4.13 DESIGN OF LONG SPAN BRIDGE (LSTB)

The typical design of the LSTB standard suspended and suspension types of bridges and its major components and parameters are as given in the following pages.

Selection of Bridge Type:

Same as for SSTB Standard, refer to chapter 4.10.2

4.13.1 LSTB Standard Suspended Bridge

Follow the Flow Chart for Design as presented in the next pages.

4.13.1.1 Design Procedure

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

Draw the bridge profile and contour plan from the survey data,
Fix the position of the bridge foundations and the span,
Design Main cables and Handrail cables,
Design Main Anchorage Foundations,
Transfer data to the bridge profile and prepare the General Arrangement Drawing,
Compile and fill in the standard design drawings,
Calculate the quantities of works and prepare the Cost Estimate.

The design work consists of the following:

- Designing the Position of the Bridge Foundations
- Cable Design
- Design of Windguy Arrangement
- Design of Main Cable Anchorages
- Design of Windguy Anchorage Foundations

4.13.1.2 Designing the Position of the Bridge Foundations

Fix the position of the bridge foundations and the actual span of the bridge in the bridge profile. Fulfill the following criteria while fixing the position of the bridge foundations.

The Bridge Foundations should be placed at least 3 meters back from a soil slope and 1.5 meters back from a rock slope.

The Bridge Foundations should be placed behind the line of angle of internal friction of the soil or rock. This angle is 35° for soil and 60° for rock.

Level the difference between the walkway cable saddles on the two banks, h should not be more than span/14.

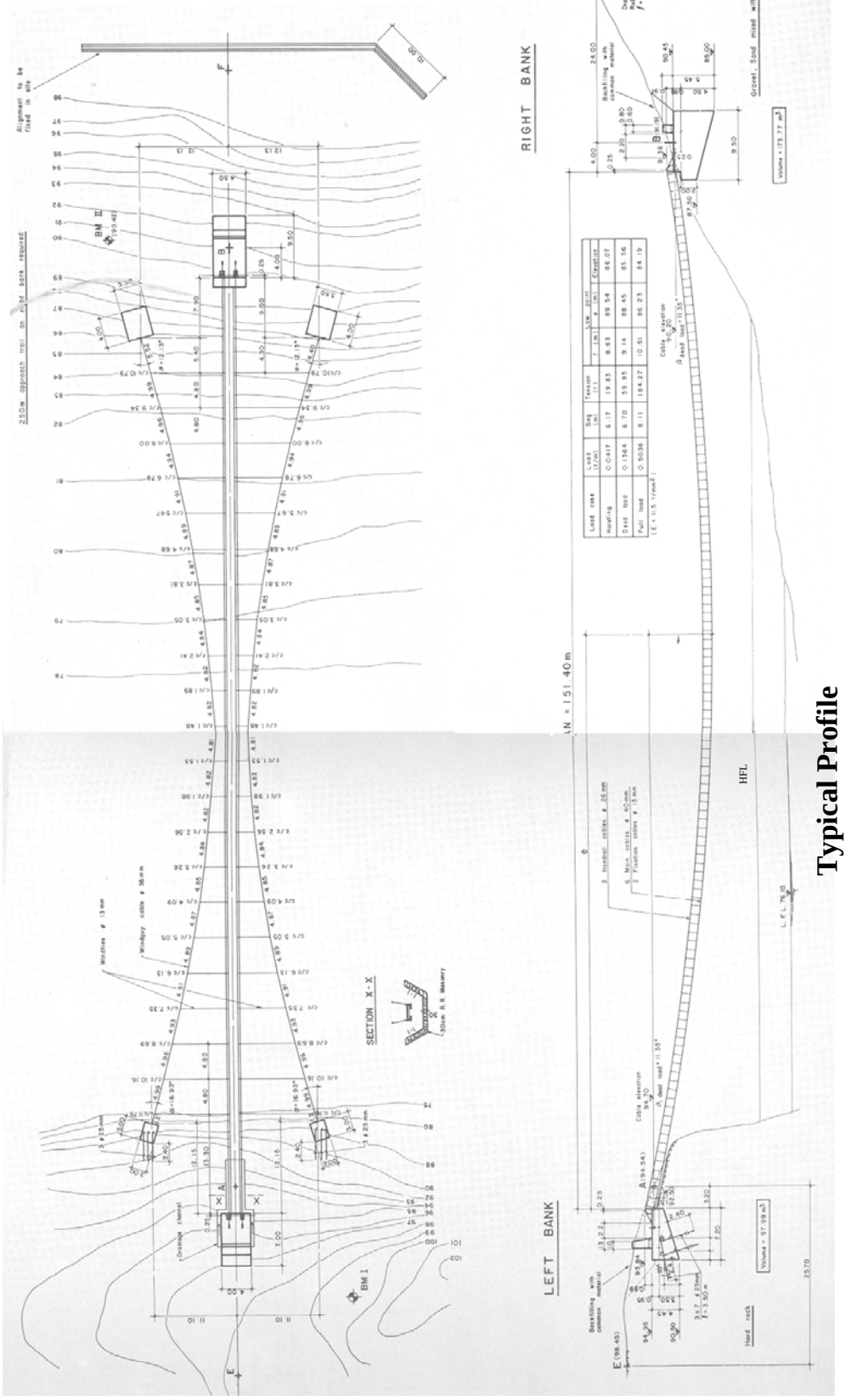
The freeboard F, between the lowest point of the bridge in dead load case (sag, $b_d = l/19$ to $l/23$) and the high flood level should be not less than 5.0 m.

4.13.1.3 Procedure for Fixing the Bridge Foundations

Procedure is same as for SSTB Standard as explained in the chapter 4.11.3 but fulfilling the criteria for LSTB standard, i.e. height difference between two banks, **h** and sag in dead load case, $\mathbf{b_d}$.

PEDESTRAIN LSTB SUSPENDED BRIDGE

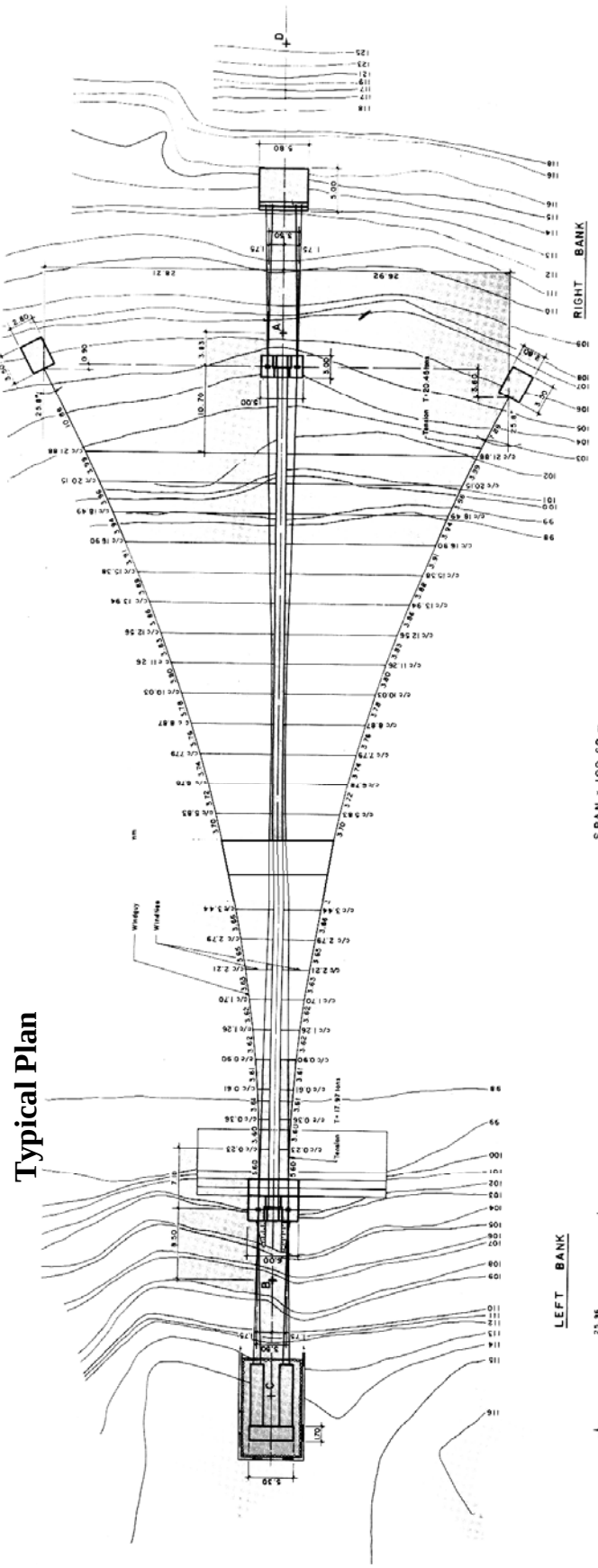
Typical Plan



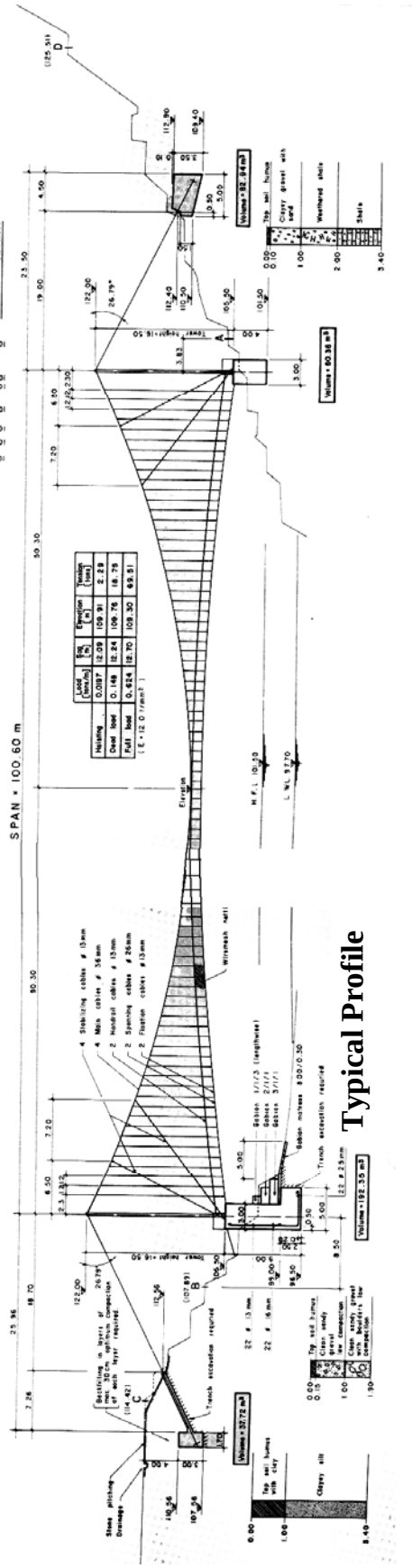
Typical Profile

PEDESTRAION LSTB SUSPENSION BRIDGE

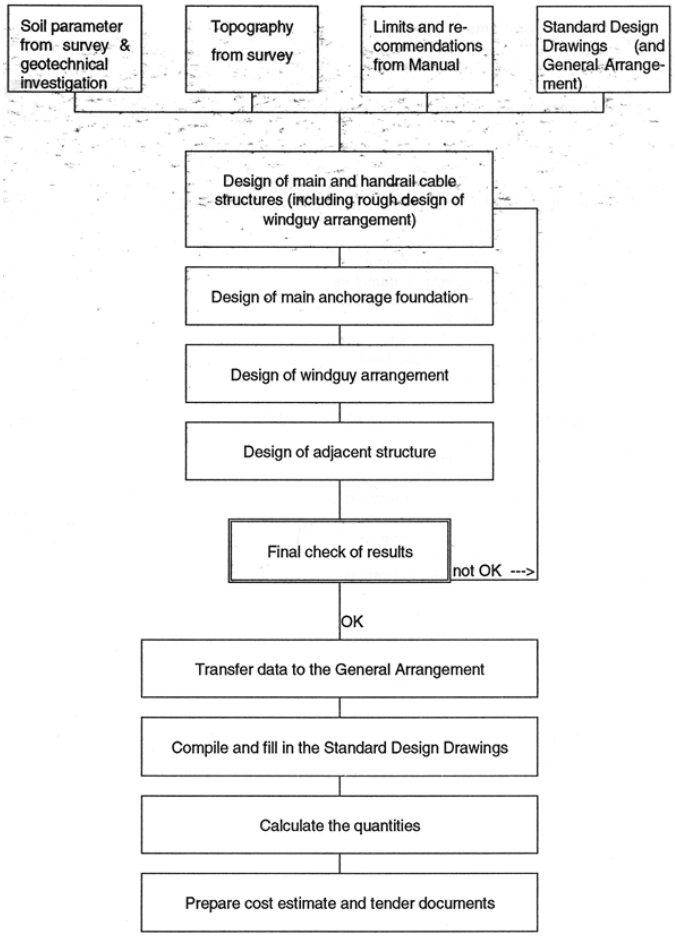
Typical Plan



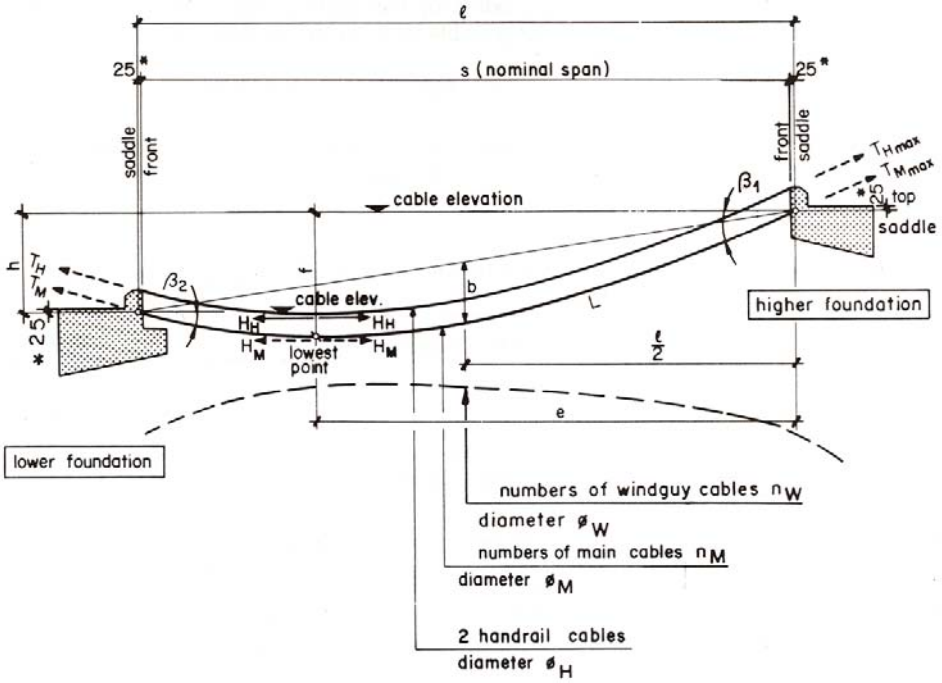
Typical Profile



Flowchart for LSTB Suspended Type Bridge Design



Layout of the Suspended Type LSTB Bridge



4.13.1.4 Cable Design

Designing the cable for a bridge involves selecting the required numbers and diameters of the handrail and main cables for a given span as per calculated maximum tension in full load case.

To design the cable combination, proceed as per the steps below.

- Fix the span of the bridge and the height difference of the cable saddles on the right and left banks from the bridge profile.
- Calculate the cable structures as per Chapter 4.4: Cable Design.

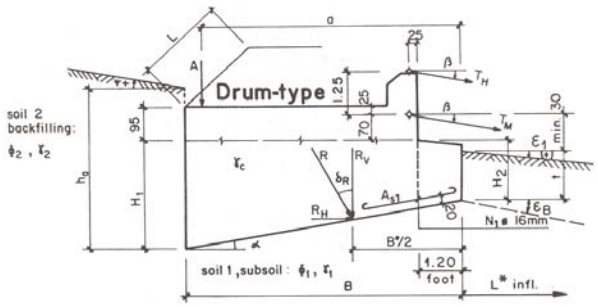
4.13.1.5 Design of Foundations

The sizes of the foundations are not fixed as in the SSTB design as per span, but is has to be designed. There is a range of sizes as per the number of the main cables. The range of sizes is to fit the standard anchor parts inside the foundation. Designer should choose the optimum size within the given range as per maximum forces on the foundation blocks, soil/rock parameters and topography.

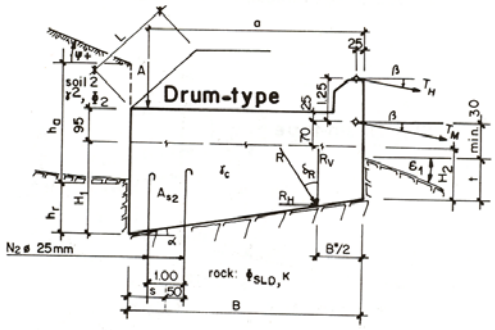
Design the main anchorage foundation as per statical analysis as described in Chapter 4.9.

The typical designs of the main anchorage foundations are of two types:

- **Drum type Main Cable Foundation up to 6 main cables**

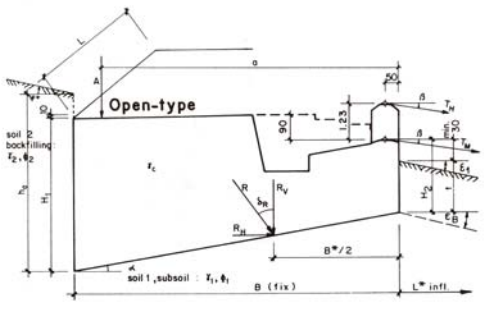


On Soil

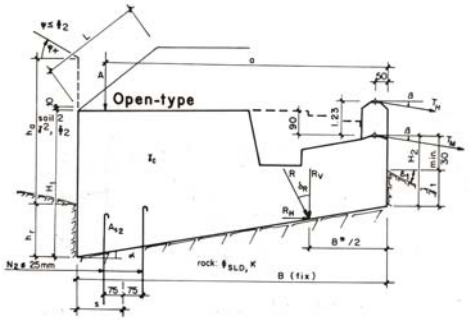


On Rock

- **Open type Main Cable Foundation above 6 main cables**



On Soil



On Rock

Standard Main Anchorage Block on Soil

Soil	Drum			Open		
Dim. \ n_M	2	4	6	8	10	12
H_1 min	1.20	1.50	2.00	3.70	3.70	3.70
H_1 max	3.50	4.00	4.50	6.70	6.70	6.70
H_2 min	1.20	1.20	1.20	2.00	2.00	2.00
H_2 max	3.50	4.00	4.50	5.80	5.80	5.80
B min	4.80	6.20	7.90	9.50	11.00	12.50
B max	6.50	5.90	11.00	9.50	11.00	12.50
L min	2.90	2.90	3.30	5.00	5.70	5.70
L max	5.00	5.00	6.50	7.50	8.00	8.00

Standard Main Anchorage Block on Rock

Rock	Drum			Open		
Dim. \ n_M	2	4	6	8	10	12
H_1 min	1.20	1.50	2.00	2.90	3.20	3.45
H_1 max	3.00	4.00	4.50	6.70	6.70	6.70
H_2 min	0.50[1)]	0.80[1)]	1.00	1.45[1)]	1.45	1.45
H_2 max	3.00	4.00	4.50	5.80	5.80	5.80
B min	3.60	5.00	6.70	9.50	11.00	12.50
B max	5.50	8.50	9.50	9.50	11.00	12.50
L min	2.90	2.90	3.30	4.80	5.40	5.40
L max	4.50	5.00	5.50	7.50	8.00	8.00
	1.00	1.00	1.50	1.75	1.75	1.75

4.13.1.6 Design of Windguy Arrangement

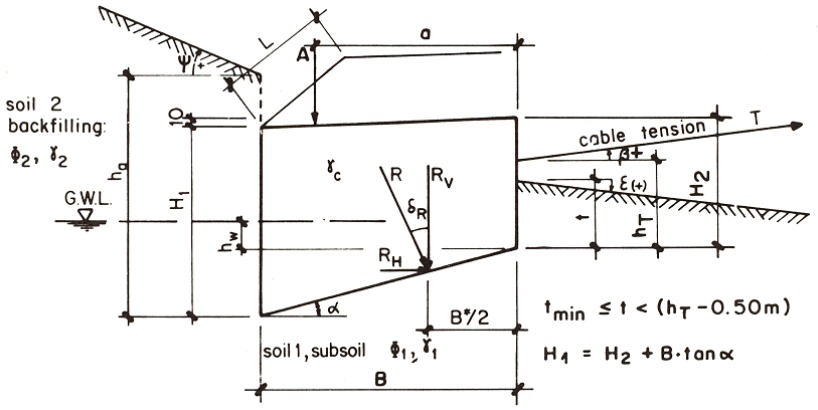
Calculate the Windguy Arrangement as per Chapter 4.6.2.

4.13.1.7 Design of Windguy Anchorage Foundation

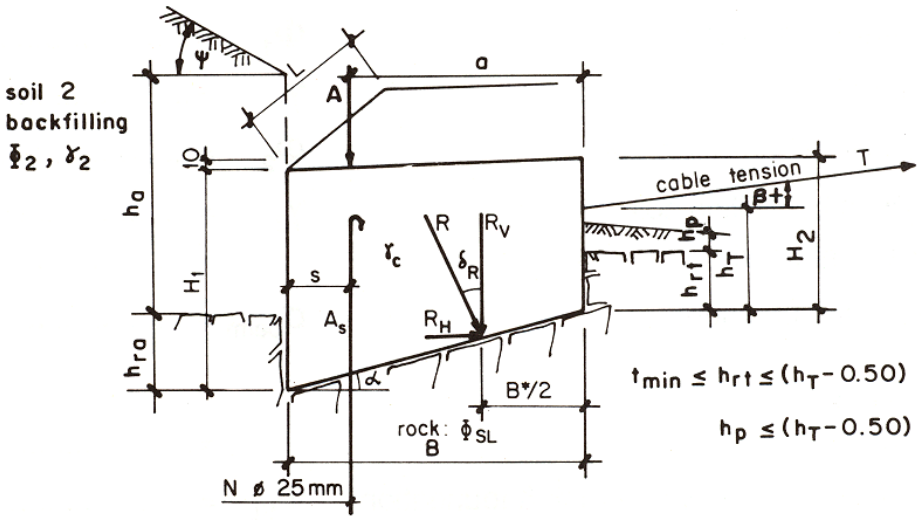
The principal of Windguy anchorage foundation is identical of the main cable anchorage foundation.

The typical designs of the Windguy Cable foundations are of two types:

Foundation on Soil



Foundation on Rock



There is a range of sizes as per the number and diameter of the windguy cables. The range of sizes is to fit the standard anchor parts inside the foundation. Designer should choose the optimum size within the given range as per maximum tension on the Windguy cable, soil/rock parameters and topography.

Windguy Cable Anchorages with Standard anchorage length on soil

Wind-guy cables	1 ϕ26mm		1 ϕ32mm		1 ϕ36mm or 1 ϕ40mm		
B min B max	2.00 2.40		2.50 3.10		2.90 3.50		
L min L max	1.50 3.50		1.50 3.50		1.80 4.00		
h_T max	2.00		2.20		2.50		
For β (deg)	≤ 4.5	> 4.5	≤ 6	> 6	-3 to 0	1 to 6	7 to 12
h_T min	0.40	0.60	0.50	0.70	0.70	0.95	1.20
H_2	h_T + 0.40		h_T + 0.50		h_T + 0.8	h_T + 0.7	h_T + 0.4

Extended anchorage length on Soil

Wind-guy cables	1 ϕ26mm		1 ϕ32mm		1 ϕ36mm or 1 ϕ40mm		
B min B max	2.50 3.00		3.20 3.90		3.60 4.30		
L min L max	1.50 3.50		1.50 3.50		1.80 4.00		
h_T max	2.50		2.80		3.00		
For β (deg)	≤ 4.5	> 4.5	≤ 6	> 6	-3 to 0	1 to 6	7 to 12
h_T min	0.40	0.70	0.60	0.80	0.70	1.00	1.35
H_2	h_T + 0.40		h_T + 0.50		h_T + 0.9	h_T + 0.65	h_T + 0.4

Standard anchorage length on Rock

Wind-guy cables	1 ϕ26mm		1 ϕ32mm		1 ϕ36mm or 1 ϕ40mm		
B min B max	1.70 2.40		2.50 3.10		2.60 3.50		
L min L max	1.20 3.00		1.50 3.50		1.60 4.00		
h_T max	2.00		2.20		2.50		
For β (deg)	≤ 4.5	> 4.5	≤ 6	> 6	-3 to 0	1 to 6	7 to 12
h_T min	0.40	0.60	0.50	0.70	0.70	0.95	1.20
H_2	h_T + 0.40		h_T + 0.50		h_T + 0.8	h_T + 0.7	h_T + 0.4
s	0.75		0.75		0.75		

4.13.1.8 Drawings

The Bridge Standard Drawings represent the centerpiece of the Standard Design. They are composed as a unit component system and are categorized in two categories:

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

Standard Drawings are presented in the Volume C: Drawings, Reference-4, LSTB Manual.

4.13.2 LSTB Standard Suspension Bridge

Follow the Flow Chart for Design as presented in the next page.

4.13.2.1 Design Procedure

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

Draw the bridge profile and contour plan from the survey data,

Fix the position of the Walkway / Tower foundations and the span,

Select Standard Towers

Design Main cables and Spanning cables from,

Design Main Anchorage Foundations,

Design Walkway / Tower foundations

Design stabilizing cables

Design Windguy Arrangement

Design Windguy Anchorage foundations.

Transfer data to the bridge profile and prepare the General Arrangement Drawing,

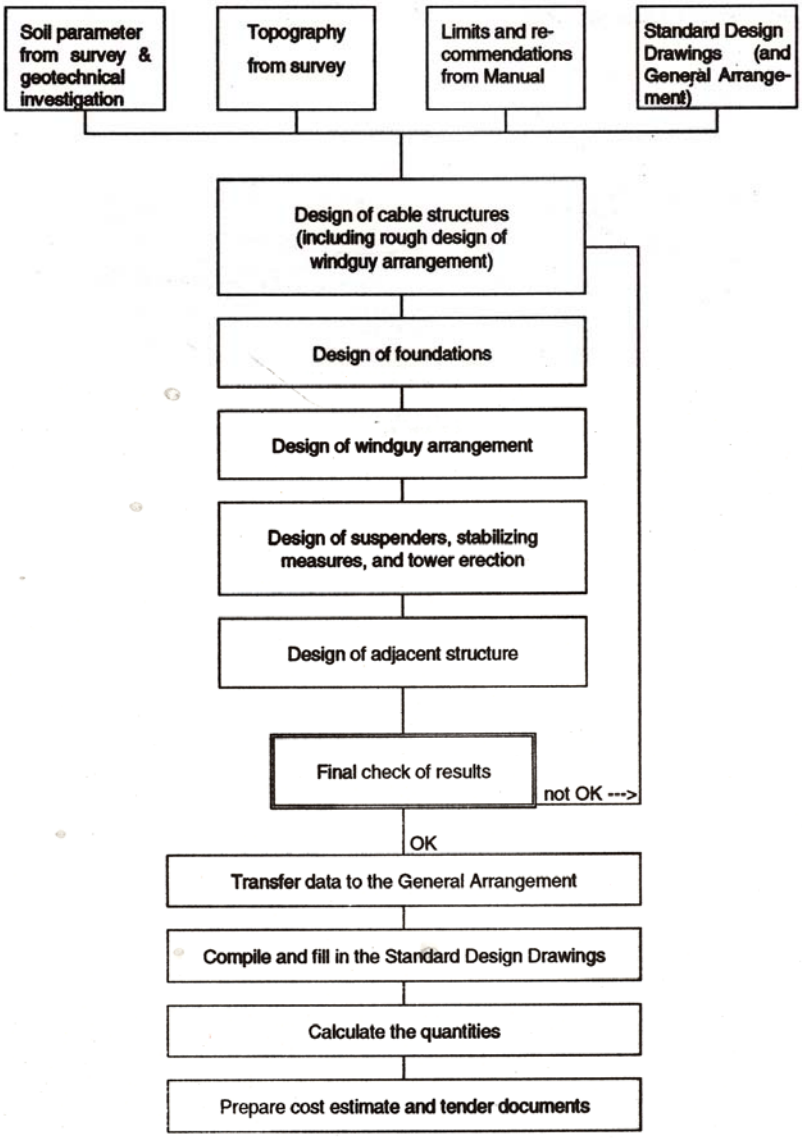
Compile and fill in the standard design drawings,

Calculate the quantities of works and prepare the Cost Estimate.

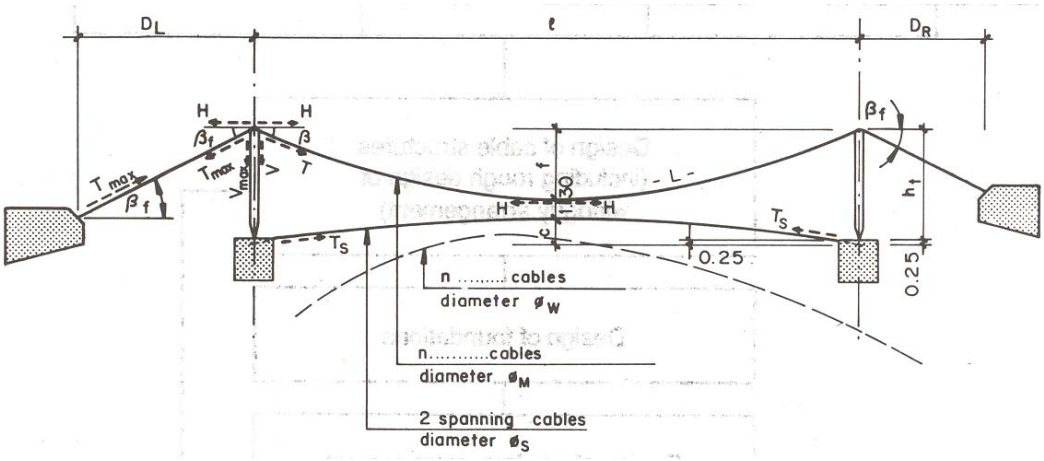
4.13.2.2 Design Procedure for Fixing the Bridge Foundations

Procedure is same as for SSTB Standard as explained in the chapter 4.12.3.

Flowchart for LSTB Suspension Type Bridge Design



Layout of the Suspension Type LSTB Bridge



The design work consists of the following:

- Cable structure
- Selection of Tower
- Walkway and Tower Anchorages
- Main Cable Anchorages
- Stabilizing Cables
- Windguy Arrangement
- Windguy Anchorage Foundations.

4.13.2.3 Design of Cable Structure and Tower Selection

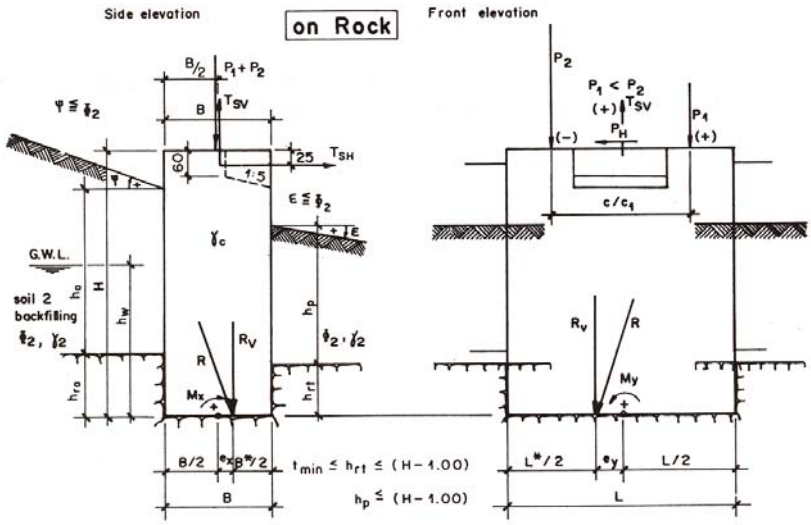
Design of Cable structures and Tower selection is done in different combinations. Standard Towers and Cable structures are selected to result optimum design. Refer Chapter 4.4.

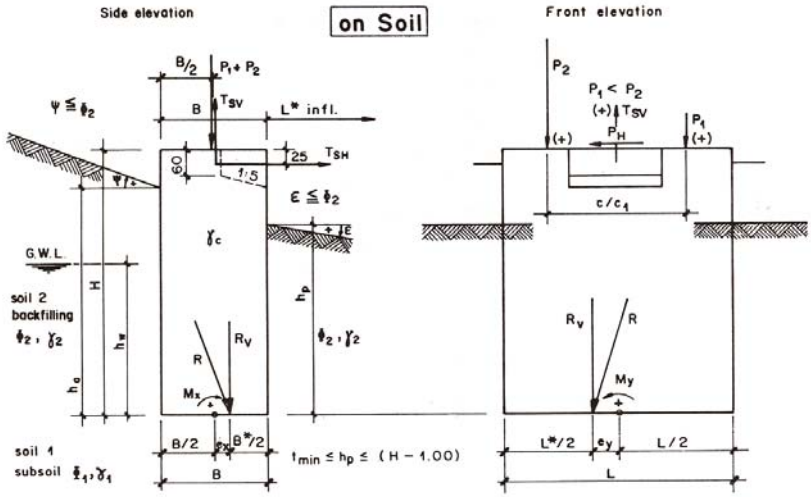
4.13.2.4 Design of Walkway Foundations

Design the main anchorage foundation as per statical analysis as described in Chapter 4.7 and 4.9.

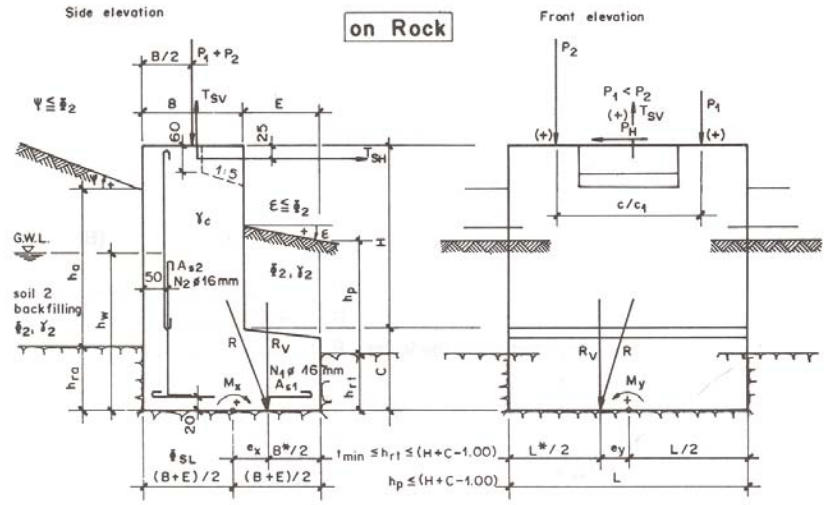
The typical designs of the walkway foundations are of two types:

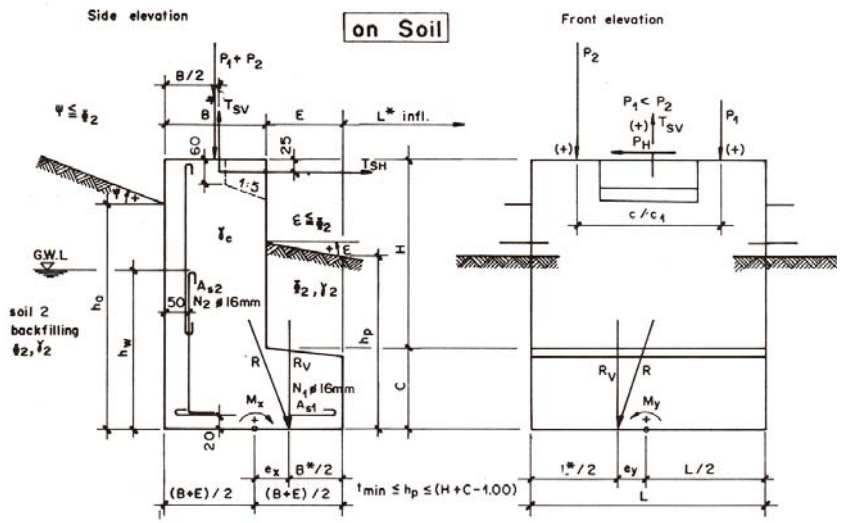
- **Without Foot**





- **With Foot**





There is a range of sizes as per the C/C_1 and C/C_2 (Tower Leg distance and Hold down bolt distance of tower leg). The range of sizes is to fit the standard anchor parts inside the foundation. Designer should choose the optimum size within the given range as per maximum forces for different loading conditions on the foundation blocks, soil/rock parameters and topography.

Walkway and Tower Foundation
Foundation with foot

c/c1	3.50	3.50	4.00	4.00
c/c2	383	488	550	566
B	2.20	2.90	2.90	3.10
L min L max	5.50 8.50		6.00 9.00	
(H+C) min (H+C) max	2.40 9.00	2.40 10.00		
C min	1.00	1.20		
E min	0.75	1.00		

Foundation without foot

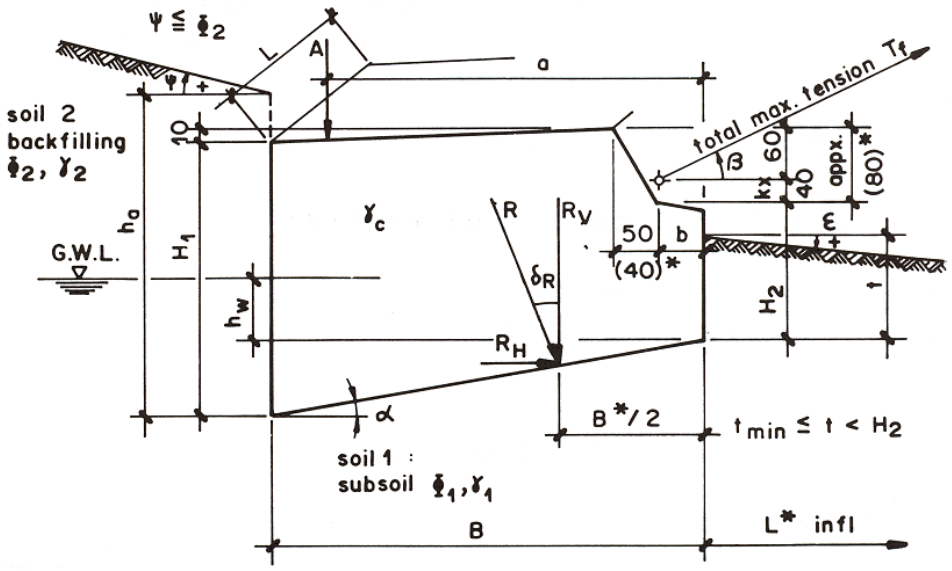
c/c1	3.50	3.50	4.00	4.00
c/c2	383	488	550	566
B min B max	2.20 4.50	2.90 5.00		3.10 5.00
L min L max	5.50 8.50		6.00 9.00	
H min H max	2.40 9.00	2.40 10.00		

4.13.2.5 Design of Main Cable Foundation

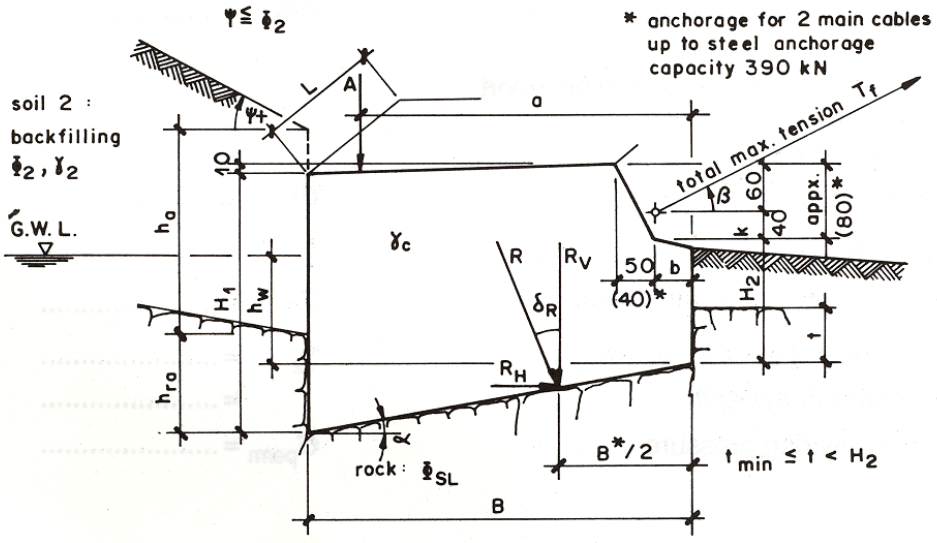
Design the main anchorage foundation as per statical analysis as described in Chapter 4.9.

The typical designs of the Main Cable foundations are of two types:

- **Foundation on Soil**



- **Foundation on Rock**



There is a range of sizes as per the C/C_1 and number of the main cables. The range of sizes is to fit the standard anchor parts inside the foundation. Designer should choose the optimum size within the given range as per maximum tension on the foundation blocks, soil/rock parameters and topography.

Main Anchorage on Soil/Rock

No. of main cables	2 cables	2 cables	4 cables	4 cables	6 cables	8 cables
c/c1 (m)	3.5	3.5	3.5	4.00	4.00	4.00
Max. steel anchorage capacity (kN)	390	610	1220	1220	1830	2440
B min B max	3.80 4.40	4.40 5.00	4.90 5.50	4.90 5.50	5.40 6.00	5.90 6.50
L min L max	4.90 6.90	5.10 7.10	5.90 7.90	6.40 8.40	7.10 9.10	7.90 9.90
H1 min H1 max	2.50 4.50	3.10 5.20	3.30 5.50	3.30 5.50	3.50 6.00	3.70 6.50
H2 min H2 max	1.20 3.80	1.40 4.20	1.50 4.50	1.50 4.50	1.60 5.00	1.60 5.50
B	0	0	0.50	0.50	1.00	1.00

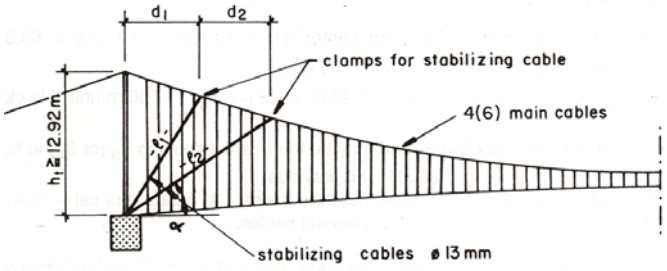
4.13.2.6 Determination of Suspender Length

Calculate the Suspender Lengths as per Chapter 4.8.2

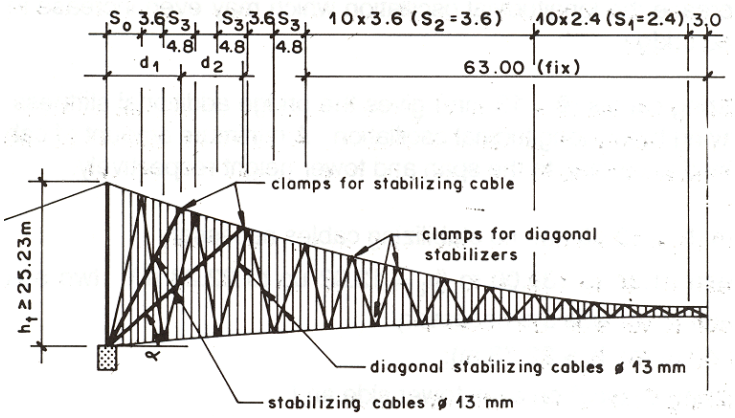
4.13.2.7 Design of Stabilizing Measures

There are following types of the Stabilizing Measures:

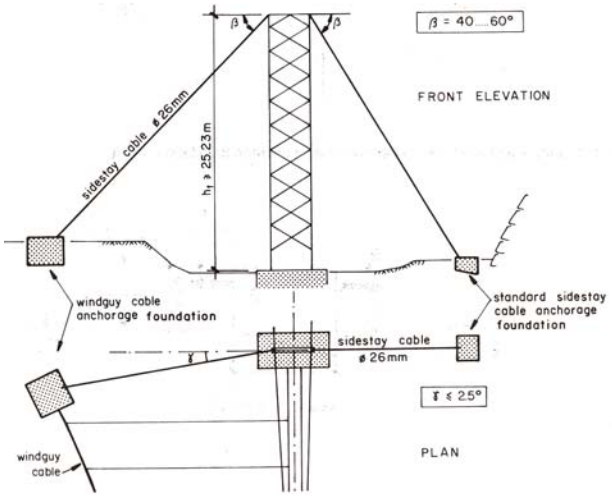
- Stabilizing Cables for bridge span >120.0m and up to 142.0m



- Diagonal Stabilizers for bridge span >142.0m



- Lateral Stabilization of the Tower for tower height >25.23m



The type of stabilizing measures depends upon the span of the bridge. Design respective stabilizing measures as per Chapter 8.9: Design of Stabilizing Measures, Reference – 4: LSTB Manual, Volume A: Design.

4.13.2.8 Design of Windguy Arrangement

Calculate the Windguy Arrangement as per Chapter 4.6.2.

4.13.2.9 Design of Windguy Anchorage Foundation

The design is identical to that for Suspended type bridge as per chapter 4.13.1.7.

4.14 DRAWINGS

The Bridge Standard Drawings represent the centerpiece of the Standard Bridge Design. They are composed as a unit component system and are categorized in two categories:

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

Standard Drawings are presented in the Volume C: Drawings, Reference-4, LSTB Manual.

4.15 COST ESTIMATE

4.15.1 Existing Practices

There are two approaches to the construction of SSTB standard bridges:

- **Implementation by the Community**

SSTB standard, both suspended and suspension type, is in general implemented through the community.

The responsibility of construction and management goes to the Users' Committee. The local people take the lead role during every stage of construction. It does not mean that the local people do the work only as volunteers, free of cost. Local participation in the construction work is calculated in the cost.

Form No. 3 (SSTB Manual), Volume 2 is used for estimating the bridge cost in this approach.

- **Implementation by Contractor through Public Tender**

LSTB standard, both suspended and suspension type, is in general implemented by the contractor through public tender.

In this approach, the contractor takes the responsibility for transportation from the office to the site, construction and site management. Form No. 4 of SSTB Manual in case of SST bridge and Cost Estimate Form of LSTB Manual are used in this approach for calculating the cost estimate.

4.15.2 Quantity Survey and Cost Estimate

The quantity calculation in both the approaches is the same. Except for the quantity of earth work and additional protective structures, the quantities of construction materials for the foundations and other bridge elements are standardized.

The following form is used for quantity calculation:

- **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 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 the cables and other construction materials not available locally.
  - Calculate the quantities of Works and Labor (only for community approach).

- **Rate Analysis**

In the community approach, in case of construction, the labour rate does not include tax and overheads. 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.

In the contract approach, prepare a 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.

- **In the Community approach, Summary of Estimated Cost:**

Abstract of Cost

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

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.

- **In the contract approach, Summary of Estimated Cost:**

Abstract of Cost

Compute the Abstract of Cost of the bridge as per the quantities of works (from the Quantity Calculation Sheets) and the rates (from the 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.