Chapter 4

Regular Check on Road

4 Regular Check on Road

4.1 Risk Analysis of Road Slope Disasters

DoR engineers have had difficulty evaluating the risk of slope disaster and properly deciding the countermeasures due to lack of experience of slope disaster investigation. Therefore, a score rating system, which makes it easy to understand the risks and is commonly used in Japan, would be recommended for the evaluation. The score rating of the system has been confirmed to make it suitable for the evaluation results by the experts, incorporating the characteristics of the slope disasters in the targeted areas.

In this Project, the risk in road slope disaster in Bhutan has been analyzed by a quantification theory of one of the multiple statistical analysis methods based on the evaluation sheets created by JET. The result of the analysis is utilized for road disaster management in DoR.

4.1.1 Issues on the Regular Check

The issues on the regular check on the slope disasters on roads are summarized in Bhutan as follows:

- Factors which affect slope disasters are vague, so it is unclear which items need investigating in the field.
- Methodology of risk evaluation on slope disaster has not been established.
- Lack of geologists/geotechnical engineers to evaluate slope disaster risk.
- There is little rationale to determine the priority for countermeasures.

In order to solve those issues, we have discussed the risk of each slope disaster and identified the factors by using a quantification theory (type 1), which is a type of multivariate statistical analysis.

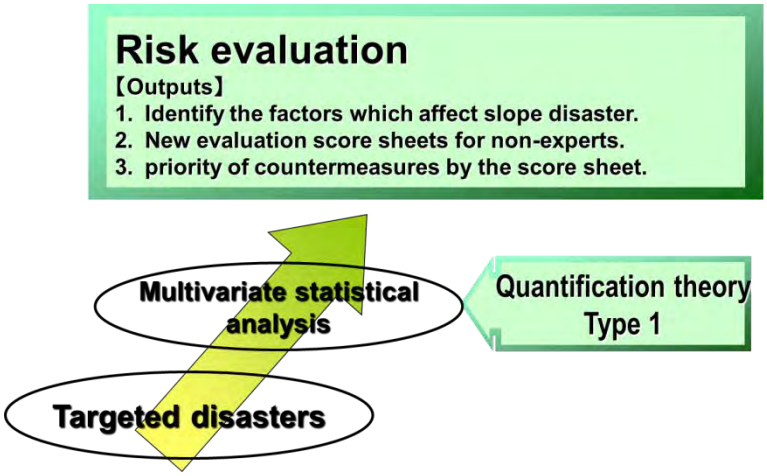


Figure 4.1.1 Schematic Figure of the Output of Quantification Theory (Source: JET)

The following outputs have been established by the analysis of the quantification theory in the Project.

- Identify the factors which affect slope disaster and their contribution quantitatively.
- Develop new evaluation sheets for DoR road engineers in Bhutan.
- Determine the priority for countermeasures by the evaluation sheets.

4.1.2 Method of the Risk Analysis

The basic factors of slope disasters do not only depend on topographic features and geological conditions, but also on water condition and slope disaster history. These items intricately affect the basic factors. A quantification theory which is one type of multivariate statistical analysis facilitates analyses for these kinds of intricate data. The quantification theory has four (4) types; I, II, III and IV, depending on dependent variables and explanatory variables.

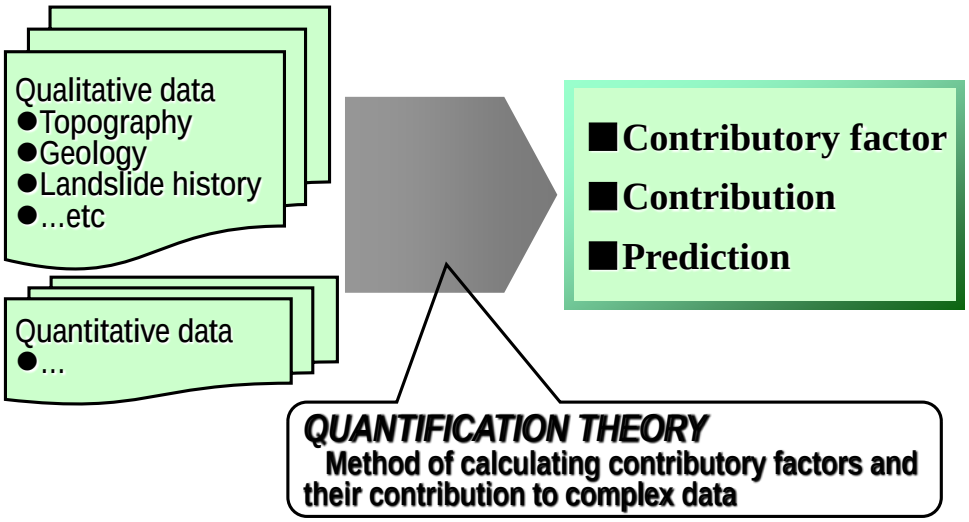


Figure 4.1.2 Methodology of Quantification Theory (Source: JET)

In the Project, JET and DoR have implemented the slope inspection for more than 450 sites on the national roads and divided the sites into three (3) ranks based on the risk for slope disasters as described in Chapter 3.5. The three (3) ranks of the evaluation have been used for analysis as dependent variables. JET and DoR have also checked the condition of topography, geology, water and disaster record, etc. in the evaluation sheets. The results of the evaluation sheets have been used for the analysis of the explanatory variables.

Item		factor	category of score		check	score
topography	Collapsed factor	talus slope, clear convex break of slope, eroded toe of slope , overhang, w ater catchment slope	3 or more correspondences			
			2 correspondences			
			1 correspondences		✓	
			no correspondence			
Geological conditions	Soil	susceptible to erosion less strength w ith w ater	marked			
			a little marked			
			None		✓	
	Rock	high density of cracks and a w eak layers, susceptible to erosion, fast w eathering	marked			
			a little marked		✓	
			None			
	Structure	dip slope of bedding plane	It corresponds.			
			None		✓	
		debris on impermeability bedrock, the upper part is a hard /the toe of slope is w eak.	marked			
			a little marked			
			None		✓	
Surface codition	Topsoil, detached rock and unsteady rock		instability			
			a little unstable		✓	
			stability			
	Spring w ater		notable spring w aster			
			seepage			
			none		✓	
	Surface condition		bare land w ith minor vagetation			
			intermediate (bare・grass・tree)		✓	
			mainly structure, mainly tree			
Profile	Height (H), dip (i)		height	H≧50m		
				30≦H＜50m		
				15≦H＜30m	✓	
				H＜15m		
			dip	i≧70°		
				45°≦i＜70°	✓	
				i＜45°		
Anomaly	Surface collapse, small fallen rock, gully, erosion, piping hole, subsidence, heaving, bending of tree root, fallen tree, crack, open crack, anomaly of countermeasure		2 or more correspondences・clarity			
			certain・unclarity		✓	
			none			
			sum total		(A)	

Figure 4.1.3 Example of the Result of the Evaluation Sheet (Source: JET)

4.1.3 Methodology of the Quantification Theory

The quantification theory type I enables quantitative dependent variables to be predicted based on various qualitative explanatory variables. Dependent variables are the desired result of analyses. Explanatory variable items affect dependent variables. In this case, the explanatory variables are not quantitative data but qualitative data such as photo interpretation, surface anomalies and geological structure, etc. On the other hand, the

dependent variable is the result of risk assessment which is classified into 1, 2 and 3 ranks, by the experienced engineers mentioned before. The dependent variable is also qualitative data for the quantification theory type I.

Items and categories of qualitative explanatory variables are as shown in the original disaster inspection sheets in the following table for the analysis.

Table 4.1.1 Example Item and Category for the Analysis (Source: JET)

Item	Category-1	Category-2	Category-3
Photo interpretation	Exists clearly	Exists clearly	Exists clearly
Surface anomalies	Significant crack/step	Slight deformation	No anomalies
Geological structure	Fault/fracture/dip slope	Undip slope/no feature	
Main rock of slope disaster	Colluvial deposit	Soft rock	Hard rock
Hydrological feature	Spring water/seepage	Surface water	No water observed
Existing record	Yes	No	
Damage on road/house	Yes	No	

In the quantification theory type I, each category should be allocated the numerical values so that the variable would be able to be calculated the same as a multiple regression analysis. The outline of the calculation method of quantification theory type I is described as follows;

Hypothetically, the dependent variable and the answer of the category for each item are shown in the following figure.

Data No. i	Item j / Category k / dependent variable	1				2				.....	R			
		1	2	…	c_1	1	2	…	c_2		1	2	…	c_R
1	y_1		○			○								○
2	y_2	○					○					○		
3	y_3				○				○	.....	○			
・	・			・				・					・	
・	・			・				・					・	
・	・			・				・					・	
・	・			・				・					・	
・	・			・				・					・	
n	y_n	○				○								○

Figure 4.1.4 Data Format on Quantification Theory Type I (Source: JET)

Here, dummy variables are assigned to indicate which data corresponds to which category on each item.

$$\delta_i(jk) = \begin{cases} 1 \text{----In case that data i corresponds to Category k on Item j} \\ 0 \text{---In case of others} \end{cases}$$

In the table above, the data No.1 is $\delta 1(11)=0$, $\delta 1(12)=1$,----, $\delta 1(1c_1)=0$, $\delta 1(21)=1$, $\delta 1(22)=0$,----, $\delta 1(2c_1)=0$, ----, $\delta 1(R_1)=0$, $\delta 1(R_2)=0$, *and* $\delta 1(Rc_R)=1$. Based on this data, the

following formula on the dummy variables is utilized to predict the dependent variables:

$$Y_i = a_{11}\delta_i(11) + a_{12}\delta_i(12) + \cdots + a_{RC_R}\delta_i(RC_R)$$

$$= \sum_{j=1}^{R} \sum_{k=1}^{cj} a_{jk}\delta_i(jk)$$

a_{jk} is a weighting factor of Category k on Item j, which is generally called a category score. a_{jk} should be calculated to match the predicted value Y_i to the actual value y_i, i.e. the following value should be minimized by the least-square method which is the same as regression analysis.

$$\sum_{i=1}^{n}(y_i - Y_i)^2$$

The category score is a weighting factor of the items and directly affects the dependent variable. Therefore, a category range, which is defined as the difference between the maximum and minimum category score, is the degree of contribution to the dependent variable. To put it simply, the larger the category range of the item, the higher its contribution to the predicted value of the dependent variable.

A partial correlation coefficient, which is obtained with the above mentioned analyses, can be considered to be a correlation coefficient that does not influence other items. The partial correlation coefficient r is calculated as follows:

$$r = \frac{r_{xy} - r_{xz}r_{yz}}{\sqrt{1-r_{xz}^2}\sqrt{1-r_{yz}^2}}$$

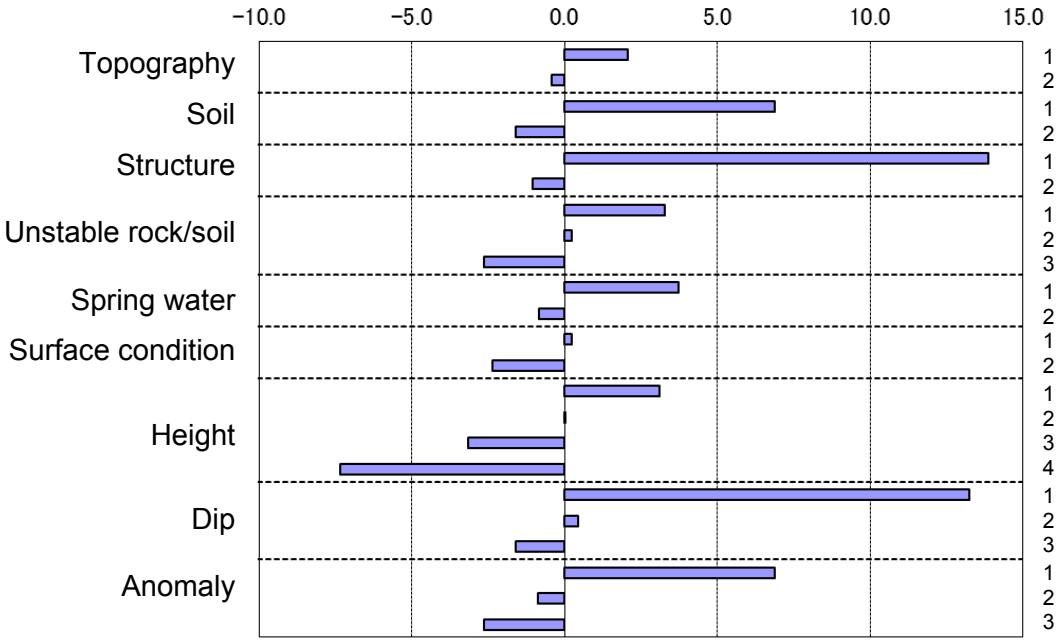
r_{xy}: correlation coefficient of variable X and Y
r_{xz}: correlation coefficient of variable X and Z
r_{yz}: correlation coefficient of variable Y and Z

4.1.4 Results of the Risk Analysis

a. Category Score and Partial Correlation Coefficient

The category score is indicated in the following figure. The score is a coefficient that correlates to the contribution of the item, and it influences the dependent variable directly. The hazard on slope disasters is large when the category score is high, and conversely is small when the category score is low.

The analysis assesses the hazard of each slope with disaster causes such as topographic features and geological conditions, and disaster history. As a result, factors and their contributions that affect the hazard on slope disaster have been ascertained.



	Topography	Geological conditions		Surface condition			Profile		Anomaly
	Collapsed factor	Soil	Structure	Unstable rock/soil (Topsoil, detached rock and unsteady rock)	Spring water	Surface condition	Height (H), dip (i)		Surface collapse, small fallen rock, gully, erosion, piping hole, subsidence, heaving, bending of tree root, fallen tree, crack, open crack, anomaly of countermeasure
	Talus slope, clear convex break of slope, eroded toe of slope, overhang, water catchment slope	Susceptible to erosion less strength with water	Dip slope of bedding plane				Height	Dip	
1	2 or more correspondences	marked	It corresponds.	instability	notable spring waster or seepage	bare land with minor vegetation or intermediate (bare/grass/ tree)	H≧50m	i≧70°	2 or more correspondences/ clarity
2	1 or less correspondences	a little marked or none	none	a little unstable	none	mainly structure, mainly tree	30≦H＜50m	45°≦i＜70°	certain/unclarity
3				stability			15≦H＜30m	i＜45°	none
4							H＜15m		

Figure 4.1.5 Category Score of Debris Slope Failure (Source: JET)

Category range and partial correlation coefficient on each item are indicated in the table below. The range is the difference between maximum and minimum values of the category score, and indicates the contribution of the dependent variable. In other words, an item with a large range has a greater effect when predicting the dependent variable. Partial correlation coefficient is the index that shows the contribution of each item on the dependent variable. The nearer the absolute figure of the partial correlation coefficient to 1.0, the higher the contribution to the dependent variable.

Table 4.1.2 Category Range and Partial Correlation Coefficient of Debris Slope Failure
(Source: JET)

Item	Category range		Partial correlation coefficient	
Topography	2.493	9th	0.063	8th
Soil	8.501	5th	0.219	5th
Structure	14.929	1st	0.244	1st
Unstable rock/soil	5.924	6th	0.097	7th
Spring water	4.571	7th	0.114	6th
Surface condition	2.586	8th	0.052	9th
Height	10.427	3rd	0.228	4th
Dip	14.855	2nd	0.236	2nd
Anomaly	9.508	4th	0.231	3rd

The results of the risk analysis for the slope disasters by the quantification theory are provided in the Appendix 13.

b. Development of Bhutanese Evaluation Sheets

JET proposes new evaluation sheets for the inspection of rock slope failure, debris slope failure and landslides, which are suitable to the conditions of geology and topography in Bhutan, by using a category score that directly affects the dependent variables. The scoring of the new evaluation sheet is based on the relative difference of the category score and has been adjusted as 100 points at a maximum.

After the Project, DoR could utilize the evaluation sheets and evaluate the risk of slope disasters on roads by checking the sheets and assigning scores (100 points maximum).

Each of the evaluation sheets are indicated in the following pages:

Management Number	T	R	0	1	R	F	0	0	1	0

Evaluation sheet (rock slope failure)

Mountain side

Inspector	Takeshi KUWANO
Organization	JICA Expert Team

[Causes] (A)

Item		factor	category of score		Point	score
topography	Collapsed factor	talus slope, clear convex break of slope, eroded toe of slope , overhang, water catchment slope	3 or more correspondences		10	
			2 correspondences		9	
			1 correspondences		6	
			no correspondence		-10	
Geological conditions	Soil	susceptible to erosion less strength with water	marked		16	
			a little marked		4	
			None		3	
	Rock	high density of cracks and a weak layers, susceptible to erosion, fast weathering	marked		8	
			a little marked		7	
			None		6	
	Structure	dip slope of bedding plane	It corresponds.		-	*
			None		-	
		debris on impermeability bedrock, the upper part is a hard /the toe of slope is weak.	marked		-	*
			a little marked		-	
			None		-	
Surface codition	Topsoil, detached rock and unsteady rock		instability		17	
			a little unstable		0	
			stability		-1	
	Spring water		notable spring waster		12	
			seepage		6	
			none		5	
	Surface condition		bare land with minor vagetation		7	
			intermediate (bare･grass･tree)		6	
			mainly structure, mainly tree		6	
Profile	Height (H), dip (i)		height	H≧50m	12	
				30≦H＜50m	10	
				15≦H＜30m	8	
				H＜15m	-4	
			dip	i≧70°	13	
				45°≦i＜70°	-2	
				i＜45°	-7	
Anomaly	Surface collapse, small fallen rock, gully, erosion, piping hole, subsidence, heaving, bending of tree root, fallen tree, crack, open crack, anomaly of countermeasure		2 or more correspondences･clarity		6	
			certain･unclarity		5	
			none		2	
			sum total		(A)	
					0	

* : No score

[Disaster type]

Rock slope failure	
Debris slope failure	

[Main check object]

Cut slope	
Natural slope	

[Countermeasure] (B) = (A) +α or (A) ×0

Effectiveness of existing countermeasures	point (α)	check
Potential slope failure are prevented enough, or, it is defended enough when it is generated.	×0	
Potential slope failure are considerably prevented, or it is considerably defended when it is generated.	−20	
Potential slope failure are partly prevented, or it is partly defended when it is generated. However, it is not enough for the remaining factors.	−10	
There is no countermeasure, or there is not effective even if countermeasures are not performed.	±0	

sum total (B)

[History] (C)

Level of disaster history	point	check
There is a history about large fallen rocks and slope failures that were obstacles to the road traffic after construction of recent measures.	100	
There is a history about large fallen rocks and slope failures that gets to the road though there is no obstacle to traffic.	70	
There is a history about small fallen rocks and slope failures that did not get to the road.	40	
No disaster records	0	
	(C)	

(D) =MAX (B,C)

Score in evaluation from cause	(B) 0
Score in evaluation from history	(c) 0
Among (B)&(C), large one.	(D)=MAX(B,C) **0**

[Overall judgment]

Rank	Response	Check
1	Countermeasure work is necessary.	
2	Though urgent countermeasure is not necessary, regular inspections are needed.	✓
3	Countermeasure work is not necessary.	

[Description]

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Figure 4.1.6 New Score of the Evaluation Sheet for Rock Slope Failure (Source: JET)

Management Number	T	R	0	1	R	F	0	0	1	0

Evaluation sheet (debris slope failure)

Mountain side

Inspector	Takeshi KUWANO
Organization	JICA Expert Team

[Causes] (A)

Item		factor	category of score		Point	score
topography	Collapsed factor	talus slope, clear convex break of slope, eroded toe of slope , overhang, water catchment slope	3 or more correspondences		6	
			2 correspondences		5	
			1 correspondences		3	
			no correspondence		2	
Geological conditions	Soil	susceptible to erosion less strength with water	marked		12	
			a little marked		1	
			None		0	
	Rock	high density of cracks and a weak layers, susceptible to erosion, fast weathering	marked		-	*
			a little marked		-	
			None		-	
	Structure	dip slope of bedding plane	It corresponds.		22	
			None		2	
		debris on impermeability bedrock, the upper part is a hard /the toe of slope is weak.	marked		-	*
			a little marked		-	
			None		-	
Surface codition	Topsoil, detached rock and unsteady rock		instability		8	
			a little unstable		3	
			stability		0	
	Spring water		notable spring waster		8	
			seepage		7	
			none		2	
	Surface condition		bare land with minor vagetation		3	
			intermediate (bare･grass･tree)		2	
			mainly structure, mainly tree		0	
Profile	Height (H), dip (i)		height	H≧50m	7	
				30≦H＜50m	3	
				15≦H＜30m	-1	
				H＜15m	-7	
			dip	i≧70°	21	
				45°≦i＜70°	4	
				i＜45°	1	
Anomaly	Surface collapse, small fallen rock, gully, erosion, piping hole, subsidence, heaving, bending of tree root, fallen tree, crack, open crack, anomaly of countermeasure		2 or more correspondences･clarity		12	
			certain･unclarity		2	
			none		0	
			sum total		(A)	
					0	

* : No score

[Disaster type]

Rock slope failure	
Debris slope failure	

[Main check object]

Cut slope	
Natural slope	

[Countermeasure] (B) = (A) +α or (A) ×0

Effectiveness of existing countermeasures	point (α)	check
Potential slope failure are prevented enough, or, it is defended enough when it is generated.	×0	
Potential slope failure are considerably prevented, or it is considerably defended when it is generated.	−20	
Potential slope failure are partly prevented, or it is partly defended when it is generated. However, it is not enough for the remaining factors.	−10	
There is no countermeasure, or there is not effective even if countermeasures are not performed.	±0	

sum total	(B)

[History] (C)

Level of disaster history	point	check
There is a history about large fallen rocks and slope failures that were obstacles to the road traffic after construction of recent measures.	100	
There is a history about large fallen rocks and slope failures that gets to the road though there is no obstacle to traffic.	70	
There is a history about small fallen rocks and slope failures that did not get to the road.	40	
No disaster records	0	
	(C)	

(D) =MAX (B,C)

Score in evaluation from cause	(B) 0
Score in evaluation from history	(c) 0
Among (B)&(C), large one.	(D)=MAX(B,C) **0**

[Overall judgment]

Rank	Response	Check
1	Countermeasure work is necessary.	
2	Though urgent countermeasure is not necessary, regular inspections are needed.	✓
3	Countermeasure work is not necessary.	

[Description]

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Figure 4.1.7 New Score of the Evaluation Sheet for Debris Slope Failure (Source: JET)

Mangement number	T	R	0	1	R	F	0	0	1	0

Evaluation sheet (landslide)

Inspector	Takeshi KUWANO
Organization	JICA Expert Team

[Main body of landslide]

Mountain side	
Valley side	
Both	

[Causes] (A)

category			Point	score
Topographical factor	Result of photo interpretation	exist clearly	10	
		exist but partial and not clear	9	
		exist but not clear	6	
	Surface anomalies	large and new cracks, steps and subsidence	47	
		small and old cracks, steps and subsidence	7	
		slight deformation	-2	
		no anomalies	-6	
Geological conditions	Geological structure	fault, fracture zone	3	
		dip slope	4	
		undip slope/ no characteristic feature	11	
	Main rock formation of landslide body	metamorphic rock (schist, quartzite, phyllite etc.)	7	
		sedimentary rock (sandstone, limestone etc.)	-5	
		igneous rock (granite etc.)	0	
		quaternary deposit (colluvial deposit etc.)	20	
	Hydrological feature	much springs / much seepage	12	
		little springs /little seepage	11	
		trace of water	10	
		no water observed	2	
	sum total (maximum points:100)		(A)	0

[History] (B)

category			point	score
Records of Landslide	Existing record (documents or patrimony)	obvious	100	
		slight	75	
		none	0	
	Damage on road facilities and houses	obvious	100	
		slight	75	
		none	0	
	sum total (Among aboved scores, large one.)		(B)	0

(C)=MAX(A,B)

Score in evaluation from cause	(A)	0
Score in evaluation from history	(B)	0
Among (B)&(C), large one.	(C)=MAX(A,B)	0

[Countermeasure] (D) = (c) + α or (c) x 0

category		point (α)	check
There is no countermeasure		±0	
Effectiveness of countermeasure	No effect	±0	
	Some effect	-30	
	High effect	x0	
sum total		(D)	

[Overall judgment]

Rank	Response	Check
1	Countermeasure work is necessary.	
2	Though urgent countermeasure is not necessary, regular inspections are needed.	
3	Countermeasure work is not necessary.	

[Description]

Figure 4.1.8 New Score of the Evaluation Sheet for Landslide (Source: JET)

4.2 Preparation of Regular Check Sheet

4.2.1 Regular Check format

Regular checks are conducted for slope sites where the rank of overall judgment by the inspection is either “1” or “2”. These checks utilize maintenance and management for slope disaster.

Regular checks for slope disaster on roads are a management method which reduces the risk on roads. It is used to check the slope disasters such as rock slope failure, debris slope failure, landslides and debris flow by engineers with regular check sheets.

By using regular check sheets, engineers are able to find anomalies and events which may be connected to rock slope failure, debris slope failure, landslides and debris flow, before slope disaster happens. Furthermore, it is necessary to judge the safety and stability by grasping deterioration conditions on roads because roads and natural slopes are disintegrating year after year.

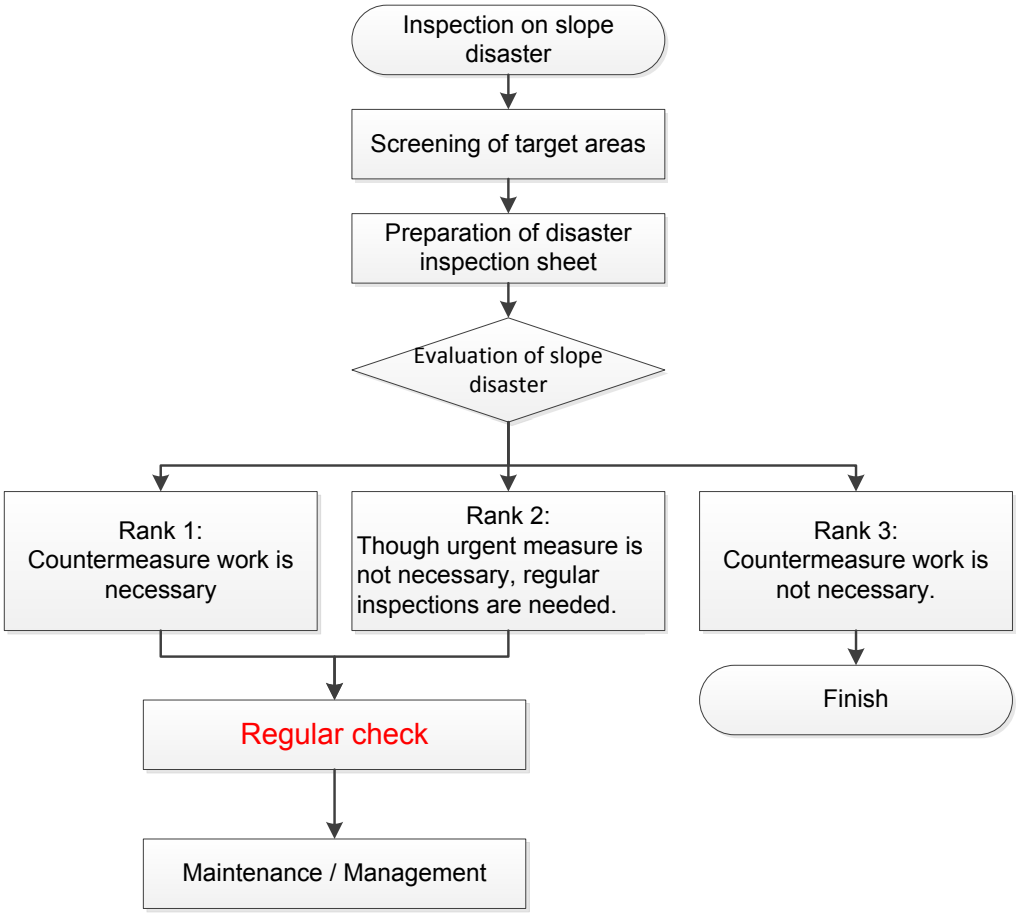


Figure 4.2.1 Positioning of Regular Check for Slope Disaster on Roads (Source: JET)

Forms that are as simple and easy to use as possible are developed on the basis of the Japanese forms. All the necessary information needs to be filled in on the form according to the condition of the road slopes in Bhutan. Fixed-point photographic observation should be

used to record findings and changes in the field.

There are three (3) check sheets:

- Regular check sheet A (general information),
- Regular check sheet B (results of the check), and
- Photo sheet

a. Regular Check Sheet A (general information)

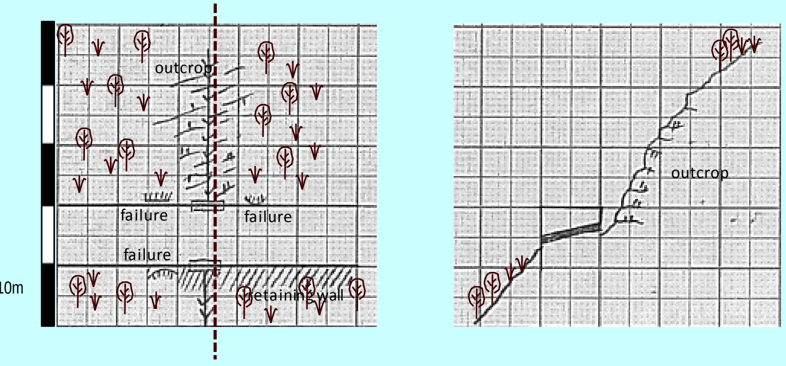
Regular check sheet A is the one to describe the general attributes such as management office, road type/No., latitude and longitude, full view photo/schematic sketch, location map, disaster type, estimated disaster volume, proposed countermeasures, and judgment.

Format of the sheet is common among the four (4) types of disaster. Summary of the site conditions are shown on the sheet. The blue shaded areas of the sheets in the following figure shall be described in the regular checks Users can gain a rough understanding of the site situation from this sheet.

Regular Check Sheet A

Management office	*Trongsa*				Road type/name	*Primary National Highway*	*No.1*	
Management No.	*T R 0 1 D F 0 0 4 0*	Distance from start point	km from	*Trongsa*	Length on road *10* m	latitude *N 27°27'15.6"*	longitude *E 90°23'46.4"*	
Inspector	*Takeshi KUWANO*	Organization	*JICA Expert Team*		Date	*February/ 9/ 2015*		

Schematic sketch	Road slope	**Mountain side**	**Valley side**
	Disaster type	*Debris flow*	
	Judgment	***Rank 2***	
	Estimated disaster volume	*Damage to the box culvert.*	
	To be checked	*①Enlarged crack on rock slope, Erosion of unstable rock* *②New/enlarged step/cliff* *③Increased spring water* *④New/enlarged step/settlement on road* *⑤Clogged drainage*	
	Timing of regular check	*- After rainy season (every October)* *- Heavy rainfall (ex. 2-3 days continuous rainfall)* *- Big earthquake*	
Location map (S = 1:50,000)	Environmental & social consideration	*- Noise and vibrations by construction.* *- Interception of wild animals/livestocks/habits* *- Discharge of sediment by construction*	
	Proposed counter-measures (Type, Quantity)	*Repair of the box culvert.*	



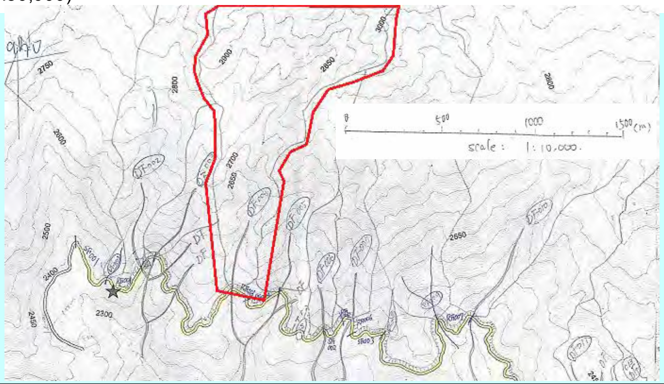


Figure 4.2.2 Example of Regular Check Sheet A (Source: JET)

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b. Regular Check Sheet B (Results of the Check)

The regular check sheet B is filled in when engineers check the targeted slope on site. The procedure of the description of the check sheet is as follows. Also an example of the check sheet is shown in the figure below.

The description of Management office, Management number, Road designation, Location, Distance, Disaster, Address, Landmark, Latitude and Longitude is the same as the disaster inspection sheet mentioned before. The date when engineers check the targeted slope at site is filled in.

The overall condition and situation of potential disasters and roads are described in "Condition" as quantitative as possible. To quantitatively grasp the progress of anomalies such as cracks, steps and volume, measurements of the width, length and height with rulers is effective on a regular basis.

Countermeasures and remedial actions to control/restrict the slope disasters are proposed in "Proposed remedial action". The engineers should describe countermeasures he/she propose at the site even if the proposed countermeasures would be modified after detailed investigation.

Points to be described are as follows:

- Rock slope failure: progress and anomalies of potential rock slope failure such as new rockfall(s), enlarged crack(s) on rock slope and erosion of unstable rock(s), which can affect the road and its traffic, are checked.
- Debris slope failure/landslide: progress and anomalies of potential debris slope failure/landslides such as new failure(s), swelling, new/enlarged step(s)/cliff(s) and new/enlarged crack(s) on slope, which can affect the road and its traffic, are checked.
- Debris flow: progress and anomalies of potential debris flow such as filling up of debris sediment, overflow of debris on road, clogged culvert and new failure(s) on river slope, which can affect the road and its traffic, are checked.
- Spring water: anomalies of spring water such as depletion, decrease, increase, new spring and turbidity, which are highly connected with slope disaster activities, are checked.
- Road: anomalies of road surfaces such as new/enlarged step(s)/settlement(s) and new/enlarged crack(s) on roads, which are related with slope disaster activities, are checked.
- Countermeasures: anomalies of existing countermeasures such as damage, deformation, clogged drainage and overflowed drainage are checked.
- Other problems: anomalies other than those above are described.

Regular Check Sheet B

Management office	*Trongsa*													Road type/name	*Primary National Highway*		*No.1*		
Management No.	*T*	*R*	*0*	*1*	*D*	*F*	*0*	*0*	*4*	*0*	Distance from start point	*0*	km from	*Trongsa*	Length on road	*10*	m	latitude	*N 27°27'15.6"*	longitude	*E 90°23'46.4"*
Mountain side	*Debris flow*										*Rank 2*			**Valley side**	*0*			*0*			

Date	*June 18, 2015*					
①Enlarged crack on rock slope, Erosion of unstable rock	*small rock fall at the bottom*					
②New /enlarged step/cliff	*None*					
③Increased spring w ater	*None*					
④New /enlarged step/settlement on road	*None*					
⑤Clogged drainage	*None*					
Checker	*Takeshi KUWANO*					
Condition	*Several small rock falls (20-30cm) were found at the bottom of the slope. However, no bad effect to the road.*					
Proposed remedial action	*No problem* *No need remedial action*					

Figure 4.2.3 Example of Regular Check Sheet B (Source: JET)

KOKUSAI KOGYO CO., LTD.
EARTH SYSTEM SCIENCE CO., LTD.
ORIENTAL CONSULTANTS CO., LTD.
OYO INTERNATIONAL CORPORATION

c. Photo Sheet

The photo sheet is composed of at least the following photos;

- Front view of the target slope
- Side view of the target slope with road
- Notable findings (anomalies) on the site
- Slope surface conditions
- Existing countermeasures
- Stream from top of debris flow
- Stream from bottom of debris flow
- Full view of upstream of debris flow
- Full view of downstream of debris flow
- Crossing point of road and stream from upstream of debris flow
- Crossing point of road and stream from downstream of debris flow

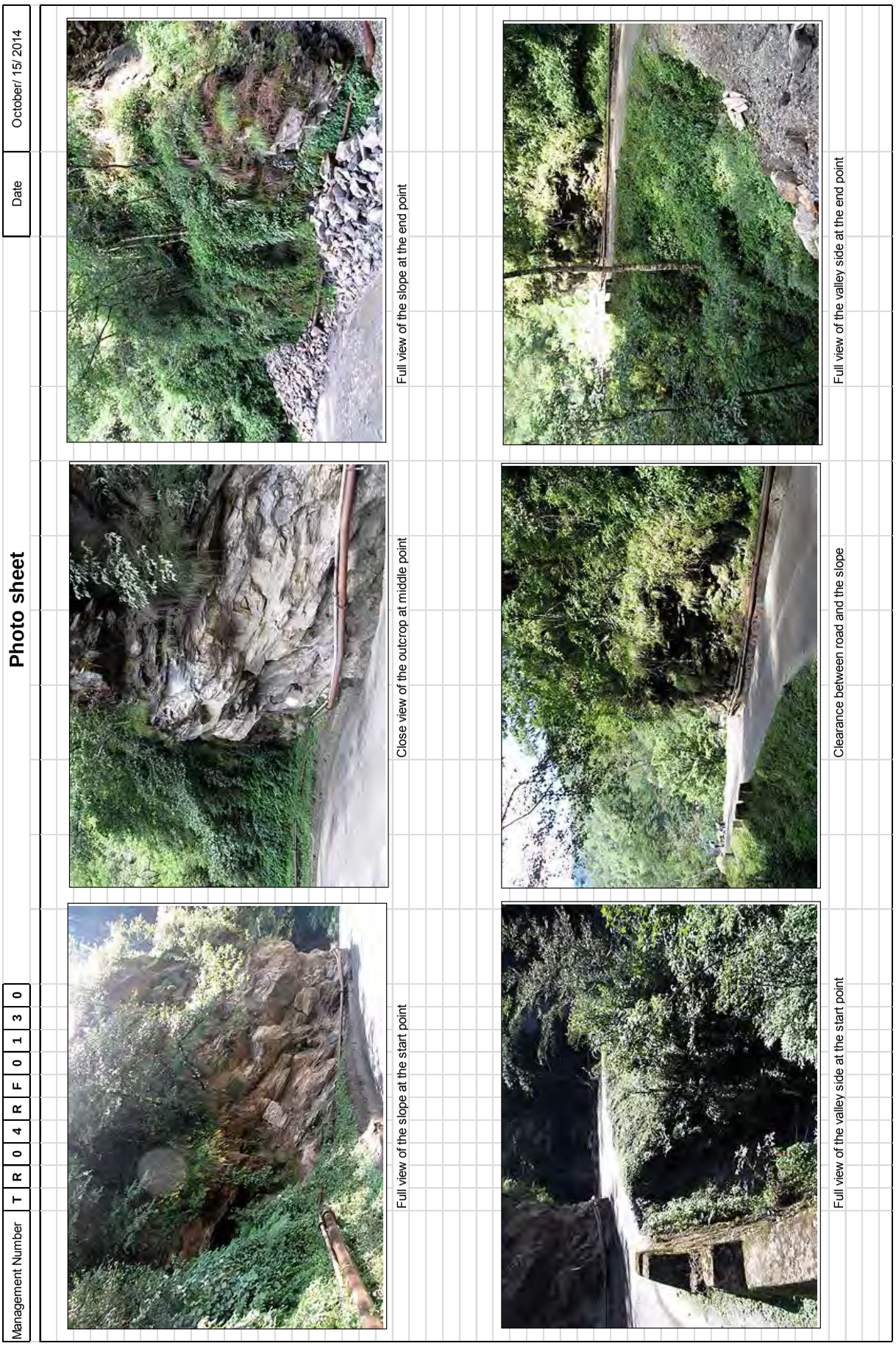


Figure 4.2.4 Example of Photo Sheet for Regular Check (Source: JET)

4.2.2 Preparation of Regular Check Sheet

Type, scale and risk of the slopes have been classified through the road slope inventory survey performed in the 457 target slopes. As a result, 207 slopes as potential risk slopes (Risk Rank I & II) are selected for regular check.

Regular checks of the potential risk slopes are proposed to minimize the risks of slope failures. Therefore, regular check sheets are prepared, before performing the regular check, for the results of the detailed field surveys.

The regular check sheet consists of the information described in the Table 4.2.1. Monitoring of check sheet appears to be required considering local conditions including topography, geology, metrology, etc. Some of the topographical and geological factors are shown in Figure 4.2.5.

Table 4.2.1 Information to be Included in the Regular Check Sheet (Source: JET)

Item to be included	Description
➢ Overall assessment ➢ Technical comments	Add an “Expert Comment” field and pay attention to the disaster factors not reflected in the score.
➢ Possible measures ➢ Comments on environmental and social considerations	Describe possible measures, as well as guidelines and methods for comprehensive measures, including environmental and social considerations.
➢ Points and methods of inspection ➢ Points to be noted in fixed-point photography	Describe preparations for inspection, points where fixed-point photography is performed, and issues to be considered.
➢ Changes in state of roads to be noted ➢ Examples of changes in state of roads	Describe deformation to be noted, how the change in state of roads developes, and the extent of the change.
➢ Timing of inspection	In Bhutan, inspection is required after heavy rain or earthquakes, as well as in the snow-melt season. Describe the frequency of inspection.
➢ Possible disaster type	Describe the type and the scale of the disaster.
➢ Action to take if a change in state from the perspective of road maintenance is observed	Describe several steps (temporary actions and measures, permanent measures) to be taken to ensure road maintenance and traffic flow.

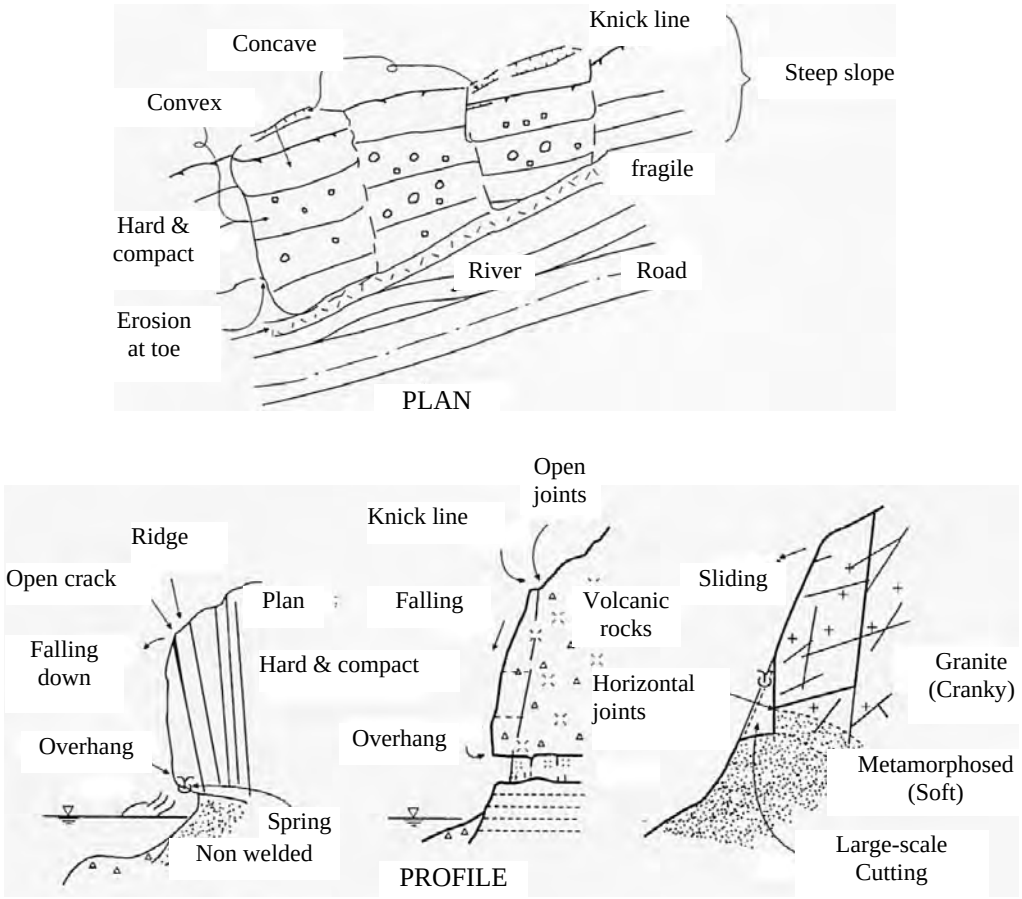


Figure 4.2.5 Topographical and Geological Factors in General (Source: JET)

a. Area and Points to be Checked in Each Type of Road Disasters

Regular checks for rock slope failures, debris slope failures and landslides are conducted at places where there are potential sources of disasters which can affect roads. The places are checked through visual inspection. The regular checks for debris flow are conducted near road areas. If needed, an additional check for the upper river basin is conducted.

In case there are structural countermeasures such as a retaining wall, gabion, check dam and/or fence, etc., not only deformations/anomalies of the structures but also new fallen rocks/debris behind the structure are checked.

a.1 Area to be Checked

The following table and figures give a rough indication of the area to be checked in the regular checks.

Table 4.2.2 Rough Indication of the Area to be Checked
(Source: Road Management Technical Center[*1])

Disaster type	Area to be checked	Remarks
Rock slope failure	Slope where unstable rocks may directly affect the road, until convex break (changing line of gradient) of slope.	If needed, an additional detailed check for upper slope over the convex break is conducted.
Debris slope failure	Slope where unstable soil on the surface may directly affect the road, until convex break (changing line of gradient) of slope. In case of a slope where the toe (bottom) is cut off, the check is from the top of the slope through to the bottom including any ditches or steps.	
Landslide	Landslide area which may directly affect the road, including scarps and slope behind the scarps.	If needed, an additional detailed check around the targeted landslide is conducted.
Debris flow	Crossing culvert, river conditions near the road and check dam and the area (slope) behind it. Deposits of debris from road area to the area which is less than 10 degrees of the river bed.	If needed, an additional detailed check for the upper river basin is conducted.

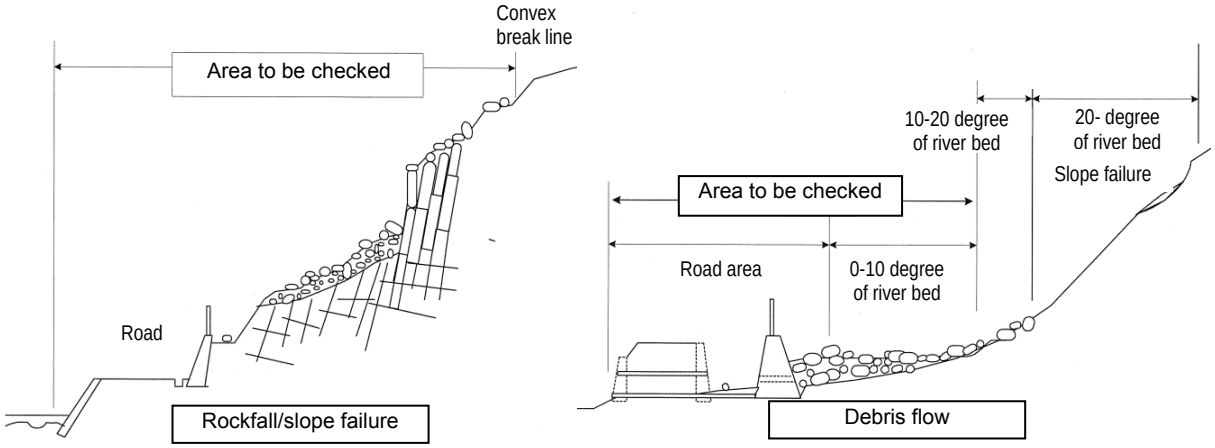


Figure 4.2.6 Rough Indication of the Area to be Checked
(Source: Road Management Technical Center[*1])

a.2 Points to be Checked

Various items must be checked regularly to assess whether anomalies and deformation found during the slope disaster investigation are related to (are a potential trigger of) a potential slope disaster. Therefore it is necessary to carry out comprehensive technical judgment based on site observations including of expansion of cracks, changes to water ways (i.e. increases or decreases in water flow volumes, etc.), new deformations, vegetation and weathering.

The points to be checked at the site and its warning levels are described as follows:

a.2.1 Rock Slope Failures

- Fallen rocks on a road
- Detached rocks and unstable rocks on a slope
- Erosion around the unstable rocks on a slope

- Fallen rocks at the bottom of a slope
- Fallen rocks behind existing countermeasures such as retaining walls, fences and gabions

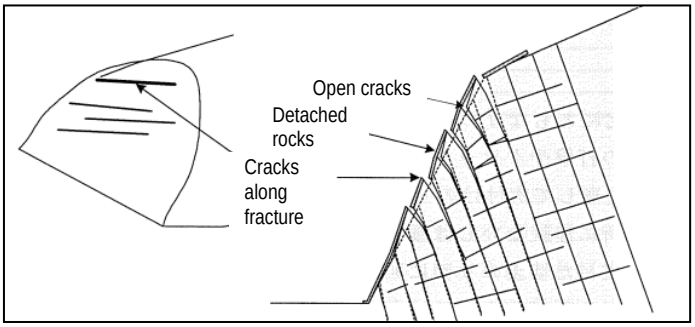


Figure 4.2.7 Example of Points to be Checked for Rock Slope Failure
(Source: Road Management Technical Center[*1])

a.2.2 Debris Slope Failures

- Fallen soil on road
- Cracks, open cracks, erosion, step, gullies, swelling, changes in volume or new sources of spring water or surface water on slope
- Fallen soil at the bottom of slope
- Fallen soil behind existing structures such as retaining walls, fences and gabions
- Cracks, open cracks, steps, subsidence, uplift and deformation of existing countermeasures such as retaining walls, fences and gabions
- Deformation and uplift of ditch
- Tilting and deformation of tree

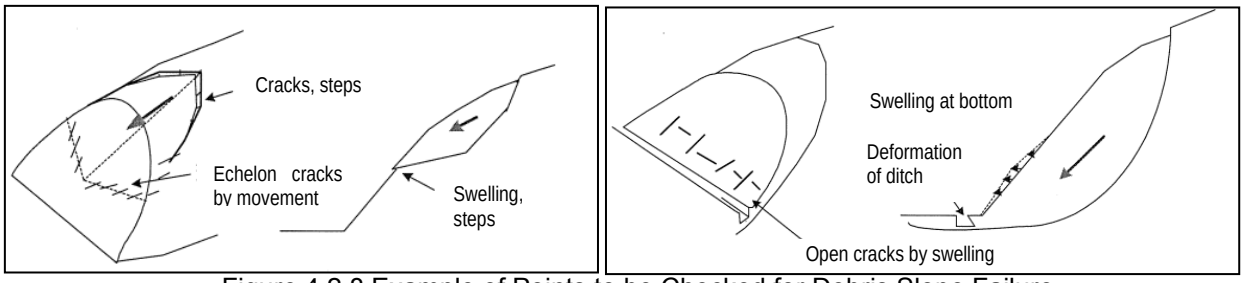


Figure 4.2.8 Example of Points to be Checked for Debris Slope Failure
(Source: Road Management Technical Center[*1])

a.2.3 Landslides

- Cracks, steps, subsidence, uplift and deformation on road.
- Spring water on slope (changes in volume, etc.)
- New spring water around the area
- Increase and decrease/depletion of groundwater level around the area

- Cracks, open cracks, steps, subsidence, uplift and deformation of existing countermeasures such as retaining walls, fences and gabions
- Deformation and uplift of ditches
- Tilting and deformation of trees

a.2.4 Debris Flows

- Deposits of debris behind existing structures such as check dams or gabions
- Increase of debris deposits and turbidity in river
- Tilting and deformation of trees
- Debris slope failures on river/stream banks in upper river basin
- Lowering of water level (= formation of natural dams in upper stream areas)
- Abnormal odor and ambient noise (= emergence of huge debris slope failure in upper stream areas)

b. Regular Check Sheet

The check sheets are prepared when engineers check the targeted slope at site. The check sheet procedure is as follows below. The general form of the check sheet is shown in Figure 4.2.2-4.2.4.

The descriptions of the management office, management number, road designation, location, distance, disaster, address, landmark, and latitude and longitude are indicated as well as the disaster inspection sheet mentioned before. Following items can be included in the check sheet.

- Date: date that engineers check the targeted slope at site and fill the sheet.
- Rock slope failures: progression and anomalies of potential rockfalls such as new rockfall(s), enlarged crack(s) on rock slopes, and erosion of unstable rock(s), which can affect the road and its traffic, are checked.
- Debris slope failures/landslides: progression and anomalies of potential slope failures/landslides such as new failure(s), swelling, new/enlarged step(s)/cliff(s) and new/enlarged crack(s) on slopes, which can affect the road and its traffic, are checked.
- Debris flows: progression and anomalies of potential debris flows such as filling up of debris sediment, overflow of debris on road, clogged culvert and new failure(s) on river slopes, which can affect the road and its traffic, are checked.
- Spring water: anomalies of spring water such as depletion, decrease, increase and turbidity, which are highly connected with slope disaster activities, are checked.
- Roads: anomalies of road surface such as new/enlarged step(s)/settlement(s) and new/enlarged crack(s) on roads, which are related with slope disaster activities, are checked.

- Countermeasures: anomalies of the existing countermeasures such as damage, deformation, clogged drainage and overflowed drainage are checked.

- Other problems: anomalies other than those above are described.

- Conditions: overall condition and situation of potential disasters and roads are described as quantitative as possible. To grasp the progression of anomalies such as cracks, steps and volume quantitatively, measurement of the width/length/height with rulers is effective on a regular basis.

- Proposed remedial actions: emergency actions and works including sandbags/gabions installation and simple monitoring to prevent further progression of the potential disasters are proposed. The engineers should describe the actions that he/she proposes at the site even if the proposed remedial action would be modified after the emergency investigation.

- Purposed countermeasures: middle/long term countermeasures to control/restrict the slope disasters are proposed. The engineers should describe countermeasures he/she proposes at the site even if the proposed countermeasures would be modified after detailed investigation.

To monitor the progression of potential disasters, fixed-point photos are useful. The fixed-point photos of each regular check should be utilized. An example of check sheet is shown in Figure 4.2.2-4.2.4 as mentioned before.

4.2.3 Environmental and Social Consideration on Road Slope Disaster

The regular check sheet is created on the basis of the results of the road slope inventory and the risk analysis of the disaster factors. The following table lists shows the major information items for environmental and social consideration to be included in the regular check sheet created as part of the Project.

Table 4.2.3 Environmental and Social Consideration in the Regular Check Sheet (Source: JET)

Item to be included	Description
➢ Possible measures ➢ Comments on environmental and social considerations	Describe possible measures, as well as guidelines and methods for comprehensive measures, including environmental and social considerations.

The information on Japanese inspection sheets is not sufficient to planning disaster management measures based on detailed field surveys and monitoring; to implementing measures taking into account environmental and social considerations; and to properly perform maintenance after the implementation of the measures so that they remain effective for a long time. Therefore, the regular check sheet includes these items, especially comments on environmental and social considerations.

In the Project, JET has created an environmental and social checklist and examined the impact based on the JICA Guidelines for Environmental and Social Considerations[*2].

The following table describes the environmental and social items expected on each stage (plan, construction and maintenance) for the implementation of countermeasures.

Table 4.2.4 Expected Environmental and Social Consideration and the Impact (source: JET)

Items	Contents	Yes/No	Impact		
			Plan	Construction	Maintenance
Air pollution	Air pollution by traffic	Yes			Vehicles for maintenance and inspection could release pollution materials.
	Air pollution by constructions	Yes		Construction vehicles could release pollution materials.	
	Air pollution by countermeasures	No Pollution materials are NOT released from the measure.			
Water pollution	Water pollution by constructions	Yes		Mud water could flow out with debris by cutting and filling.	
	Water pollution by drainage water	No Pollution materials are NOT released from the measure.			
	Water pollution by drainage water from parking	No Parking is NOT constructed by the measure			
	Water quality impact by drainage	Yes		Flow of surface water could be changed by the construction	
	Water pollution by countermeasures	No Pollution materials are NOT released from the measure			
Waste	Waste from parking	No Parking is NOT constructed by the measure.			
	Waste by constructions	Yes		Waste could be generated with the constructions.	
	Waste soil by constructions	Yes		Waste soil could be generated with the constructions.	
Noise and vibrations	Noise and vibrations by constructions	Yes		Construction vehicles, drilling machines etc. could generate noise and vibrations	
Ground subsidence	Ground subsidence by groundwater drainage	Yes		Ground subsidence could occur from groundwater drainage with the constructions.	Ground subsidence could occur from groundwater drainage.
Offensive odors	Offensive odors by	No Offensive			

	constructions	odors are NOT released from the measure			
Bottom sediment	Pollution of bottom sediment by constructions	No The measures do not affect the bottom sediment.			
Accidents	Traffic accidents under constructions	Yes		Risk of traffic accidents could increase due to traffic regulation from the constructions.	
	Construction accidents	Yes		Slope disasters could happen.	
Protected areas	Protected area by law or international regulation	Yes		Constructions could destroy protected areas.	
Biota and ecosystems	Protecting habitat of wild animals/plants	Yes		Constructions could destroy protected habitats.	
	Habits of rare species	Yes		Constructions could destroy habitats.	
	Ecological impact	Yes		Wild animals could invade the construction sites. Constructions could affect nest building.	Vegetation for slope stability could affect the ecosystem in the area.
	Interception of wild animals/ livestocks/ habits	Yes			Animals/ livestocks/ habits could be intercepted by the countermeasures.
	Exotic species	Yes			Exotic species could affect the ecosystem.
	Environmental impact in untouched areas	Yes		Constructions could affect environmental impact in untouched areas.	Construction could affect environmental impact in untouched areas.
Water usage	Negative impact for surface water and groundwater	Yes		Negative impacts could occur for surface water and groundwater from the drainage.	Negative impacts could occur for surface water and groundwater from the drainage.
Geographical features	Slope disasters by bad geology	Yes		Constructions could be a trigger of slope disasters	
	Slope disasters by cutting/filling	Yes		Constructions could be a trigger of slope disasters	
	Discharge of sediment by constructions	Yes		Constructions could be a trigger of discharge of sediment	
	Modification of topography and geological structure by constructions	Yes		Topography and geological structures could be heavily modified by the constructions	
Involuntary resettlement	Involuntary resettlement	Yes	Resettlement and compensation for farming and grazing could be necessary for the constructions.		
Lifestyle and	Lifestyle and	Yes	Land acquisition		

livelihood	livelihood		could be necessary for the constructions.		
Heritage	Cultural heritage	No The measure is constructed on current roads, not near heritage sites			
Landscape	Landscape	Yes			Countermeasures could impair landscape.
Ethnic minorities and indigenous people	Ethnic minorities and indigenous people	No The measure is constructed on current roads, not near residential areas			
Working conditions	Working conditions	Yes		Poor working conditions and lack of safety measures/ education could be a trigger of accidents Labor could usurp local residents	

The following table summarizes the possible mitigation measures for the environmental and social items which have an impact for the condition. The detailed checklists are provided in the Appendix 14.

Table 4.2.5 Impact Items and Mitigation Measures (Source: JET)

Items	Contents	Mitigation measure
Air pollution	Air pollution by traffic	The volume of the air pollution materials is estimated based on the past traffic. However, the construction work for the countermeasures for slope disasters is the same as normal constructions, which means that it does not release worse pollution materials.
	Air pollution by constructions	Use of low-emission vehicles, decent ration of construction sites, and deconcentration of construction periods are useful. In case of resident areas, watering for the slopes and the roads is necessary to control the dust. Smaller machines for construction are selected, and idling for the machine is stopped. Sound insulating walls are available to avoid spreading pollution materials.
Water pollution	Water pollution by constructions	Quality standard of discharge water is set. Facilities for purification and filtration are installed. Smaller machines for construction are selected to decrease rolling debris A temporary ditch is constructed to prevent debris from flowing out by cutting and filling with rainfall.
	Water quality impact by drainage	Drainage countermeasures are designed based on the detailed investigation and analysis. The concept of the drainage is not to change the current water flow. Monitoring during/after constructions is needed.
Waste	Waste by constructions	The contractor is educated about waste, and prepares and submits check sheets.
	Waste soil by	Less waste soil is considered when designing the

	constructions	countermeasures. Waste soil is recycled for other construction sites. Waste sites are selected for certain areas. The contractor is educated about waste soil, and prepares and submits check sheets.
Noise and vibrations	Noise and vibrations by constructions	The noise and vibrations are not avoidable; it is explained to the local residents. The construction period is limited only to the daytime. Sound insulating walls are available to avoid noise.
Ground subsidence	Ground subsidence by groundwater drainage	Drainage countermeasures are designed based on the detailed investigation and analysis. The concept of the drainage is not to change the current ground water level. Monitoring during/after construction is needed. However, a slope disaster would occur due to excessive ground water. Understanding that slope disasters and ground subsidence is a trade-off relationship is needed.
Accidents	Traffic accidents under constructions	The contractor is educated about the risk of traffic accidents. Fluorescent panels are installed.
	Construction accidents	Excessive cutting is avoided. The construction is tentatively suspended when it is raining or the snow is melting, and when cracks are opening on the slope. Monitoring during/after construction is needed.
Protected areas	Protected area by law or international regulation	Confirmation is needed when planning. Countermeasures are considered if needed.
Biota and ecosystems	Protecting habitat of wild animals/plants	Confirmation is needed when planning. Countermeasures are considered if needed.
	Habits of rare species	Confirmation is needed when planning. Countermeasures are considered if needed.
	Ecological impact	Original wild vegetation is available. Nests are transferred to safer areas. The construction is postponed to winter season when not nest building. A Fence preventing wild animals from entering is needed. Nest boxes are installed for birds.
	Interception of wild animals/ livestocks/ habits	Bridge(S) and fences are needed for water ditches. Bigger box culverts are installed to avoid the interception of wild animals/ livestock/ habitats
	Exotic species	Original wild vegetation is available.
	Environmental impact in untouched areas	Confirmation is needed when planning. Countermeasures are considered if needed.
Water usage	Negative impact for surface water and groundwater	Drainage countermeasures are designed based on the detailed investigation and analysis. The concept of the drainage is not to change the current ground water level. Monitoring during/after construction is needed. However, slope disasters would occur due to excessive surface and ground water. Therefore it is necessary to understand that the change of water conditions is not avoidable.
Geographical features	Slope disasters by bad geology	Slope disasters and countermeasure are considered beforehand under bad geology. Covering by plastic sheets is useful to avoid the penetration of rainfall.
	Slope disasters by cutting/filling	Slope disasters and countermeasures are considered beforehand under cutting/filling construction. A surface ditch is installed on a landslide block to avoid flowing into the roads.
	Discharge of sediment by constructions	The contractor is educated about the procedure. Temporary protection fencing is installed.
	Modification of topography and geological structure by constructions	Excessive cutting is avoided. However, it is necessary to understand that modification of topography and geological structures are not avoidable.
Involuntary	Involuntary	Involuntary resettlement is avoided as much as possible when

resettlement	resettlement	planning. Several stakeholder meetings are available to persuade the local residents. Compensation for resettlement, farming and grazing are necessary beforehand. Relocation destination is secured and relocation cost is compensated.
Lifestyle and livelihood	Lifestyle and livelihood	Land acquisition is avoided as much as possible when planning. Several stakeholder meetings are available to persuade the local residents. Compensation for resettlement, farming and grazing are necessary beforehand. Relocation destination is secured and relocation cost is compensated.
Landscape	Landscape	Excessive impairing is avoided when planning, such as greening of slope surface. However, understanding that modification of landscape is not avoidable is needed.
Working conditions	Working conditions	The contractor is educated about the working conditions and safety measures. The manual is useful for the laborers.

The following table shows the degrees of these impacts for the main countermeasures in Chapter 2.4. The table for the degrees of the impacts for each countermeasure is provided in the Appendix 15.

Table 4.2.6 Degree of the Impacts for the Main Countermeasures (source: JET)

Items	Contents	Surface drainage (Open ditch)	Earth removal	Counter weight fill	Concrete Crib	Retaining Wall	Check Dam
Air pollution	Air pollution by constructions	3	3	3	3	3	3
Water pollution	Water pollution by constructions	4	2	2	4	4	4
	Water quality impact by drainage	3	3	3	4	4	3
Waste	Waste by constructions	3	1	3	3	3	2
	Waste soil by constructions	3	1	3	3	3	2
Noise and vibrations	Noise and vibrations by constructions	2	2	2	2	2	2
Ground subsidence	Ground subsidence by groundwater drainage	3	4	4	4	4	4
Accidents	Traffic accidents under constructions	2	2	2	2	2	2
	Construction accidents	2	2	2	2	2	2
Protected areas	Protected area by law or international regulation	2	2	2	2	2	2
Biota and ecosystems	Protecting habitat of wild animals/plants	2	2	2	2	2	2
	Habits of rare species	2	2	2	2	2	2
	Ecological impact	2	2	2	2	2	2
	Interception of wild animals/ livestocks/ habits	2	2	2	2	2	2
	Exotic species	4	3	3	4	4	4
	Environmental impact in untouched areas	3	2	2	3	3	3
Water usage	Negative impact for surface water and groundwater	2	3	3	4	4	4
Geographical features	Slope disasters by bad geology	3	1	1	3	3	3
	Slope disasters by cutting/filling	3	1	1	3	3	3
	Discharge of sediment by constructions	3	1	1	3	3	3
	Modification of topography and geological structure	3	1	1	3	3	3
Involuntary resettlement	Involuntary resettlement	2	2	2	2	2	2
Lifestyle and livelihood	Lifestyle and livelihood	2	2	2	2	2	2
Landscape	Landscape	3	1	1	1	2	2
Working conditions	Working conditions	2	2	2	2	2	2

Note: 1: Large impact is expected.
2: Some impact is expected.
3: Small impact is expected.
4: No impact is expected.

4.3 Priority of Slope which is Required to apply Countermeasures on Slope Disaster

The road authority shall grasp the location and condition of hazardous slopes on which countermeasures shall be applied preferentially as one of the important processes in designing a road slope management plan. However, since many hazardous road slopes exist throughout Bhutan, the road authority shall pick out higher priority hazardous slopes from them. In this Project, the slope inspections and regular checks have been carried out to know the site condition and hazard of the slopes. And then, prioritization was done by analysis/evaluation of the slopes which were deemed to have a higher hazard. Urgency and practicability were considered as items of evaluation for the prioritization.

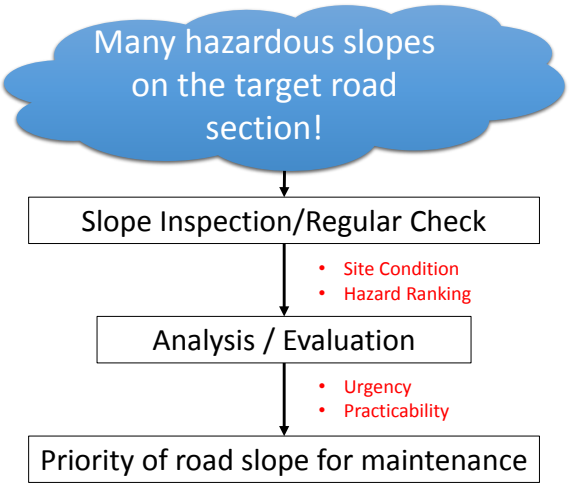


Figure 4.3.1 Concept of Prioritization of Countermeasures for Hazardous Road Slopes
(Source: JET)

Items of evaluation for the prioritization of countermeasures for hazardous road slopes are as follows:

Table 4.3.1 Items for Prioritization of Countermeasures for Hazardous Road Slopes
(Source: JET)

Item		Remarks
1.	Level of Importance of road	Road grade categorized in Bhutan
2.	Hazard Ranking	Result of the inspection or the regular check
3.	Difficulty of work	Technical capacity of Bhutan
4.	Social and environmental impacts	Social and environmental impacts caused by proposed countermeasure works
5.	Scale of work	3 work scales categorized based on the estimated cost of the works

At the first step of the evaluation, the urgency of conducting countermeasures on a hazardous slope is considered using the grade of road and hazard ranking of target slopes. And then, practicability of the countermeasures is considered using the remaining three (3) items: difficulty of work, social and environmental impacts, and scale of work. In the Project, a higher practicability slope is deemed a higher priority slope.

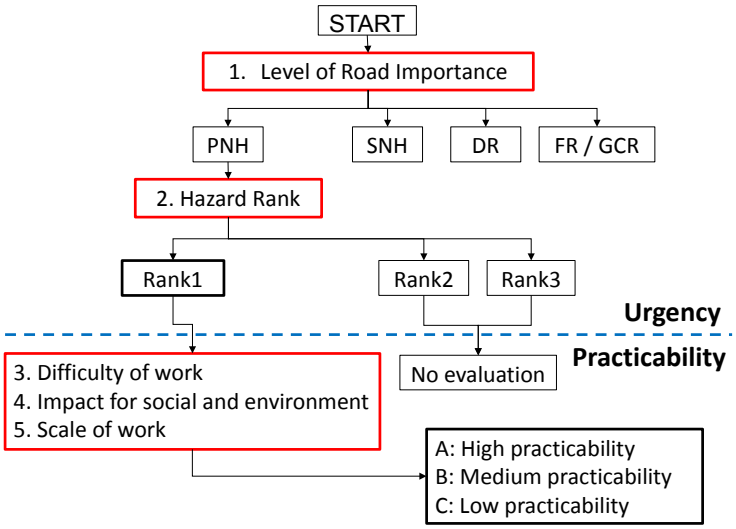


Figure 4.3.2 Flow Chart of Prioritization of Road Slope (Source: JET)

4.3.1 Urgency

Urgency of slope has been evaluated in consideration of grade of road where the target slope is located and hazard ranking of the target slope.

a. Level of Road Importance

Roads in Bhutan are categorized into four (4) grades of road as follows:

- Primary National Highway
- Secondary National Highway
- Dzongkhag road
- Farm road / GC road

In the roads above, the Primary National Highway (hereinafter called PNH) is the highest grade of road in Bhutan, and the specification of the road is applied for major trunk roads in the country. Therefore, the PNH shall be deemed a road which has the highest level of importance. The remaining roads are listed as follows in descending order of level of importance: Secondary National Highway, Dzongkhag road and Farm road / GC road. A road with a higher level of importance shall be deemed a higher priority road. Therefore, in case prioritization is carried out for several grades of road, the prioritization shall be carried out in each grade of road separately.

b. Hazard Ranking

The slope inspection is carried out for all target road slopes to grasp actual site condition and hazard ranking. The result of the inspection shall be compiled to make the slope inventory. After making the slope inventory, higher hazard ranking slopes shall be checked regularly to confirm the actual site condition and hazard level. If the site condition has changed from the

site condition at the previous check / inspection, the hazard of the slope shall be re-evaluated according to the latest site condition of slope. The slope shall be evaluated as one of three (3) ranks of hazard.

Table 4.3.2 Definition of Slope Hazard Ranking (Source: JET)

Rank	Definition
Rank 1	Countermeasure work is necessary
Rank 2	Regular check is needed
Rank 3	Countermeasure work is not necessary

Further information of the hazard ranking is mentioned in Chapter 3.5.3 in this report. A slope with a higher ranking of hazard is deemed a slope with a higher urgency for implementation of countermeasures.

c. Urgency

As mentioned above, the urgency of slope is evaluated in consideration of "Grade of road" and "Hazard ranking" of slope.

The results of the regular checks done in the Project reveals the following breakdown among a total of 457 slopes on the target road section: 63 slopes (13%) are classified as Rank 1; 145 slopes (32%) are classified as Rank 2; and 249 slopes (55%) are classified as Rank 3.

The slopes in Rank 1 shall be dealt with immediately by countermeasures. However, due to budgetary and capacity issues regarding the DoR, it will be difficult to deal with many hazardous slopes (13% of total slopes) in a short period. Therefore, higher priority slopes have been picked out from among the high urgency slopes in consideration of practicability, which are mentioned below.

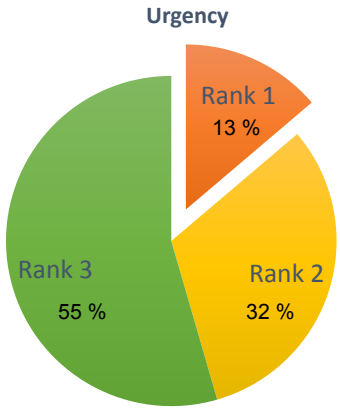


Figure 4.3.3 Circular Chart of Ratio of the Hazard Slope (Source: JET)

4.3.2 Practicability

Practicability has been evaluated for slopes in Rank 1 only. The following three (3) items are considered for evaluation of practicability:

- Technical **difficulty** of countermeasure work
- Social and environmental **impact** caused by countermeasure work
- **Scale** of countermeasure work

Higher practicability slope is deemed a slope on which countermeasure works: are not difficult, do not have a large social and/or environmental impact, and are not large scale

(expensive).

a. Difficulty of Work

Difficulty of work is evaluated by whether or not countermeasure works proposed at inspection/regular check are able to be constructed by the Bhutanese with their own capacity. The proposed countermeasure works are selected from the standard countermeasure works mentioned in Chapter 2.4 in the report. The works are categorized as a work which is available by domestic capacity and requires external technical and/or budgetary support. Difficulty of proposed countermeasure work shall be considered for evaluation of practicability. Difficulty is evaluated for slopes in Rank 1, and categorized into A or B as follows:

- Rank1A: The work requires external technical support
- Rank1B: The work can be done with Bhutan's own capacity

Slopes in Rank 1B are deemed higher practicability than slopes in Rank 1A.

b. Social and Environment Impacts

When considering priorities, it is important to evaluate social and environmental impacts. In this evaluation stage, social and environmental impacts by construction of countermeasure work have been considered. At the same time as conducting the regular checks, the expected impacts of construction of possible countermeasure works were described in the Regular Check Sheet A to aid in the selection process of proposed countermeasure works. Regarding social and environmental impacts, they have been discussed in Chapter 4.2.3.

25 items of impact are suggested as the items expected by the standard countermeasure works in Chapter 4.2.3. The expected items can be applied even if the item is not mentioned in the list of the 25 items. Based on the expected social and environmental impacts, practicability of the slope is evaluated.

Even though the social and environmental impacts shall be evaluated according to the degree of impact, it is difficult to quantitatively evaluate the actual impact in the regular check stage. Therefore, the degree of social and environmental impact is evaluated according to the number of items of impact by the countermeasure work. The criterion of evaluation is shown in Table 4.3.3.

Table 4.3.3 Criterion of Social and Environmental Impacts (Source: JET)

Impact	Criterion
Large	more than 5 items
Medium	3 to 4 items
Small	Less than 3 items

c. Scale of Countermeasure Work

The scale of countermeasure work is also one of the important factors to evaluate practicability. The work scale is categorized into three (3) ranks based on estimated construction cost of the proposed countermeasure work. Criterion of categorization of work scale in the case of DoR is outlined as shown in Table 4.3.4.

Table 4.3.4 Criterion of Scale of Work (Source: JET)

Scale of work	Criterion
Large	More than 15,000,000 Nu
Medium	More than 4,000,000 Nu and less than 15,000,000 Nu.
Small	Less than 4,000,000 Nu

In order to estimate work scale, the rough construction cost of the work proposed in the Regular Check is estimated in each target slope. At first, the rough unit cost of each standard countermeasure work is calculated, and then the estimated construction cost of the work is obtained based on quantity of the work estimated and also in the site checking. For calculation of unit cost of the work, the estimation standard[*3] of MoWHS for civil work has been applied. For work which is not mentioned in the estimation standard, typical cross sections in several specifications of the work were prepared, and then the estimated unit cost was calculated based on them. In case of work for which the unit cost is difficult to obtain using the estimation standard, the typical unit cost of the work in Japan is applied for calculation of rough construction costs. The list of unit cost of the works for estimation of construction cost is attached on the Appendix of the report.

The calculated construction cost is obtained to estimate the scale of proposed countermeasure works for target slope. Therefore, it shall be taken into account that the estimated cost is different from actual construction cost of the work.

Slope that requires smaller scale work is deemed a slope in higher practicability.

d. Practicability

As mentioned above, practicability of target slope is evaluated based on the following three (3) factors: difficulty of work, degree of social and environmental impact, and work scale.

At first, the three (3) factors are given points according to the condition of the slope, and then practicability is evaluated depending on the score of practicability (Sp) which is obtained from the total points of the three factors. The points of each factor shall be decided from Table 4.3.5. The score of practicability is obtained by the following formula (4.3.1).

$$Sp = De \times Ise \times Sw$$ ---------- (Formula 4.3.1)

where,

Sp: Score of Practicability
De Difficulty of work
Ise: Impact on social and environment (social and environmental impacts)
Sw: Scale of work

Table 4.3.5 Point of Each Factor of Practicability Evaluation (Source: JET)

Factor of evaluation	Judgement	Point
Difficulty of work	A: External support is required	1
	B: Under Bhutanese capacity	2
Impact on social and environment (social and environmental impacts)	Large impact	1
	Medium impact	3
	Small impact	6
Scale of work	Large scale	1
	Medium scale	2
	Small scale	3

The score of practicability (Sp) is categorized as three (3) ranks according to the criterion in Table 4.3.6.

Table 4.3.6 Criterion of Practicability Evaluation (Source: JET)

Parameter	Evaluation	Criterion
Practicability	A High practicability	More than 18 points
	B: Medium practicability	More than 10 points and less than 18 points
	C: Low practicability	Less than 10 points

Practicability of the hazardous slopes on the pilot sites is evaluated. The results reveal the following for the total 63 slopes: 9 slopes are evaluated as rank A of practicability; 6 slopes are evaluated as rank B; and 48 slopes are evaluated as Rank C.

The slope evaluated rank A is deemed a slope which is high urgency and high practicability. Therefore, those rank A slopes are also deemed slopes which shall be given high priority to apply countermeasure work.

The result of prioritization can be shown on GIS Map based on the slope disaster database which is mentioned in Chapter 5. Grasping the location and distribution of high priority slopes will contribute to the design of the road slope management plan.

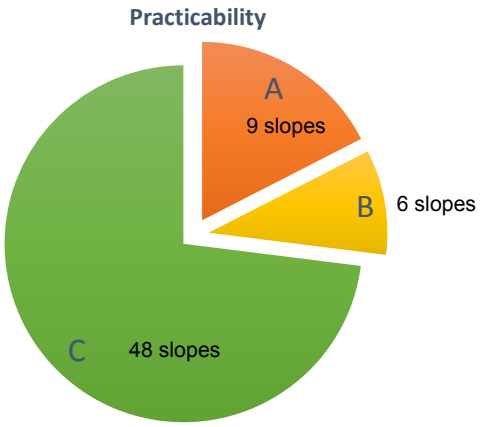


Figure 4.3.4 Circular Chart of Ratio of Practicability of the Slope (Source: JET)

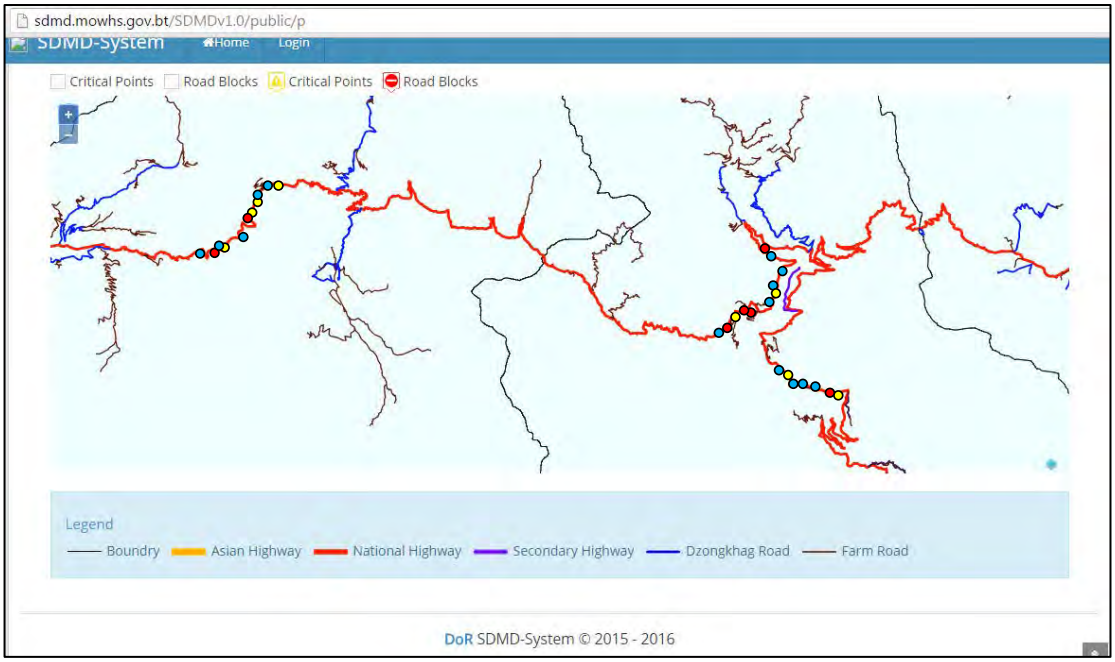
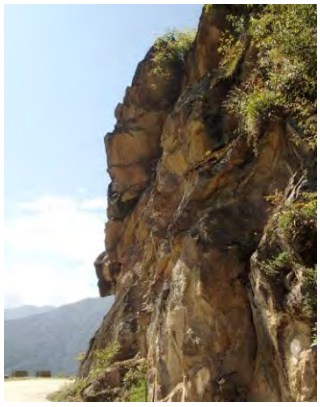


Figure 4.3.5 Imaged GIS Map of Result of the Practicability Evaluation (Source: JET)

The result of the prioritization for 63 hazardous slopes is shown as the list in Appendix of the report. Typical slopes for each rank of practicability are shown in Table 4.3.7 as references.

Table 4.3.7 Typical Hazard Slope in Each Practicability Rank (Source: JET)

Rank A (High Practicability)	Management No.	WPP0120980
	Road Grade	PNH
	Hazard Rank	1B
	Estimated disaster volume	Rockfall (100m^3)
	Impact on social and environment (social and environmental impacts)	Medium
	Proposed countermeasure	Rock excavation
	Scale of work	Small (Nu.2,360,000)
Rank B (Medium Practicability)	Management No.	TPP0121330
 	Road Grade	PNH
	Hazard Rank	1B
	Estimated disaster volume	Rockfall (350m^3)
	Impact of social and environment (social and environmental impacts)	Medium
	Proposed countermeasure	Rock excavation
	Scale of work	Medium (Nu.4,212,000)
Rank C (Low Practicability)	Management No.	WPP0120880
	Road Grade	PNH
	Hazard Rank	1A
	Estimated disaster volume	Rockfall 6,600m^3
	Impact of social and environment (social and environmental impacts)	Large
	Proposed countermeasure	Rock excavation+_ Rock net
	Scale of work	Large (Nu.50,002,000)

4.3.3 Prioritization

The prioritization shall be taken into consideration when designing the road slope management plan. As a result, the plan can become more efficient and effective to implement maintenance works.

In this Project, a slope which has high urgency and high practicability is deemed a high priority slope. This prioritization method mentioned in this report only takes into consideration technical aspects. Actually, priority of the work will not only need to take into consideration technical aspects, but also political decisions or limitations of budgetary allocation as well. The master plan for road slope management shall eventually be designed in consideration of these aspects.

At present, the road management plan of DoR is prepared by the following procedure:

- Site observation after monsoon season by the regional offices of DoR to identify problematic sites
- Estimation of construction cost for required maintenance work of the problematic sites
- Submission of a list of required maintenance work of problematic sites with estimated cost from regional offices to the head office of DoR
- Making plans for maintenance of problematic sites based on the lists submitted to the head office of DoR

Basically, the current procedure for preparing the management plan of DoR is almost the same as the work procedure until prioritization is conducted in the Project. The work procedure and method of the Project will increase accuracy, evaluation grounds and standards to be clarified more than the existing method of DoR. And the management plan can be designed more logically and systematically.

Table 4.3.8 Comparison Between Existing Method and Proposed Method (Source: JET)

	Existing method of DoR	Proposed method by the Project
1	Site observation after monsoon season	Regular Checks (Chapter 4)
2	Estimation of construction cost for problematic sites	Evaluation of Urgency / Practicability (Chapter 4.3)
3	Submission of list of problematic sites	Sharing the data through slope disaster database via the internet (Chapter 5)
4	Making a plan for maintenance of problematic sites for the whole country	Prioritization, Slope disaster database (Chapter 4.3 and 5)

4.4 Implementation of Regular Check

4.4.1 Preparations for Regular Check

Regular check is carried out according to the procedure mentioned in 4.2.2, and involves filling in a regular inspection sheet. The regular check is defined as a normal road check with high attention to stability of the slopes.

The frequency of regular checks is adjusted in accordance with slope conditions, traffic volume and other engineering and social conditions. The major objective of this inspection is to check the stability of the slopes, and to take immediate and suitable action for prevention of disasters related to traffic function and environment.

Regular checks are planned to be performed every October (after rainy season), and in emergency cases of consecutive heavy precipitation. Conditions under which regular checks are to be conducted are finalized based on further discussion with DoR.

A regular check is scheduled to be implemented within this year. Countermeasures might be carried out in high risk potential slopes of Risk Rank I. Regular inspections of relatively high risk slopes of Risk Rank II are to be performed regularly and abnormalities are to be recorded.

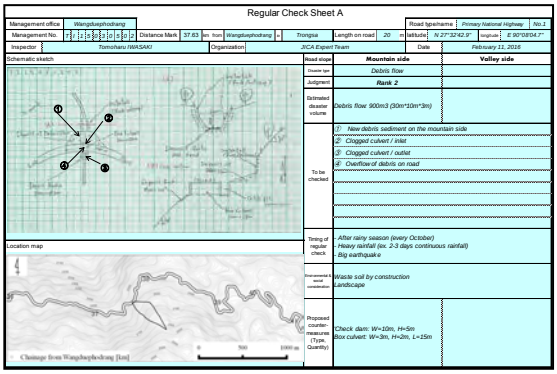
Regular checks are continuously implemented in locations where slope disasters were recorded in previous inspections. When implementing regular checks engineers are to pay attention not only to the inspection site but also the surrounding area.

4.4.2 Results of Regular Check

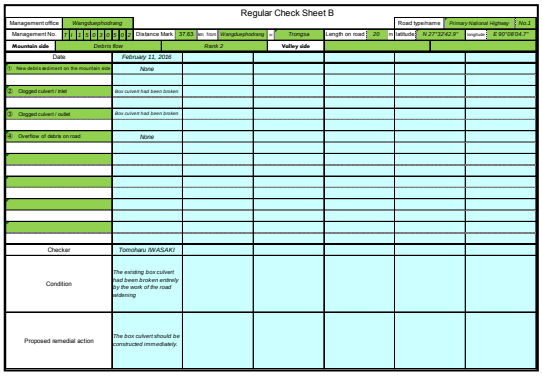
At the end of September 2015, JET and the C/Ps began to carry out the regular check - including filling in check sheets - for the 208 slopes of Rank 1 and 2 that were selected as targets of the regular check in the Project. The first regular check for the 208 slopes was completed before the next rainy season, which was by the end of February 2016.

The results of the regular check are recorded in the “Regular Check Sheet (Attachment 2)” and are summarized in the ”Regular Check List (Table 4.4.1 - Table 4.4.2 and Attachment 2) ”.

Figure 4.4.1 Regular Check for Rank 1 & Rank 2 Slopes (Source: JET)



a) Sheet A



b) Sheet B

c) Photo Sheet

Figure 4.4.2 Sample of Regular Check Sheet (Source: JET)

Table 4.4.1 Regular Check List (1) (Source: JET)

Basic information						Regular Check Result		
Section	Management Office	Road No.	Management No.	Disaster type		Judgment		Remedial Action
				Mountain side	Valley side	Mountain side	Valley side	
S-1	Wangduephodrang	1	WPP0120020	Debris slope failure	Debris slope failure	Rank 3	Rank 2	
S-1	Wangduephodrang	1	WPP0120040	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120050	Debris flow	-	Rank 2	-	✓
S-1	Wangduephodrang	1	WPP0120070	Debris flow	-	Rank 2	-	✓
S-1	Wangduephodrang	1	WPP0120090	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120100	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120110	Debris slope failure	Debris slope failure	Rank 1B	Rank 2	✓
S-1	Wangduephodrang	1	WPP0120120	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120130	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120140	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120190	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120200	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120210	Debris flow	-	Rank 2	-	✓
S-1	Wangduephodrang	1	WPP0120220	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120230	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120240	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120250	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120260	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120270	Debris slope failure	Debris slope failure	Rank 1B	Rank 2	
S-1	Wangduephodrang	1	WPP0120290	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120300	Debris slope failure	Debris slope failure	Rank 2	Rank 3	✓
S-1	Wangduephodrang	1	WPP0120310	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120320	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120330	Debris flow	-	Rank 1A	-	✓
S-1	Wangduephodrang	1	WPP0120360	Landslide	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120370	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120390	Debris flow	-	Rank 2	-	✓
S-1	Wangduephodrang	1	WPP0120410	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120460	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120470	Rock slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120490	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120500	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120510	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	✓
S-1	Wangduephodrang	1	WPP0120540	Rock slope failure	Debris slope failure	Rank 1A	Rank 3	
S-1	Wangduephodrang	1	WPP0120570	Debris slope failure	Debris slope failure	Rank 1B	Rank 3	
S-1	Wangduephodrang	1	WPP0120600	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120620	Debris slope failure	Debris slope failure	Rank 3	Rank 1A	
S-1	Wangduephodrang	1	WPP0120640	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120650	Rock slope failure	Rock slope failure	Rank 1B	Rank 2	
S-1	Wangduephodrang	1	WPP0120660	Rock slope failure	Rock slope failure	Rank 1B	Rank 2	✓
S-1	Wangduephodrang	1	WPP0120670	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120710	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120720	Rock slope failure	Rock slope failure	Rank 1B	Rank 2	✓
S-1	Wangduephodrang	1	WPP0120740	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120750	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	✓
S-1	Wangduephodrang	1	WPP0120760	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120770	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120780	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120790	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120810	Rock slope failure	Rock slope failure	Rank 3	Rank 2	
S-1	Wangduephodrang	1	WPP0120820	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120830	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0120870	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120880	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	✓
S-1	Wangduephodrang	1	WPP0120900	Debris flow	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0120910	Rock slope failure	Rock slope failure	Rank 3	Rank 2	
S-1	Wangduephodrang	1	WPP0120920	Debris flow	-	Rank 2	-	✓
S-1	Wangduephodrang	1	WPP0120930	Rock slope failure	Rock slope failure	Rank 3	Rank 2	
S-1	Wangduephodrang	1	WPP0120970	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0120980	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	
S-1	Wangduephodrang	1	WPP0121000	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0121020	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	✓
S-1	Wangduephodrang	1	WPP0121030	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	✓
S-1	Wangduephodrang	1	WPP0121070	Landslide	-	Rank 2		
S-1	Wangduephodrang	1	WPP0121090	Landslide	-	Rank 2		
S-1	Wangduephodrang	1	WPP0121100	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0121110	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0121120	Debris flow	-	Rank 2	-	✓
S-1	Wangduephodrang	1	WPP0121130	Rock slope failure	Debris slope failure	Rank 2	Rank 2	
S-1	Wangduephodrang	1	WPP0121140	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-1	Wangduephodrang	1	WPP0121160	Landslide	-	Rank 2	-	
S-1	Wangduephodrang	1	WPP0121170	Debris flow	-	Rank 1B	-	
S-1	Wangduephodrang	1	WPP0121180	Landslide	-	Rank 1B	-	

Table 4.4.2 Regular Check List (2) (Source: JET)

Basic information						Regular Check Result		
Section	Management Office	Road No.	Management No.	Disaster type		Judgment		Remedial Action
				Mountain side	Valley side	Mountain side	Valley side	
S-2	Trongsa	1	TPP0120060	Landslide		Rank 2	-	
S-2	Trongsa	1	TPP0120070	Landslide		Rank 2	-	
S-2	Trongsa	1	TPP0120080	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0120100	Rock slope failure	Rock slope failure	Rank 2	Rank 3	✓
S-2	Trongsa	1	TPP0120110	Landslide	-	Rank 2	-	
S-2	Trongsa	1	TPP0120120	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120130	Debris flow	-	Rank 1B	-	✓
S-2	Trongsa	1	TPP0120140	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120150	Landslide	Debris slope failure	Rank 3	Rank 1B	✓
S-2	Trongsa	1	TPP0120160	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0120170	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120180	Rock slope failure	Rock slope failure	Rank 1A	Rank 1B	
S-2	Trongsa	1	TPP0120190	Landslide	Debris slope failure	Rank 3	Rank 1B	
S-2	Trongsa	1	TPP0120220	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0120260	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0120270	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-2	Trongsa	1	TPP0120280	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0120300	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120320	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120330	Rock slope failure	Rock slope failure	Rank 1B	Rank 3	
S-2	Trongsa	1	TPP0120340	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120350	Debris slope failure	Debris slope failure	Rank 3	Rank 2	
S-2	Trongsa	1	TPP0120370	Debris slope failure	Debris slope failure	Rank 1B	Rank 3	
S-2	Trongsa	1	TPP0120380	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120390	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120400	Debris slope failure	Debris slope failure	Rank 1B	Rank 3	
S-2	Trongsa	1	TPP0120420	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120430	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120440	Debris flow	Debris flow	Rank 1B	-	
S-2	Trongsa	1	TPP0120450	Landslide	-	Rank 2	-	
S-2	Trongsa	1	TPP0120490	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120500	Landslide	-	Rank 2	-	
S-2	Trongsa	1	TPP0120530	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120570	Debris slope failure	Debris slope failure	Rank 1A	Rank 2	
S-2	Trongsa	1	TPP0120620	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-2	Trongsa	1	TPP0120630	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120670	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120730	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120750	Debris slope failure	Debris slope failure	Rank 1A	Rank 3	
S-2	Trongsa	1	TPP0120760	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120770	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120780	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0120820	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0120850	Rock slope failure	Rock slope failure	Rank 1A	Rank 1A	✓
S-2	Trongsa	1	TPP0120860	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0120870	Rock slope failure	Rock slope failure	Rank 1A	Rank 3	
S-2	Trongsa	1	TPP0120880	Debris slope failure	Debris slope failure	Rank 1A	Rank 3	✓
S-2	Trongsa	1	TPP0120910	Rock slope failure	Rock slope failure	Rank 1B	Rank 3	✓
S-2	Trongsa	1	TPP0120930	Rock slope failure	Rock slope failure	Rank 1B	Rank 3	✓
S-2	Trongsa	1	TPP0120940	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121080	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121090	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0121120	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	✓
S-2	Trongsa	1	TPP0121130	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121180	Debris slope failure	Debris slope failure	Rank 3	Rank 1A	✓
S-2	Trongsa	1	TPP0121200	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121230	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0121310	Landslide	-	Rank 1B	-	✓
S-2	Trongsa	1	TPP0121320	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-2	Trongsa	1	TPP0121330	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	
S-2	Trongsa	1	TPP0121340	Landslide	-	Rank 2	-	
S-2	Trongsa	1	TPP0121370	Rock slope failure	Debris slope failure	Rank 1A	Rank 3	✓
S-2	Trongsa	1	TPP0121390	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	
S-2	Trongsa	1	TPP0121400	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121430	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121440	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0121450	Rock slope failure	Debris slope failure	Rank 3	Rank 3	
S-2	Trongsa	1	TPP0121500	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0121520	Rock slope failure	Rock slope failure	Rank 1A	Rank 3	
S-2	Trongsa	1	TPP0121530	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0121700	Landslide	-	Rank 1A	-	✓
S-2	Trongsa	1	TPP0121780	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0121840	Debris flow	-	Rank 2	-	

Table 4.4.3 Regular Check List (3) (Source: JET)

Basic information						Regular Check Result		
Section	Management Office	Road No.	Management No.	Disaster type		Judgment		Remedial Action
				Mountain side	Valley side	Mountain side	Valley side	
S-2	Trongsa	1	TPP0121880	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0121900	Landslide	-	Rank 2	-	✓
S-2	Trongsa	1	TPP0121910	Landslide	-	Rank 2	-	
S-2	Trongsa	1	TPP0121950	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0121980	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122010	Debris slope failure	Debris slope failure	Rank 3	Rank 3	
S-2	Trongsa	1	TPP0122030	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122040	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0122050	Rock slope failure	Debris slope failure	Rank 2	Rank 2	
S-2	Trongsa	1	TPP0122060	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122070	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0122090	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122100	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0122130	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0122140	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122150	Rock slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0122160	Rock slope failure	Debris slope failure	Rank 1B	Rank 3	
S-2	Trongsa	1	TPP0122170	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122190	Debris flow	-	Rank 2	-	
S-2	Trongsa	1	TPP0122200	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	1	TPP0122220	Rock slope failure	Rock slope failure	Rank 1A	Rank 3	
S-2	Trongsa	4	TRP0450010	Rock slope failure	Rock slope failure	Rank 1B	Rank 2	
S-2	Trongsa	4	TRP0450020	Debris flow	-	Rank 2	-	
S-2	Trongsa	4	TRP0450070	Landslide	-	Rank 1A	-	✓
S-2	Trongsa	4	TRP0450110	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450130	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450150	Rock slope failure	Rock slope failure	Rank 1B	Rank 3	
S-2	Trongsa	4	TRP0450170	Rock slope failure	Rock slope failure	Rank 1A	Rank 3	
S-2	Trongsa	4	TRP0450260	Debris slope failure	Debris slope failure	Rank 2	Rank 1B	✓
S-2	Trongsa	4	TRP0450270	Debris flow	-	Rank 2	-	✓
S-2	Trongsa	4	TRP0450280	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	
S-2	Trongsa	4	TRP0450290	Debris flow	-	Rank 1B	-	
S-2	Trongsa	4	TRP0450310	Rock slope failure	Rock slope failure	Rank 1B	Rank 2	
S-2	Trongsa	4	TRP0450340	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450360	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450380	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450410	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450420	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-2	Trongsa	4	TRP0450470	Debris flow	-	Rank 1B	-	✓
S-2	Trongsa	4	TRP0450490	Debris flow	-	Rank 1B	-	✓
S-2	Trongsa	4	TRP0450550	Landslide	-	Rank 2	-	
S-3	Trongsa	4	TRP0420010	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	
S-3	Trongsa	4	TRP0420020	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	
S-3	Trongsa	4	TRP0420030	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420040	Rock slope failure	Rock slope failure	Rank 1A	Rank 3	
S-3	Trongsa	4	TRP0420050	Rock slope failure	Rock slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420060	Rock slope failure	Rock slope failure	Rank 2	Rank 2	
S-3	Trongsa	4	TRP0420070	Debris slope failure	Debris slope failure	Rank 1A	Rank 2	
S-3	Trongsa	4	TRP0420080	Rock slope failure	Rock slope failure	Rank 1A	Rank 2	✓
S-3	Trongsa	4	TRP0420090	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420110	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420130	Rock slope failure	Rock slope failure	Rank 1B	Rank 1A	✓
S-3	Trongsa	4	TRP0420150	Debris flow	-	Rank 1A	-	✓
S-3	Trongsa	4	TRP0420160	Debris slope failure	Debris slope failure	Rank 1A	Rank 1A	✓
S-3	Trongsa	4	TRP0420210	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420230	Debris flow	-	Rank 2	-	✓
S-3	Trongsa	4	TRP0420460	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420550	Debris slope failure	Debris slope failure	Rank 2	Rank 2	
S-3	Trongsa	4	TRP0420560	Rock slope failure	Rock slope failure	Rank 1A	Rank 1A	
S-3	Trongsa	4	TRP0420570	Debris slope failure	Debris slope failure	Rank 2	Rank 3	
S-3	Trongsa	4	TRP0420580	Debris flow	-	Rank 2	-	
S-3	Trongsa	4	TRP0420590	Debris slope failure	Debris slope failure	Rank 2	Rank 3	

a. Number of the Target Slope for Regular Check

The number of target slopes of the regular check is 208 slopes, as shown in the table below.

The breakdown of slopes for disaster types is as follows: rock slope failure has the highest number of target slopes at 76 slopes; debris slope failure has the second highest number with 66 slopes; debris flow has the third highest number at 47 slopes; and landslide has the fewest number of slopes at 19 slopes. Regarding sections, section II has the highest number of target slopes at 114 slopes.

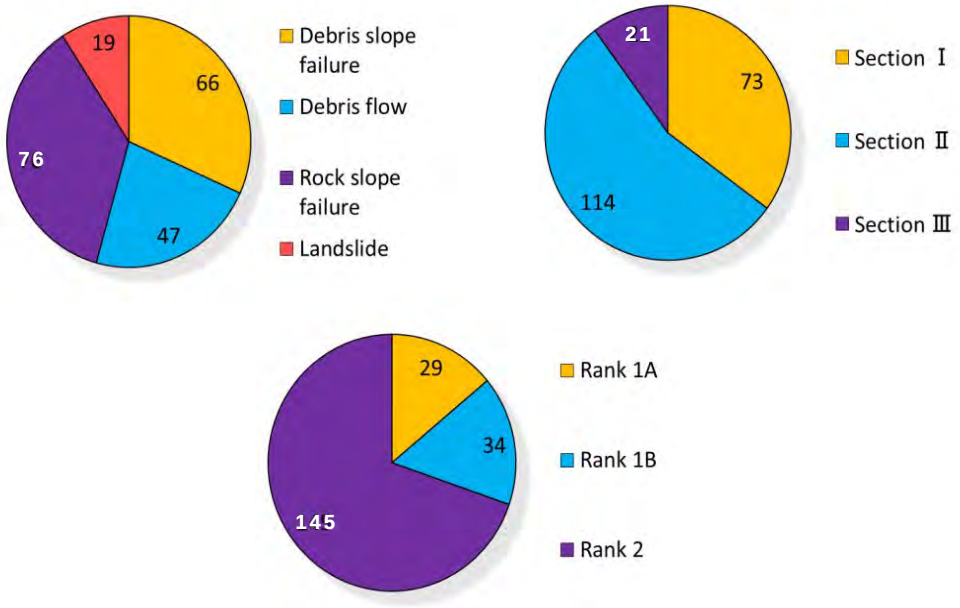
Table 4.4.4 Number of Target Slopes for Regular Check (Source: JET)

Disaster type

Name	Rank 1A	Rank 1B	Rank 2	Total
Debris slope failure	7	6	53	66
Debris flow	2	6	39	47
Rock slope failure	18	17	41	76
Landslide	2	5	12	19
Total	29	34	145	208

Section

Name	Rank 1A	Rank 1B	Rank 2	Total
Section Ⅰ	6	12	55	73
Section Ⅱ	14	22	78	114
Section Ⅲ	9	0	12	21
Total	29	34	145	208



b. Remedial Action

In the 208 slopes where regular checks were carried out, there were 46 slopes where immediate remedial action is necessary, and those characteristics are explained below.

Table 4.4.5 Number of the Slopes where Remedial Action is Necessary (Source: JET)

Name	Rank 1A	Rank 1B	Rank 2	Total
Debris slope failure	3	2	1	6
Debris flow	2	3	15	20
Rock slope failure	7	7	1	15
Landslide	2	2	1	5
Total	14	14	18	46

b.1 Remedial action for Culverts Crossing the road at Debris Flows

The sites of debris flow have the highest number of slopes where remedial action is necessary. The existing culverts have often been blocked up with soil and boulder(s), or it has been destroyed by road widening works. In those sites, the removal of soil and boulders in the culverts or the reconstruction of the culverts is immediately necessary as remedial action.

a) Soil and boulder in the culvert (WPP0120330)

At the time of inspection, March 5, 2015 — After road widening works, February 11, 2016

b) Existing box culvert has been destroyed by road widening works (WPP0120210)

Figure 4.4.3 Example of the Site of Debris Flow where Remedial Action is Necessary (Source: JET)

b.2 Remedial Action for a Cut Slope of the Rock/Debris Slope Failures

At some cut slopes of the Rock/Debris Slope Failure, there are unstable boulders and slope overhangs, and they should be removed immediately.

In addition, many roadside ditches are destroyed due to road widening works, and they should be rebuilt again immediately.

a) Unstable overhand
(TPP0121370)

b) Unstable rock / boulder (WPP0121020)

c) Existing roadside ditch was broken due to road widening (TPP0122170)

Figure 4.4.4 Example of the Rock/Debris Slope Failure where Remedial Action is Necessary (Source: JET)

b.3 Remedial Action for Landslides

Regarding landslides, the supply of the water by surface water and the mountain stream has a big influence on stability. Because the existing roadside ditches were destroyed due to road widening works, they should be rebuilt again immediately.

At the time of inspection, February 11, 2015
There is a roadside ditch.

After road widening works, October 9, 2016, Existing roadside ditches was destroyed due to road widening.

Figure 4.4.5 Example of the Landslide where Remedial Action is Necessary (Source: JET)

c. Revision of the Rank after Regular Checks

The original rank of four slopes was revised as a result of the regular checks.

Table 4.4.6 Revision of the Rank after Regular Checks (Source: JET)

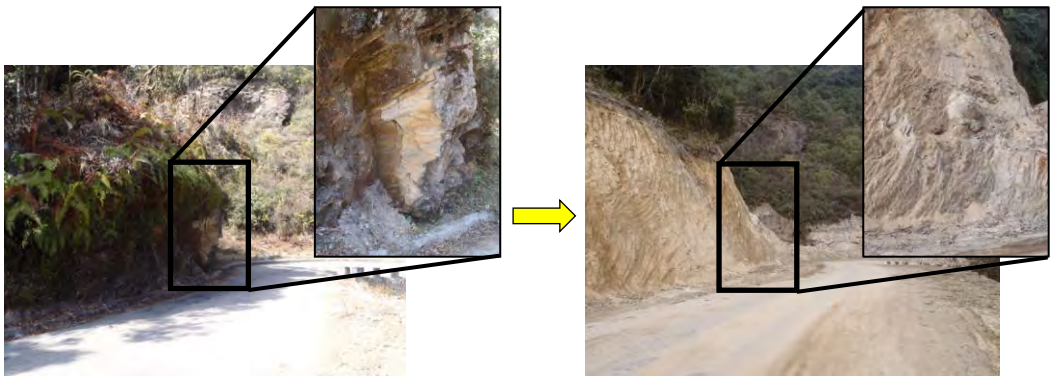
Management No.		Section	Road No.	Original Rank	After a revision
WPP0120200	Mountain side	S-1	1	Rank 1B	Rank 2
TPP0121450	Mountain side	S-2	1	Rank 2	Rank 3
TPP0122010	valley side	S-2	1	Rank 2	Rank 3
TRP0450550	Mountain side	S-2	4	Rank 1B	Rank 2

WPP0120200: The cut slope on the mountain side was reconstructed for road-widening. Since the unstable overhang was removed as a result, the classification should be changed from "Rank 1B" to "Rank 2". However, it is not classified as Rank 3 because some unstable rocks are still remaining on the slope.

At the time of inspection, March 5, 2015 — At the time of regular check, February 11, 2016

Figure 4.4.6 Site Condition before and after the Regular Check at WPP0120200 (Source: JET)

TPP0121450: The target rock slope has been removed through excavation for road widening. As a result, the classification should be changed from "Rank 2" to "Rank 3".



At the time of inspection, February 24, 2015 — At the time of regular check, February 3, 2016

Figure 4.4.7 Site Condition before and after the Regular Check at TPP0121450 (Source: JET)

TPP0122010: The target slope has been removed through excavation work. As a result, the classification should be changed from "Rank 2" to "Rank 3".

At the time of inspection, February 10, 2015

At the time of regular check, October 8, 2015

Figure 4.4.8 Site Condition before and after the Regular Check at TPP0122010 (Source: JET)

TRP0450550: The landslide countermeasure was already carried out after slope inspection. As a result, the classification should be changed from "Rank 1B" to "Rank 2". However, it is not at Rank3 because some cracks are found on the new retaining wall.

At the time of inspection, October 3, 2015

At the time of regular check, February 1, 2016

Figure 4.4.9 Site Condition before and after the Regular Check at TRP0450550 (Source: JET)

d. Proposed Countermeasure

In the regular checks, countermeasures were proposed for each slope.

The proposed countermeasures are shown in the Regular Check Sheet (Attachment 2). The details of the proposed countermeasures, including the type, amount, and so on are explained in "4.3 Priority of Countermeasures on Slope Disaster" of Chapter 4. Please refer to it.

(Reference)

*1 Road Management Technical Center, Creation and Operation Guide of Disaster Risk Management Record, pp. 49-57, 1996

*2 Japan International Cooperation Agency, Guidelines for Environmental and Social Considerations, 2010

*3 Ministry of Works and Human Settlement, Bhutan Schedule of Rates (Civil), 2012

Chapter 5

Database of Slope Disaster

5 Database of Slope Disasters

5.1 General

A Slope Disaster Database is developed to efficiently accumulate and update the road slope inventory and slope inspection sheet. Additionally, the database functions to grasp the road conditions. The completed GIS Database is set at the maintenance division in the DoR HQ. It is managed and updated by the DoR officers under the maintenance division. For the purpose of this system, the database is developed by discussions and cooperation with the DoR officers. The features and policy of the database are as follows:

- The database system has GIS functions so that the locations of the slope inventory, slope inspection sheets and critical points of disasters are defined in the Map.
- The database is developed on the web base system for the DoR officers (undefined) to view and operate, so the public is able to see the information.
- From the perspective of self-sustainable development by DoR staff, the database is developed with a simple and user-friendly system.
- After development of the database, the manual for users is prepared for updating data and maintaining the system.

5.2 Module structure

Through the discussion with the DoR staff in the maintenance division, the modules and details of each module were decided. The database is prepared as two kinds of modules. One is the main module for accumulating the slope inventory and slope inspection record. The other is for the web information system to grasp road conditions. The details are as follows.

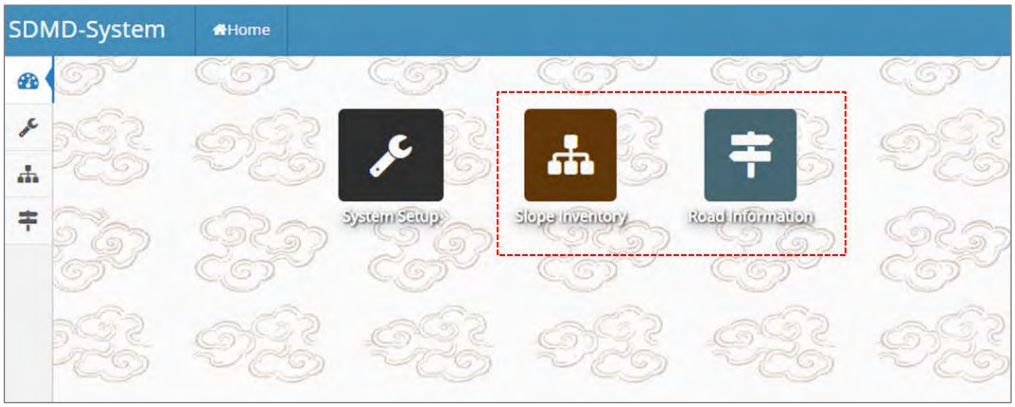


Figure 5.2.1 Module Entrance Display (Source: JET)

5.2.1 Management of Slope Inspection Sheet and Regular Check Sheet

The module is the main part of the database of slope disaster. The purpose of this module is to efficiently accumulate the slope inventory and slope inspection record. The module has functions to view, update and add to these sheets.

a. Structure

The data of slope inspection sheets and regular check sheets are saved in the server at the Maintenance Division in the DoR HQ. As the module is managed by the DoR officers, the module has a member login system to identify the operating person(s) (DoR staff) who is authorized to operate the module.

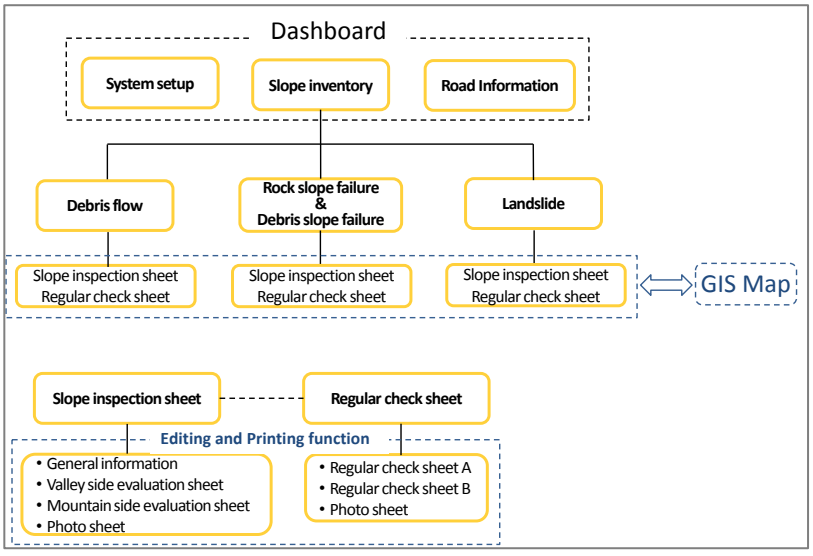


Figure 5.2.2 Database Structure of the Module (Source: JET)

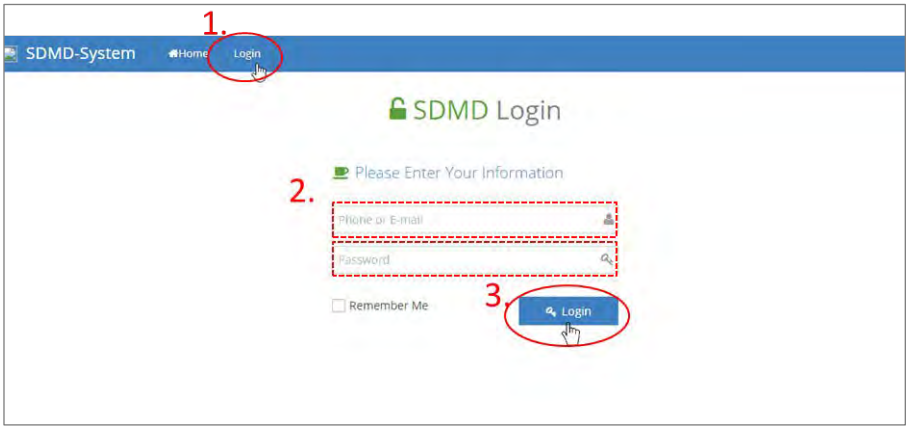
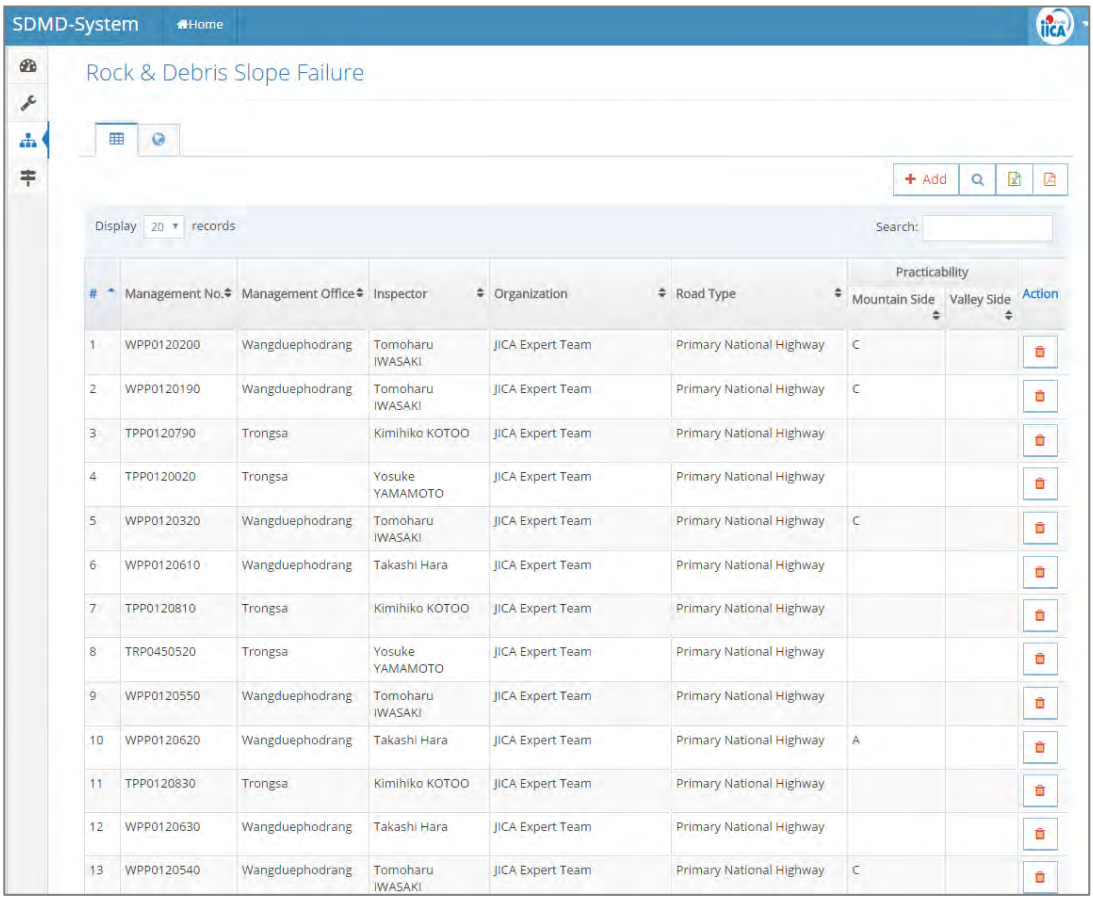


Figure 5.2.3 Login System Display (Source: JET)

a.1 Data input form

The data of slope inspection sheets and regular check sheets can be edited directly on the web and filled-in using fixed forms to avoid missing input and data failure.



#	Management No.	Management Office	Inspector	Organization	Road Type	Practicability		Action
						Mountain Side	Valley Side	
1	WPP0120200	Wangduephodrang	Tomoharu IWASAKI	JICA Expert Team	Primary National Highway	C		
2	WPP0120190	Wangduephodrang	Tomoharu IWASAKI	JICA Expert Team	Primary National Highway	C		
3	TPP0120790	Trongsa	Kimihiko KOTOO	JICA Expert Team	Primary National Highway			
4	TPP0120020	Trongsa	Yosuke YAMAMOTO	JICA Expert Team	Primary National Highway			
5	WPP0120320	Wangduephodrang	Tomoharu IWASAKI	JICA Expert Team	Primary National Highway	C		
6	WPP0120610	Wangduephodrang	Takashi Hara	JICA Expert Team	Primary National Highway			
7	TPP0120810	Trongsa	Kimihiko KOTOO	JICA Expert Team	Primary National Highway			
8	TRP0450520	Trongsa	Yosuke YAMAMOTO	JICA Expert Team	Primary National Highway			
9	WPP0120550	Wangduephodrang	Tomoharu IWASAKI	JICA Expert Team	Primary National Highway			
10	WPP0120620	Wangduephodrang	Takashi Hara	JICA Expert Team	Primary National Highway	A		
11	TPP0120830	Trongsa	Kimihiko KOTOO	JICA Expert Team	Primary National Highway			
12	WPP0120630	Wangduephodrang	Takashi Hara	JICA Expert Team	Primary National Highway			
13	WPP0120540	Wangduephodrang	Tomoharu IWASAKI	JICA Expert Team	Primary National Highway	C		

Figure 5.2.4 List of Rock Slope Failure and Debris Slope Failure (Source: JET)

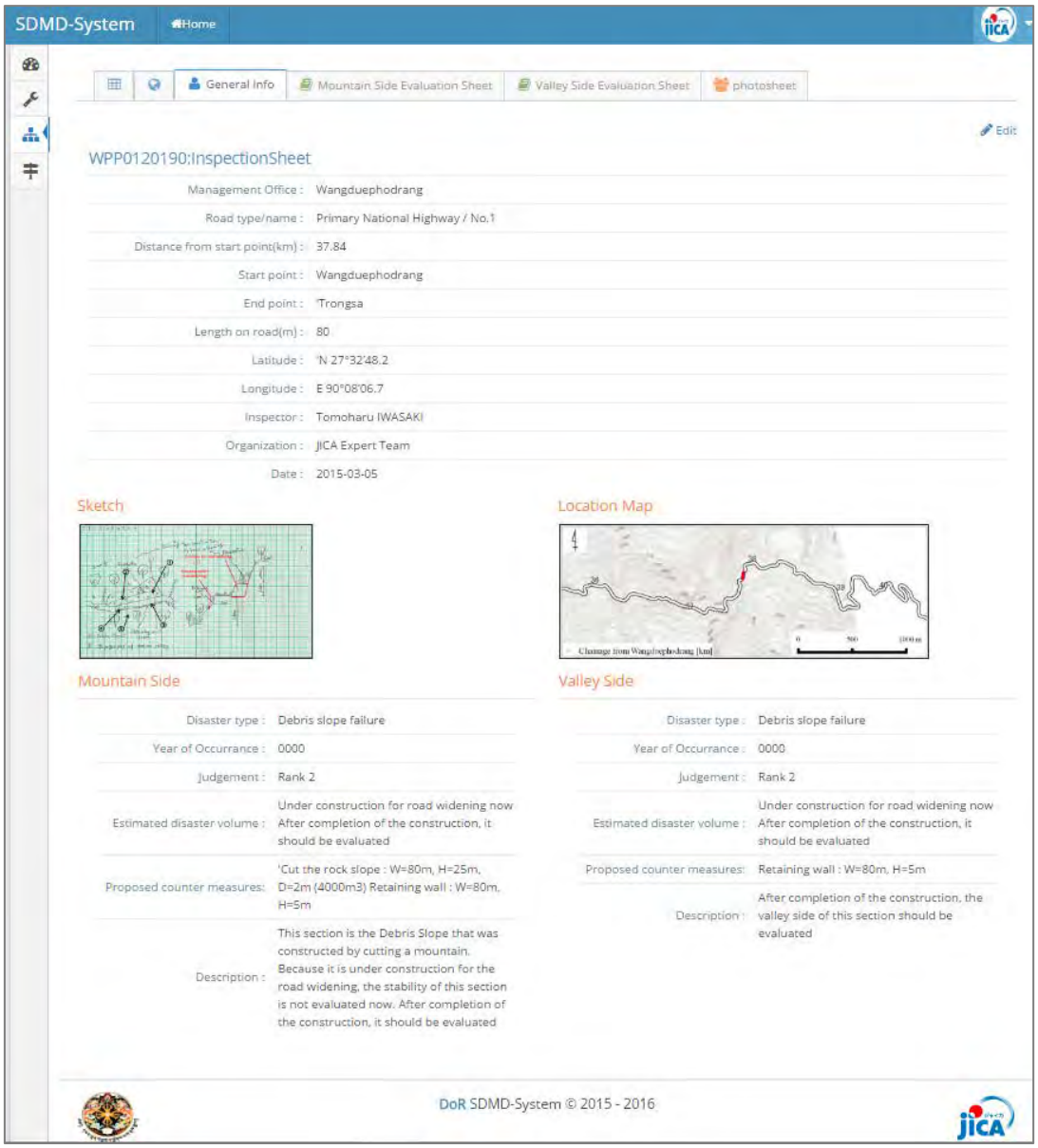


Figure 5.2.5 Samples of General Information and Slope Inspection Sheets (Source: JET)

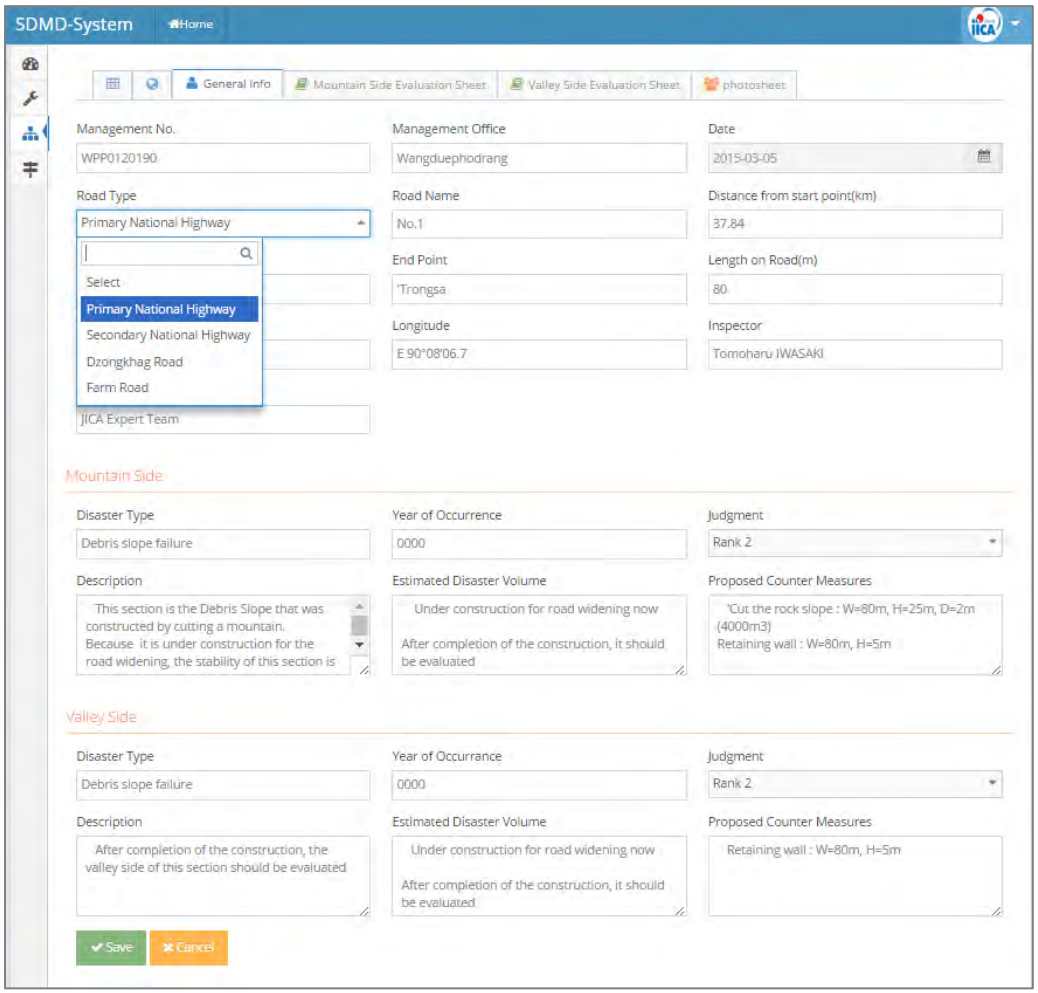


Figure 5.2.6 Sample Editing Function of General Information and Slope Inspection Sheets (Source: JET)

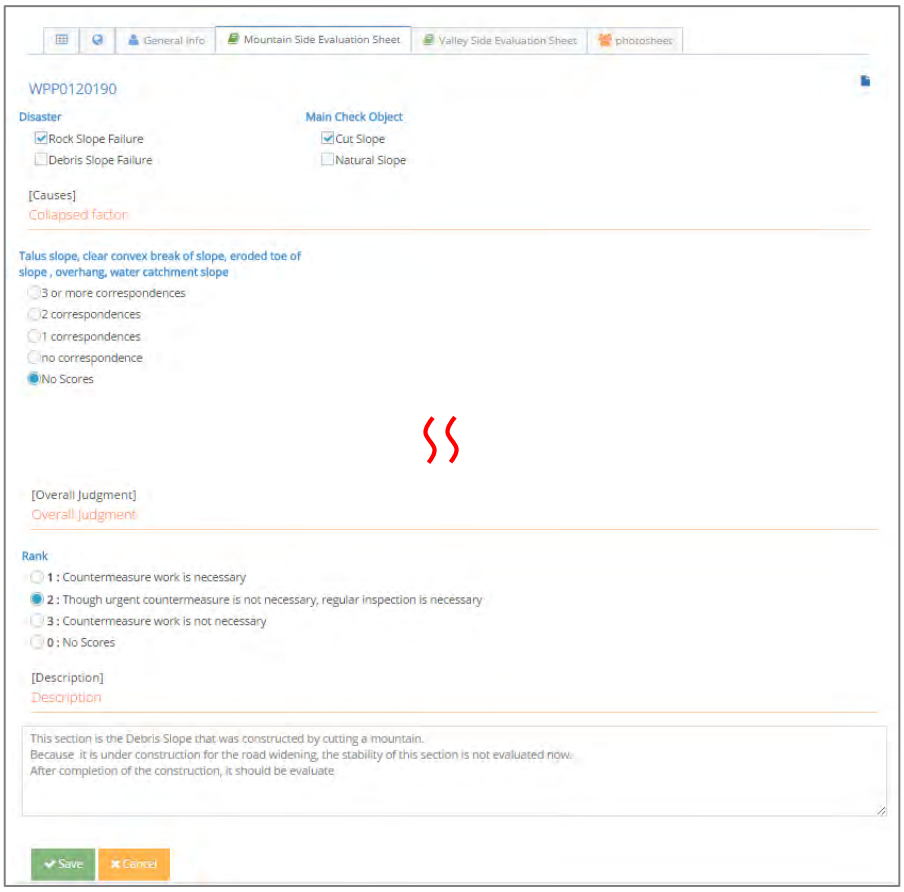


Figure 5.2.7 Sample Editing and View Function of Evaluation and Slope Inspection Sheets (Source: JET)

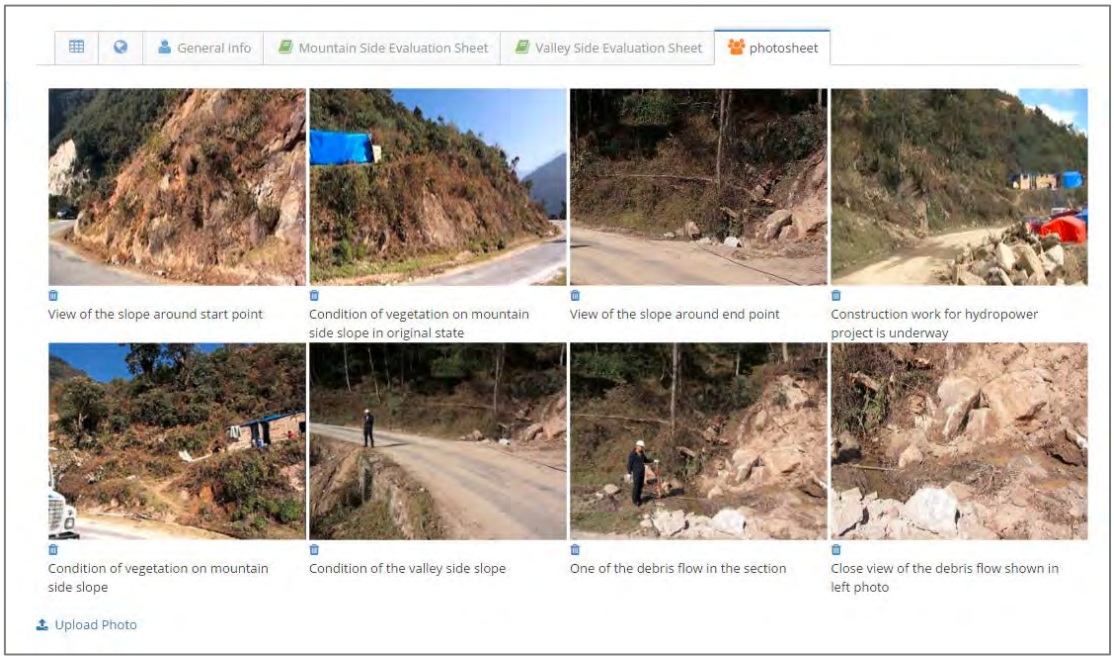


Figure 5.2.8 Sample of Photo Upload System and Photo Sheet (Source: JET)

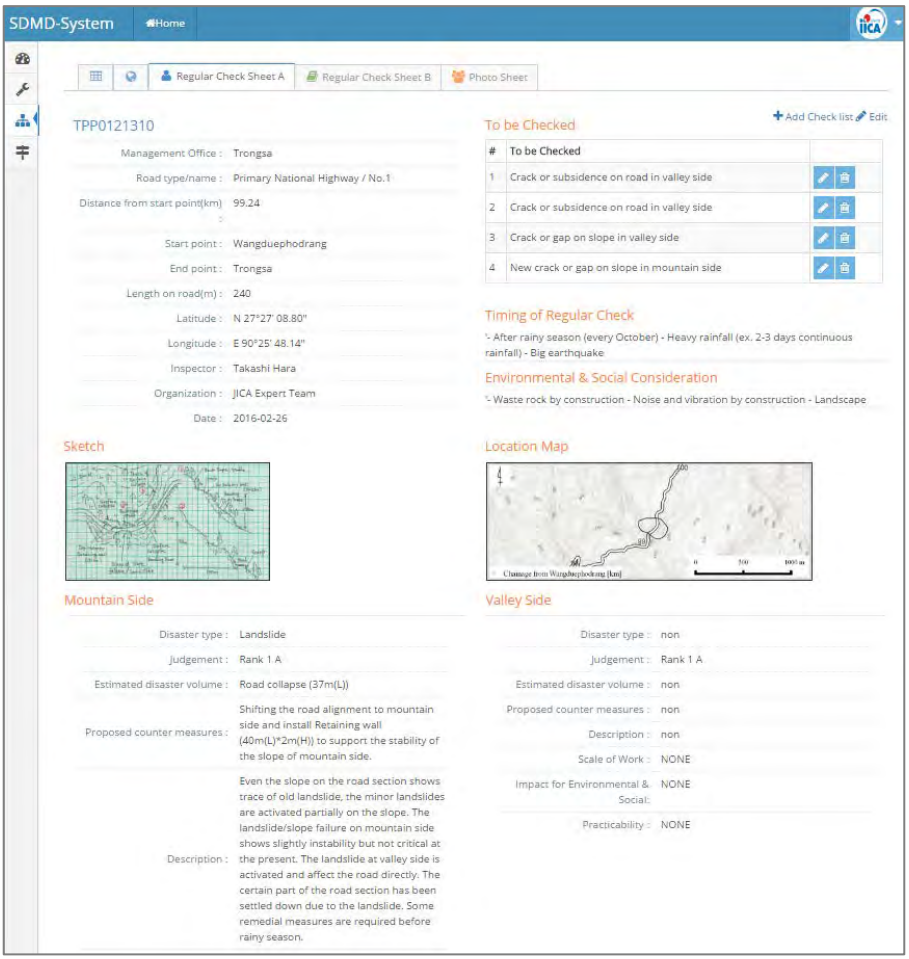


Figure 5.2.9 Sample of View Function of Regular Check Sheet A (Source: JET)

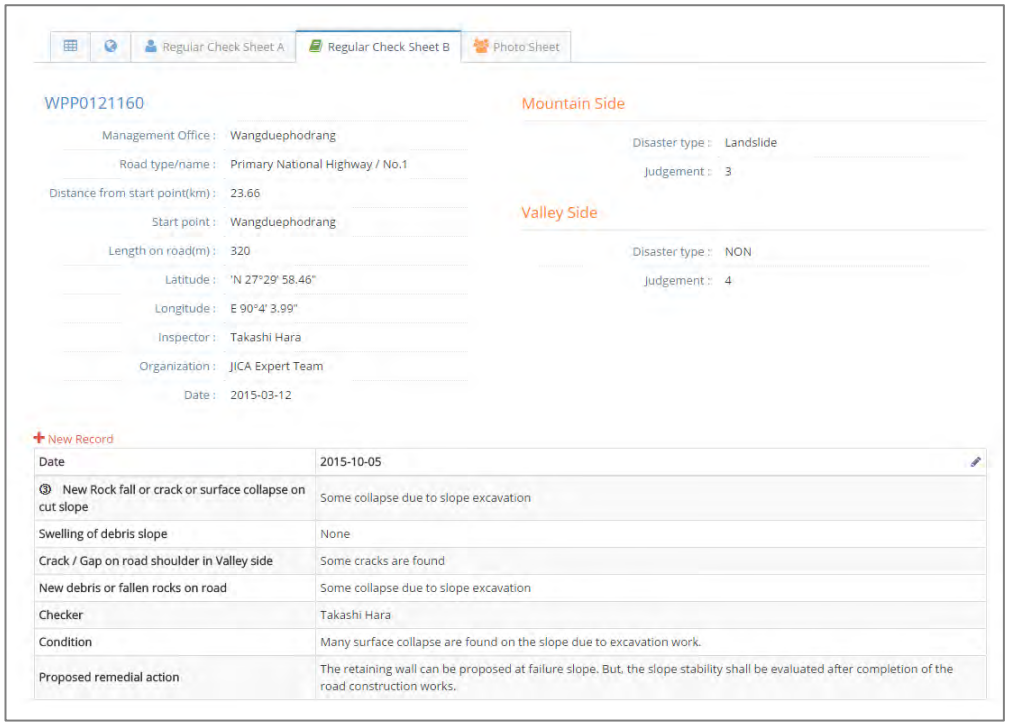


Figure 5.2.10 Sample of View Function of Regular Check Sheet B (Source: JET)

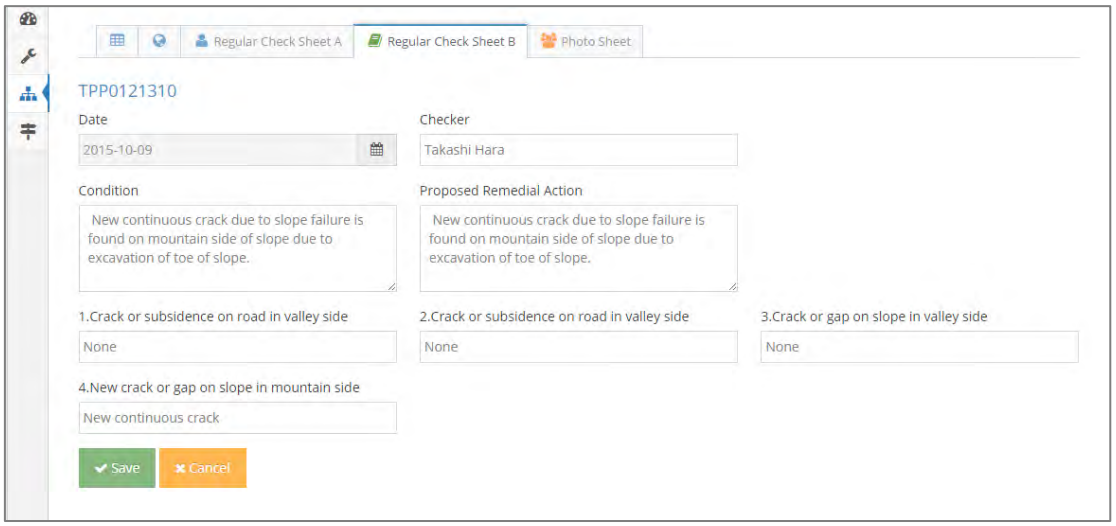


Figure 5.2.11 Regular Check Record Function of Regular check Sheet B (Source: JET)

a.2 Printing function

Basically, the data input form is user-friendly for ease of editing. However, print-out of forms need to be taken to the field during inspection. These forms, in A3 format, include the slope inspection sheet and regular check sheet. Others that require hard copies include the following: general information sheet; evaluation sheet and photo sheet for inspection sheet; and regular check sheet A, B, and photo sheet for regular check sheet. Therefore, this module has the printing function. The function is automatically arranged from the data input form and exported to A3- size paper.

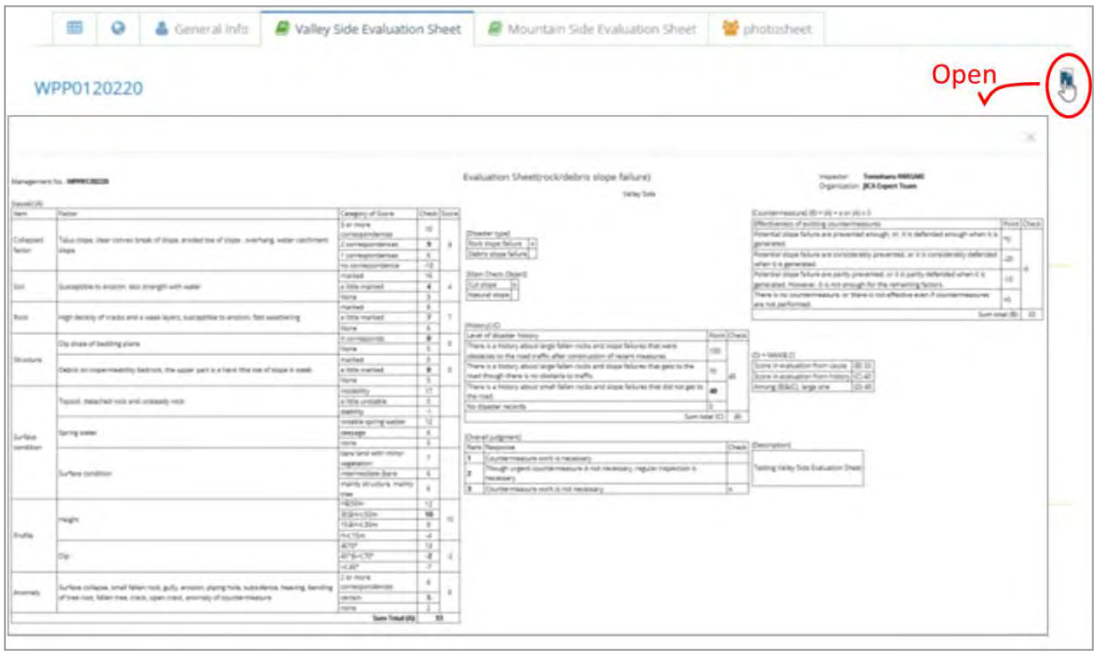


Figure 5.2.12 Sample of Printing Function; General Information and Slope Inspection Sheet

(Source: JET)

b. Linkage with GIS Map

The stored slope inspection sheets and regular check sheets are linked with a GIS map to define its location on the map. The polygon and polyline are categorized by disaster type and are linked with the slope inspection sheet and regular check sheet. These sheets can be opened by identifying the specific area and line in the map. In this database, debris slope failures and rock failures are expressed as polylines along the road lines. Landslides and debris flows are expressed as polygons (shown in Figure 5.2.4). The polygons and polylines are created and edited as a GIS application, which is separate software from the database.

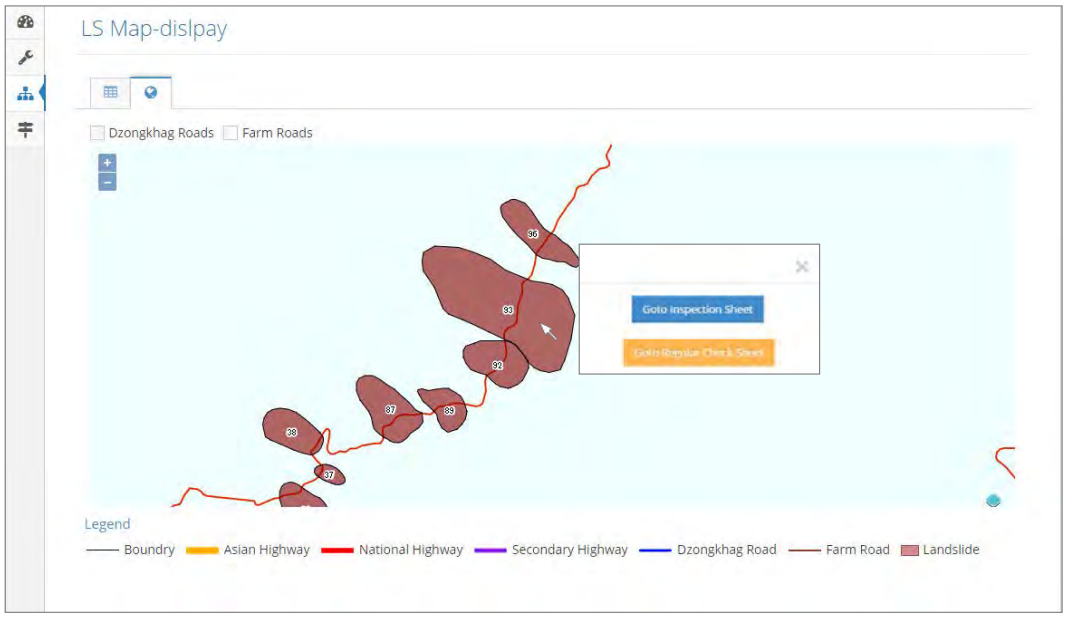


Figure 5.2.13 Sample of Landslide GIS Map Linked with Inspection and Regular Check Sheet (Source: JET)

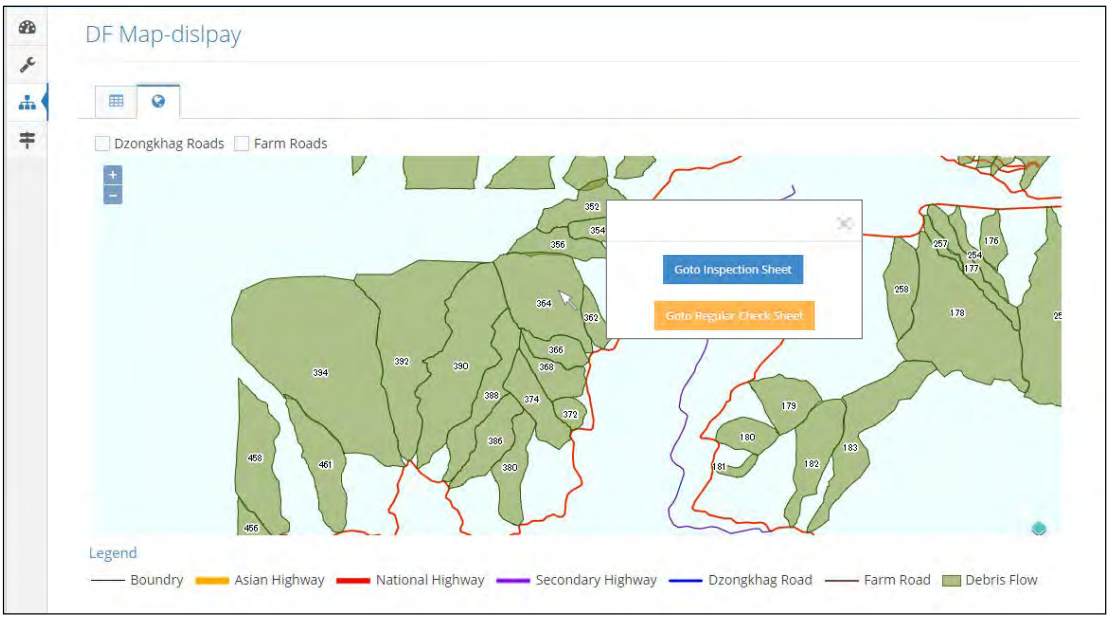


Figure 5.2.14 Sample of Debris Flow GIS Map Linked with Inspection and Regular Check Sheet (Source: JET)

Figure 5.2.15 Sample of Debris Slope Failure and Rock Slope Failure GIS Map Linked with Inspection and Regular Check Sheet (Source: JET)

5.2.2 Road Condition Information System (RCIS)

The purpose of this module is for DoR and the public to recognize road conditions through the web system. The information is collected by the road officer in the Regional DoR office, and the photo, accompanied with a description, is updated every morning. Simultaneously, the photos and description function is linked with a GIS map, so one is able to identify the information and location on the map, which is shown in the web system. This module introduces the information showing that roadblocks are dependent on meteorological observations.

a. Module Contents

The module consists of two types of information, as described below.

a.1 Critical point information

Road conditions of critical disaster points and heavy rain and snow coverage are displayed in the map with photos along with its descriptions. The distance from the monitoring point is updated every day in the morning. The monitoring point is a fixed point and the selection criterion of prior traffic roads is focused on the area of mountain roads and critical disaster points. The critical disaster points are selected by the maintenance division of DoR.

a.2 Roadblock information

The information of roadblock caused by slope disasters and road widening construction is displayed on the maps with photos along with its descriptions. The information is displayed when the slope disasters occur and where road widening construction takes place. The description contents also include the blockade start and end point, and estimated blockade period.

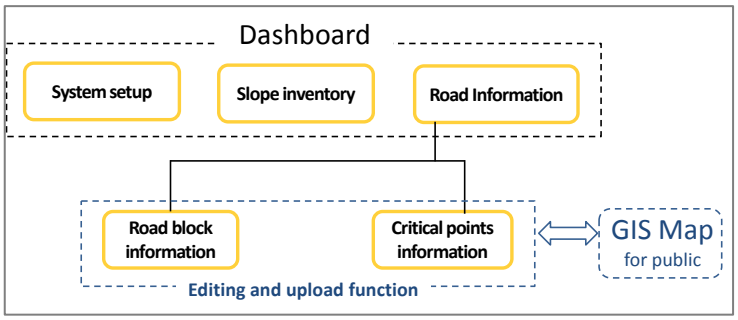


Figure 5.2.16 Database Structure of the Module (Source: JET)

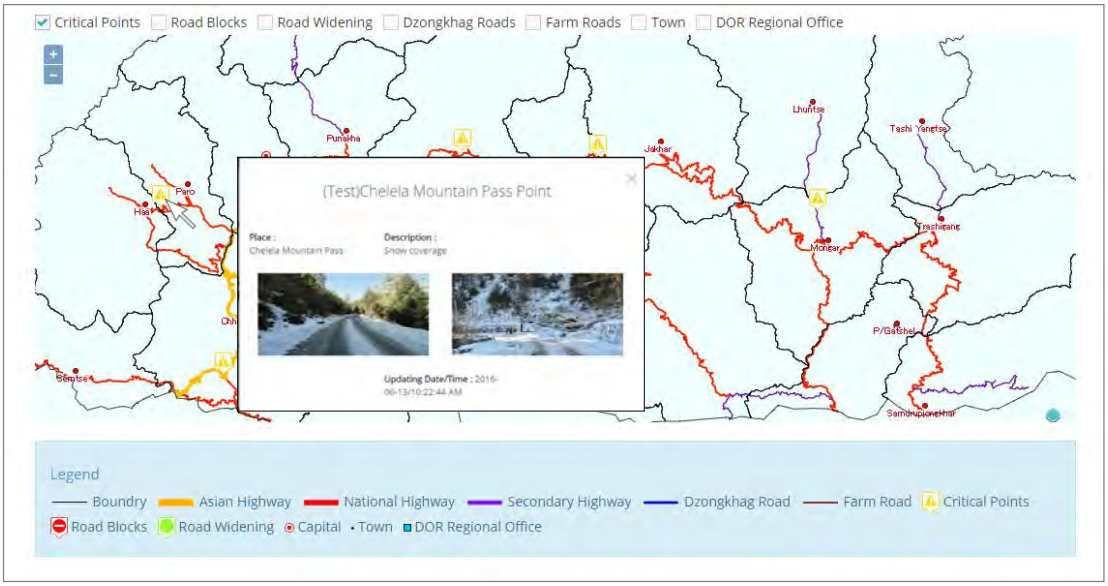


Figure 5.2.17 Sample of Photo, Description Function and Critical Point (Source: JET)

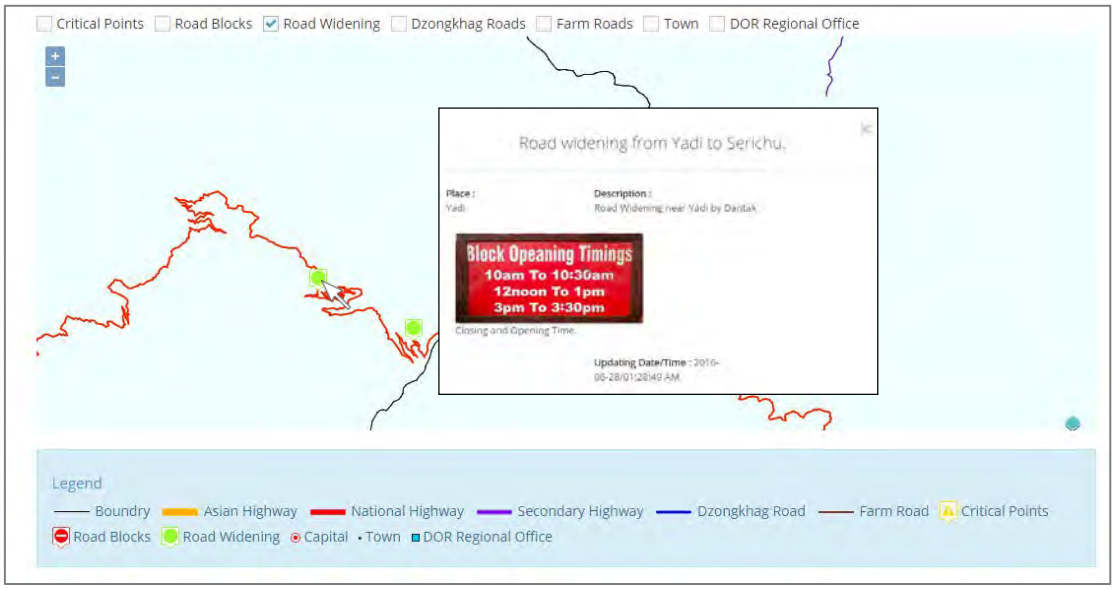


Figure 5.2.18 Sample of Photo, Description Function and Road Widening Construction Point (Source: JET)

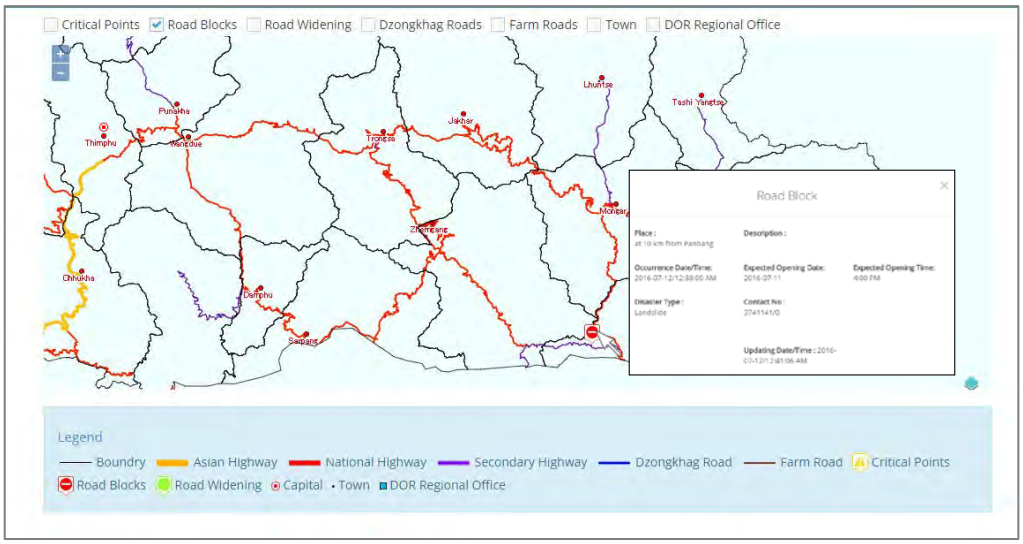


Figure 5.2.19 Sample of Photo, Description Function and Road Block Point (Source: JET)

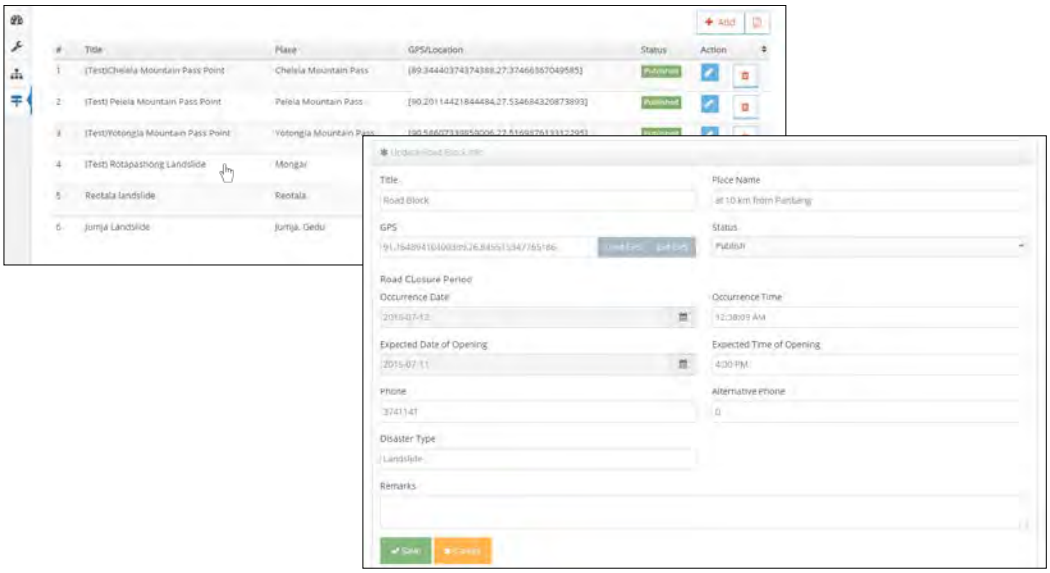


Figure 5.2.20 Sample of Editing Function of Road Block Point for Login User (Source: JET)

b. Advanced activity

The Government-to-Citizen (G2C), in consultation with DoR, is developing a smart phone application named “Bhutan Road Safety” (shown in Figure 5.2.6). Because this information system is mainly to inform the road conditions to the public, it is designed to be convenient for the public users to use the application on phones with Android and iOS operating systems. The data is updated under the 3G data transmission. The application can be downloaded through the Android and iOS system. Regarding the data import system, first, the data is imported into the web information system developed by this Project. And then, the data is automatically transferred to the mobile application.

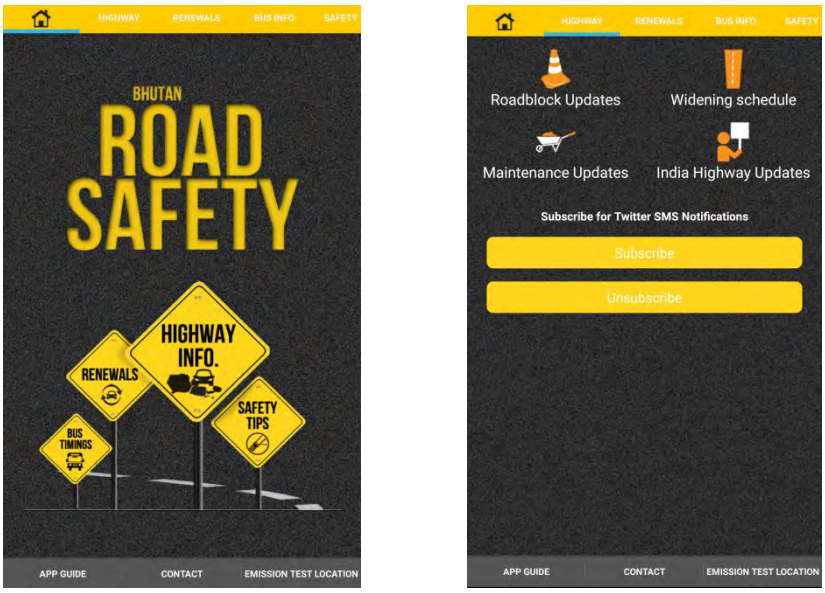


Figure 5.2.21 Display of Android Application System (Source: DoR)

5.3 GIS Map Function

The database has a GIS map function and is linked with the slope inspection sheet, regular check sheet, and web information system for road conditions. Additionally, the map layers consist of the administrations and topographic information. In the database, the layers can be displayed and selected through a check-in and check-out system by the users and according to the surrounding conditions, especially in terms of the necessity for topographic recognition, and internet environment of the users. The layers are selected according to the list shown in Table 5.3.1. This data was collected from DoR and the relevant organizations.

Table 5.3.1 List of Layers for GIS Map in the Database (Source: JET)

Categorization	File	Source	Remarks
Administration	・ National boundary ・ Dzongkhag (district) Boundary ・ Gewog (ward) boundary	NLC	
	Capital, Secondary capital and Town point	NLC, DoR, public map	Capital, secondary capital for each Dzongkhag City, Town
Road	Road line	DoR	Asian Highway Primary Highway Secondary Highway Dzongkhag road Firm road
DoR Information	Regional office point	DoR	Regional office,

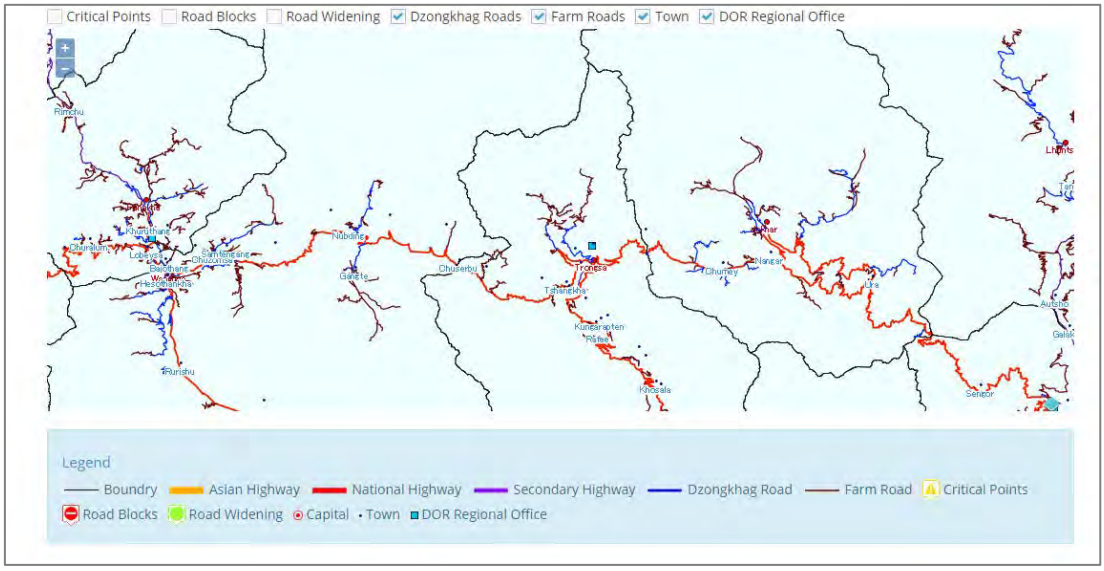


Figure 5.3.1 Display of GIS Map in the Database (Source: JET)

5.4 System Structure

The database is applied in Maria DB relational database management system (RDBMS). The system is originally derived from MySQL and is a compatible system from the aspect of database engine. Additionally, Maria DB is a relatively compatible system with the Android system. In terms of linking with other devices, Maria DB is suitable for this database.

- Zend Framework 2

Software Development Management Dashboard (SDMD) system is developed in Zend Framework 2, which is a Hypertext Preprocessor (PHP) based framework. The latest technologies like Bootstrap are used to be more dynamic and have mobile friendly interfaces. Zend Framework 2 is an open source framework for developing web applications and services using PHP 5.3+. Zend Framework 2 is used currently to develop large systems, because its structure and high performance Model View and Controller (MVC) implementation can be divided into modules and separate modules, so that each module will have individual MVC.

- Openlayer3

Openlayer3 is used in SDMD system for displaying GIS data and maps. Openlayer 3 has a high-performance, feature-packed library for mapping needs. It makes heavy use of the new capabilities of modern Web browsers (Canvas, WebGL) and opens a whole new world of possibilities such as client-side vector rendering and integration of 3D data.

5.5 Technical Transfer Activity for GIS Database

5.5.1 Road Type Categorization

a. Technical transfer activity

The GIS database has the function of managing road lines categorization for the entire country. However, the road line data collected by DoR is insufficient with regard to categorization of types of road. Additionally, the categorization has not been updated since year 2010. Taking this into consideration, re-categorization of road types was carried out in cooperation with the DoR officers. The final output of this categorization is operated by Arc GIS and QGIS applications. The details of the revised contents and road lines are shown in Table 5.5.1 and Figure 5.5.1.

Table 5.5.1 List of Road Categorization (Source: JET, DoR)

Categorized road type	Revised contents
Asian Highway (AH)	Categorization from PNH targeted from Thimphu to Phuentsholing
Primary National Highway (PNH)	Categorization from SNH and revision of road line
Secondary National Highway (SNH)	Change from under construction to completed construction
Dzongkhag Road	Categorization from feeder road, and revision of road line
Urban Road	Categorization from existing road in Thimphu city
Gewog Center Road	Collected data by DoR officers (not completed)

b. Cooperation with Centre for GIS Co-ordination (CGISC)

The CGISC established and managed under NLC is the unit for the purpose of sharing the activities and technical operations regarding to GIS application. For the time being, DoR is not a member of CGISC regardless of MoWHS member registration. But the data collections of Whole Bhutan road line and Gewog administrative office point are conducted by using GIS database in Maintenance division, DoR. Therefore the JICA project team advised for DoR to register CGISC for the perspective of effective common data sharing with different government agency.

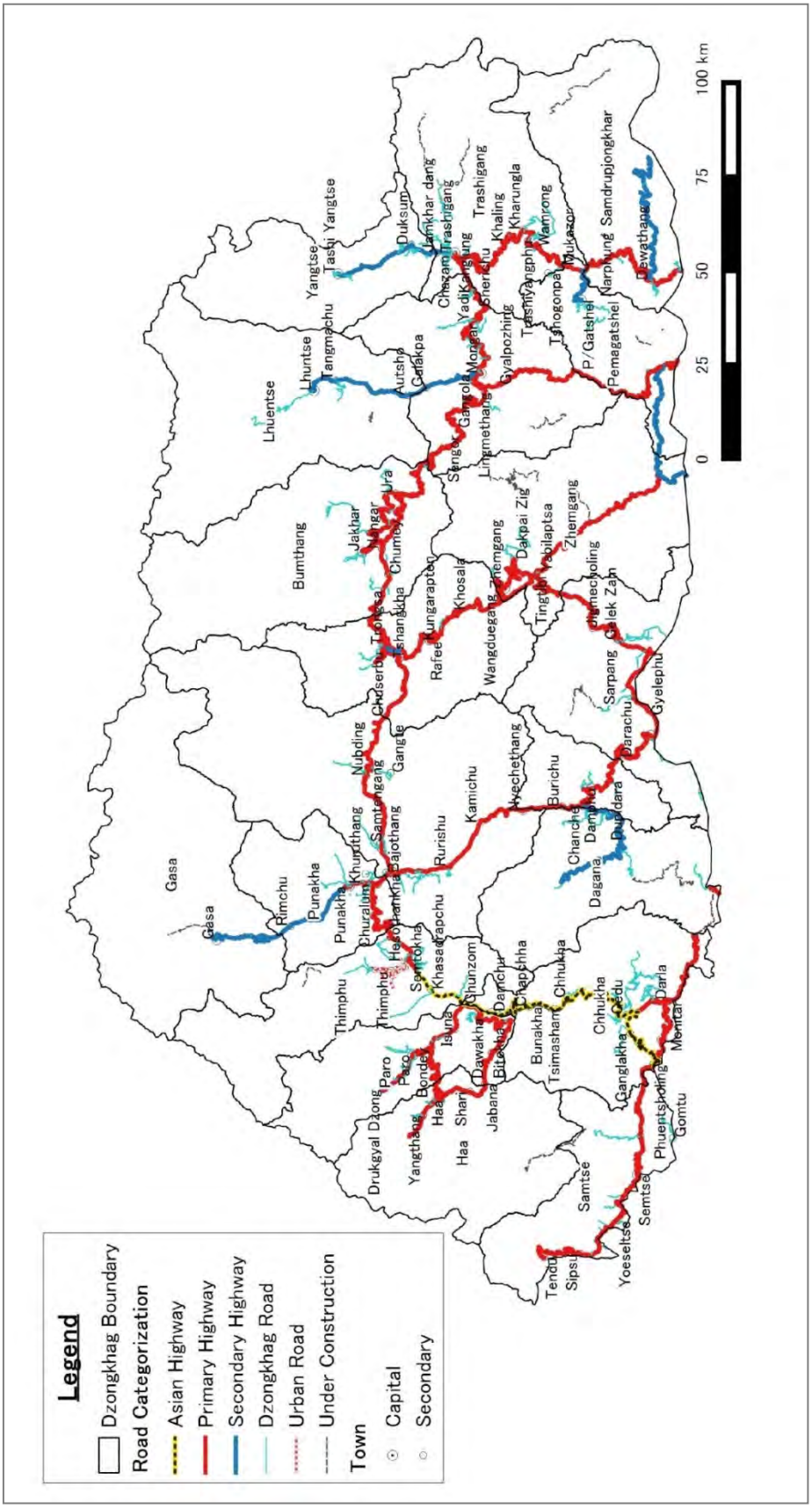


Figure 5.5.1 Categorized Road Line (Source: JET, DoR)

5.5.2 Technical discussion for developing the database

The technical discussions for developing the database were conducted in DoR, Thimphu. The purpose of the technical discussions was to summarize the opinions of the DoR staff members as the database users and reflect their opinion in the database.

a. The first technical discussion

The first technical discussion of developing the database was conducted on 11 of June 2015. The participants of this technical discussion were mainly from the Maintenance Division though there were also participants from the Bridge Construction Section of the Construction Division. For developing the database, the operation setting should be a simple and user-friendly system and the condition of the database should be compatible with local/regional internet environments. The results of discussion and information from DoR staff members are reflected in the database operation system. The topics of this discussion are as follows:

- Explanation and reconfirmation of the modules
- How to input data in consideration of internet conditions in Bhutan
- How to update the information and the arrangement of the person-in-charge to take data from the field officer
- How to display and update the GIS map and decide who operates the GIS for disaster type polygons and lines
- The perspective of compilation with Bridge Inventory

b. The second technical discussion

The second technical discussion of developing the database was conducted on 1st of June 2016. The participants of this technical discussion were mainly chief engineer levels of each division including IT section. The main purpose of this discussion was to revise information and to complete the database system with more self-sustainable operation. The main topics of this discussion were as follows:

- Revision of each item to provide more detailed and fixed
- Privilege for regional officer
- Compatibility with the mobile smartphone application

Figure 5.5.2 Photo of Technical Discussion Seminar (Source: JET)

5.5.3 Technical Transfer of Knowledge for Creating GIS Disaster Polygons and Polylines

The polygon and polyline areas categorized by disaster type can be linked with the sheets of slope inventory and slope inspection records. In the process of creating polygons and polylines, the database does not have a function for creating polygons and polylines by itself without avoiding the complexity of a database structure. Therefore, the polygons and polylines are created independently by GIS application and are updated in the database. With regard to the sentence above, the technical transfer of knowledge for creating polygons and polylines is conducted by DoR staff members. The main contacts of DoR staff members are as follows: Ms. Phuntso, who is in charge of GIS at DoR; Mr. Dorji, from HQ of the Maintenance Division; and Mr. Tempa, from the Geotechnical Division. The OJT on how to create polygons and polylines was conducted. The detailed contents of the OJT are as follows:

- How to make Geo-references for the scanned field map to be compiled into the GIS
- How to create polygons and polylines from Geo-referenced map
- How to put and arrange the data information for each polygon and polyline in the attribute table of GIS

5.5.4 Technical Transfer of Knowledge for Taking Road Lines from GPS to GIS

The database of slope disaster has GIS functions and road lines will be updated by DoR staff in case of change of road lines or construction of a new road. Additionally, when GIS activity starts in this Project, the DoR Jurisdiction road will be managed by GIS application. In particular, the jurisdiction of Gewog road is changed from Dzongkhag to DoR, and all Gewog roads in Bhutan will be integrally managed under DoR.

In consideration of the conditions just mentioned above, the technical transfer of knowledge on how to track logged data by portable GPS and import it into GIS is necessary. The key recipients of the technical transfer to conduct technical transfer are Ms. Phuntso, who is in charge of GIS at DoR, and additionally Mr. Dorji at HQ of the Maintenance Division, as well as Mr. Tempa in the Geotechnical Division. In addition, the technical transfer activity was

conducted through a technical seminar targeted for Regional office in DoR.

Technical seminar in field on how to take track logged data by portable GPS

Technical seminar in office on how to import GIS

Figure 5.5.3 Photos of Technical Transfer Seminars (Source: JET)

5.6 Manual for database of slope disaster

After developing the database, the database will be maintained and updated by DoR. Therefore, the user's manual for DoR was prepared. The content of the manual has been specifically developed with the purpose of enabling DoR officers to conduct basic operations such as editing and updating of the data in future in mind. Additionally, the operation method of GIS application (QGIS) regarding the data operation of the main database is described in the appendix. The table of contents of the user's manual is shown in Table 5.6.1.

Table of Contents

Figure 5.6.1 Table of Contents (Source: JET)

Chapter 6

Advice to DoR

6 Advice to DoR

6.1 Advice to DoR regarding the countermeasures for slope disasters

We offer advice to DoR to improve site conditions and countermeasures for slope disasters based on the knowledge obtained through the Project.

6.1.1 Typical road slope disaster in Bhutan

Many cases of failure on cut slopes and embankments are found on/along the national roads in the Project. The main cause of failure on cut slopes can be considered to be the unsuitable angle of cut slope against geological material of the slope. The main causes of the failure on embankments can be considered to be 1) poor quality of embankment (e.g. inadequacy of compaction, unsuitable control of moisture contents); 2) lack of bearing capacity of footing on embankment; and 3) inadequate drainage system in embankment. The investigation, design and construction supervision will be carried out properly to avoid the causes mentioned above, so that the slope disasters will be decreased in the future.

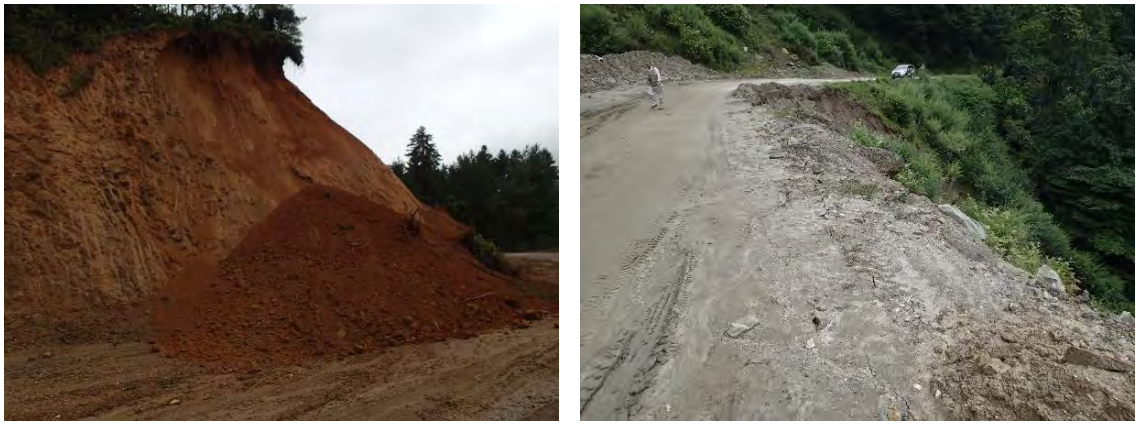


Figure 6.1.1 Photo of Typical Slope Disasters in Bhutan, Cut Slope Failure (left), Subsidence with Crack on Earth Fill Work Section (right) (Source: JET)

DoR has the guideline*1 regarding cut slope angles. In the guideline, cut slope angles are defined depending on the four following types of material of slope: rock, hard soil, soft soil, and ordinary soil. On the other hand, many cut slope failures are found on the actual cut slopes on the site. As mentioned above, the cause of the failure on cut slopes can be considered to be the unsuitable angle of a cut slope against geological material of the slope. Therefore, the guideline quality should be improved to contribute the mitigation of slope disasters. The guideline will be reviewed with the aim to help the engineers to decide the suitable slope angle easily and to fit the actual geological condition in Bhutan.

In most cases, countermeasures executed after disasters occurred cost more than the countermeasures on slope disaster-prone sections in road construction stages since the target area becomes wider and the condition of work becomes more severe. Therefore, appropriate investigation, design based on the results of investigation, and construction supervision are required in addition to reviewing the guideline. Those appropriate works will contribute to mitigate slope disaster in Bhutan.

6.1.2 Countermeasure works for slope disaster

Countermeasure works are found on many road slopes along the national road in Bhutan. In many cases, the countermeasure works are applied to stabilize a slope which is made by excavation work or earth fill work to secure road width. Countermeasure works executed on slopes along the access road for dam construction have been conducted by the contractor of India or Joint Venture between local and foreign companies. On the other hand, countermeasure works for the national highway are executed by a local company in many cases. Therefore, some differences such as the type of countermeasure works between both cases can be seen.

In the beginning of the Project, the questionnaire survey to the C/P of DoR regarding available countermeasure works in Bhutan was conducted. As shown in Chapter 2 in this report, it has been clarified from the survey results that retaining walls and relatively simple earth works such as excavation and earth filling are available in Bhutan. However, the works which require specific materials and higher techniques such as ground anchor or steel piling work as well as tunneling are difficult to be conducted by the local contractor (refer to 2.4.2 Structural Countermeasure). On the other hand, even though the works do not require difficult techniques to be implemented, there are difficult cases to conduct since the required works are costly because the work area is broad.

Advice for current situation of countermeasures for slope disasters in Bhutan is shown below.

a. Small scale countermeasure works for slope disasters

Many countermeasure works which were carried out by DoR have been conducted on relatively small scale failed slopes (100 m^2 ~ 600 m^2). The work type of most of all cases are the excavation work, to make the slopes stable; and the stability work by gabion or masonry retaining wall at the toe part of slopes.

Figure 6.1.2 Photo of Typical Countermeasure Works in Bhutan, Excavation Work (left), Masonry Retaining Wall (right) (Source: JET)

The countermeasures in sufficient alignment and specification can be expected to have an efficacy against slope disasters even with such simple works. Therefore, it is important to make a design of countermeasure works properly based on the detail site investigation to know the actual condition of target slope. Additionally, maintenance of countermeasure facilities shall be carried out properly to secure the quality and efficacy of the facilities. On the other hand, it will be difficult to deal with the slope disasters by only such typical works of DoR. It will be an indispensable requirement for DoR to apply the countermeasure works that have more restraining force to larger scale disasters.

The works discussed above are applied for disaster of slope failures and/or rockfalls. On the other hand, there are not many cases applying the respective countermeasure works for landslide and debris flow. According to the results of the site inspection in the Project, not so many landslide hazard slopes are found, and its conditions are not high emergency for implementing countermeasures in comparison to the cases of slope failures. However, slopes that have debris flow hazards are found in many cases, and most of these cases of debris flow hazard slopes are evaluated as high urgency hazards due to insufficient drainage system for the debris flow. Generally culvert or bridge under the road can be applied mainly as a countermeasure work for debris flow to make the flowed debris discharge through those facilities. Furthermore, many cases of debris flow hazard slopes can be dealt with by expansion of dimension of existing culvert or installation of additional culvert. Since those works are not difficult and do not require a high expense, it is recommended that debris flow hazard slopes shall be given a higher priority to apply countermeasure works.

b. Large scale countermeasure works for slope disasters

In this project, 11 slopes are evaluated as slopes which have a high hazard rank and an estimated high cost for implementing countermeasure works, and are shown on Table 6.1.1.

Table 6.1.1 List of the highest hazard slopes with high cost of implementing countermeasure works (Source: JET)

Management No.	Road No.	Disaster type	Hazard rank	Est. cost*
WPP0121030	NPH1	Rock slope failure	Rank 1a	206
TPP0120850	NPH1	Rock slope failure	Rank 1a	175
TPP0120870	NPH1	Rock slope failure	Rank 1a	260
TRP0420010	NPH4	Rock slope failure	Rank 1a	218
TRP0420020	NPH4	Rock slope failure	Rank 1a	140
TRP0420040	NPH4	Rock slope failure	Rank 1a	140
TRP0420080	NPH4	Rock slope failure	Rank 1a	156
TRP0420130	NPH4	Rock slope failure	Rank 1a	272
TRP0420160	NPH4	Debris slope failure	Rank 1a	1,015
TRP0420560	NPH4	Rock slope failure	Rank 1a	158
TRP0450280	NPH4	Rock slope failure	Rank 1a	189

*: Million Ngultrum (direct cost of work)

For those slopes, ground anchor works and/or large scale earth works and high retaining wall are estimated as countermeasures. It can be considered that ordinal countermeasure works for slope disasters will be difficult to be applied, especially the two slopes namely the Management No. TPP0120850 (commonly called Thumang Cliff) and the Management No. TRP0420160 (commonly called Reotala Cliff). Both slopes are ranked as high urgency hazards due to failures that occur frequently and each slope' condition to construct the works are extremely severe. Moreover, it also can be considered that the construction work for the Thumang cliff will require not only the direct cost as shown on Table 6.1.1 but also an extremely huge expense for temporary works because the slope is enormous with unstable conditions. Furthermore, the tunnel work is considered as alternative countermeasure work for the two slopes to avoid critical hazard road section. Contents of the discussion regarding this matter are mentioned in the next chapter.

6.2 Background of Grant Tunnel Project

6.2.1 Importance of Primary National Highways (Widening of Existing Highways)

Since Bhutan is a mountainous and land locked country, the road network system is primarily used as the transportation infrastructures due to the absence of the rail connections and limited air connectivity. The overall objectives of the government in the transportation sector is to improve all major highways to primary national highway standard (double lane) to facilitate safe and smooth movement of all types of vehicular traffic. The main objective of DoR is to achieve the national goal of poverty reduction and economic growth through road construction. Especially, the goal of poverty reduction and Gross National Happiness can be achieved through: enhancement of rural accessibility, provide the road connectivity to minimize the walking distance of rural population, enhance the reliability of road network by providing better riding comfort, lesser travel time, safer roads and finally reduce the impact on the environment.

Considering the importance and utmost necessity to up-grade the existing highway to a higher standard to avoid fatal incidences, the government had instructed DoR to widen or up-grade the existing highway to the primary national highway standards during the 11th Five Year Plan (2013-2018). The present government has further decided to widen Primary National Highway No.1 (PNH-1) ahead of other PNHs, which is the only highway running east to west in the country and has the principal cities connecting to the south-bound national highways, whereby one could travel in small car from Thimphu to Trashigang in a matter of 12-13 hours in the future. This will promote ensuring equitable development in all corners of the country including reduction in the rural to urban migration. Therefore, it is important to widen the existing PNH-1 to make the road network reliable, safer and more comfortable means of communication with reduced travel time with minimum impact on the vulnerable environment. In addition, this will facilitate transportation of equipment and material for the on-going Hydro-Electric Projects of Punatsangchu I, Punatsangchu II, Mangdechu and other expected hydropower project in the eastern Bhutan. The widening work through whole section of PNH-1 is planned to be completed by June 2018.

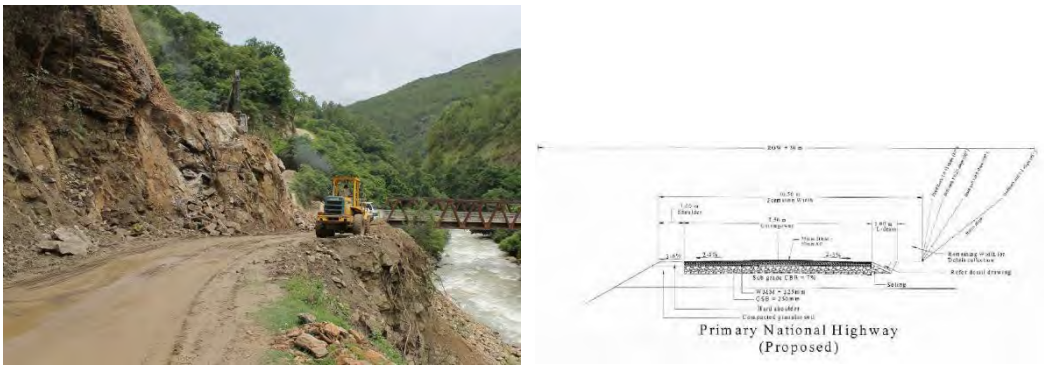


Figure 6.2.1 Photo of Widening Work in Wangdue (left), Typical Cross Section of PNH (right)
(Source: DoR)

6.2.2 Bottleneck for Widening

However, DoR is bound to face difficulties due to fragile geological conditions and extreme geomorphologic characteristics of an area in Trongsa District. The highway passes through rugged terrains, extreme climatic conditions, unstable slopes, steep cliffs, and volatile

ecosystems at the area, which would definitely be a great challenge to the road engineers and to the general public at large. The area is "Thumang Cliff".

In 2010, there was a serious landslide at Thumang Cliff due to a road widening work and the road was completely blocked for a week after a large number of boulders rolled down the hillside. After the incident, DoR decided not to cut the slope in order to avoid a further disaster. Even now, a section including the landslide area remains untouched while widening works are going on at the other sections. Therefore, this section will be a **missing link** and safe and stable movement of vehicular traffic cannot be achieved even if all other sections are widened.

Figure 6.2.2 Landslide at Thumang Cliff
(Source: RSTA*[1])

As for the other national highways, there is a very serious disaster-prone area which is "Reotala Cliff" in Trongsa along Primary National Highway No.4 (PNH-4). Road block due to landslide occurs every year during monsoon and rolling boulders sometimes hit the vehicle. This is not only causing economic loss but also is threatening people' life. DoR's regional office needs to keep several excavators on standby at the site to clear the block whenever there is a landslide. This causes lot of financial and human recourse implications for DoR. Because DoR needs to spend substantial amount of budget every year to maintain the slope and worker's life is always exposed to danger. And also it is difficult for normal vehicles to pass through the section even after removing boulders because road surface condition is very rough. PNH-4 is also a very important trunk highway, therefore, DoR is planning to widen the highway after completion of widening of PNH-1. At that time, Reotala Cliff will be a bottleneck point as same as Thumang Cliff for PNH-1.

Figure 6.2.3 Landslide at Reotala Cliff
(Source: Kuensel*[3])

At present, "Master Plan Study for Road Slope Management in Bhutan" in collaboration with JICA is executing and road slope disaster management inspections such as field survey is being performed in the selected sections along PNHs. DoR requested the JICA Expert Team (JET) to include Thumang Cliff and Reotala Cliff in the survey target in order to understand detailed geological condition of the slope and study a possible permanent countermeasure for the slope stabilization. According to the progress report from JET, both slopes consist of relatively fresh with partially weathered rock together with debris covering surface of top portion of the slope without vegetation. The road is unstable especially when seepage water increases in the slope. Unstable bedrock with open cracks is eminent in whole slopes. Debris flows exist in both sides as well as in the middle of the section. JET concludes that these are one of the most remarkable slope failures and some permanent countermeasures should be installed at both mountain side and valley side as early as possible. And JET proposes to study bypass with tunnel as an alternative of the countermeasures because construction cost of tunnel could be cheaper than that of slope protection method in some of the severely unfavorable geological

locations.

6.2.3 Necessity of Application of Japanese Advanced Technology

As explained above, upgrading the existing PNHs with solving the difficult problem on implementing permanent countermeasures at the disaster-prone landslide area is extremely important in order to achieve the national goal of poverty reduction and economic growth. However, there is no experience of planning/construction of both large-scale slope protection method and tunnel in Bhutan so far, therefore, DoR would like to request Japanese government to provide grant aid to implement the study and the relevant construction work in consideration the application of Japanese advanced civil engineering technologies.

6.2.4 Objectives of the Project/Program

a. Overall goal

Since the road network in Bhutan being the primary communication and transportation means, the overall goal of the project is to make the road network system more reliable, safer and comfortable. With more reliable and safer road network, Bhutan can achieve the goal of poverty reduction through equal socio-economic development in all corners of the country. This will also help in addressing the rural-urban migration – challenge faced by the government, which is main hurdle in developing the rural areas of Bhutan.
And also, there is an increasing need of disaster management in Bhutan to enhance the socio-economic status of the rural communities as well as upgrade the existing road network to cope with increasing vehicular traffic. The country's fragile terrain, high ridges and deep gorges, scattered settlement and low population density are some of the constraints which hinder the development of road network in Bhutan. Every monsoon, there are many landslides and roadblocks in most parts of the country. The government also spends millions of Ngultrum in the monsoon damage restoration works such as rebuilding protection walls and in some cases realignment of the entire road. Coping with the above mentioned issues on disaster management is also one of the objectives of the Project.

b. Project/program purpose

Project purposes are;

- To ensure smooth and stable vehicular traffic on PNH-1 and PNH-4 by avoiding fatal landslide, and

- To receive technical transfer on advanced technology, such as slope protection method or tunnel, from Japan to Bhutanese engineers (DoR, private company, etc.)

*Note: There are many similar locations along PHNs where slope protection method or tunnel can be applied in order to improve road network. DoR considers that this grant aid project can be a precedent and knowhow and technology from this project can be also applied for other locations.

c. Location and related information

- Country scale map indicating the project/program site

Figure 6.2.4 Country Scale Map Indicating the Project Sites (Source: JET)

- Address of the project/program site, the access time from the capital or a major city, socioeconomic data on the administrative region (state/province/prefecture) or city where the site is located

  - Thumang Cliff: about 15km west of Trongsa town
  - Reotala Cliff: about 30km south of Trongsa town

- Reasons for the selection of the site (the priority status of the sites, if plural)

[Thumang Cliff]

DoR cannot implement widening at this location because of fragile geological conditions and extreme geomorphologic characteristics. Therefore, this section will be a missing link and safe and stable movement of vehicular traffic on PNH-1 cannot be achieved even if all other sections are widened. JET also concludes in the on-going project that these are one of the most remarkable slope failures and some permanent countermeasures should be installed at both mountain side and valley side as early as possible.

[Reotala Cliff]

Reotala Cliff is the most critical and large-scaled landslide area on PNH-4 and road block due to landslide occurs every year during monsoon. DoR is planning to widen PNH-4 after completion of widening of PNH-1. At that time, Reotala Cliff will be a bottleneck point as same as Thumang Cliff for PNH-1. JET also concludes in the on-going project that these are one of the most remarkable slope failures and some permanent countermeasures should be installed at both mountain side and valley side as early as possible.

- Landowner (private or public estate) and the right to use the land for the project
  - Mainly government land
- Situation of the proposed site (land inclination, drainage, electric power and water supply, telephone lines, etc.)

[Thumang Cliff]

The site inclination or the slope is more than 80^{o} and have abundant water supply, however, within few 10 meters the land is gentle for setting the project site offices, labor camps etc. There is no electricity but mobile phone facilities are available.

[Reotala Cliff]

The site inclination or the slope is almost 90^{o} in most areas and have abundant water supply. However, within one km, the land is gentle for setting the project site offices, labor camps etc. There is no electricity but mobile phone facilities are available.

- Security situation
  - There is no security threat of any kind.

d. Outline of the facility

- Lay out plan of the existing facility which would be rehabilitated/improved
  - No existing facility (new construction in this project)
- Size of the site/facility and their photographs

Based on the past study on bypass with tunnel by DoR, outline of bypass plan is shown below;

Figure 6.2.5 Proposed Bypass Route at Thumang Cliff (Source: JET)

Figure 6.2.6 Proposed Bypass Route at Reotala Cliff (Source: JET)

- Facilities' design, construction standards in the requesting country

[For road design]

- Road Survey & Design Manual (First Edition June 2005)
- INITIAL PROJECT DOCUMENT (IPD)

[For slope protection design]

Japanese standard shall be applied because there is no standard on design of slope protection in Bhutan.

[For tunnel design]

Japanese standard shall be applied because there is no standard on tunnel design in Bhutan.

- Country from which materials are potentially available for construction

- Most of the construction materials like cement, reinforcement steel and local construction materials like boulders, aggregate, sand etc. are available in Bhutan. Some special materials should be from India and Japan.

- Estimated cost of construction (equivalent to 7.(2))

The total estimated cost for the project is **US$ 40 million** including the cost for design and supervision.

6.3 Advice for Background of Grant Tunnel Project

6.3.1 Geotechnical Aspect

The National Highway No.1 is prone to sudden rock falls which are mainly caused by heavy rain fall especially in the monsoon season.

Figure 6.3.1 Thumang Cliff along the National Highway No.1 (Source: JET)

Under the current road development plan, the road is widened by two lanes through excavating the Cliff's slope through bench-cutting or dynamite. Cracks or fissures are clearly developing on the cliff's surface due to its petrological character and steep angle of slope. Once the face of the slope is weakened due to the erosion caused by the heavy rain, the excavated rock (slope) comes prone to disintegration or falling because a lack of protection works on them. In this erosive condition the tentative countermeasures such as slope cutting will neither be permanent works which contribute the safety of the road users (drivers) nor be cost efficient construction works with a high benefit-cost ratio (BCR) because of continuous budget outflows into the construction works.

In this case in Japan, a new paradigm shift of road planning would be needed to utilize the geological and topographical features in this type of areas. The hardness of rock itself is maintained according to the results of geological investigation implemented near Thumang Cliff. The short cutting method of tunneling is proposed from the following aspects:

- To shorten and straighten the road route dramatically so the connectivity is improved between both ends of the road route/section.

- To utilize the rock hardness to form a stable arch in combination with the Rock Dynamics (Engineering).

- To employ the current/conventional engineering technology exemplified in the hydro power development such as water tunneling (conduit pipe) or water diverting works (tunneling).

6.3.2 New Austrian Tunneling Method (NATM)

New Austrian Tunneling Method (NATM) is defined as the underground passage dug through the mountain/rock for the use of passage of road. Originally developed in Austria in 1962 (Rabcewicz), construction with NATM has spread throughout the world due to its simple mechanism of arch formation mechanics (geological conditions around the tunnel's inner space) and tunnel support system (iron support, shotcrete and rock bolt).

The main aspect of the approach in NATM is dynamic design based on rock mass classification as well as the in situ deformation observed. So the economical use of the tunnel support system is carried out.

NATM is based on the following principles*[4]

- Application of the strength of rock mass: the method relies on the inherent strength of the rock mass.
- Shotcrete protection: loosening and excessive rock mass deformation should be minimized by applying a sealing of shotcrete immediately after opening of the face.
- Measurements: every deformation of the excavation must be measured by the instruments such as deformation sensors (monitoring).
- Primary Lining: the primary lining should be thin using wire or Lattice girders.
- Closing the invert: the invert should be closed as quickly as possible so as to complete the arch action and create a load-bearing ring.
- Rock mass classification: the participation of the geologist is very important because the primary support as well as further support designs require rock mass classification.

The Japanese Society of Civil Engineers has organized a wide range of technical know-how and practical knowledge, and has issued the "Standard Specifications for Tunneling-2006: Mountain Tunneling (English version) as the guideline which the engineers should follow when they plan to construct a tunnel in the mountainous area as that in Thumang Cliff*[5].

When taking into consideration the site geological conditions practically the following aspects should be examined:

- The surface topological condition: the tunneling portal is affected by the surface topological conditions such as landslide-like topology or talus deposits when the excavation around the tunnel portal is implemented. In the Thumang Cliff area, the north side area has talus deposit topology, thus the positioning of the portal should be examined so as to reduce the effect from the disturbance of the abnormal topology.

- The rock mass classification of the support system is influenced by geological heterogeneous factors such as fractures, fissures, and cracks. The fundamental examination for the feasibility of the tunneling is based on the elastic wave velocity analysis that is affected by the heterogeneity/homogeneity of the geology. The standardized classification of the rock mass in the planned mountain should be constructed for authentication of the supporting system.

- The logistics for the iron support system and concrete supply chain system should be necessary for both reliable and sustainable methods of construction on site. The industrialized construction system should be necessary in a wide range of the supply system such as concrete delivery (shotcrete), iron bar (rock bolt and support) as well as heavy machines (drill-jumbo, cutter-machine, and ventilation system).

(Reference)

*1 Ministry of the Works and Human Settlement, Guideline on use of Standard Work Items for Common Road Works

*2 Road Safety and Transport Authority, http://www.rsta.gov.bt/

*3 Kuensel, http://www.kuenselonline.com/

*4 Japan Society of Civil Engineers, Standard Specifications for Tunneling (Japanese version) 2006: Mountain Tunnels (New Austrian Tunneling Method), 2007

*5 Japan Society of Civil Engineers, Standard Specifications for Tunneling (English version) 2006: Mountain Tunnels (New Austrian Tunneling Method), 2007

Chapter 7

Technical Transfer

7 Technical Transfer

7.1 Methodology

7.1.1 Basic Policy of Technical Transfer

When JET conducts the slope inventory with DoR as part of the Project, technology and knowledge are transferred with the following basic policies:

Use of seminars: seminars of specific topics such as image interpretation and determination of disaster factors should be provided to facilitate the C/P's understanding by combining OJT in the field.

Fixed C/P members: Preferably, the C/P personnel should remain unchanged to ensure technology transfer. This was confirmed at the first SC.

Effective sharing of technical information: All used documents should be converted into digital data. When a new member joins, existing documents should be given to the new member and they should be explained in detail to prevent any delay in technology transfer due to personnel changes of the C/Ps.

Technology transfer as teams: To improve skills, DoR personnel should work together in a team with JET to perform a series of tasks, including the selection of sections to be surveyed, screening, field surveys, and creation of the inventory and the regular check sheet.

Regarding the risk analysis and the regular check, DoR should work together in a team with JET to perform the factor analysis and create and use regular checks to improve their skills. For the purpose of technology transfer, detailed explanations, particularly on how the tasks related to the slope disaster inspection and the regular check should be linked to the road slope management master plan, are given to DoR through repeated theory courses (classroom lectures) and practice sessions (field inspections).

7.1.2 Method of Technical Transfer

The technical transfer is mainly divided into 6 parts; OJT, pilot project, workshop, seminar, training in Japan, and public relations.

OJT and pilot project have been implemented through the daily actives in the Project, and the methodology and results are described in the previous chapters.

Technology transfer workshops are to facilitate understanding of a wide variety of basic technologies when each report is prepared, as well as seminars to deliver individual expert skills are provided to facilitate technology transfer. The seminars are provided in several phases in combination with OJT in areas such as inspection techniques, analysis, and slope disaster management measures, and they ensure technology transfer.

Training in Japan is provided to help the Bhutanese to understand the techniques used in Japan for slope disaster inspection, along with a wide variety of slope disaster management technologies and techniques. The training is around 15 days long, including classroom lectures, to provide enough time to visit sites and road maintenance facilities.

Public relations is to gain an internal and external understanding of the Project and to promote the use of the results of the Project by using the technology transfer workshop and seminars, the DoR website, and a project newsletter in the form of a leaflet. JET sees this as a way to transfer know-how to provide disaster management training and address public relations issues for the C/Ps, as well as to convey the importance of building consensus with the local community.

The objectives and inputs of each item of the technical transfer are summarized as the following Table 7.1.1 to ensure that the technical transfer is effective.

Table 7.1.1 Objectives and Inputs on Technical Transfer (Source: JET)

Item	Objectives	Contents
OJT	✓ Grasp the technology of screening, inspection, analysis, evaluation, database, and countermeasures on slope disaster on roads. ✓ Discuss master plan on roads and manual.	・Collaboration on desk work, site inspection, reconnaissance, monitoring, and construction ・Advice on countermeasures with DoR ・Establishment of manual
Pilot Project	✓ Understand actual method of plan, design, cost estimation, construction, and maintenance of countermeasures. ✓ Understand cooperation of residents and stakeholders for construction	・ Collaboration on plan, design, cost estimation, construction and maintenance of countermeasures ・ Stakeholder meetings ・ Public relations for local residents
Workshop	✓ Review and discussion of the progress of the Project ✓ Understanding of a wide variety of basic technologies ✓ Understanding and education of slope disaster management ✓ Disaster management training for the parties involved	1st session ・ Presentation of Progress Report ・ Examples in Japan 2nd session ・ Presentation of Interim Report 3rd session ・ Presentation of Draft Final Report ・ Disaster management education
Seminar	✓ Ensure the understanding of specific areas that expert skills are gained. ➢ In different areas ➢ Multiple sessions	・ Slope disaster inspection (field inspection) ・ Screening ・ Slope inventory and a regular check ・ Database and GIS ・ Countermeasures etc.
Training in Japan	✓ Understand “what is a slope disaster?” and “what is disaster management?” for landslide management in Bhutan in the future. ✓ Understand actual slope disaster countermeasures management	・ Visit Land, Infrastructure and Transportation Ministry in Japan ・ Visit local authorities in Japan ・ Visit universities and research institutes ・ Visit private consultants
Public relations	✓ To gain an internal and external understanding of the Project and promote the use of the results of the Project	・ DoR website, ・ Project newsletter ・ Stakeholder meeting

7.2 Structure of Technical Transfer

The technology and knowledge for the slope inspection on roads and the management method are transferred to the C/P members in DoR, especially Working Group (WG) members as the following Table 7.2.1. The WG consists of engineers form Thimphu Headquarters and nine (9) Regional Offices which covers all roads in Bhutan to disseminate the technology to the entire regional offices in Bhutan effectively and efficiently. The members in WG are supposed to re-transfer the technology they have gained through the Project to other engineers who cannot join OJT, workshop or seminar in each regional office (Figure 7.2.1). JET, therefore, distributes the digital data of materials for explanation to C/Ps in WG as well as the printed handouts that were used in the OJT, workshops and seminars to redistribute to other engineers.

Table 7.2.1 List of the Working Group in DoR (Source: JET)

No	Name	Position	Organization
1	Dorji Tshering	Deputy Executive Engineer	Headquarters, Thimphu
2	Dilip Kr. Thapa	Executive Engineer	Headquarters, Thimphu
3	Phuntsho Wangmo	Assistant Architect	Headquarters, Thimphu
4	Dhendup Dorji,	Engineer	Regional Office, Tashigang
5	Nim Dorji	Assistant Engineer	Regional Office, Lingmethang
6	Wangchuk	Engineer	Regional Office, Trongsa
7	Karma Dorji	Executive Engineer	Regional Office, Sarpang
8	Sonam Thinley	Assistant Engineer	Regional Office, Lobesya
9	Drakpa Wangdi	Executive Engineer	Regional Office, Thimphu
10	Neten Tshering	Deputy Executive Engineer	Regional Office, Samdrup Jongkhar
11	Karchung	Deputy Executive Engineer	Regional Office, Zhemgang
12	Prabin Gurung	Deputy Executive Engineer	Regional Office, Phuentsholing.

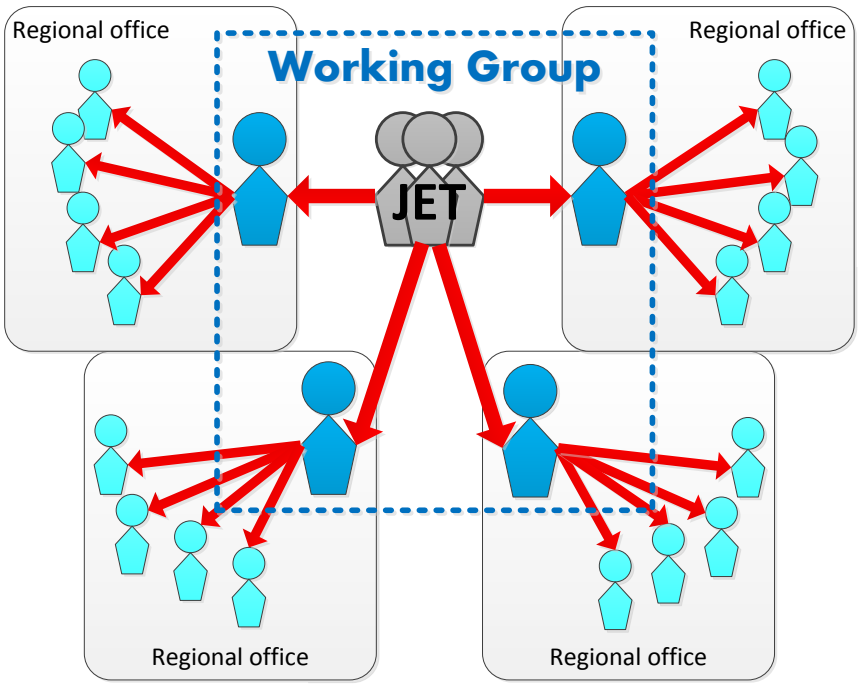


Figure 7.2.1 Schematic Figure of Technical Transfer and Re-transfer (Source: JET)

On the other hand, C/Ps in WG cannot easily participate in the workshops/seminars because they are the main engineers in each regional office and have enormous tasks in daily job, and it takes much time for domestic transportation in Bhutan, for example it takes almost two days from eastern major city, Trashigang, to capital Thimphu.

Therefore, the workshops/seminars and the related trainings are held at the two major cities, Thimphu (western Bhutan) and Trongsa (central Bhutan), with the same topics/themes so that all C/Ps in WG are able to join the activities in the Project, which means that JET has two technical transfers for each topic/theme in two cities. The C/Ps from the western regional offices participates in the activities of the Project in Thimphu and the C/Ps from the central and eastern regional offices participate in the activities in Trongsa (Figure 7.2.2).

Beside Thimphu (western Bhutan) and Trongsa (central Bhutan), JET has a workshop or a seminar in a place where DoR staffs can join them. In that case, the lecturer is WG member who has already been transferred while JET attends them as an observer.

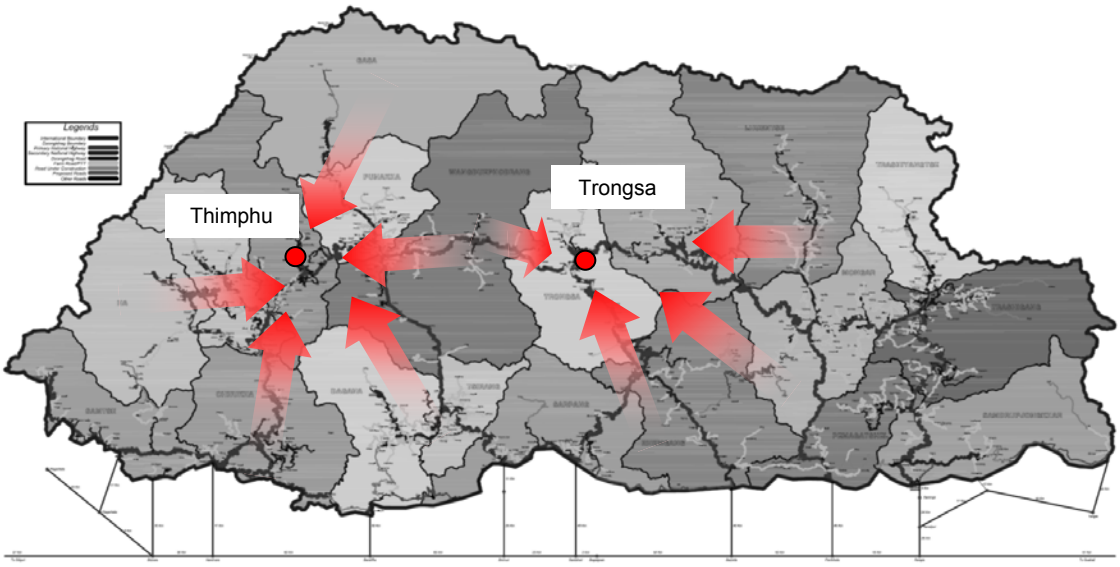


Figure 7.2.2 Technical Transfers in Thimphu and Trongsa (Source: JET)

7.3 Technical Transfer Workshops

Technical transfer workshop is mainly to review and discuss the progress of the Project; therefore, it is held three times during the Project period after the official reports are submitted by JET. The targeted participants are C/Ps, relevant ministries and agencies, private sector, and universities.

The 1st technical transfer workshop was held on 17th February 2015 in Thimphu and on 3rd March 2015 in Trongsa with the aim of informing the contents, policy, and procedure of the Project and the results of the component 1 "Inspection manual" and a part of the component 2 "Slope disaster inspection on roads" to the relevant stakeholders. The workshop was presented by JET and C/P. The agenda of the workshop in Thimphu is as follows;

1.	Opening speech Director, DoR	9:30-9:35
2.	Outline of the Project Mr. Kuwano, Team leader, JET	9:35-9:50
3.	Slope disaster type Mr. Kuwano, Team leader, JET	9:50-10:10
4.	Slope disaster on roads in Bhutan Mr. Tempa Thinley, Engineer, DoR	10:10-10:30
5.	Standard countermeasures for slope disasters Mr. Hara, Slope stability countermeasure, JET	10:30-10:50
6.	Data/information collection Mr. Yamamoto, Environmental & social consideration, JET	11:10-11:20
7.	Screening Mr. Hara, Slope stability countermeasure, JET	11:20-11:40
8.	Preparation of road slope inventory Mr. Kuwano, Team leader, JET	11:40-12:00
9.	Activity plan Mr. Kuwano, Team leader, JET	12:00-12:10
10.	Closing speech Chief Engineer, DoR	12:10-12:15

Figure 7.3.1 1st Technical Transfer Workshop (Left: Thimphu, Right: Trongsa) (Source: JET)

The 2nd technical transfer workshop was held on 21st October 2015 in Thimphu and on 26th October 2015 in Trongsa with the aim of informing the results of the component 2 "Slope disaster inspection on roads", the component 3 "Inspection database", and component 4 "Advice for countermeasures" to the relevant stakeholders. The workshop was presented by JET and C/P. The agenda of the workshop in Thimphu is as follows;

1.	Opening speech	9:25-9:30
	Mr. Kuwano, Team leader, JET	
2.	Progress of the Project	9:30-9:40
	Mr. Kuwano, Team leader, JET	
3.	Methodology of road slope inventory	9:40-10:00
	Mr. Tempa Thinley & Mr. Phuntsho Wangmo, DoR	
4.	Hazard evaluation and inventory results	10:00-10:20
	Mr. Kuwano, Team leader, JET	
5.	Geological investigation	10:20-10:40
	Mr. Tozawa, Investigation and Monitoring, JET	
6.	Standard countermeasures for slope disasters	10:40-11:00
	Mr. Hara, Slope stability countermeasure, JET	
7.	Road maintenance in Bhutan	11:15-11:30
	Mr. Dorji Tshering, DoR	
8.	Database of slope disaster	11:30-11:50
	Mr. Cheku, Assistant of database management, JET	
9.	Results of the training in Japan	11:50-12:10
	Mr. Drakpa Wangdi, Mr. Karchung & Mr. Sonam, DoR	
10.	Activity plan	12:10-12:25
	Mr. Kuwano, Team leader, JET	
11.	Closing speech	12:25-12:30
	Chief Engineer, DoR	

Figure 7.3.2 2nd Technical Transfer Workshop (Left: Thimphu, Right: Trongsa) (Source: JET)

The 3rd (final) technical transfer workshop was held on 10th June 2016 with the aim of informing the results of the entire contents on the Project to the relevant stakeholders. All C/P came to Thimphu to attend the workshop for detailed discussion and understanding. The opening speech was done by Mr. Phuntsho Wangdi, Secretary, MoWHS.

The 3rd workshop was presented by C/P supported by JET because C/P proposed that "C/P should deliver the presentations about the slope disaster inspection and the GIS database that they have been transferred through the Project"

The agenda of the workshop is as follows;

1.	Opening speech	10:00-10:10
	Mr. Phuntsho Wangdi, Secretary, MoWHS	
2.	Keynote speech	10:10-10:20
	Mr. Yamada, Chief Representative, JICA Bhutan Office	
3.	Outline of the Project	10:20-10:40
	Mr. Kuwano, Team leader, JET	
4.	Slope disaster type and Selection of survey sections	11:00-11:20
	Mr. Kuwano, Team leader, JET	
5.	Screening	11:20-11:40
	Mr. Hara, JET, Mr. Karma and Mr. Jambay Tenzin, DOR	
6.	Slope inspection on road	11:40-12:10
	Mr. Kotoo, JET, Mr. Dendup and Mr. Neten Tsherng, DoR	
7.	Hazard evaluation and inspection results	12:10-12:30
	Mr. Iwasaki, JET, Mr. Wangchuck and Mr. Nim Dorji, DoR	
8.	Regular check	14:00-14:20
	Mr. Kotoo, JET, Mr. Tempa and Mr. Sonam Thinley, DoR	
9.	Priority of countermeasures on slopes disaster	14:20-14:50
	Mr. Hara, JET, Mr. Dorji Tshering and Mr. Karchung, DoR	
10.	Database of slope disaster	14:50-15:20
	Mr. Saito, JET, Ms. Phuntsho and Mr. Drakpa, DoR	
11.	Closing speech	15:20-15:30
	Mr. Karma, Director, DoR, MoWHS	

Figure 7.3.3 3rd Technical Transfer Workshop (Source: JET)

7.4 Seminars

Seminars are mainly to ensure the participants gain understanding of specific fields required for attaining expert skills. 18 seminars have been held during the Project period as shown in Figure 7.4.1. The targeted participants are C/Ps.

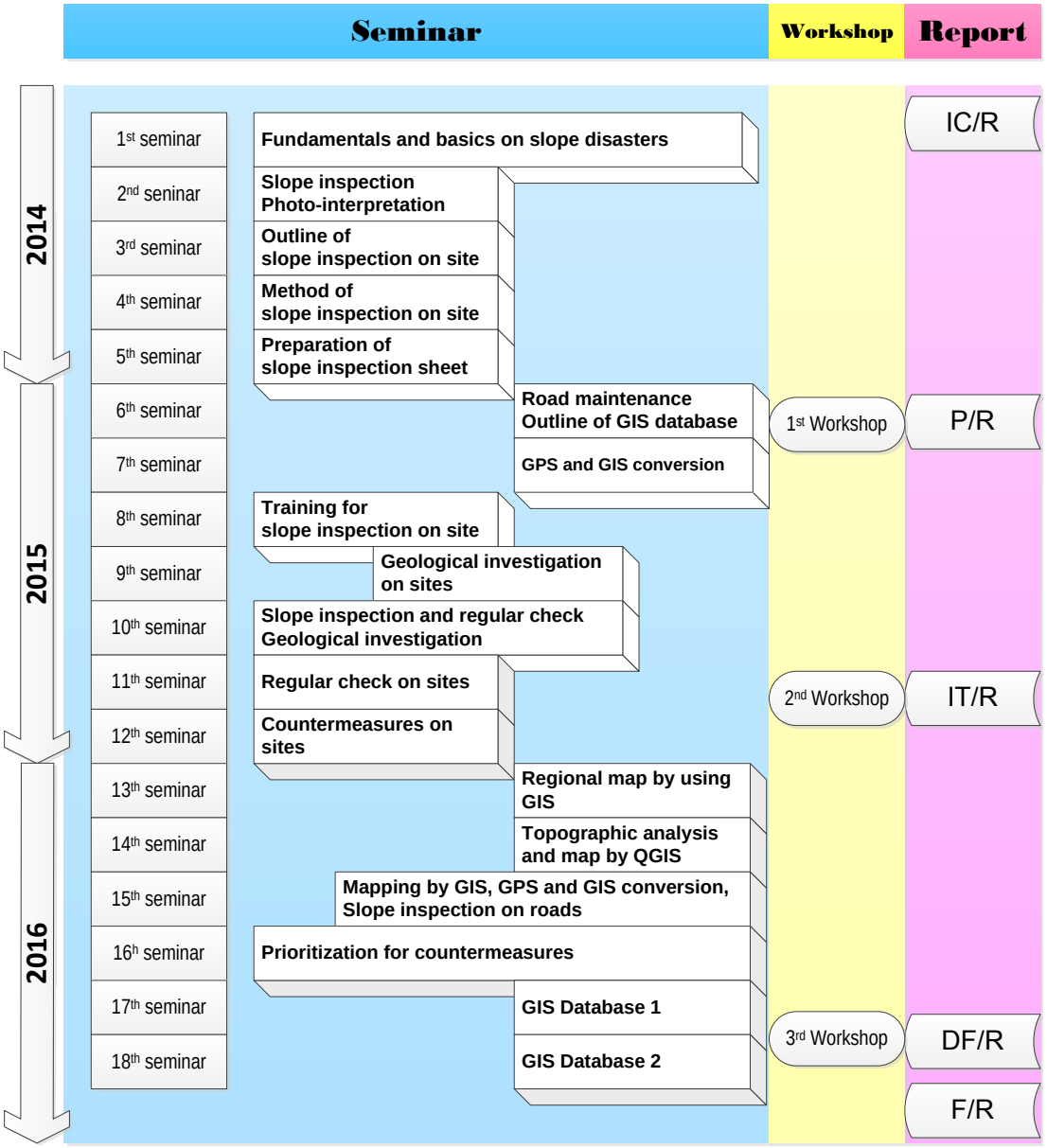


Figure 7.4.1 Schedule and Contents of the Seminars (Source: JET)

The seminars for certain themes have been conducted by the JET to accelerate C/P's understanding for screening, inspection, analysis, evaluation, management and GIS mapping in the Project as the following Table 7.4.1.

Table 7.4.1 Summary of Seminars (Source: JET)

No.	Theme	Date/time	Venue	C/P	JET
1	Fundamentals and basics on slope disasters	19 August, 2014, 14:30-16:00	DoR, Thimphu	12	Kotoo, Hara
		22 August, 2014, 14:00-16:00	DoR, Trongsa	14	
2	Slope inspection & Aerial photo-interpretation	30 September, 2014, 14:30-16:30	DoR, Thimphu	7	Kuwano, Tozawa, Yamamoto
		9 October, 2014, 14:30-16:30	DoR, Trongsa	10	
3	Outline of slope inspection on site	12 November, 2014, 13:30-16:30	No.1 road, east of Wangdue Phodrang	7	Kotoo
		10 October, 2014, 8:30-10:30	No.1 road, west of Trongsa	7	Kuwano, Tozawa, Yamamoto
4	Method of slope inspection on site	12 November, 2014, 13:30-16:30	No.1 road, east of Wangdue Phodrang	7	Kotoo
		21 November, 2014, 9:30-11:30	No.1 road, west of Trongsa	6	
5	Preparation of slope inspection sheets	19 December, 2014, 13:30-16:30	No.1 road, Dochula	7	Kotoo
		12 December, 2014, 9:30-16:30	No.1 road, west of Trongsa	5	
6	Road maintenance Outline of GIS database	9 February, 2015, 14:00-15:30	DoR, Thimphu	6	Suganuma, Saito
		6 February, 2015, 9:00-11:00	DoR, Trongsa	9	
7	GPS and GIS conversion	10 March, 2015, 10:00-17:30 11-13 March, 2015, 10:00-17:00	Kawang, Mewang, Genekha, Dagala in Thimphu	2	Saito
8	Training for slope inspection on sites	14 April, 2015, 8:30-14:30	No.1 road near Trongsa	5	Kotoo
9	Geological investigation on sites	4 July, 2015, 8:45-10:30	Nalajin village, No.1 road near Trongsa	6	Tozawa, Kuwano, Iwasaki
10	Slope inspection and regular check, Geological investigation	6 July, 2015, 14:00-16:00	DoR, Thimphu	12	Tozawa, Kuwano, Iwasaki
11	Regular check on sites	28 August, 2015, 8:30-15:30	DoR, Lingmetheng	7	Kotoo
		4 September, 2015, 10:30-14:30	DoR, Trongsa	5	Kotoo, Sasaki
12	Countermeasures on sites	20 October, 2015, 14:00-17:00	No.1 road near Thimphu	6	Hara, Tozawa, Kuwano
		26 October, 2015, 13:00-16:00	No.4 road near Trongsa	7	
13	Regional map by using GIS	22 December, 2015, 9:15-15:30	DoR, Thimphu	12	Saito, Sasaki
14	Topographic analysis and map by QGIS	15 January, 2016, 9:30-16:00	DoR, Thimphu	4	Sasaki
		18 January, 2016, 10:00-16:00	DoR, Trongsa	3	
15	Mapping by GIS, GPS and GIS conversion, Slope inspection on roads	23 March, 2016, 9:00-17:00 24 March, 2016, 9:00-17:00 25 March, 2016, 9:00-17:00	DoR Phuentsholing, No.4 road and Gewog Road near Phuentsholing	14	Saito, Kotoo
16	Prioritization for countermeasures	15 April, 2016, 14:00-16:00	DoR, Thimphu	7	Hara, Kuwano
17	GIS database 1	1 June, 2016, 14:00-16:30	DoR, Thimphu	9	Saito
18	GIS database 2	20 June, 2016, 9:00-14:00	DoR, Lobeysa	13	Saito
		23 June, 2016, 14:00-17:30	DoR, Trashigang	16	
		27 June, 2016, 10:00-14:00	DoR, Thimphu	5	
		29 June, 2016, 9:00-12:00	DoR, Phuentsholing	6	

a. Fundamentals and Basics on Slope Disasters

Table 7.4.2 Outline of 1st Seminar (Source: JET)

Theme	Fundamentals and basics on slope disasters	
Date/Time	19 August, 2014, 14:30-16:00	22 August, 2014, 14:00-16:00
Venue	DoR, Thimphu	DoR ,Trongsa
Participants	Dorji Tsheing (HQ) Dilip Kr. Thapa (HQ) Phuntsho Wangmo (HQ) Tshering Wangdi "B" (HQ) Choki Wangmo (HQ) Penpa Dorji (HQ) Drakpa Wangdi (RO, Thimphu) Drakpa Wangdi (RO, Thimphu) Karma Dorji (RO, Sarpang) Sonam Thinley (RO, Lobesya) Prabin Gurung (RO, Phuentsholing) JET: Kotoo, Hara	Dorji Tsheing (HQ) Chunu Glalley (RO, Trongsa) Wangchuk (RO, Trongsa) L.Gautaun (RO, Trongsa) Bumpa Dema (RO, Trongsa) Tougay Cloedup (RO, Trongsa) Dhendup Dorji (RO, Tashigang) Nim Dorji (RO, Lingmethang) Neten Tshering (RO, Samdrup Jongkhar) Karchung (RO, Zhemgang) Kelzong Chophel (RO, Zhemgang) Teanam Tamang (RO, Zhemgang) Saroj Rai (RO, Zhemgang) Naseuyan Timsina (RO, Zhemgang) JET: Kotoo, Hara
Contents	• What is a “slope disaster”!? • Countermeasures for slope disasters • Questionnaires for existing conditions regarding; A) Available countermeasure works in Bhutan B) Past road disaster record C) Record of maintenance works for the slope disasters • Free Discussion	

Figure 7.4.2 Photos of 1st seminar (Source: JET)

b. Slope Inspection and Aerial Photo-Interpretation

Table 7.4.3 Outline of 2nd Seminar (Source: JET)

Theme	Slope inspection and Aerial photo-interpretation	
Date/Time	30 September, 2014, 14:30-16:30	9 October, 2014, 14:30-16:30
Venue	DoR, Thimphu	DoR ,Trongsa
Participants	Tshering Wangdi "B" (HQ) Phuntsho Wangmo (HQ) Tobgay (RO, Thimphu) Drakpa Wangdi (RO, Thimphu) Karma Dorji (RO, Sarpang) Sonam Thinley (RO, Lobesya) Prabin Gurung (RO, Phuentsholing) JET: Kuwano, Tozawa, Yamamoto	Sonam Dorji (RO, Trongsa) R.L.Gautaun (RO, Trongsa) Bumpa Dema (RO, Trongsa) Tougay Choedup (RO, Trongsa) Kezang Wangdi (RO, Trongsa) Laxuman Rai (RO, Trongsa) Dendup Dorji (RO, Trashigang) Nim Dorji (RO, Lingmethang) Neten Tshering (RO, Samdrup Jongkhar) Karchung (RO, Zhemgang) JET: Kuwano, Tozawa, Yamamoto
Contents	• Slope Inspection on Road A) Outline of the Project B) Outline of slope inspection C) Screening of targeted areas D) Preparation of inspection sheets E) Regular check for maintenance • Aerial photo-interpretation and its application for civil engineering A) Aerial photograph B) Aerial photo interpretation (photogrammetry) C) Example of aerial photo interpretation D) Practice of interpreting an aerial photo	

Figure 7.4.3 Photos of 2nd Seminar (Source: JET)

c. Outline of Slope Inspection on Site

Table 7.4.4 Outline of 3rd Seminar (Source: JET)

Theme	Outline of slope inspection on site	
Date/Time	12 November, 2014, 13:30-16:30	10 October, 2014, 8:30-10:30
Venue	No.1 road, east of Wangdue Phodrang	No.1 road, west of Trongsa
Participants	Dilip Kr. Thapa (HQ) Dorji Tsheing (HQ) Phuntsho Wangmo (HQ) Karma Dorji (RO, Sarpang) Sonam Thinley (RO, Zhemgang) Drakpa Wangdi (RO, Thimphu) Prabin Gurung (RO, Phunentsholing) JET: Kotoo	Nim Dorji (RO,Mongar-Lingmethang) Sonam Dorji (RO, Trongsa) Neten Tshering (RO, Samdrup Jongkhar) Karchung (RO, Zhemgang-Tingtibi) R.L.Gautaun (RO, Trongsa) Kezang Wangdi (RO, Trongsa) Laxuman Rai (RO, Trongsa) JET: Kuwano, Tozawa, Yamamoto
Contents	• Objective and necessity • Classification and categories A) Debris flows B) Landslides C) Debris slope failure (1) Rock slope failure	

Figure 7.4.4 Photos of 3rd Seminar (Source: JET)

d. Method of Slope Inspection on Site

Table 7.4.5 Outline of 4th Seminar (Source: JET)

Theme	Method of slope inspection on site	
Date/Time	12 November, 2014, 13:30-16:30	21 November, 2014, 9:30-11:30
Venue	No.1 road, east of Wangdue Phodrang	No.1 road, west of Trongsa
Participants	Dilip Kr. Thapa (HQ) Dorji Tsheing (HQ) Phuntsho Wangmo (HQ) Karma Dorji (RO, Sarpang) Sonam Thinley (RO, Zhemgang) Drakpa Wangdi (RO, Thimphu) Prabin Gurung (RO, Phunentsholing) JET: Kotoo	Dhendup Dorji (RO, Tashigang) Nim Dorji (RO, Lingmethang) Neten Tshering (RO, Samdrup Jongkhar) Karchung (RO, Zhemgang) Kozeng Wangdi (RO, Trongsa) Dorji Tsheing (HQ) JET: Kotoo
Contents	• Method of slope inspection • Confirmation of the site on topography maps • Evaluation of hazard	

Figure 7.4.5 Photos of 4th Seminar (Source: JET)

e. Preparation of Slope Inspection Sheets

Table 7.4.6 Outline of 5th Seminar (Source: JET)

Theme	Preparation of slope inspection sheets	
Date/Time	19 December, 2014, 13:30-16:30	12 December, 2014, 9:30-16:30
Venue	No.1 road, Dochula	No.1 road, west of Trongsa
Participants	Tempa Thinley (HQ) Dorji Tsheing (HQ) Phuntsho Wangmo (HQ) Karma Dorgi (RO, Sarpang) Sonam Thinley (RO, Lobesya) Drakpa Wangdi (RO, Thimphu) Prabin Gurung (RO, Phuentsholing) JET: Kotoo	Bumpa Dema (RO Trongsa) Chunu Galley (RO Trongsa) Sonam Choki (RO Trongsa) Kelzang Wangdi (RO Trongsa) Krishna Kumar Gautam (RO Trongsa) JET: Kotoo
Contents	• Preparation of slope inspection sheets • Classification of slope disaster • Evaluation of hazard	

Figure 7.4.6 Photos of 5th Seminar (Source: JET)

f. Road Maintenance and Outline of GIS Database

Table 7.4.7 Outline of 6th Seminar (Source: JET)

Theme	Road maintenance and outline of GIS database	
Date/Time	9 February, 2015, 14:00-15:30	6 February 2015, 9:00-11:00
Venue	DoR, Ministry's Conference Hall, Thimphu	Conference Room, Trongsa
Participants	Phuntsho Wangmo (HQ) Tempa Thinley (HQ) Tashi Tenzin (HQ) Karma Dorji (RO, Sarpang) Sonam Thinley (RO, Lobesya) Tobgay (RO, Thimphu) JET: Suganuma, Saito	Neten Tshering (RO, Samdrup Jongkhar) Kezang Wangdi (RO Tshangkha) Bumpa Dema (RO Trongsa) Jigme Dorji (RO Trongsa) Karchung (RO Trongsa) Wangchuk (RO Trongsa) Chunu Galley (RO Trongsa) Thinley Phuntsho (RO Trongsa) Sonam Dorji (RO Trongsa) JET: Suganuma, Saito
Contents	• Road Maintenance on Slope Disaster Prevention A) What is "Slope Disaster Prevention"? B) Introduction of Road Slope Maintenance Work C) Free Discussion on Present Issues in Maintenance Field in Bhutan • GIS Database for Road Disaster Management A) What is "GIS?" B) Linkage of Inspection Sheet database and GIS Map C) GIS database for Road Slope Management in Japan. D) 4. Outline of GIS database in this project.	

Figure 7.4.7 Photos of 6th Seminar (Source: JET)

g. GPS and GIS Conversion

Table 7.4.8 Outline of 7th Seminar (Source: JET)

Theme	GPS and GIS conversion
Date/Time	10 March, 2015, 10:00-17:30 11-13 March, 2015, 10:00-17:00
Venue	Kawang, Mewang, Genekha, Dagala in Thimphu
Participants	Tempa Thinley (HQ) Phuntsho Wangmo (HQ) JET: Saito
Contents	• Acquisition of track log by portable GPS • Transfer the GPS data to PC • Conversion to GIS shape file from GPS data • Mapping by GIS shape files • Revision of road line by satellite images etc.

h. Training for Slope Inspection on Sites

Table 7.4.9 Outline of 8th Seminar (Source: JET)

Theme	Training for slope inspection on sites
Date/Time	14 April, 2015 8:30-14:30
Venue	No.1 road near Trongsa
Participants	Wangchuk (RO Trongsa) Tashi Dorji (RO Trongsa) Nar Bdr Jogi (RO Trongsa) Karma Dorgi (RO Trongsa) Kelzang Wangdi (RO Trongsa) JET: Kotoo
Contents	• Site training for inspection • Discussion

Figure 7.4.8 Photos of 8th Seminar (Source: JET)

i. Geological Investigation on Sites

Table 7.4.10 Outline of 9th Seminar (Source: JET)

Theme	Geological investigation on sites
Date/Time	4 July, 2015 8:45-10:30
Venue	Nalajin village, No.1 road near Trongsa
Participants	Dorji Tshering (HQ) Drakpa Wangdi (RO Thimphu) Jambay Tenzin (RO Lingmethang Mongar) Wangchuk (RO Trongsa) Neten Tshering (RO Samdrup Jongkhar) Nim Dorji (RO Samdrup Jongkhar) JET: Tozawa, Kuwano, Iwasaki
Contents	• Site training for drilling survey • Discussion

Figure 7.4.9 Photos of 9th Seminar (Source: JET)

j. Slope Inspection and Regular Check, Geological Investigation

Table 7.4.11 Outline of 10th Seminar (Source: JET)

Theme	Slope inspection and regular check, Geological investigation
Date/Time	6 July, 2015 14:00-16:00
Venue	DoR, Thimphu
Participants	Dorji Tshering (HQ) Tempa Thinley (HQ) Phuntsho Wangmo A (HQ) Drakpa Wangdi (RO Thimphu) Sonam Thinley (RO Lobeysa Punakha) Karchung (RO Lobeysa Punakha) Dendup Dorji (RO Trashigang) Jambay Tenzin (RO Lingmethang Mongar) Wangchuk (RO Trongsa) Karma Dorji (RO Tintibi Zhemgang) Neten Tshering (RO Samdrup Jongkhar) Nim Dorji (RO Samdrup Jongkhar) JET: Tozawa, Kuwano, Iwasaki
Contents	• Results of slope inspection A) Objectives of the Slope Inspection B) Target Area for Inspection & Inventory C) Slope Disaster Distribution Map D) Field Inspection and Slope Inventory E) Slope Inventory F) Example of the Inspection Sheet G) The count of the Inspection Result H) Activities from now on • Regular check for road maintenance A) Outline of Regular Check B) Method of Regular Check C) Implementation of Regular Check D) Maintenance and Management • Geological investigation for slope disaster (Theory) A) Geological Investigation in Road Construction in JP B) Application of geological investigation in road construction C) Theory in General D) Measurement E) Geophysics F) Boring

Figure 7.4.10 Photos of 10th Seminar (Source: JET)

k. Regular Check on Sites

Table 7.4.12 Outline of 11th Seminar (Source: JET)

Theme	Regular check on sites	
Date/Time	28 August, 2015, 8:30-15:30	4 September, 2015, 10:30-14:30
Venue	No.1 road near Lingmetheng	No.1 road near Trongsa
Participants	Neten Tshering (RO Samdrup, Jongkhar) Dorji Tshering (HQ) Dhendup Dorji (RO Tashigang) Nim Dorji (RO Samdrup, Jongkhar) Jambay Tenzin (RO Lingmethang) Galay (RO Lingmethang) Tsheun Dema (RO Lingmethang) JET: Kotoo	Wangchuk (RO Trongsa) Karma Dorgi (RO Zhemgang) Koncho Tempel (RO Zhemgang) Nar Bdr Jogi (RO Trongsa) Kelzang Wangdi (RO Trongsa) JET: Kotoo, Sasaki
Contents	• Road slope disaster management by evaluation sheet and regular check sheet • Discussion	

Figure 7.4.11 Photos of 11th Seminar (Source: JET)

l. Countermeasures on Sites

Table 7.4.13 Outline of 12th Seminar (Source: JET)

Theme	Countermeasures on sites	
Date/Time	20 October, 2015, 14:00-17:00	26 October, 2015, 13:00-16:00
Venue	No.1 road near Thimphu	No.4 road near Trongsa
Participants	Dorji Tshering (HQ) Tempa Thinley (HQ) Phuntsho Wangmo (HQ) Drakpa Wangdi (RO Thimphu) Sonam Thinley (RO Lobeysa Punakha) Karchung (RO Lobeysa Punakha) JET: Hara, Tozawa, Kuwano	Dorji Tshering (HQ) Dendup Dorji (RO Trashigang) Jambay Tenzin (RO Lingmethang Mongar) Wangchuk (RO Trongsa) Karma Dorji (RO Tintibi Zhemgang) Neten Tshering (RO Samdrup Jongkhar) Nim Dorji (RO Samdrup Jongkhar) JET: Hara, Tozawa, Kuwano
Contents	• Explanation of the catalog of countermeasures • Discussion of the flowchart of countermeasures	

Figure 7.4.12 Photos of 12th Seminar (Source: JET)

m. Regional Map by Using GIS

Table 7.4.14 Outline of 13th Seminar (Source: JET)

Theme	Regional map by using GIS
Date/Time	22 December, 2015, 9:15-15:30
Venue	DoR, Thimphu
Participants	Tempa Thinley (HQ) Dorji Tshering (HQ) Phuntsho Wangmo (HQ) Jambay Tenzin (RO Lingmithang) Karma Dorji (RO Sarpang) Sonam Thinley (RO Lobesya) Nim Dorji (RO Samdrup Jongkhar) Karchung (RO Lobesa) Dendup Dorji (RO Trashigang) Wangchuck (RO Trongsa) Neten Tshering (RO Samdrup Jongkhar) Drakpa Wangdi (RO Thimphu) JET: Saito, Sasaki
Contents	• Making of regional maps • How to use QGIS

Figure 7.4.13 Photos of 13th Seminar (Source: JET)

n. Topographic Analysis and Map by QGIS

Table 7.4.15 Outline of 14th Seminar (Source: JET)

Theme	Topographic analysis and map by QGIS	
Date/Time	15 January, 2016, 9:30-16:00	18 January, 2016, 10:00-16:00
Venue	DoR, Thimphu	DoR, Trongsa
Participants	Dorji Tshering (HQ) Phuntsho Wangmo (HQ) Karchung (RO Lobeyasa) Sonam Thinley (RO Lobeyasa) JET: Sasaki	Wangchuck (RO Trongsa) Jambay Tenzin (RO Lingmethang) Nim Dorji (RO Samdrup Jongkar) JET: Sasaki
Contents	• Explanation of the catalog of countermeasures • Discussion of the flowchart of countermeasures	

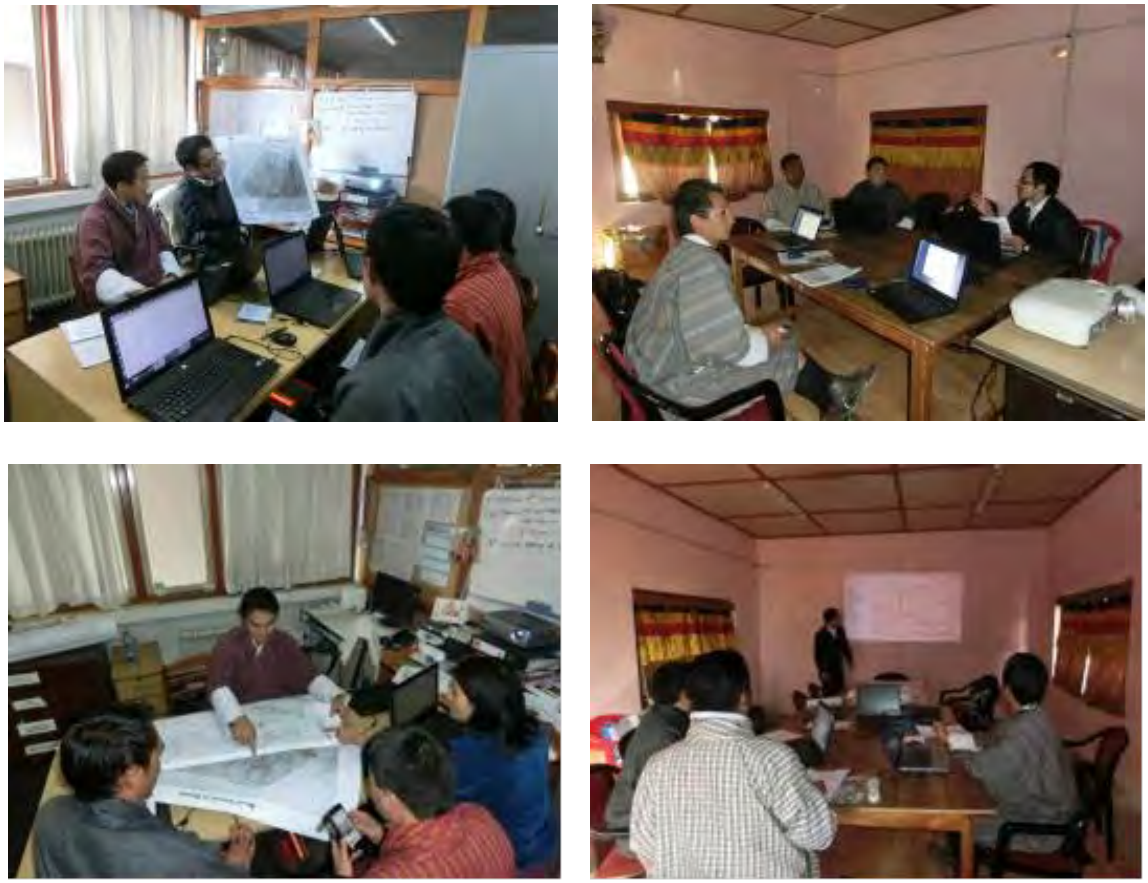


Figure 7.4.14 Photos of 14th Seminar (Source: JET)

o. Mapping by GIS, GPS and GIS Conversion, Slope Inspection on Roads

Table 7.4.16 Outline of 15th Seminar (Source: JET)

Theme	Mapping by GIS, GPS and GIS conversion, Slope inspection on roads
Date/Time	23 March, 2016, 9:00-17:00 24 March, 2016, 9:00-17:00 25 March, 2016, 9:00-17:00
Venue	DoR Phuentsholing, No.4 road and Gewog Road near Phuentsholing
Participants	NetenTshering (RO Samdrup Jhongkhar) DorjiTshering (HQ) Dhendup Dorji (RO Trashigang) Jambay Tenzin (RO Lingmethang) Nim Dorji (RO SamdrupJhongkhar) Wangchuk (RO Trongsa) Karchung (RO Tingtibi) Drakpa Wangdi (RO Thimphu) Sonam Thinley (RO Lobesya) Phuntsho Wangmo (HQ) Karchung (RO Lobeysa) Tempa Thinley (HQ) Chimi Lhamo (RO Phuentsholing) Karma Lhamo (RO Phuentsholing) JET: Kotoo, Saito
Contents	• Making of regional maps by using GIS • Acquisition of road arraignment by portable GPS, and conversion to GIS • Flow of the maintenance of slope disaster on roads • Training of slope inspection and regular check

Figure 7.4.15 Photos of 15th Seminar (Source: JET)

p. Prioritization for countermeasures

Table 7.4.17 Outline of 16th Seminar (Source: JET)

Theme	Prioritization for countermeasures
Date/Time	DoR Thimphu
Venue	15 April, 2016, 14:00-16:00
Participants	Dorji Tshering (DoR HQ) Tempa Thinley (DoR HQ) Phuntsho Wangmo (DoR HQ) Yeshey Tshomo (DoR HQ) Drakpa Wangdi (RO Thimphu) Sonam Thinley (RO Lobeysa Punakha) Karchung (RO Lobeysa Punakha) JET: Hara, Kuwano
Contents	• Result of regular check and countermeasure • Prioritization of slope for countermeasure

Figure 7.4.16 Photos of 16th Seminar (Source: JET)

q. GIS database 1

Table 7.4.18 Outline of 17th Seminar (Source: JET)

Theme	GIS database 1
Date/Time	1 June, 2016, 14:00-16:30
Venue	DoR Thimphu
Participants	Tshewang Dorji (Chief Engineer, Bridge division) Karma Wangdi (Chief Engineer, Construction division) Lungten Jamtsho (Chief Engineer, Design division) Dorji Gyeltshen (Chief Engineer, Maintenance division) Karma Tenzin (Principal Engineer, Design division) Tshering Gyeltshen (Principal Engineer, Design division) Phuntsho Wangmo (Assistant Architect, Maintenance division) Dorji Tshering (Executive Engineer, Maintenance division) Yeshi (I.T officer) JET: Saito
Contents	• Introduction of current status of the GIS database • Discussion on information provision of the road traffic information system • Discussion on access right of the database by DoR engineers

Figure 7.4.17 Photos of 17th Seminar (Source: JET)

r. GIS database 2

Table 7.4.19 Outline of 18th Seminar (Source: JET)

Theme	GIS database 2			
Date/Time	20 June, 2016, 9:00-14:00	23 June, 2016, 14:00-17:30	27 June, 2016, 10:00-14:00	29 June, 2016, 9:00-12:00
Venue	DoR, Lobeysa	DoR, Trashigang	DoR, Thimphu	DoR, Phuentsholing
Participants	Chetan Tshering Rinchen Gyetshen Kezang Dawa Sonam Tobgay Bala ram Acharya Karchung Karchuna Sonam Thinley Ugyen Tshomo Sonam Yangki Nima Wangchuk Sanjai Kr. Bomzan Aita Tenzin Doya	Jambay Wangchuk Tashi Wangmo Dendup Dorji Cheki Wangchuk Karma Tshewang Arjun Bdr Katwai Chencho Zam Raju Jimba Tamang Naley Tenzin Dema Namgay Wangmo Tshering Deki Ngawang Peday	Dhan Raj Chhetri Tempa Thinley Yeshey Tshomo Dorji Tshering Phuntsho Wangmo JET: Saito	Mari Maya Dorji Tshering Nir Maya Chhetri Chunu Galley Samten zangmo Hemlal JET: Saito

	JET: Saito	Chimi wangmo Sangay Chenga Dorji JET: Saito		
Contents	• Technical Transfer of method of operation of the GIS database • Acquisition of road arraignment by portable GPS, and conversion to GIS			

Figure 7.4.18 Photos of 18th Seminar (Source: JET)

7.5 Training in Japan

Training is provided in Japan to help the Bhutanese counterparts to understand the techniques used in Japan for the slope disaster inspection, along with a wide variety of slope disaster management technologies and techniques. The training itself is around 15 days, including classroom lectures, to provide enough time to visit sites and road maintenance facilities.

A total of 12 people, three people from the Head Office of DoR and nine people from regional offices participated in the training. Priority is given to DoR personnel who have actively participated in tasks such as field inspections. The training was provided in 8-26 on July 2015. This is after the field inspections in the first year and an inspection report has been completed and DoR has acquired basic skills and knowledge of disaster management technology, however, the training was held before the development of the regular checks and master plan begins. The training took place in the highway and national prefectural road maintenance facilities and road disaster management research laboratories. The trainees learned the road maintenance practices designed for each type of road and acquired basic road disaster management skills with practical applicability, bearing in mind that they share this information after returning to their country. The summary of the training is as follows.

Table 7.5.1 Contents of Training in Japan (Source: JET)

Item	Contents
Date	8 July to 26 July, 2015 (19 days)
Purposes	1. Understand necessary/utilizable technologies on structural countermeasures on roads, which are suitable in Bhutan, based on countermeasures on roads in Japan. 2. Grasp workflows, concepts and perspectives on road slope management and disaster management in government. 3. Gain a better understanding of the significance of the Slope Disaster Inspection in the Project for achieving the project outputs.
Visit place	・ Visit Land, Infrastructure and Transportation Ministry in Japan ・ Visit universities and research institutes ・ Visit private consultants

Table 7.5.2 Participants of Training in Japan (Source: JET)

	Photo	Name	DoR: Department of Roads
1		Mr. Dorji Tshering	Deputy Executive Engineer, DoR HQ Road Maintenance Division, Thimphu
2		Mr. Tempa Thinley	Engineer, DoR HQ Geotechnical Division, Thimphu
3		Ms. Phuntsho Wangmo	Assistant Design Architect, DoR HQ Road Maintenance Division, Thimphu

4		Mr. Drakpa Wangdi	Executive Engineer, DoR Regional Office Thimphu
5		Mr. Sonam Thinley	Junior Engineer, DoR Regional Office Lobeysa Punakha）
6		Mr. Karchung	Engineer, DoR Regional Office Lobeysa Punakha
7		Mr. Dendup Dorji	Engineer, DoR Regional Office Trashigang
8		Mr. Jambay Tenzin	Engineer, DoR Regional Office Lingmethang Mongar
9		Mr. Wangchuk	Engineer, DoR Regional Office, Trongsa
10		Mr. Karma Dorji	Officinating Chief Engineer/Executive Engineer, DoR Regional Office Tintibi Zhemgang
11		Mr. Neten Tshering	Assistant Engineer, DoR Regional Office Samdrup Jongkhar
12		Mr. Nim Dorji	Assistant Engineer, DoR Regional Office Samdrup Jongkhar

Table 7.5.3 Schedule of the Training in Japan (Source: JET)

Date	Place/ Transportation	Organization	Contents
8-Jul	Paro - Bangkok	Airplane【KB128】11:30-15:30	
9-Jul	Bangkok	Application of VISA	
10-Jul	Bangkok	Application of VISA	
11-Jul	Bangkok - Sapporo	Airplane【TG670】23:45-08:30	
12-Jul	Sapporo		
13-Jul	Sapporo	JICA Sapporo	am: Briefing pm: Orientation
14-Jul	Sapporo, Hokkaido	Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure and Transportation National Research and Development Agency, Public Works Research Institute, Civil Engineering Research Institute for Cold Region	Lectures
15-Jul	Sapporo, Hokkaido	Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure and Transportation	Site visit
16-Jul	Otaru, Hokkaido	Hokkaido Regional Development Bureau, Ministry of Land, Infrastructure and Transportation	am: Lectures pm: Site visit
17-Jul	Sapporo, Hokkaido Sapporo→Tokyo	Hokkaido University	am: Lectures pm: Transportation
18-Jul	Tokyo		
19-Jul	Tokyo		
20-Jul	Tokyo		
21-Jul	Takasaki, Gunma	Takasaki Office, Ministry of Land, Infrastructure and Transportation	Site visit
22-Jul	Tsukuba, Ibaraki	Public Works Research Institute Geological Museum	am: Lectures pm: Visit
23-Jul	Tokyo	East Japan Expressway Company JICA Tokyo	am: Lectures pm: Report preparation
24-Jul	Tokyo	JICA Tokyo	am: Report preparation pm: Report presentation
25-Jul	Haneda - Bangkok	Airplane【TG683】10:35-15:05	
26-Jul	Bangkok - Paro	Airplane【KB129】04:45-06:45	

The remarks for the training trip to Japan are as follows;

- The trainees were asking lots of question to lecturers at each organization. Those questions were about a wide range of structural countermeasures, government organizations, systems, etc. which are useful for application in Bhutan.
- The trainees were welcomed to all organizations in Japan. The lecturers kindly answered the question form the trainees at the sites and the lectures.
- The lecturers included many examples and experiences in Japan to their presentations, which were highly appreciated by the trainees.
- The trainees received high quality presentations including what they learned at the evaluation meeting on the last day of the training. The trainees considered the experiences in Japan and analyzed the characteristics in Bhutan in the presentation.

Figure 7.5.1 Photos of the Training in Japan (Source: JET)

7.6 Public Relations

JET has produced several newsletters in order to inform its activities, seminars, workshops and future activities under the Project of road slope management.

The newsletters have been published three times since the beginning of the Project. The first newsletter was published in August 2014, the second one in February 2015 and the third in October 2015. Furthermore, the final newsletter was published in June 2016.

The newsletters have been distributed to the MoWHS, the GNHC and DoR regional offices during the seminars and SC.

Figure 7.6.1 Publication of 1st Newsletter for the Project (Source: JET)

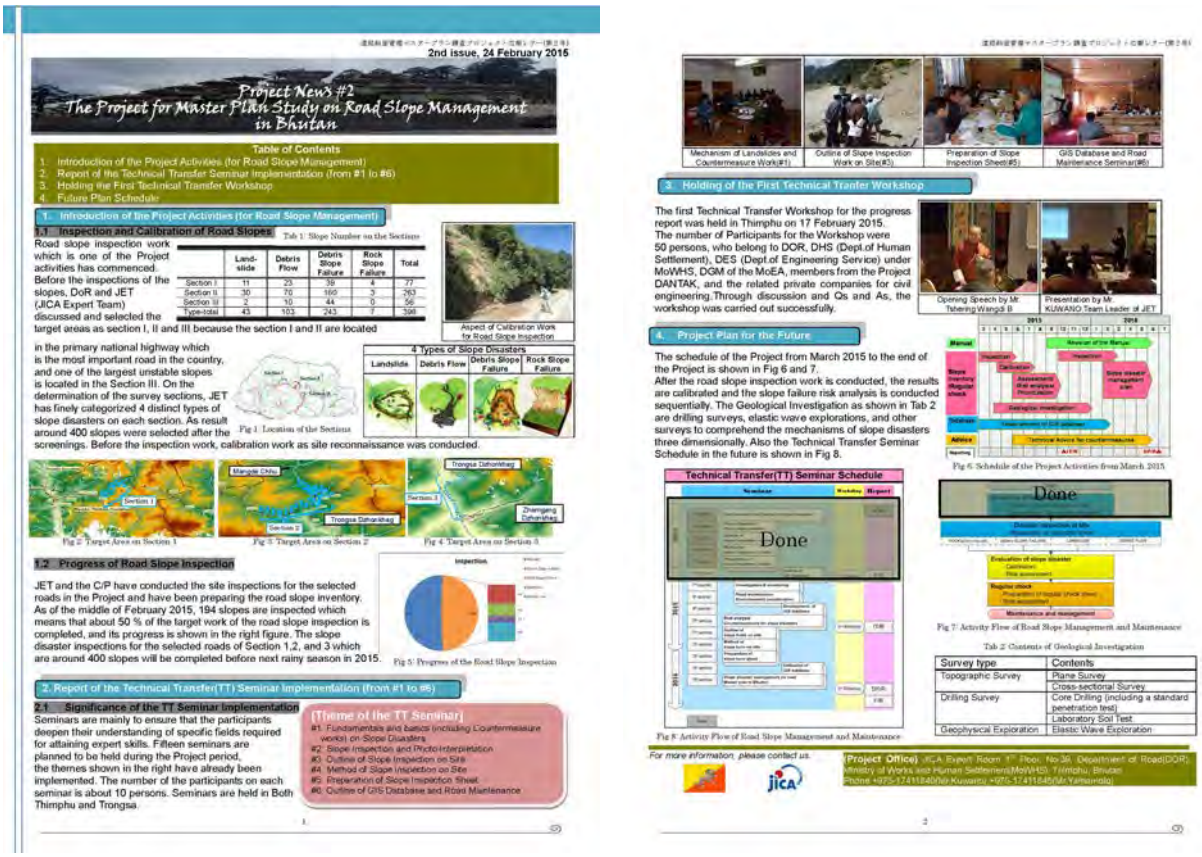


Figure 7.6.2 Publication of 2nd Newsletter for the Project (Source: JET)

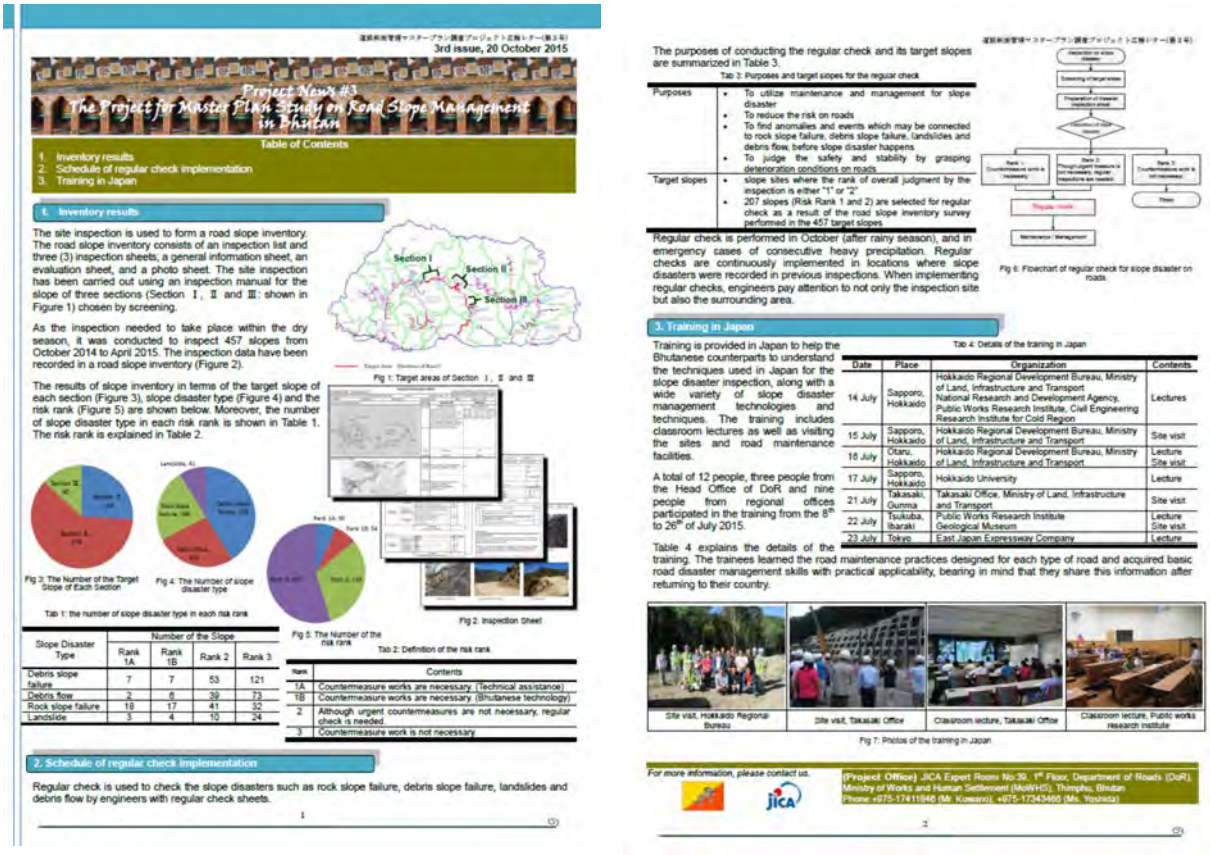


Figure 7.6.3 Publication of 3rd Newsletter for the Project (Source: JET)

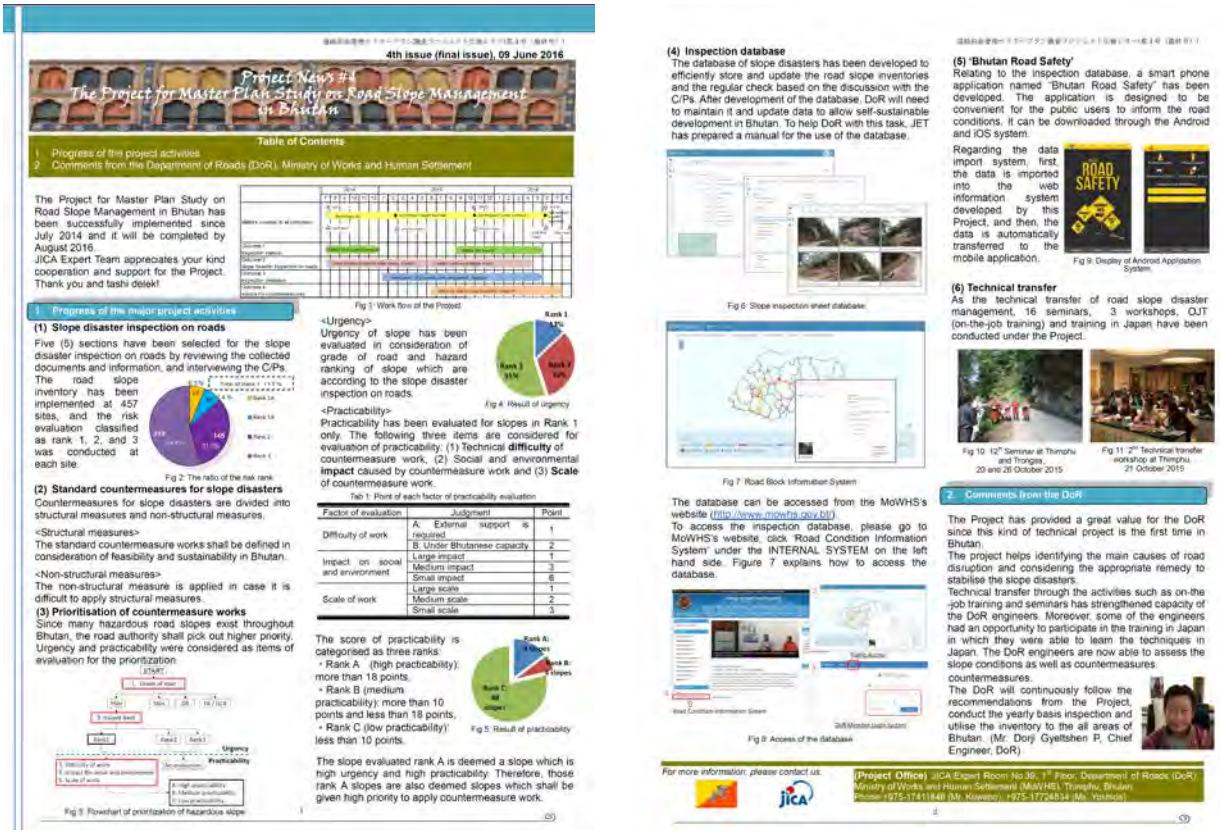


Figure 7.6.4 Publication of 4th Newsletter for the Project (Source: JET)

7.7 Steering Committees

The Steering Committee (SC) is held with relevant organizations in Bhutan, in order to establish smooth cooperative system, to have common understanding about the progress and issues of the Project, and to facilitate decision making and problem solving. The establishment and operation of the SC should be handled by C/P, and JET is to assist the C/P in holding committee meetings.

Table 7.7.1 Plan of SC (Source: JET)

Item	Contents
Contents	• Approval of activity plan • Confirmation of progress • Discussion of issues • Discussion of necessary matters related to the Project
Members	Chairman: Director of DoR Member: DoR Chief Engineer (Maintenance Division), DoR engineers, GNHC, other related organization, JICA Bhutan Office, JET
Schedule	1st: July 2014 2nd: October 2015 3rd: July 2016
Participants	Around 10-15

The initial SC was held on 30 July, 2014 to explain the role of the SC followed by the explanation of the Project's outline, the contents of IC/R, the determination of the target sections and the role of stakeholders to the concerned organizations and agencies. The contents of the 1st SC are summarized in the following table and its Minutes of Meeting is included in the Appendix.

Table 7.7.2 Contents of the 1st SC (Source: JET)

Item	Contents
Date/Time	30 July, 2014 15:30-16:40
Venue	Conference room, DoR Headquarters
Contents	• Role of the SC • Outline of the Project • Contents of IC/R • Determination of the target sections for the Project • Role of stakeholders
Participants	DoR Mr. Karma Galay (Director) Mr. Tshering Wangdi 'B' (Chief Engineer) Mr. Dorji Tshering (Deputy Executive Engineer) Mr. Tshering Paljore (Chief Engineer, Planning Division) (Observer) Mr. Karma Wangdi (DoR) (Chief Engineer, Design Division) (Observer) Other Ministries/Organizations Mr. Kuenzang L. Sangay (Deputy Chief Planning Officer, GNHC representative) Ms. Sangay Choden (GNHC representative) JICA Ms. Yumiko Asakuma (Resident Representative, JICA Bhutan Office) Mr. Yasunori Tonegawa (Deputy Assistant Director, JICA HQ) Mr. Masanori Sunada (Project Formation Advisor, JICA Bhutan Office) Mr. Krishna Subba (Program officer, JICA Bhutan Office) JICA Expert Team Mr. Takeshi Kuwano (Team leader/ Slope stability management)

	Mr. Kimihiko Kotoo (Vice team leader/ Slope inspection) Mr. Yosuke Yamamoto (Coordinator/Environmental & social consideration)

The 2nd SC was held on 21 October, 2015 to explain the contents of IT/R, the background and proposal of the tunnel project and the activity plan to the concerned organizations and agencies. The contents of the 2nd SC are summarized in the following table and its Minutes of Meeting is included in the Appendix.

Table 7.7.3 Contents of the 2nd SC (Source: JET)

Item	Contents
Date/Time	21 October, 2015 14:30-16:00
Venue	Conference room, DoR Headquarters
Contents	• Contents of IT/R • Background and proposal of tunnel project • Activity plan
Participants	DoR Mr. M.N. Lamichaney (Officiating Director) Mr. Tshering Wangdi 'A' (Chief Engineer, Construction Division) Mr. Tshering Wangdi 'B' (Chief Engineer, Maintenance Division) Mr. Dorji Tshering (Executive Engineer, Maintenance Division) Mr. Tashi Phuntsho (Executive Engineer, Bridge Division) JICA Ms. Yumiko Asakuma (Resident Representative, JICA Bhutan Office) Ms. Tomoko Miyata (Project Formation Advisor, JICA Bhutan Office) Mr. Krishna Subba (Program officer, JICA Bhutan Office) JICA Expert Team Mr. Takeshi Kuwano (Team leader / Slope stability management) Mr. Takashi Hara (Slope stability countermeasure) Mr. Masanori Tozawa (Investigation and monitoring) Ms. Haruka Yoshida (Coordinator / Environmental & social consideration) Mr. Cheku (Assistant of slope stability database management) Mr. Pema Tshering (Project Assistant)

The 3rd (final) SC was held on 9th June, 2016 to explain the contents of DF/R, the handover of the equipment and the plan for the Final Report to the concerned organizations and agencies. The contents of the 3rd SC are summarized in the following table and its Minutes of Meeting is included in the Appendix.

Table 7.7.4 Contents of the 3rd SC (Source: JET)

Item	Contents
Date/Time	9 June, 2016 14:30-16:00
Venue	Conference room, DoR Headquarters
Contents	• Contents of DF/R • Handover of the equipment • Plan for the Final Report
Participants	DoR Mr. Karma Galay (Director) Mr. Dorji Gyeltshen P (Chief Engineer, Maintenance Division) Mr. Lungten Jamtsho (Chief Engineer, Design Division) Mr. Tshewang Dorji (Chief Engineer, Bridge Division) Mr. Dorji Tshering (Executive Engineer, Maintenance Division) Gross National Happiness Commission (GNHC)

	Ms. Kuenzang L. Sagy (Deputy Chief Research Officer) JICA Mr. Koji Yamada (Chief Representative, JICA Bhutan Office) Ms. Tomoko Miyata (Project Formulation Advisor, JICA Bhutan Office) Mr. Krishna Subba (Senior Program officer, JICA Bhutan Office) JICA Expert Team Mr. Takeshi Kuwano (Team leader / Slope stability management) Mr. Kimihiko Kotoo (Vice team leader / Slope inspection) Mr. Takashi Hara (Slope stability countermeasure) Mr. Tomoharu Iwasaki (Slope risk analysis) Mr. Takashi Saito (Slope stability database system) Ms. Haruka Yoshida (Coordinator) Mr. Pema Tshering (Project Assistant)

7.8 For development of a road slope management master plan

The purpose of the Project is to introduce the inspection techniques for road slope disaster management into Bhutan so that DoR will be able to manage the slope disasters. The Project identifies high-risk road slopes and contributes to the development of "a road slope management master plan".

A road slope management master plan is a procedure for the implementation of countermeasures and management of slopes effectively and efficiently, and the general flow is as follows:

1) Evaluate the current hazard of slope disasters.

2) Propose the countermeasure methods and calculate the cost for the highest hazard slopes.

3) Discuss the priority of countermeasures based on the hazard, the countermeasure method, and the cost.

* Implement appropriate management until the completion of countermeasures.

The priority based on the substantial reasons will be determined by the master plan, so that it is possible to implement the countermeasures in series with sufficient budgets.

Before the Project, there had not been any technology for evaluation of the hazard on slope disasters in Bhutan; therefore, the master plan had not contributed to the road construction, the road widening and the maintenance in the country. DoR had decided the priority based on the convenience on roads and the scale of towns, and had not considered the slope disasters which seriously affect the transportation in Bhutan.

In the Project, "current hazard of slope disasters" has been evaluated with high accuracy as Rank 1-3 by introduction of the slope disaster inspection on roads which is the general methodology for the evaluation in Japan. For the higher rank slopes (Rank 1-2), "countermeasure method and the cost" have been proposed, and "priority of countermeasures" has been discussed. Additionally, "appropriate management until the completion of countermeasures" is conducted by the regular check in the sites and the slope disaster database as an effective tool in the Project.

As stated above, each technology transferred in the Project greatly contributes to the development of the road slope management master plan in Bhutan. The technical transfer on the road slope management master plan has been successfully implemented in the Project since JET conducted the related activities with DoR engineers.

However, the establishment of the master plan is a pilot activity for only 450 slopes in the limited areas in the National Roads 1 and 4. Therefore, JET sincerely hopes that DoR will implement the slope disaster inspection for all the roads in Bhutan with the technology that has been transferred in the Project and develop the road slope management master plan in the country.

Appendix 1

Minutes of Meeting on the Project

MINUTES OF MEETINGS
BETWEEN
DEPARTMENT OF ROADS
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
ON
TECHNICAL COOPERATION PROJECT FOR CRITICAL SLOPE TREATMENT / STABILIZATION ALONG THE ROAD NETWORK IN BHUTAN

The Japanese Detailed Planning Survey Team (hereinafter referred to as "the Team") organized by Japan International Cooperation Agency (hereinafter referred to as "JICA") headed by Mr. Nobuyuki Tsuneoka, Senior Advisor of JICA, visited Bhutan from November 25, 2013 to December 5, 2013 for the purpose of working out the details concerning "Technical Cooperation Project for Critical Slope Treatment/Stabilization along the Road Network in Bhutan" (hereinafter referred to as "the Project")

During its stay in Bhutan, the Team exchanged views and had a series of discussions with Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR") and the concerned organizations of Bhutan with respect to necessary measures to be taken by JICA and the Royal Government of Bhutan (hereinafter referred to as "RGOB") represented by DOR for the appropriate formulation of the Project.

As a result of the discussions, DOR and JICA agreed upon the matters referred to in the document attached hereto.

Thimphu, December 3, 2013

Karma Galay
Director
Department of Roads
Ministry of Works and Human Settlement
Kingdom of Bhutan

Nobuyuki Tsuneoka
Leader
Detailed Planning Survey Team
Japan International Cooperation Agency
Japan

Rinchen Wangdi
Chief Program Coordinator
Development Cooperation Division
Gross National Happiness Commission
Kingdom of Bhutan

ATTACHED DOCUMENT

I. RECORD OF DISCUSSIONS

Both sides agreed that the Record of Discussions (R/D) will determine the framework of the Project. The draft R/D is attached to this Minutes of Meetings for reference as shown in Appendix-1. It will be agreed and signed between DOR, Gross National Happiness Commission and JICA after the formal approval of both sides.

II. CHANGE OF THE PROJECT TITLE

Both sides agreed to change the Project title from "Technical Cooperation Project for Critical Slope Treatment/Stabilization along the Road Network in Bhutan" to "Project for Master Plan Study on Road Slope Management in Bhutan".

Appendix-1 Draft Record of Discussions

(DRAFT)
RECORD OF DISCUSSIONS

ON

PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN

AGREED UPON BETWEEN

GROSS NATIONAL HAPPINESS COMMISSION

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Thimphu, XX, 2013

Yumiko Asakuma
Chief Representative
Japan International Cooperation Agency
Japan

Karma Tshiteem
Secretary
Gross National Happiness Commission
Kingdom of Bhutan

Witnessed by

Karma Galay
Director
Department of Roads
Ministry of Works and Human Settlement
Kingdom of Bhutan

Based on the Minutes of Meetings on the Detailed Planning Survey on Project for Master Plan Study on Road Slope Management in Bhutan (hereinafter referred to as "the Project") signed on December 3, 2013 between Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR"), Gross National Happiness Commission (hereinafter referred to as "GNHC") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with DOR and relevant organizations to develop a detailed plan of the Project.

Both sides agreed the details of the Project and Main Points Discussed as described in the Appendix 1 and the Appendix 2, respectively, and to request their respective governments to proceed with the necessary procedures for implementation of the Project.

Both sides also agreed that DOR, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Kingdom of Bhutan (hereinafter referred to as "Bhutan").

The Project will be implemented within the framework of the Colombo Plan Technical Cooperation Scheme and the Note Verbales to be exchanged between the Government of Japan (hereinafter referred to as "GOJ") and the Royal Government of Bhutan (hereinafter referred to as "RGOB").

The effectiveness of the Record of Discussions is subject to the exchange of the Note Verbales.

Appendix 1: Project Description
Appendix 2: Main Points Discussed

Appendix 1

PROJECT DESCRIPTION

Both sides confirmed that there is no change in the Project Description agreed on in the Minutes of Meetings on the concerning Detailed Planning Survey on the Project signed on December 3, 2013.

I. BACKGROUND

Bhutan is dominantly covered by the mountainous areas spreading from the Himalaya. Road traffic is, therefore, the most important and vital transportation system for Bhutan. The major highway network in the country consists of 5 national highways; National Highway No.1 transversally crossing the country in a direction of east and west and 4 national highways advancing southward to the border with India. The total extension of the road in the country is, however, rapidly expanding; it was around a length of 2,300 km in 1990 and stretched to around a length of 3,900 km in 2003 and around a length of 10,600 km in 2013.

In regard to national programs in road sector, the Ministry of Works and Human Settlement (hereinafter referred to as "MOWHS") established the Road Sector Master Plan in 2006. In the master plan, MOWHS aims to expand and improve the national and Dzongkhag road network, to enhance the feeder road network, and to repair or replace or maintain bridges in the coming 20 years until 2027. Meanwhile, in the 10th Five Year Plan targeting from 2008 to 2013, RGOB set a goal of making any access to the nearest road within 2 hours or less.

Since most parts of the road network in Bhutan pass through steep slopes of the precipitous mountainous areas, the slope disaster frequently obstruct the road network in Bhutan. Slope disasters often isolate a Dzongkhag from the capital and other Dzongkhags, disrupt road traffic, and consequently hamper travel and transport of agricultural crops. In the aim of mitigating the damage caused by slope disasters, DOR introduced countermeasures against slope disasters utilizing vegetation and reinforcement. Due to a lack of experience and expertise, however, DOR is facing difficulties in implementing effective countermeasures against slope disasters.

In addition, in order to enhance the ability to grasp an inventory of dangerous slopes requiring countermeasures, RGOB requested GOJ to implement "the Technical Cooperation Project for Critical slope treatment/stabilization along the Road Network in Bhutan". In response to this request, JICA had series of discussion with DOR and other authorities concerned of Bhutan. Based on the agreements between JICA and the authorities concerned of Bhutan, the Minutes of Meetings was signed on December 3, 2013, which leads both parties to conclude this Record of Discussions.

II. OUTLINE OF THE PROJECT

1. Title of the Project
   Project for Master Plan Study on Road Slope Management in Bhutan

2. Expected Goals which will be attained after the Project Completion
   (1) Goal of the Proposed Project
   Slope stability inspection and regular updating are conducted, and record cards of slope stability inspection "Slope Karte" are maintained by DOR.

   (2) Goal which will be attained through implementation of the Proposed Project
   Critical slopes are identified, and a plan for slope treatment/ stabilization is established by DOR.

3. Outputs
   (1) Manuals for slope stability inspection and diagnosis are prepared.

   (2) Slope stability inspection is conducted and road slope inventory is produced for the selected road section(s).

   (3) Slope stability database including Slope Karte is established for the selected road section(s).

   (4) Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte.

   The selected road section(s) is to be decided at the first SC meeting and stipulated as a section of national highways between major towns. The selected road section(s) is subject to the availability of budget and time.

4. Activities
   (1) For the output (1) "Manuals for slope stability inspection and diagnosis are prepared."
   (a) Prepare manuals for slope stability inspection and diagnosis.
   (b) Establish terminology for each slope disaster type in Bhutan.
   (c) Revise the manuals for slope stability inspection prepared in (a).

   (2) For the output (2) "Slope stability inspection is conducted for the selected road section(s)."
   (a) Collect records of disaster and information on countermeasures under taken along the selected road section(s).
   (b) Select target segments for the inspection in accordance with degree of risk.
   (c) Screen the slopes in the target segments selected in (b), by aerial photo reading or geomorphic analysis.
   (d) Confirm the result of screening in (c) on site and decide the target slopes for the inspection.
   (e) Conduct field surveys at the target slopes in (d), and produce road slope inventory with the aim of preparing Slope Karte.

(f) Execute supplementary surveys including investigation boring and seismic exploration at a couple of slopes to understand mechanism of typical slope failure.
(g) Prepare Slope Karte through organizing and analyzing the results of the surveys.
(h) Carry out training including OJT for the target group concerning slope stability inspection and Slope Karte operation.

(3) For the output (3) "Slope stability database is established for the selected road section(s)."
(a) Establish a database system for managing the results of slope stability inspection including Slope Karte.
(b) Prepare operation manuals for the slope stability database system.

(4) For the output (4) "Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte."
(a) Review design documents prepared by DOR.
(b) Give advice on investigation for design of countermeasures.

5. Input
(1) Input by JICA
JICA will take, at its own expense, the following measures according to the normal procedures under the Colombo Plan Technical Cooperation:
(a) Dispatch of Mission
- Team Leader/Slope Stability Management Expert (Inspection and Manual)
- Slope Stability Management Expert (Inspection)
- Slope Stability Management Expert (Countermeasure)
- Slope Stability Database System Expert
- Road Maintenance Expert
- Coordinator/Assistant of Slope Stability Management

(b) Training
- Training in Bhutan: OJT, Workshop/Seminar
- Training in Japan

(c) Machinery and Equipment
- GPS for survey: 3 units
- Laser Range Finder: 3 units

In case of importation, the machinery, equipment and other materials under II-5 (1) (c) above will become the property of the RGOB upon being delivered C.I.F. (cost, insurance and freight) to the Bhutan authorities concerned at the ports and/or airports of disembarkation.

Input other than indicated above will be determined through mutual consultations between JICA and DOR during the implementation of the Project, as necessary.

(2) Input by DOR

DOR will take necessary measures to provide at its own expense:

(a) Services of DOR's counterpart personnel and administrative personnel as referred to in II-6;
(b) Suitable office space with necessary equipment;
(c) Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;
(d) Information as well as support in obtaining medical service;
(e) Credentials or identification cards;
(f) Available data (including maps and photographs) and information related to the Project;
(g) Running expenses necessary for the implementation of the Project;
(h) Expenses necessary for transportation within Bhutan of the equipment referred to in II-5 (1) (c) as well as for the installation, operation and maintenance thereof; and
(i) Necessary facilities to the JICA experts for the remittance as well as utilization of the funds introduced into Bhutan from Japan in connection with the implementation of the Project

6. Implementation Structure

The Project organization chart is given in the Annex 2.

(1) DOR

(a) Project Director: Chief Engineer for Maintenance Division
(b) Maintenance Division
(c) Construction Division
(d) Design Division
(e) Planning and Monitoring Division

Project Director will bear overall responsibility of the Project.

(2) JICA Experts

The JICA experts will give necessary technical guidance, advice and recommendations to DOR on any matters pertaining to the implementation of the Project.

(3) Steering Committee

Steering Committee (hereinafter referred to as "SC") will be established in order to facilitate inter-organizational coordination. SC will be held at least twice a year and whenever deems it necessary. A list of proposed members of SC is shown in the Annex 3.

(4) Working Group

Working Group (hereinafter referred as "WG") will be established and function as a technical unit on a daily-work basis to correspond to the JICA mission. A list of proposed members of WG will be proposed and finalized in the first SC meeting after commencement of the Project.

7. Project Site(s) and Beneficiaries

(1) Project Site

The main activities of the Project will be implemented at DOR's headquarters and the selected road section(s) mentioned in II.3.

(2) Direct beneficiaries

Direct beneficiaries of the Project will be the staff of DOR.

(3) Indirect beneficiaries

Indirect beneficiaries are road users as well as people living in the selected road section(s).

8. Duration

The duration of the Project will be twenty four (24) months. The tentative Plan of Operation is shown in Annex 1.

9. Reports

JICA will prepare and submit the following reports to DOR in English.

(1) 10 copies of Inception Report at the commencement of the first work period in Bhutan.

(2) 10 copies Progress Report at the time of 7 months after the commencement of the first work period in Bhutan.

(3) 10 copies Interim Report at the time of 13 months after the commencement of the first work period in Bhutan.

(4) 10 copies Draft Final Report at the time of 22 months after the commencement of the first work period in Bhutan.

(5) 20 copies Final Report within one (1) month after the receipt of the comments on the Draft Final Report.

10. Environmental and Social Considerations

(1) DOR agreed to abide by 'JICA Guidelines for Environmental and Social Considerations' in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

III. UNDERTAKINGS OF DOR, RGOB

1. DOR, RGOB will take necessary measures to:

(1) ensure that the technologies and knowledge acquired by the Bhutan nationals as a result of Japanese technical cooperation contributes to the economic and social development of Bhutan, and that the knowledge and experience acquired by the personnel of Bhutan from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and

(2) grant privileges, exemptions and benefits to the JICA experts referred to in II-5 (1) above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in Bhutan.

(3) provide security-related information as well as measures to ensure the safety of the JICA experts;

(4) permit the JICA experts to enter, leave and sojourn in Bhutan for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.

2. Other privileges, exemptions and benefits will be provided in accordance with the Note Verbales to be exchanged between GOJ and RGOB.

IV. EVALUATION

JICA will conduct the following evaluations and surveys to mainly verify sustainability and impact of the Project and draw lessons. DOR is required to provide necessary support for them.

1. Ex-post evaluation three (3) years after the project completion, in principle.
2. Follow-up surveys on necessity basis

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting support for the Project, DOR will take appropriate measures to make the Project widely known to the people of Bhutan.

VI. MUTUAL CONSULTATION

JICA and DOR will consult each other whenever any major issues arise in the course of Project implementation.

VII. AMENDMENTS

The Record of Discussions may be amended by the Minutes of Meetings between JICA and GNHC in consultation with DOR.
The Minutes of Meetings will be signed by authorized persons of each side who may be different from the signers of the Record of Discussions.

Annex 1 Tentative Plan of Operation
Annex 2 Project Organization Chart
Annex 3 A List of Proposed Members of Steering Committee

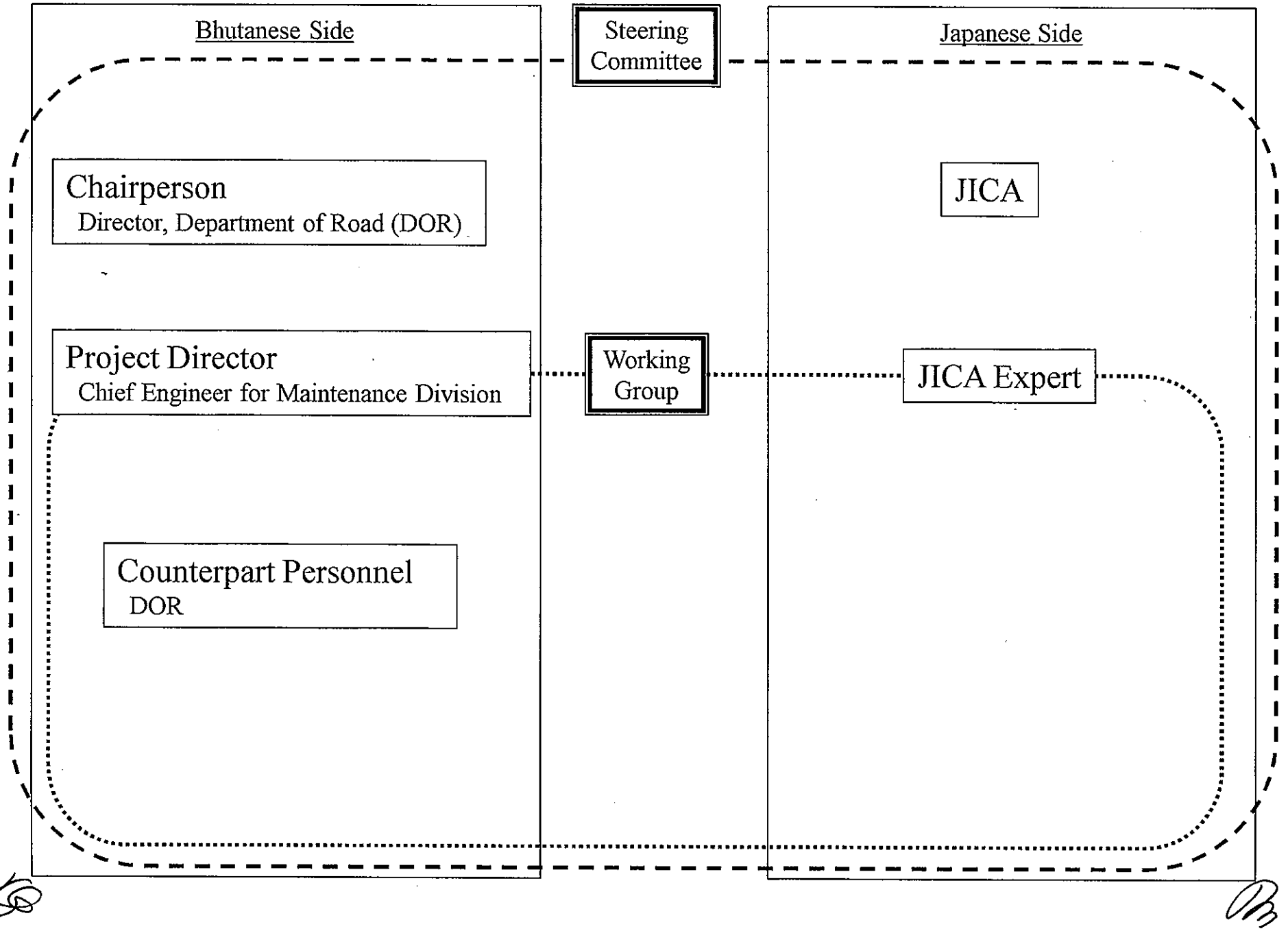
Annex1

Draft, Tentative Plan of Operation[PO], Project for Master Plan Study on Road Slope Management in Bhutan

	Activities	Year 1												Year 2											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Output1	**Manuals for slope stability inspection and diagnosis are prepared.**																								
1-1	Prepare manuals for slope stability inspection and diagnosis.	■	■	■	■	■	■	■	■	■	■														
1-2	Establish selection standards of countermeasures for each slope disaster type.			■	■	■	■	■	■	■	■														
1-3	Revise the manuals for slope stability inspection prepared in 1-1.								■	■	■	■	■	■	■	■	■								
Output2	**Slope stability inspection is conducted for the selected road section(s).**																								
2.1	Collect records of disaster and information on countermeasures under taken along the selected road section(s).	■	■	■	■	■	■							■	■	■	■								
2.2	Select target segments for the inspection in accordance with degree of risk.		■	■	■	■								■	■	■	■								
2.3	Screen the slopes in the target segments selected in 2-2, by aerial photo reading or geomorphic analysis.			■	■	■	■									■	■	■	■						
2.4	Confirm the result of screening in 2-3 on site and decide the target slopes for the inspection.						■												■						
2.5	Conduct field surveys at the targeted slopes in 2-4, with the aim of preparing Slope Karte.							■	■	■	■	■	■	■						■	■	■	■	■	
2.6	Execute supplementary surveys including investigation boring and seismic exploration at a couple of slopes to understand mechanism of typical slope failure.												■	■									■		
2.7	Prepare Slope Karte through organizing and analysing the results of the surveys.												■	■	■							■	■	■	
2.8	Carry out training including OJT for the target group concerning slope stability inspection and Slope Karte operation.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Output3	**Slope stability database is established for the selected road section(s).**																								
3.1	Establish a database system for managing the results of slope stability inspection including Slope Karte.													■	■	■	■	■	■	■	■	■	■	■	■
3.2	Prepare operation manuals for the slope stability database system.																		■	■	■	■			
Output4	**Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte.**																								
4.1	Review design documents prepared by DOR.																								
4.2	Give advice on investigation for design of countermeasures.																								
Administrative Activities																									
Steering Committee		▲												▲										▲	
Inception Report		▲																							
Interim Report/Progress Report								PR ▲						ITR ▲											
Draft Final Report/Final Report																							DFR ▲		FR ▲

Annex 2

Organization chart of the Project



Annex 3

LIST OF PROPOSED MEMBERS OF STEERING COMMITTEE

Chairperson: Director, Department of Roads (DOR)

Members:

(1) Bhutanese Side

1) DOR

- Project Director: Chief Engineer for Maintenance Division

2) Representative from GNHC

(2) Japanese Side

1) JICA

2) JICA Experts

- Team Leader/Slope Stability Management Expert (Inspection and Manual)
- Slope Stability Management Expert (Inspection)
- Slope Stability Management Expert (Countermeasure)
- Slope Stability Database System Expert
- Road Maintenance Expert
- Coordinator/Assistant of Slope Stability Management

(3) Others

- Relevant personnel accepted by SC, if necessary

Appendix 2

MAIN POINTS DISCUSSED

I. PROJECT PERIOD

Both sides agreed that the duration of the project should be 24 months from the first dispatch of JICA study team.

II. OUTPUTS OF THE PROJECT

(1) Referring to Ⅱ-3 (2), number of slopes to be inspected will be 400 at maximum. Those slopes will be located in the selected road section(s).

(2) Referring to Ⅱ-3 (4), pilot sites will be selected from Slope Karte. "Giving advice" is stipulated in Ⅱ-4 (4), and does not include engineering services.

(3) The selected road section(s) is one or two section(s) identified by SC.

III. INSPECTION TEAM

Both sides agreed that two inspection teams will be established at the first SC meeting. The member of the inspection team will contain at least one Japanese expert and one DOR engineer.
If the third inspection team or more is established by Bhutanese engineers, JICA study team will support in checking the implementation of inspection and Slope Karte operation.

IV. TECHNICAL TRANSFER DURING THE PROJECT

Both sides agreed that technical transfer on slope stability inspection, preparation of Slope Karte, and establishment of the database will be done at OJT basis.
Workshops/Seminars will be held twice in Bhutan.
Training in Japan will be held early or middle period of the Project. DOR requested that trainees in Japan will be one from each of nine DOR's regional offices and three from DOR's headquarters.

V. OPERATION AND MAINTENANCE OF SLOPE KARTE

Both sides agreed that DOR should conduct the remaining slope stability inspection as well as regular updating of Slope Karte by themselves.

VI. OTHERS

DOR requested for two vehicles for the Project considering the lack of transportation.

Appendix 2

Record of Discussions
on the Project

RECORD OF DISCUSSIONS

ON

PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN

AGREED UPON BETWEEN

GROSS NATIONAL HAPPINESS COMMISSION

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Thimphu, 10th March, 2014

Yumiko Asakuma
Chief Representative
Japan International Cooperation Agency
Japan

Karma Tshiteem
Secretary
Gross National Happiness Commission
Kingdom of Bhutan

Witnessed by

Karma Galay
Director
Department of Roads
Ministry of Works and Human Settlement
Kingdom of Bhutan

Based on the Minutes of Meetings on the Detailed Planning Survey on Project for Master Plan Study on Road Slope Management in Bhutan (hereinafter referred to as "the Project") signed on December 3, 2013 between Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR"), Gross National Happiness Commission (hereinafter referred to as "GNHC") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with DOR and relevant organizations to develop a detailed plan of the Project.

Both sides agreed the details of the Project and Main Points Discussed as described in the Appendix 1 and the Appendix 2, respectively, and to request their respective governments to proceed with the necessary procedures for implementation of the Project.

Both sides also agreed that DOR, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Kingdom of Bhutan (hereinafter referred to as "Bhutan").

The Project will be implemented within the framework of the Colombo Plan Technical Cooperation Scheme and the Note Verbales to be exchanged between the Government of Japan (hereinafter referred to as "GOJ") and the Royal Government of Bhutan (hereinafter referred to as "RGOB").

The effectiveness of the Record of Discussions is subject to the exchange of the Note Verbales.

Appendix 1: Project Description
Appendix 2: Main Points Discussed
Appendix 3: Minutes of Meetings on the Detailed Planning Survey on the Project signed on December 3, 2013

Appendix 1

PROJECT DESCRIPTION

Both sides confirmed that there is no change in the Project Description agreed on in the Minutes of Meetings on the concerning Detailed Planning Survey on the Project signed on December 3, 2013.

I. BACKGROUND

Bhutan is dominantly covered by the mountainous areas spreading from the Himalaya. Road traffic is, therefore, the most important and vital transportation system for Bhutan. The major highway network in the country consists of 5 national highways; National Highway No.1 transversally crossing the country in a direction of east and west and 4 national highways advancing southward to the border with India. The total extension of the road in the country is, however, rapidly expanding; it was around a length of 2,300 km in 1990 and stretched to around a length of 3,900 km in 2003 and around a length of 10,600 km in 2013.

In regard to national programs in road sector, the Ministry of Works and Human Settlement (hereinafter referred to as "MOWHS") established the Road Sector Master Plan in 2006. In the master plan, MOWHS aims to expand and improve the national and Dzongkhag road network, to enhance the feeder road network, and to repair or replace or maintain bridges in the coming 20 years until 2027. Meanwhile, in the 10th Five Year Plan targeting from 2008 to 2013, RGOB set a goal of making any access to the nearest road within 2 hours or less.

Since most parts of the road network in Bhutan pass through steep slopes of the precipitous mountainous areas, the slope disaster frequently obstruct the road network in Bhutan. Slope disasters often isolate a Dzongkhag from the capital and other Dzongkhags, disrupt road traffic, and consequently hamper travel and transport of agricultural crops. In the aim of mitigating the damage caused by slope disasters, DOR introduced countermeasures against slope disasters utilizing vegetation and reinforcement. Due to a lack of experience and expertise, however, DOR is facing difficulties in implementing effective countermeasures against slope disasters.

In addition, in order to enhance the ability to grasp an inventory of dangerous slopes requiring countermeasures, RGOB requested GOJ to implement "the Technical Cooperation Project for Critical slope treatment/stabilization along the Road Network in Bhutan". In response to this request, JICA had series of discussion with DOR and other authorities concerned of Bhutan. Based on the agreements between JICA and the authorities concerned of Bhutan, the Minutes of Meetings was signed on December 3, 2013, which leads both parties to conclude this Record of Discussions.

II. OUTLINE OF THE PROJECT

1. Title of the Project

Project for Master Plan Study on Road Slope Management in Bhutan

2. Expected Goals which will be attained after the Project Completion

(1) Goal of the Proposed Project

Slope stability inspection and regular updating are conducted, and record cards of slope stability inspection "Slope Karte" are maintained by DOR.

(2) Goal which will be attained through implementation of the Proposed Project

Critical slopes are identified, and a plan for slope treatment/ stabilization is established by DOR.

3. Outputs

(1) Manuals for slope stability inspection and diagnosis are prepared.

(2) Slope stability inspection is conducted and road slope inventory is produced for the selected road section(s).

(3) Slope stability database including Slope Karte is established for the selected road section(s).

(4) Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte.

The selected road section(s) is to be decided at the first SC meeting and stipulated as a section of national highways between major towns. The selected road section(s) is subject to the availability of budget and time.

4. Activities

(1) For the output (1) "Manuals for slope stability inspection and diagnosis are prepared."

(a) Prepare manuals for slope stability inspection and diagnosis.
(b) Establish terminology for each slope disaster type in Bhutan.
(c) Revise the manuals for slope stability inspection prepared in (a).

(2) For the output (2) "Slope stability inspection is conducted for the selected road section(s)."

(a) Collect records of disaster and information on countermeasures under taken along the selected road section(s).
(b) Select target segments for the inspection in accordance with degree of risk.
(c) Screen the slopes in the target segments selected in (b), by aerial photo reading or geomorphic analysis.
(d) Confirm the result of screening in (c) on site and decide the target slopes for the inspection.
(e) Conduct field surveys at the target slopes in (d), and produce road slope inventory with the aim of preparing Slope Karte.

(f) Execute supplementary surveys including investigation boring and seismic exploration at a couple of slopes to understand mechanism of typical slope failure.
(g) Prepare Slope Karte through organizing and analyzing the results of the surveys.
(h) Carry out training including OJT for the target group concerning slope stability inspection and Slope Karte operation.

(3) For the output (3) "Slope stability database is established for the selected road section(s)."
(a) Establish a database system for managing the results of slope stability inspection including Slope Karte.
(b) Prepare operation manuals for the slope stability database system.

(4) For the output (4) "Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte."
(a) Review design documents prepared by DOR.
(b) Give advice on investigation for design of countermeasures.

5. Input
(1) Input by JICA
JICA will take, at its own expense, the following measures according to the normal procedures under the Colombo Plan Technical Cooperation:
(a) Dispatch of Mission
- Team Leader/Slope Stability Management Expert (Inspection and Manual)
- Slope Stability Management Expert (Inspection)
- Slope Stability Management Expert (Countermeasure)
- Slope Stability Database System Expert
- Road Maintenance Expert
- Coordinator/Assistant of Slope Stability Management

(b) Training
- Training in Bhutan: OJT, Workshop/Seminar
- Training in Japan

(c) Machinery and Equipment
- Vehicle for survey:2 units
- GPS for survey: 3 units
- Laser Range Finder: 3 units

In case of importation, the machinery, equipment and other materials under II-5 (1) (c) above will become the property of the RGOB upon being delivered C.I.F. (cost, insurance and freight) to the Bhutan authorities concerned at the ports and/or airports of disembarkation.

Input other than indicated above will be determined through mutual consultations between JICA and DOR during the implementation of the Project, as necessary.

(2) Input by DOR

DOR will take necessary measures to provide at its own expense:

(a) Services of DOR's counterpart personnel and administrative personnel as referred to in II-6;
(b) Suitable office space with necessary equipment;
(c) Supply or replacement of machinery, equipment, instruments, vehicles, tools, spare parts and any other materials necessary for the implementation of the Project other than the equipment provided by JICA;
(d) Information as well as support in obtaining medical service;
(e) Credentials or identification cards;
(f) Available data (including maps and photographs) and information related to the Project;
(g) Running expenses necessary for the implementation of the Project;
(h) Expenses necessary for transportation within Bhutan of the equipment referred to in II-5 (1) (c) as well as for the installation, operation and maintenance thereof; and
(i) Necessary facilities to the JICA experts for the remittance as well as utilization of the funds introduced into Bhutan from Japan in connection with the implementation of the Project

6. Implementation Structure

The Project organization chart is given in the Annex 2.

(1) DOR

(a) Project Director: Chief Engineer for Maintenance Division
(b) Maintenance Division
(c) Construction Division
(d) Design Division
(e) Planning and Monitoring Division

Project Director will bear overall responsibility of the Project.

(2) JICA Experts

The JICA experts will give necessary technical guidance, advice and recommendations to DOR on any matters pertaining to the implementation of the Project.

(3) Steering Committee

Steering Committee (hereinafter referred to as "SC") will be established in order to facilitate inter-organizational coordination. SC will be held at least twice a year and whenever deems it necessary. A list of proposed members of SC is shown in the Annex 3.

(4) Working Group

Working Group (hereinafter referred as "WG") will be established and function as a technical unit on a daily-work basis to correspond to the JICA mission. A list of proposed members of WG will be proposed and finalized in the first SC meeting after commencement of the Project.

7. Project Site(s) and Beneficiaries

(1) Project Site

The main activities of the Project will be implemented at DOR's headquarters and the selected road section(s) mentioned in II.3.

(2) Direct beneficiaries

Direct beneficiaries of the Project will be the staff of DOR.

(3) Indirect beneficiaries

Indirect beneficiaries are road users as well as people living in the selected road section(s).

8. Duration

The duration of the Project will be twenty four (24) months. The tentative Plan of Operation is shown in Annex 1.

9. Reports

JICA will prepare and submit the following reports to DOR in English.

(1) 10 copies of Inception Report at the commencement of the first work period in Bhutan.

(2) 10 copies Progress Report at the time of 7 months after the commencement of the first work period in Bhutan.

(3) 10 copies Interim Report at the time of 13 months after the commencement of the first work period in Bhutan.

(4) 10 copies Draft Final Report at the time of 22 months after the commencement of the first work period in Bhutan.

(5) 20 copies Final Report within one (1) month after the receipt of the comments on the Draft Final Report.

10. Environmental and Social Considerations

(1) DOR agreed to abide by 'JICA Guidelines for Environmental and Social Considerations' in order to ensure that appropriate considerations will be made for the environmental and social impacts of the Project.

III. UNDERTAKINGS OF DOR, RGOB

1. DOR, RGOB will take necessary measures to:

(1) ensure that the technologies and knowledge acquired by the Bhutan nationals as a result of Japanese technical cooperation contributes to the economic and social development of Bhutan, and that the knowledge and experience acquired by the personnel of Bhutan from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and

(2) grant privileges, exemptions and benefits to the JICA experts referred to in II-5 (1) above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in Bhutan.

(3) provide security-related information as well as measures to ensure the safety of the JICA experts;

(4) permit the JICA experts to enter, leave and sojourn in Bhutan for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.

2. Other privileges, exemptions and benefits will be provided in accordance with the Note Verbales to be exchanged between GOJ and RGOB.

IV. EVALUATION

JICA will conduct the following evaluations and surveys to mainly verify sustainability and impact of the Project and draw lessons. DOR is required to provide necessary support for them.

1. Ex-post evaluation three (3) years after the project completion, in principle
2. Follow-up surveys on necessity basis

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting support for the Project, DOR will take appropriate measures to make the Project widely known to the people of Bhutan.

VI. MUTUAL CONSULTATION

JICA and DOR will consult each other whenever any major issues arise in the course of Project implementation.

VII. AMENDMENTS

The Record of Discussions may be amended by the Minutes of Meetings between JICA and GNHC in consultation with DOR.
The Minutes of Meetings will be signed by authorized persons of each side who may be different from the signers of the Record of Discussions.

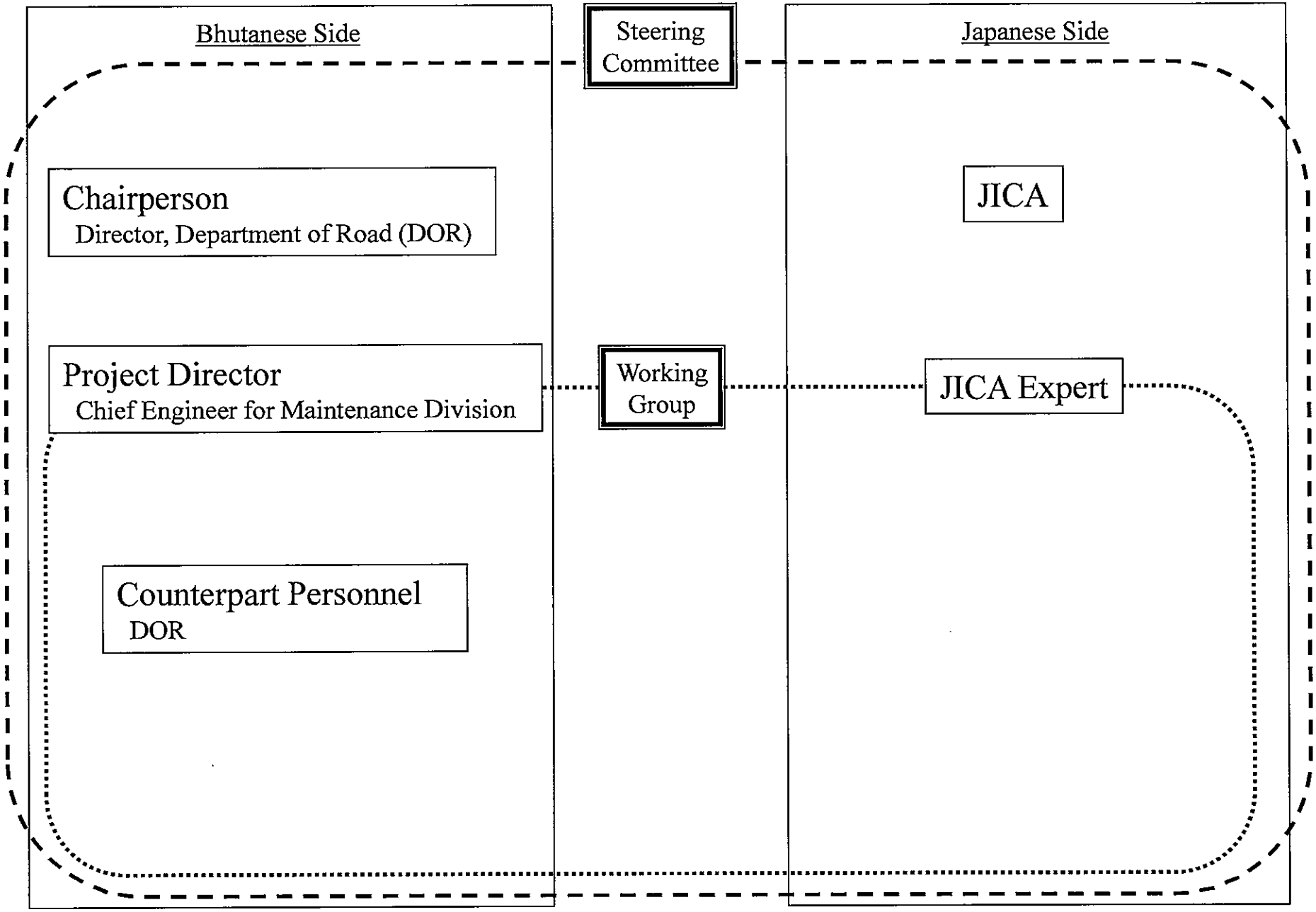
Annex 1 Tentative Plan of Operation
Annex 2 Project Organization Chart
Annex 3 A List of Proposed Members of Steering Committee

Draft, Tentative Plan of Operation[PO], Project for Master Plan Study on Road Slope Management in Bhutan

	Activities	Year 1												Year 2											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Output1	**Manuals for slope stability inspection and diagnosis are prepared.**																								
1-1	Prepare manuals for slope stability inspection and diagnosis.	■	■	■	■	■	■	■	■	■	■	■													
1-2	Establish selection standards of countermeasures for each slope disaster type.			■	■	■	■	■	■	■	■	■													
1-3	Revise the manuals for slope stability inspection prepared in 1-1.								■	■	■	■	■	■	■	■	■	■							
Output2	**Slope stability inspection is conducted for the selected road section(s).**																								
2.1	Collect records of disaster and information on countermeasures under taken along the selected road section(s).	■	■	■	■	■	■							■	■	■	■								
2.2	Select target segments for the inspection in accordance with degree of risk.		■	■	■	■								■	■	■	■								
2.3	Screen the slopes in the target segments selected in 2-2, by aerial photo reading or geomorphic analysis.			■	■	■	■									■	■	■	■						
2.4	Confirm the result of screening in 2-3 on site and decide the target slopes for the inspection.						■	■											■	■					
2.5	Conduct field surveys at the targeted slopes in 2-4, with the aim of preparing Slope Karte.							■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
2.6	Execute supplementary surveys including investigation boring and seismic exploration at a couple of slopes to understand mechanism of typical slope failure.												■	■	■	■	■	■	■	■	■	■	■	■	
2.7	Prepare Slope Karte through organizing and analysing the results of the surveys.												■	■	■	■	■	■	■	■	■	■	■	■	
2.8	Carry out training including OJT for the target group concerning slope stability inspection and Slope Karte operation.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■
Output3	**Slope stability database is established for the selected road section(s).**																								
3.1	Establish a database system for managing the results of slope stability inspection including Slope Karte.													■	■	■	■	■	■	■	■	■	■	■	■	
3.2	Prepare operation manuals for the slope stability database system.																		■	■	■	■	■		
Output4	**Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte.**																								
4.1	Review design documents prepared by DOR.																								
4.2	Give advice on investigation for design of countermeasures.																								
Administrative Activities																									
Steering Committee		▲												▲										▲	
Inception Report		▲																							
Interim Report/Progress Report								PR ▲						ITR ▲											
Draft Final Report/Final Report																							DFR ▲		FR ▲

Annex 2

Organization chart of the Project



Annex 3

LIST OF PROPOSED MEMBERS OF STEERING COMMITTEE

Chairperson: Director, Department of Roads (DOR)

Members:

(1) Bhutanese Side

1) DOR

- Project Director: Chief Engineer for Maintenance Division

2) Representative from GNHC

(2) Japanese Side

1) JICA

2) JICA Experts

- Team Leader/Slope Stability Management Expert (Inspection and Manual)
- Slope Stability Management Expert (Inspection)
- Slope Stability Management Expert (Countermeasure)
- Slope Stability Database System Expert
- Road Maintenance Expert
- Coordinator/Assistant of Slope Stability Management

(3) Others

- Relevant personnel accepted by SC, if necessary

Appendix 2

MAIN POINTS DISCUSSED

I. PROJECT PERIOD

Both sides agreed that the duration of the project should be 24 months from the first dispatch of JICA study team.

II. OUTPUTS OF THE PROJECT

(1) Referring to Ⅱ-3 (2), number of slopes to be inspected will be 400 at maximum. Those slopes will be located in the selected road section(s).

(2) Referring to Ⅱ-3 (4), pilot sites will be selected from Slope Karte. "Giving advice" is stipulated in Ⅱ-4 (4), and does not include engineering services.

(3) The selected road section(s) is one or two section(s) identified by SC.

III. INSPECTION TEAM

Both sides agreed that two inspection teams will be established at the first SC meeting. The member of the inspection team will contain at least one Japanese expert and one DOR engineer.
If the third inspection team or more is established by Bhutanese engineers, JICA study team will support in checking the implementation of inspection and Slope Karte operation.

IV. TECHNICAL TRANSFER DURING THE PROJECT

Both sides agreed that technical transfer on slope stability inspection, preparation of Slope Karte, and establishment of the database will be done at OJT basis.
Workshops/Seminars will be held twice in Bhutan.
Training in Japan will be held early or middle period of the Project. DOR requested that trainees in Japan will be one from each of nine DOR's regional offices and three from DOR's headquarters.

V. OPERATION AND MAINTENANCE OF SLOPE KARTE

Both sides agreed that DOR should conduct the remaining slope stability inspection as well as regular updating of Slope Karte by themselves.

VI. OTHERS

DOR requested for two vehicles for the Project considering the lack of transportation.

MINUTES OF MEETINGS
BETWEEN
DEPARTMENT OF ROADS
AND
JAPAN INTERNATIONAL COOPERATION AGENCY
ON
TECHNICAL COOPERATION PROJECT FOR CRITICAL SLOPE TREATMENT / STABILIZATION ALONG THE ROAD NETWORK IN BHUTAN

The Japanese Detailed Planning Survey Team (hereinafter referred to as "the Team") organized by Japan International Cooperation Agency (hereinafter referred to as "JICA") headed by Mr. Nobuyuki Tsuneoka, Senior Advisor of JICA, visited Bhutan from November 25, 2013 to December 5, 2013 for the purpose of working out the details concerning "Technical Cooperation Project for Critical Slope Treatment/Stabilization along the Road Network in Bhutan" (hereinafter referred to as "the Project")

During its stay in Bhutan, the Team exchanged views and had a series of discussions with Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR") and the concerned organizations of Bhutan with respect to necessary measures to be taken by JICA and the Royal Government of Bhutan (hereinafter referred to as "RGOB") represented by DOR for the appropriate formulation of the Project.

As a result of the discussions, DOR and JICA agreed upon the matters referred to in the document attached hereto.

Thimphu, December 3, 2013

Karma Galay
Director
Department of Roads
Ministry of Works and Human Settlement
Kingdom of Bhutan

Nobuyuki Tsuneoka
Leader
Detailed Planning Survey Team
Japan International Cooperation Agency
Japan

Rinchen Wangdi
Chief Program Coordinator
Development Cooperation Division
Gross National Happiness Commission
Kingdom of Bhutan

ATTACHED DOCUMENT

I. RECORD OF DISCUSSIONS

Both sides agreed that the Record of Discussions (R/D) will determine the framework of the Project. The draft R/D is attached to this Minutes of Meetings for reference as shown in Appendix-1. It will be agreed and signed between DOR, Gross National Happiness Commission and JICA after the formal approval of both sides.

II. CHANGE OF THE PROJECT TITLE

Both sides agreed to change the Project title from "Technical Cooperation Project for Critical Slope Treatment/Stabilization along the Road Network in Bhutan" to "Project for Master Plan Study on Road Slope Management in Bhutan".

Appendix-1 Draft Record of Discussions

(DRAFT)
RECORD OF DISCUSSIONS

ON

PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT IN BHUTAN

AGREED UPON BETWEEN

GROSS NATIONAL HAPPINESS COMMISSION

AND

JAPAN INTERNATIONAL COOPERATION AGENCY

Thimphu, XX, 2013

Yumiko Asakuma
Chief Representative
Japan International Cooperation Agency
Japan

Karma Tshiteem
Secretary
Gross National Happiness Commission
Kingdom of Bhutan

Witnessed by

Karma Galay
Director
Department of Roads
Ministry of Works and Human Settlement
Kingdom of Bhutan

Based on the Minutes of Meetings on the Detailed Planning Survey on Project for Master Plan Study on Road Slope Management in Bhutan (hereinafter referred to as "the Project") signed on December 3, 2013 between Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR"), Gross National Happiness Commission (hereinafter referred to as "GNHC") and the Japan International Cooperation Agency (hereinafter referred to as "JICA"), JICA held a series of discussions with DOR and relevant organizations to develop a detailed plan of the Project.

Both sides agreed the details of the Project and Main Points Discussed as described in the Appendix 1 and the Appendix 2, respectively, and to request their respective governments to proceed with the necessary procedures for implementation of the Project.

Both sides also agreed that DOR, the counterpart to JICA, will be responsible for the implementation of the Project in cooperation with JICA, coordinate with other relevant organizations and ensure that the self-reliant operation of the Project is sustained during and after the implementation period in order to contribute toward social and economic development of Kingdom of Bhutan (hereinafter referred to as "Bhutan").

The Project will be implemented within the framework of the Colombo Plan Technical Cooperation Scheme and the Note Verbales to be exchanged between the Government of Japan (hereinafter referred to as "GOJ") and the Royal Government of Bhutan (hereinafter referred to as "RGOB").

The effectiveness of the Record of Discussions is subject to the exchange of the Note Verbales.

Appendix 1: Project Description.
Appendix 2: Main Points Discussed

Appendix 1

PROJECT DESCRIPTION

Both sides confirmed that there is no change in the Project Description agreed on in the Minutes of Meetings on the concerning Detailed Planning Survey on the Project signed on December 3, 2013.

I. BACKGROUND

Bhutan is dominantly covered by the mountainous areas spreading from the Himalaya. Road traffic is, therefore, the most important and vital transportation system for Bhutan. The major highway network in the country consists of 5 national highways; National Highway No.1 transversally crossing the country in a direction of east and west and 4 national highways advancing southward to the border with India. The total extension of the road in the country is, however, rapidly expanding; it was around a length of 2,300 km in 1990 and stretched to around a length of 3,900 km in 2003 and around a length of 10,600 km in 2013.

In regard to national programs in road sector, the Ministry of Works and Human Settlement (hereinafter referred to as "MOWHS") established the Road Sector Master Plan in 2006. In the master plan, MOWHS aims to expand and improve the national and Dzongkhag road network, to enhance the feeder road network, and to repair or replace or maintain bridges in the coming 20 years until 2027. Meanwhile, in the 10th Five Year Plan targeting from 2008 to 2013, RGOB set a goal of making any access to the nearest road within 2 hours or less.

Since most parts of the road network in Bhutan pass through steep slopes of the precipitous mountainous areas, the slope disaster frequently obstruct the road network in Bhutan. Slope disasters often isolate a Dzongkhag from the capital and other Dzongkhags, disrupt road traffic, and consequently hamper travel and transport of agricultural crops. In the aim of mitigating the damage caused by slope disasters, DOR introduced countermeasures against slope disasters utilizing vegetation and reinforcement. Due to a lack of experience and expertise, however, DOR is facing difficulties in implementing effective countermeasures against slope disasters.

In addition, in order to enhance the ability to grasp an inventory of dangerous slopes requiring countermeasures, RGOB requested GOJ to implement "the Technical Cooperation Project for Critical slope treatment/stabilization along the Road Network in Bhutan". In response to this request, JICA had series of discussion with DOR and other authorities concerned of Bhutan. Based on the agreements between JICA and the authorities concerned of Bhutan, the Minutes of Meetings was signed on December 3, 2013, which leads both parties to conclude this Record of Discussions.

II. OUTLINE OF THE PROJECT

1. Title of the Project
   Project for Master Plan Study on Road Slope Management in Bhutan

2. Expected Goals which will be attained after the Project Completion
   (1) Goal of the Proposed Project
   Slope stability inspection and regular updating are conducted, and record cards of slope stability inspection "Slope Karte" are maintained by DOR.

   (2) Goal which will be attained through implementation of the Proposed Project
   Critical slopes are identified, and a plan for slope treatment/ stabilization is established by DOR.

3. Outputs
   (1) Manuals for slope stability inspection and diagnosis are prepared.

   (2) Slope stability inspection is conducted and road slope inventory is produced for the selected road section(s).

   (3) Slope stability database including Slope Karte is established for the selected road section(s).

   (4) Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte.

   The selected road section(s) is to be decided at the first SC meeting and stipulated as a section of national highways between major towns. The selected road section(s) is subject to the availability of budget and time.

4. Activities
   (1) For the output (1) "Manuals for slope stability inspection and diagnosis are prepared."
   (a) Prepare manuals for slope stability inspection and diagnosis.
   (b) Establish terminology for each slope disaster type in Bhutan.
   (c) Revise the manuals for slope stability inspection prepared in (a).

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   (c) Screen the slopes in the target segments selected in (b), by aerial photo reading or geomorphic analysis.
   (d) Confirm the result of screening in (c) on site and decide the target slopes for the inspection.
   (e) Conduct field surveys at the target slopes in (d), and produce road slope inventory with the aim of preparing Slope Karte.

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(g) Prepare Slope Karte through organizing and analyzing the results of the surveys.
(h) Carry out training including OJT for the target group concerning slope stability inspection and Slope Karte operation.

(3) For the output (3) "Slope stability database is established for the selected road section(s)."
(a) Establish a database system for managing the results of slope stability inspection including Slope Karte.
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(d) Information as well as support in obtaining medical service;
(e) Credentials or identification cards;
(f) Available data (including maps and photographs) and information related to the Project;
(g) Running expenses necessary for the implementation of the Project;
(h) Expenses necessary for transportation within Bhutan of the equipment referred to in II-5 (1) (c) as well as for the installation, operation and maintenance thereof; and
(i) Necessary facilities to the JICA experts for the remittance as well as utilization of the funds introduced into Bhutan from Japan in connection with the implementation of the Project

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(5) 20 copies Final Report within one (1) month after the receipt of the comments on the Draft Final Report.

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III. UNDERTAKINGS OF DOR, RGOB

1. DOR, RGOB will take necessary measures to:

(1) ensure that the technologies and knowledge acquired by the Bhutan nationals as a result of Japanese technical cooperation contributes to the economic and social development of Bhutan, and that the knowledge and experience acquired by the personnel of Bhutan from technical training as well as the equipment provided by JICA will be utilized effectively in the implementation of the Project; and

(2) grant privileges, exemptions and benefits to the JICA experts referred to in II-5 (1) above and their families, which are no less favorable than those granted to experts and members of the missions and their families of third countries or international organizations performing similar missions in Bhutan.

(3) provide security-related information as well as measures to ensure the safety of the JICA experts;

(4) permit the JICA experts to enter, leave and sojourn in Bhutan for the duration of their assignments therein and exempt them from foreign registration requirements and consular fees.

2. Other privileges, exemptions and benefits will be provided in accordance with the Note Verbales to be exchanged between GOJ and RGOB.

IV. EVALUATION

JICA will conduct the following evaluations and surveys to mainly verify sustainability and impact of the Project and draw lessons. DOR is required to provide necessary support for them.

1. Ex-post evaluation three (3) years after the project completion, in principle.
2. Follow-up surveys on necessity basis

V. PROMOTION OF PUBLIC SUPPORT

For the purpose of promoting support for the Project, DOR will take appropriate measures to make the Project widely known to the people of Bhutan.

VI. MUTUAL CONSULTATION

JICA and DOR will consult each other whenever any major issues arise in the course of Project implementation.

VII. AMENDMENTS

The Record of Discussions may be amended by the Minutes of Meetings between JICA and GNHC in consultation with DOR.
The Minutes of Meetings will be signed by authorized persons of each side who may be different from the signers of the Record of Discussions.

Annex 1 Tentative Plan of Operation
Annex 2 Project Organization Chart
Annex 3 A List of Proposed Members of Steering Committee

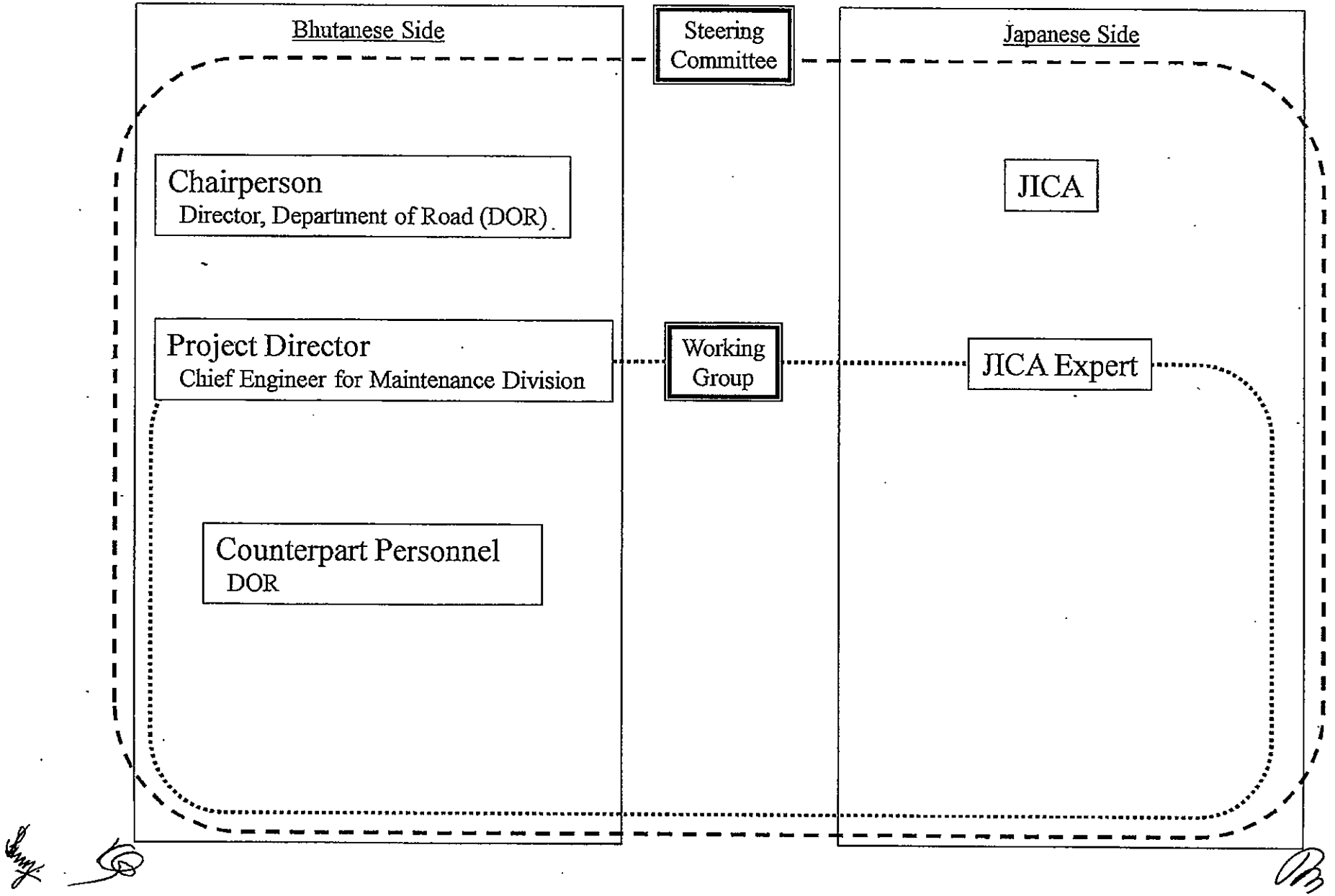
Annex1

Draft, Tentative Plan of Operation[PO], Project for Master Plan Study on Road Slope Management in Bhutan

	Activities	Year 1												Year 2											
		1	2	3	4	5	6	7	8	9	10	11	12	1	2	3	4	5	6	7	8	9	10	11	12
Output1	Manuals for slope stability inspection and diagnosis are prepared.																								
1-1	Prepare manuals for slope stability inspection and diagnosis.	■	■	■	■	■	■	■	■	■	■														
1-2	Establish selection standards of countermeasures for each slope disaster type.			■	■	■	■	■	■	■	■														
1-3	Revise the manuals for slope stability inspection prepared in 1-1.								■	■	■	■	■	■	■	■	■	■							
Output2	Slope stability inspection is conducted for the selected road section(s).																								
2.1	Collect records of disaster and information on countermeasures under taken along the selected road section(s).	■	■	■	■	■	■							■	■	■	■								
2.2	Select target segments for the inspection in accordance with degree of risk.		■	■	■									■	■	■	■								
2.3	Screen the slopes in the target segments selected in 2-2, by aerial photo reading or geomorphic analysis.			■	■	■	■									■	■	■	■						
2.4	Confirm the result of screening in 2-3 on site and decide the target slopes for the inspection.						■	■											■	■					
2.5	Conduct field surveys at the targeted slopes in 2-4, with the aim of preparing Slope Karte.							■	■	■	■	■	■	■	■					■	■	■	■	■	
2.6	Execute supplementary surveys including investigation boring and seismic exploration at a couple of slopes to understand mechanism of typical slope failure.												■	■	■								■	■	
2.7	Prepare Slope Karte through organizing and analysing the results of the surveys.												■	■	■							■	■	■	
2.8	Carry out training including OJT for the target group concerning slope stability inspection and Slope Karte operation.	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	
Output3	Slope stability database is established for the selected road section(s).																								
3.1	Establish a database system for managing the results of slope stability inspection including Slope Karte.													■	■	■	■	■	■	■	■	■	■	■	■	
3.2	Prepare operation manuals for the slope stability database system.																	■	■	■	■				
Output4	Giving advice on one or two pilot sites to be implemented by DOR based on Slope Karte.																								
4.1	Review design documents prepared by DOR.																								
4.2	Give advice on investigation for design of countermeasures.																								
Administrative Activities																									
Steering Committee		▲												▲										▲	
Inception Report		▲																							
Interim Report/Progress Report								PR ▲						ITR ▲											
Draft Final Report/Final Report																							DFR ▲		FR ▲

Annex 2

Organization chart of the Project



Annex 3

LIST OF PROPOSED MEMBERS OF STEERING COMMITTEE

Chairperson: Director, Department of Roads (DOR)

Members:

(1) Bhutanese Side

1) DOR

- Project Director: Chief Engineer for Maintenance Division

2) Representative from GNHC

(2) Japanese Side

1) JICA

2) JICA Experts

- Team Leader/Slope Stability Management Expert (Inspection and Manual)
- Slope Stability Management Expert (Inspection)
- Slope Stability Management Expert (Countermeasure)
- Slope Stability Database System Expert
- Road Maintenance Expert
- Coordinator/Assistant of Slope Stability Management

(3) Others

- Relevant personnel accepted by SC, if necessary

Appendix 2

MAIN POINTS DISCUSSED

I. PROJECT PERIOD

Both sides agreed that the duration of the project should be 24 months from the first dispatch of JICA study team.

II. OUTPUTS OF THE PROJECT

(1) Referring to Ⅱ-3 (2), number of slopes to be inspected will be 400 at maximum. Those slopes will be located in the selected road section(s).

(2) Referring to Ⅱ-3 (4), pilot sites will be selected from Slope Karte. "Giving advice" is stipulated in Ⅱ-4 (4), and does not include engineering services.

(3) The selected road section(s) is one or two section(s) identified by SC.

III. INSPECTION TEAM

Both sides agreed that two inspection teams will be established at the first SC meeting. The member of the inspection team will contain at least one Japanese expert and one DOR engineer.
If the third inspection team or more is established by Bhutanese engineers, JICA study team will support in checking the implementation of inspection and Slope Karte operation.

IV. TECHNICAL TRANSFER DURING THE PROJECT

Both sides agreed that technical transfer on slope stability inspection, preparation of Slope Karte, and establishment of the database will be done at OJT basis.
Workshops/Seminars will be held twice in Bhutan.
Training in Japan will be held early or middle period of the Project. DOR requested that trainees in Japan will be one from each of nine DOR's regional offices and three from DOR's headquarters.

V. OPERATION AND MAINTENANCE OF SLOPE KARTE

Both sides agreed that DOR should conduct the remaining slope stability inspection as well as regular updating of Slope Karte by themselves.

VI. OTHERS

DOR requested for two vehicles for the Project considering the lack of transportation.

Appendix 3

Minutes of Meeting for Steering Committee

MINUTES OF MEETING
ON INCEPTION REPORT FOR
PROJECT FOR MASTER PLAN STUDY
ON ROAD SLOPE MANAGEMENT IN BHUTAN
AGREED UPON BETWEEN
DEPARTMENT OF ROADS
AND THE JAPAN INTERNATIONAL COOPERATION AGENCY

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the JICA Expert Team (hereinafter referred to as "JET") to the Kingdom of Bhutan on the Project for Master Plan Study on Road Slope Management in Bhutan (hereinafter referred to as "the Project") in order to explain and consult with the Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR") on the contents of the Inception Report of the Project (hereinafter referred as to "the Inception Report") from July 30, 2014.

As a result of discussions, both sides agreed to the matters described on the attached sheets.

Thimphu, August 4, 2014

桑野 健

Takeshi Kuwano
Team leader,
The Expert Team,
Japan International Cooperation Agency

Karma Galay
Director,
Department of Roads,
Ministry of Works and Human Settlement,
Kingdom of Bhutan

Attachment

I. Acceptance of the Inception Report

DOR agreed and accepted the contents of the Inception Report and the undertakings by DOR for the execution of the Project explained by JET. Detailed methods will be adjusted in the course of the Project with mutual cooperation.

II. Determination of the target sections for the Project

JET explained the target sections for the Project where JET and DOR shall prepare the Slope Inventory and the Slope Karte. The target sections have been selected in consideration of the condition on 1) Topography and geological aspects, 2) Connecting a large population to urban areas, 3) Social and economic importance, and 4) Technical transfer to DOR. Both sides agreed that the target sections are shown in **Annex-1**.

III. The Structure of the Project Execution

DOR and JET explained about the structure of the Project which is a component of the JICA's Technical Cooperation Program. The issues discussed are as follows;

1. In accordance with the Record of Discussions agreed upon by DOR and JICA on December 3rd 2013, DOR agreed to set up the Steering Committee (hereinafter referred as "SC") chaired by the Director of DOR in order to facilitate inter-organization coordination. The members are shown in **Annex-2**.
2. DOR also agreed to establish Working Group (hereinafter referred as "WG") as a technical unit on a daily-work basis consisting of technical staff from the DOR, HQ and the Regional Offices of DOR to conduct technical matters for particular issues. The members are shown in **Annex-3**.
3. Both sides agreed that the SC would be conducted on a regular basis as scheduled in **Annex-4**.
4. JET shall organize several Technical Seminars and Workshops at Thimphu Office and Trongsa Office because it is difficult for regional engineers to gather together at Thimphu. JET and DOR think that the sharing of technical skills and hands-on experiences for the regional engineers are important components of the Project and will be conducted throughout the Project period. DOR agreed that DOR assign the counterpart personnel.

III. Discussion on the significant issues

1. Training in Japan

- The training in Japan will be held on July 2015 to improve the technical skills of DOR after DOR implement the actual inspection and investigation in Bhutan supported by JET.

2. The number of the inspection sites

- The maximum number of inspection sites in the Project is 400 sites in the target sections as the Record of Discussions agreed upon by DOR and JICA on December 3rd 2013.

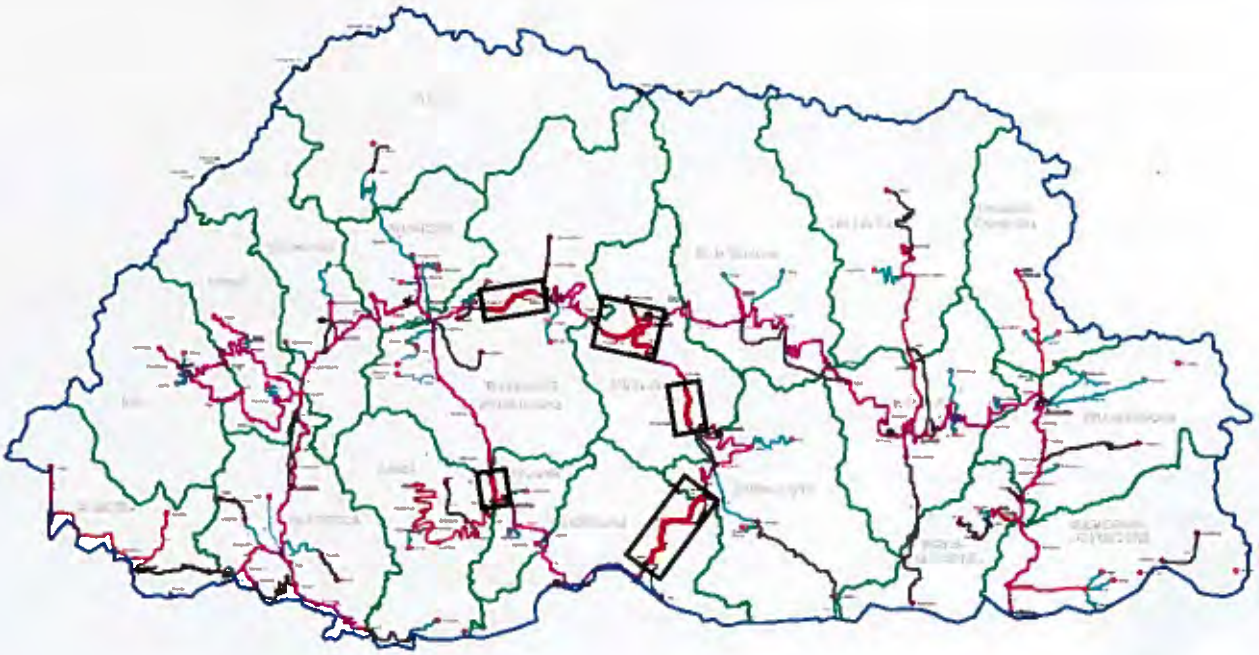
3. Provision of the vehicles

- JICA shall provide two 4WD cars to DOR in the Project period. The vehicle will be owned by JICA. It will be handed over to DoR after the completion of the Project.

Annex-1 Target sections for the Project
Annex-2 Members of the Steering Committee
Annex-3 Members of the Working Group
Annex-4 Schedule and Contents of the Steering Committee Meetings
Annex-5 List of members who attended 1st Steering Committee

Annex-1

Target sections for the Project



: the target sections for the Project

Annex-2

Members of the Steering Committee

Position	Name and Organization	Title/ position
Chairperson	Mr. Karma Galay (DOR)	Director
Members	Mr. Tshering Wangdi 'B'(DOR)	Chief Engineer (Maintenance Division)
	Mr. Dorji Tshering (DOR)	Deputy Executive Engineer.
	Mr. Takeshi Kuwano (JET)	Team Leader/ Road slope management.
	Mr. Kimihiko Kotoo (JET)	Vice Team leader/ slope stability inspection
	Mr. Kunzang L. Sangay (GNHC)	Deputy Chief Planning Officer (Representative)
	JICA HQ and/or JICA Bhutan Office	(Representative)

Annex-3

Members of the Working Group

Name and Title	DOR Office/Place
Mr. Dorji Tshering, Deputy Executive Engineer.	Headquarter, Thimphu
Mr. Dilip Kr. Thapa, Executive Engineer.	Headquarter, Thimphu
Ms. Phuntsho Wangmo, Assistant Architect.	Headquarter, Thimphu
Mr. Dhendup Dorji, Engineer.	Regional Office, Tashigang
Mr. Nim Dorji, Assistant Engineer.	Regional Office, Lingmethang
Mr. Wangchuk, Engineer.	Regional Office, Trongsa
Mr. Karma Dorji, Executive Engineer.	Regional Office, Sarpang
Mr. Sonam Thinley, Assistant Engineer.	Regional Office, Lobesya
Mr. Drakpa Wangdi, Executive Engineer.	Regional Office, Thimphu
Mr. Neten Tshering, Deputy Executive Engineer.	Regional Office, Samdrup Jongkhar
Mr. Karchung, Deputy Executive Engineer.	Regional Office, Zhemgang
Mr. Prabin Gurung, Deputy Executive Engineer.	Regional Office, Phuentsholing.

Annex-4

Proposed Schedule and Contents of the Steering Committees

No.	Proposed Date	Contents / Objectives
1	July 30 2014	Inception Report
2	February 2015	Progress Report
3	October 2015	Interim Report
4	July 2016	Draft Final Report

Steering Committee will be held whenever deems it necessary.

Annex-5

List of members who attended 1st Steering Committee

<BHUTAN SIDE>

Department of Roads, Ministry of Works and Human Settlement (DOR)

Mr. Karma Galay (Director)

Mr. Tshering Wangdi 'B' (Chief Engineer)

Mr. Dorji Tshering (Deputy Executive Engineer)

Mr. Tshering Paljore (Chief Engineer, Planning Division) (Observer)

Mr. Karma Wangdi (DoR) (Chief Engineer, Design Division) (Observer)

Other Ministries/Organizations

Mr. Kuenzang L. Sangay (Deputy Chief Planning Officer, GNHC representative)

Ms. Sangay Choden (GNHC representative)

<JAPAN SIDE>

JICA

Ms. Yumiko Asakuma (Resident Representative, JICA Bhutan Office)

Mr. Yasunori Tonegawa (Deputy Assistant Director, JICA HQ)

Mr. Masanori Sunada (Project Formation Advisor, JICA Bhutan Office)

Mr. Krishna Subba(Programofficer, JICA Bhutan Office)

JICA Expert Team

Mr. Takeshi Kuwano (Team leader / Slope stability management)

Mr. Kimihiko Kotoo (Vice team leader / Slope inspection)

Mr. Yosuke Yamamoto (Coordinator/Slope inspection/Environmental & social consideration)

MINUTES OF MEETING
ON 2ND STEERING COMMITTEE FOR
PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT
IN BHUTAN
AGREED UPON BETWEEN
DEPARTMENT OF ROADS AND
THE JAPAN INTERNATIONAL COOPERATION AGENCY

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the JICA Expert Team (hereinafter referred to as "JET") to the Kingdom of Bhutan on the Project for Master Plan Study on Road Slope Management in Bhutan (hereinafter referred to as "the Project") in order to conduct with the Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DOR").

As a result of discussions on this 2nd steering committee, all parties agreed to the matters described on the attached sheets.

Thimphu, October 21, 2015

Takeshi Kuwano	**M. N. Lamichaney**
Team Leader,	Officiating Director,
The Expert Team,	Department of Roads,
Japan International Cooperation Agency	Ministry of Works and Human Settlement,
Japan	Kingdom of Bhutan

Attachment

I. Acceptance of the Interim Report

DOR agreed and accepted the contents of the Interim Report as follows and the undertakings by DOR for the execution of the Project explained by JET.

1. JET has been steadily conducting four (4) components of the Project with cooperation of DOR since JET started it on August 2014. As of the end of September 2015, the draft of Inspection Manual has been completed in Component 1, the slope inventory have been prepared on the Section I, II and III on the roads based on the slope inspection in Component 2, the GIS database is being established in Component 3, and technical advices are being delivered for a tunnel project in Thumang Cliff on the Primary National Highway No. 1 in Component 4.

2. JET has classified 457 slopes into three (3) hazard ranks based on the slope inspection on the Section I, II and III on the National Road No.1 and No.4. Rank 1 is 64 sites, for which, "countermeasure works are necessary." Rank 2 is 143 sites, for which, "although urgent countermeasures are not necessary, regular checks are needed." Rank 3 is 250 sites, for which "countermeasure work is not necessary."

3. The significance is followed by "The technical guideline of slope stability works in Road Construction in Japan (2009)". The results of investigation give the efficiency in proceeding road projects because uncertainty is contained by the knowledge from the investigation in giving the road planner a well decision making. As for the results of the investigation on site, treatments are advisable for the stability in the basement of the current road at site 1 (Thomang Cliff) in view of the fact that the surface layer (overburden) is relatively thick, which has a potential to slide when there would be rise in groundwater in the rainy season after the combined examination from the topography map, geophysics (seismic refraction method) and boring data.

4. Standard countermeasure for slope disasters has been finalized through discussion between JET and CPs of DOR. Those standard measures were categorized into 2 types as one which can be done by local capacity and one which is required external supports. The flowcharts to select the suitable countermeasure on site have been prepared. The inspector shall select countermeasure by using the flowchart at inspection on the site.

5. JET has decided the modules for database of slope disaster as "Slope inventory and Slope inspection record" and "Web information system for road condition". The purpose of the database is for DOR to efficiently gather and update the road slope inventory and slope inspection sheet. Additionally the database has the function of understanding the road

condition. The database system has the GIS function so that the location of the slope inventory, slope inspection record and critical disaster point are linked on the Map. From the perspective of self-sustainability, the database is developed as a simple and user friendly system. Finally, the user's manual is being prepared for updating and maintaining the database system.

II. Proposal of the Tunnel Project in Thomang Cliff

DOR has explained that the Thomang Cliff rock slope failure is one of the most problematic stretches on the Thimphu-Trashigang Primary National Highway. A permanent solution is very much needed because:

I. It lies on the one of the busiest national highway. It has 3rd highest traffic with over 700 vehicles per day.

II. No alternative routes to reach Trongsa, Bumthang, Mongar, Lhuntse, Trashiyagtse and Trashigang if the road is blocked at this area. This is thereof, a life line to eastern Bhutan which has larger population.

III. The rock slope failure is active and yearly road is being blocked for about 3-5 days at this point. Further damages to road are foreseen at this point.

IV. DOR has decided to skip the widening of highway within the proposed tunneling stretch expecting a permanent solution will be in place near future.

However, DOR has also stressed that out of all the permanent solutions, tunneling at this point is found to be more suitable. This is because; the area is very large and with a slight modification to the natural slope, it might trigger very large scale of landslides or rock slope failure. JET has also the same view on this matter. DOR has informed the floor that a proposal of permanent solution (tunnel) at Thomang Cliff has been submitted to JICA through the Gross National Happiness Commission.

III. Acceptance of Activity Plan

DOR agreed and accepted the activity plan since October 2015 as follows explained by JET.

1. The Inspection Manual will be revised and finalized by April 2016 in Component 1, the regular check for Rank 1 and 2 will be completed by March 2016 and subsequently a

slope disaster management plan will be discussed in Component 2, the GIS database will be established and a manual for the database will be prepared in Component 3, and technical advices will be continuously delivered on a detailed survey and a design of slope countermeasures in Component 4.

2. Technical seminars on specific theme will be implemented for the staff of DOR.
3. Draft Final Report will be submitted on June 2016. Final Report which is revised on comments by DOR will be submitted on August 2016.

Annex-1: List of members who attended 2nd Steering Committee

Annex-1

List of members who attended 2nd Steering Committee

<BHUTAN SIDE>

Department of Roads, Ministry of Works and Human Settlement (DOR)

Mr. M.N. Lamichaney (Officiating Director)

Mr. Tshering Wangdi 'A' (Chief Engineer, Construction Division)

Mr. Tshering Wangdi 'B' (Chief Engineer, Maintaince Division)

Mr. Dorji Tshering (Executive Engineer, Maintaince Division)

Mr. Tashi Phuntsho (Executive Engineer, Bridge Division)

<JAPAN SIDE>

JICA

Ms. Yumiko Asakuma (Resident Representative, JICA Bhutan Office)

Ms. Tomoko Miyata (Project Formation Advisor, JICA Bhutan Office)

Mr. Krishna Subba (Program officer, JICA Bhutan Office)

JICA Expert Team

Mr. Takeshi Kuwano (Team leader / Slope stability management)

Mr. Takashi Hara (Slope stability countermeasure)

Mr. Masanori Tozawa (Investigation and monitoring)

Ms. Haruka Yoshida (Coordinator / Slope inspection / Environmental & social consideration)

Mr. Cheku (Assistant of slope stability database management)

Mr. Pema Tshering (Project Assistant)

MINUTES OF MEETING
ON 3RD (FINAL) STEERING COMMITTEE FOR
PROJECT FOR MASTER PLAN STUDY ON ROAD SLOPE MANAGEMENT
IN BHUTAN
AGREED UPON BETWEEN
DEPARTMENT OF ROADS AND
THE JAPAN INTERNATIONAL COOPERATION AGENCY

The Japan International Cooperation Agency (hereinafter referred to as "JICA") dispatched the JICA Expert Team (hereinafter referred to as "JET") to the Kingdom of Bhutan on the Project for Master Plan Study on Road Slope Management in Bhutan (hereinafter referred to as "the Project") in order to conduct with the Department of Roads, Ministry of Works and Human Settlement (hereinafter referred to as "DoR").

As a result of discussions on this 3rd steering committee, all parties agreed to the matters described on the attached sheets.

Thimphu, June 9, 2016

桑野 健

Takeshi Kuwano
Team Leader,
The Expert Team,
Japan International Cooperation Agency
Japan

Karma Galay
Director
Department of Roads
Thimphu · Bhutan

Karma Galay
Director,
Department of Roads,
Ministry of Works and Human Settlement,
Kingdom of Bhutan

Attachment

I. Acceptance of the Draft Final Report

DoR agreed and accepted the contents of the Draft Final Report as follows and the undertakings by DoR for the execution of the Project explained by JET. DoR send comments to JET by 1st July 2016, to finalize the report as Final Report, which is submitted on August 2016.

1. Type of road slope disaster is categorized four; debris slope failure, rock slope failure, landslide and debris flow. The slope inspections has been carried out for 457 slopes on the Section I, II and III on the National Road No.1 and No.4, and the inspection results were recorded in the inspection sheets and inspection list. As a hazard evaluation, JET has classified 457 slopes into four (4) hazard ranks based on the slope inspection. Rank 1A is 29 sites, Rank 1B is 34 sites, Rank 2 is 145 sites, and Rank 3 is 249 sites. Total of 208 slopes of Rank 1 and Rank 2, were selected for the regular check among the 457 slopes.

2. JET has carried out the prioritization for countermeasure implementation. The target is the slopes of the inspection in the project. The hazardous slopes have been prioritized using factors such as the urgency and the practicability of the countermeasure implementation for the slope, based on the result of the slope inspection and the regular check. 11 slopes as high priority, six slopes as medium priority and remaining slopes as low priority are categorized.

3. JET has developed Slope Disaster Database. The database has two kinds of modules: Module 1 is for the "slope inspection sheets" and "regular check sheets". Module 2 is Web Information System. The purpose of Module 1 is to accumulate and update the slope inspection sheets and the regular check sheet in an efficient manner for DoR. The Module 2 is to provide road condition including road block information through web basis. The database system has GIS function so that location of the slope inventory, the slope inspection record and critical disaster point are linked on the map. From the perspective of self-sustainability, the database has been developed as a simple and user-friendly system. The user's manual has been prepared for updating and maintaining the database system.

II. Handover of the equipment

The certificate of handing over the equipment was signed by Mr. Yamada, Chief representative of the JICA Bhutan Office and Mr. Karma Galay, Director of the DoR. The following equipment was officially handed over from JICA to DoR, MoWHS.

Table 1 List of equipment

No.	Item	Quantity
1	Toyota Hilux Vigo (2015 model) MR0FR22G500791701/A687085	1
2	Toyota Hilux Vigo (2015 model) MR0FR22GX00792584/A697665	1
3	Laser rangefinder Leica DISTO-D510	3
4	Portable GPS GARMIN Map62sc with battery charger	3

Annex-1: List of members who attended 3rd Steering Committee

Annex-1

List of members who attended 3rd Steering Committee

<BHUTAN SIDE>

Department of Roads, Ministry of Works and Human Settlement (DoR)

Mr. Karma Galay (Director)

Mr. Dorji Gyeltshen P (Chief Engineer, Maintenance Division)

Mr. Lungten Jamtsho (Chief Engineer, Design Division)

Mr. Tshewang Dorji (Chief Engineer, Bridge Division)

Mr. Dorji Tshering (Executive Engineer, Maintenance Division)

Gross National Happiness Commission (GNHC)

Ms. Kuenzang L. Sagy (Deputy Chief Research Officer)

<JAPAN SIDE>

JICA

Mr. Koji Yamada (Chief Representative, JICA Bhutan Office)

Ms. Tomoko Miyata (Project Formulation Advisor, JICA Bhutan Office)

Mr. Krishna Subba (Senior Program officer, JICA Bhutan Office)

JICA Expert Team

Mr. Takeshi Kuwano (Team leader / Slope stability management)

Mr. Kimihiko Kotoo (Vice team leader / Slope inspection)

Mr. Takashi Hara (Slope stability countermeasure)

Mr. Tomoharu Iwasaki (Slope risk analysis)

Mr. Takashi Saito (Slope stability database system)

Ms. Haruka Yoshida (Coordinator / Slope inspection / Environmental & social consideration)

Mr. Pema Tshering (Project Assistant)

Appendix 4

Questionnaire Sheet for Existing/ Available Countermeasure Works in Bhutan

Questionnaire for Exisitng/Available Countermeasure Works in Bhutan

Name: _____ Regional Office Name: _____

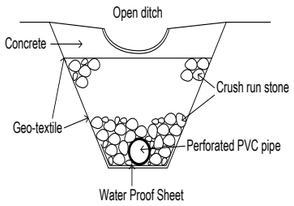
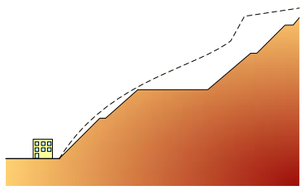
No.	Countermeasure Work	is it available in Bhutan? y/n	
1	Water Channel (Surface drainages)		
2	Horizontal Drainage		
3	Drainage Well		
4	Drainage Tunnel		
5	Buttress (Counterweight Fill)		
6	Piliing		
7	Ground Anchor		
8	Grating Crib Work		
9	Slope Crib work (Shotcrete)		
10	Slope Vegetation		
11	Retaining Wall (Concrete)		
12	Retaining Wall (Gabion/Masonry)		
13	Anchor Work		
14	Sabo Dam (Check Dam)		
15	French Cascade		
16	Shed Work		
17	Ground Anchor/Rock Bolt		
18	Wire Rope Net		
19	Removal Work		
20	Concrete Retaining Wall		
21	Foot Protection Work		
22	Shifting Route		
23	Protection Wall (Concrete) and Fence		
24	Protection Wall (Gabion/Masonry)		
25	Rock Removal		
26	Rockfall Net		
27	Fixeing Work by Concrete		
28	Rock Shed		
29	Bonding		
30	Others	Type of work	
31	Others	Type of work	

Appendix 5

Catalogue of Countermeasure Works

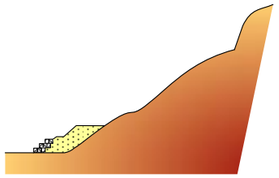
CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

LANDSLIDE

Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Surface Drainage (Open ditch)		To collect surface water and to properly drain it out from the landslide area	This is the one of the simplest countermeasure works for landslides. The work can be expected to avert infiltration of rainfall into the landslide block. Generally, maintenance of the work will not be difficult.	A flexible type of drainage maybe required so that it can adjust to movements in the ground surface due to landslide activity. Otherwise, the drainage will be damaged by the ground movements, and then the water will penetrate into landslide from the damaged points.	General open ditch construction will be feasible in Bhutan. However, in the case the ditch construction entails the use of special materials such as corrugated steel piping, the feasibility will depend on the presence of contractors able to carry out work using such materials.	Generally, the effect of the work is assumed to be difficult in the design stage.	Domestic
Open-Blind Ditch (French drain)		To properly collect and to discharge the surface water and shallow groundwater in the landslide area	In case the groundwater level is near to the surface in the landslide area, the work will be effective in draining the groundwater and surface water.	If the groundwater level is deeper than 2 m from the ground surface, the blind ditch (conduit) part will not function.	General open-blind ditch construction will be feasible in Bhutan. However, in the case the construction of the surface ditch part entails the use of special materials such as corrugated steel piping, the feasibility will depend on the presence of contractors able to carry out work using such materials.		Domestic
Horizontal Drainage		To collect groundwater to draw down the groundwater level in the landslide area	This is one of the general countermeasure works for landslides. The ordinary drilling machine can be used for the work. Since the work does not require large scale preparation, it can be applied as an emergency countermeasure.	If the target groundwater level is deep, the work shall not be applied, and maximum length of the drainage shall be less than 50m The work will be difficult to apply if the landslide consists of material with a lot of boulders.	The percussion drilling machine for anchor work is recommended for this work. However, even rotary drilling machines, which can drill in a horizontal direction, can be adopted for this work.	Maintenance of the drainage pipes is required regularly after completion of the work.	Domestic + External technical support
Drainage Well		To collect deep groundwater to draw down the groundwater level in the landslide area.	The well can be adopted if the landslide block is massive and deep to collect groundwater by horizontal drainage.	Generally, the work will require specific machineries and materials such as a small excavator, cylinder liner plate, and small drilling machine, and so on.	The work will be able to be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.		International
Earth Removal		To reduce the sliding force of landslides by removing the head part of landslide block	This is one of the simplest countermeasure works for landslides. The work can be expected to have a direct effect for stability of landslides. The work can be used as an emergency countermeasure work.	Depending on the shape of slip surface, the work may not contribute to making stable conditions of the slope.	It will be feasible in Bhutan; any local contractor can carry out the work.	The work may trigger another landslide which is located above the target landslide.	Domestic

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

LANDSLIDE

Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Counterweight Fill		To increase the resisting force against the sliding force of landslides.	This is one of the simplest countermeasure works for landslides. The work can be expected to have a direct effect for stability of landslides. The work can be used as emergency countermeasure work.	Depending on the location of fill (embankment) on the slope, the work may not contribute to making stable conditions on the slope.	It will be feasible in Bhutan; any local contractor can carry out the work	The work may trigger another landslide which is located down from the target landslide.	Domestic
Steel Pile work		To increase the resisting force against the sliding force of landslides by shear strength of piles.	This work is designed to stop a landslide from moving through structural strength. Therefore, the work can be expected to have a direct effect on stability of landslides.	The pile work will not work properly under the following conditions: ・ Locations that show steep slip surface or; ・ Locations on an active landslide; and ・ Locations which consists of loose material	The work can be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.	The piles for landslide countermeasures, shall not be driven piles but shall be installed in boreholes.	Domestic + External technical support
Cast-in place concrete Shaft (Caisson)		To increase the resisting force against the sliding force of landslides by shear strength of shaft piles.	This work is designed to stop landslides from moving through structural strength. Therefore, the work can be expected to have a direct effect for stability of landslide. If the restraint force of steel piles is insufficient for the required force to stop the landslide, the shaft work can be adopted. The shaft work can be carried out manually to dig the borehole for the the caisson depending on the site condition.	The pile work will not work properly under the following conditions: ・ Locations that show steep slip surface and; ・ Locations on an active landslide; ・ Locations which consists of loose material; and ・ The shaft work requires a firm ground foundation for the structure.	The work can be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India. The work will be costly.		Domestic + External technical support
Ground Anchor		To fix a landslide body by transferring tension stress of structure to firm ground	The work can be used in the following cases: ・ No ground reaction force is expected at a steep slope; ・ Immediate effect is required for emergency; and ・ Stabilization measures will be required at the toe part of landslide against partial collapse.	The work requires specific machineries, equipment and materials. Such work may not attain its intended effect if the length of the anchor (free length of anchor) needs to be more than 20 m.	The work will be able to be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India. The work will be costly.	A lift-off test is required to check whether the anchor is keeping the planned tension stress or not.	Domestic + External technical support

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

DEBRIS SLOPE FAILURE

Item		Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Ditch on slope			To collect surface water and to properly drain it out of the slope	This is the one of the simplest countermeasure works. The work can be expected to avert infiltration of rainfall into the slope. Generally, maintenance of the work will not be difficult.	Nothing special	It will be feasible in Bhutan; any local contractor is able to carry out the work. It is one of the common slope countermeasure works in Bhutan	Regular maintenance is required. The work shall be designed to be constructed on the steps (benches) between the slopes.	Domestic
Re-vegetation			To support stability of slope surface.	The work can be recommended to apply to all cut slopes if possible. Advantages of the work are as follows: ・It is cheap ・Easy to implement ・Good for environment and landscape	Good effects are not expected on loose conditions of slope surface. If the work is adopted on a loose surface slope, wicker fence or crib works shall be combined with the work to keep plants on the slope.	It will be feasible in Bhutan; any contractor can carry out the work. It is one of the common slope countermeasure works in Bhutan	Plants for the work shall use local species to avoid changing the environment around the site.	Domestic
Wicker Fence			To maintain stability of a slope surface until the plants planted in the re-vegetation work grow sufficiently	The work can be adopted on a loose surface slope to keep the material of slope surface. The fence can be made by wood and wooden branches. No machinery is required to implement the work.	The work will be difficult to adopt on hard rock slopes.	It will be feasible in Bhutan; any contractor can carry out the work.		Domestic
Wooden Log Crib			To keep stability of a slope surface until the plants planted in the re-vegetation work grow sufficiently	The work has almost the same function as a wicker fence. The main materials for the work will be wood and stone.	The work will be difficult to adopt on hard rock slopes.	It will be feasible in Bhutan; any contractor can carry out the work.		Domestic
RRM Retaining Wall	Masonry Wall		To avoid erosion of slope surface and to keep stability of a slope surface	The work can have a good effect on slopes, especially sediment and weathered rock slopes. The work is designed to avoid erosion and weathering on the surface of slopes. Required materials for the work is boulder and concrete.	The masonry wall shall not be expected to support slope stability as the retaining wall does. The wall shall not be adopted on a slope which has many water seepages without any drainage work for the water.	It will be feasible in Bhutan; any contractor can carry out the work. It is one of the common slope countermeasure works in Bhutan	Weep-hole shall be put on the wall to discharge water from behind the wall.	Domestic
	Bended Wall		To support stability of a slope surface and avoid erosion of slope surface	The work can be adopted if the slope cannot be secured at the appropriate/standard angle due to the limitation of site or topography. The work can be applied to various slope conditions such as a slope with earth pressure or failure-prone slope by water seepage.	The work shall not be installed at slope(s) where excavation of the toe part of the slope(s) (for installation of the wall) will make conditions of the slope unstable.	It will be feasible in Bhutan; any contractor can carry out the work. It is one of the common slope countermeasure works in Bhutan, especially Gabion and Masonry wall	Weep-hole shall be put on the wall to discharge water from behind the wall. The retaining wall can be made by Gabion or Reinforced Concrete.	Domestic

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

DEBRIS SLOPE FAILURE

Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
RCC Crib retaining wall		To retain slope stability and to avoid erosion and weathering of the slope	It can be used in emergency cases. According to the structure of the wall, the wall does not receive water pressure from the back slope and can flexibly follow deformation of the back slope.	The design for members of the wall shall be made properly. It will be difficult to obtain an expected retaining force on slope stability.	The work has been applied in Bhutan	Members of the wall shall be stored to be used for emergency cases.	Domestic
Barrier Wall (Concrete / Gabion)		To avert failed debris or fallen rocks from reaching the road	If the countermeasure work is difficult to apply on the slope directly, the work can be installed as a prevention measure.	Sufficient space to catch failed debris or rocks shall be required between the slope and the wall.	It is one of the common slope countermeasure works in Bhutan, especially Gabion and Masonry wall	A rock protection fence will generally be attached on top of the wall. Regular maintenance will be required to secure an open space behind the wall.	Domestic
Re-shaping slope with Benching		To make stable slope conditions with appropriate/ standard angle	The work gives a direct effect on slope stability. It is recommended to consider adoption of the work as the first step.	Since a space for machinery like an excavator is required, the work will be difficult to be adopted on steep slopes.	The work is just simple earth work. It is feasible in Bhutan.	When the work is planned, it shall be studied whether the excavation work will disturb the stability of neighboring slopes. Surface drainage shall be installed on benching	Domestic
Shotcrete		To avoid erosion, weathering and infiltration of water into the slope	The work can be adoptadopted on various types of slopes.	Since the work does not have a retaining function, the work shall not be applied on slopes where many unstable rocks are found.	The work will be able to be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.	If a lot of water seepage is found on a slope, weep holes shall be frequently put on shotcrete surface.	Domestic + External technical support
Surface Protection		To support the slope surface stability	The work can be adoptadopted on various types (forms) of slopes and is a way of avoiding cutting the trees on the slope.	The work may not be adopted on the slope which is considered to have potential of large scale of failure, and which consists of hard rocks.	There are some cases of the work in Bhutan. But the costs are still high.		External technical support
Ground Anchor		To fix a slope surface by transferring tension stress of structure to firm ground	In the following cases, this work will be appropriate. ・No ground reaction force can be expected at a steep slope, ・Immediate effect is required for emergency	The work requires specific machineries, equipment, and materials. The effects of this work may not be obtained as planned; in case the anchor length required (free length of anchor) is more than 20 m.	The work will be able to be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India. The work will be costly.	A lift-off test is required to check whether the anchor is keeping the planned tension stress or not.	Domestic + External technical support

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

DEBRIS SLOPE FAILURE							
Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
RC Concrete Crib		To support slope surface stability and prevent erosion.	The work can be adopted to various types (forms) and materials of slope. Generally, this work can be applied with ground anchor work.	The work is not used for artificial slopes.	The work is a common measure for slope stability in Japan. It will require technical support from Japan if the work is applied in Bhutan.		International

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

ROCK SLOPE FAILURE

Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Rock Removal		To remove problematic parts or unstable rocks on slope	The work has a direct effect on hazards of rock slope failures or rockfalls. This work shall be the first option to consider for rock slope failure measures.	The following slope conditions may not be good for implementation of this work. ・ Hard and massive rocks; ・ Steep / overhanging slopes; and ・ No access for the machinery for excavation	The work will be feasible in Bhutan depending on site conditions. Knowledge and experience for works on steep slopes will be required.		Domestic
Concrete Retaining Wall		To support stability of slopes and avoid erosion and weathering of slope surface	The work can be adopted if the slope cannot be secured at the appropriate/standard angle due to limitations of site or topography. The work can be applied to various slope conditions such as failure-prone slopes from water seepage.	The work shall not be installed at the slope where excavation of the toe part of the slope for installation of the wall will make unstable conditions of the slope.	It will be feasible in Bhutan; any contractor can carry out the work. This is one of the common slope countermeasure works in Bhutan, especially Gabion and Masonry wall	Weep-hole shall be put on the pitching wall to discharge water from behind the wall. The retaining wall can be made by Gabion, Masonry or Reinforced Concrete.	Domestic + External technical support
Barrier Wall (Concrete / Gabion)		To avert fallen rocks from reaching the road	In case of the countermeasure work is difficult to apply on the slope directly as with rock removal or protection rock net; this work can be installed as a prevention measure.	Sufficient space to catch failed debris or rocks shall be required between the slope and the wall.	This is one of the common slope countermeasure works in Bhutan, especially Gabion and Masonry wall	A rock protection fence will generally be attached on top of the wall. Regular maintenance will be required to secure an open space behind the wall.	Domestic + External technical support
Protection Rock Net		To fix unstable rocks at original position	The work shall be adopted in case unstable rocks cannot be removed because of the site conditions.	Since the net shall be fixed by anchor bolt on the slope, such work is not recommended to be adopted on slopes with fractured or weathered rocks.	The work can be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.	Generally, stages for the work will be required.	International
Rock Bolt (Nailing)/Anchor		To fix loose rock slope or unstable rocks at original position	The work shall be adopted for unstable rocks or unstable rock slopes	This work is not recommended to be applied in fractured or weathered rock slopes.	The work can be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.	Generally, the work is adopted in combination with shotcrete or concrete crib work.	Domestic + External technical support

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

DEBRIS FLOW

Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Sabo Dam		To catch debris, big boulders or wood debris from trees flowing in the river, such as during a flood, and to discharge only water or with a minimal amount of debris	The work can be adopted in the following cases. ・ Expected volume of debris is massive ・ The river is deep	Firm ground is required for foundation of the dam	The work can be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.. The work will be costly.		International
Check Dam (Gabion / RRM)		To break speed of debris or water flow, and to catch some debris, boulders or wood debris from trees flowing in the river, such as during a flood.	The work can be applied on small tributary valleys or gulleys as well. The work can be adopted on various gradients of valleys	The dam may not work properly in valleys where there are a lot of debris deposits.	It will be feasible for Bhutan, especially if it is made by Gabion and Masonry wall		Domestic
Buffer Forest		To break energy of debris flow	The work can be adopted on gentle ground. Advantages of the work are as follows: ・ Low cost and easy to implement ・ Good for environment and landscape	The work cannot be adopted in the following cases. ・ Steep slopes ・ Rocky slopes	It will be feasible for Bhutan,		Domestic
Shed Work		To discharge debris flow or river water without affecting the road	The work can be adopted in the following cases, ・ The estimated volume of debris flow is too massive to be stopped by a Sabo dam ・ The height of the river bed is higher than the road.	If the height of the river bed is lower than the road, the work cannot be applied.	The work will not be able to be carried out by Joint Venture (consisting of local contractors and contractors from other countries such as India). The work will be costly.	The width and inclination of shed shall will be designed based on the river width and gradient	International
Culvert / Bridge (RRM)		To make flowing debris pass under the road	The work can be adopted in various conditions of water streams.	It cannot be adopted if large size boulders or large amounts of debris surpassing the dimension of water stream are expected to flow down the stream.	The work is a common facility in Bhutan.		Domestic

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

ROCK FALL

Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Rock Removal		To remove unstable rocks on slopes	The work has a direct effect on hazards of rockfalls. The work shall be the first option to consider for rockfall measures.	The following slope conditions may not be good for implementation of the work: ・ The place is too high to conduct the work ・ The machinery for excavation is unable to access the site	The work will be feasible in Bhutan depending on site conditions. Knowledge and experience for work on steep slopes will be required.		Domestic + External technical support
Protection Wall (Concrete / Gabion)	 	To avert fallen rocks from reaching the road	If the countermeasure work is difficult to apply on the slope directly as with rock removal or protection rock net, this work can be installed as a prevention measure.	Sufficient space to catch failed debris or rocks shall be required between the slope and the wall.	This work is one of the common slope countermeasure works in Bhutan, especially Gabion or Mason wall.	A rock protection fence will generally be attached on top of the concrete wall. Regular maintenance will be required to secure an open space behind the wall.	Domestic
Rock Catch Net		To avert fallen rocks from reaching the road by catching fallen rocks from slopes	The work can be adopted on the slope where unstable rocks are extensively distributed.	The net shall not be expected to deal with large energy of fallen rocks. The target rocks shall not be big rocks or rocks at a high slope.	The work can be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India..	Regular maintenance will be required to secure a space behind the net.	International
Fixing Work by shotcrete		To fix unstable rocks at original position	The work shall be adopted if the unstable rocks cannot be removed because of the site conditions.	Since the work does not have a retaining function, the work shall not be applied on slopes where many or massive unstable rocks are found.	The work will be able to be carried out by Joint Venture consisting of local contractors and contractors from other countries such as India.	Safety measures for the work shall be required due to the high-place work and the worker also shall be required experiences of the high-place work.	Domestic + External technical support
Shed Work		To protect roads from fallen rocks	This work can be adopted for the slope where many unstable rocks, which are difficult to deal with by other measures, are found.	The shed work has capacity limitations for bearing against falling rock energy. Estimated falling rock energy shall be examined in the design stage of the work.	The work will not be able to be carried out by Joint Venture consisting of local contractors and contractors from other countries. The work will be costly.		International

CATALOG OF COUNTERMEASURE WORKS FOR SLOPE DISASTERS

OTHERS							
Item	Photo/Drawing	Purpose	Availability	Limitation	Feasibility in Bhutan	Remarks	Application
Tunnel -Route Shift-		To avoid problematic road sections by shifting routes	The work can be adopted for road sections that cannot be dealt with by other countermeasures because of site conditions or for economic reasons.	The availability shall be determined according to not only topographical and geological conditions, but also economic or political planning.	Depending on the site conditions, the work will not be able to be carried out by Joint Venture (consisting of local contractors and contractors from other countries). The work will be costly.		International
Bridge -Route Shift-		To avoid problematic road sections by shifting routes	The work can be adopted for road sections that cannot be dealt with by other countermeasures because of site conditions or for economic reasons.	The availability shall be determined according to not only topographical and geological conditions, but also economic or political planning.	Depending on the site conditions, the work will not be able to be carried out by Joint Venture (consisting of local contractors and contractors from other countries). The work will be costly.		Domestic / International

Appendix 6

Land Use Data in Bhutan

◆ Ratio of Land Cover in Bhutan

Category	(km^2)	(%)
Fir	3,453	8.6
Mixed Conifer	4,868	12.1
Blue Pine	1,286	3.2
Chir Pine	1,009	2.5
Conifer Forest (Total)	**10,616**	26.5
Broad Leaf+ Conifer Leaf	**1,358**	3.4
Broad Leaf Forest	**13,749**	34.3
Conifer Plant	**20**	0.1
Broad Lea Plant	**44**	0.1
Forest Plantation	**64**	0.2
Scrub Forest	**3,258**	8.1
Forest (Total)	**29,045**	72.5

Natural Pastures	1,553	3.9
Improv. Pastures	11	0.0
Pasture (Total)	**1,564**	3.9

Irrigation Wetland	387	1.0
Rainfed Wetland	0	0.0
Wetland Cultivation	**388**	1.0
Terraced Dryland	111	0.3
Unterraced Dryland	866	2.2
Dryland Cultivation	**977**	2.4
Tseri	**883**	2.2
Mixed Cultivation	**840**	2.1
Agricultute(Total)	**3,088**	7.7

Category	(km^2)	(%)
Apple Orchards	13	0.0
Citrus Orchards	10	0.0
Orchards	**22**	0.1
Cardamon Plantation	35	0.1
Areca nut Plantation	0.4	0.0
Ginger Plantation	0.3	0.0
Horticulture Plantation	**36**	0.1
Horticulture(Total)	**58**	0.1

Settlement	**31**	0.1

Snow Glacier	2,989	7.5
Rock Outcrops	2,008	5.0
Water Spreads	304	0.8
Marshy areas	35	0.1
Landslip/erosion	954	2.4
Others(Total)	**6,289**	15.7

Forest (Total)	**29,045**	72.5
Pasture (Total)	**1,564**	3.9
Agricultute(Total)	**3,088**	7.7
Horticulture(Total)	**58**	0.1
Settlement	**31**	0.1
Others(Total)	**6,289**	15.7
Grande Total	**40,077**	100.0

<Reference>
Atlas of Bhutan: Land Cover and Area Statistics of 20 Dzongkhags 1997,
Ministry of Agriculture, Royal Government of Bhutan