 55/1Acon, ……..., 58Acon | RB/US: …… |
| | | RB/DS: …… |
| | | LB/US: …… |
| | | LB/DS: …… |

**Designed by:** ……... **Date:** ……

**Cable hoisted by:** …… **Date:** ……..

***Example:***

⇒ ***Selected Drawings***

**Steel Drawings**

| Drawing Title | | Drawing No | Required Drawing |
|---|---|---|---|
| **Walkway and Anchors** | | | |
| Steel Crossbeams | Spanning Cable ∅ 26 or 32mm | 07N | **07N** |
| Suspenders | for 2 main cables ∅ 26 or 32mm | 31N | **32N** |
| | for 4 main cables ∅ 26 or 32mm | 32N | |
| Main Cable Anchors with Turnbuckle | for 2 main cables ∅ 26 or 32mm | 42N | **44N** |
| | for 4 main cables ∅ 26 or 32mm | 44N | |
| Walkway and Tower Foundation | c/c1 = 2.5m | 92N | **94N** |
| | c/c1 = 3.5m | 94N | |
| Steel Deck | Standard Panel | 08A | **08A** |
| | Special Panel | 10A | **10A** |
| **Towers** | | | |
| Assembly and Layout | Tower No. 1, Height = 5.50m | 141N | **144N** |
| | Tower No. 2, Height = 7.35m | 142N | |
| | Tower No. 3, Height = 9.20m | 143N | |
| | Tower No. 4, Height = 11.05m | 144N | |
| Base Element | Tower No.1, 2, 3 & 4 | 100N | **100N** |
| Intermediate Element | Tower No.1, 2, & 3 | 109N | **110N** |
| | Tower No.4 | 110N | |
| Top Element | Tower No.1, 2, & 3 | 119N | **121N** |
| | Tower No. 4 | 121N | |
| Saddle | Tower No.1, 2, 3 & 4 | 135N | **135N** |
| **Optional** | | | |
| Windguy Parts | Windguy Cable Clamps for One Cable ∅ 26 or 32mm | 11A | **NA** |
| | Windguy Cable Anchorage for one Cable ∅ 26 or 32mm | 50A | **NA** |

**Construction Drawings**

| Drawing Title | Drawing No | Required Drawing |
|---|---|---|
| Walkway Fitting | 19Ncon | **19Ncon** |
| Main Cable Anchors | 42/1Ncon, ……..…,50 Ncon | RB: **44/1Ncon** |
| | | LB: **48 Ncon** |
| Walkway and Tower Foundations | 92/1Ncon, ……..,94/7 Ncon | RB: **94/2Ncon** |
| | | LB: **94/7Ncon** |
| Windguy Cable Anchors (Optional) | 55/1Acon, ……., 58Acon | RB/US: **NA** |
| | | RB/DS: **NA** |
| | | LB/US: **NA** |
| | | LB/DS: **NA** |

# Form No. 3 : Quantity & Cost Estimate for Community Approach

# Form No. 3

## Quantity & Cost Estimate for Community Approach

(total 12 pages)

Bridge Name: .....

River Name: .....

District Name: .....

Estimated by: .....

Approved by: .....

Date: .....

# COST ESTIMATE: Summary of Estimated Cost

| | |
|---|---|
| Bridge Number : | Bridge Name: |
| Span, m : | River: |
| Tower Height, m: | District: |
| Type of Bridge : Suspension | Region: |

**Mode of Execution: Community Approach**

**Bridge Cost**

| | Description | Cost NRs. | % |
|---|---|---|---|
| **100** | **Materials and Road Transportation** | | |
| 110 | Wire Ropes (Cables) | | |
| 120 | Steel Parts | | |
| 130 | Steel Deck | | |
| 140 | G. I. Wire | | |
| 150 | Cement | | |
| 170 | Tools | | |
| 180 | Road Transportation | | |
| | **Sub-total** of Materials and Road Transportation | | |
| **200** | **Labor** | | |
| 210 | Transportation (portering) from Road Head to Site | | |
| 220 | Local Materials Collection (skilled/unskilled labor) | | |
| 230 | Construction Works (skilled/unskilled labor) | | |
| | **Sub-total** of Labor | | |
| **Total Actual Bridge Cost** (Sub-total of Material+Sub-total of Labor) | | | |

**Contribution**

| Kind of Contribution | Local Contribution, NRs. | | | | | Outside Contribution, NRs. | | | Total NRs. |
|---|---|---|---|---|---|---|---|---|---|
| | DDC | VDC/ Municip-ality | Local Institu-tion | Individ-uals | Users' Committee | | | | |
| Wire Ropes (Cables) | | | | | | | | | |
| Steel Parts | | | | | | | | | |
| Steel Deck | | | | | | | | | |
| G. I. Wire | | | | | | | | | |
| Cement | | | | | | | | | |
| Tools | | | | | | | | | |
| Cash | | | | | | | | | |
| Road Transportation | | | | | | | | | |
| Labor | | | | | | | | | |
| **Total Contribution** | | | | | | | | | |

| **Breakdown of the Contribution** | | % |
|---|---|---|
| Local Contribution, NRs. | | |
| Outside Contribution, NRs. | | |
| **Total NRs.** | | |

| **Cost Per Meter Span, NRs.** | |
|---|---|

# COST ESTIMATE: Summary of Actual Cost*

| | |
|---|---|
| Bridge Number : | Bridge Name: |
| Span, m : | River: |
| Tower Height, m: | District: |
| Type of Bridge : Suspension | Region: |

**Mode of Execution: Community Approach**

**Bridge Cost**

| | Description | Cost NRs. | % |
|---|---|---|---|
| **100** | **Materials and Road Transportation** | | |
| 110 | Wire Ropes (Cables) | | |
| 120 | Steel Parts | | |
| 130 | Steel Deck | | |
| 140 | G. I. Wire | | |
| 150 | Cement | | |
| 170 | Tools | | |
| 180 | Road Transportation | | |
| | **Sub-total** of Materials and Road Transportation | | |
| **200** | **Labor** | | |
| 210 | Transportation (portering) from Roadhead to Site | | |
| 220 | Local Materials Collection (skilled/unskilled labor) | | |
| 230 | Construction Works (skilled/unskilled labor) | | |
| | **Sub-total** of Labor | | |
| **Total Actual Bridge Cost** (Sub-total of Material+Sub-total of Labor) | | | |

**Contribution**

| Kind of Contribution | Local Contribution, NRs. | | | | | Outside Contribution, NRs. | | | Total NRs. |
|---|---|---|---|---|---|---|---|---|---|
| | DDC | VDC/ Municip-ality | Local Institu-tion | Individ-uals | Users' Committee | | | | |
| Wire Ropes (Cables) | | | | | | | | | |
| Steel Parts | | | | | | | | | |
| Steel Deck | | | | | | | | | |
| G. I. Wire | | | | | | | | | |
| Cement | | | | | | | | | |
| Tools | | | | | | | | | |
| Cash | | | | | | | | | |
| Road Transportation | | | | | | | | | |
| Labor | | | | | | | | | |
| **Total Contribution** | | | | | | | | | |

| **Breakdown of the Contribution** | | % |
|---|---|---|
| Local Contribution, NRs. | | |
| Outside Contribution, NRs. | | |
| **Total NRs.** | | |

| **Cost Per Meter Span, NRs.** | |
|---|---|

* This Form to be filled only after completion of the bridge to calculate the actual bridge cost.

# COST ESTIMATE : Abstract of Cost (Page 1of 2)

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **100 Materials & Transportation** | | | | | |
| 110 Wire Ropes[1] | Ø 13 mm | m | | | |
| | Ø 26 mm | m | | | |
| | Ø 32 mm | m | | | |
| | **Total 110 Wire Ropes** | | | | |
| **120 Steel Parts** | | | | | |
| 121 Fabrication[2] | Steel Parts | kg | | | |
| | Reinforcement steel | kg | | | |
| 122 Supply of Thimbles[3] | Ø 13 mm | pc | | | |
| | Ø 26 mm | pc | | | |
| | Ø 32 mm | pc | | | |
| 123 Supply of Bulldog Grips[3] | Ø 13 mm | pc | | | |
| | Ø 26 mm | pc | | | |
| | Ø 32 mm | pc | | | |
| 124 Miscellaneous Supply[2] | Bolts, Nuts and Washers | kg | | | |
| | Binding Wire | kg | | | |
| | PE Pipes, dia. 63mm[4] | m | | | |
| 125 Rust Prevention[2] | Hot Dip Galvanization (Steel to be Galvanized) | kg | | | |
| | **Total 120 Steel Parts** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **130 Steel Deck** | | | | | |
| 131 Fabrication[5] | Steel Deck | kg | | | |
| 132 Rust Prevention[5] | Hot Dip Galvanization (Steel to be Galvanized) | kg | | | |
| | **Total 130 Steel Deck** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **140 G. I.. Wire[6]** | 141 G. I.. Wire | kg | | | |
| | **Total 140 G. I.. Wire** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **150 Cement[6]** | 151 Cement | bags | | | |
| | **Total 150 Cement** | | | | |

# COST ESTIMATE : Abstract of Cost (Page 2 of 2)

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **170 Tools** | 171 Tools | set | 1 | | |
| | **Total 170 Tools** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **180 Road Transportation**[7] | 181 Materials and Wire Ropes | kg | | | |
| | **Total 180 Road Transportation** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| **200 Transportation (portering) from road head to site**[8] | | | | | |
| 210 Transportation from roadhead to site | 211 Porter (unskilled labor)* | md | | | |
| | 212 By Mule* | kg | | | |
| | **Total 210 Transportation from road head to site** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| 220 Local Material Collection[8] | 221 Skilled Labor* | md | | | |
| | 222 Unskilled Labor* | md | | | |
| | **Total 220 Local Material Collection** | | | | |

| Description | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|
| 230 Construction Works[8] | 231 Skilled Labor* | md | | | |
| | 232 Unskilled Labor* | md | | | |
| | **Total 230 Construction Works** | | | | |

1 Refer to Sheet Quantity Calculation "110 Wire Rope" (Page 5)
2 Refer to Sheet Quantity Calculation "120 Steel Parts" (Page 5)
3 Refer to the respective "Steel Drawings"
4 Refer to the respective "Construction Drawing of the Main Cable Anchor"
5 Refer to Sheet Quantity Calculation "130 Steel Deck" (Page 5)
6 Refer to Sheet "List of Construction Materials" (Page 7)
7 Refer to Sheet "Transportation Weight" (Page 8)
8 Refer to Sheet "Quantity of Works and Labor" (Page 9)
* Apply District rates.

# COST ESTIMATE: Quantity Calculation (Page 1of 3)

**110 Wire Ropes (Cables)**

| Type | Pieces | No. | Single Length (m) | Ø (mm) | Length per Type per Ø | | |
|---|---|---|---|---|---|---|---|
| | | | | | Ø 13mm | Ø 26mm | Ø 32mm |
| Main Cable | | | | | | | |
| Spanning Cable | | 2 | | | | | |
| Handrail Cable | | 2 | | 13 | | | |
| Fixation Cable | | 2 | | 13 | | | |
| Windguy Cable Upstream (optional) | | 1 | | | | | |
| Windguy Cable Downstream (optional) | | 1 | | | | | |
| Windties (optional) | | | | 13 | | | |
| **Total length per Ø in meter** | | | | | | | |
| **Total length, m** | | | | | | | |
| **Weight of cable per m length** | | | | | 0.67 | 2.57 | 3.9 |
| **Total weight of cable per Ø in kg** | | | | | | | |
| **Total weight, kg** | | | | | | | |

Note: Above Quantities are derived from Form No. 2: Cable Design Form

**120 Steel parts**

| DRAWINGS | | Units | Structural Steel (kg) | Reinforce-ment Steel (kg) | Binding Wire (kg) | Nuts, Bolts & Washers (kg) | Steel to be galvanized (kg) | Transport Weight (kg) |
|---|---|---|---|---|---|---|---|---|
| No. | Name | | | | | | | |
| | Steel Cross Beams | | | - | - | | | |
| | Suspenders | | | | | | | |
| | Main Cable Anchor with Turnbuckle | | | | | | | |
| | Main Cable Anchor with Direct Cable Connection | | | | | | | |
| | Walkway/Tower Foundation, R/B | | | | | | | |
| | Walkway/Tower Foundation, L/B | | | | | | | |
| | Tower | | | | | | | |
| | Windtie Cable Clamps (optional) | | | | | | | |
| | Windguy Cable Anchorage (optional) | | | | | | | |
| | Windguy Cable Drum Anchor (optional) | | | | | | | |
| | Others | | | | | | | |
| **Total Steel Parts** | | | | | | | | |

130 **Steel Decks**

| DRAWINGS | | Units | Structural Steel (kg) | Steel to be galvanized | Transport Weight (kg) |
|---|---|---|---|---|---|
| No. | Name | | | | |
| 08A | Standard Panel | | | | |
| 10A | Special Panel | | | | |
| | **Total** | | | | |

Note: The above Units and Quantities are derived from the respective Steel Drawings.

# COST ESTIMATE: Quantity Calculation (Page 2 of 3)

**230 Construction**

| Location | Soil $m^3$ | Soft Rock $m^3$ | Hard Rock $m^3$ | Back-filling $m^3$ |
|---|---|---|---|---|
| Main Cable Anchors | | | | |
| Right Bank | | | | |
| Left Bank | | | | |
| Walkway and Tower Foundations | | | | |
| Right Bank | | | | |
| Left Bank | | | | |
| Windguy Cable Anchors (optional, only if applicable) | | | | |
| Right Bank, U/S | | | | |
| Right Bank, D/S | | | | |
| Left Bank, U/S | | | | |
| Left Bank, D/S | | | | |
| Other Structures | | | | |
| Right Bank | | | | |
| Left Bank | | | | |
| Right Bank | | | | |
| Left Bank | | | | |
| **Total Right Bank** | | | | |
| **Total Left Bank** | | | | |
| **Grand Total** | | | | |

**Foundation Excavation:**

**Right Bank**

$L_{avr.}$ = ____ m

$B_{avr.}$ = ____ m

$H_{avr.}$ = ____ m

Volume, $V = L_{avr.} \times B_{avr.} \times H_{avr.}$

= ____ $m^3$

**Left Bank**

$L_{avr.}$ = ____ m

$B_{avr.}$ = ____ m

$H_{avr.}$ = ____ m

Volume, $V = L_{avr.} \times B_{avr.} \times H_{avr.}$

= ____ $m^3$

Note: The above Quantities are to be calculated from the General Arrangement Drawing.

| Location | Concrete Works | | Cement Stone Masonry | | Dry Stone Masonry | | | |
|---|---|---|---|---|---|---|---|---|
| | 1:3:6 $m^3$ | 1:2:4 $m^3$ | Coursed Hammer Dressed 1:4 $m^3$ | Coursed Hammer Dressed 1:6 $m^3$ | Coursed Hammer Dressed dry $m^3$ | Broken Stone $m^3$ | Cement Plaster 1:4 $m^2$ | Plumb Concrete 1:3:6 + 40% Broken stone $m^3$ |
| Main Cable Anchors | | | | | | | | |
| Right Bank | | | | | | | | |
| Left Bank | | | | | | | | |
| Walkway and Tower Foundations | | | | | | | | |
| Right Bank | | | | | | | | |
| Left Bank | | | | | | | | |
| Windguy Cable Anchors (optional, only if applicable) | | | | | | | | |
| Right Bank, U/S | | | | | | | | |
| Right Bank, D/S | | | | | | | | |
| Left Bank, U/S | | | | | | | | |
| Left Bank, D/S | | | | | | | | |
| Other Structures | | | | | | | | |
| Right Bank | | | | | | | | |
| Left Bank | | | | | | | | |
| Right Bank | | | | | | | | |
| Left Bank | | | | | | | | |
| **Total Right Bank** | | | | | | | | |
| **Total Left Bank** | | | | | | | | |
| **Grand Total** | | | | | | | | |

Note: The above Quantities are derived from the respective Construction Drawings.

# COST ESTIMATE: Quantity Calculation (page 3 of 3)

## List of Construction Materials

### 140/1 Fence Knitting

| Item | Bridge Span (m) (m) | Requirement per meter span (kg) (kg) | Total Weight (kg) |
|---|---|---|---|
| 12 SWG G. I.. Wire | | 3.9 | |

### 140/2 G.I. Wires for Gabion Boxes (For maintenance only, if required)

| Box Size (m) | Volume ($m^3$) | Mesh Wire 10 SWG | | Mesh Wire 7 SWG | | Mesh Wire 12 SWG | |
|---|---|---|---|---|---|---|---|
| | | Requirement per $m^3$ | Weight kg | Requirement per $m^3$ | Weight kg | Requirement per $m^3$ | Weight kg |
| 2.0/1.0/1.0 | | 12.08 | | 1.58 | | 0.48 | |
| 3.0/1.0/1.0 | | 11.70 | | 1.37 | | 0.43 | |
| 2.0/1.0/0.3 | | 22.33 | | 3.75 | | 1.08 | |
| 3.0/1.0/0.3 | | 21.94 | | 3.33 | | 1.00 | |
| Total | | | | | | | |
| | | | | | | Total weight of Gabion Wire, kg | |

### 230 Construction

| Item | Unit | Total Quantity of Works | | Requirement per | Cement | | Sand | | Gravel | | Hammer Dressed Stone | | Broken Stone | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | L/B | R/B | L/B | R/B | L/B | R/B | L/B | R/B | L/B | R/B |
| | | L/B | R/B | Unit | ($m^3$) | | ($m^3$) | | ($m^3$) | | ($m^3$) | | ($m^3$) | |
| Construction of Gabions | $m^3$ | | | 1.10 | | | | | | | | | | |
| Concrete 1:3:6 | $m^3$ | | | 4.4 | | | | | | | | | | |
| | | | | 0.47 | | | | | | | | | | |
| | | | | 0.89 | | | | | | | | | | |
| Concrete 1:2:4 | 14 | | | 6.4 | | | | | | | | | | |
| | | | | 0.45 | | | | | | | | | | |
| | | | | 0.85 | | | | | | | | | | |
| Grouting of Holes | nos. | | | 0.04 | | | | | | | | | | |
| | | | | 0.01 | | | | | | | | | | |
| Coursed Hammer Dressed Stone Masonry 1:4 | $m^3$ | | | 2.28 | | | | | | | | | | |
| | | | | 0.42 | | | | | | | | | | |
| | | | | 1.1 | | | | | | | | | | |
| Coursed Hammer Dressed Stone Masonry 1:6 | $m^3$ | | | 1.5 | | | | | | | | | | |
| | | | | 0.47 | | | | | | | | | | |
| | | | | 1.1 | | | | | | | | | | |
| Dry Coursed Hammer S/M | $m^3$ | | | 1.1 | | | | | | | | | | |
| Plumb Concrete 1:3:6 + 40% Broken Stone | $m^3$ | | | 2.64 | | | | | | | | | | |
| | | | | 0.28 | | | | | | | | | | |
| | | | | 0.54 | | | | | | | | | | |
| | | | | 0.50 | | | | | | | | | | |
| Dry Broken Stone Masonry | $m^3$ | | | 1.1 | | | | | | | | | | |
| 1.4 Cement Plaster 20 mm thick | $m^2$ | | | 0.16 | | | | | | | | | | |
| | | | | 0.024 | | | | | | | | | | |
| **Total Quantity of Construction Materials** | | | | **L/B** | | | | | | | | | | |
| | | | | **R/B** | | | | | | | | | | |
| | | | | **Total** | | | | | | | | | | |

# COST ESTIMATE: Transportation Weight

**180 Transportation**

| S. N. | Materials | Quantity kg | Remarks |
|---|---|---|---|
| 1 | Steel Parts | | **Refer to:** Refer to Sheet Quantity Calculation "120 Steel Parts" (page 5) |
| 2 | Steel Deck | | Refer to Sheet "130 Steel Deck" (page 5) |
| 3 | Cement | | Refer to Sheet "List of Construction Materials" (page 7) |
| 4 | Fencing G. I. Wire | | |
| 5 | Gabion Wires | | |
| 6 | Tools | 100.0 | |
| | **Sub-Total Materials** | | |
| 8 | Wire Ropes (Cables) | | Refer to Sheet Quantity Calculation "110 Wire Ropes" (page 5) |
| | **Total of Materials and Wire Ropes** | | |

# COST ESTIMATE: Quantity of Works and Labor

| S.N. | Description | Quantity | Unit | Labor input per unit | | Mandays | | Remarks |
|---|---|---|---|---|---|---|---|---|
| | | | | skilled | unskilled | skilled | unskilled | |
| **A.** | **Local Material Collection[1]** | | | | | | | |
| 1 | Hammer Dressed Stone | | $m^3$ | 5.00 | 3.00 | | | |
| 2 | Broken Stone | | $m^3$ | | 5.00 | | | |
| 3 | Natural Gravel | | $m^3$ | - | 4.00 | | | |
| | Brocken Gravel | | $m^3$ | | 10.00 | | | |
| 4 | Sand | | $m^3$ | - | 3.00 | | | |
| 5 | Bamboo | | pcs. | - | 0.25 | | | |
| | | | | | **A. Total Local Material Collection** | | | |
| **B.** | **Construction Works[2]** | | | | | | | |
| 6 | Foundation Excavation in Soil | | $m^3$ | - | 1.70 | | | |
| 7 | Foundation Excavation in Soft rock | | $m^3$ | - | 2.50 | | | |
| 8 | Foundation Excavation in Hard Rock | | $m^3$ | - | 12.00 | | | |
| 9 | Hard Rock hole drilling and grouting | | nos. | 0.10 | 2.00 | | | |
| 10 | Coursed Dry Stone Masonry | | $m^3$ | 1.00 | 1.00 | | | |
| 11 | Cement Stone Masonry (1:4) | | $m^3$ | 1.50 | 3.00 | | | |
| 12 | Cement Stone Masonry (1:6) | | $m^3$ | 1.50 | 3.00 | | | |
| 13 | Concrete RCC 1:2:4 | | $m^3$ | 1.00 | 4.00 | | | |
| 14 | Concrete RCC 1:3:6 | | $m^3$ | 1.00 | 4.00 | | | |
| 15 | Plumb Concrete, 1:3:6 + 40% B/S | | $m^3$ | 0.50 | 4.00 | | | |
| 16 | Cement Plaster (1:4) | | $m^2$ | 0.22 | 0.22 | | | |
| 17 | Gabion Works | | $m^3$ | 0.35 | 0.40 | | | |
| 18 | Tower Erection* | | m | 0.5 | 5.00 | | | |
| 19 | Cable Pulling** | | m | 0.05 | 0.40 | | | |
| 20 | Walkway Erection*** | | m | 0.50 | 2.00 | | | |
| 21 | Fence Knitting*** | | m | - | 0.30 | | | |
| | | | | | **B. Total Construction Works** | | | |

1 Refer to the List of Construction Materials, "230 Construction" (page 7)
2 Refer to Quantity Calculation, "230 Construction" (page 6)
* Quantity is equal to total tower height
** Quantity is equal to total length of cables of all Ø except 13mm.
Refer to Sheet Quantity Calculation "110 Wire Ropes" (page 5)
*** Quantities are equal to bridge span

| S.N. | Description | Total | Unit | Porter Days* | Labor Input per Unit md | Mandays Porter | Remarks |
|---|---|---|---|---|---|---|---|
| | | a | b | c | d | e = axcxd | |
| **C.** | **Portering** | | | | | | |
| 16 | Transport of Materials | | tons | | 25.00 | | |
| 18 | Transport of Wire Rope (Cable) | | tons | | 45.00 | | |
| | | | | | **C. Total Portering** | | |

| Summary (A+B+C) | Total Mandays | Rate Rs. | Total Cost Rs. |
|---|---|---|---|
| Skilled Labor | | | |
| Unskilled Labor | | | |
| Porter (Unskilled Labor) | | | |
| **Total Labor Cost** | | | |

* Porter Days = 2 x Normal Walking Days without Load

# COST ESTIMATE: List of Tools

| S.N. | Description | Unit | Quantity | Remarks |
|---|---|---|---|---|
| | **A. Tools for Construction** | | | |
| 1 | Shovel | pc | 2 | |
| 2 | Pick axe | pc | 2 | |
| 3 | Crowbar (1 ¼") | pc | 2 | |
| 4 | Large hammer (5 kg) | pc | 1 | |
| 5 | Large hammer (3 kg) | pc | 2 | |
| 6 | Stone dressing hammer (1 kg) | pc | 12 | |
| 7 | Long chisel (2' x 1") | pc | 2 | |
| 8 | Stone breaking chisel | pc | 2 | |
| 9 | Stone dressing chisel | pc | 15 | |
| 10 | Square bottom | pc | 2 | |
| 11 | Plum bob | pc | 2 | |
| 12 | Measuring tape (5 m) | pc | 1 | |
| 13 | Sieving Wire mesh (1.5 m) (3 $mm^2$) | pc | 1 | |
| 14 | Level pipe (5 m) | pc | 1 | |
| 15 | Mason thread | roll | 1 | |
| | **B. Tools for Bridge Erection** | | | |
| 1 | Pliers | pc | 2 | |
| 2 | Slide wrench 12" | pc | 1 | |
| 3 | Ring wrench size 18/19 mm | pc | 1 | |
| 4 | Ring wrench size 20/22 mm | pc | 1 | |
| 5 | Ring wrench size 30/32 mm | pc | 1 | |
| 6 | Masonry trowel | pc | 4 | |
| 7 | Headpan | pc | 6 | |
| 8 | Plastic sheet (15 m) | pc | 1 | |
| 9 | Hacksaw Frame | pc | 1 | |
| 10 | Hacksaw blade | pc | 10 | |
| 11 | Kerosene tin | pc | 4 | |
| 12 | Inexpensive bag | pc | 1 | |
| 15 | Tool Box | pc | 1 | |
| 16 | Claw Hammer | pc | 1 | |
| 17 | Nails (3") | kg | 1 | |

# COST ESTIMATE: Rate Analysis

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **120** | **Fabrication of Steel Parts and Steel Deck** | | | | | |
| 121 | **Fabrication of Steel Parts per kg** | | | | | |
| | Materials | Structural Steel* | kg | 1.11 | | |
| | Labor | Skilled (Workshop Rate) | md | 0.11 | | |
| | | Unskilled (Workshop Rate) | md | 0.11 | | |
| | | | | | **Sub-total** | |
| | | | | | **Tools and Plants (7%)** | |
| | | | | | **Sub-total** | |
| | | | | | **Overhead and VAT** | |
| | | | | | **Total cost per kg** | |
| 122 | **Fabrication of Reinforcement Steel per kg** | | | | | |
| | Materials | Reinforcement Steel* | kg | 1.11 | | |
| | Labor | Skilled (Workshop Rate) | md | 0.03 | | |
| | | Unskilled (Workshop Rate) | md | 0.04 | | |
| | | | | | **Sub-total** | |
| | | | | | **Overhead and VAT** | |
| | | | | | **Total cost per kg** | |
| **130** | **Fabrication of Steel Deck per kg** | | | | | |
| | Materials | Structural Steel* | kg | 1.11 | | |
| | Labor | Skilled | md | 0.11 | | |
| | | Unskilled | md | 0.11 | | |
| | | | | | **Sub-total** | |
| | | | | | **Tools and Plants (7%)** | - |
| | | | | | **Sub-total** | |
| | | | | | **Overhead and VAT** | |
| | | | | | **Total cost per kg** | |
| **180** | **Road Transportation** | | | | | |
| 181 | **Transportation of Material, Equipment and Wire Ropes per ton** | | | | | |
| | Transportation by Truck | | Dist, km | Weight, t | Rate | Unit Cost |
| | From: to: | Metal led Road | | 1.00 | | |
| | From: to: | Non-Metal led Road | | 1.00 | | |
| | Transportation by Tractor (only where applicable) | | | | | |
| | From: to: | Earthen Road | | 1000.00 | | |
| | | | | | **Sub-total** | |
| | | | | | **Overhead and VAT** | |
| | | | | | **Total cost per ton** | |
| | | | | | **Total cost per kg** | |

*** Apply Rate without Vat**

# COST ESTIMATE: Official Rate

**Fiscal Year:**

| Description | | Unit | Rate |
|---|---|---|---|
| Wire Ropes | Ø 13 mm | m | |
| | Ø 26 mm | m | |
| | Ø 32 mm | m | |
| Supply of Steel Parts | Structural Steel | kg | |
| | Reinforcement Steel | kg | |
| Thimbles | Ø 13 mm | pc | |
| | Ø 26 mm | pc | |
| | Ø 32 mm | pc | |
| Bulldog Grips | Ø 13 mm | pc | |
| | Ø 26 mm | pc | |
| | Ø 32 mm | pc | |
| Miscellaneous | Bolts, Nuts and Washers | kg | |
| | Binding Wire | kg | |
| Rust Prevention | Hot Dip Galvanization | kg | |
| Workshop Labor Rate (Do not use District Rate) | Skilled | md | |
| | Unskilled | md | |
| Transportation | Truck Metal led Road | txkm | |
| | Truck Non-Metal led Road | txkm | |
| Construction | Fuel | ltr | |
| | G. I. Wire 7,10,12 SWG | kg | |
| | Cement | bag | |
| Miscellaneous | Tools | 1 set | |

Note: The above rates include VAT.

# Form No. 4 : Quantity & Cost Estimate for Public Tender & Contracting

(total 16 pages)

His Majesty's Government of Nepal
Ministry of Local Development
Department of Local Infrastructure
Development and Agricultural Roads
Trail Bridge Section

SDC/Helvetas Nepal
Trail Bridge Sub-Sector Project

# COST ESTIMATE: Summary of Cost

| | |
|---|---|
| Bridge Number : | Bridge Name: |
| Span, m : | River: |
| Type of Bridge : Suspension | District: |
| Tower Height, m: | Region: |

**Mode of Execution: Contracting**

| | DESCRIPTION | Cost, NRs. | % |
|---|---|---|---|
| 100 | Wire Ropes (Cables) | | |
| 200 | Steel Parts | | |
| 300 | Transportation | | |
| 400 | Construction | | |
| 500 | Miscellaneous | | |
| | **Total** | | |

| | |
|---|---|
| Cost per meter span | |

Total Cost in Words:

| | NAME | SIGNATURE | DATE |
|---|---|---|---|
| Estimated by | | | |
| Checked by | | | |
| Approved by | | | |

# COST ESTIMATE : Abstract of Cost (page 1 of 2)

**100 MATERIALS**

| Description | POS | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|---|
| **110 Wire Ropes*** | **111** | Ø 13 mm | m | | | |
| | **112** | Ø 26 mm | m | | | |
| | **113** | Ø 32 mm | m | | | |
| | | **Subtotal 110** | | | | |
| | | **5% Contingencies** | | | | |
| | | **Total 100 Materials** | | | | |

**200 STEEL PARTS**

| Description | POS | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|---|
| **210 Fabrication**** | **211** | Structural steel | kg | | | |
| | **212** | Reinforcement steel | kg | | | |
| **220 Supply of Thimbles***** | **221** | Ø 13 mm | pc | | | |
| | **222** | Ø 26 mm | pc | | | |
| | **223** | Ø 32 mm | pc | | | |
| **230 Supply of Bulldog Grips***** | **231** | Ø 13 mm | pc | | | |
| | **232** | Ø 26 mm | pc | | | |
| | **233** | Ø 32 mm | pc | | | |
| **240 Miscellaneous Supply**** | **241** | Bolts, Nuts and Washers | kg | | | |
| | **242** | Binding Wire | kg | | | |
| | **243** | PE Pipes dia 63mm. | m | | | |
| **250 Rust Prevention**** | **251** | Hot Dip Galvanization (Steel to be Galvanized) | kg | | | |
| | | **Subtotal 210-250 (including VAT)** | | | | |
| | | **5% Contingencies** | | | | |
| | | **Total 200 Steel Parts** | | | | |

**300 TRANSPORTATION**

| Description | POS | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|---|
| **310 Transportation****** | **311** | Materials | kg | | | |
| | **312** | Wire Ropes | kg | | | |
| | | **Subtotal 310** | | | | |
| | | **5% Contingencies** | | | | |
| | | **Total 300 Transportation** | | | | |

* Refer to Quantity Calculation Sheet "100 Wire Rope" (Page 4)
** Refer to Quantity Calculation Sheet "200 Steel Parts" (Page 4)
*** Refer to Respective "Steel Drawings"
**** Refer to Quantity Calculation Sheet "300 Transportation weight" (Page 7)

**Cost Estimate** **Abstract of Cost** (page 2 of 2)

**400 CONSTRUCTION**

| Description | POS | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|---|
| **410 Foundation Excavation*** | **411** | Soil | $m^3$ | | | |
| | **412** | Soft Rock | $m^3$ | | | |
| | **413** | Hard Rock (quarrying) | $m^3$ | | | |
| | **414** | Backfilling | $m^3$ | | | |
| **420 Construction of Gabions*** | **421** | Box Size 2 x 1 x 1.0 m | $m^3$ | | | |
| | **422** | Box Size 3 x 1 x 1.0 m | $m^3$ | | | |
| | **423** | Box Size 2 x 1 x 0.3 m | $m^3$ | | | |
| | **424** | Box Size 3 x 1 x 0.3 m | $m^3$ | | | |
| **430 Concrete Works*** | **431** | Plain Mass Concrete 1:3:6 | $m^3$ | | | |
| | **432** | Reinforced Cement Concrete 1:2:4 | $m^3$ | | | |
| | **433** | Plumb Concrete 1:3:6 + 40% Brocken Stone | $m^3$ | | | |
| | **434** | Hole Drilling & Grouting of Holes | m | | | |
| **440 Cement Stone Masonry Works*** | **441** | Coursed Hammered dressed in 1:4 c/m | $m^3$ | | | |
| | **442** | Coursed Hammered dressed in 1:6 c/m | $m^3$ | | | |
| | **443** | Cement Plaster 1:4 c/m, 20 mm thick | $m^2$ | | | |
| **450 Dry Masonry Works*** | **451** | Hammer dressed | $m^3$ | | | |
| | **452** | Broken stones | $m^3$ | | | |
| **460 Erection** | **461** | Tower Erection** | m | | | |
| | **462** | Hoisting of Cables *** Ø 26 mm | m | | | |
| | | Ø 32 mm | m | | | |
| | **463** | Erection of Walkway & Steel Deck**** | m | | | |
| | **464** | Fencing**** | m | | | |
| | | **Subtotal 410-460** | | | | |
| | | **5% Contingencies** | | | | |
| | | **Total400 Construction** | | | | |

**500 MISCELLANEOUS WORKS (For Major Maintenance only)**

| Description | POS | | Unit | Quantity | Rate | Cost |
|---|---|---|---|---|---|---|
| **510 Concrete and Masonry Works** | **511** | Dismantling of Masonry Structures | $m^3$ | | | |
| | **512** | Dismantling of Concrete Structures | $m^3$ | | | |
| **520 Pretensioning** | **521** | Cables | m | | | |
| **530 Walkway Adjustments** | **531** | Adjusting of Suspenders | m | | | |
| | **532** | Replacing of Suspenders | m | | | |
| | **533** | Adjusting of Crossbeams | m | | | |
| | **534** | Replacing of Crossbeams | m | | | |
| | **535** | Dismantling of Walkway | m | | | |
| | **536** | Refixing of Walkway & Steel Deck | m | | | |
| | **537** | Dismantling of Fencing | m | | | |
| | **538** | Replacing of Fencing | m | | | |
| **540 Finishing Works** | **541** | Retightening of Bulldog Grips, Nuts, etc. | m | | | |
| | **542** | Coaltar Application | m | | | |
| **550 Miscellaneous** | **551** | | | | | |
| | | **Subtotal 510-550** | | | | |
| | | **5% Contingencies** | | | | |
| | | **Total 500 Miscellaneous** | | | | |

* Refer to Quantity Calculation Sheet "400 Construction" (Page 5)

** Quantity is equal to total tower height,

*** Quantities are equal to cable length except 13mm dia. Refer to Quantity Calculation Sheet "100 Wire Ropes" (page 4

**** Quantities are equal to bridge span

# COST ESTIMATE: Quantity of Calculation

**100 Materials**

**110 Wire Ropes (Cables)**

| Type | Pieces | No. | Single Length (m) | Ø (mm) | Length per Type per Ø | | |
|---|---|---|---|---|---|---|---|
| | | | | | Ø 13mm | Ø 26mm | Ø 32mm |
| Main Cable | | | | | | | |
| Spanning Cable | | 2 | | | | | |
| Handrail Cable | | 2 | | 13 | | | |
| Fixation Cable | | 2 | | 13 | | | |
| Windguy cable Upstream (optional) | | 1 | | | | | |
| Windguy cableDownstream (optional) | | 1 | | | | | |
| Windties (optional) | | | | 13 | | | |
| **Total length per Ø in meter** | | | | | | | |
| Weight of cable per m length | | | | | 0.67 | 2.57 | 3.9 |
| Total weight of cable per Ø in kg | | | | | | | |
| **Total weight** | | | | | | | |
| Position of Cost Estimate | | | | | **111** | **112** | **113** |

Note: Above Quantities are derived from Form No. 2: Cable Design Form

**200 Steel Parts**

| DRAWINGS | | Units | Structural Steel (kg) | Reinforce-ment Steel (kg) | Nuts/Bolts/ Washers (kg) | Binding Wire (kg) | Steel to be galvanized (kg) | Transport Weight (kg) |
|---|---|---|---|---|---|---|---|---|
| No. | Name | | | | | | | |
| | Steel Cross Beams | | | - | - | | | |
| | Steel Decks | | | - | - | | | |
| | Suspenders | | | | | | | |
| | Main Cable Anchor with Turn Buckle | | | | | | | |
| | Main Cable Anchor with Direct Cable Connection | | | | | | | |
| | Walkwat and Tower Foundation at R/B | | | | | | | |
| | Walkwat and Tower Foundation at L/B | | | | | | | |
| | Tower | | | | | | | |
| | Windtie Cable Clamps (Optional) | | | | | | | |
| | Windguy Cable Anchorage (Optional) | | | | | | | |
| | Windguy Drum Anchorage (Optional) | | | | | | | |
| | Others | | | | | | | |
| **Total** | | | | | | | | |
| Position of Cost Estimate | | | **211** | **212** | **241** | **242** | **251** | **311** |

Note: Above Quantities are derived from the respective Steel Drawings.

# COST ESTIMATE: Quantity Calculation (Page 2)

**230 Construction**

| Location | Foundation Excavation | | | Back-filling $m^3$ |
|---|---|---|---|---|
| | Soil $m^3$ | Soft Rock $m^3$ | Hard Rock $m^3$ | |
| Main Cable Anchorage | | | | |
| Right Bank | | | | |
| Left Bank | | | | |
| Walkway and Tower Foundations | | | | |
| Right Bank | | | | |
| Left Bank | | | | |
| Windguy Cable Anchorages (Optional only) | | | | |
| Right Bank, U/S | | | | |
| Right Bank, D/S | | | | |
| Left Bank, U/S | | | | |
| Left Bank, D/S | | | | |
| Other Structures | | | | |
| | | | | |
| | | | | |
| | | | | |
| **Total** | | | | |

Note: Above Quantities are to be calculated from General Arrangement Drawing.

| Location | Concrete Works | | Cement Stone Masonry Works | | Dry Stone Masonry Works | | | Plumb |
|---|---|---|---|---|---|---|---|---|
| | 1:3:6 $m^3$ | 1:2:4 $m^3$ | Coursed Hammer Dressed 1:4 $m^3$ | Coursed Hammer Dressed 1:6 $m^3$ | Coursed Hammer Dressed dry $m^3$ | Broken Stone $m^3$ | Cement Plaster 1:4 $m^2$ | Concrete 1:3:6 + Brocken Stone $m^3$ |
| Main Cable Anchors | | | | | | | | |
| Right Bank | | | | | | | | |
| Left Bank | | | | | | | | |
| Walkway and Tower Foundations | | | | | | | | |
| Right Bank | | | | | | | | |
| Left Bank | | | | | | | | |
| Windguy Cable Anchorages (Optional, only if applicable) | | | | | | | | |
| Right Bank, U/S | | | | | | | | |
| Right Bank, D/S | | | | | | | | |
| Left Bank, U/S | | | | | | | | |
| Left Bank, D/S | | | | | | | | |
| Other Structures | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| **Total** | | | | | | | | |

Note: Above Quantities are derived from respective Construction Drawings.

# COST ESTIMATE: List of Construction Materials

**464 Fence Knitting**

| Item | Bridge span (m) | Requirement per meter span (kg) | Total Weight (kg) |
|---|---|---|---|
| 12 SWG G.I. Wire | | 3.9 | |

**420 G.I.Wires for Gabion Works**

| Box Size (m) | Volume ($m^3$) | Mesh Wire 10 SWG | | Selvege wire 7 SWG | | Binding Wire 12 SWG | |
|---|---|---|---|---|---|---|---|
| | | Requirement per $m^3$ | Weight (kg) | Requirement per $m^3$ | Weight (kg) | Requirement per $m^3$ | Weight (kg) |
| 2.0/1.0/1.0 | | 12.08 | | 1.58 | | 0.48 | |
| 3.0/1.0/1.0 | | 11.70 | | 1.37 | | 0.43 | |
| 2.0/1.0/0.3 | | 22.33 | | 3.75 | | 1.08 | |
| 3.0/1.0/0.3 | | 21.94 | | 3.33 | | 1.00 | |
| **Total** | | | | | | | |
| | | | | | | **Total Weight of Gabion Wire (kg)** | |

**400 Construction**

| Item | Units | Total Quantity of Work | Requirement per Unit | Cement (Bags) | Sand ($M^3$) | Gravel ($M^3$) | Hammer Dressed Stone ($M^3$) | Broken Stone ($M^3$) | Bamboo (Pcs) |
|---|---|---|---|---|---|---|---|---|---|
| Construction of Gabions | $m^3$ | | 1.1 | | | | | | |
| Concrete 1:3:6 | $m^3$ | | 4.4<br>0.47<br>0.89 | | | | | | |
| Concrete 1:2:4 | $m^3$ | | 6.4<br>0.45<br>0.85 | | | | | | |
| Plumb Concrete 1:3:6 + 40% Boulders (Brocken Stone) | m3 | | 2.64<br>0.28<br>0.54<br>0.5 | | | | | | |
| Grouting of Holes | nos | | 0.04<br>0.01 | | | | | | |
| Coursed Hammer Dressed Stone Masonry in 1:4 c/m | $m^3$ | | 2.28<br>0.42<br>1.1 | | | | | | |
| Coursed Hammer Dressed Stone Masonry in 1:6 c/m | $m^3$ | | 1.5<br>0.47<br>1.1 | | | | | | |
| Dry Broken Stone Masonry | $m^3$ | | 1.1 | | | | | | |
| 1:4 Cement Plaster 20 mm thick | $m^2$ | | 0.16<br>0.024 | | | | | | |
| Tower Erection | m | | 4 | | | | | | |
| **Total Quantity of Construction Materials** | | | | | | | | | |

# COST ESTIMATE: Transportation Weight

**300 Transportation**

| S.N. | 311 Materials | Quantity kg | Remarks |
|---|---|---|---|
| 1 | Steel Parts | | Refer to Quantity Calculation Sheet "200 Steel Parts" (page 4) |
| 2 | Cement | | Refer to Sheet "List of Construction Materials" (page 6) |
| 3 | Fencing G.I. Wire | | |
| 4 | Gabion Wires | | |
| | | | |
| | | | |
| | **Sub-Total Materials** | | |
| 5 | **Wire Ropes (Cables)** | | Refer to Quantity Calculation Sheet "100 Wire Ropes" (page 4) |
| | **Total of Materials & Wire Ropes** | | |

# COST ESTIMATE: Rate Analysis

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **210** | **Fabrication** | | | | | |
| **211** | **Fabrication of Structural Steel per kg** | | | | | |
| | Materials | Structural Steel* | kg | 1.11 | | |
| | Labour | Skilled | md | 0.11 | | |
| | | Unskilled | md | 0.11 | | |
| | Sub-total | | | | | |
| | Tools and Plants (7%) | | | | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per kg structural steel** | | | | | |
| **212** | **Fabrication of Reinforcement Steel per kg** | | | | | |
| | Materials | Reinforcement Steel* | kg | 1.11 | | |
| | Labour | Skilled | md | 0.03 | | |
| | | Unskilled | md | 0.04 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per kg reinforcement steel** | | | | | |
| **310** | **Transportation** | | | | | |
| **311** | **Transportation of Material and Equipment per kg** | | | | | |
| | Transportation by Truck | | Dist, km | Weight, t | Rate | Unit Cost |
| | From : | Metalled Road | | 1.00 | | |
| | To : | Non-Metalled Road | | 1.00 | | |
| | Transportation by Porter | (Rate=Daily Wage/38) | | 1000 | | |
| | Sub-total per 1000 kg | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per kg transportation of materials and equipment** | | | | | |
| **312** | **Transportation of Wire Ropes per kg** | | | | | |
| | Transportation by Truck | | | | | |
| | From : | Metalled Road | | 1.00 | | |
| | To : | Non-Metalled Road | | 1.00 | | |
| | Transportation by Porter | (Rate=Daily Wage/20) | | 1000 | | |
| | Sub-total per 1000 kg | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per kg transportation of wire ropes** | | | | | |
| **410** | **Foundation Excavation** | | | | | |
| **411** | **Foundation Excavation in Soil per $m^3$** | | | | | |
| | Labour | Unskilled | md | 1.7 | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ soil excavation** | | | | | |
| **412** | **Foundation Excavation in Soft Rock per $m^3$** | | | | | |
| | Labour | Unskilled | md | 2.5 | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ soft rock excavation** | | | | | |

* Material rates should be without VAT

**COST ESTIMATE:** **Rate Analysis** (page 2)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| 413 | **Foundation Excavation in Hard Rock per $m^3$** | | | | | |
| | Material | Fuel | ltr | 4.00 | | |
| | Labour | Unskilled | md | 5.50 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total Cost per $m^3$ hard rock excavation** | | | | | |
| 414 | **Backfilling per $m^3$** | | | | | |
| | Labour | Unskilled | md | 0.85 | | |
| | Overhead and VAT | | | | | |
| | **Total Cost per $m^3$ back filling** | | | | | |
| 420 | **Construction of Gabions** | | | | | |
| 421 | **Box Size 2.0x1.0x1.0 per $m^3$** | | | | | |
| | Materials | Mesh Wire 10 SWG* | kg | 12.08 | | |
| | | Selvage Wire 7 SWG* | kg | 1.58 | | |
| | | Binding Wire 12 SWG* | kg | 0.48 | | |
| | | Rubble | $m^3$ | 1.10 | | |
| | Labour | | | | | |
| | Fabrication of Gabions | Skilled | md | 0.23 | | |
| | | Unskilled | md | 0.10 | | |
| | Construction of Gabions | Unskilled | md | 0.20 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$** | | | | | |
| 422 | **Box Size 3.0x1.0x1.0 per $m^3$** | | | | | |
| | Materials | Mesh Wire 10 SWG* | kg | 11.7 | | |
| | | Selvage Wire 7 SWG* | kg | 1.37 | | |
| | | Binding Wire 12 SWG* | kg | 0.43 | | |
| | | Rubble | $m^3$ | 1.10 | | |
| | Labour | | | | | |
| | Fabrication of Gabions | Skilled | md | 0.21 | | |
| | | Unskilled | md | 0.10 | | |
| | Construction of Gabions | Unskilled | md | 0.20 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$** | | | | | |
| 423 | **Box Size 2.0x1.0x0.3 per $m^3$ (matress)** | | | | | |
| | Materials | Mesh Wire 10 SWG* | kg | 22.33 | | |
| | | Selvage Wire 7 SWG* | kg | 3.75 | | |
| | | Binding Wire 12 SWG* | kg | 1.08 | | |
| | | Rubble | $m^3$ | 1.10 | | |
| | Labour | | | | | |
| | Fabrication of Gabions | Skilled | md | 0.44 | | |
| | | Unskilled | md | 0.20 | | |
| | Construction of Gabions | Unskilled | md | 0.20 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$** | | | | | |

* Material rates should be without VAT

**COST ESTIMATE:** **Rate Analysis** (page 3)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **424** | **Box Size 3.0x1.0x0.3 per $m^3$** | | | | | |
| | Materials | Mesh Wire 10 SWG* | kg | 21.94 | | |
| | | Selvage Wire 7 SWG* | kg | 3.33 | | |
| | | Binding Wire 12 SWG* | kg | 1.00 | | |
| | | Rubble | $m^3$ | 1.10 | | |
| | Labour | | | | | |
| | Fabrication of Gabions | Skilled | md | 0.41 | | |
| | | Unskilled | md | 0.19 | | |
| | Construction of Gabions | Unskilled | md | 0.20 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$** | | | | | |
| **430** | **Concrete Works** | | | | | |
| **431** | **Cement Concrete 1:3:6 per $m^3$** | | | | | |
| | Materials | Cement* | bag | 4.40 | | |
| | | Gravel (5-40 mm) | $m^3$ | 0.89 | | |
| | | Sand | $m^3$ | 0.47 | | |
| | Labour | Skilled | md | 1.00 | | |
| | | Unskilled | md | 4.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ concrete 1:3:6** | | | | | |
| **432** | **Cement Concrete 1:2:4 per $m^3$** | | | | | |
| | Materials | Cement* | bag | 6.40 | | |
| | | Gravel (5-40 mm) | $m^3$ | 0.85 | | |
| | | Sand | $m^3$ | 0.45 | | |
| | Labour | Skilled | md | 1.00 | | |
| | | Unskilled | md | 4.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ 1:2:4** | | | | | |
| **433** | **Plumb Concrete,1:3:6 + 40% Brocken Stone, per m3** | | | | | |
| | Materials | Cement* | bag | 2.64 | | |
| | | Gravel (5-40 mm) | $m^3$ | 0.54 | | |
| | | Sand | $m^3$ | 0.28 | | |
| | | Brocken Stones (Max 225mm) | $m^3$ | 0.50 | | |
| | Labour | Skilled | md | 0.50 | | |
| | | Unskilled | md | 4.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ Plumb Concrete,1:3:6 + 40% Brocken Stone** | | | | | |
| **434** | **Hole Drilling & Grouting of Holes** | | | | | |
| | Labour | Skilled | md | 0.05 | | |
| | | Unskilled | md | 2.00 | | |
| | Materials | Cement* | bag | 0.04 | | |
| | | Sand | $m^3$ | 0.01 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost for one hole drilling & grouting** | | | | | |

* Material rates should be without VAT

**COST ESTIMATE:** **Rate Analysis** (page 4)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **440** | **Cement Stone Masonry Works** | | | | | |
| **441** | **Coursed Hammer Dressed Stone Masonry in 1:4 c/m per $m^3$** | | | | | |
| | Materials | Cement* | bag | 2.28 | | |
| | | Sand | $m^3$ | 0.42 | | |
| | | Dressed Stones | $m^3$ | 1.10 | | |
| | Labour | Skilled | md | 1.50 | | |
| | | Unskilled | md | 3.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ coursed hammer dressed stone masonry 1:4** | | | | | |
| **442** | **Coursed Hammer Dressed Stone Masonry in 1:6 c/m per $m^3$** | | | | | |
| | Materials | Cement* | bag | 1.50 | | |
| | | Sand | $m^3$ | 0.47 | | |
| | | Dressed Stones | $m^3$ | 1.10 | | |
| | Labour | Skilled | md | 1.50 | | |
| | | Unskilled | md | 3.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ coursed hammer dressed stone masonry 1:6** | | | | | |
| **443** | **Cement Plaster 1:4, 20 mm thick per $m^2$** | | | | | |
| | Materials | Cement* | bags | 0.16 | | |
| | | Sand | $m^3$ | 0.02 | | |
| | Labour | Skilled | md | 0.22 | | |
| | | Unskilled | md | 0.22 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^2$ cement plaster 1:4, 20 mm thick** | | | | | |
| **450** | **Dry Stone Masonry Works** | | | | | |
| **451** | **Coursed Hammer Dressed Dry Stone Masonry per $m^3$** | | | | | |
| | Materials | Dressed Stones | $m^3$ | 1.10 | | |
| | Labour | Skilled | md | 1.00 | | |
| | | Unskilled | md | 1.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ coursed hammer dressed dry stone masonry** | | | | | |
| **452** | **Packing with Broken (stratified) Stones per $m^3$** | | | | | |
| | Materials | Stratified Stones | $m^3$ | 1.10 | | |
| | Labour | Skilled | md | 1.00 | | |
| | | Unskilled | md | 1.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ for packing with broken stones** | | | | | |

* Material rates should be without VAT

**COST ESTIMATE:** **Rate Analysis** (page 5)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **460** | **Erection** | | | | | |
| **461** | **Tower Erection** | | | | | |
| | Materials | Bamboo | Pcs | 4.00 | | |
| | | Dori | Kg | 2.00 | | |
| | Labour | Skilled | md | 0.50 | | |
| | | Unskilled | md | 5.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m tower erection** | | | | | |
| **462** | **Hoisting Cables Ø 13 mm per m cable** | | | | | |
| | Labour | Unskilled | md | 0.08 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m cable ϕ 13 mm** | | | | | |
| | **Hoisting Cables Ø 26 mm per m cable** | | | | | |
| | Labour | Unskilled | md | 0.32 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m cable ϕ 26 mm** | | | | | |
| | **Hoisting Cables Ø 32 mm per m cable** | | | | | |
| | Labour | Unskilled | md | 0.48 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m cable ϕ 32 mm** | | | | | |
| **463** | **Erection of the Walkway & Steel Deck per m span** | | | | | |
| | Labour | Skilled | md | 1.30 | | |
| | | Unskilled | md | 2.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **464** | **Fence Knitting per m span (both sides)** | | | | | |
| | Materials | 12 SWG G.I. Wire* | kg | 3.90 | | |
| | Labour | Unskilled | md | 0.50 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **470** | **Local Material Collection** | | | | | |
| **471** | **Hammer Dressed Stone per $m^3$** | | | | | |
| | Labour Collection and Dressing | Unskilled | md | 5.00 | | |
| | **Cost per $m^3$ for collecting and hammer dressing stones** | | | | | |

* Material rates should be without VAT

**COST ESTIMATE:** **Rate Analysis** (page 6)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| 473 | **Broken Stones per $m^3$** | | | | | |
| | Labour | | | | | |
| | Collection and breaking | Unskilled | md | 3.00 | | |
| | **Cost per $m^3$ for collecting and breaking stones** | | | | | |
| 474 | **Sand per $m^3$** | | | | | |
| | Labour, Collection of sand | Unskilled | md | 1.50 | | |
| | Additional Haulage Distance | Unskilled | md | 0.01 | | |
| | **Cost per $m^3$ for collecting and hauling sand** | | | | | |
| 475 | **Gravel** | | | | | |
| | Collection of Natural Gravel | Unskilled | md | 4.00 | | |
| | Crushing of Gravel, % | Unskilled | md | 7.00 | | |
| | Additional Haulage Distance, m | | md | 0.01 | | |
| | **Cost per $m^3$ for breaking gravel** | | | | | |
| 500 | **Major Maintenance** | | | | | |
| 510 | **Concrete and Masonry Works** | | | | | |
| 511 | **Dismantling of Masonry Structures per $m^3$** | | | | | |
| | Labour | Unskilled | md | 2.20 | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ for dismanteling of masonry structures** | | | | | |
| 512 | **Dismantling of Concrete Structures per $m^3$** | | | | | |
| | Material | Fuel | ltr | 4.00 | | |
| | Labour | Unskilled | md | 26.00 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^3$ for dismanteling of concrete structures** | | | | | |
| 520 | **Pretensioning/Hoisting Works** | | | | | |
| 521 | **Pretensioning/Hoistingof of Cables per m cable** | | | | | |
| | Cable Ø 13 mm | | | | | |
| | Labour, Pretensioning | Skilled | md | 0.01 | | |
| | | Unskilled | md | 0.01 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m pretensioning/hoisting cables Ø 13 mm** | | | | | |
| | Cable Ø 26-40mm | | | | | |
| | Labour Loosening | Skilled | md | 0.01 | | |
| | | Unskilled | md | 0.02 | | |
| | Labour Pretensioning | Skilled | md | 0.01 | | |
| | | Unskilled | md | 0.05 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m pretensioning/hoisting cables Ø 26 - 40 mm** | | | | | |

**COST ESTIMATE:** **Rate Analysis** (page 7)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **530** | **Walkway Adjustment** | | | | | |
| **531** | **Adjusting of Suspenders per m span** | | | | | |
| | Labour | Skilled | md | 0.27 | | |
| | | Unskilled | md | 0.52 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **532** | **Replacing of Cross Beams per m span** | | | | | |
| | Labour | Skilled | md | 0.67 | | |
| | | Unskilled | md | 1.42 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **533** | **Adjusting of Crossbeams per m span** | | | | | |
| | Labour | Skilled | md | 0.22 | | |
| | | Unskilled | md | 0.48 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **534** | **Dismantling of Walkway per m span** | | | | | |
| | Labour | Unskilled | md | 0.28 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **535** | **Refixing of Walkway per m span** | | | | | |
| | Labour | Skilled | md | 0.27 | | |
| | | Unskilled | md | 0.52 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **536** | **Dismantling of Fencing per m span** | | | | | |
| | Labour | Skilled | md | 0.01 | | |
| | | Unskilled | md | 0.06 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **537** | **Replacing of New Fencing per m span** | | | | | |
| | Material | 12 SWG G.I.Wire* | kg | 3.90 | | |
| | Labour | Skilled | md | 0.02 | | |
| | | Unskilled | md | 0.13 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |

* Material Rates should be without VAT

**COST ESTIMATE:** **Rate Analysis** (page 8)

| | Description | | Unit | Unit Quantity | Rate | Unit Cost |
|---|---|---|---|---|---|---|
| **540** | **Finishing Works** | | | | | |
| **541** | **Retightening of Bulldog grips, Nuts, etc. per m span** | | | | | |
| | Labour | Unskilled | md | 0.10 | | |
| | **Total cost per m span** | | | | | |
| **542** | **Coaltar Application per m span** | | | | | |
| | Material | Coaltar | ltr | 0.20 | | |
| | | Kerosene | ltr | 0.20 | | |
| | Labour | Skilled | md | 0.02 | | |
| | | Unskilled | md | 0.07 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per m span** | | | | | |
| **543** | **Repainting of Steel Parts per $m^2$** | | | | | |
| | Labour Preparatio | Skilled | md | 0.01 | | |
| | | Unskilled | md | 0.16 | | |
| | Material | Red Oxide Zinc Chromate* | ltr | 0.25 | | |
| | Labour | Skilled | md | 0.08 | | |
| | | Unskilled | md | 0.07 | | |
| | Material Fin | Polyurethane Enamel* | ltr | 0.20 | | |
| | Labour | Skilled | md | 0.09 | | |
| | | Unskilled | md | 0.10 | | |
| | Sub-total | | | | | |
| | Overhead and VAT | | | | | |
| | **Total cost per $m^2$ steel surface** | | | | | |

* Material rates should be without VAT

# COST ESTIMATE: Official Rate

**Fiscal Year:**

| Description | | | | Unit | Rate |
|---|---|---|---|---|---|
| 110 | **Wire Ropes** | 211 | Ø 13 mm | m | |
| | | 212 | Ø 26 mm | m | |
| | | 213 | Ø 32 mm | m | |
| 210 | **Supply of Steel Parts** | 211 | Structural Steel | kg | |
| | | 212 | Reinforcement Steel | kg | |
| 220 | **Thimbles** | 221 | Ø 13 mm | pc | |
| | | 222 | Ø 26 mm | pc | |
| | | 223 | Ø 32 mm | pc | |
| 230 | **Bulldog Grips** | 231 | Ø 13 mm | pc | |
| | | 232 | Ø 26 mm | pc | |
| | | 233 | Ø 32 mm | pc | |
| 240 | **Miscellaneous** | 241 | Bolts, Nuts and Washers | kg | |
| | | 242 | Binding Wire | kg | |
| | | 243 | PE Pipes, dia 63mm | m | |
| 250 | **Rust Prevention** | 251 | Hot Dip Galvanization | kg | |
| | **Workshop Labour Rate** (Do not use District Rates) | | Skilled | md | |
| | | | Unskilled | md | |
| 310 | **Transportation** | 311/312 | Truck Metalled Road | txkm | |
| | | 311/312 | Truck Non-Metalled Road | txkm | |
| 400 | **Construction** | 520/530 | Fuel | ltr | |
| | | 440 | G.I. Wire 7,10,12 SWG | kg | |
| | | 550/560 | Cement | bag | |

Note: The above rates are including VAT