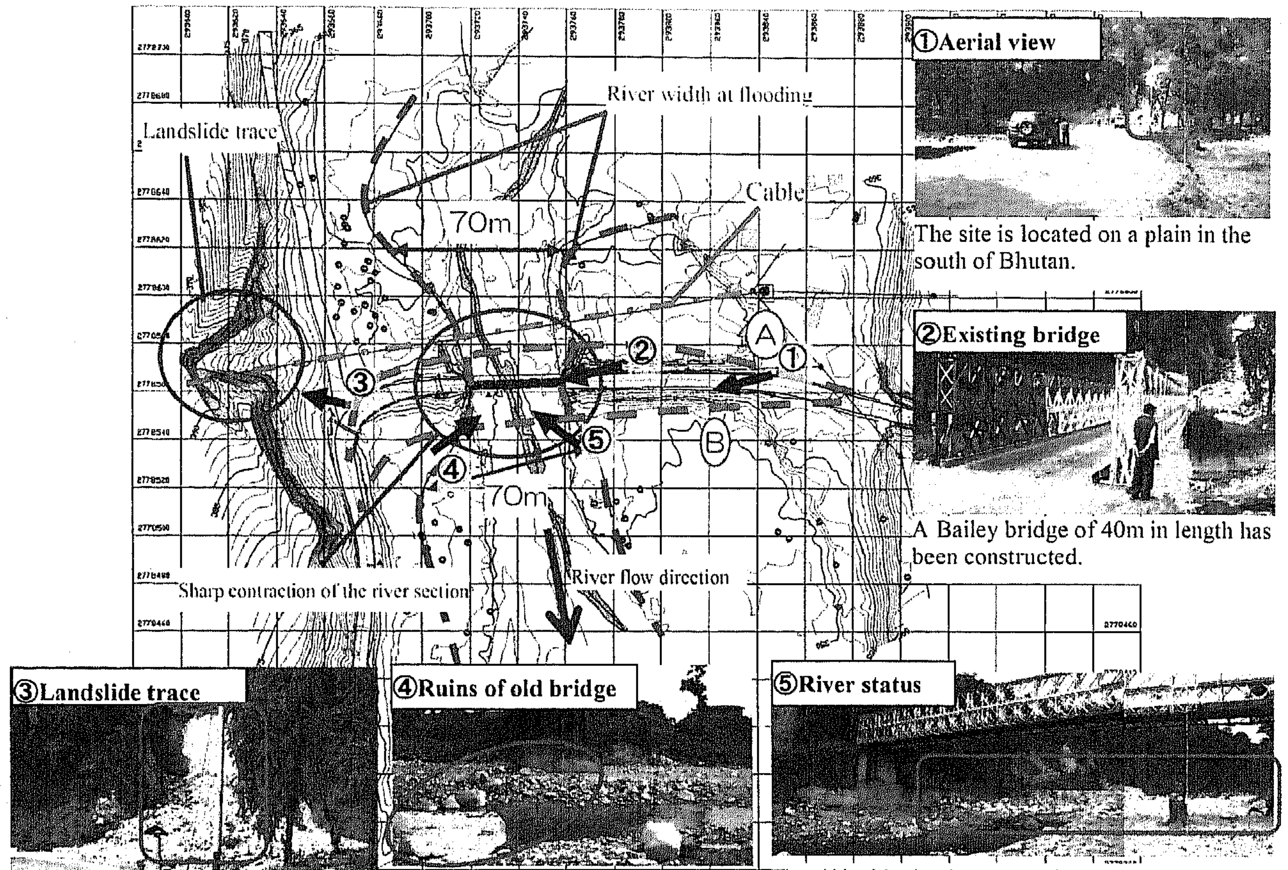
No.17 Dolkhola Bridge



The site is located on a plain in the south of Bhutan.

A Bailey bridge of 40m in length has been constructed.

A landslide trace is observed on the right bank of the upstream.

Ruins of a collapsed old bridge are observed below the existing bridge.

The width of the river increases on the upstream side and the section is sharply contracted at the location of the existing bridge. A sediment of boulders and gravels lies on the riverbed.

(1) Outline of the site

1) Outline of the topography and the geology

The site is located on a plain in the south of Bhutan. A sediment of boulders and gravels lies on the riverbed. Gravels are deposited up to the depth of around 10m. The average N value is over 50.

2) Outline of the river

The site is plain, the riverbed gradient is gentle and the river width is wider than in the mountains. Judging from the flood mark, the river section is wide on the upstream and downstream side on the existing bridge (The river width is 70m.). Since the bridge abutment of the existing bridge is overhanging, the river section is sharply contracted (The river width is 40m).

(2) Setting the bridge route

The following two routes are conceivable. As a result of comparative study, route B, which is considered superior, is adopted.

Route	Outline	Evaluation
A	A proposal of building the new bridge on the upstream of the existing bridge It is rejected because the area is close to the landslide trace and the cable may obstruct the construction work.	×
B	A proposal of building the new bridge on the downstream of the existing bridge. It is considered superior because the area has no obstacles and the plain curve is gentler than in route A.	○

(3) Setting the bridge length and the span length

As a result of calculating the flow rate at flooding based on the flood mark, the flow rate is 920m³/s and the river width on the upstream and downstream side is assumed to be around 70m. Therefore, the bridge length of the new bridge should be 70m.

As the flow rate at flooding (Q) is 920m³/s, the standard span length is: 20+0.005Q=20+0.005*920=24.6m. Also, if the impediment ratio of river flow is 5%, the total pier width is 3.5m. Considering that the minimum pier width is 2.0m per pier, it is impossible to install two piers in the river. If two piers are installed, the impediment ratio of river flow will be 5.7%, which is greater than 5%. (Pier pole width 2.0m x 2/river width 70m = 5.7%) Therefore, the bridge should have a single pier and the span length should be @35m x2.

(4) Setting the types of the substructure and foundation work

Since the skeleton height is10m, the abutment of the substructure should be inverted T-type and the pier should be wall-type. Also, since the layer of which the N value is 50 or higher at an average is observed less than 50m below the ground surface, the foundation should be a spread foundation.

(5) Setting the type of the superstructure

1) Basic conditions

- The superstructure should be applicable to the bridge length of 70m and the span length of 35m.
- It should consist of a continuous structure that excels in maintainability and trafficability.
- As the bridge is constructed at a location where the river width is relatively large, stationary scaffolding should not be adopted to ensure safety during the construction work against flooding.

2) Selection of the proposals to be compared

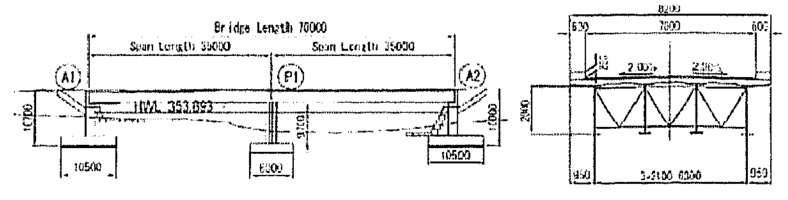
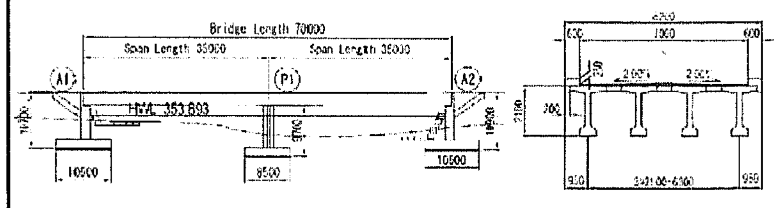
Considering 1) basic conditions and based on the bridge type selection table below, steel continuous non-composite plate girder bridge (proposal 1) and PC connection post-tension T girder bridge (proposal 2) should be selected.

supan length 35m

		Bridge type	Span length (m) 10–150	Features: Construction method	Construction in a confined area	Ease of Construction	Construction on steeply sloping	Selection: Choice	Reasons for rejection
Steel bridge		Simple non-composite plate girder bridge		Crane, launching	Slightly difficult	Easy	Normal	×	Simple girder construction
		Simple composite plate girder bridge		Crane, launching	Slightly difficult	Easy	Normal	×	ditto
		Simple non-composite box girder bridge		Crane, launching	Slightly difficult	Easy	Normal	×	ditto
		Simple composite box girder bridge		Crane, launching	Slightly difficult	Easy	Normal	×	ditto
		Continuous non-composite plate girder bridge		Crane, launching	Slightly difficult	Easy	Normal	O	
		Continuous non-composite box girder bridge		Crane, launching	Slightly difficult	Easy	Normal	×	Uneconomic span length
		Rigid frame bridge		Cable erection (diagonal suspension)	Easy	Easy	Easy	×	Topographically inappropriate
		Simple truss bridge		Overhang, launching, cable erection (straight suspension)	Easy	Easy	Easy	×	Uneconomic span length
		Langer bridge		Cable erection (straight suspension)	Easy	Easy	Easy	×	ditto
		Lohse bridge		Cable erection (straight suspension)	Easy	Easy	Easy	×	ditto
Concrete bridge	RC	Simple floor system bridge		Stationary scaffolding	Easy	Easy	Difficult	×	Simple girder construction, stationary scaffolding construction
		Simple hollow floor system bridge		Stationary scaffolding	Easy	Easy	Difficult	×	ditto
	PC	Simple post-tension T girder		Crane, erection beam	Difficult	Difficult	Normal	×	Simple girder construction
		Simple box girder		Stationary scaffolding	Easy	Difficult	Difficult	×	Simple girder construction, stationary scaffolding construction
		Continuous post-tension T girder		Crane, erection beam	Difficult	Difficult	Normal	O	
		Continuous post-tension box girder		Overhang, stationary scaffolding	Easy	Difficult	Normal	×	Uneconomic span length

3) Comparison of the types

As shown in the comparison table below, the PC connection post-tension T girder bridge (proposal 2) that excels in economic performance and constructability should be selected.

Proposals to be compared		Proposal No. 1 Simple non-composite steel plate girder bridge	Proposal No. 2 PC connection post-tension T girder bridge
Material		Steel	Concrete
Schematic diagram			
Economic performance		550 million yen (1.50)	360 million yen (1.00)
Construction	Total	22 months	18 months
	Construction method	Launching method	Erection beam method
	Outline	The procurement and delivery of a large crane to be used in construction poses a challenge. Also, it is difficult and uneconomical to cast bent foundations on a riverbed strewn with boulders, although this construction method requires the erection of bents for construction in the river. Therefore, the	The "erection beam method" should be selected, because it is commonly employed for bridges of this type and enables construction to take place during the rainy season.
	Remarks	Construction is impossible during the rainy season, because the erection of bents is essential.	Construction is possible during the rainy season.
Evaluation		× Poor economic performance, difficulties in construction	O Excellent economic performance and ease of construction

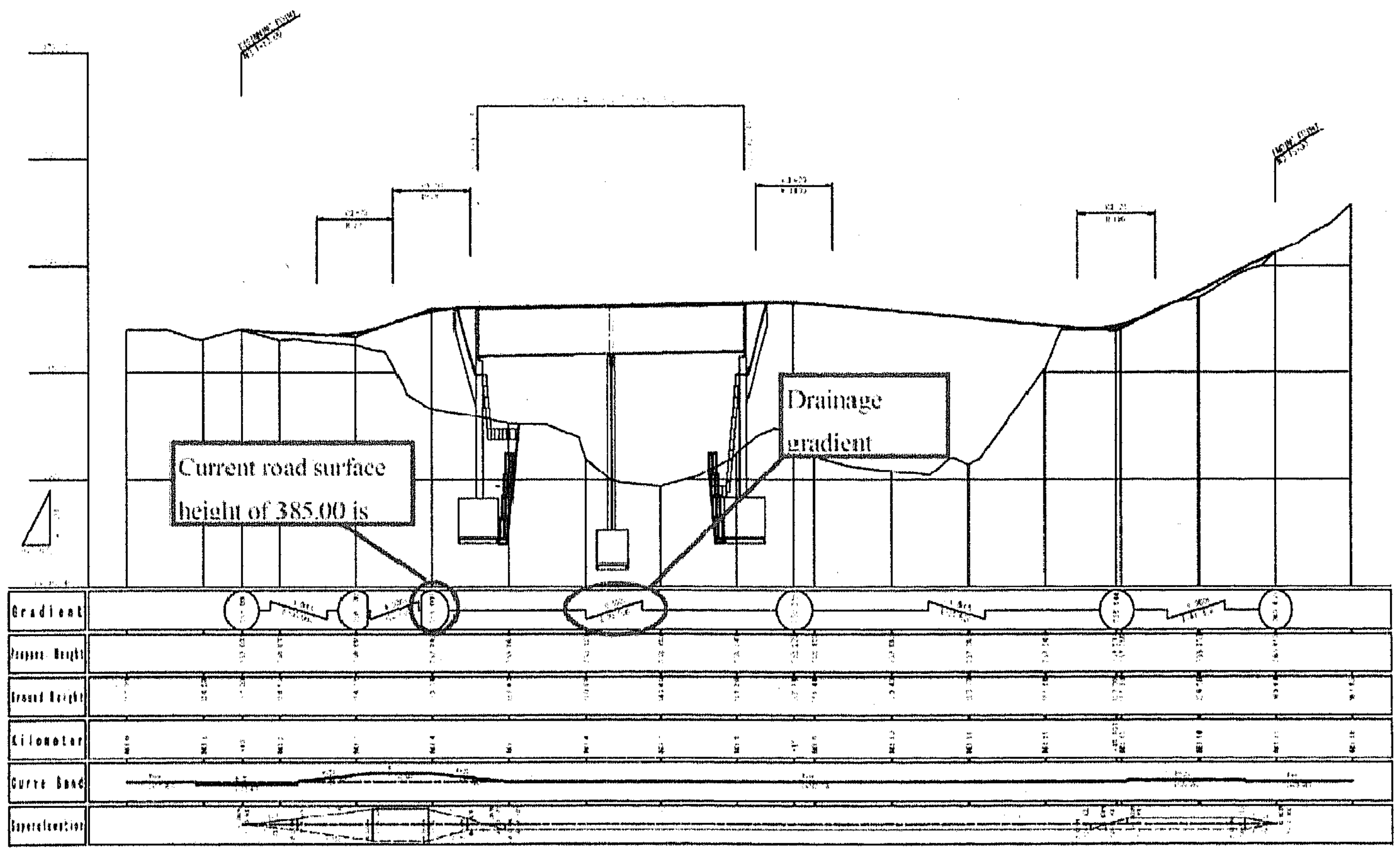
(6) Setting the planned road surface height

1) Basic conditions

- The vertical clearance should ensure a sufficient margin against the HWL (at least 1.0m higher than the water level at high flow rate Q=920m^3/s).
- The planned road surface height should be higher than the current road surface height.

2) Setting the planned road surface height

As shown in the figure to the right, the current road surface height of 385.00 should be secured at measurement point No. 1 (in front of the bridge). The road surface height should be set by assuming the vertical gradient of the bridge section to be 0.3%, that is the lowest drainage gradient.



3) Examining the margin of vertical clearance

As shown below, the vertical clearance ensures the necessary margin.

Road surface height at bridge abutment A 1	358.036m
Difference due to the horizontal gradient	0.070m(3.5m×2%)
Structural height of superstructure	2.300m
Vertical clearance	355.666m

Margin of vertical clearance Vertical clearance 355.666- HWL353.893=1.733m>1.0m ∴OK

※limit value Margin of vertical clearance become 1.0m. because of flood Inverse calculation920 ㎥/ s (Law of river structure)