SERVICE CRITERIA AGREEMENT / BASIS OF DESIGN

Project	Sapsup Bridge Local Road Bridge Programme (LRBP) Nepal
Client	Local Road Bridge Support Unit (LRBSU) Goverment of Nepal (DoLIDAR) in collaboration with Swiss Agency for Development and Cooperation (SDC)
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Date	20th July 2012

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1 OBJECTIVES FOR THE STRUCTURE`S USE

1.1 Description

1.1.1 General

In the hilly district of the Sagarmatha Zone named Khotang located in the Eastern development region of Nepal the Sapsup Bridge is to be built. The bridge connects the northern and southern river banks of the river Sapsup Khola. The bridge is designed to be motorable and is part of the development programme of the hitherto cobbled road from Maure to Foksingtar being part or the District Road Support Programme (DRSP). With the track-widening works into a 5.0m wide trunk road the Maure-Foksingtar-Road will be transformed into an all-weather road as part of the District Road Support Programme (DRSP).

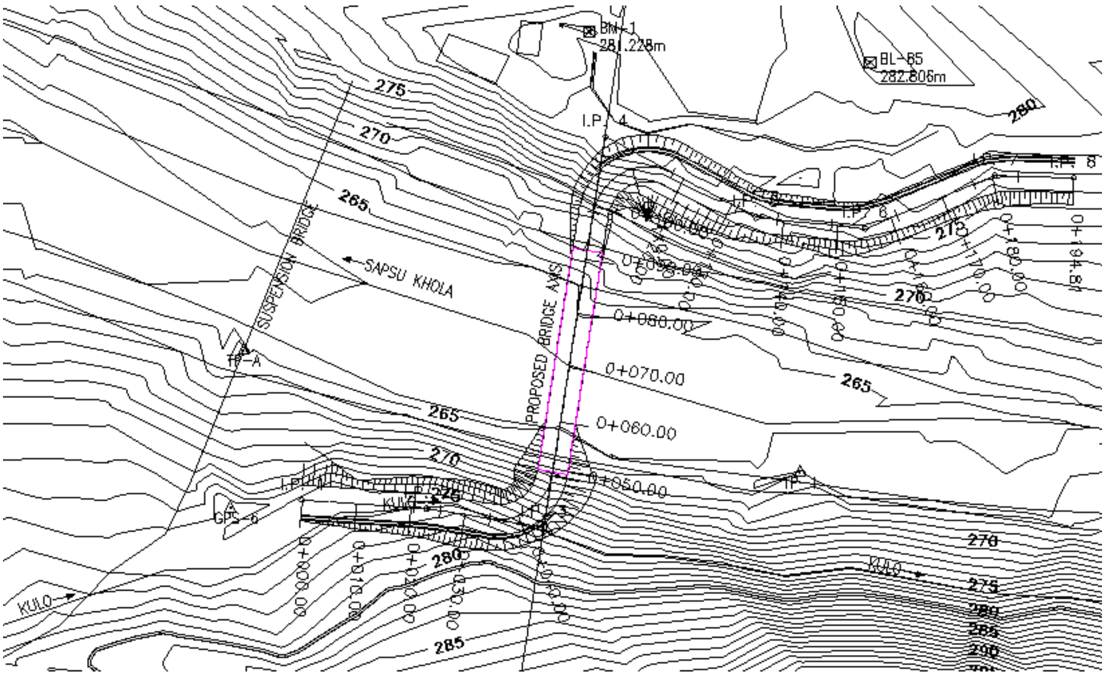

Figure 1: Topography of proposed bridge site over Sapsup Khola

1.1.2 Structure and Geometry

The Sapsup Bridge is to span over the Sapsup Khola valley with an effective span of 60m. In order to leave a maximum flow width for the high water table of river Sapsup Khola to pass through without internal supports and at the same time to provide beneficial support conditions for the bridge an inclined-leg RC frame bridge with V-struts has been conceived as per figure 2.

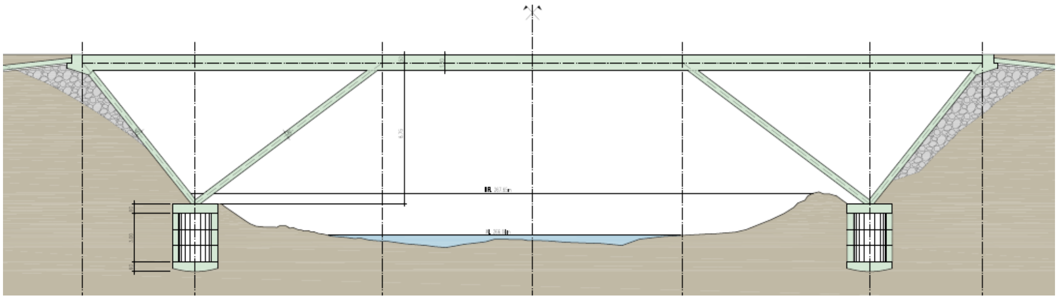

Figure 2: Longitudinal Section through Sapsup Bridge

The bridge is designed to sit on pad foundations using its V-struts to balance out the strut forces significantly reducing horizontal thrust on the foundations. The clear height from top of foundation level to the underside of the bridge deck is conceived to be 8.25m. The deck slab is 5.45m wide allowing a 0.6m wide pedestrian footpath to each side. This leaves a 4.25m wide clearance zone for the road traffic to pass through. The deck slab is conceived as a flanged beam with a minimum slab thickness towards the outer ends of 0.25m and beam height of 1.0m at the centre. The 0.6m wide footpaths to each side act as upstand beams increasing the effective depth. The structural concept includes inclined beam faces resulting in a top width of 2.0m and minimum width at the bottom of 1.5m as shown in figure 3. The inclined struts connecting to the underside of the beam use dimensions of 0.4 by 1.5m.

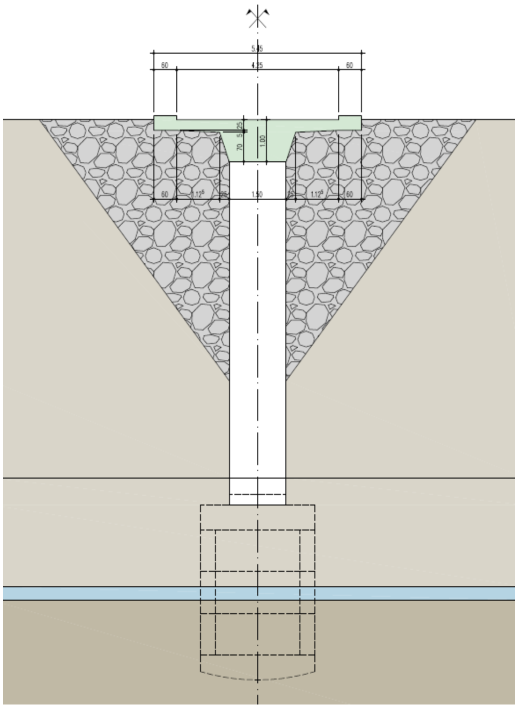

Figure 3: Typical Cross Section

1.2 Designated Use

As part of the new trunk road from Maure to Foksingtar the bridge will be subject to motor traffic. The bridge is designed to carry light weight traffic applying loads according to the load model Class A taken from the Indian Standard Specification and Code of Practice for Road Bridges IRC6-2000 [1], developed further and specified according to WGGSP-LL-spec-2012 within Design Fundamentals [14]. Loadings covering vertical, horizontal and accidental loading are defined in chapter 3. In accordance with IRC6-table 2 for carriageway widths of less than 5.3m for design purposes one lane is to be considered only using a width of 2.3m.

1.3 Design Service Life

- Structure, Foundation — 80 Years
- Bridge bearing, balustrade, waterproofing — 40 Years
- Corrosion protection — 20 Years

2 STRUCTURE

2.1 Philosophy

The bridge structure is an inclined-leg frame bridge with V-struts as described in chapter 1.1.2.

2.2 Materials

2.2.1 Concrete

Nomenclature according to IRC 21-2000 [2]	Structural elements	Exposure condition, Nomenclature acc. to *IRC21-2000* & EC2-1
M35 **f_{ck} = 35 N/mm^2**	**Superstructure above deck slab**	*Severe*: Cyclic wet and dry, high saturation with sea water & de-icers XC4, XD3, XF4
	Superstructure below deck slab	*Moderate*: Moderate humidity XC3, XD1
M30 **f_{ck} = 30 N/mm^2**	**Walls, bridge bearings and footings**	*Moderate*: Wet, rarely dry; moderate humidity; moderate saturation with de-icers XC2, XD1, XF2
	Columns	*Moderate*: Moderate humidity; moderate saturation with de-icers XC3, XD1, XF2

Table 1: Material properties: Concrete

2.2.2 Reinforcement

Reinforcement type	Grade to IRC 21-2000	Characteristic yield strength (N/mm^2)	Characteristic tensile strength (N/mm^2)	Modulus of elasticity (N/mm^2)
Deformed bars	Fe 500-	500	545	200'000

Table 2: Material properties: Reinfocement

2.3 Assumed Soil conditions

The bridge site of the proposed Sapsup Bridge belongs to the Tawa Kola formation. The bottom of the river valley is covered with alluvial deposits of about 5m magnitude comprising coarse-grained, dark grey, garnetiferous schist and schistose gneiss intercalated with white quartzite in layers of about 1 to 2m [16]. To either side the underlying bedrock steps up partially exposed to one side but mostly covered with topsoil and overgrown with grass, shrubs and trees.

The river bed is scattered with fair-sized boulders in the range of 0.5 – 3m diameter which got carried along by the river from the Lesser Himalaya. Slope stability of the rock along bridge site area is classed as “Stable”.

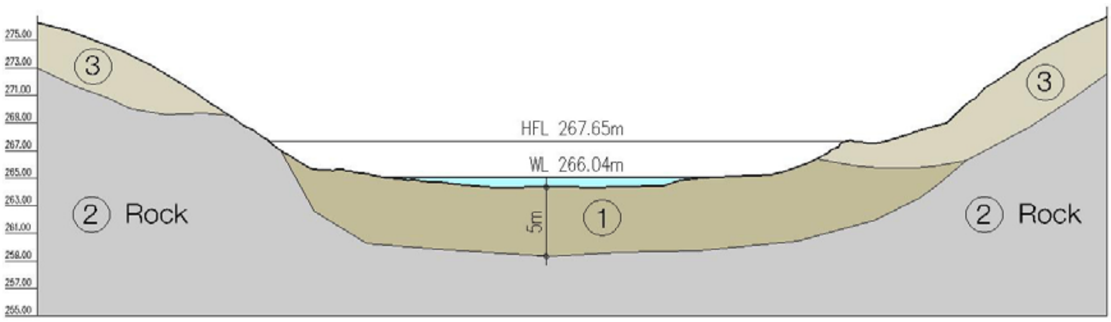

Figure 4: Soil model (Assumption)

Soil layer		Layer thickness	Unit weight	Cohesion	Angle of friction	Elastic Modulus
No.	**Description**	**[m]**	**[kN/m^3]**	**[kN/m^2]**	**[degree]**	**[MN/m2]**
1	Alluvial deposits	5	19	35	-	80 - 100
2	Rock, schitose gneiss	> 20	-	-	-	-
3	Top soil	2 - 4	19	-	-	-

Table 3: Characteristic soil properties (Assumption)

3 LOADING

3.1 Dead load

Superimposed dead load

▪ Bridge topping	t_{max} =	0.10	m,
	γ_y =	24.0	kN/m^3
	g_A =	2.40	kN/m

3.2 Live Loads

3.2.1 Road traffic loads

Load Model 1 to WGGSP-LL-spec-2012 [14]:

q_{k1} = 3.0kN/m2 — udl/area throughout (shaded area)

Q_{k1} = 160kN — axle load (moving pair of axle loads)

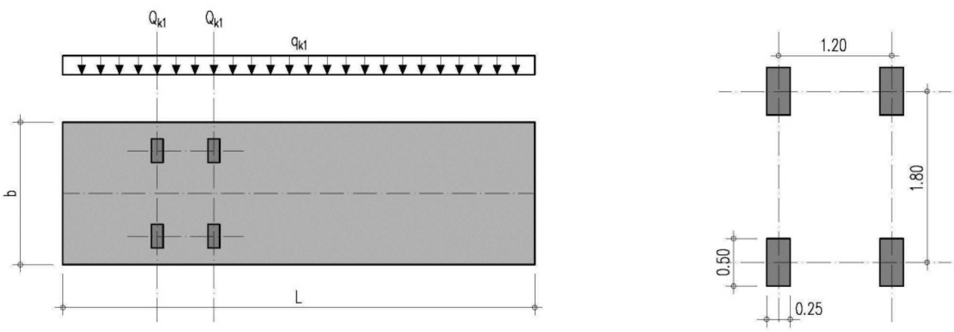

Figure 5: Road traffic loads to WGGSP specification (WGGSP-LL-spec-2012)

3.2.2 Wind

The wind load has to be calculated to be the maximum of:

w_1 = 450kg/m (4.5kN/m) — horizontal load per meter run of deck slab

w_2 = 240 kg/m2 ($2.4kN/m^2$) — horizontal area load per elevation area, less perforation area

3.2.3 Thermal expansion

▪ Structure:			
▪ Coefficient of expansion:	Concrete	αT =	$10 \cdot 10^{-6}$/°C
	Steel	αT =	$10 \cdot 10^{-6}$/°C
▪ Change in temperature (constant):	Decking	$\Delta T1$ =	±20 °C
▪ Linear temperature distribution:	Decking		
- top surface:	warm	$\Delta T2$ =	+4 °C
- bottom surface:	cold	$\Delta T2$ =	-3 °C
▪ Bridge Bearings and Expansion joints:		ΔTL =	1.5 $\Delta T1$

3.3 Accidential loading conditions

3.3.1 Vehicle impact

Vehicle impact to act at 0.4m above datum level distributed uniformly 1.50m wide

Frontal collision — Qdx = 1500 kN

Lateral collision Qdy = 600 kN

3.3.2 Earthquake forces [1]

$F_{acch} = \alpha \times \beta \times \lambda \times g$ Horizontal seismic force

$F_{accv} = 0.5 \times \alpha \times \beta \times \lambda \times g$ Vertical seismic force

Earthquake parameters

$\alpha = 0.08$ Horizontal seismic coefficient for zone V

$\beta = 1.5$ Soil type / foundation system coefficient

$\lambda = 1.0$ Importance factor

g Dead Load

4 OBJECTIVES OF PROTECTION AND HAZARDS

4.1 General

In future the new Sapsup Bridge shall be serviced and maintained with minimum obstruction to the ongoing traffic within tight budget and resources.

4.2 Earthquake Resistance

The site is located within a seismic active area.

The design philosophy of the Sapsup Bridge fulfils the design requirements of an earthquake resisting structure providing lateral stability and robustness. For a Class II building cosmetic damage is accepted however, the structure must not collapse. The structural design and detailing takes this into account. The bearing length is designed to be min 3.8m (L/70) to prevent sliding off the bearings of the bridge during the case of an earthquake.

4.3 Vehicle impact (collision)

Vehicle impact is deemed to be an accidental loading scenario. Structural members are designed to withstand the impact of a vehicle.

4.4 River flooding

Extreme high water does not impact the conceived bridge and therefore does not need to be considered in the bridge design. Footings to be extended down to bedrock level to prohibit scouring.

5 ULTIMATE LIMITE STATE (ULS)

The governing types of limit states have to be checked within the structural calculations and are as follows:

Type 1: Check of the structure's overall stability

Type 2: Ultimate limit state design of the superstructure's

Type 3: Ultimate limit state design of foundations

ULS Type 1 / Type 2 / Type 3:					
Actions		γ_F	Type 1	Type 2	Type 3
Dead Loads	- unfavourable	$\gamma_{G,sup}$	1.10	1.35	1.00
	- favourable	$\gamma_{G,inf}$	0.90	0.80	1.00
Imposed Load	- in general	γ_Q	1.50	1.50	1.30
	- road traffic	γ_Q	1.50	1.50	1.30
Underground forces					
Soil surcharge	- unfavourable	$\gamma_{G,sup}$	1.10	1.35	1.00
	- favourable	$\gamma_{G,inf}$	0.90	0.80	1.00
Earth pressure	- unfavourable	$\gamma_{G,Q,sup}$	1.35	1.35	1.00
	- unfavourable	$\gamma_{G,Q,inf}$	0.80	0.70	1.00
Water pressure	- unfavourable	$\gamma_{G,Q,sup}$	1.05	1.20	1.00
	- unfavourable	$\gamma_{G,Q,inf}$	0.95	0.90	1.00

Table 4: ULS, Factors of safety

6 SERVICEABILITY REQUIREMENTS

Objectives of protection / Life cycle Requirements		Action / Impact	Provision
Serviceability:			
1	Deflexion: Total deflectio limit: $\delta_{tot} = \delta_g + \delta_q \leq L / 300$ Live load deflexion limit: $\delta_q \leq L / 500$	- Dead load - Superimposed load - Imposed loads (Load model WGGSP-LL-spec-2012)	- Design to Design Fundamentals 2012 [14] - Cross section to be of sufficient stiffness
2	Waterproofing and dewatering: Provide sound dewatering	- Rain	- Provide drainage system
3	Cracking	- Loads - Temperature - Restraint to movement	- Provide minimum reinforcement to Design Fundamentals 2012 [14]

4	BridgeBearings / Expansion joints: Maintain functionality	- Atmospheric impact - Ageing	- Servicing - Maintain/replace expansion joints during bridge renovation cycle
5	Earthquake: Maintain structure's integrity	- Maintain vertical load bearing capacity of bridge bearings	- Apply minimum dimensions to avoid collapse
6	Keep Foundation settlement within acceptable limits	Dead Load, Super Dead Load, Underground Forces	- Utilisation of foundation's safe load bearing capacity <100%
7	Vibration		- No vibration criteria to be adhered to
Durability			
8	Bridge topping und waterproofing to be immaculate	- Precipitation	- Repair / Replace bridge topping during service cycle - Use waterproofing membrane acc. to manufacturer's recommendations
9	Atmospheric Impact	- Precipiitation, freezing, de-icing agent, CO_2	- Use frost-resistant concrete for deck slab - Use sufficient cover to reinforcement
Inspections			
10	Inspection to underside of bridge	- accessibility of undersurface of bridge	Apply inspection regime of DoR

Table 4: ULS, Factors of safety

7 ENVIRONMENT AND THIRD PARTY REQUIREMENTS

7.1 Requirements

The bridge shall be built with least impact on surrounding nature and individuals.

8 HYDROLOGY

8.1 General

No hydrological investigations have been conducted

Findings from site visit 24/08/2011 [15]

- Confining the existing river's natural channel is not advisable
- Placing the pier's stem/shaft in the river waterway is not advisable, both from the construction point of view and possible risk of boulder impact on it or risk of boulders obstructing / confining the waterway.

8.2 Discharge cross section

The discharge cross section of the existing river bed will not be impaired by the bridge. No action required.

9 SERVICE AND MAINTENANCE REQUIREMENTS

The bridge is part of the District Road Support Programme and therefore subject to the service and maintenance programme of the road development agency. Inspections must be carried out regularly under the guidance of experienced members of staff. Ordinary inspection intervals must not exceed 5 years. The findings must be well documented. Extraordinary inspections may take place if required.

Checked elements must comprise structural and safetycomponents:

- Deck slab
- Bearings
- Supporting RC frame structure
- Railings

10 IDENTIFIED RESIDUAL HAZARDS

- Fire on top and underneath bridge due to accident
- Freight discharge, overturning and falling over of heavy vehicle impairing balustrade in case of accident
- Dynamic response during earthquake event
- Scouring of supporting structure and footings

11 REFERENCES

11.1 Codes and guidelines

[1] IRC:6-2000; Standard Specifications and code of practice for road bridges; Section II: Loads and Stresses (4th revision); The Indian Roads Congress (New Delhi, 2000)

[2] IRC:21-2000; Standard Specifications and code of practice for road bridges; Section III: Cement Concrete (Plain and Reinforced, 3rd revision); The Indian Roads Congress (New Delhi, 2000)

[3] IRC:22-1986; Standard Specifications and code of practice for road bridges; Section VI: Composite Construction, 1st revision); The Indian Roads Congress (New Delhi, 1991)

[4] IS:800-2007; General Construction in steel – Code of practice (3rd revision); Bureau of Indian Standards (New Delhi, 2007)

[5] IS:2062-1999; Steel for general structural purposes – Specification (5th revision); Bureau of Indian Standards (New Delhi, 1999)

[6] IS:2062;1999 Specification of hot rolled medium and high tensile structural steel (7th revision); Bureau of Indian Standards (New Delhi, 1999)

[7] IS:1786-1985; Specification for high strength deformed steel bars for and wires for concrete reinforcement, 3rd revision, 3rd reprint 1992); Bureau of Indian Standards (New Delhi, 1985)

[8] IS:456-2000; Indian Standard – Plain and reinforced concrete (Code of practice, 4th revision); Bureau of Indian Standards (New Delhi, 2000)

[9] Eurocode 0: Basis of Structural design; European Standard; European Committee for Standardization (CEN, Brussels, 2010)

[10] Eurocode 1: Actions on Structures; European Standard; European Committee for Standardization (CEN, Brussels, 2010)

[11] Eurocode 2: Design of Concrete Structures; European Standard; European Committee for Standardization (CEN, Brussels, 2010)

[12] Eurocode 3: Design of Steel Structures; European Standard; European Committee for Standardization (CEN, Brussels, 2010)

[13] Eurocode 4: Design of Composite Steel and Concrete Structures; European Standard; European Committee for Standardization (CEN, Brussels, 2010)

[14] Design Fundamentals; Government of Nepal (DoLIDAR) / WGG Schnetzer Puskas Ingenieure AG (Kathmandu, 2012)

11.2 Project reports

[15] Sapsup Khola site Visit Report; LRBSU; Nepal (August 2011)

[16] Sapsup Alternative, Preliminary Conceptual Design for Proposed Sapsup Khola Bridge; LRBSU; Nepal (Sept. 2011)

[17] Geo-Technical/Hydrological Investigation – Khotang Report; AKARA Engineering & Associates PVT LTD; Kathmandu, Nepal (April 2012)

[18] Geological Report of Sapsup Khola, Khotang District along Maure-Phoksingtar Road; PhD (Eng. Geologist) Mr. Prakash Das Ulak, LRBP (May 2012)

12 APPROVAL

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13 DISTRIBUTION

To	Date of issue				
	preliminary	amenended	rev. a	rev. b	rev. c
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