Royal Government of Bhutan

Ministry of Works and Human Settlement

Department of Roads

"Towards Quality Infrastructure"

Reference Manual, Bridges

Foreword

The “Bridge Engineering Manual” is published by Bridge Division of Department of Roads. Its main purpose is to provide necessary information to the field engineers the basic step-by-step procedures of bridge engineering at the time of planning so that it ultimately becomes conversant with the actual design, construction and maintenance of bridges. This would guide the field engineers starting from selection of bridge site to construction of small span bridges without having to refer to Bridge Division.

The manual covers from collection of preliminary data for bridge site selection, detailed survey to selection of type of bridge for a particular location based on various engineering aspects. It also covers requirement of temporary and low cost bridges on less important roads. The basic design considerations for only sub-structure are included in the manual. The design and drawings of super-structures are already standardized by Bridge Division from 3m to 20m span for concrete bridges and from 24m to 72 m span for steel bridges. The list of all these standard drawings is attached as **Attachment 1** at the end of the manual.

The various aspects of inspection and maintenance of highway bridges are also covered in this manual. The inspection form should be properly filled after inspecting the bridge and appropriate action taken (if any) in order to save time and money and to ensure safe and uninterrupted flow of traffic.

This manual would be subjected to reviews and refinements from time to time and suggestions are welcomed from all for improvement of this manual.

Phuntsho Wangdi
Director
Department of Roads

Date: June 2005
Place: Thimphu

ACKNOWLEDGEMENT

The publication of Technical Standard Manual was initiated by our Director Mr. Phuntsho Wangdi in order to help and guide the engineers working both in the Fields and at Head Quarter. I would like to acknowledge him for his continuous support and guidance in bringing out this manual.

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I would also like to thank all the staff of Bridge Division and all those who were involved in bringing out this manual.

The support and financial assistance given by EFRC Support Project in publishing this manual is also gratefully acknowledged.

Karma Wangdi
Member
Technical Standard Committee
Department of Roads

CONTENTS

Inventory of Motorable Bridges (as of Feb 2005)

SN	Type of Bridges	Nos	Length (mtr)
1	RC T-Beam	46	846.80
2	RC Slab	17	299.35
3	Pre-stressed Concrete	6	331.00
4	RCC Arch	1	120.00
5	Steel Pony Truss	4	197.00
6	Steel Langar Arch	1	95.20
7	Composite	23	335.56
8	Bailey Bridges	94	2,496.35
9	Bailey Suspension	5	475.80
10	Steel Hamilton	6	187.60
11	Steel Truss/Girder	9	560
12	Multi-Cell Box Culvert	1	24.00
13	Submersible	7	193.50
14	Wooden	2	27.00
	Total	**222**	**6,181.96**
1	**Total Permanent bridges**	**121**	**3,182.81**
2	**Total Semi-Permanent bridges**	**99**	**2,972.15**
3	**Total Temporary bridges**	**2**	**27.00**
	Grand Total	**222**	**6,181.96**

Section 1: Preliminary Works

1.1 Collection of General Data

This includes preparation and collection of the following maps:

1) Index Map showing the proposed location of the bridge, general topography of the area, the existing means of communication and important towns and villages in the area.

2) A Contour Plan showing all the topographical features for a sufficient distance on either side of the proposed bridge site. All the probable bridge sites under consideration shall be indicated on the plan.

1.2 Preliminary Survey

The preliminary survey is carried out to study more than one alternative bridge sites. Usually the probable bridge sites are first located in topo sheets and thereafter these sites are visited to collect certain preliminary data required for thorough examination of the alternative bridge sites from which the final site shall be selected.

1.3 Collection of Preliminary Data for Selection of Bridge Sites

The proposed bridge site should satisfy the following requirements:

1. The channel should be well defined and narrow.
2. The river course should be stable and has high and stable banks.
3. There should be uniform flow at the proposed bridge site.
4. The bridge site should be far away from the confluence of large tributaries especially at the upstream side.

5. For meandering rivers the proposed bridge sites should be at its nodal points.
6. The site should have a straight approach road and a square crossing.
7. The site should be easily approachable from all sides and should give maximum service to the locality.
8. The bridge should connect the road alignment, existing or proposed, with shortest approach roads.
9. Curvature in the bridge proper should be avoided unless forced by site conditions.
10. The bridge site should be such that there is no requirement of costly river training works.
11. The proposed bridge site should be sound from geological consideration.
12. Materials and labour required for construction of bridge should be available near the proposed bridge sites.

Section 2: Detailed Survey

After examining the preliminary data collected and considering the merits and demerits of all the alternative bridge sites, the site which satisfies most of the requirements for an ideal bridge site, should be finally selected. Once this is done, detailed survey for this selected site should be carried out as under:

a) A detailed survey should be carried out using total station showing all the topographical features both upstream and downstream of the proposed site up to 200 to 500 meters on either side of the river.
b) The plan and the cross-section of the river along the proposed bridge site should be generated using the above survey data. The Highest Flood Level (HFL), Ordinary Flood Level (OFL) and Low Water Level (LWL) should be clearly indicated.
c) The nature of the stream whether perennial, seasonal or tidal.
d) The nature of the river bed.
e) The type of river bed materials.

f) Catchments Area and Run-off Data.
g) Geological Data.

Section 3: Sub - Soil Investigation

In order to determine the nature of the soil through which the substructure and the foundation of the proposed bridge will pass and on which the foundations will rest, the sub-soil investigation is necessary. Both preliminary and the detailed sub-soil investigation are generally undertaken at the proposed pier or abutment location.

Core Drilling at Bridge Foundations

The purpose of carrying out the sub-soil investigation is to get the following information:

a) Nature of the soil deposit up to sufficient depth (usually 1.25 to 1.5 times the proposed depth of foundation from bed level)

b) Thickness and composition of each soil layer.

c) Thickness and composition of rock (if rocky strata are available)

d) The engineering properties of the soil and the rock strata required for the design of bridge foundation.

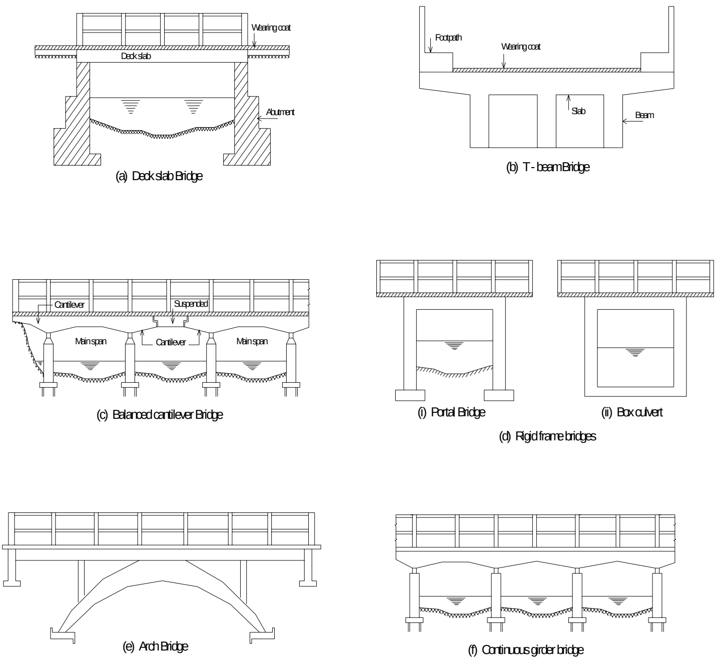
Core Samples from Drilling

Based on the sub-soil investigation report the type of foundations, depth of foundations, etc. are decided. The type of bridge to be constructed for a particular location is also decided based on the sub-soil report.

Section 4: Classification of Highway Bridges

Highway bridges are classified from various considerations such as:

a) Life span of the bridge – temporary, permanent, semi-permanent bridge.
b) Purpose of the bridge – viaduct, road over bridge, swing bridge and lift bridge.
c) Span of the bridge – minor, major and long span bridge.
d) Load carrying capacity of the bridge – Class B, Class A and Class AA Bridge.



Type of Bridges

e) Material of construction of the bridge – timber, masonry, RCC, pre-stressed, steel, composite bridge.

f) Span arrangement of the bridge – simply supported, continuous, cantilever, balanced cantilever bridge.
g) Structural arrangement of the bridge – slab, girder, box cell, box girder, portal frame, arch, plate girder, trussed girder, cable stayed and suspension bridge.

Section 5: Selection of Type of Bridge

The selection of the type of bridge to be adopted requires careful examinations of all the factors governing economy, safety, durability, availability of materials and equipment, maintenance cost, etc. The selection of particular bridge type depends on the following considerations:

a) Channel characteristics i.e. bed materials, depth of water, scour depth, etc
b) Hydraulic data – velocity, design discharge, etc
c) Soil condition and its load bearing capacity
d) Frequency and duration of flood
e) Traffic volume
f) Availability of funds
g) Availability of labour and materials and their unit cost
h) Time period of construction
i) Transport and erection facilities available
j) Strategic considerations
k) Aesthetic considerations
l) Maintenance cost

Section 6: Economy and Aesthetics

The fundamental objectives of bridge design are safety, serviceability, economy and elegance. A design can be considered successful only when all four of these goals have been achieved. Safety and serviceability are achieved through the systematic application of scientific principles. Economy and elegance, on the other hand, are achieved through nonscientific means which depend on the creativity of the engineer.

6.1 Life-cycle costs

The cost-effectiveness of bridges cannot be judged on the basis of construction cost alone. Bridge costs are best compared on the basis of life-cycle cost which is the total cost of construction, operation, amortization, and demolition, including the costs and benefits arising from changes in existing traffic patterns. Reducing the consumption of materials during construction through optimization of span lengths and cross-section dimensions will have little effect on the total life-cycle cost.

6.2 Construction costs

The construction cost of a concrete bridge can be broken down into the following structure:

1. Mobilization
2. Structure
   - Substructure
     - Foundation
     - Piers, abutments
   - Superstructure
     - False work, formwork
     - Materials
       - Concrete
       - Reinforcing steel
       - Pre-stressing steel
3. Accessories
4. Design and construction management

Mobilization is the work required before construction can begin, such as providing access to the construction site, preparation of site facilities, procurement of equipment, etc. Accessories include bearings, expansion joints, drainage system, guardrails, deck waterproofing system, and wearing surface.

6.3 Aesthetics

Aesthetically pleasing bridges are distinguished by transparency, slenderness and the lack of unnecessary ornamentation, all of which result in an efficient use of materials. Elegance in bridge design is considered as a function of both abstract structural form and the relationship between structural form and environment. Structures that are aesthetically pleasing as independent objects are not always suited to their surroundings. Therefore, the appearance of a proposed design must be evaluated from all possible viewpoints.

Section 7: Highway Bridge Loading

The following loads, forces and stresses shall be considered in the design of road bridges and all members shall be designed to sustain safely the effect of various loads, forces and stresses that may act together.

a) Dead load
b) Live load
c) Impact or dynamic effect of live load
d) Wind load
e) Longitudinal forces caused by the tractive effort of vehicles or by braking of vehicles and/ or those caused by restraint to movement of free bearings.
f) Centrifugal force
g) Seismic forces
h) Temperature stresses
i) Secondary stresses
j) Erection stresses

The loadings as well as design criteria are laid down by the Indian Roads Congress (IRC) Codes of practice.

Section 8: Temporary and Low Cost Bridges

8.1 Temporary Bridges

Temporary bridges are used in less important roads where the traffic is less and the loading is light. Sometimes due to shortage of fund, temporary bridges are constructed which are later replaced with permanent bridges when fund permits. It is also widely used during war when a channel or a river has to be crossed by the military for the movement of troops, ammunitions and food supply. Timber bridges, Bailey bridges and Callender-Hamilton bridges are few examples of temporary bridge.

8.2 Timber Bridge

Timber Bridge

The temporary bridges on less important road or on a diversion during replacement of an existing bridge or as fair-weather bridges are usually of timber construction. It is also used in forest roads where timber is found in plenty and at cheaper cost. The timbers used for bridge works shall be seasoned and treated with preservatives such as creosote oil. The design shall be based on safe working stresses for tension, compression and bending of a particular type of timber.

8.3 Bailey Bridge

Bailey bridges were designed during the Second World War and extensively used in military operation as temporary bridges. These bridges are also used as semi-permanent bridges. This is a steel truss bridge of 'through' type having steel panels of 3050 mm long and 1450 mm high. These panels are of welded construction and are pin-jointed to adjacent panels. As the span increases, the panels are arranged both side by side or one above the other to increase the load carrying capacity.

Bailey Bridge with steel decking

The bridge is designated according to the number of trusses and stories by which the bridge girders are formed. The first word indicates number of trusses side by side and the second word indicates number of panels one above the other. For example ‘single single (SS)’ indicates single truss one storied. Similarly, ‘tripple double (TD)’ indicates three trusses side by side having two stories. Heaviest girder is the ‘tripple tripple (TT)’ with three trusses side by side and three storied trusses.

8.4 Bailey Suspension Bridge

This type of bridge is suitable for hilly terrains where intermediate pier is not possible as in deep rivers. Its span varies from 200 feet to 400 feet (61 meters to 122 meters) and has restricted load carrying capacity of only 18 tons. It has four main components – span, cable, tower and anchorage parts.

Bailey Suspension Bridge

Once the foundation is complete, towers are erected by constructing a false base using Erection Davits, Winch, etc. Cables are then passed over the saddle and tied with the anchorage through the Twewhella Grabs. The launching of stiffening girder of SS construction is carried out from both ends simultaneously using two main cables, on each side of bridges, to support the ends of span through rope trolleys.

8.5 Callender-Hamilton Bridge

Callender – Hamilton Bridge

Callender-Hamilton Bridges were originally designed for the army to carry military loadings. This type of bridge covers a span of 12.0 m to 42.0 m and is a ‘through type’ truss like Bailey bridge and is also used as semi-permanent and permanent bridge. These bridges are constructed in multiples of 3.0 meters. The total load carrying capacity of these bridges varies from 18 tonnes to 30 tonnes vehicle.

It is erected using temporary intermediate supports or by launching from one bank to the other like Bailey bridges.

8.6 Low Cost Bridges

These types of bridges are constructed when sufficient funds are not available. The temporary bridges also come under this category. The two types of low cost bridges are causeways and submersible bridges.

(i) Causeways

Causeways are constructed under the following circumstances:

- When the importance of the road is not much and the stream carries little or no water during dry seasons and small discharge during monsoon.
- The flood discharge in the stream flows only for small duration.
- In hilly roads where small water courses cross the roads at frequent intervals.

(ii) Submersible Bridges

In submersible bridges, ordinary floods will pass below the bridge deck and high floods will pass over the deck. It is used when economy has to be achieved for shortage of funds and the choice is between low cost bridge and no bridges at all.

Section 9: Abutments

The piers and abutments are the supporting members through which the loads from the superstructure are transferred to the foundations. The abutments also function as earth retaining structures in addition to transferring the vertical and horizontal loads from the superstructure to the foundation.

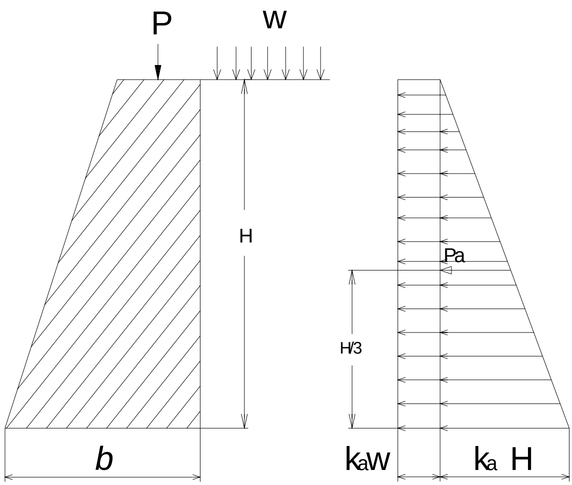
Bridge abutments can be made of stone masonry, plain concrete or reinforced concrete. The layout of the piers and abutments should be provided with semicircular cutwaters to facilitate streamlined flow and to reduced scour.

9.1 Design consideration for Abutments

In abutment design, the forces to be considered are:

1) Dead load due to superstructure.
2) Live load on the superstructure.
3) Self weight of the abutment.
4) Longitudinal forces due to tractive effort and braking and due to temperature variation.
5) Horizontal force due to wind on superstructure.
6) Active earth pressure at the back including live load surcharge effect.

Of all the above forces, the earth pressure is the most difficult to compute correctly. The magnitude of earth pressure varies with the character of the material used for backfill, the moisture content, etc. It is important in abutment construction to place the fill material carefully and to arrange for its proper drainage.



Abutment with surcharge load and pressure diagram

The following are the modes of failure of the abutments:

a) Overturning

There must be sufficient margin of safety against overturning of the abutments as a whole about the toe. This may be given by,

$$\frac{\sum M_s}{\sum M_o} \geq 2.0$$

Where $\sum M_s$ = sum of all the stabilizing moments about toe

$\sum M_o$ = sum of all the overturning moments about toe

b) Sliding

The tendency of the abutments to sliding due to the horizontal force is resisted by μV, where μ is the coefficient of friction between the soil and the base of foundation and V is the total vertical load on the foundation. Adequate factor of safety against failure should be allowed. Let H be the total horizontal sliding force and V be the total vertical load. For stability,

$$\frac{\mu V}{H} \geq 1.5$$

In the absence of elaborate tests, the following values of μ may be adopted:

		μ
1)	Coarse grained soil without silt	0.55
2)	Coarse grained soil with silt	0.45
3)	Silt	0.35

In high abutments, the total earth pressures on the walls are comparatively high and the base friction μV may not be capable of resisting the sliding of the abutments. In such cases, shear key is provided below the base. Such a key develops passive pressure which resists completely the sliding tendency of the wall.

c) Soil Pressure

The intensity of soil pressure at the toe and heel is given by

$$p_1 = \frac{\sum W}{b}\left(1 + \frac{6e}{b}\right) \qquad \text{at toe}$$

$$p_2 = \frac{\sum W}{b}\left(1 - \frac{6e}{b}\right) \qquad \text{at heel}$$

Where $\sum W$ is the sum of all vertical forces, *e* is the eccentricity and *b* is the base width of the abutment.

p_1 at toe should not exceed the safe bearing capacity off the soil. Similarly, p_2 at heel should be compressive. If p_2 comes to be tensile, the heel will be lifted above the soil, which is not permissible. In an extreme case, p_2 may be zero where e = b/6. Hence in order that tension is not developed, the resultant should strike the base within the middle third.

9.2 Backfill behind Abutment

The backfill material should be of clean broken stone, gravel, sand or any other pervious material of adequate length to form a wedge of cohesionless backfill and should be compacted in layers. Cohesive backfill should be compacted in layers by rollers to maximum dry density at optimum moisture content.

Adequate number of weep wholes should be provided to drain out the water accumulated at the back of the abutments. The weep wholes should be made at a dip on the outer side for the facility of easy drainage. The back of the weep holes should be properly packed and protected with filter materials of varying sizes. Its spacing should not exceed one meter in both horizontal and vertical directions.

9.3 Approach Slab

Adequately reinforced concrete approach slab should be provided on the backfill. The slab should cover the full width of the roadway and extend for a length of not less than 3.5 m into the approach. The approach slab is usually 150 mm thick and is reinforced both ways.

9.4 Wing Walls

The wing walls are the most important structure in bridge works. It protects the abutments and approach roads from scouring. It is usually built of stone masonry or reinforced cement concrete depending on the site requirement. The minimum lengths of upstream and downstream wing walls are 6 m and 4 m respectively and oriented at 45° to the longitudinal axis of the bridge. However, the length and its orientation may be changed to suit the site requirement.

Section 10: Foundations

The design of foundations is an important part of the overall design for a bridge and affects to a considerable extent the aesthetics, the safety and the economy of the bridge. In order to design the foundation for a bridge, the designer must determine the following reasonably and accurately:

(i) the maximum likely scour depth,
(ii) the minimum grip length required,
(iii) the soil pressure at the base and
(iv) the stress in the structure constituting the foundation.

The foundation should be taken to a depth which is safe from scour, and is adequate from considerations of bearing capacity, settlement stability and suitability of strata at the founding level.

10.1 Scour at Abutments and Piers

The pattern of scour occurring at a bridge across a river depends on many factors including discharge, bed slope, bed material, direction of flow, and alignment of piers, their shape and size. Hence the prediction of scour depth is difficult. The mean depth of scour 'd_{sm}' in meters below the highest flood level may be calculated from the equation:

$$d_{sm} = 1.34\left(\frac{D_b^{\ 2}}{K_{sf}}\right)^{1/3}$$

Where D_b = the discharge in cumecs per m width. The value of 'D_b' shall be the maximum of the following:

(i) the total design discharge divided by the effective linear waterway between abutments or guide bunds, as the case may be.
(ii) the value obtained taking into account any concentration of flow through a portion of the waterway assessed from the study of the cross section of the river. Such modifications of the value may not be deemed applicable to minor bridges with l < 60 m.
(iii) actual observations, if any.

K_{sf} = the silt factor for a representative sample of the bed material obtained up to the level of the deepest anticipated scour and given by the expression $1.76\sqrt{d_m}$, 'd_m', being the weighted mean diameter in millimeters. The value of 'K_{sf}' for bed material normally recommended for various grades of materials are given below:

Type of bed material	*d_m weighted mean diameter of particle in mm*	*value of 'K_{sf}' silt factor*
fine silt	0.081	0.500

fine silt	0.120	0.600
fine silt	0.158	0.700
medium silt	0.233	0.850
standard silt	0.323	1.000
medium sand	0.505	1.250
course sand	0.725	1.500
fine gravel and sand	0.988	1.750
heavy sand	1.290	2.000

The maximum depth of scour (for design of foundation) below the highest flood level (HFL) at obstructions and configurations of the channel shall be estimated from the value of d_{sm} on the following basis:

1) For design of piers and abutments located in a straight reach and having individual foundations without any floor protections works:

   (i) in the vicinity of piers $2.00\ d_{sm}$

   (ii) near abutments
   - $1.27\ d_{sm}$ approach retained
   - $2.00\ d_{sm}$ scour all around

2) For the design of floor protection works, for raft foundations or shallow foundations, the following scour values shall be adopted:

   (i) in a straight reach $1.27\ d_{sm}$

   (ii) at a moderate bend $1.50\ d_{sm}$

   (iii) at a severe bend $1.75\ d_{sm}$

   (iv) at a right angled bend $2.00\ d_{sm}$

The values of scour depths may be suitably increased where actual observed data is available on similar structures in the vicinity of the proposed bridge.

10.2 Grip Length

Unless the foundations are rested on rock, adequate grip length (embedment) below the maximum scour level should be provided. The minimum required grip length is specified as one-third the maximum scour depth for road bridges. The purpose of grip length is to ensure stability under heavy flood conditions and to facilitate mobilization of passive pressure against horizontal forces.

Section 11: Bridges Built by Department of Roads

With increasing number of road networks within the country, DoR has built many bridges. Most of the bridges built are Bailey bridges which are replaced later with permanent ones. The Bridge Division has developed standard design drawings (concrete bridges) from 3 m to 20 m for the superstructure. The major bridges are built with funding from external agencies like JICA, Helvetas, Project Dantak, etc. One of the major bridges built recently by DoR is Daina Kuenphenzam, 320 m Bailey Suspension Bridge on Samtse – Sipsoo Road.

Daina Kuenphen Zam (Samtse), 320 m Bailey Suspension Bridge

The following are some of the major bridges built and being built in the country.

(a) Bridges Constructed under Japan Government Grant, Phase 1

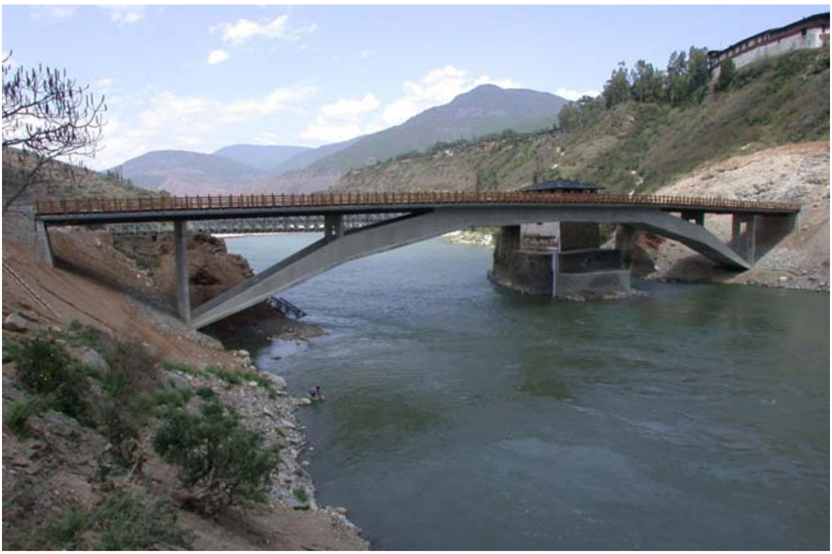
The Government of Japan has built 5 bridges in the country during the Phase 1 project. They are Chamkharzam at Bumthang, Mangdezam at Mangdichu, Bjeezam at Trongsa, Whacheyzam at Wangdue and Kurizampa at Mongar. The constructions of bridges were completed in the year 2003 and its average cost per unit length was Nu. 1,950,729/-. The Japan Government would be constructing 3 more bridges during Phase 2.

Mangde Zam (Zhemgang Dzongkhag), Steel Langer Arch, Span 95.2 m

Bjee Zam (Trongsa Dzongkhag), Steel Pony Truss, Span 43.0 m

(b)Punatshangchu Bridge at Wangdue (Funded by Helvetas)

This bridge was built with financial assistance from Helvetas. It is a 2 lane RC Polygonal Arch Bridge and its cost per unit length was Nu. 625,000/-.



Punatshangchu Bridge (Wangdue), RC Polygonal Arch, Span 120 m

(c) Three Bridges on Expressway Project (under construction)

There are three bridges being built on Thimphu – Babesa Expressway Project. These are 4 lane bridges funded by RGoB and is average cost per unit length is Nu. 727,806/-

Thimphuchu Bridge (Expressway), Continuous Girder Steel Arch, Span 78.0m

Semtorongchu Bridge (Expressway), Post-tensioned Box Girder, Span 43.5m

Ngabirongchu Bridge (Expressway), RC T-Girder Arch, Span 123.0 m

(d) Bridges Built by Project Dantak

The Project Dantak plays a major role in development of road network in our country. Apart from construction and maintenance of highways they had built many bridges. The following are some of the bridges built by Project Dantak.

Cha Zam (Trashigang Dzongkhag), Steel Truss Bridge, 90.0 m

Chunzom Bridge, Prestressed Concrete Cantilever Bridge, Span 77.0 m

Bondey Zam, (Paro Dzongkhag), Steel Truss Bridge, 67.0 m

Section 12: Inspection and Maintenance of Bridges

Periodical and a meaningful inspection of highway bridges is an important essential input for any useful and effective bridge management system for ensuring safe and uninterrupted flow of traffic. Tremendous economic loss and the likely public criticism resulting from any disruption due to the failure of a bridge or its acquiring “Highly Distressed” status requiring partial closure or load restriction do not warrant any neglect or laxity in maintenance of bridges. Therefore, regular inspection through well qualified and adequately experienced bridge engineers is essential.

The inspections could be classified as follows:

1) **Routine Inspection**
   It involves general examination of the structure, conducted on a regular basis, to look for obvious outward physical evidence of distress that might require repair or maintenance attention.

2) **In-depth Inspection**
   It requires detailed visual examination of all superstructures and substructures elements particularly incase of old bridges.

3) Special Inspection

It is undertaken after special events such as an earthquake, cyclone or passage of unusually heavy loads.

Some of the common locations of deficiencies are:

1) Deterioration and cracks in concrete
2) Evidence of foundation settlement and movement
3) Metalwork cracks
4) Loose connections
5) Damaged members
6) Poorly framed structural details
7) Indiscriminate past repairs
8) Excessive vibrations
9) Distress near expansion joints
10) Inoperative expansion bearings

Components like bearings, expansion joint, drainage spout, etc. should be maintained properly. The bearings have to be kept clean, free of dust and debris. The rockers, pins, rollers and sliding plate should be free of corrosion and should be lubricated periodically. Rattling of bearings under live load indicates loose bearings.

Expansion joints are to be checked for freedom of movement, proper clearance and correct vertical alignment. Substructure movement can cause closed or widely opened joints. Cracks are often found in the wearing coat in the neighbourhood of expansion joint. If such cracks occour, the reasons should be investigated and remedial measures taken up early.

Two bridge inspection forms (Form 1 and 2) are attached for the substructure and the superstructure respectively. It should be filled properly at the time of inspecting the bridges. Appropriate actions (if any) should be taken as per the report for the proper functioning of the bridge.

BRIDGE INSPECTION FORM

Form 1

	Name of Bridge	Field Division DoR	Dzongkhag	Crossing River/ Stream	Date dd/mm/yy
	Type of Bridge	**Span of Bridge**	**Name of Road**	**Inspected by:**	**Remarks**

SUBSTRUCTURE

	Component	Type of Structure	Cause of Damage		Present Condition	Judgement
1)	**Abutment**	(a) Masonry on Rock ( )	(a) Scouring ( )			
	(a) Left Bank ( )	(b) Masonry ( )	(b) Settlement ( )	1) (a)		
	(b) Right Bank ( )	(c) Concrete ( )	(c) Movement ( )	1) (b)		
2)	**Pier**	(d) Others ( )	(d) Cracking ( )			
	(a) Left Bank ( )		(e) Spalling ( )	2) (a)		
	(b) Right Bank ( )		(f) Exposure and corrosion	2) (b)		
3)	**Foundation**		of reinforcement ( )			
	(a) Left Bank ( )		(g) Wear of surfaces ( )	3) (a)		
	(b) Right Bank ( )		(h) Landslides ( )	3) (b)		
4)	**Wingwall**		(i) Slope failure ( )			
	(a) Left Bank ( )		(j) Others ( )	4) (a)		
	(b) Right Bank ( )			4) (b)		
5)	**Embankment**					
	(a) Left Bank ( )			5) (a)		
	(b) Right Bank ( )			5) (b)		

JUDGEMENT: A = GOOD, B = URGENT REPAIR; C = REPAIR IN FUTURE; D = RECONSTRUCTION

BRIDGE INSPECTION FORM

Form 2

	Name of Bridge	Field Division DoR	Dzongkhag	Crossing River/ Stream	Date dd/mm/yy
	Type of Bridge	**Span of Bridge**	**Name of Road**	**Inspected by:**	**Remarks**

SUPERSTRUCTURE

	Component	Type of Structure	Cause of Damage		Present Condition	Judgement
1)	**Beam/Girders**	(a) Masonry on Rock ( )	(a) Loose connections ( )			
		(b) Masonry ( )	(b) Excessive vibration ( )	1)		
		(c) Concrete ( )	(c) Movement ( )			
2)	**Deck Slab**	(d) Others ( )	(d) Cracking ( )			
			(e) Spalling ( )	2)		
			(f) Exposure and corrosion			
3)	**Bearing**		of reinforcement ( )			
	(a) Left Bank ( )		(g) Wear of surfaces ( )	3) (a)		
	(b) Right Bank ( )		(h) Damaged members ( )	(b)		
4)	**Expansion Joints**		(i) Inoperative expansion			
	(a) Left Bank ( )		bearings ( )	4) (a)		
	(b) Right Bank ( )		(j) Distress near expansion	(b)		
5)	**Trusses & Railings**		joints ( )			
			(k) Others ( )	5)		

JUDGEMENT: A = GOOD, B = URGENT REPAIR; C = REPAIR IN FUTURE; D = RECONSTRUCTION

Attachment 1

Bridge Division has developed Standard Design Drawings for Road Bridges from 3 meter to 72 meter span. The loading capacity of the bridge is 24 tons (240 kN). The following are the details of the standard bridges.

Sl.#	Bridge Type	Drawing No.	Span	Carriage Width	Remarks
1	Slab Bridge	SB1-5.5-03	3 m	5.5 m	
2	Slab Bridge	SB1-6.7-03	3 m	6.7 m	
3	Slab Bridge	SB1-5.5-04	4 m	5.5 m	
4	Slab Bridge	SB1-6.7-04	4 m	6.7 m	
5	Slab Bridge	SB1-5.5-05	5 m	5.5 m	
6	Slab Bridge	SB1-6.7-05	5 m	6.7 m	
7	Slab Bridge	SB1-5.5-06	6 m	5.5 m	
8	Slab Bridge	SB1-6.7-06	6 m	6.7 m	
9	Slab Bridge	SB1-5.5-07	7 m	5.5 m	
10	Slab Bridge	SB1-6.7-07	7 m	6.7 m	
11	Slab Bridge	SB1-5.5-08	8 m	5.5 m	
12	Slab Bridge	SB1-6.7-08	8 m	6.7 m	
13	Slab Bridge	SB1-5.5-09	9 m	5.5 m	
14	Slab Bridge	SB1-6.7-09	9 m	6.7 m	
15	Slab Bridge	SB1-5.5-10	10 m	5.5 m	
16	Slab Bridge	SB1-6.7-10	10 m	6.7 m	
17	Slab Bridge	SB1-5.5-11	11 m	5.5 m	
18	Slab Bridge	SB1-6.7-11	11 m	6.7 m	
19	Slab Bridge	SB1-5.5-12	12 m	5.5 m	
20	Slab Bridge	SB1-6.7-12	12 m	6.7 m	
21	Deck Girder Bdg.	SB2-5.5-14	14 m	5.5 m	
22	Deck Girder Bdg.	SB2-5.5-16	16 m	5.5 m	
23	Deck Girder Bdg.	SB2-5.5-18	18 m	5.5 m	
24	Deck Girder Bdg.	SB2-5.5-20	20 m	5.5 m	

Standard Bearings, Expansion Joint and Drainage Spout Drawings for Deck Girder Bridges:

Sl.#	Bridge Type	Drawing No.	Span	Carriage Width	Remarks
1	Standard Bearings	SB2-5.5-B	14 – 20 m	5.5 m	
2	Expansion Joint	EJ-1	14 – 20 m	5.5 m	
3	Drainage Spout	DS-1	8 – 20 m	5.5 m + 6.7 m	

For spans more than 20 meter we have Standard Steel Bridges from 24 to 72 meter. Following are the details of the standard steel bridges.

Sl.#	Bridge Type	Drawing No.	Span	Carriage Width	Remarks
1	Steel Truss Bridge	1224-A301 – A307	24.0 m	5.5 m	
2	Steel Truss Bridge	1224-B301 – B307	28.8 m	5.5 m	
3	Steel Truss Bridge	1224-C301 – C307	33.6 m	5.5 m	
4	Steel Truss Bridge	1224-D301 – D307	38.4 m	5.5 m	
5	Steel Truss Bridge	1224-E301 – E307	43.2 m	5.5 m	
6	Steel Truss Bridge	1224-F301 – F307	48.0 m	5.5 m	
7	Steel Truss Bridge	1224-G301 – G307	52.8 m	5.5 m	
8	Steel Truss Bridge	1224-H301 – H307	57.6 m	5.5 m	
9	Steel Truss Bridge	1224-I301 – I307	62.4 m	5.5 m	
10	Steel Truss Bridge	1224-J301 – J307	67.2 m	5.5 m	
11	Steel Truss Bridge	1224-K301 – K307	72.0 m	5.5 m	

References

1) Design and Construction of Highway Bridges by K.S. Rakshit

2) Essentials of Bridge Engineering by D. Johnson Victor

3) Reinforced Concrete Structures (Vol. II) by B.C. Punmia

4) Bridge Inspector's Reference Manual (IRC:SP:52-199)

5) GRSE Portable Steel Bridge – Technical Manual

"Bridging the Gaps"

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