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BHUTAN STANDARD

Draft Bhutan Standard on Road-Geometric Design and Alignment
Requirements



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FOREWORD

This Bhutan Standard for Road-Geometric Design and Alignment Requirements was developed by Bhutan Standards Bureau and adopted as Bhutan Standard after the draft finalized by the Civil Engineering Technical Committee TC01 and approved by the Bhutan Standards Bureau Board (BSB Board) on Day Month 2021.

This document is to be read in conjunction with relevant International codes.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS: 2-1960. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

This standard is subjected to systematic review after five years to keep pace with the market trends, industrial and technological developments or as and when deemed necessary. Any suggestions and further information may be directed to the concerned Technical Committee.

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**BHUTAN STANDARD FOR ROAD-GEOMETRIC DESIGN AND ALIGNMENT
 REQUIREMENTS**

1 Scope

This standard deals with two main aspects of road construction, namely, classification criteria and geometric design for the alignment of roads in Bhutan.

2 Normative References

The following documents are indispensable for application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including amendments) applies;

IRC 52: 2019-Guidelines for the alignment survey and geometric design of hill roads. (*Third Revision*)

IRC SP 73: 2018- Manual of specifications and standards for two laning of highways with paved shoulder. (*Second Revision*)

3 Terms and Definition

For the purpose of this standard, the following terms and definition shall apply;

3.1 Access Road

Access Roads refer to roads that provide access to various places and institutions such as Health Centres, Education Centres, Telecommunication Stations, Public Institutions, Private areas, etc.

3.2 Asian Highway

The Asian Highway Network (AH), also known as the Great Asian Highway, is a cooperative project among countries in Asia and Europe and the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), to improve the highway systems in Asia. Thimphu - Phuentsholing Highway has been designated as Asian Highway No. 48 (Class II). The design standards for Asian Highways in Bhutan shall be at least equivalent to the design standards of Primary National Highways (PNH).

3.3 Carriageway

Carriageway refers to the part of the road normally used for vehicular traffic.

3.4 Cross Drainage Structures

Cross drainage structures refer to those structures which allow water to pass from one side to other side of the road. They include structures such as bridges, culverts, hume-pipes, causeways, etc.

3.5 Design Speed

According to AASHTO, design speed is defined as the "the maximum safe speed that can be maintained over a specified section of highway when conditions are so favorable that the design features of the highway govern." Design speed is not necessarily the road's maximum safe speed. The highest design speed for a road or segment is the design speed of its least favorable part.

3.6 Drain

Drain includes a ditch, gutter, watercourse, bridge, culvert, tunnel and pipe.

3.7 Dzongkhag Road

Dzongkhag Roads are all internal roads within a Dzongkhag(s) including roads that connect a Dzongkhag Center and a Gewog Center; or, two Dzongkhag Centers not otherwise designated as national highway; or, a Gewog Center to an existing road of equal or higher classification.

3.8 Farm Road

Farm Roads are those roads that link farmland areas/villages to an existing road of equal or higher classification to enable the transportation of inputs to the farms and agriculture products to the market.

3.9 Formation width

Formation width is the sum of the widths of pavements or carriage way including separators, drains, space for debris collection and shoulders.

3.10 Hairpin bend curve radius

Hair pin bend refers to an acute curve (often one of a series) in a road, especially on a steep incline which causes a vehicle to turn 180°.

3.11 Horizontal curve radius

Road curves are irregular bends in roads that bring change to direction of the road gradually. Curves provided in the horizontal plane are known as horizontal curves.

3.12 National Highway

National Highways are designated roads that conform to the standards for national and international highway specified by the Department of Roads. There are three types of National Highways in Bhutan, namely Asian Highway, Primary National Highway and Secondary National Highway.

3.13 Primary National Highway

Primary National Highways are roads of strategic and economic importance. They can cater to traffic volume of over 200 commercial vehicles per day (CVPD). They should be of the shortest possible route between two designated places and have at least two lanes.

3.14 Road Batter Slope

Batter slopes in road refer to the road side slope on both the hill side and valley side of the road.

3.15 Road right of way

Road right of way refers to the strip of land reserved for future expansion of the carriageway.

3.16 Secondary National Highway

Secondary National Highway is a road with strategic importance

- i. which connects a Dzongkhag Center to a road of same or higher classification; or
- ii. which provides connectivity between two Dzongkhag Centers.

They should be the shortest possible route between two designated points and can cater to traffic volume of around 100-200 commercial vehicles per day.

3.17 Shoulder

Shoulder is the portion of the roadway contiguous with the traveled way that accommodates stopped vehicles, emergency use, and lateral support of subbase, base, and surface courses.

3.18 Sight Distance

The safe and efficient movement and operation of vehicular traffic on roads which depends on the longest distance a driver can see in front of him at any instance, is termed as sight distance.

3.19 Space for Debris collection

It is an additional space kept toward the hill side of the road to prevent road blockage by accommodating minor slips.

3.20 Thromde Road

Thromde Roads are those which fall within the municipal area but do not form a part of the National Highways.

4 Classification of Roads

As per Section 9 of the Road Act of Bhutan, 2013, Road Network in the country is classified into the following types:

- i. National Highway;
 - a. Asian Highway;
 - b. Primary National Highway;
 - c. Secondary National Highway;
- ii. Dzongkhag Road;
- iii. Thromde Road;
- iv. Farm Road; and
- v. Access Road

The details on how roads are classified into the above-mentioned categories can be found in the Road Classification and Network Information of Bhutan, 2020.

5 Terrain Classification

The geometric design of a highway is influenced significantly by terrain conditions. Terrain is classified by the general slope of the country across the highway alignment. The criterion for terrain classification is given in **Table 1**. While classifying a terrain, short isolated stretches of varying terrain should not be taken into consideration.

Table 1 Terrain classification

Terrain Classification	Cross Slope
Level (L)	0-10 %
Rolling (R)	10-25 %
Mountainous (M)	25-60 %
Steep (S)	>60 %

6 Design Speed

The Design Speed of 60, 50, 40, 30, 20, 15 and 10 kilometers per hour is used for roads in Bhutan. The relation between design speed, highway classification and terrain classification are as given below in **Table 2**.

Table 2 Design speed for different categories of Road for different terrains in kmph

Terrain	Primary National Highway	Secondary National Highway	Dzongkhag Road	Farm Road
Level (L)	60	50	40	30
Rolling (R)	50	40	30	25
Mountain (M)	40	30	20	15
Steep (S)	30	20	15	10

Note 1 - Asian Highways must conform to Asian Highway Standard and should at the least have the standards of a Primary National Highway

Note 2 - For Thromde Roads, the design speed depends on the terrain but generally it shall be taken as 30 kmph.

7 Sight Distance

For safety it is necessary that sight distance of adequate length should be available to permit drivers enough time and distance to control their vehicles. Sight distances at blind curves are usually governed by the distance required for stopping (stopping distance).

The safe stopping sight distance are calculated by adding up the lag distance (distance traveled the vehicle during the reaction) and braking distance (distance travelled by the vehicle after brakes are applied).

Therefore, safe stopping sight distance (SSD) = Lag distance + Braking Distance

$$SSD = 0.278 Vt + V^2 / (254f)$$

Where, V = speed in Km/h

t = reaction time in seconds

f = coefficient of friction

Considering reaction time as 2.5 seconds and coefficient of friction as 0.4, stopping distance for different road categories shall be given according to their design speed as given in **Table 3**;

Table 3 Safe stopping distance for different design speeds

SN	Design Speed (Km/h)	Safe stopping sight distance (m)
1	10	8
2	15	13
3	20	18
4	25	24
5	30	30
6	40	44
7	50	59
8	60	77

8 Cross Sections

8.1 Cross Sectional Features

Roads have the following cross-sectional features;

- i. Road right of way
- ii. Carriageway
- iii. Drain
- iv. Shoulder
- v. Space for Debris collection
- vi. Formation width

Formation width is the sum of the widths of pavements or carriage way including separators, drains, space for debris collection and shoulders.

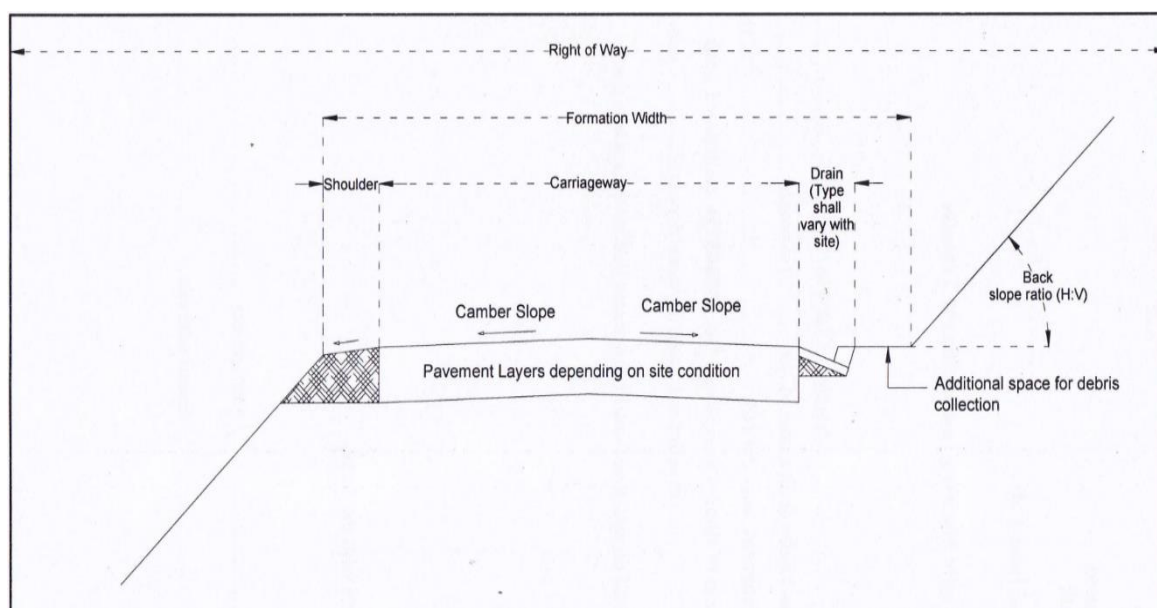


Fig 1 Typical Cross Section of a Road

8.2 Road Batter Slope

The angle of the road batter slopes depends on the type of slope material. The road batter slopes according to the slope material is given in **Table 4**.

Table 4 Cross Section Standards for Farm Road

Slope Material	Batter Slope
Hard Rock	1 V: 0.12 H
Soft Rock	1 V: 0.2. 5H
Hard Soil	1 V: 0.5 H
Ordinary Soil	1 V: 1 H

8.3 Cross Sectional Standards

The cross-sectional standards for different categories of roads are as given below;

8.3.1 Primary National Highway

The cross-sectional standards for different cases of Primary National Highway are given below in **Table 5**.

Table 5 Cross Section Standards for Primary National Highway

Cross Section Features	Road with Valley on one side and Hill on the other side (Typical Road)	Road with valley on both side (Embankment)	Road with Hill on both sides (Box cut)	Roads along Plain area
Right of Way (m)	30 m (50 ft or 15 m from centerline on either side of road)			
No. of Lanes	2	2	2	2
Carriageway (m)	5.5-7.5	5.5-7.5	5.5-7.5	5.5-7.5
Camber	On both side	On both side	On both side	On both side
Camber Slope (%)	2-4	2-4	2-4	2-4
Super Elevation (%)	<7	<7	<7	<7
Shoulder	1 m on valley side	0.5 m at both sides	No shoulder	0.5 m at both sides
Shoulder Slope (%)	4-6	4-6	NA	4-6
Drain	1 m on hill side	No drain	1 m on both sides	1 m on both sides
Debris Collection	1 m on hill sides	Not required	1 m on both sides	Not required
Formation Width (m)	8.5-10.5	6.5-8.5	9.5-11.5	8.5-10.5

Note 1 - Asian Highways must conform to Asian Highway Standard and should at the least have the standards of a Primary National Highway

Note 2 - Standard carriageway width is 7.5 m. Lower carriageway width can be adopted by the designer with instruction from the Department of Roads (DoR).

Note 3 - In exceptional case, the shoulder width can be reduced to 0.75 m and this will be based on the designer's judgement

Note 4 - The type of drain provided on the road will be decided by the designer based on the relevant rainfall and discharge data

Note 5 - 1-meter space for debris collection may be kept only wherever practicable.

8.3.2 Secondary National Highway

The cross-sectional standards for different cases of Secondary National Highway are given below in **Table 6**.

Table 6 Cross Section Standards for Secondary National Highway

Cross Section Features	Road with Valley on one side and Hill on the other side (Typical Road)	Road with valley on both side (Embankment)	Road with Hill on both sides (Box cut)	Roads along Plain area
Right of Way (m)	30 m (50 ft or 15 m from centerline on either side of road)			
No. of Lanes	1 intermediate lane	1 intermediate lane	1 intermediate lane	1 intermediate lane
Carriageway (m)	3.75-5.5	3.75-5.5	3.75-5.5	3.75-5.5
Camber	On both side	On both side	On both side	On both side
Camber Slope (%)	2-4	2-4	2-4	2-4
Super Elevation (%)	<7	<7	<7	<7
Shoulder	1 m on valley side	0.5 m at both sides	No shoulder	0.5 m at both sides
Shoulder Slope (%)	4-6	4-6	NA	4-6
Drain	1 m on hill side	No drain	1 m on both sides	1 m on both sides
Debris Collection	1 m on hill sides	Not required	1 m on both sides	Not required
Formation Width (m)	6.75-8.5	4.75-6.5	5.75-7.5	6.75-8.5

Note 1 - Industrial roads should at the least have the cross-sectional standard of a Secondary National Highway and the pavement thickness of a Primary National Highway.

Note 2 - Standard carriageway width is 5.5 m. Lower carriageway width can be adopted by the designer with the instruction from the Department of Roads (DoR).

Note 3 - In exceptional case, the shoulder width can be reduced to 0.75 m and this will be based on the designer's judgement

Note 4 - The type of drain provided on the road will be decided by the designer based on the relevant rainfall and discharge data.

Note 5 - 1-meter space for debris collection may be kept only wherever practicable.

8.3.3 Dzongkhag Road

The cross-sectional standards for different cases of Dzongkhag Road are given below in **Table 7**.

Table 7 Cross Section Standards for Dzongkhag Road

Cross Section Features	Road with Valley on one side and Hill on the other side (Typical Road)	Road with valley on both side (Embankment)	Road with Hill on both sides (Box cut)	Roads along Plain area
Right of Way (m)	18.3 m (30 ft or 9.15 m from centerline on either side of road)			
No. of Lanes	1	1	1	1
Carriageway (m)	3.5	3.5	3.5	3.5
Camber	On both side	On both side	On both side	On both side
Camber Slope (%)	2-4	2-4	2-4	2-4
Super Elevation (%)	<7	<7	<7	<7
Shoulder	1 m on valley side	0.5 m at both sides	No shoulder	0.5 m at both sides
Shoulder Slope (%)	4-6	4-6	NA	4-6
Drain	1 m on hill side	No drain	1 m on both sides	1 m on both sides
Debris Collection	1 m on hill sides	Not required	1 m on both sides	Not required
Formation Width (m)	6.5	4.5	5.5	6.5

Note 1 - In exceptional case, the shoulder width can be reduced to 0.75 m and this will be based on the designer's judgement.

Note 2 - The type of drain provided on the road will be decided by the designer based on the relevant rainfall and discharge data.

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Note 3 - 1-meter space for debris collection may be kept only wherever practicable.

8.3.4 Thromde Road

Thromde roads are further classified into:

- Primary Road,
- Secondary Road,
- Tertiary Road and
- Access Roads

The details on how this classification is done can be found in the Spatial Planning Standards, 2017 of Department of Human Settlement under MoWHS as well as in the Road Classification and Network Information of Bhutan, 2020 booklet. In thromde roads, additional cross-sectional features such as parking, cycling lane and pedestrian path can be found. Thromde roads must conform to the minimum standard given in **Table 8**.

Table 8 Minimum Cross Section Standards for Thromde Road

Cross Section Features	Primary Road	Secondary Road	Tertiary Roads	Access Road
No. of Lanes	2	2	1	1
Lane width (m)	3	3	3	3
Drain Width (m)	0.6	0.6	0.6	0.6
Pedestrian Path Width (m)	1.5	1.5	1.5	1.5
cycling lane width (m)	1.5	1.5	1.5	1.5
Parking width (m)	2.5	2.5	2.5	2.5
Road Right of way	Lane width + drain width + pedestrian path width + cycling lane width + parking width			

Note - It is up to the planner to decide on the requirement of higher no. of lanes for a road and to decide the requirements of drains, pedestrian path, cycling lanes and parking widths.

8.3.5 Farm Road

The cross-sectional standards for different cases of Farm Road are given below in **Table 9**.

Table 9 Cross Section Standards for Farm Road

Cross Section Features	Road with Valley on one side and hill on the other side (Typical Road)
Right of Way (m)	12.2 m (20 ft or 6.1 m from centerline on either side of the road)
Carriageway (m)	3.5
Camber	On one side
Camber Slope (%)	3-5
Super Elevation (%)	<7
Shoulder	0.8 m on valley side
Shoulder Slope (%)	4-6
Drain	0.8 m on hill side
Debris Collection	Not required
Formation Width (m)	5.1

8.3.6 Access Road

Access Roads at the least should have the standards of a Farm Road.

9 Horizontal Alignment

9.1 Horizontal curve radius

These horizontal curves shall have the minimum radius as given in **Table 10** as per the terrain and the category of road for the vehicle to transition on the road smoothly. The radius of a curve is measured based on the road's centerline.

Table 10 Minimum road curve radius for various category of road of different terrain classification in m

Terrain	Primary National Highway	Secondary National highway	Dzongkhag Road	Farm Road
Level (L)	115	75	75	15
Rolling (R)	80	75	25	15
Mountain (M)	50	25	15	12.5
Steep (S)	30	15	15	12.5

Thromde roads must have a minimum of 15 m curve radius

9.2 Hairpin bend curve radius

The relation between minimum curve radius at hair pin bends and road classification is given in **Table 11**.

Table 11 Limiting curve radius at hairpin bends for different category of roads

Road Category	Limiting curve radius at hairpin bends (m)
Primary National Highway	15
Secondary National Highway	15
Dzongkhag Road	12.5
Thromde Roads	12
Farm Road	12.5

9.3 Extra widening at curves

When a vehicle negotiates a horizontal curve, the rear wheels do not exactly follow the path of the front wheels. Their path is shifted towards the center of the curve in relation to the front wheels path. In curves the drivers of the vehicles have a tendency to keep a greater clearance between them as compared to the straight sections of the road. For that, the width of carriageway of roads at curves should be made wider than on the straight sections. In order to maintain a wider carriageway at the curve, extra widening is done at the curves and the width of the extra widening depends on the number of lanes of the carriageway and the radius of the curve. The amount of extra width to be provided on curves is given on **Table 12**.

Table 12 Extra width to be provided at the curves in m based on radius of the curve and no of lanes

Radius of Curve (m)	Up to 20	21 to 40	41 to 60	61 to 100	101 to 300	Above 300
Two-lane	1.5	1.5	1.2	0.9	0.6	Nil
Single-lane	0.6	0.6	0.6	Nil	Nil	Nil

9.4 Passing Places

Passing places are required on single lane hill roads to facilitate crossing of vehicles approaching from the other direction and to tow aside a disabled vehicle so that it does not obstruct traffic. They should be provided at the rate 3 numbers per kilometer.

In Bhutan passing places should be provided for Dzongkhag Roads and Farm Roads as well for Secondary National Highway and Access Roads which have a carriageway width lower than 4 m.

Nominal size of passing place is 3 m wide inclusive of the shoulder, 30 long on the inner edge and 20 m long on the outer edge.

10 Vertical Alignment

Road gradient is the ruling that has to be considered during the design of the vertical alignment of the road. Gradient simply refers to the steepness of a section of the road. The ruling, limiting and exceptional gradient for different category of road is given in **Table 13**.

Table 13 Ruling, Limiting and Exceptional gradient for different category of roads

Road Category	Ruling Gradient (%)	Limiting Gradient (%)	Exceptional Gradient (%)
Primary National Highway	5	8	10
Secondary National Highway	5	8	10
Dzongkhag Road	8	10	12
Thromde Roads	8	10	12
Farm Road	8	10	12

Note 1 - Ruling gradient is the maximum gradient with which the designer must attempt to design the vertical profile of the road.

Note 2 - Limiting gradient is the gradient steeper than the ruling gradient than the designer can use where the topography of the place compels it and where adoption of gentler gradient would add up enormously to the cost of the project.

Note 3 - Exceptional gradients very steep gradients the designer can adopt at unavoidable situations. These gradients shall not exceed continuously for more than 100 meters.

11 Pavement

The pavement thickness for all types of pavement should be designed by the designer taking into account of the projected traffic and the CBR of the soil. However, all pavement designs must fulfill the minimum pavement requirement for different categories of road. The minimum requirement for pavement is given in **Table 14**.

Table 14 Minimum pavement requirement for different categories of roads

Road Category	Pavement Requirement
Primary National Highway	Asphalt Concrete or Cement Concrete
Secondary National Highway	Asphalt Concrete or Cement Concrete
Dzongkhag Road	Asphalt Concrete or Cement Concrete
Thromde Roads	Asphalt Concrete or Cement Concrete
Farm Road	Fully compacted subgrade

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In case of flexible pavement, the pavement design shall include a minimum of the following layers as given in **Table 15** for different categories of roads.

Table 15 Minimum pavement layer requirement for different categories of roads for flexible pavement

Road Category	Pavement Requirement
Primary National Highway	GSB+WMM+DBM+AC
Secondary National Highway	GSB+WMM+AC
Dzongkhag Road	GSB+WMM+PMC/AC
Thromde Roads	GSB+WMM+PMC/AC
Farm Road	Fully compacted subgrade

Note 1 - GSB refers to Granular Sub Base

Note 2 - WMM refers to Wet Mix Macadam

Note 3 - DBM refers to Dense Bituminous Macadam.

Note 4 - AC refers to Asphalt Concrete

Note 5 - PMC refers to Premix Carpet

Note 6 - Industrial Roads must have pavement equivalent to that of Primary National Highway.

12 Cross Drainage Structures

Cross drainage structures refer to those structures which allow water to pass from one side to other side of the road. They include structures such as bridges, culverts, hume-pipes, causeways, etc. Every kilometer of roads must have a minimum of 5 cross drainages structures to allow water collected on one side to be passed down to the valley side of the road. The minimum size of cross drainage should be 1200 mm diameter hume-pipe.

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