13	Bulldog Grips MS forged ISI standard	ϕ 13	12	for fixing first & joining **Fixation Cable** ϕ 13 mm	……	1.4 D
14		ϕ ….	2	for **Handrail Cable** ϕ 26 or 32 mm	……	…D
15		ϕ ….	2	for **Walkway Cable** ϕ 26 or 32 mm	……	…D

A = ………………………… kg Total transportation Weight B+C+D+R+0.16 kg	B = ………………………… kg Total Structural Steel = (u+g)	g = 10.64 kg Steel to be galvanized
C = 0.32 kg Nuts, Bolts, Washers	D = ……… kg Bulldog Grips	R = …………kg Reinforcement Steel

fill in the ϕ of the required Bulldog Grips plus the weight from the table below

compute total weights from weight column of material list

Fill in :

Bridge Name
No, Bank &
Span

Width of Walkway

No of required foundation

HMG / Ministry of Local Development
DoLIDAR / Short SpanTrail Bridge Standard

Bridge Name:

No: Bank: Span:

Steel Drawing:

Saddles & Reinforcement for RCC Deadman & Gravity Soil Anchor for 2 Walkway Cables

Walkway Width : ....cm

Set for one Foundation

1 or 2 ....

Date : Sept 20, 2001 **Drawing No. 20D2**

Cable ϕ mm	Bulldog Grips for two cables	Weight (kg/pc)	Weight Total kg
26	10	1.10	11.00
32	12	1.30	15.60

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 steel including galvanization to be transported to the site.
B : This is the total structural steel raw or untreated. This includes steel profiles, plates and flats but not reinforcement bars and other steel items.
C : This is the weight of Nuts, Bolts & Washers. (galvanized weight)
D : This is the weight of Bulldog Grips or Thimbles, if required. (galvanized weight)
R : This is the raw weight of Reinforcement Steel or Plain Rods they are never galvanized.

The total transportation weight A = B + C + D + R

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

Above distinction is made for quotation purposes, because the price per kg (or piece) is varying greatly among each other. Reinforcement steel is much cheaper and Nuts & Bolts are much more expensive than structural steel.

The weight of steel to be galvanized is necessary, to obtain the price for galvanization **separately,** without the cost of the steel as such.

Usually steel drawings are 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 of which one complete set is absolutely necessary at the site. Depending on the required width of the walkway the corresponding “Walkway Fitting” & “CSM Tower” drawings have to be selected (either 70 cm or 106 cm).

- **Walkway Fitting Drawing**
  (for 70 or 106 cm walkway)
- **Details of CSM Tower & RCC Core**
  (for 70 or 106 cm walkway)

The CSM Tower & RCC Core, drawing no. 20Dcon70 or 20Dcon106, are identical for all bridges.

For the actual anchorage arrangements there are two main categories of drawings:

- **Soil Anchor Drawings**
- **Rock Anchor Drawings**

Both drawing types are complete designs and are fulfilling respective parameters selected in the design form. Also in both drawings the necessary quantities of construction materials are already calculated. These have to be filled in respective tables given in the cost estimate Form No. 3 or 4.

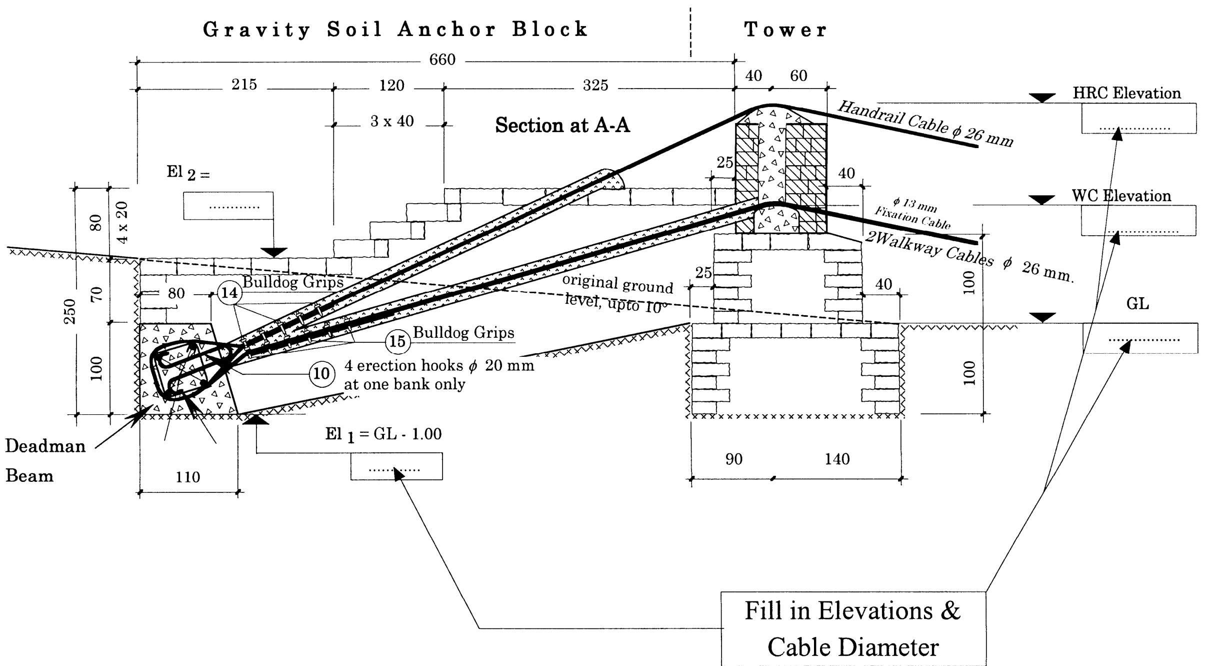
The Soil Anchor Drawings are sub-divided in to:

- Soil Anchor Block in Flat Ground
- Soil Anchor Block in Hill Slope

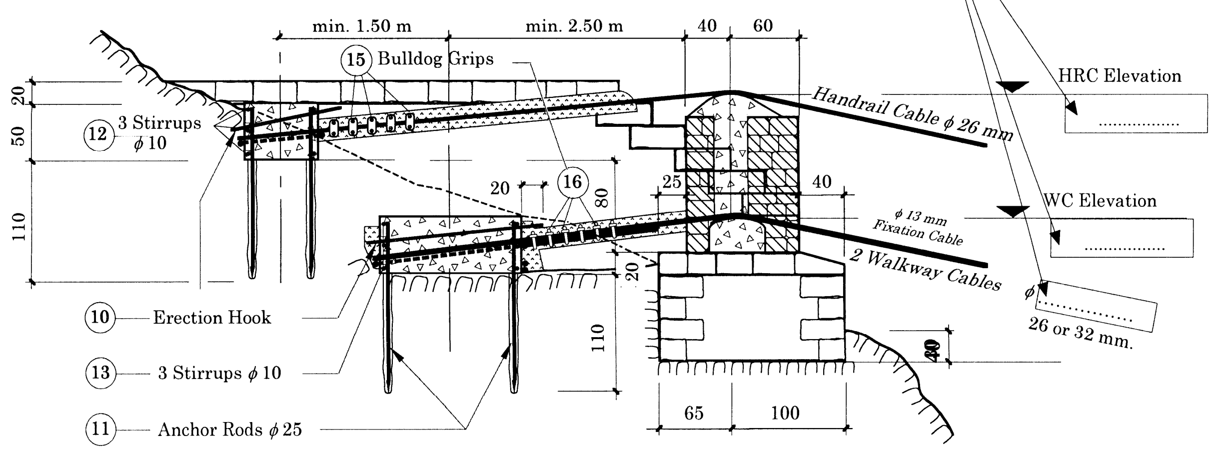
In flat ground with a gradient of max 10^o the block types 1F – 15F are applicable, whereas in slopes over 10^o the block types 1S – 9S are to be applied.

It is absolutely necessary to fill in the Elevation 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.

Example : Soil Anchor



Example : Rock Anchor



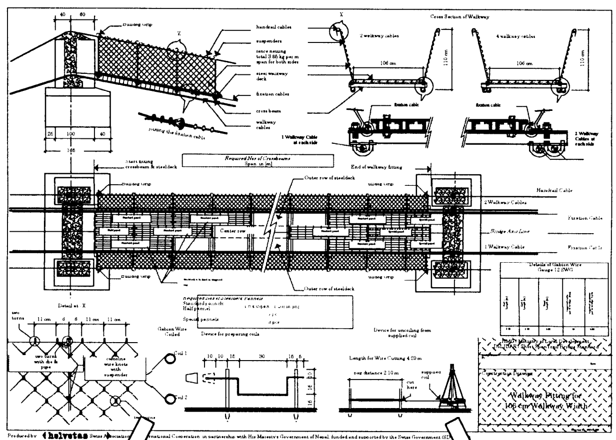
4.11.8.3 Relationship Between Construction and Steel Drawings

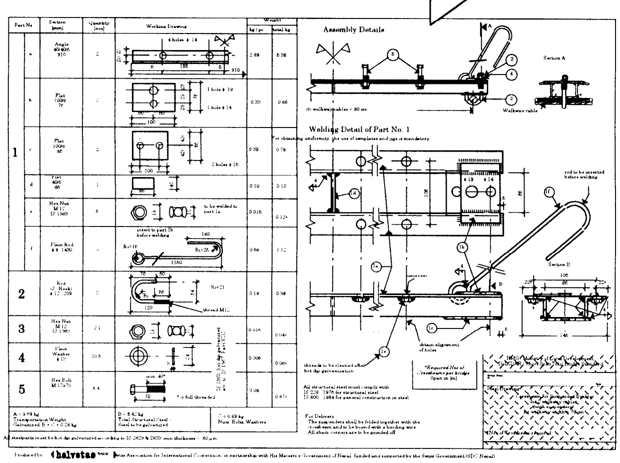
Each Construction Drawing has related Steel Drawings. Respective related drawing numbers are mentioned on the drawing itself and also respective steel parts numbers are shown on the construction drawing for easy reference.

The Construction Drawing "Walkway Fitting", Nos **19Dcon70** or **19Dcon106** is showing the superstructure of the bridge. The related Steel drawings are the corresponding Steel Crossbeam and Steel deck Drawings.

Construction Drawing No 19

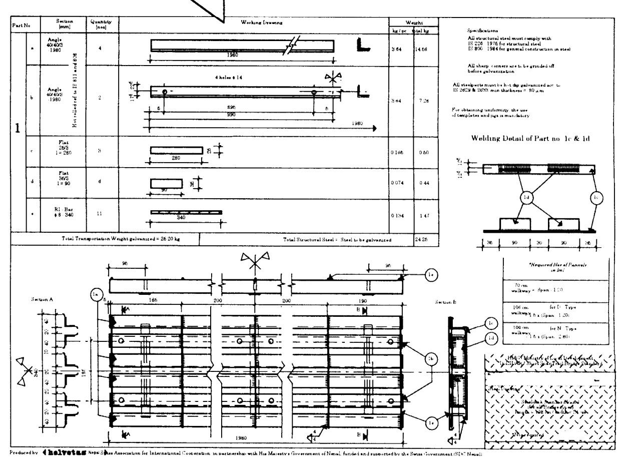
"Walkway Fitting"





Steel Drawing Nos 01 - 03

"Crossbeam"



Steel Drawing Nos 08 - 10

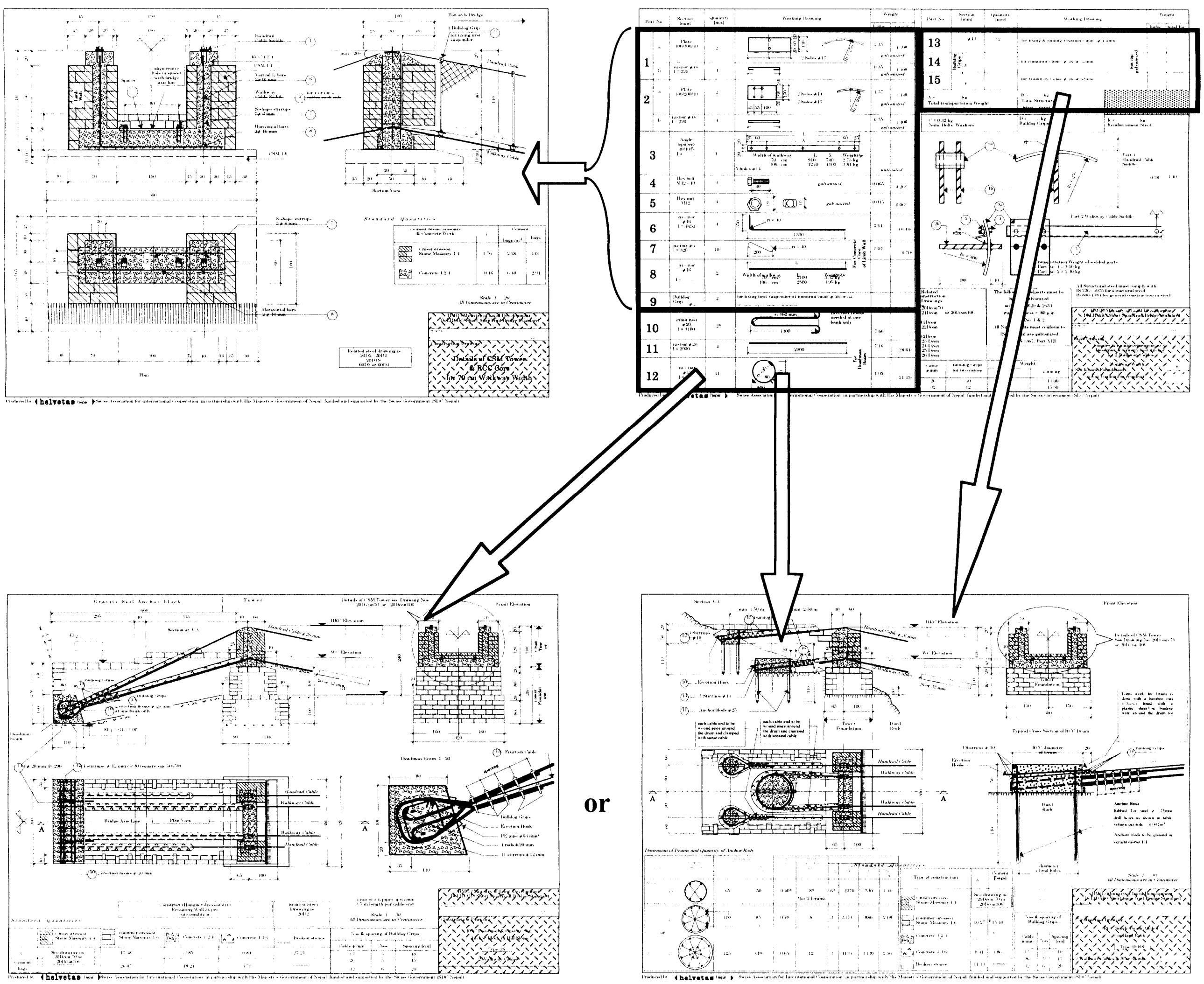
"Steeldeck"

The Steel Drawings for Saddle and Reinforcement, Nos 20 & 60 are related to the corresponding Construction Drawings Nos *20Dcon70* (70 cm walkway), or *20Dcon106* (106 cm walkway).

Furthermore, depending of the soil conditions (soil or rock), the Steel Drawing Nos *20 & 60* are related either to Anchor Drawings "Soil" or "Rock" as shown below.

Construction Drawing No 20
"Details of CSM Tower & RCC Core"

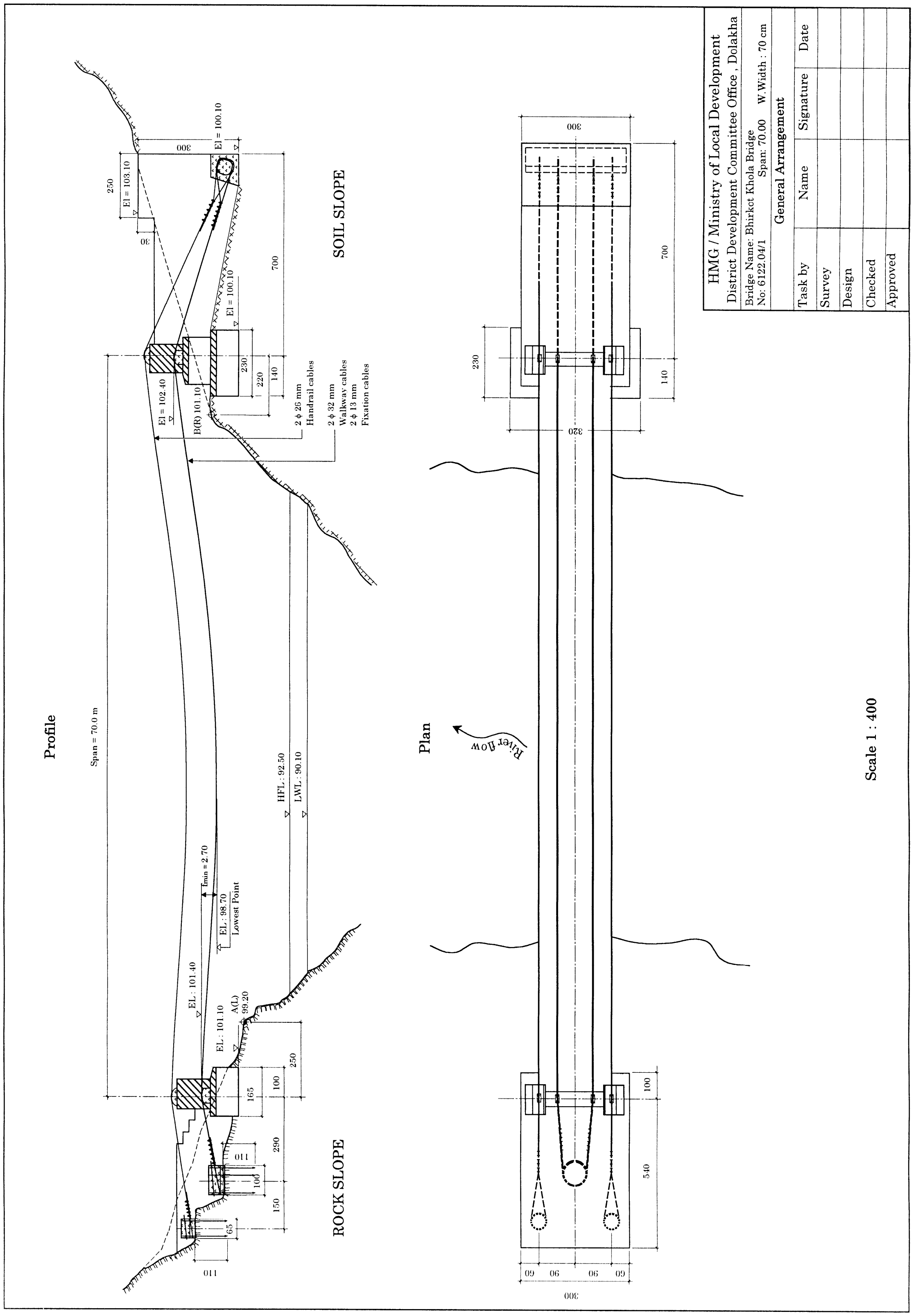
Steel Drawing Nos 20 or 60
"Saddles and Reinforcement"



Construction Drawings Nos 21 - 49
"SOIL ANCHORS"

Construction Drawing Nos 61 - 67
"ROCK ANCHORS"

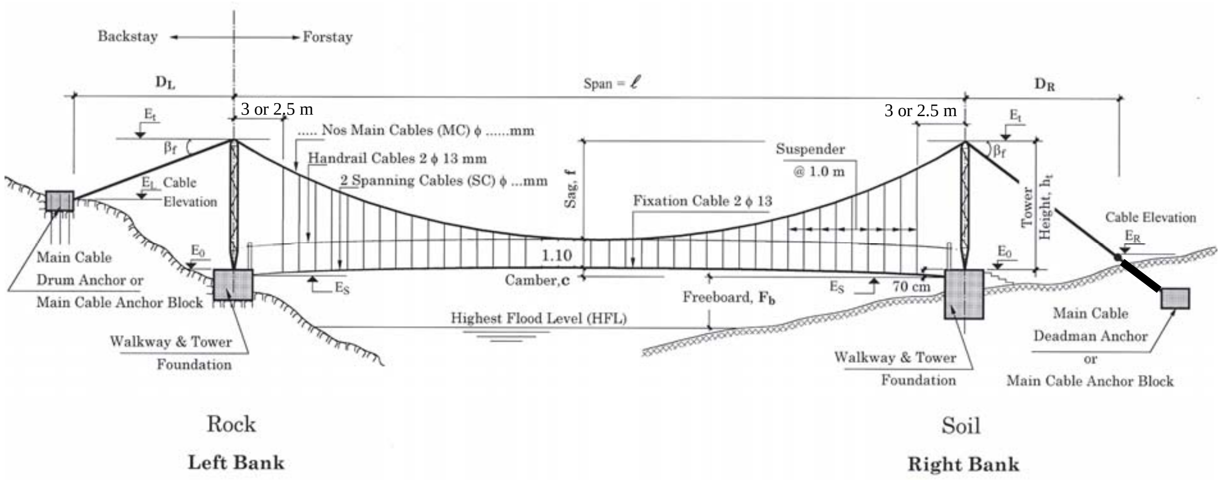
4.11.9 General Arrangement and Design Example



4.12 DESIGN OF SHORT SPAN TRAIL BRIDGE (SSTB) SUSPENSION TYPE

4.12.1 The Major Components of the Suspension Type Bridge

The sketch below shows the major bridge components and parameters.



4.12.2 Design Procedure

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

- Draw the bridge profile from the survey data
- 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 (Refer Chapter 4.10.2).

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.

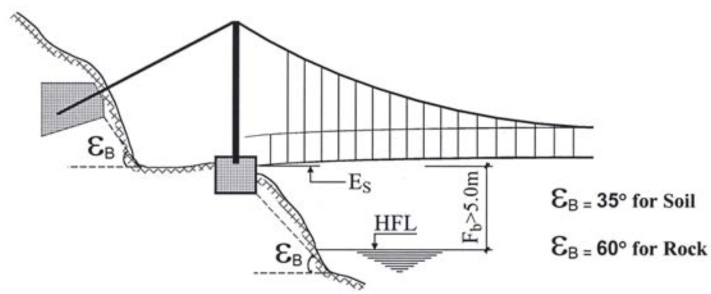
4.12.3 Designing the Position of the Walkway & Tower Foundations

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 **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 3.2.6.
- Fix the position of the walkway and the tower foundations on both the banks as per the following procedure:

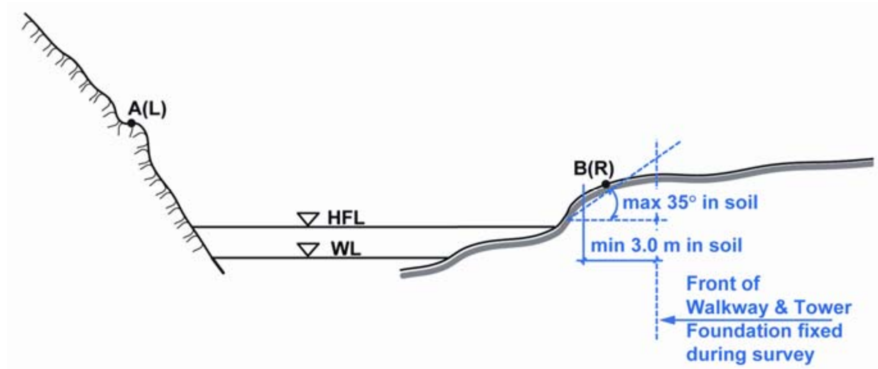
Case-1: When the Tentative Position of the Walkway and the Tower Foundations has been fixed during the Survey.

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.

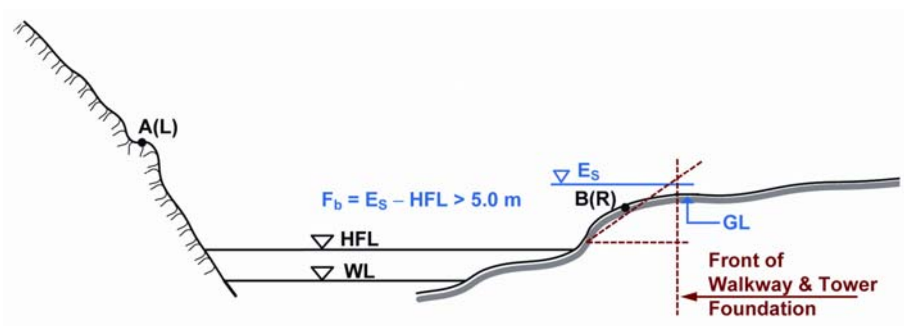
Draw the safe slope line. The front of the foundation should be behind this slope line and also sufficiently back from the bank/slope edge. If the minimum required distance from the bank/slope edge is not sufficient or out of the safe slope line, shift its position backward.

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.

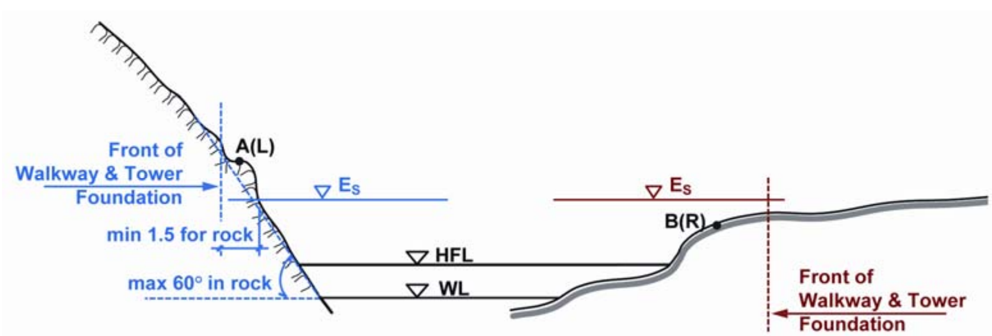
Mark the elevation line of the spanning cable anchor point (**E_s**). **E_s = G.L. + 0.55m**. Check the available freeboard **F_b**. **$F_b = E_s - HFL$**, which should not be less than 5.0m**.** If the freeboard is not enough rise the **E_s**. In case of flat topography, raise the E_s = G.L. + 1.55 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.

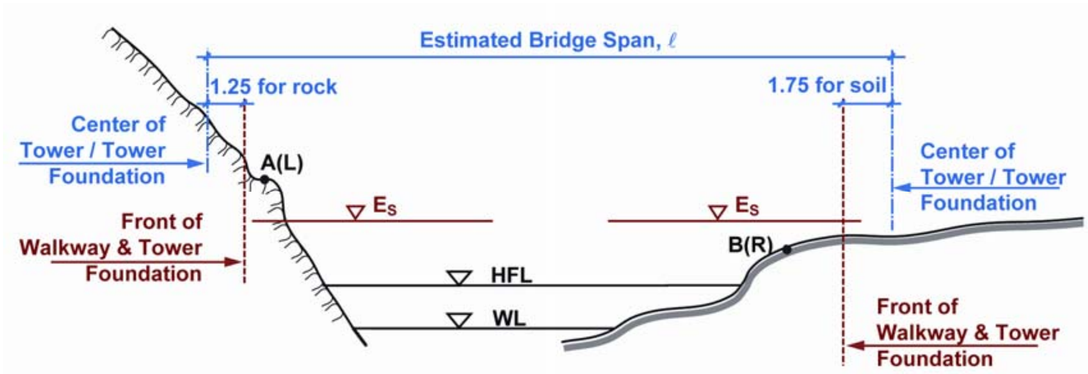
Once the elevation of the spanning cable anchor point **E_s** has been established on one bank, draw this elevation line towards the other bank.

Draw the safe slope line. Mark the front of the foundation according to the **E_s** line behind the safe slope line maintaining the minimum required distance from the bank/slope edge.



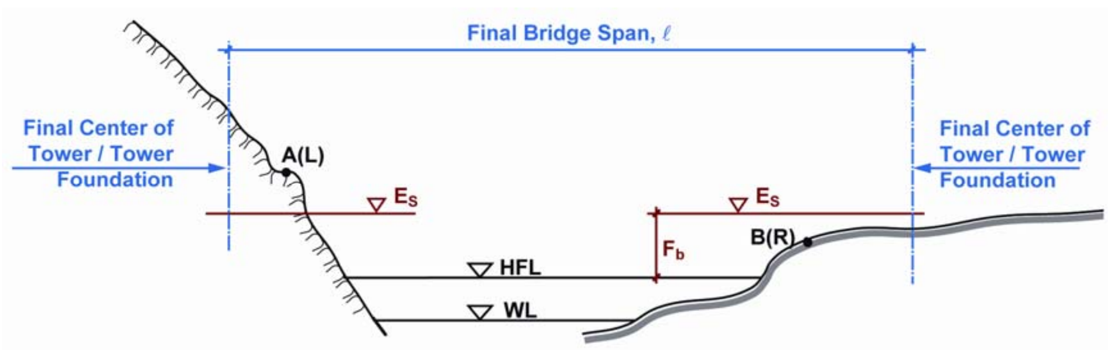
Step 4: Determine the Bridge Span, *l*.

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 **E_s**.

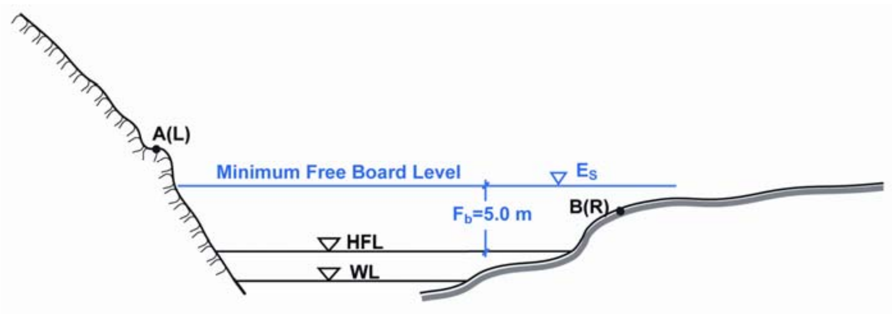


Case-2: When the Position of the Walkway and the Tower Foundations has not been fixed during the Survey.

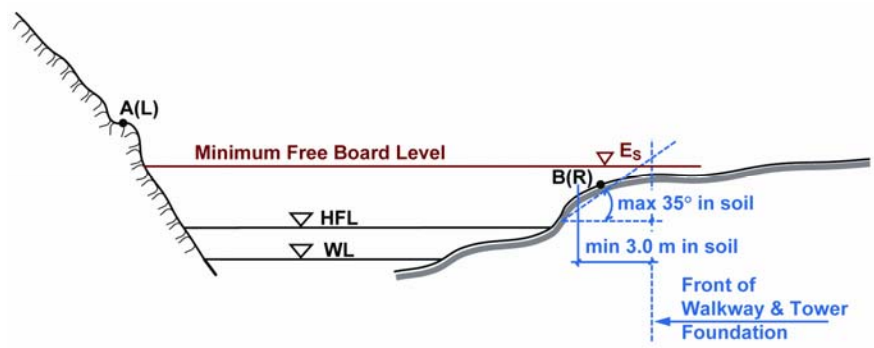
Step 1: Fix the Front of the Walkway & Tower Foundations on one bank.
Fix the position of the front of the tower on the lower bank or the bank which has a limited defined area for positioning the foundation.

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.

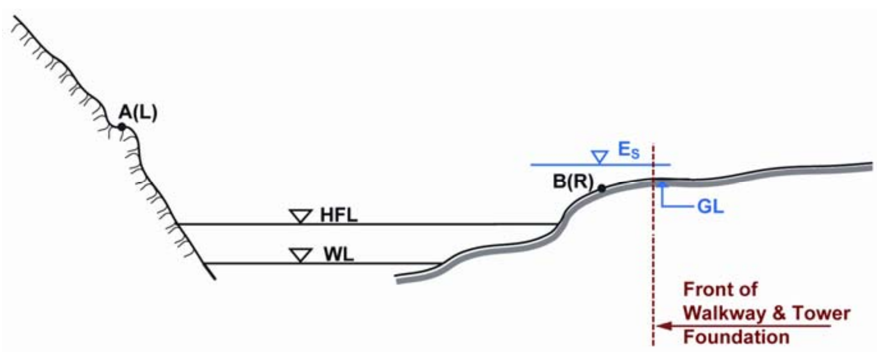
If the bank is flat and the bank height is low and prone to the flooding or excessive bank erosion, the foundation should be placed sufficiently back from the bank edge to ensure the long term safety of the bridge.



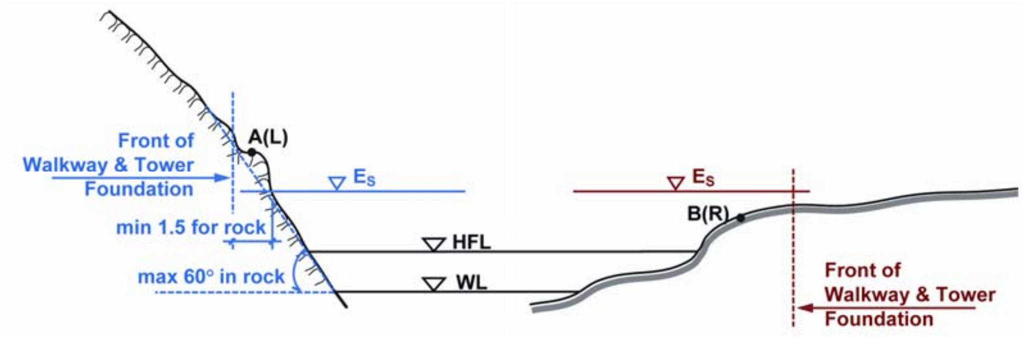
Step 2: Fix the Freeboard Level.
Mark the minimum freeboard level. The minimum freeboard from the highest flood level is 5.0 meters. The minimum freeboard level will be the lowest possible position (Elevation, $\mathbf{E_s}$) of the spanning cable anchor point.



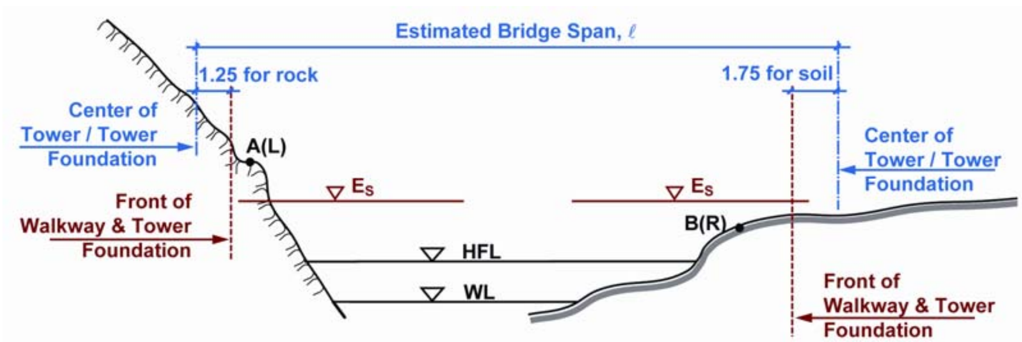
Step 3: Fix the Elevation of the Spanning Cable Anchor point.
Mark the elevation line of the spanning cable anchor point $\mathbf{E_s}$ at the minimum freeboard level. Check the height from the ground level **($\mathbf{E_s}$ - G.L.)**, which should be 0.55 or 1.55 or 2.55 or 3.55 m (max). Adjust $\mathbf{E_s}$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



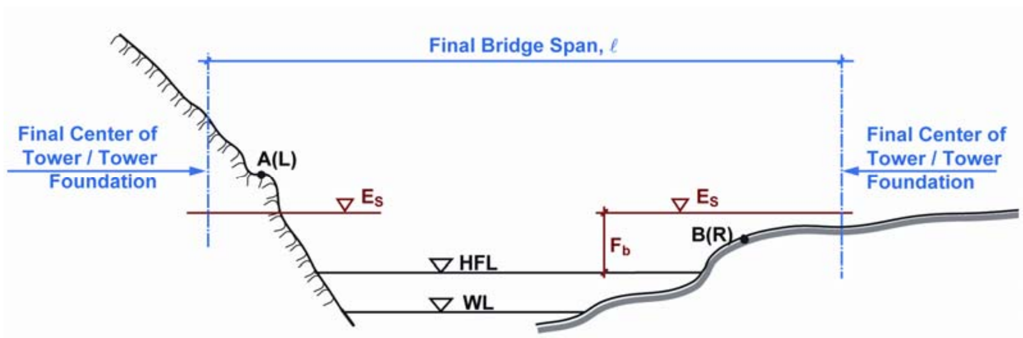
Step 4: Fix the Front of the Walkway and the Tower Foundations on the other bank.
Same as Step 3 of Case-1.



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 E_s.



4.12.4 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 4.4.

The span of an SSTB suspension bridge has to be adjusted to an integer value. The first suspender from the tower is at distances of 2.5 m for uneven spans and 3.0 m for even spans. The suspender to suspender spacing is 1.0 m. The walkway width is always 106 cm. The walkway (spanning) cable is always of ϕ26 or 32mm diameter. The main cables can be 2xϕ26mm, 4xϕ26mm, 2xϕ32mm and 4xϕ32mm. The tower heights are 5.50, 7.35, 9.20 and 11.05 m. The level difference between the vertexes of the main cable and the walkway cable at mid-span is 1.10 m.

The camber of the walkway cable in dead load geometry is in general 1.5% of the span.

The weight of the walkway system of the SSTB standard suspension bridge includes:

1.	Steel deck	37.21 kg /m
2.	Walkway beam including pipes	37.00 kg/m
3.	Wire mesh	4.05 kg/m
4.	Handrail & Fixation cables 4ϕ13mm	2.56 kg/m
5.	Suspenders (maximum)	8.30 kg/m
6.	Walkway cable 2ϕ26mm	5.02 kg/m
	Total walkway system weight	94.14 kg/m

The live load is as per these norms: for spans over 50 m, $p = \left(300 + \frac{5000}{span}\right).walkway / width.$ kg/m span and for spans up to 50 m, $p = 400$ x walkway/width kg/m span. The cable properties have already been mentioned above.

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

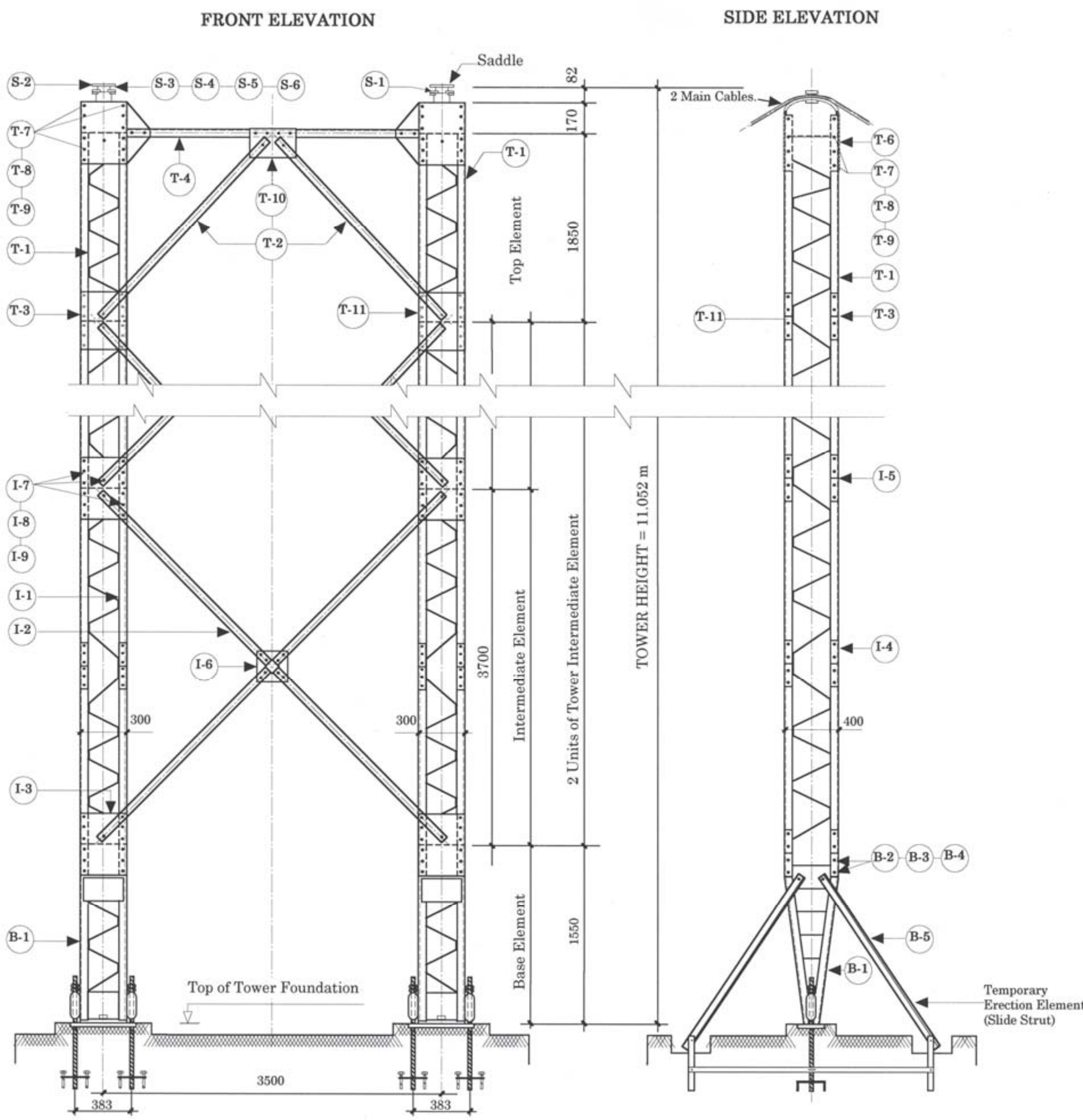
- Determine the span of the bridge from the bridge profile as per Chapter 4.12.3.
- Select the number and diameter of the Main Cables, the diameter of the Spanning Cables and the type of Standard Tower from the **Table 4.1: Selection of Cables and Standard Towers** according to the bridge span.

Tower

The tower of the SSTB standard suspension bridge is a hinged tower. Its height is divided into four elements: 1) Base element, 2) Intermediate element, 3) Top element and 4) Saddle. The center to center distance of the tower legs, c/c1 is 2.5 m or 3.5 m. The center to center distance of the holding anchor rods in one leg, c/c2 is 383 cm. The selection of the tower for the SSTB standard is done as per the table used for cable selection. The tower type is depends on the span of the bridge.

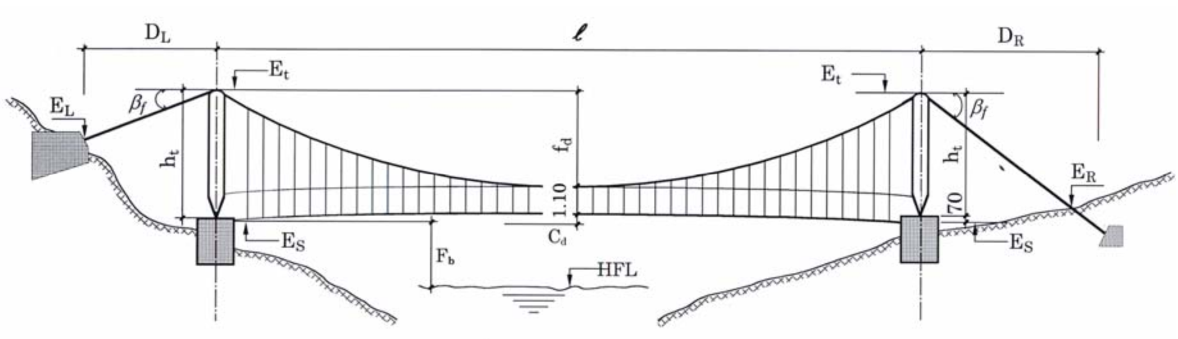
The temporary erection parts are fitted to the base element of the tower only during the erection of the tower. After the cable has been hoisted and the walkway fitting work has been completed, the cables at the saddle of the tower are clamped tight and the temporary erection parts are removed. The saddle should be greased regularly during the cable hoisting and walkway fitting period so that the cable can slide over the tower saddle without making the tower lean forward.

Typical design of the tower:



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) ℓ **=** .... m

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

3. Highest Flood Level **HF**L **=** .... m

4. **Freeboard** (min. 5.00m) **F_b** = **E_s - HFL** = **F_b** **=** $\boxed{\text{................. m}}$

(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 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 f_d, the dead load camber c_d of the spanning cable and the main cable inclination at the tower saddle $ß_f$ in the full load case.

Table 4.1: Selection of Cables and Standard Tower

Span *l* m	Tower Height/ (Type) h_t m	Cables Nos. & diameter Main mm	 Spanning mm	 Windguy mm	Dead Load Sag f_d m	Hoisting Sag f_h m	Camber c_d m	Full load Backstay Angle $ß_f$ 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 4.1: Selection of Cables and Standard Tower (continued)

Span l m	Tower Height/(Type) h_t M	Cables Nos. & diameter: Main mm	Spanning mm	Windguy mm	Dead Load Sag f_d m	Hoisting Sag f_h m	Camber c_d m	Full load Backstay Angle $ß_f$ deg.
66.0	9.20 (3)	2 ø 32	2∅ 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				∅ 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 4.1: Selection of Cables and Standard Tower (continued)

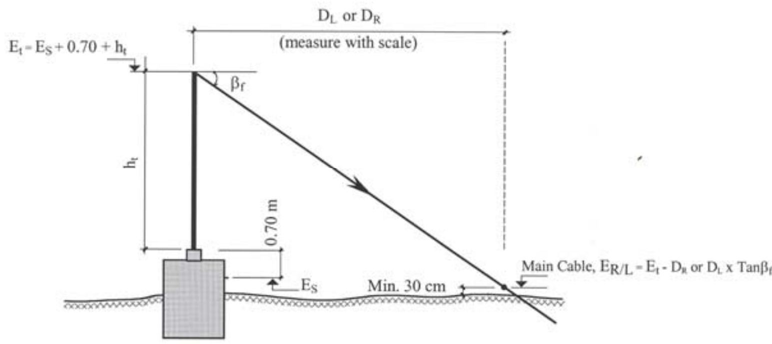
Span	Tower Height/ (Type)	Cables Nos. & diameter			Dead Load Sag	Hoisting Sag	Camber	Full load Backstay Angle
		Main	Spanning	Windguy				
l m	h_t m	mm	mm	mm	f_d m	f_h m	c_d m	$ß_f$ deg.
101.0	11.05	4 ø 32	2 ø 32	ø 26 (Optional only)	8.35	8.03	2.30	20.00
102.0					8.40	8.07	2.25	20.00
103.0					8.50	8.17	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

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

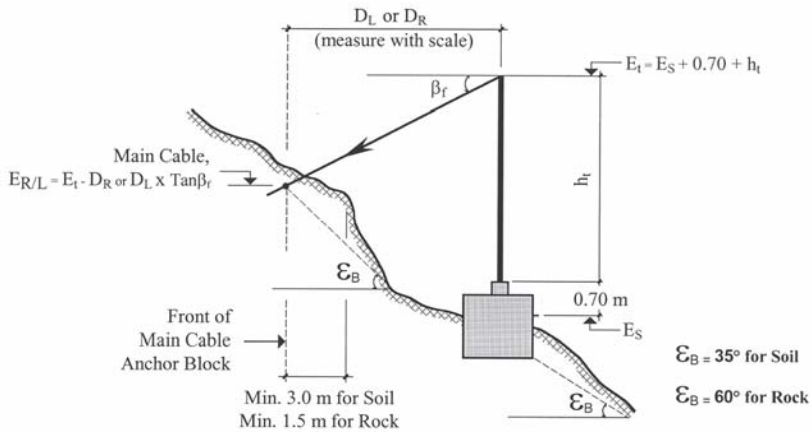
Fix the position of the Main Anchorage Foundation Blocks on both the banks in the bridge profile as per the steps below:

- 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 $\mathbf{D_L}$ or $\mathbf{D_R}$ backstay distance with a scale in the bridge profile.

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

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

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 4.5.9.A)
** Windties = Refer to Design of Windguy Arrangement (Chapter 4.5.9.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	ℓ	= ………..… m
2.	Hoisting Sag (from "**Table: Selection of Cables and Standard Tower**" 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 =	$\mathbf{h_t - f_h}$	= ……....... m

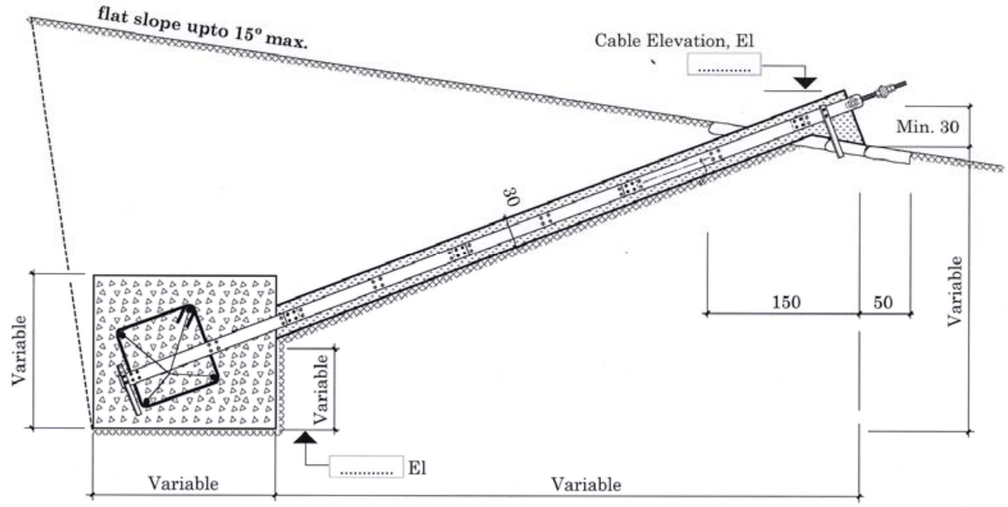
4.12.5 Design of the Main Cable Anchor

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 4.9.

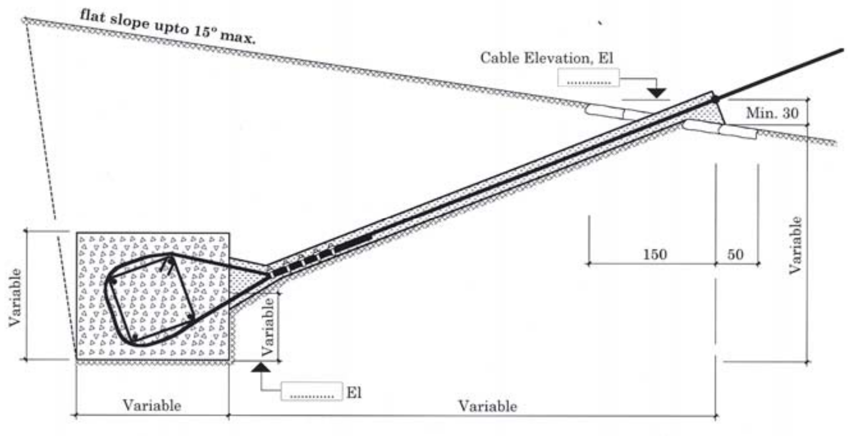
The design of the Main Cable Anchor Blocks is mainly to select the standard anchor block types suitable to the given cable combination, geology and topography of the site. Fill in the required data in the corresponding selected drawings.

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.

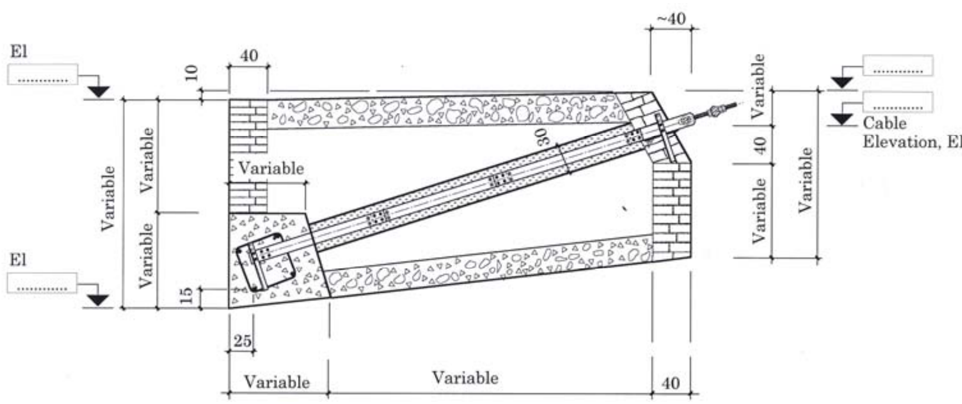
1. Main Cable Deadman Anchor Block with turn buckle on Flat Topography



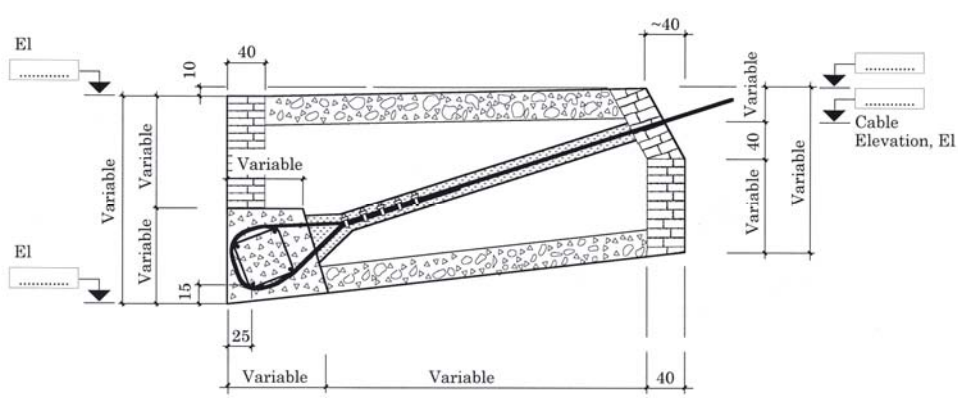
2. Main Cable Deadman Anchor Block with direct cable connection on Flat Topography



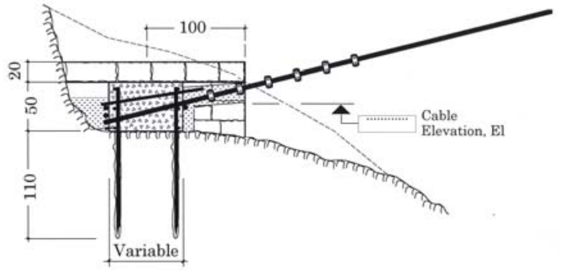
3. Main Cable Gravity Anchor Block with turn buckle on Hill Slope Topography



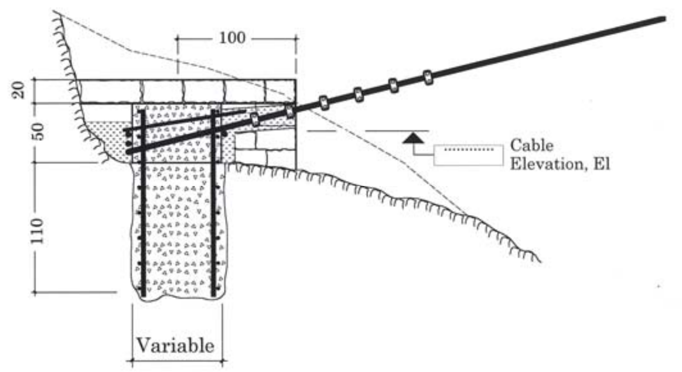
4. Main Cable Gravity Anchor Block with direct cable connection on Hill Slope Topography



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 4.12.4).
- 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.
- 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 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 5.1**
for Soil and Flat Ground	(Direct Cable Connection)	:	**Table 5.2**
for Soil and Hill Slope	(Cable Connection with Turnbuckle)	:	**Table 5.3**
for Soil and Hill Slope	(Direct Cable Connection)	:	**Table 5.4**
for Hard, Soft or Fractured Rock	(Cable Connection with Turnbuckle)	:	**Table 5.5**
for Hard Rock	(Direct Cable Connection)	:	**Table 5.6**
for Fractured Hard Rock or Soft Rock	(Direct Cable Connection)	:	**Table 5.7**

- **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 5.1: 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 5.2: 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 5.3: 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 5.4: 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 5.5: 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 5.6: 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 5.7: Selection of the Main Cable Drum Anchor in Fractured Hard Rock or Soft Rock (Direct Cable Connection)

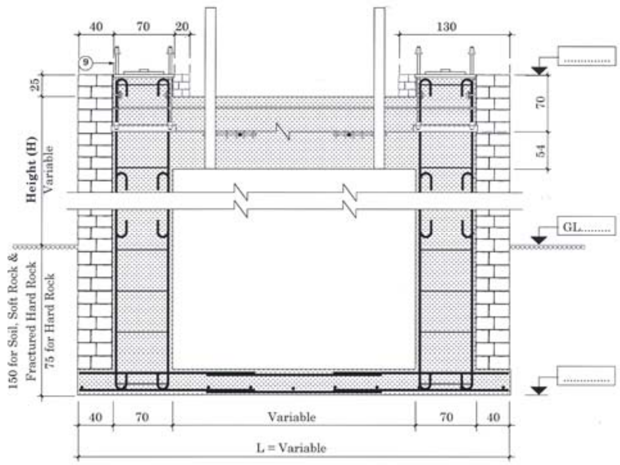
Main Cable, mm	Anchor Type	Drawing No
2x26 or 2x32	DR-3	49Ncon
4x26 or 4x32	DR-4	50Ncon

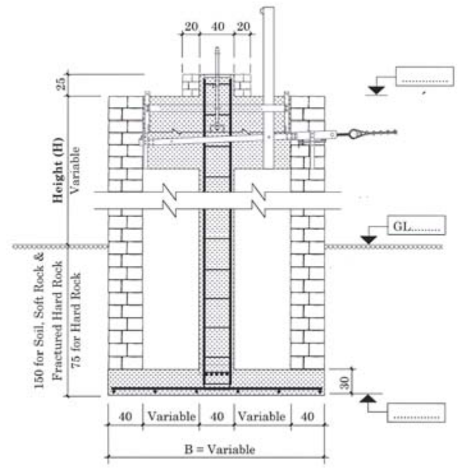
4.12.6 Walkway and Tower Foundation Design

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 4.7 & 4.9 and general design concept of reinforced concrete structures.

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 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 & 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 6.1**
  In Hard Rock : **Table 6.2**
  In Fractured Hard Rock or Soft Rock : **Table 6.3**

- 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 6.1: **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 6.2: 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 6.3: 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

4.12.7 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 4.8. 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 SSTB Suspension Type Manual.

The calculation is based on the fixed geometry of the bridge as per the **table 4.1: Selection of Cables and Standard Towers in** Chapter 4.12.4. 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.

4.12.8 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

4.12.8.1 Windguy Arrangement (Optional)

The design maximum wind speed is calculated as 160km/h for Nepal (see also Chapter 4.1.1. 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.

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.

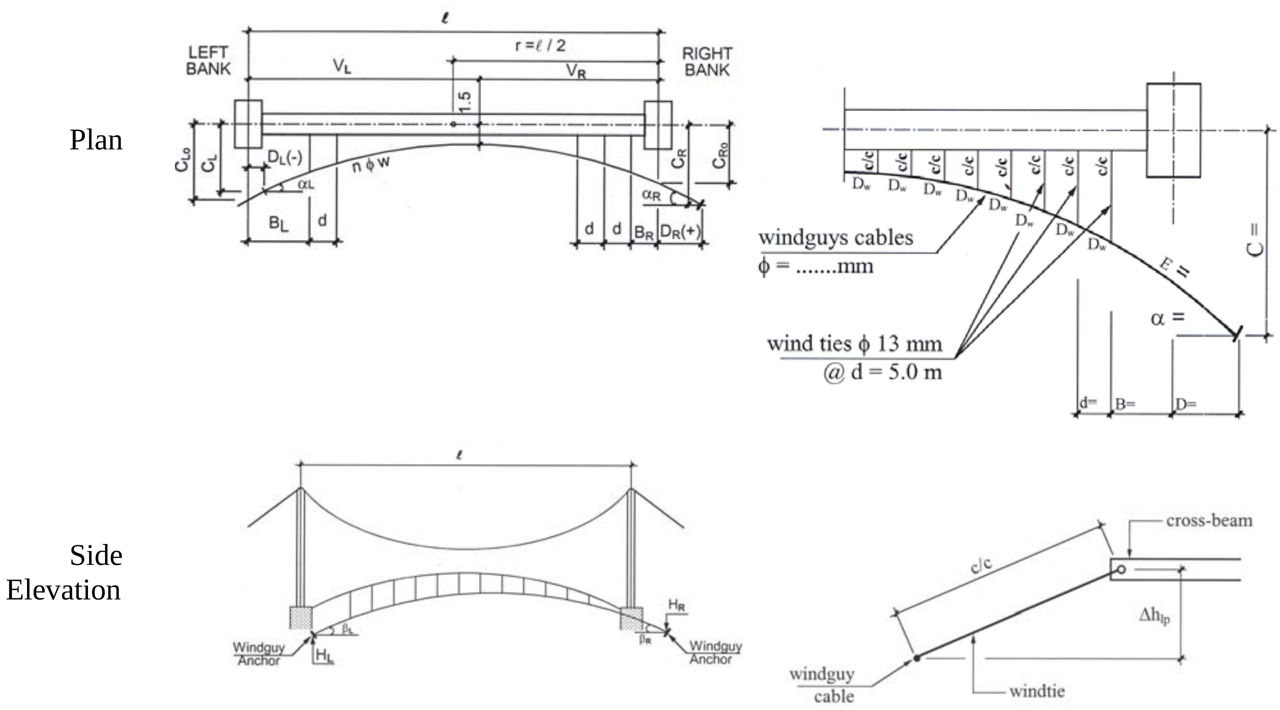
A. Design of Windguy Arrangement

For detailed design calculations of the Windguy Arrangement, refer to chapter 4.6.2.

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 4.12.4.

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

⇒ **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 Δh_{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 α_L (or α_R).
- Draw a straight line with the given $\mathbf{C_{Lo}}$ (or $\mathbf{C_{Ro}}$), and horizontal angle α_L (or α_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).

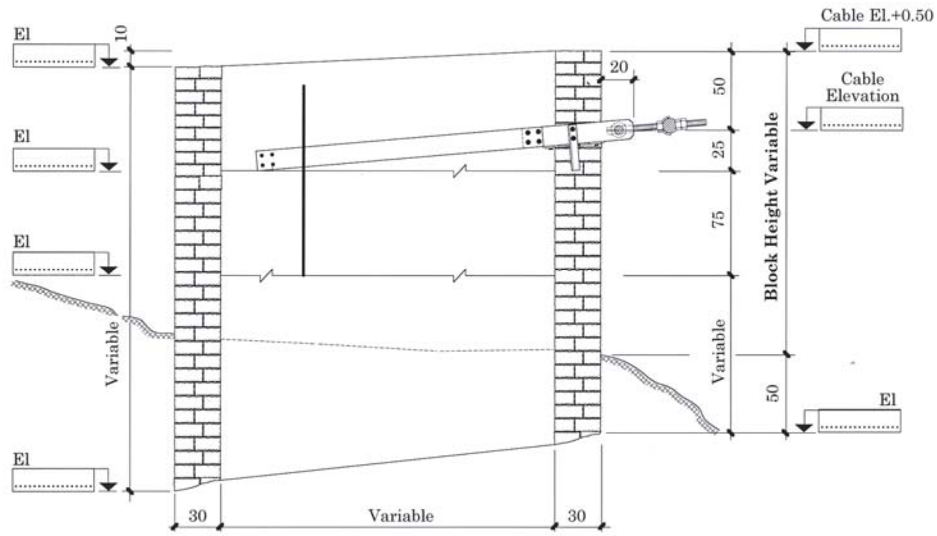
- Calculate the Windguy Arrangement for both upstream and downstream.

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

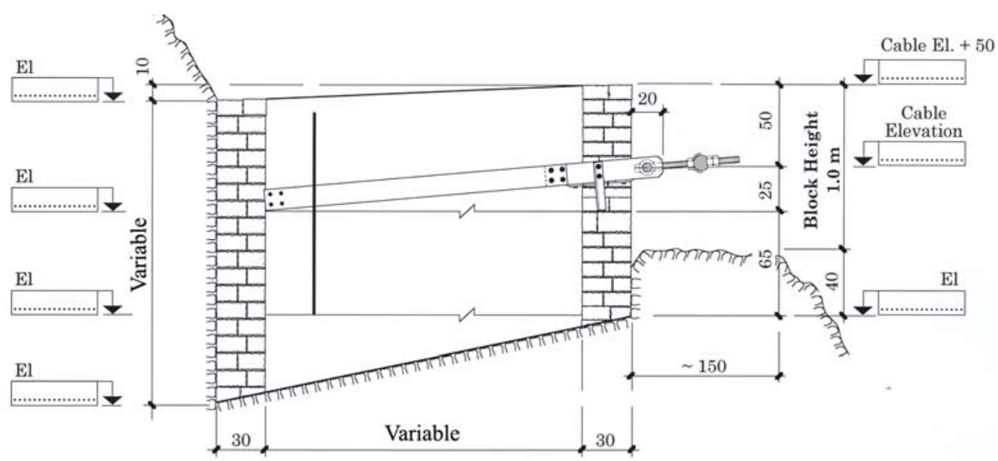
B. Windguy Anchorage Foundation Blocks Design (Optional)

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.

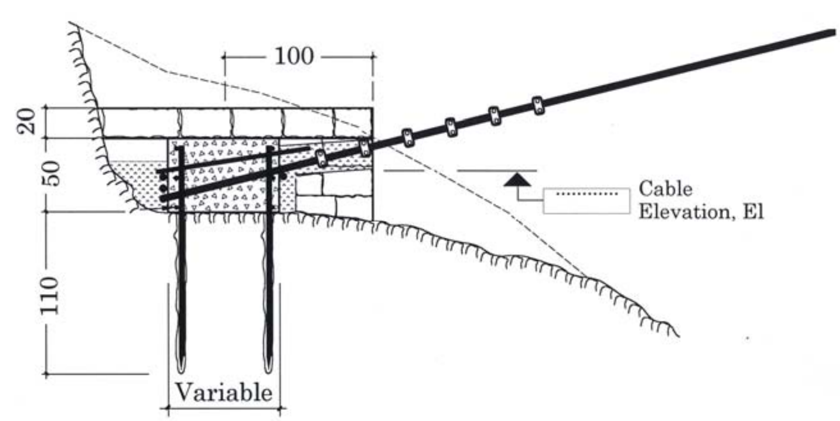
1. Gravity Anchor Block in Soil



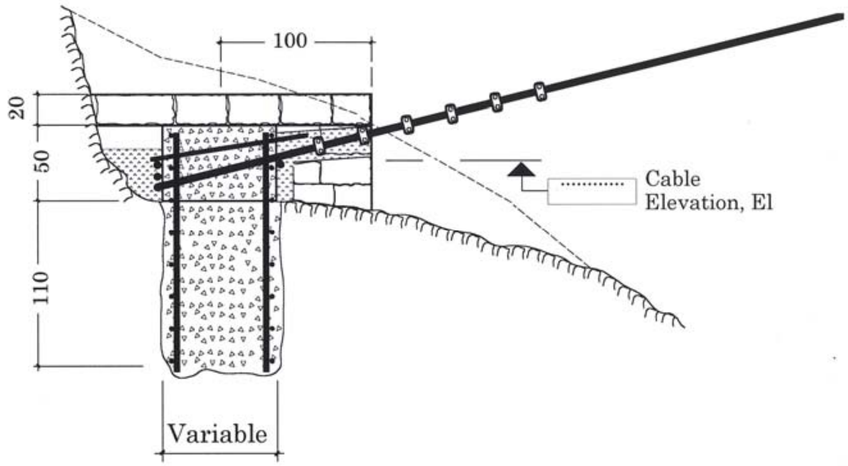
2. Gravity Anchor Block in Rock



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 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 8.1**
In all types of Rock (Anchor Block)	:	**Table 8.2**
In Hard Rock (Drum Anchor)	:	**Table 8.3**
In Fractured Hard Rock or Soft Rock (Drum Anchor)	:	**Table 8.4**

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 8.1: 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 8.2: 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 8.3: 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 8.4: Selection of Windguy Cable Drum Anchor in Fractured or Soft Rock

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

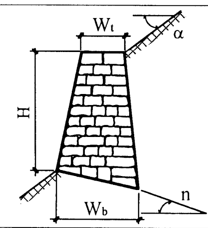
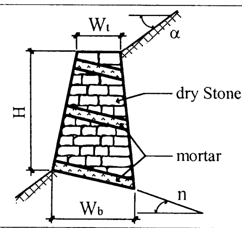
4.12.8.2 Retaining structures

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.

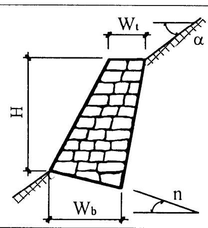
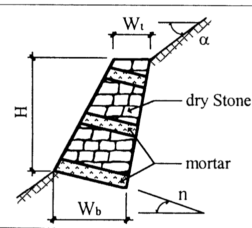
Retaining walls are used when the earth to be retained is loose soil with a great protection height. For the design of the retaining wall, use the following table.

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

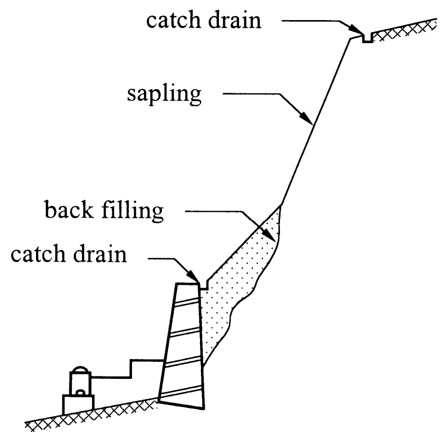
Type	Dry Stone			Banded Dry Stone / Masonry
Section				
Top width, W_t	0.50 m			0.50 m
Base width, W_b	0.29H	0.3H	0.33H	> 0.5H
Back batter	3 : 1	4 : 1	5 : 1	3 : 1
Inward dip of foundation, n	1 : 3	1 : 4	1 : 5	1 : 3
Foundation depth	≥ 0.50 m	≥ 0.50 m	≥ 0.50 m	≥ 0.50 m
Range of height, H	< 6 m	< 4 m	<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

4.12.8.3 Slope Protection Measures

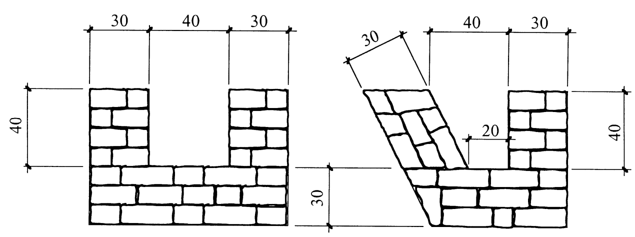
Slope protection measures depend on the factors influencing slope instability. It is recommended that a bridge site be selected, where there are no slope instability features (refer to Chapter 2.3.1). However, it is often necessary to drain out the surface runoff and seepage water from the slope as a 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.

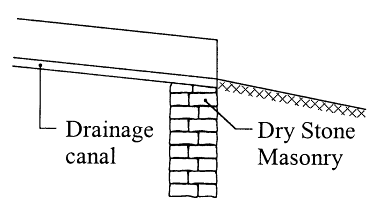
The choice depends on the position of the anchorage foundation and the profile of the natural terrain as shown in the sketch below.



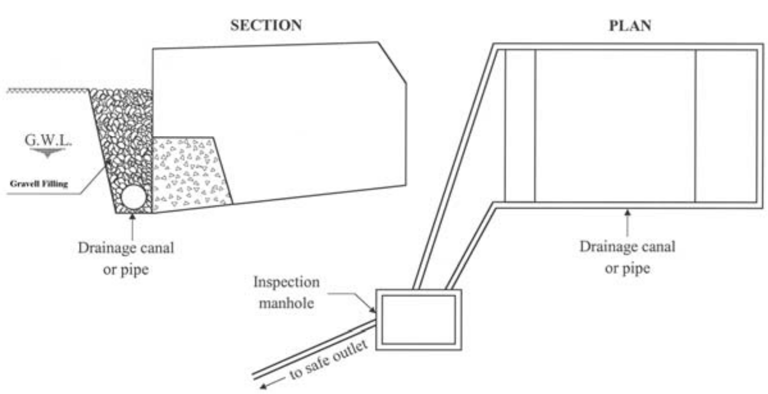
The drain should be open type. The following design shows the typical sections of the drain.



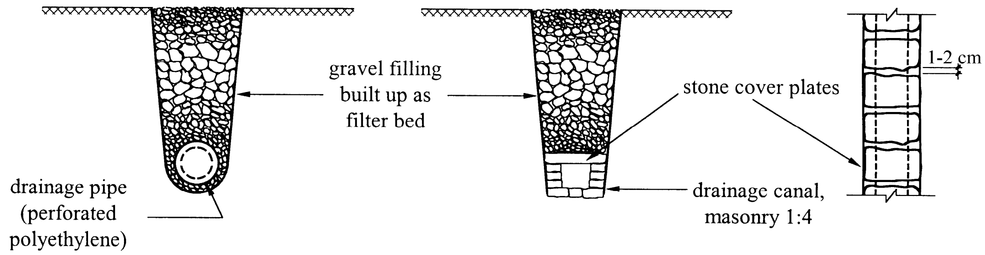
To avoid self-scouring, the drain outlet should be protected as shown in the following sketch.



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.

4.12.8.4 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 respective technical manuals.

4.12.9 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 4.12.11: Bridge Standard Drawings.

In addition, prepare a General Arrangement drawing for individual bridge designs. For this refer to Chapter 4.12.10 and 4.12.12: General Arrangement Drawing.

4.12.10 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 4.12.3, 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 $\boldsymbol{\beta_f}$
- 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 4.12.12 General Arrangement and Design Example.

4.12.11 Bridge Standard Drawings

4.12.11.1 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, SSTB Suspension Type Manual

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 07	**A** **N**	For **A**ll Bridge Types For Suspensio**n** Bridge Types
CONSTRUCTION DRAWINGS	56	N**con**	**con**struction drawings
	Anchor Types for Main Cables		
		DA 5 **AB 7** **DR 3**	**D**eadman **A**nchor Type **5** **A**nchor **B**lock Type **7** **D**rum **R**ock Type **3**
	Anchor Types for Windguy Cables		
		WAB 2 **WDR 1**	**W**indguy **A**nchor **B**lock Type **2** **W**indguy **D**rum **R**ock Anchor Type **1**
	Walkway and Tower Foundations		
		TF 11	**T**ower **F**oundation Type **11**

4.12.11.2 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: Nos	Main Cables: c/c_1 [m]	Main Cables: ϕ [mm]	Turnbuckle or Direct Cable Connection	Drawing No.
SOIL	FLAT GROUND	All Soil Types: Gravelly, Sandy or Silty	DEADMAN ANCHORS "DA" TYPES	2	2.50	26	With Turnbuckle Direct Cable Connection	42/1Ncon 42/2Ncon
						32	With Turnbuckle Direct Cable Connection	42/3Ncon 42/4Ncon
				4	3.50	26	With Turnbuckle Direct Cable Connection	44/1Ncon 44/2Ncon
						32	With Turnbuckle Direct Cable Connection	44/3Ncon 44/4Ncon
	HILL SLOPE		GRAVITY BLOCK ANCHORS "AB" TYPES	2	2.50	26	With Turnbuckle Direct Cable Connection	42/5Ncon 42/6Ncon
				4	3.50		With Turnbuckle Direct Cable Connection	44/5Ncon 44/6Ncon
				2	2.50	32	With Turnbuckle Direct Cable Connection	42/7Ncon 42/8Ncon
		Gravelly or Sandy Soil		4	3.50		With Turnbuckle Direct Cable Connection	44/7Ncon 44/8Ncon
		Silty Soil		4	3.50	32	With Turnbuckle Direct Cable Connection	44/9Ncon 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 Nos	Main Cables ϕ [mm]	Block Height [m]	Foundation Type	Drawing No.
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 ϕ [mm]	Block Height [m]	Foundation Type	Drawing No.
SOIL	All Soil Types: Gravelly, Sandy or Silty	One Cable ϕ 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

Group	Subgroup	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 ϕ 26mm, c/c_1 = 2.50m, with Turn Buckle, all Soil Types	42/1Ncon
		2 Cables ϕ 32mm, c/c_1 = 2.50m, with Turn Buckle, all Soil Types	42/3Ncon
		4 Cables ϕ 26mm, c/c_1 = 3.50m, with Turn Buckle, all Soil Types	44/1Ncon
		4 Cables ϕ 32mm, c/c_1 = 3.50m, with Turn Buckle, all Soil Types	44/3Ncon
		2 Cables ϕ 26mm, c/c_1 = 2.50m, Direct Cable Connection, all Soil Types	42/2Ncon
		2 Cables ϕ 32mm, c/c_1 = 2.50m, Direct Cable Connection, all Soil Types	42/4Ncon
		4 Cables ϕ 26mm, c/c_1 = 3.50m, Direct Cable Connection, all Soil Types	44/2Ncon
		4 Cables ϕ 32mm, c/c_1 = 3.50m, Direct Cable Connection, all Soil Types	44/4Ncon
	GRAVITY BLOCK ANCHORS IN HILL SLOPES	2 Cables ϕ 26mm, c/c_1 = 2.50m, with Turn Buckle, all Soil Types	42/5Ncon
		2 Cables ϕ 32mm, c/c_1 = 2.50m, with Turn Buckle, all Soil Types	42/7Ncon
		4 Cables ϕ 26mm, c/c_1 = 3.50m, with Turn Buckle, all Soil Types	44/5Ncon
		4 Cables ϕ 32mm, c/c_1 = 3.50m, with Turn Buckle, gravelly or sandy Soil	44/7Ncon
		4 Cables ϕ 32mm, c/c_1 = 3.50m, with Turn Buckle, silty Soil	44/9Ncon
		2 Cables ϕ 26mm, c/c_1 = 2.50m, Direct Connection, all Soil Types	42/6Ncon
		2 Cables ϕ 32mm, c/c_1 = 2.50m, Direct Connection, all Soil Types	42/8Ncon
		4 Cables ϕ 26mm, c/c_1 = 3.50m, Direct Connection, all Soil Types	44/6Ncon
		4 Cables ϕ 32mm, c/c_1 = 3.50m, Direct Connection, gravelly or sandy Soil	44/8Ncon
		4 Cables ϕ 32mm, c/c_1 = 3.50m, Direct Cable Connection, silty Soil	44/10Ncon
		2 Cables ϕ 26 or 32mm, c/c_1 = 2.50m, with Turn Buckle, all Rock Types	45Ncon
		4 Cables ϕ 26 or 32mm, c/c_1 = 3.50m, with Turn Buckle, all Rock Types	46Ncon
	DRUM ROCK ANCHORS	2 Cables ϕ 26 or 32mm, c/c_1 = 2.50m, Direct Connection, in hard Rock	47Ncon
		4 Cables ϕ 26 or 32mm, c/c_1 = 3.50m, Direct Connection, in hard Rock	48Ncon
		2 Cables ϕ 26 or 32mm, c/c_1 = 2.50m, Direct Connection, fractured/soft Rock	49Ncon
		4 Cables ϕ 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 ϕ 26mm, Block Height 1.0m, for all Soil Types	55/1Acon
		1 Cable ϕ 26mm, Block Height 2.0m, for all Soil Types	55/2Acon
		1 Cable ϕ 26mm, Block Height 3.0m, for all Soil Types	55/3Acon
		1 Cable ϕ 26mm, Block Height 4.0m, for all Soil Types	55/4Acon
		1 Cable ϕ 26mm, Block Height 1.0m, for all Rock Types	56Acon
		1 Cable ϕ 26mm, Drum Type in hard Rock	57Acon
		1 Cable ϕ 26mm, Drum Type in fractured or soft Rock	58Acon

4.12.11.3 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 Steel deck Special Panel, length = 223 cm / width = 34 cm	08A 10A
WINDGUY PARTS	Windties Cable Clamps for Windguys Cable ø 26 or 32 mm Windguys Cable Anchorage for one Cable End ø 26 or 32 mm	11A 50A
SUSPENDERS	Suspenders for 2 Main Cables ϕ26 or 32mm Suspenders for 4 Main Cables ϕ26 or 32mm	31N 32N
MAIN CABLE ANCHORS	Main Cable Anchorage for 2 Main Cables ϕ26 or 32mm Main Cable Anchorage for 4 Main Cables ϕ26 or 32mm	42N 44N
WALKWAY & TOWER FOUNDATION	Walkway and Tower Foundation, c/c_1 = 2.50m, c/c_2 = 383mm Walkway and Tower Foundation, c/c_1 = 3.50m, c/c_2 = 383mm	92N 94N
TOWERS	Guide for selecting Towers, Main Cables and Spanning Cables Assembly and Layout for Tower No. 1, Height 5.50 m Assembly and Layout for Tower No. 2, Height 7.35 m Assembly and Layout for Tower No. 3, Height 9.20 m Assembly and Layout for Tower No. 4, Height 11.05 m Base Element for Tower Nos. 1, 2, 3 or 4 Intermediate Element for Tower Nos. 1, 2 or 3 Intermediate Element for Tower No. 4 Top Element for Tower Nos. 1, 2 or 3 Top Element for Tower No 4 Saddle for Tower Nos. 1, 2, 3 or 4	99N 141N 142N 143N 144N 100N 109N 110N 119N 121N 135N

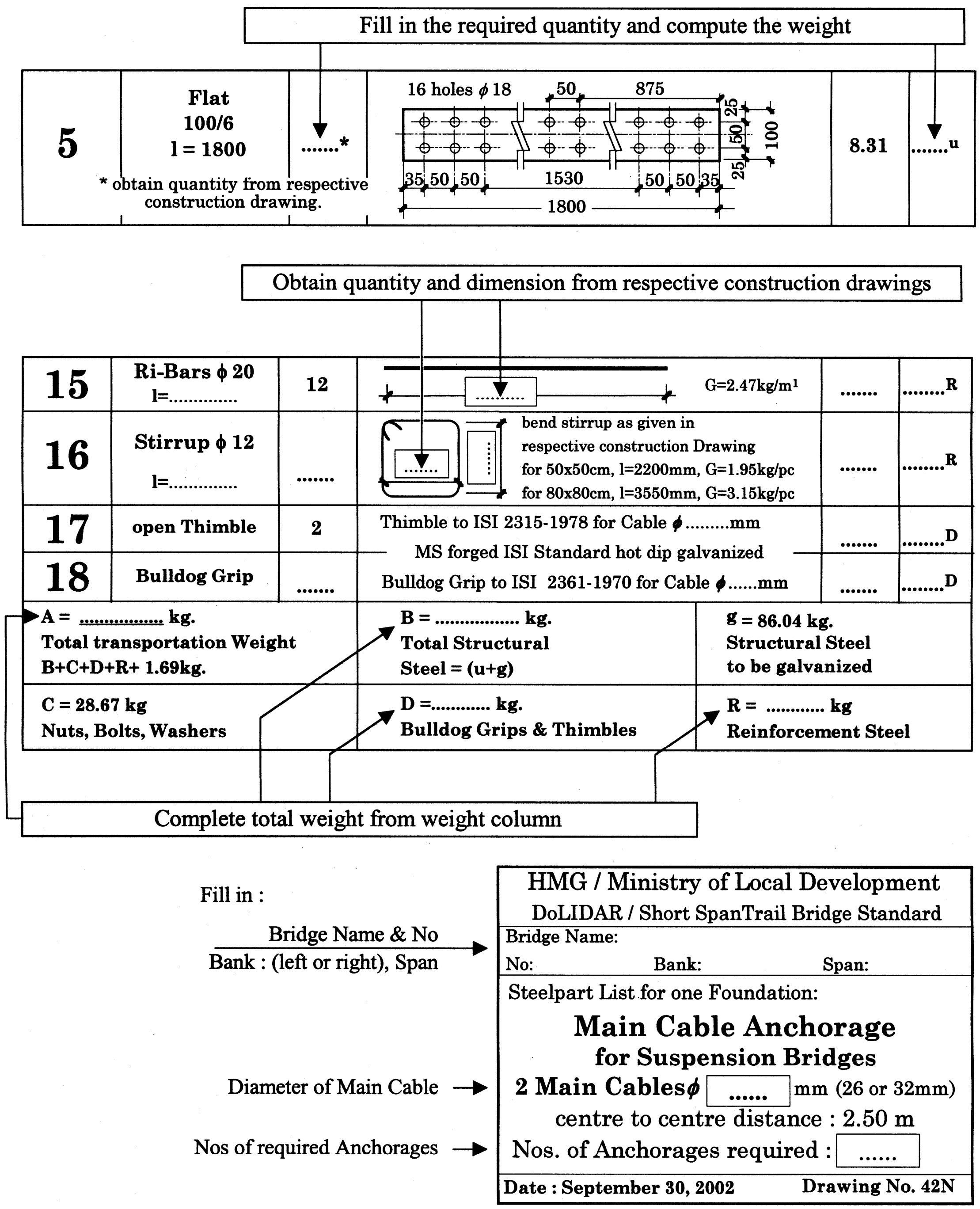
4.12.11.4 Concept of the Standard Drawings

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^o slope
  ⇒ Gravity Block Anchors for Hill Slopes of more than 15^o
  ⇒ 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 = 2.50m, and seven options for the four Main Cables with c/c_1 = 3.50m.

- **Windguy Cable Anchors**

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

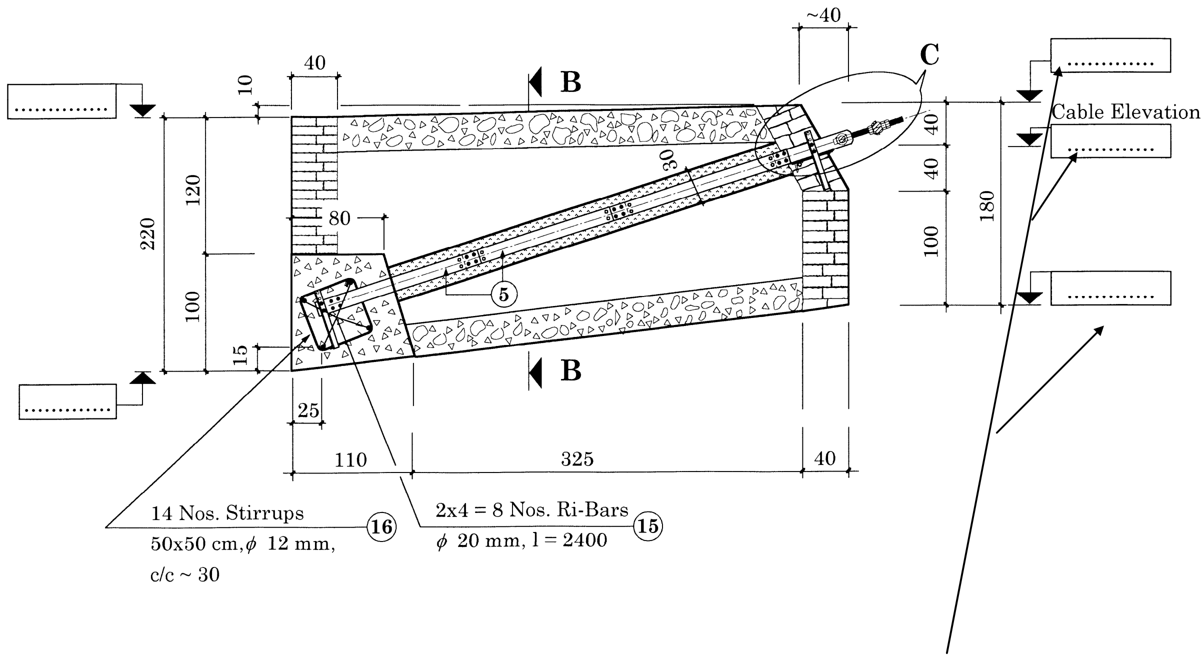
⇒ Gravity Block Anchors for different Soil/Rock conditions with variable Block Heights (five types)
⇒ Drum Rock Anchors for fractured or soft Rock or for hard Rock (two types)

All drawing types are complete designs and fulfill their respective parameters selected in the design form. Also, in all drawings, the necessary quantities o f 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, Volume II, SSTB Suspension Type Manual.

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.

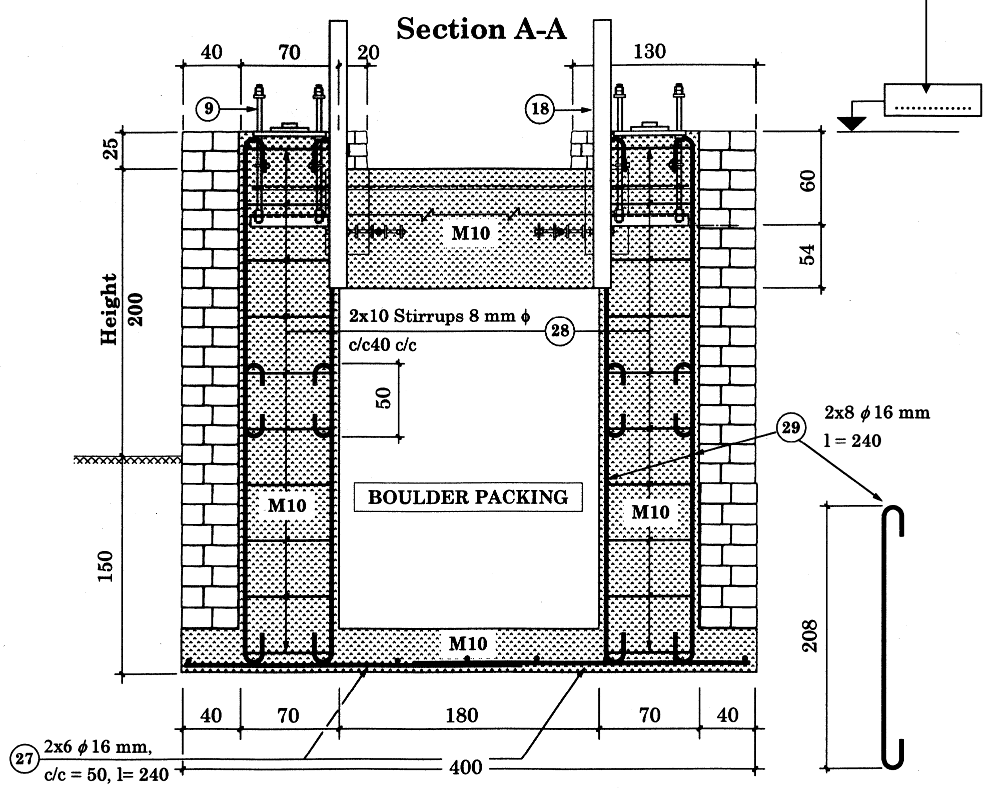
Examples of Construction Drawings:

Main Cable Anchor Block:



Walkway and Tower Foundation:

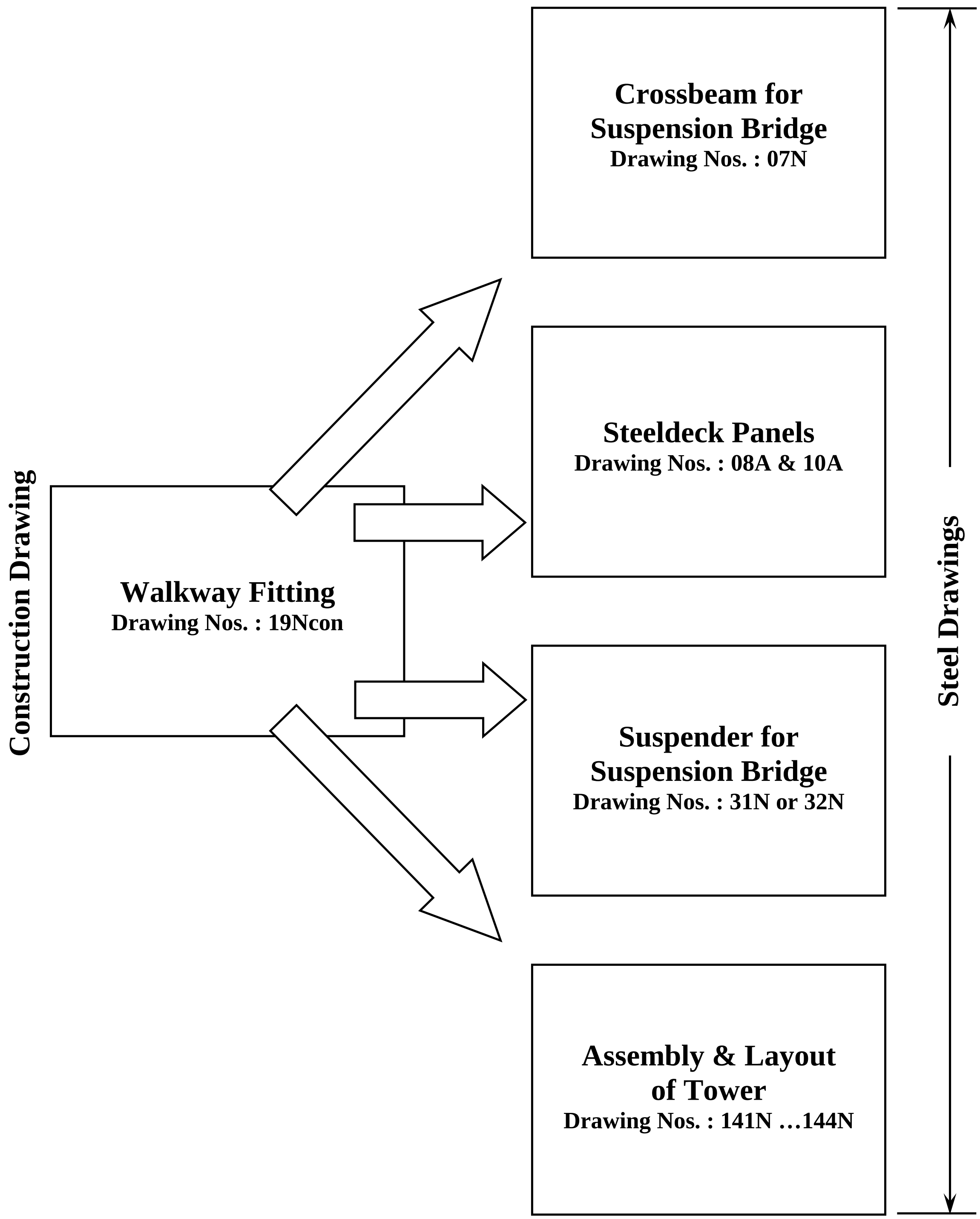
Fill in all respective Elevations.



4.12.11.5 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*.

4.12.12 General Arrangement and Design Example